



energy

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Key

Different development sectors are colour coded below. To aid navigation through the case studies in this Guide, the colour codes denote the applicability of case study sustainability solutions to each of the various development sectors. The colour coding can be found in the bottom corners of each of the case studies.



Home owner



Residential



Commercial



Retail



Infrastructure



Education



Health



Leisure

Hertfordshire energy facts

In Hertfordshire in 2005, **an estimated 2,204 GWh of electricity and 7,892 GWh of gas were consumed** in the residential sector. (www.defra.gov.uk)

In 2006 the **household sector** accounted for **35% of energy use**. (www.nef.org.uk)

The **average person** in the UK **uses 1,930 units or kilowatt hours** of electricity per year. (www.nef.org.uk)

The Bedfordshire and Hertfordshire Energy Advice Centre runs the **Warmer Homes Greener Herts bulk discount insulation scheme**, providing insulation to residents at a reduced cost.

The Home Energy Conservation Act, 1995, has set a target of at least a **30% reduction in CO₂ emissions from domestic premises**. Defra are currently reviewing the Act. (www.defra.gov.uk)

Targets have been set in the East of England Plan, May 2008, for **10% of the region's energy to come from renewable sources** by 2010 and 17% by 2020.

The **Climate Change Levy is a tax on the use of fossil fuels in the non-domestic sector** and forms a key part of the UK Government's Climate Change programme. Energy from renewables and approved Combined Heat and Power schemes is exempt from the Levy.

Hertfordshire's forecast **population growth over the 25 years from 2006 to 2031 is 195,100** a percentage increase of 18.4 (ONS 2008). That means electricity and gas consumption are also set to increase, making renewable energy generation more important.

The 2007 **Housing Green Paper** establishes targets for all new homes to emit 25% less carbon from 2010, 44% less from 2013 and to be **zero carbon from 2019**. (www.goeast.gov.uk)

Hertfordshire County Council and several local authorities purchase green electricity from renewable sources for their public buildings. The use of Combined Heat and Power generation is **reducing the county's CO₂ emissions**. An example is the Letchworth Leisure Centre in North Hertfordshire.

Turning electrical equipment off at the mains rather than using the standby mode **makes a difference** - 8% of household energy is used by appliances on standby.

A scheme called **Schools Energy Challenge** is taking a whole school approach to water and energy management, involving staff and pupils. It gives access to grants, offering up to £3,000 to implement efficiency measures.

Legislation seeks to reduce the energy consumption of buildings by 25% and to increase the provision of renewable energy to meet 10% of on-site demand (PPS22: Renewable Energy).

Turning down the thermostat by 1°C can save you a further 10% of a household energy bill whilst not negatively affecting the comfort of occupants. (sepa.org.uk)

The **energy consumed** each year by UK commerce and industry releases about **60 million tonnes of carbon** into the atmosphere. (www.sepa.org.uk)

The Climate Change Act aims to **reduce carbon dioxide emissions** through domestic and international action to 26-32% below 1990 levels by 2020, and at least 60% by 2050. (www.goeast.gov.uk)

Nuclear power stations provided 23% of UK's electricity in 2003. By 2010, a third will be at the end of their operating lives. (www.news.bbc.co.uk)

Basic principles

Principles of energy

Approximately 50% of all UK carbon dioxide emissions are generated by the energy consumption of buildings. Reducing energy consumption in buildings is a key objective of national government. Excessive energy consumption is not only an environmental concern, but is also beginning to raise economic concerns, as energy prices have increased significantly in recent years.

Legislation has recently been introduced to increase energy efficiency in building stock throughout Europe. In the UK, this takes the form of revisions to Building Regulations, which now require an improvement in energy performance of 25% against the 2002 Regulations for all new build projects. Refurbishments and extensions are subject to different requirements.

Energy White Paper: Our energy future

The UK Government White Paper sets out the intentions for energy generation and use in the coming years, including specific targets for greenhouse gas emissions:

- 60% reduction in CO₂ emissions by 2050

Energy efficiency in the built environment and the use of renewable energy are key factors in the proposals to meet this target. If the target is to be achieved in 2050 30–40% of the UK's energy supply will need to come from renewable energy sources. This will be achieved through large scale installations, but also through small scale generation at a local level.

Energy Services Directive

The Energy Services Directive, effective in the UK from 17 May 2008, aims to enhance the cost effective improvement of energy end use efficiency. Article 5 requires public sector organisations to lead by example and take up cost effective energy efficiency improvements that generate the largest savings in the shortest space of time.

Further information is available at:
www.defra.gov.uk/Environment/climatechange/uk/energy/energyservices/index.htm

PPS 22

Planning Policy Statement 22: 'Renewable Energy', places an obligation on regional planning bodies to encourage local renewable energy projects, to support the Government's policy on the reduction of CO₂ emissions. In Hertfordshire, this equates to a target of 153,000 GWh of renewable energy production by 2010.

Further information is available at:
www.communities.gov.uk

Energy Performance of Buildings Directive

The EU Directive on the Energy Performance of Buildings came into force in January 2006, with the aim of reducing energy use and associated emissions from the built environment throughout Europe.

Each country within the European Union will set minimum standards for energy efficiency in buildings, including the consideration of alternative energy technologies for new buildings and the improvement of the energy performance of existing buildings when renovations are carried out. In the UK, these requirements are being addressed through Building Regulations, and are included in Part L, 2006.

From the 1st October 2008 the Directive requires all landlords and property owners to provide an Energy Performance Certificate EPC when they construct, sell, lease or modify a building. They must also ensure that air conditioning systems with an output of greater than 250kW have received an energy inspection by 4th January 2009.

Only accredited companies can provide EPCs. By complying with legislation and following the recommendations supplied with the EPC on how to improve energy efficiency, you can reduce your energy bills and cut its carbon emissions.

From 1st October 2008, public authorities and institutions occupying buildings with a floor area over 1000m² and visited by a large number of the public must put on view a Display Energy Certificate (DEC). DECs show the actual energy usage of a building, the Operational Rating, and help the public see the energy efficiency of a building.

A DEC is always accompanied by an Advisory Report that lists cost effective measures to improve the energy rating of the building. DECs are valid for one year whilst the Advisory Report is valid for seven years.

Further information is available at: www.europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_001/l_00120030104en00650071.pdf

Did you know?

The Climate Change and Sustainable Energy Act 2006 promotes renewable energy sources, making it cheaper and easier for people to generate their own energy. It requires the Government to submit an annual report to parliament regarding current levels of greenhouse gas emissions and the efforts being made to reduce them. It also introduces targets for the take up of the microgeneration of energy.

Principles of energy

Building Regulations - Part L 2006

The 2006 issue of Part L 'Conservation of Fuel and Power' contains a number of significant changes to the required performance of buildings and to the information that must be submitted to Building Control.

The new standards will account for energy improvements of between 23.5 –28% dependant on services strategy on the 2002 Building Regulations in all new buildings. The following requirements also now apply:

- pressure testing
- elimination of overheating from excessive solar gains
- provision of information on the efficient operation of the building

In addition, there are requirements for wider improvements when work is carried out on existing buildings. In domestic buildings this involves the upgrade of whole elements (e.g. external walls) where work is being carried out to a part of that element. In non-domestic buildings, energy improvements to building services and the incorporation of renewable energy technologies are required, where feasible.

The Government has set out its policy that new homes will be zero carbon from 2016, and an ambition that new schools be zero carbon from 2016, public sector non-domestic buildings from 2018 and all other non-domestic buildings by 2019.

