Green Buildings in Norfolk

21 examples of renewable energy in action

Campaign to Protect Rural England
NORFOLK

INTRODUCTION

THIS BOOKLET brings together examples of buildings in Norfolk that are pioneering the use of renewable energy and energy-conscious building techniques. Our aim is to educate and inspire others.

Some of the projects are ambitious in their scale and design, such as the Ecotech Centre in Swaffham and the National Trust Visitor Centres on the North Norfolk Coast. Others have been undertaken by passionate individuals making best use of the knowledge and skills at their disposal.

Examples include a backpacker's hostel, a church, a major office development, schools, holiday cottages, an environment centre and a children's bookshop, along with many 'ordinary' homes. Whether we are designing buildings for sleeping, shopping, working, studying or day-to-day living, we can put renewable energy into action.

The range of technologies is also impressive. Geothermal heat pumps draw heat from the earth while wind turbines, both big and small, convert the energy of the wind. Roof mounted solar panels use the energy of the sun to generate electricity or heat water. In addition to these technologies, architects use the building's orientation, water supply, ventilation and insulation to improve energy conservation. You will find a comprehensive appendix on all these features towards the back of the booklet.

CPRE Norfolk believe that Building Regulations and planning policies must be tightened so that all new buildings are designed with energy conservation in mind. However, we all must consider what action we can take now to improve the buildings that we live and work in. While most green buildings are exclusive designs, renewable energy can be applied to ordinary homes as well. This is an ambition that more and more people are realising throughout the county, as highlighted by the final example in the booklet.

There are a few firsts in Norfolk…did you know, for example, that the UK's first earth sheltered affordable housing scheme is sited at Honingham and the UK's first building to filter rainwater for drinking is sited at Blakeney?

Norfolk really is leading the way.

James Frost
Director
CPRE Norfolk

BUILDINGS ARE NUMBERED 1 TO 21 for ease of reference and appear accordingly within the booklet. Please use this map to identify their locations within the county.

FURTHER INFORMATION ON THE RELEVANT FEATURES of the buildings is provided in an appendix towards the back of the booklet.

classrooms of the future

SINCE THE TURN OF THE MILLENNIUM, Local Education Authorities across the country have been developing Classroom of the Future projects under a grant funded initiative by the Department for Education and Skills. Norfolk County Council had three projects; Hobart High School, Thurlton Primary School and Hevingham Primary School. The projects were completed between June 2003 and March 2004.

SUSTAINABILITY was a fundamental design aim. Very high levels of insulation were included in the walls and roofs of the schools, reducing the boiler requirement to a domestic scale. Careful use of natural daylight and ventilation has also assisted in making comfortable working environments.

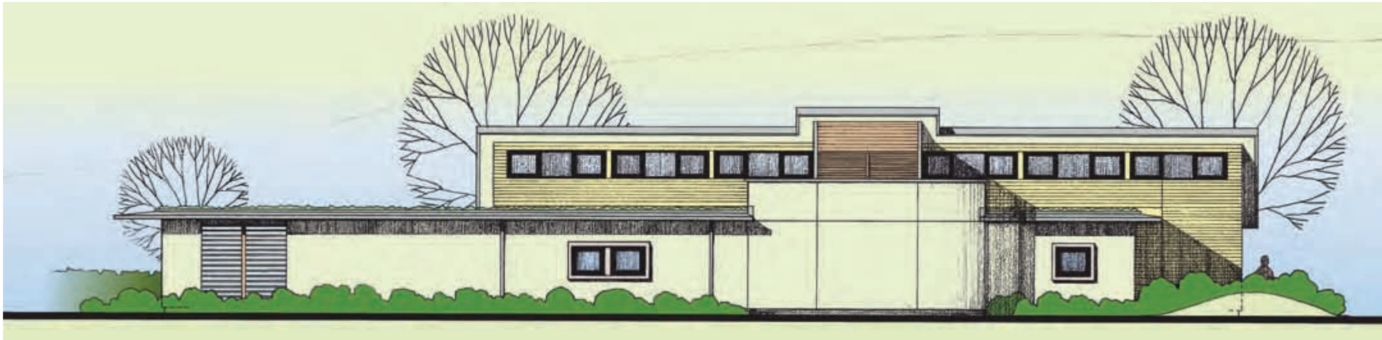
UNDECORATED CEDAR AND MILL FINISHED aluminium were used during construction of the classrooms, together with reclaimed telegraph poles as columns. Sedum roofs have been incorporated and rainwater is re-used to supply flushing systems in the lavatory areas.