Further information is available at: www.communities.gov.uk

Code for Sustainable Homes

In December 2006, the Government published the Code for Sustainable Homes, which outlines national standards for measuring sustainable design and construction in new housing development. The Code awards points for energy improvements above Building Regulations Approved Document L (2006). It also encourages energy efficient improvements to internal and external lighting and Ecolabelled white goods. Code compliance has been required for new social housing developments, which must meet Code level 3 as a minimum since April 2008. From 1st May 2008 it has been mandatory for all new homes to be rated against the Code. A Code Certificate must be included within the Home Information Pack (HIP).

In 2006 the Government announced a 10 year timetable towards a target that all new homes from 2016 must be built to zero carbon standards, to be achieved through a step by step tightening of the Building Regulations. A Code for Sustainable Non-dwellings is being considered by the Government.

Further information is available at: www.communities.gov.uk

Further policy has been introduced in England and Wales to encourage the use of renewable energy. This is being addressed on a large scale, for example with off-shore wind farms, but requirements are also being passed on to building owners/developers to make use of small scale renewable energy generation solutions to meet a proportion of the energy load of their building or development.

Principles of sustainable energy

This module promotes energy efficient construction processes and building operations, the use of sustainable approaches to design and increased renewable energy generation. The basic principles of energy management in design/building operation are listed below.

1 energy hierarchy

Following the energy hierarchy is one of the most effective ways in which to reduce the environmental impacts of buildings. Measures are listed below:

- **be lean – reduce energy demand:**
 - use passive environmental systems, e.g. natural ventilation, daylighting, passive solar gains
 - use high levels of insulation and air tightness in the building fabric
 - specify energy efficient services, controls and appliances
- **be green – use renewable energy:**
 - use low/zero carbon technologies to provide as much of the energy load as is technically and economically feasible
- **be clean – minimise use of fossil fuel:**
 - use efficient fossil fuel technologies, for example Combined Heat and Power, condensing boilers, etc
 - buy electricity on a green tariff to support new renewable energy projects

2 energy efficiency and renewable energy options

There are many possible options, some of which are applicable in all development types, others of which may be specific to particular development sectors, location or style of architecture. Further details are

provided in the 'Solutions' section.

Options for improving efficiency in the building fabric include:

- enhanced insulation values
- improved air tightness
- shading provision
- double/triple glazed windows

Options for improving the efficiency of building services include:

- high efficiency boilers and chillers
- natural ventilation
- increased natural daylighting
- chilled beams
- underfloor heating
- efficient controls systems
- insulation of pipes, ducts and vessels

The following items further reduce building energy consumption once occupied:

- low energy light bulbs, including compact fluorescent lighting
- energy efficient white goods:
 - fridge
 - freezer
 - washing machine
 - tumble-dryer
 - dishwasher

Alternative energy options include:

- combined heat and power
- solar water heating
- photovoltaic panels
- small scale wind turbines
- ground source heat pumps
- biomass

Lastly, to further reduce the impact of using conventional energy sources, a Green Energy Tariff (electricity generated from off-site renewable energy) can support the development of new large scale renewable energy installations.

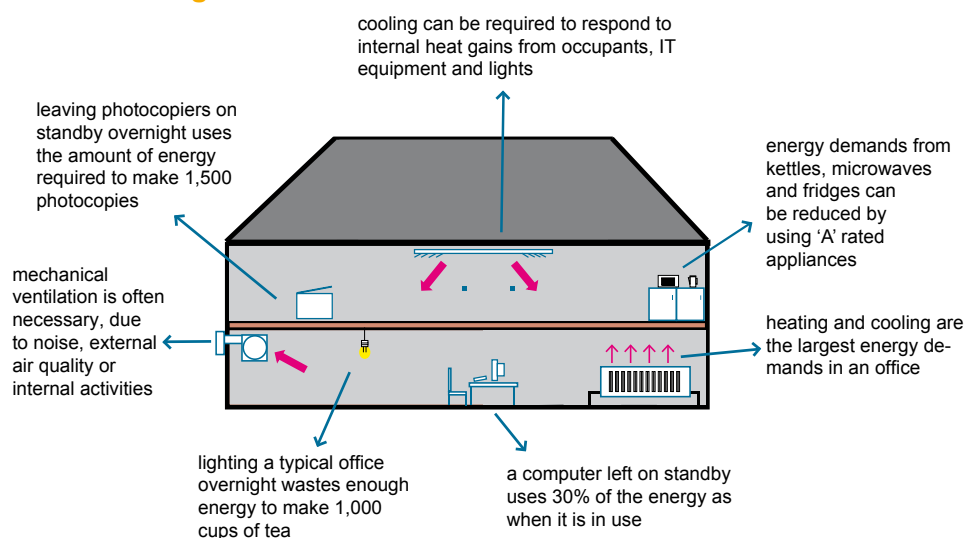
Benefits of energy management

Choosing an appropriate range of energy efficiency and renewable energy solutions can deliver significant benefits:

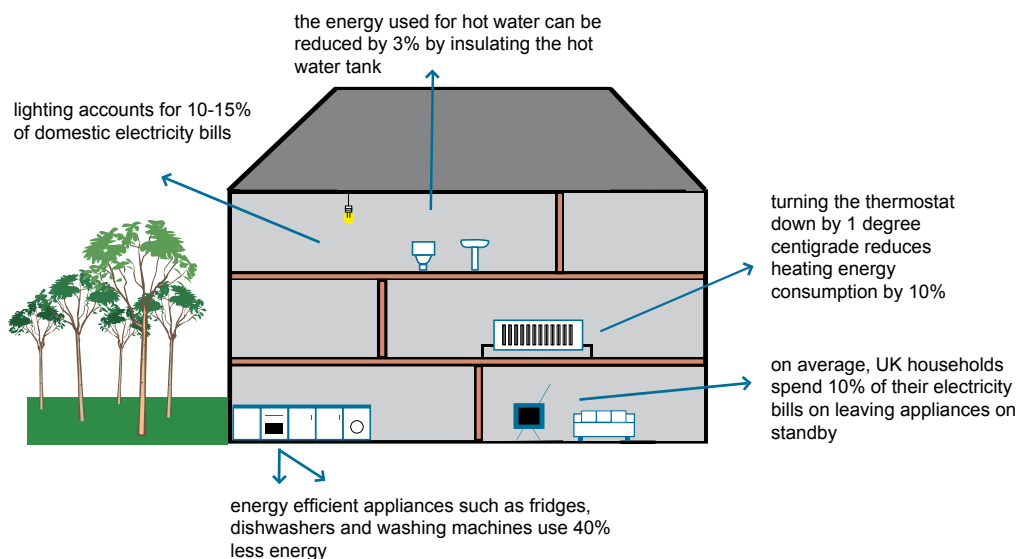
- social and economic benefits, including:
 - reduced energy bills
 - reduced maintenance bills (e.g. if natural ventilation is pursued instead of air conditioning)
 - awareness raising from highly visual technologies
- environmental benefits, for example:
 - reduced carbon dioxide and other atmospheric emissions
 - improved local air quality
 - better management of (and less reliance on) finite fossil fuel resources

Energy Demand in Buildings

Office



House



Solutions

energy efficiency in developments

There are many different energy efficiency options. Their applicability depends on the type of project, in particular whether it is a new building or a refurbishment. The following section describes low energy solutions and renewable energy options, drawing specific attention to considerations relevant to different sectors.

design

In the case of new buildings, energy issues should be given consideration at the early stages of design (ideally at project inception) to enable the best technical and economic solutions to be achieved. At an early design stage there are many opportunities to develop an integrated approach to energy use and savings, including the determination of the physical form and characteristics of the building. Consideration should be given to the following:

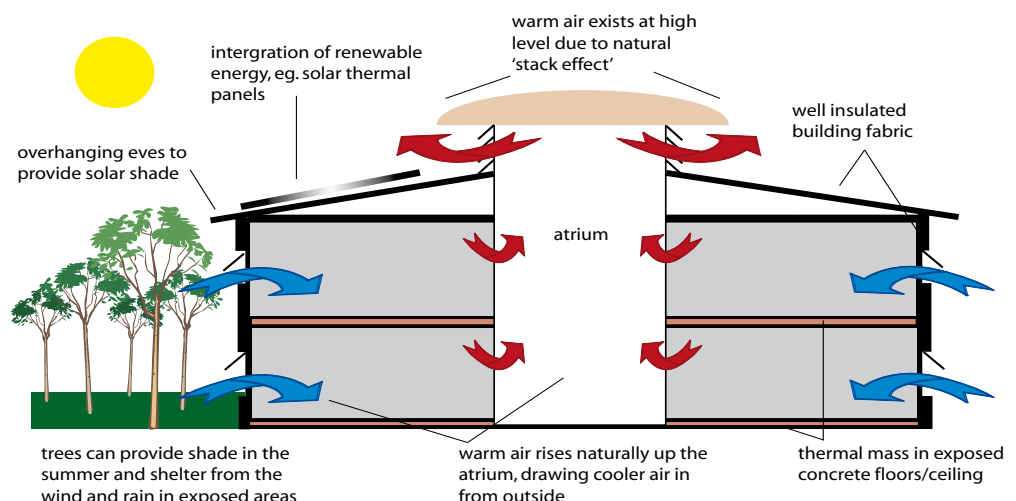
- orientation - sun path around the site, prevailing wind direction and the need for clear views
- reducing the amount of exposed external area compared with enclosed internal volume

- incorporation of atria, courtyards or sunspaces can reduce energy consumption in deep plan buildings
- thermal mass should be fully considered and included or excluded as appropriate, to correspond with activity and occupancy patterns
- landscape design can influence the microclimate (and reduce energy demand) by providing shelter from driving rain and wind
- the ratio of glazing to solid material in the external walls can be optimised to provide benefits from natural light and useful solar gains, whilst avoiding excessive heat losses or gains

These measures are influenced by decisions made throughout the design process. Cost implications are variable. In many cases, these design choices can lower capital costs through reducing building service requirements. In addition, these energy saving measures typically require little or no maintenance and last throughout the lifespan of the building with no energy input.

Where appropriate, these issues should also be applied to refurbishment projects, although it is recognised that the majority of these factors will be predetermined.

Energy Efficient Design



materials specification

The materials specified for use in the construction of a building heavily influence energy performance, in both new build and refurbishment projects.

Insulating the building fabric to a high standard is an effective way of reducing energy use and is also a cost effective solution. U-Values listed in Building Regulations should be considered as a minimum standard and should always be improved on as far as is technically and commercially practicable.

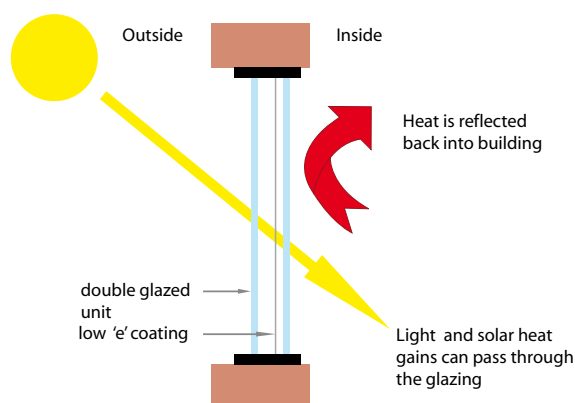
U-Values

The rate of heat loss through a building element, such as a wall, roof or floor, depends on a number of factors. It is industry convention to combine all the effects of these factors into a single measurement, termed a "U-Value".

The U-Value is the rate of heat transfer through a building element, subject to the difference in internal and external temperature. The lower the U-Value, the less significant the heat losses are, which results in a more energy efficient building.

Careful detailing of the building fabric and junctions between building elements such as windows and external walls also reduces heat losses from air leakage. Targets for air leakage rates should be specified at the design stage and verified during construction through pressure testing, which gives the opportunity to address any problem areas.

The specification of glazing should be carefully considered. Low U-Values can be achieved through the selection of low 'e' coated glass, the use of argon rather than air in the cavity between the panes, or through the use of triple glazing. Although these specifications can be more expensive than standard glazing options, they can offset costs for building services through reducing heat gains and/or losses.



Energy Efficient Glazing

Commonly available energy efficient windows include the following:

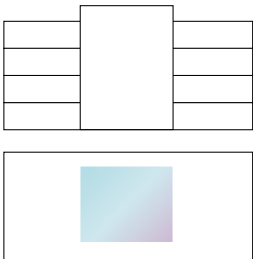
- low 'e' coating – this is a thin film of metal oxides or semiconductors placed directly onto a pane of glass to reduce heat transfer. In a double glazed unit, the film is applied to the outer surface of the inner pane to reflect heat back into the room. There is virtually no associated visual impact and solar energy still passes into the building.
- argon filled cavity – it is possible to use gases other than air in the cavity of double glazed units. Argon is a typical alternative, which reduces heat transfer due to the properties of the gas.

internal environment – ventilation, heating, cooling

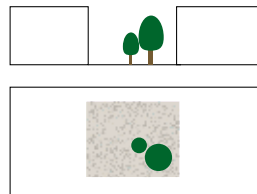
Energy efficiency can also be achieved through the incorporation of passive environmental control features. In particular, the use of daylighting, natural ventilation and passive heating and cooling can create a low energy building with reduced environmental impacts, whilst still achieving comfortable internal conditions for occupants.

Passive systems need to respond to and be appropriate for the local environment and include the following:

atria and courtyards

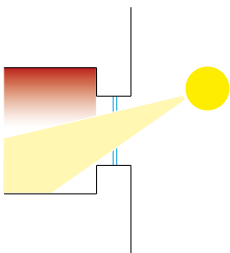


Enclosed glass volume, can be used to bring daylight and natural ventilation into the centre of deep plan buildings.

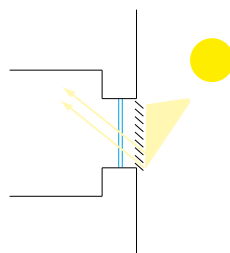


Void in the middle of a building, or group of buildings, which is open to the elements.

optimisation of glazed areas for balance of daylight against heat gains and losses



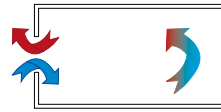
Uncontrolled solar gains can result in overheating.



The use of solar shading allows diffused light into the space and keeps excessive heat gains out.