AT HEVINGHAM, a geo-thermal heating system has been used to heat classrooms in winter and cool them in summer. The system extracts heat from the earth by a 'geo-thermal coil' located under the classroom and playing field. Solar panels preheat water.

AT THURLTON, a 6.5kW mini-wind turbine provides a contribution to the classrooms' energy requirements.

NORFOLK SCHOOLS

Use	Schools
Location	Thurlton Primary School, Church Road, Thurlton, NR14 6RN Hobart High School, Kittens Lane, Loddon, NR14 6JU Hevingham Primary School, New Road, Hevingham, NR10 5NH
Architect	NPS Consultants
Contact	01603 706000
Features	Geothermal Heating [Hevingham] Small Scale Wind Turbine [Thurlton] Rainwater Harvesting Increased Insulation



EXCELLENT EXAMPLES OF ENERGY-CONSCIOUS ARCHITECTURE, the buildings demonstrate the benefits of renewable energy to the children. Recording meters for the different technologies have been installed so that the children can easily read, monitor and carry out project work on energy issues as part of the curriculum.

THE OLD BARNS

Use	Private Residence
Location	Upper Stoke, Norwich, Norfolk
Architect	Peter Skinner
Contact	Skinner Architecture 01625 576777
Features	Heating from Biomass Geothermal Heating Increased Insulation Rainwater Harvesting

THE PRINCIPAL AIM OF THE OWNERS was to create a modern, energy efficient dwelling which would respect the character of the existing buildings and greatly improve their setting in the surrounding landscape.

ECO-FRIENDLY CONSTRUCTION TECHNIQUES were employed in an endeavour to keep environmental impact to a minimum during the conversion of a group of redundant farm buildings for residential use.

RECYCLED SHEEP'S WOOL provides high levels of insulation and gives a low energy requirement throughout the buildings. A geothermal heat pump provides hot water and heats an under floor heating system while a multi-fuel stove in the main living area provides an efficient source of extra heating when needed.

RECLAIMED BRICKWORK AND NATURAL OAK BOARDING have been used externally and organic paints used throughout. The main barn has been covered in zinc to replace the asbestos sheeting, whilst other roofs use reclaimed clay pantiles and slate to match the original materials.

NATURAL DAYLIGHT IS USED to the best advantage throughout the building and rainwater is recycled for use in the toilets and the washing machine.

THE BUILDINGS, dating back to the 17th century, have been converted and restored in a traditional style, incorporating green technologies wherever possible.

EVACUATED SOLAR TUBES provide all the hot water for both hostels, the laundry in the Stables, the loo block in the Granary and the under floor heating system.

WATER USAGE IS REGULATED by low flush option toilets, waterless urinals at the campsite and low-flow water settings in the showers.

ENERGY SAVINGS ARE MADE BY all the buildings being insulated to a level higher than required by building regulations while low energy lightbulbs and movement sensors reduce energy used for lighting.

ACCOMMODATING THOUSANDS of visitors throughout the year the two hostels are an excellent example of the use of modern technologies in traditional building renovation.

DEEPDALE FARM HOSTELS

Use	Backpackers and Group Hostels
Location	Burnham Deepdale, Norfolk, PE31 8DD
Architect	Jason Borthwick
Contact	info@deepdalefarm.co.uk 01485 210256 www.deepdalefarm.co.uk
Features	Solar Water Heating Increased Insulation Water Management Systems

JUNIPER HOUSE IS AN URBAN DEVELOPMENT of low energy offices, social housing and a public garden in the heart of King's Lynn. The offices were, until recently, the home of the King's Lynn and West Norfolk Borough Council.

AN INNOVATIVE LOW ENERGY STRATEGY was adopted in the design and construction of the building and many environmentally sound features were incorporated. The building structure is an integral part of the heating and cooling processes and high levels of insulation and air-tightness minimise heat loss through the fabric.

THE BRICK OFFICE BUILDING has a metal roof within which are situated solar panels that help heat the hot water for the building. The south facing top storey has windows running along its whole length. These provide excellent working light and are sheltered from excessive heat gain by projecting eaves and internal blinds within the triple-glazed windows.

THE CONSTRUCTION METHODS adopted have enabled the building structure to retain heat in winter, stay cool in summer and as a result avoid the need for large boilers and air-conditioning. High insulation levels and the use of concrete decks to store and circulate warm and cool air create a comfortable working environment with minimal energy needs. Great care has been taken with all aspects of energy use, including water-saving measures, thus reducing energy costs during the lifetime of the building.

DESIGNED AS LIFETIME HOMES, the houses have energy-conscious heating and ventilating systems.

JUNIPER HOUSE

Use	Offices, Private Residences & Public Garden
Location	Juniper House, Chapel Street, King's Lynn, Norfolk, PE30 1EX
Architect	Jeremy Stacey
Contact	01366 328735 email@jeremystaceyarchitects.co.uk www.jeremystaceyarchitects.co.uk
Features	Solar Water Heating Improved Glazing

ECOTECH CENTRE

Use	Visitor Centre
Location	Turbine Way, Swaffham, Norfolk, PE37 7HT
Architect	Lucas Hickman Smith Architects
Contact	info@ecotech.org.uk 01760 726100 www.ecotech.org.uk
Features	Passive Solar Design Heating from Biomass Large Scale Wind Turbine

THE ECOTECH CENTRE was conceived in 1995 by a partnership of individuals and organisations led by Breckland District Council. It was delivered under the European Social Fund 5b program for rural development and handed over to the Ecotech Charitable Trust in 1998. The centre was opened to the public in 1999.

DESIGNED TO BE KINDER on the environment, the Ecotech Centre provides a comfortable and fascinating venue to visit and work in. Constructed from Norwegian Spruce taken from managed forests, it is believed to contain the largest volume of timber in any structure in the region.

INNOVATIVE DESIGN FEATURES include 800m^2 of passive solar glazing, external walls designed to retain heat and prevent condensation, and under-floor heating circuits which heat in the winter and cool in the summer. All this is controlled by a sophisticated building management system. The on-site biomass boiler uses locally produced wood waste for the heating system.

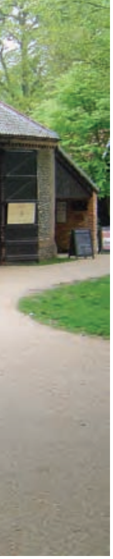
THE MOST IMPRESSIVE visitor attraction is the Enercon E-66 wind turbine with a unique viewing platform located just under the hub. In 1999 it was the UK's first multi-megawatt wind turbine and one of a new generation of direct drive, variable speed wind turbines brought to the UK by Ecotricity. A second turbine was opened in July 2003.

BUILT ON A FORMER BROWN FIELD SITE, the grounds are an example of how a site can be reclaimed and conservation methods integrated into landscape management. The grounds provide a variety of wildlife habitats, an organic garden and heritage orchard.

THE NATIONAL TRUST has two visitor centres on the North Norfolk coast, at Sheringham Park and Brancaster. The Trust has incorporated renewable energy technologies into both buildings providing a working model of sustainability for visitors and staff.

AT SHERINGHAM, the management of plantation woodland on the Sheringham Park and Felbrigg Hall estates produces large quantities of low-grade timber of marginal economic value. This timber provides a ready source of fuel for a wood-chip fired boiler for water and space heating at the visitor centre.

RAINWATER IS HARVESTED from the buildings and collected for use in plant propagation and flushing toilets. Waterless urinals in the new toilet block further contribute to water saving. An underground sewage treatment plant replaced the sceptic tanks and is designed to discharge clean water.