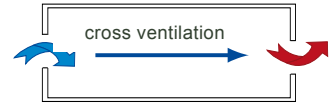
narrow floor plates (to facilitate natural ventilation)

narrow floor plates: opening on single side



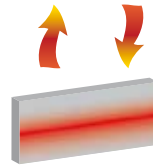
maximum depth of 7m for effective natural ventilation via an opening on one side of the space.

narrow floor plates: openings on opposite sides

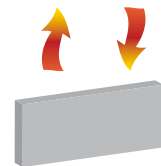


maximum depth of 15m for effective natural ventilation via openings on opposite sides of the space.

thermal mass



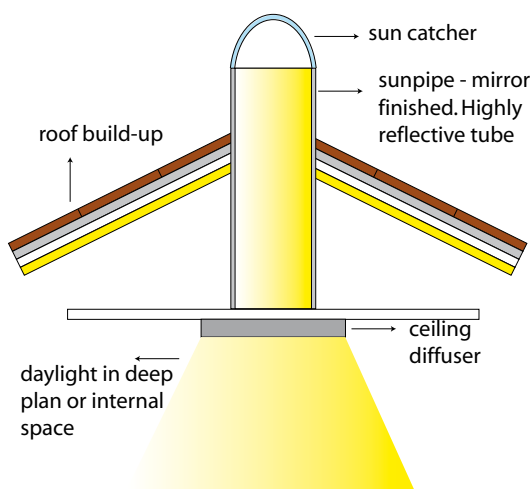
Materials such as concrete, brick and stone absorb heat, which can have a cooling effect in a building.



Stored heat is released, subject to a time delay.

Natural ventilation can be used in situations where the external conditions are free from excessive noise or poor air quality and where the intended use of the space allows. In narrow plan buildings, a typical approach is to use openable windows. In larger spaces, additional measures would be required, for example the use of a 'stack effect' system (see earlier energy efficient design diagram).

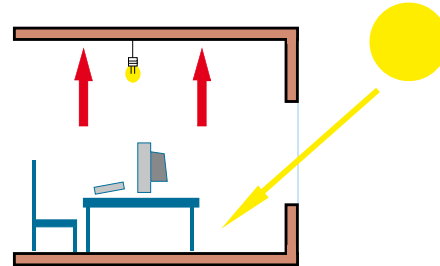
The use of natural light rather than artificial systems can offer significant energy savings. Techniques to bring light further into deep plan buildings include design features such as atria and courtyards. Sun pipes can also be used and can either be included during construction, or can be retrofitted.



Passive solar design is the capture of useful solar gains (heat) to offset heating energy requirements. Atria and sun spaces are typical examples of this approach.

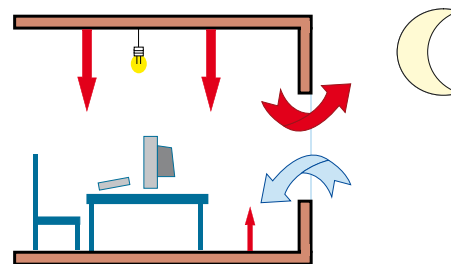
Passive cooling techniques save energy, but also avoid the use of environmentally damaging refrigerants. The most simple and economic approach is the use of night purge ventilation in buildings with exposed thermal mass. However, this is not appropriate for every building and alternatives include the use of absorption cooling from waste heat, surface or ground water cooling, ground coupled air cooling, displacement ventilation, and evaporative cooling.

night purge ventilation



Daytime:

During the day, heat gains from occupants, activities and solar energy are stored in the thermal mass of exposed concrete, stone or brick in the walls, floor and ceilings. This cools the space during the day without using energy.



Night time:

At night, the heat that has built up during the day is released from the building fabric and leaves the space through an open window or vent. The space is then cool for the start of the next day. In winter, the vents can be closed and the heat retained.

building services

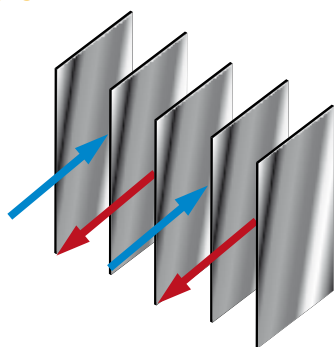
Building services equipment, such as boilers, air handling units and lighting systems use energy to provide comfortable internal conditions for building occupants. Where it has been determined that mechanical services are required to provide comfortable internal conditions, efficient plant should always be specified.

Boilers with an operating efficiency of over 90% are readily available and should be specified to ensure efficient use of fuel. Splitting the heating system in larger buildings into sections serving particular areas can reduce energy use by allowing the system to be switched off in unoccupied spaces.

If a mechanical ventilation system is required, then high efficiency fans should be specified to minimise energy use. Heat recovery should also be included, in the form of plate heat exchangers, thermal wheels, or run-around coils. Plate heat exchangers are the most simple and economic option, with no moving parts or energy required for operation.

plate heat exchangers

Air (or water) moving in opposite directions is separated by thin sheets of metal, which allow heat transfer. In this way, heat can be recovered from the exhaust air and used to pre-heat incoming air.



The use of air conditioning and comfort cooling should be restricted to those areas where it is strictly necessary.

Artificial lighting systems for use internally and externally should be as energy efficient as possible. Low energy light bulbs are widely available and use only 20% of the energy of standard bulbs, and can therefore offer significant energy and maintenance/replacement savings.

For refurbishment projects, services should be upgraded wherever possible. If costs are prohibitive, then more economic measures could be implemented, such as insulation of pipes and ductwork.

building management systems/controls

The use of an appropriate control system can significantly reduce energy wastage. For example, sensors can be used to detect when there is sufficient daylight in a space and can dim or switch off the artificial lights in response.

A BMS (Building Management System) is a sophisticated network of sensors and controls covering all building services. Systems can be programmed for optimum operation and minimal energy use. These systems are typically installed on larger projects.

Use of a BMS facilitates energy monitoring and can highlight areas of excessive use where savings could be made. In smaller buildings, a simpler approach could be to take regular meter readings.

Variable speed controls on pumps and fans can save a significant amount of energy. This allows building services to use only the energy that is required, rather than continuously operating at full capacity.

Many of these systems can be retrofitted, although this is less cost-effective than their inclusion at the design and construction stage.

Consideration should be given to the maintenance implications of installing controls and sensors. In a few instances, the additional maintenance and replacement costs associated with e.g. additional sensors and motorised controls (such as daylight sensitive lighting) can be greater than the cost savings arising from reduced energy consumption.

sector specific issues

Different types of buildings have individual requirements in terms of energy use. Some points for consideration are listed below.

residential

Passive systems, such as natural ventilation and daylighting are traditional solutions for domestic buildings. Passive solar design can be particularly effective, with south facing sun spaces giving free energy and pleasant living conditions.

An alternative low energy approach which is emerging from the influence of Scandinavian design is the construction of a well insulated sealed building with a mechanical ventilation system incorporating efficient heat recovery.

Small scale renewables can be appropriate. Technologies which lend themselves to this particular sector include solar thermal and photovoltaic panels, biomass and small scale wind turbines. Combined Heat and Power units for domestic use are currently emerging onto the market.

commercial

Although natural ventilation is the first choice in terms of energy conservation, it is not always appropriate in commercial developments. If the site is noisy, has poor

air quality or high internal heat gains from intensive use of IT or other equipment, it may be appropriate to seal the building and provide a mechanical ventilation system. In this case, measures for energy efficiency should be adopted, such as free cooling and heat recovery.

The purchase of efficient IT equipment reduces energy consumption and can have further benefits by reducing cooling loads, as less energy is released as heat.

The use of daylight should be promoted and could be combined with control systems to switch off artificial lights when they are not required. This is typically a significant source of energy consumption in commercial buildings and should be designed to be as energy efficient as possible.

Atria can be particularly effective in this sector and can be used to bring natural light in and encourage air movement in deep plan spaces.