SHERINGHAM PARK & BRANCASTER MILLENNIUM ACTIVITY CENTRE

Use	Visitor Centre	Residential Outdoor Activity Centre
Location	Sheringham Park, Upper Sheringham, Norfolk, NR26 8TB	Brancaster Millennium Activity Centre, Dial House, Brancaster Staithe, King's Lynn, Norfolk, PE31 8BW
Architect	Tom Ground	Paul Bancroft Architects
Contact	01263 820550 sheringhampark@nationaltrust.org.uk www.nationaltrust.org.uk	01485 210719 brancaster@nationaltrust.org.uk www.nationaltrust.org.uk
Features	Photovoltaic Panels Solar Water Heating Small Scale Wind Turbine Geothermal Heating Rainwater Harvesting Heating from Biomass	

IN THE BRANCASTER MILLENNIUM ACTIVITY CENTRE, historically known as Dial House, the heating system is controlled by a Building Energy Management System. The system predicts and responds to weather conditions and occupancy rates, adjusting temperatures accordingly.

SPACE HEATING AND HOT WATER services are supplied by an LPG fuelled high efficiency condensing boiler. Additional energy is recovered from the mud in a creek adjacent to the building by means of a heat-pump and is used for space heating. The building is thermally insulated by use of Warmcell insulation.

THE SOUTH FACING ROOF is fitted with a photothermal solar panel and seven photovoltaic panels. These preheat the domestic hot water service and provide electricity for the building. In a typical year, the photothermal panel recovers 1300kW of thermal energy and the photovoltaics generate 400kW of electricity. Additionally, a small wind turbine installed at the rear of the building generates electricity to power low energy lighting in the building.

TERNERY HUT

Use	Warden Accommodation
Location	Scolt Head Island, Brancaster
Architect	Lucas Hickman Smith Architects
Contact	Paul Lucas 01953 607343 paul@lucashickmansmith.co.uk
Features	Photovoltaic Panels Increased Insulation Rainwater Harvesting

CONSTRUCTED FOR ENGLISH NATURE in 2005, the Ternery Hut provides living accommodation for a summer resident warden on one of Britain's oldest National Nature Reserves. Scolt Head is a valuable habitat for a wide range of coastal birds, especially a colony of terns that return every year to breed.

WELSH SOURCED, untreated, Western Red Cedar clads the timber framed building. The mono-pitched roof recreates the surrounding landscape and provides additional wildlife habitat.

THE REMOTE NATURE of the site requires the building to be self sufficient. Recycled newspaper and sheep's wool provide high levels of insulation.

PHOTOVOLTAICS SUPPLY the building's electricity requirements and rainwater is re-used to supply water to the shower room and kitchen. There is a composting toilet and waste water is filtered through a reed bed.

A LANDMARK RENOVATION OF A GRADE II* LISTED BUILDING in the centre of Norwich, the Greenhouse includes a shop, café, courtyard garden, meeting rooms and an office. It is run by a charitable trust working to raise public awareness of environmental issues and promote solutions to climate change.

RENOVATED TO A HIGH STANDARD of energy efficiency, low-embodied energy materials such as cork, recycled paper and wool provide excellent insulation, and work to create a warm building together with double, triple and quadruple glazing.

A NEW OPEN PLAN WAS CREATED by the removal of the interior wooden and lath/plaster walls. This allows warm air from the south facing rooms to travel freely round the building to the colder north facing rooms and keep a more constant temperature. High levels of insulation and the open plan design mean that for much of the year the main supply of heating comes from the people using the building with a gas condensing boiler as a back-up.

THE GREENHOUSE was the first Grade II* listed building in Norfolk to install a solar hot water system on its roof. It has a line of photovoltaic panels located on the south elevation. The organic garden is also covered with a glass photovoltaic roof which produces a substantial amount of the building's electricity needs and has the capacity to export unused electricity to the local grid.

THREE SMALL WIND TURBINES are being installed and will be monitored to explore the potential for this type of micro-generation in Norwich. The building demonstrates in a very practical way the many environmental choices that can be applied to existing and new architecture.

THE GREENHOUSE

Use	Shop, Café, Meeting Rooms, Office
Location	42-46 Bethel Street, Norwich, NR2 1NR
Architect	Paul Goddard St. James, Diss, Norfolk, IP22 5TB 01379 652272
Contact	info@greenhousetrust.co.uk 01603 631007 www.greenhousetrust.co.uk
Features	Solar Water Heating Photovoltaic Panels Increased Insulation Improved Glazing Rainwater Harvesting

THREE OWLS FARM COTTAGES

Use	Holiday Accommodation
Location	Three Owls Farm, Saxlingham Road, Blakeney, Norfolk, NR25 7PD
Architect	Ian Witcomb
Contact	Ecotecture Architects 01263 740738
Features	Solar Water Heating Geothermal Heating Water Management Systems Rainwater Harvesting

THREE OWLS FARM COTTAGES were the first buildings in the UK to be granted permission to filter rainwater for drinking. The cottages are built to a very high specification of eco-standards and provide luxury holiday accommodation.