Alternative energy technologies can be suitable, although Combined Heat and Power does not tend to be suitable for most commercial developments due to intermittent occupancy and a relatively low heat demand.

education

Traditionally, passive measures are used in primary and secondary schools. The activities in further and higher education buildings can require a more energy intensive services strategy, again efficient equipment should be specified.

Controls systems to prevent lights being left on in unoccupied classrooms, corridors and toilets should be incorporated.

The use of renewable energy technologies can be particularly appropriate in education buildings, to raise awareness of energy issues. There are several examples of schools with small scale wind turbines in Hertfordshire and across the UK.

health

Alternative energy technologies can be particularly appropriate for hospital buildings. A large roof space is typically available for installations of solar or photovoltaic panels.

Combined heat and power systems lend themselves to this type of building, as there is a high and constant energy demand for both electricity and heat. Ground source heating/cooling can also be effective where site conditions permit.

industrial

The approach to energy efficiency on industrial buildings very much depends on the activities being carried out. For example, there may be processes on site which generate waste heat, which could be reclaimed and used to heat other areas of the building.

Did you know?

The Enhanced Capital Allowance Scheme encourages businesses to invest in energy saving measures.

Further information can be found at: www.eca.gov.uk

Alternatives to fossil fuel energy

The use of low or zero carbon energy sources reduces the use of conventional energy and associated greenhouse gas emissions and can be a source of cheap or free energy. The suitability of renewable energy technologies varies from project to project and is dependent on site factors, location and funding availability.

In addition to the consideration of technical and economic feasibility on projects, it is vital to address social issues associated with the installation, including visual impact and noise.

The following table gives an overview of available technologies:

Combined Heat and Power: Both electricity and thermal energy (for space heating and/or hot water) are produced from a single energy source, which is typically natural gas. Although not a renewable energy technology, this is a very efficient use of fuel and reduces overall carbon emissions.

This technology is most efficient when sized to operate at a constant 'base load' which would require additional systems to meet the peaks of demand. Possible variations on the basic system include the addition of absorption chillers, or the use of biomass as a fuel source, although it should be noted that these options will have an impact on the economics of the system. This technology is best suited to buildings where there is a heat demand that matches electrical demand, such as process industries, swimming pools, community heating systems and hospitals.



Solar Panels: Solar collectors generate hot water from solar energy which is most commonly used to offset conventional energy use for provision of hot water for showers and taps. This technology is well established, reliable and presents reasonable economic paybacks.

Panels are ideally applied to south facing roofs pitched at 30-45° and can be freestanding or integrated into the roof, with pipework leading into the building and connected to a storage tank with a back-up heating supply.



Photovoltaic Panels: Photovoltaic panels use solar energy to produce electricity and are available in a variety of styles, colours and materials. Systems are best elevated at 30-45° from horizontal. The panels can be freestanding, or can be integrated into the south facing facades or roofs of buildings. It is also possible to use the cells as glass laminates.

Currently very expensive, the economics of the systems may improve in the coming years, as advances are made in manufacturing and as conventional energy prices are set to rise.



Alternatives to fossil fuel energy (cont'd)

Wind Turbines: Turbines can be used to generate electricity from wind and are available in a variety of sizes and scales. Suitable sites must be exposed and have an average wind speed above 5 metres per second for a large portion of the year.

There are various options for the configuration of turbines. Small scale models can be roof mounted. Typically they have an output of around 1.5kW, which would be sufficient to provide the annual hot water load on a typical family home. Alternatively, small scale freestanding models are available. These turbines then range in size up to industrial scale models that can be seen on wind farms.

Ducted wind turbines are currently under development. These are designed for urban applications and incorporate a small photovoltaic panel. Total output is around 60 Watts.

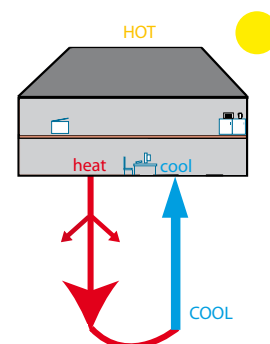


Ground Source Heat Pumps (GSHP): Heat pumps convert low grade thermal energy from a constant temperature source, such as the ground or a body of water, to high grade energy that can be used for space heating or hot water. They are available in different sizes, for both domestic heating and commercial premises. GSHPs are well suited to new build applications as their efficiency is improved when supplying low temperature distribution systems such as underfloor heating.

The high 'coefficient of performance' of the heat pumps mean that this is a very energy efficient technology – for each unit of energy used to operate the heat pump, around four units of heating energy is produced. The use of this technology is restricted to sites with enough land to either lay pipework in trenches, to dig boreholes, or with access to a suitable body of water.

GSHPs are well suited to new build applications as their efficiency is improved when supplying low temperature distribution systems such as underfloor heating.

This technology, coupled with photovoltaic electricity makes it even more attractive to reducing CO₂ emissions. Energy from the photovoltaic cells can be used to run the ground source heat pump.



Biomass: The use of energy crops in a biomass boiler to provide heating and hot water is considered to be a 'carbon neutral' process, as the amount of CO₂ released during combustion is equivalent to that which is absorbed during the growing cycle of the energy crops.

This technology requires a site with enough land to grow several acres of energy crops, such as willow and Miscanthus. Equipment and facilities for the harvesting and storage of the crops is also required. Alternatively, fuel can be delivered in the form of woodchips or pellets, which also requires a large storage facility.

Automated systems feed the fuel through to the combustion chamber from a hopper, which needs to be refilled on a regular basis. On domestic scale systems, this is typically once per week, but depends on the system size and energy demand. Ash also has to be removed approximately once every month.

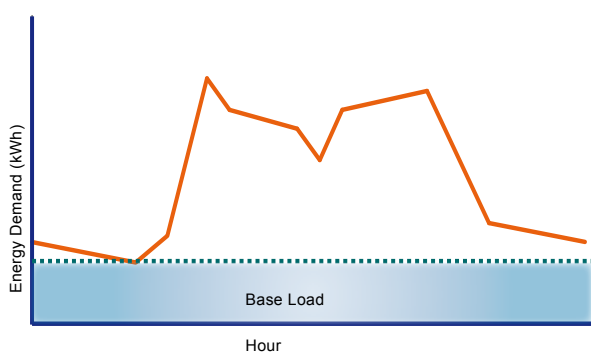
If considering this technology on an urban site, care should be taken to ensure that the specified equipment meets the requirements of any designated smoke control zone.



base load

A base load is a minimum amount of power constantly demanded by systems and activities in a building. This is illustrated in the following graph showing a generic demand profile:

Example Daily Energy Demand



The base load is that below the dotted line. This represents a constant demand from appliances and machinery in the building which are operational for 24 hours per day. Peak energy demands result from increased activity in the building throughout the day.

COP (Coefficient of Performance)

Coefficient of Performance is the ratio of heat output to electrical energy used. For a typical ground source heat pump, a COP of between 3 and 5 can be expected, i.e. for every one unit of electricity used to operate the heat pump, between 3 and 5 units of useful heat energy will be produced.

Did you know?

A Department of Trade and Industry commissioned a survey into public attitudes towards renewables in 2006 and found that 85% of the general public support the use of renewable energy.

81% are in favour of wind power and just over three fifths would be happy to live within 5km of a wind power development

Building integrated energy efficient and renewable technologies

introduction

Beaufort Court at Kings Langley is the headquarters of RES (Renewable Energy Systems) Group, who converted the original 1930s poultry farm to 2,665m² of sustainable office accommodation in 2003. The site originally supplied eggs to the nearby Ovaltine factory, but fell into disrepair after production ceased in the 1960s. The farm originally comprised a horse-shoe shaped barn, a coach house and seven hectares of land. The original buildings have been retained and the ground floor has been extended into the courtyard using steel a frame with a green roof.

description

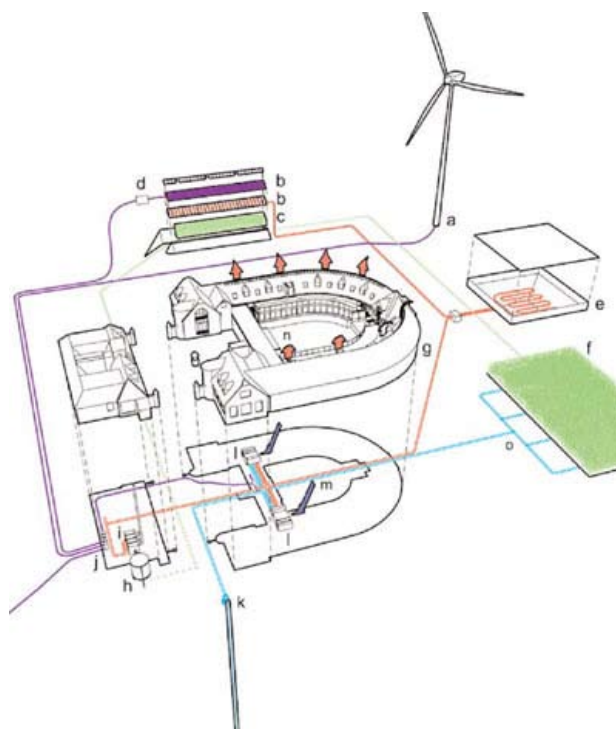
A number of integrated energy efficient and renewable technologies have been incorporated to meet all energy requirements on site, with no associated emissions.

passive solar - Large windows and rooflights are used throughout the development. Deciduous trees have been planted to take advantage of passive solar energy while avoiding overheating.

solar energy - 54m² of hybrid photovoltaic solar thermal panels and 116m² of solar thermal panels provide both heat and electricity to the offices.

underground heat store - Excess heat in summer is moved to the underground store, which consists of 1,400m³ of water covered by a floating insulated lid. From autumn through to spring, the stored heat is used to pre-heat the air supplied to the offices via the mechanical ventilation system.

wind turbine - A 225 kW 50m high wind turbine produces twice the annual amount of electricity required on the site, with the excess exported to the National Grid.



borehole cooling - Water is taken from an aquifer via a 75m borehole and is first used to cool the ventilation air supply. The water is then circulated through chilled beams in the offices, before finally being used to irrigate the biomass crops.

biomass - Energy crops are grown and harvested on site to fuel the 100kW biomass boiler.



Cont...

project team

- Renewable Energy Systems (RES)
- Studio E Architects
- Max Fordham LLP
- Esbensen Consulting Engineers
- Shell Solar Energy B.V.
- Netherlands Energy Research Foundation (ECN)

further information

- www.beaufortcourt.com



Environmental benefits

zero carbon emissions
100% on site generation of energy needs

Cost

Not available

Application

refer to key

Other considerations

Not available



Building integrated energy efficiency

introduction

Roche UK's new office complex brings together 1200 employees on a single site in Welwyn Garden City, Hertfordshire. It provides 21,800m² of modern work space, named 'Hexagon Place' to reflect the company's hexagonal brand. It has been designed to the highest environmental standards, in particular to keep CO₂ emissions to around 26% below current Building Regulation (2002) limits.

description

From the outset, the company specified a building with a low environmental footprint. The project team used a wide range of established and cutting edge sustainable technologies in its design. These include:

thermal zoning - The building is split into a number of separately controlled thermal zones which can be individually adjusted using the automated Building Management System (BMS).

high performance cladding - Sustainably certified (Forestry Stewardship Council) oak timber cladding, blocks unwanted heat gain in the summer and minimises energy loss in winter.

building air-tightness - The whole building was tested for air tightness by the BRE, and significantly beat (current) industry standards. This will offer potentially huge energy savings over the life cycle of the building.

borehole cooling - 120m deep boreholes

Environmental benefits

BREEAM Excellent rating
CO₂ emissions 26% lower than 2002 Building Regulation limits
Low global warming potential
Reduced water consumption

Cost

c £75m



reject the buildings' unwanted heat gains into the underground aquifer providing near free cooling. Combined with environmentally friendly ammonia and propane chillers, the cooling system for the site has a very low global warming potential.

water minimisation - Flow regulators and a leak detection system reduce water consumption.

sub-metering - A number of sub meters around the building help monitor and manage water and energy inputs in strategic areas.

Roche also endorses a green transport policy to further reduce CO₂ emissions, by encouraging staff to use sustainable methods of travel. The facility achieved a BREEAM score of 10 out of 10 and an 'Excellent' rating.

project team

Building Design Partnership (BDP)
Roche

further information

welwyn.corporate_affairs@roche.com

Application

refer to key

Other considerations

Not available



Low cost energy saving measures

introduction

Francis Combe School is a secondary school attended by 718 students. It was built in the 1950s and has a system-built structure with a number of wings that are one, two and three storeys in height.

The school was approached by the School Standards and Curriculum Division of Hertfordshire County Council to apply for the School Energy grant. The school Standards and Curriculum Division identified a number of improvements and new energy saving opportunities that would be suitable for the school and reported on approximate costs and annual savings.

description

Energy saving measures installed include new boiler controls, thermostatic radiator valves, electronic room thermostats, replacement of electronic space heating and low energy lighting.

Anticipated savings per year are 177,856 kWh or 10.96 tonnes of carbon. This equates to £1,550 or 6.5% of the total fuel bill. The payback time is 4.8 years.



project team

Francis Combe School
Hertfordshire County Council

further information

www.est.org.uk
www.franciscombe.herts.sch.uk

Environmental benefits

improved operational energy efficiency

Cost

total cost of measures was £7,438, with a School Energy grant of £3,000 and a cost to the school of £4,438.
6.5% reduced fuel bill

Application

refer to key

Other considerations

Not available



On-site renewable energy generation

introduction

The Ford Dagenham Diesel Centre is a £325 million investment manufacturing unit for diesel engines at Dagenham in Essex. The facility was opened in 2003 and was constructed on a 500 acre site. Ford came to the conclusion that there was a good business case for creating London's first wind park as part of the regeneration of Dagenham, generating 100% cost-effective 'green' electricity to help power the facility's Clean Room Assembly Hall.



description

Ford consulted with the British Wind Energy Association (BWEA) and worked with Ecotricity (wind power company) as project partners. Ecotricity carried out the feasibility study and environmental assessments and produced the planning application. This work included consulting with local communities, the local airport and the Royal Society for the Protection of Birds.

The installation included two 1.8MW wind turbines located on different sides of the site. The turbines generate an annual electricity output of 6.7GWh, which is sufficient to meet 100% of the electricity needs of the Centre. German super-quiet E66 Enercon turbines were installed, with a hub height of 85m and a blade length of 35m.

The turbines were funded through a 'Merchant Wind Power' arrangement, where Ecotricity meets the capital costs, installation and maintenance of the turbines and Ford has a contract to buy the electricity produced.