CONVERTED FROM A REDUNDANT PIG STY, the existing building was extended using sustainable materials wherever possible and practical.

WATER IS RECYCLED using an 18,000 litre rainwater harvesting tank. Normally only reusable for garden water and toilet flushing, here it is blended with potable water from a bore hole after pre-screening and filtering. A UV filter enables all the water to be approved for drinking and washing. Additional in-line filters are fitted to the kitchen taps.

SOLAR VACUUM TUBES have been installed to heat water for the accommodation. Water is also conserved by using dual flush WCs.

HEAT FROM THE GROUND is also being used. The geothermal properties are harnessed through horizontal “slinkies” via a heat exchanger providing under-floor heating throughout the cottages. A reversible unit aids cooling in the summer when the terracotta tiled floor acts as a heat sink.

THE UK'S FIRST EARTH SHELTERED SOCIAL HOUSING SCHEME is located in the Norfolk village of Honingham. It is a working model of environmentally responsible development applied to rented accommodation and demonstrates that social housing can deliver zero heated, zero CO_2 emission buildings with no loss of comfort. Peddars Way Housing Association under the auspices of the Flagship Housing Group commissioned Jeremy Harrall of SEArch Architects to deliver their beacon environmental project.

ORIENTATED SOUTH, THE FOUR SINGLE STOREY DWELLINGS encourage direct sunlight into the buildings to provide the main heat source while taking advantage of passive ventilation techniques for cooling. The mass of the structure maintains a constant internal temperature, storing heat gained from the sun and then releasing it back into the buildings when the outdoor temperature is lower than that indoors.

STREAMLINING THE CONSTRUCTION PROCESS has allowed conventional foundations to be dispensed with together with subterranean excavation, lintels, skirting boards, roof trusses and plastering reducing further the development's negative environmental impact.

AN EARTH COVERING ENVELOPES THE BUILDING, which in turn has a tanking membrane installed to prevent the ingress of water. Between this membrane and the soil there is a layer of 140mm of extruded polystyrene reducing the amount of heat lost from the building. Further energy savings are achieved with the benefit of solar water heating panels mounted on the roof.

LOW RUNNING COSTS are the next result, as demonstrated by tenants Garry and Keron Lawson with average weekly bills of £3.80 for electricity and £1.75 for water.

HONINGHAM EARTH SHELTERED SOCIAL HOUSING SCHEME

Use	Private Residence
Location	15-19 Fellowes Road, Honingham, Norfolk
Architect	Jeremy Harrall [SEArch]
Contact	SEArch Architects 01406 364646
Features	Passive Solar Design Solar Water Heating Earth Sheltering Passive Ventilation

LITTLE WALSINGHAM in Norfolk is a spiritual home for thousands of pilgrims each year. In recent years the 50 year old Parish Church of the Annunciation became inadequate for the increasing numbers of visitors to the shrine. In 2003 plans for a new Church were approved.

AT THE CENTRE of an important conservation area the site is surrounded by listed buildings. Apart from simple economic considerations the church authorities are mindful of the need to set an example of good environmental stewardship.

THE EXTERIOR OF THE NEW BUILDING has been designed to use traditional local materials and contribute to the character of the setting. The heating and electrical installations are fuelled by renewable energy and it is hoped that the resulting building will prove to be carbon neutral or better.

HEAT DRAWN FROM BELOW GROUND is upgraded by a 17.5kW heat pump and distributed to under floor heating. 132 solar cells, covering 91m^2, on a south facing roof slope towards the rear of the site provide 10.5kW maximum output of electricity for the building. Any surplus is fed into the national grid.

VISITED BY LARGE NUMBERS of tourists each year, it is hoped that the church, due for completion in October 2006, will prove to be a pioneering exemplar of energy efficiency and an educational resource.