Environmental benefits

100% on-site generation of energy needs

Cost

Electricity was supplied to Ford at a reduced rate. This was possible for the following reasons:

- distribution costs were cut
- Ford was a guaranteed purchaser of green electricity
- exemption from the Climate Change Levy

The two wind turbines will result in annual emissions savings of:

- Carbon dioxide: 5,762 tonnes
- Sulphur dioxide: 67 tonnes
- Nitrogen oxide: 20 tonnes

project team

Ford Motor Company
Ecotricity

further information

www.ecotricity.co.uk
www.est.org.uk/practicalhelp

Application

refer to key

Other considerations

Not available



Low-tech energy efficient housing

introduction

Gallions Ecopark is an affordable housing scheme of 39 houses at Thamesmead, developed by Gallions Housing Association. The homes contain a combination of cost effective and practical energy efficiency design solutions that are easy to use and maintain.

The aim was to show that energy efficient sustainable housing need not be high-tech and can be built within realistic budgets. The houses achieved an EcoHomes Excellent rating and a SAP rating of 100.

description

Energy efficiency measures include:

- low U-value materials, e.g. double glazed, argon filled windows of 1.1W/m²K
- roof mounted solar collectors
- internal and external energy efficient lighting
- underfloor heating and mechanical ventilation in a few homes
- a high level of air tightness
- sunspaces behind south facing elevations for a few homes

Monitoring was achieved through installing a set of meters including humidity meters, electricity meters, heat metering (of the solar panels and gas boiler) and water meters. Monitoring has shown the following:

- all homes showed a reduction in gas consumption, the homes with the south facing sun space achieving the highest reduction of 32%



- the airtightness levels outperformed Building Regulation specifications

project team

Gallions Housing Association
Wilmot Dixon
PRP Architects and Project Services
Fulcrum Consulting

further information

www.gallionsecopark.co.uk
www.gallionsha.co.uk

Environmental benefits

overall energy consumption is 26% lower than a standard terraced house and is EcoHomes Excellent

Cost

Not available

Application

refer to key

Other considerations

Not available



Building integrated energy efficiency

introduction

Construction of Great Notley Primary School in Essex was completed in 1999. The building has since won awards for an innovative approach to low energy design.

The £1.2 million development relies heavily on the use of passive energy systems throughout. The environmental impacts of the school are further reduced by the extensive use of recycled materials and sustainable materials such as timber cladding and a green roof.



description

The building form has been designed to allow all spaces to be day lit and naturally ventilated. The roof design incorporates clerestory windows which enhance both air movement and light in the classrooms and assembly areas.

The façade design includes solar shading devices such as brise soleil and large overhangs to minimise overheating, thereby avoiding the need for cooling.

The external envelope has been designed to include a high level of insulation within a breathing wall construction. This results in low heat losses and a reduced energy requirement for heating the school.

The sedum roof also provides a high level of insulation in the roof and in addition provides thermal mass to modulate any heat gains from internal activities, or associated with the daylighting strategy.

project team

Essex County Council
Alford Hall Monaghan Morris
Atelier Ten

further information

www.atelierten.com/ourwork/greatNotley.asp

Environmental benefits

high levels of natural light
energy consumption comparable with 2006 Building Regulations

Cost

Not available

Application

refer to key

Other considerations

Not available



Building integrated renewable energy

introduction

Co-operative Insurance Services (CIS), the insurance sector within Co-operative Financial Services (CFS), is based in a 13-storey building on Portland Street in Manchester, which was originally constructed in 1962.

As part of an internal environmental policy and an awareness of climate change impacts, CIS decided to retro-fit micro wind turbines on the roof of the building to provide a small part of the electricity demand.

description

CIS installed 19 turbines on the roof of their headquarters building. This is the largest ever commercial application of micro-wind turbines in the UK. The wind turbines will produce 44,000kWh of renewable energy each year, which is equivalent to 3% of the annual energy demand of the building.

Each of the turbines has a height of approximately 3m and is rated at 1kW. The wind speed on the roof of the 13 storey building is higher and less turbulent than at ground level, which results in ideal operating conditions for the turbines. Under these conditions, the payback on each of the £2,500 turbines is expected to be 4 – 5 years.



CIS has also recently started to re-clad a tower in at their headquarters building with solar panels. This will be Europe's largest vertical solar array, with all three sides of the 25 storey building's service tower clad in energy generating solar panels. 7,244 solar photovoltaic panels, designed to convert daylight into electricity, will create 180,000 units of renewable electricity each year. This is enough energy to make 9,000,000 cups of tea.

project team

Co-operative Insurance Services
Windsave

further information

www.cis.co.uk
www.windsave.com

Environmental benefits

3% on-site renewable energy generation

Cost

£2,500 per turbine
4-5 year payback

Application

refer to key

Other considerations

Not available



Building integrated energy efficiency and renewable technologies

introduction

Kingsmead Primary School in Cheshire opened in 2004 and provides places for 150 pupils within a new housing development. Sustainable design issues were taken into account throughout the design and construction process, which has resulted in a low energy building and a positive learning environment for the pupils.



description

The principles of the energy hierarchy (be lean, be green and be clean) were observed in the building design. Energy demand has been reduced through the orientation and siting of the building. It has also been reduced through the use of passive energy systems such as daylighting and natural ventilation and a super-insulated building envelope.



'Green' energy technologies have been adopted as follows:

solar photovoltaics- A 5 kW peak system is expected to supply 15% of the school's annual electricity demand.

solar water heating- Solar panels are mounted on an A-frame on the south facing roof. The water heated by the system will be stored in a low-pressure heat store, before being heated further by the biomass system.

biomass- The biomass boiler meets around 60% of the heat demand of the school. The fuel supply consists of waste woodchip from a local source.

The use of these renewable energy systems has resulted in a reduction of annual emissions by approximately 5 tonnes of CO₂ each year.

project team

Cheshire County Council
Willmott Dixon
White Design Architects
Mander Strucutral Design
Arup Engineering

further information

www.est.org.uk/practicalhelp
www.cheshirerenewables.org.uk/schools.htm
www.white-design.co.uk

Environmental benefits

60% heat demand met by renewable energy
15% power demand met by renewable energy

Application

refer to key

Cost

Not available

Other considerations

Not available



Building integrated energy efficient and renewable technologies

introduction

The Devonshire Building is a flagship environmental building for the University of Newcastle and is home to laboratories and office spaces for the University's multidisciplinary Environmental and e-Science Research Centre.

From the outset of the project it was decided that the building should demonstrate and achieve the highest possible environmental and sustainable design targets. The building has high quality finishes and has an annual energy demand approximately 30% lower than the UK best practice targets at the time of construction in 2004. It was the first university laboratory building to achieve a BREEAM Excellent rating.

description

Within the building, there are a number of different spaces, ranging from the closely controlled laboratories to a central atrium with passive environmental controls. The following measures have been incorporated to reduce the energy load of the building:

façade engineering - The façade is highly glazed, which enhances the availability of daylight in the building. To avoid overheating and an excessive cooling load, motorised shading has been included.

heating and cooling - Cooling is provided via an active beam system, using free cooling from a thermal water storage tank within the ground via a series of plate heat exchangers. Heat from the office spaces and cold rooms is rejected into a 40,000 litre

geothermal water tank. A conventional chiller is provided as a back-up and the heating plant is fully condensing and utilises low water temperatures to maximise heat recovery.

lighting - Movement and daylight sensors are used in the lighting controls to minimise waste.

natural ventilation - The office areas have automatically controlled openable windows for ventilation and for night purge cooling.

photovoltaic panels: - 184m² of PV cells have been installed on the roof and have a peak output of 25kW.

BEMS (Building Energy Management System) - A fully functional, graphics driven BEMS has been provided to facilitate fully automatic control of the building and its systems.

project team

University of Newcastle Upon Tyne
 The Dewjo'c Partnership
 WSP
 White Young Green
 Shepherd Engineering Services

further information

www.greenspec.co.uk/html/design/imgbank/devonshire.html
www.heepi.org.uk/buildings/buildings_resources.htm
www.battlemccarthy.com/projects/education/devonshire.html
www.estates.ncl.ac.uk/projects/devonshire/in-

Environmental benefits

BREEAM Excellent
 30% lower energy consumption than construction best practice at 2004

Cost

Not available

Application

refer to key

Other considerations

Not available



Ultra low energy housing

introduction

The Hockerton housing project is the first earth-covered, self-sufficient housing development. Self-built by the occupants, who are committed to living in a way that is environmentally sensitive, the development has no need for space heating and uses less than 25% of the energy of a conventional house.

description

The Hockerton development consists of a terrace of five ultra-low-energy houses incorporating a range of energy saving measures that have completely eliminated the need for space heating. The most important features are:

building orientation - The orientation of the houses allows for maximum winter solar gain, as they have a south-facing conservatory running the full width of the dwellings.

building fabric - Concrete is used extensively, which provides thermal mass to absorb and release solar heat gains. The houses are wrapped in 300mm insulation and have triple glazing to minimise heat losses. An earth covering to the north further reduces heat losses.

space heating and hot water - Space heating is provided purely through the passive solar arrangement, using large areas of south facing glazing and thermal mass. Domestic hot water is provided by an air-to-water heat pump located in the conservatory, which is connected to a storage cylinder.



ventilation - In summer, houses are ventilated through a large opening light in each bay, adjacent to a corresponding light in the conservatory roof. In winter, air is extracted from the bathroom, kitchen and utility room. This is passed through a heat exchanger to warm incoming fresh air.

renewable energy - The development has two wind turbines, which together are capable of generating 10kW of power and are estimated to produce 24,000 kWh annually.

project team

Robert & Brenda Vale
Occupants of Hockerton Housing Project

further information

www.bbc.co.uk/nottingham/360/where_to_go/hockerton_housing_project/tour_04.shtml

www.hockerton.demon.co.uk/virtualtour/VT-BB-CRN.html

Environmental benefits

energy consumption is less than 25% of that of a conventional house

Cost

Not available

Application

refer to key

Other considerations

Not available



Healthcare combined heat and power

introduction

The Western General Hospital cares for more than 150,000 patients every year and it provides specialist acute health care. It has 800 acute beds and 34 day beds.

description

The Hospital has an Energy Services Agreement with Scottish and Southern Energy Plc who owns, operates and maintains the energy plant and equipment. This plant and equipment provides all the heat and power required by the hospital. To implement this, Scottish and Southern Energy has installed new boilers and a Combined Heat and Power (CHP) system to generate electricity, steam and hot water efficiently.

Hospitals generally have large continuous heat and power demands and CHP is an ideal solution. A gas fired reciprocating engine CHP was installed after the current and projected heat and power loads were evaluated. The CHP system generates approximately 1MW of electricity which is fed into the main supply to the Hospital's high voltage ring main. The system is sized to match the site's base load and can therefore be run at full output all year around.

Waste heat is recovered from the engine cooling and lubrication systems and is used to generate hot water at approximately 90°C. This is supplied to the hospital plant rooms, providing heating and domestic hot water.

The on-site generation of hot water, steam and electrical power allows a system efficiency of approximately 77% to be achieved. This is a



significant improvement over traditional grid imports and boiler operation, and produces primary energy savings of more than 30%. The system generates approximately 7.8GWh of electricity annually, producing a net carbon saving of approximately 800 tonnes / annum.

project team

Western General Hospital
Scottish and Southern Energy Plc
Cadogan Consultants

further information

www.scottish-southern.co.uk
www.actionenergy.org.uk
www.chpa.co.uk

Environmental benefits

30% energy savings

Cost

Not available

Application

refer to key

Other considerations

Not available



Further information and references

- 1 Part L Building Regulations: Conservation of Fuel and Power
DCLG
(Department for Communities and Local Government)
Eland House
Bressenden Place
London SW1E 5DU
Telephone: 020 7944 4400

www.communities.gov.uk
- 2 Planning Policy Statement 22:
Renewable Energy
DCLG
Eland House
Bressenden Place
London SW1E 5DU
Telephone: 020 7944 4400

www.communities.gov.uk
- 3 Hertfordshire WasteAware
Telephone: 08457 425000

www.wasteaware.org.uk
- 4 Energy White Paper: Our energy future – creating a low carbon economy
Department for Trade and Industry
Response Centre
1 Victoria Street
London SW1H 0ET
Telephone: 020 7215 5000

www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf
- 5 The Carbon Trust – extensive database of best practice guidance and information on grants and loans (non domestic buildings)
3 Clement's Inn
London WC2A 2AZ
Telephone: 0800 085 2005

www.thecarbontrust.co.uk
- 6 The Energy Savings Trust – extensive database of best practice guidance and information on grants and loans (domestic buildings)
21 Dartmouth Street
London SW1H 9BP
Telephone: 020 7222 0101

www.est.org.uk

Further information and references

- 7 Hertfordshire Renewable Energy Strategy
Environment Department
Hertfordshire County Council
County Hall
Pegs Lane
Hertford SG13 8DQ
Telephone: 01438 737555

www.hertsdirect.org/yrccouncil/hcc/env/plan/hres/
- 8 London Energy Partnership: Integrating renewable energy into new developments: Toolkit for planners, developers and consultants
Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA
Telephone: 020 7983 4000

www.london.gov.uk/mayor/environment/energy/docs/renewables_toolkit.pdf
- 9 Green Consumer Guide - energy efficient white goods database

www.greenconsumerguide.com/whitegoods.php
- 10 Building Services Research Information Service
BSRIA
Old Bracknell Lane West
Bracknell
Berkshire RG12 7AH
Telephone: 01344 465600

www.bsria.co.uk
- 11 Construction Industry Research & Information Association
CIRIA
Classic House
174-180 Old Street
London EC1V 9BP
Telephone: 020 7549 3300

www.ciria.org.uk
- 12 Royal Institute of British Architects
RIBA
66 Portland Place
London W1B 1AD
Telephone: 020 7580 5533

www.riba.org/go/RIBA/Home.html

Further information and references

- 13 Chartered Institute of Building Services Engineers
CIBSE
222 Balham High Road
Balham
London SW12 9BS
Telephone: 020 8675 5211 www.cibse.org/index.cfm
- 14 Building Research Establishment
BRE
Garston
Watford WD25 9XX
Telephone: 01923 664000 www.bre.co.uk
- 15 Climate Change Levy www.defra.gov.uk
- 16 Association for the Conservation of Energy www.ukace.org
- 17 British Wind Energy Association www.bwea.com
- 18 Low Carbon Building Programme www.est.org.uk/housingbuildings/funding/lowcarbonbuildings
- 19 Combined Heat and Power Association www.chpa.co.uk
- 20 Combined Heat and Power Quality Assurance www.chpqa.com
- 21 National Energy Foundation www.nef.org.uk
- 22 Code for Sustainable Homes
DCLG
Eland House
Bressenden Place
London SW1E 5DU www.communities.gov.uk
- 23 Building a Greener Future
DCLG
Eland House
Bressenden Place
London SW1E 5DU www.communities.gov.uk