THE CHURCH OF THE ANNUNCIATION

Use	Place of Worship
Location	Friday Market Place, Little Walsingham, Norfolk, NR22 6DB
Designer	Anthony Rossi
Contact	01328 821590
Features	Geothermal Heating Photovoltaic Panels

THE ZICER BUILDING

Use	Research & Educational Institute
Location	University of East Anglia, Norwich
Architect	RMJM Cambridge Ltd
Contact	Martyn Newton [Assistant Director, Facilities] UEA 01603 592052
Features	Passive Solar Design Photovoltaic Panels Increased Insulation Improved Glazing Passive Ventilation

THE ZUCKERMANN INSTITUTE for Connective Environmental Research (ZICER) is part of the School of Environmental Sciences at the University of East Anglia in Norwich.

ONE OF THE MOST ENERGY-EFFICIENT buildings in Europe, ZICER incorporates high thermal-mass Termodeck concrete slabs for heating and cooling the building passively. It has triple and quadruple glazed windows and its insulation rates are far in excess of current UK standards.

THE ZICER BUILDING WON the first ever Low Energy Building of the Year Award, as sponsored by the Carbon Trust, in November 2005.

ELECTRICITY FOR USE in the building is provided by a 32.8kW array of photovoltaic cells. In the summer months the system exports to the national grid. A ventilation heat recovery system using a regenerative heat exchanger is 86 per cent efficient in recovering the heat from ventilation and keeps air conditioning to a minimum.

THE BUILDING USES recycled aggregates in its foundations and timber from managed sources in its construction.

BUILT BY THE ARCHITECT as a permanent residence for himself and his family, this house includes four bedrooms, two bathrooms, a study, a library, a double garage and a sitting room. It is roofed with grass and fronted with glass, with some traditional Norfolk flints to blend in with the surrounding landscape.

ORIENTATED DUE SOUTH, 75% of the dwelling is buried in a grassy bank with the first floor projecting outward to maximise natural light to the main living spaces.

THE CURVED ROOF CANTILEVERS past the first floor living room to provide solar shading in summer months while allowing solar gain in winter months. Sedum plants on the roof soften the built form in a landscaped setting. All rooms benefit from natural light except the plant and utility rooms.

SUPER INSULATED TO REDUCE heating requirements, the structure provides a thermal store and is constructed from giant polystyrene bricks filled with concrete.

A GEOTHERMAL HEAT PUMP provides heating and hot water with electricity bought on a green tariff. Buried pipework takes heat from the ground and the heat pump exchanges this energy to provide for an under floor heating system.

THE DWELLING has low-water use taps and recycles rainwater for the toilets.

HILL HOUSE

Use	Private Residence
Location	Gimingham
Architect	Tom Ground
Contact	C & M Partnership 01603 666151
Features	Geothermal Heating Earth Sheltering Rainwater Harvesting

QUAKER BARNS are part of a former large farm building complex, which like many farms in the 1980s came into disuse. In 2002, the cart shed and grain storage barn were converted into two dwellings and rented as holidays lets.

STRAW BALE WAS USED to fill what was once open storage. The walls are veiled externally by fibreglass panels that span the original oak frame.

NO WINDOW OPENINGS ARE IMMEDIATELY APPARENT. Natural light penetrates through opaque windows set into the depth of the straw bale walls. Windows on the south side open up onto gardens and are oak or frameless double glazed units sliding in simple steel frames. Reused car window seals provide draughtproofing while glass pantiles bringing high level light into the interior.

INTERNALLY THE TWO BARNS DIFFER IN THEIR TREATMENT. The larger two-storey barn pays respect to the original barn structure whereas the smaller barn is more of a hybrid since it ties two buildings together which were once separate. Local materials such as knapped flint and exposed brick are used as interior finishes.

THE MAJORITY OF MATERIALS AND SUPPLIERS USED were obtained within a 5 mile radius of the barns. The intention was to use sustainable sources, have high levels of insulation and advantageous orientation for solar gain to keep both building and energy costs down.

QUAKER BARNS

Use	Holiday Accommodation
Location	Haveringland
Architect	Anthony Hudson
Contact	020 7490 3411 info@hudsonarchitects.co.uk www.hudsonarchitects.co.uk
Features	Straw Bale Insulation

DRAGONFLIES

Use	Private Residence
Location	Thursford Road, Little Snoring, Norfolk, NR21 0JL
Contact	c/o CPRE Norfolk 01603 761660
Features	Small Scale Wind Turbine Rainwater Harvesting

STANDING IN 17 ACRES of beautiful countryside and adjoining the river Stiffkey, 'Dragonflies' was a dilapidated cart shed when John and Cilla Bowns set about renovating it in 2002. They were very mindful to respect the environment as far as possible in selecting the materials for the building work and services for the dwelling.

INSTEAD OF CONNECTING the building to the national grid they installed a 6.5kW wind turbine. The 16m high mast is olive green to blend in with the surroundings. The turbine supplies all of the required electricity for the home for many months of the year. A generator is used to boost the battery at other times.

RAINWATER IS COLLECTED from the roof and channelled into a newly created wildlife pond. A colony of water voles has established itself in one of the ditches near the turbine, suggesting that the wind turbine has not had a negative effect on the wildlife.

MORE AWARE THAN MOST of the value of power, Mr and Mrs Bowns have adjusted their lives accordingly. "After being totally independent from the national grid and completely responsible for managing our electricity supply we would say no volt is ever wasted. When there is little or no wind, lights and other appliances have to be off as much as possible."

PIERRE AND ROSALIE GUERIN are the proud owners of the UK's first Huf House with solar heating. Mr. Guerin visited Germany twice to take a look at the work of the German company and decided to invest. The property in Downham Market is the first of its kind in Norfolk.

HUF-HAUS ARE A GERMAN COMPANY specialising in prefabricated house design. The houses are tailored to suit the needs of the owners and the surrounding landscape. A Huf Solar Home incorporates the very best of Huf architecture with an impressive CO_2 emissions balance.

THE SITE TOOK 3 MONTHS to prepare before the Huf workmen arrived with the house on the back of several trucks. It took just four days to assemble and make watertight and a further two to three months to install the internal fittings before the couple moved in.

A STRIKING DESIGN of posts, beams and glass, the house is both extremely air tight and very thermally efficient. Large areas of glazing to the south and west maximize use of the sun. Overhanging eaves provide shade and external blinds reflect heat to provide cooling when required. Internal and external environment sensors ensure that a constant temperature is maintained.

SOLAR PANELLING CONNECTS to a high specification boiling system, providing hot water to the house. The south facing roof is wired for photovoltaics to be installed in the future.

BLITHE HOUSE

Use	Private Residence
Location	The Rowens, Downham Market, Norfolk, PE38 9HR
Contact	Huf-Haus 01932 586550 T A Millards 01603 610916 J Breheny 01449 720282
Architect	Peter Huf [Huf-Haus]
Consulting Engineers	T A Millards
Groundworks	J Breheny Contractors Ltd
Features	Passive Solar Design Solar Water Heating

NORFOLK CHILDREN'S BOOK CENTRE

the UK's only wind powered bookshop!

Use	Shop & Private Residence
Location	Alby, Norwich, Norfolk, NR11 7HB
Installer	Proven Energy 01560 485570 info@provenenergy.com
Contact	enquiries@ncbc.co.uk 01263 761402 www.ncbc.co.uk www.r-wind.co.uk
Features	Small Scale Wind Turbine

FREELANCE SOUND ENGINEER and specialist children's bookshop owner, Simon Brocklehurst, has an interest in wind powered energy. In 1999, he took a step towards energy self-sufficiency with the installation of a wind turbine in the garden of his house and bookshop.

THE 6KW TURBINE has a rotor diameter of 5.6 metres and is supported by a 9 metre cylindrical pole. The wooden blades cause no radio or TV interference and the turbine is quiet and reliable as it does not require a gearbox.

THE TURBINE STARTS TO GENERATE POWER at a wind speed of 6mph, charging a battery, which feeds 240volt AC into the household and bookshop mains circuits. The conventional mains supply is only used if the battery has no power or if the electrical demand from the household and bookshop is too great. Any excess power is used to heat water.

HALF THE ANNUAL electrical needs of the house and bookshop are produced, approximately 12,000 kW/hr.

"FOR ME THE REWARD of seeing power coming in from a natural renewable source far outweighs the shock of the initial financial investment – the turbine will take years to pay for itself but I've got years and years of feeling good". This is Simon's view on the short and long term value of investing in renewable energy.

LIME HOUSE

Use	Private Residence
Location	52a Dereham Road, Mattishall, Norfolk, NR20 3NS
Contact	Colin Williams Building Consultancy 01362 850171
Designer	Colin Williams
Features	Heating from Biomass Increased Insulation Passive Ventilation Rainwater Harvesting

WHEN BUILDING his own house, Colin Williams, addressed issues of sustainability at every opportunity. Lime House took five years to design and build, winning the Norwich and Peterborough competition for self-build housing in the UK in 2002.

THE GROUND FLOOR IS LARGELY OPEN PLAN with windows on all sides to maximize solar gain. A small wood burner using local waste wood provides most of the space heating. Warm air circulates by natural convection to the first floor. Natural ventilation of the bathrooms and kitchen is achieved by a passive ventilation system which uses no electricity.

DOMESTIC HOT WATER, cooking and a supplementary radiator system are provided by an Esse oil fired cooker connected to a thermal storage tank. Stored water, heated largely by surplus heat from the cooker, circulates around the radiator system in the morning when the wood burner and cooker are cold. It stores enough hot water for around 4 hours.

MATERIALS WERE SELECTED TO MINIMISE ENVIRONMENTAL IMPACT and embodied energy, and to create a healthy internal environment. Using lime mortar to construct about 60% of the walls will allow the bricks to be reclaimed, an equivalent saving of 3500 gallons of petrol. The internal walls are finished with lime plaster and decorated with plant-based paints. Recycled newspaper insulates the walls and roof. Carpets are avoided by using European Redwood and Norfolk pamment tiles flooring.

A RAINWATER RECOVERY SYSTEM collects rainwater from the roof and filters it for storage in a tank under the flowerbeds in the front garden. It is used for flushing toilets, washing clothes and garden uses.

GOOD INSULATION, an airtight structure and the use of non-fossil fuel for most of the heating has resulted in calculated CO_2 emissions of approximately half of those of a typical modern house. When the temperature outside is zero, the total space heating requirement is just 6k.

JASMINE HOUSE

Use	Private Residence
Location	Blakeney
Owners	Marion & Francis Chalmers
Architect	Michael Brackenbury
Design	Maharishi Sthapatya Veda
Builder	Tim Hewitt
Contact	Marion Chalmers 01263 741028
Features	Passive Solar Design Solar Water Heating Heating from Biomass Rammed Earth Construction

DESIGNED ON THE PRINCIPLES of Vedic architecture, Jasmine House is the first of its kind in Norfolk. According to the ancient system of Sthapatya Veda, a house that is correctly designed and built to be in harmony with its natural environment will look beautiful and be a fortune-creating home for those who live in it.

ORIENTATION, PLACEMENT & PROPORTION are critical. The main entrance faces due east, the direction of the rising sun and rooms are placed to correspond with the Earth's changing energy cycles.

DESIGNED TO BE HEATED BY THE SUN, the earth walls retain solar energy through the day and radiate warmth to the inside of the house in the cooler evening. Overhangs on the first floor and roofing give protection from the high sun, preventing overheating. Large full-length windows give natural cross ventilation and allow cooling.

JASMINE HOUSE IS THE FIRST structural rammed earth house in Norfolk with the walls on the ground floor made of locally sourced earth and sand. The mix is breathable but has a high thermal capacity, retaining heat but keeping the interior cool during hot weather. The upper storey of the house is a timber frame structure, faced with cedar boarding. The majority of materials used in the construction of the earth walls were sourced from within a 20 mile radius. All materials and labour were sourced locally where possible.

A VERY EFFICIENT CONDENSING BOILER provides a back-up, but even in winter an even temperature inside the house is maintained for some time before internal generation of heat is required. A wood burning stove supplied with local wood is a further alternative.

THREE LARGE SOLAR PANELS on the south side of the roof provide plenty of hot water whenever there is enough sun and supplement the conventional system at other times.

THE HOUSE WON the Daily Telegraph Homebuilding and Renovating Magazine Best Ecological Home 2004 and the North Norfolk Environment Award for Green Buildings 2003.

Green Buildings in Norfolk

Further information on the features of green buildings

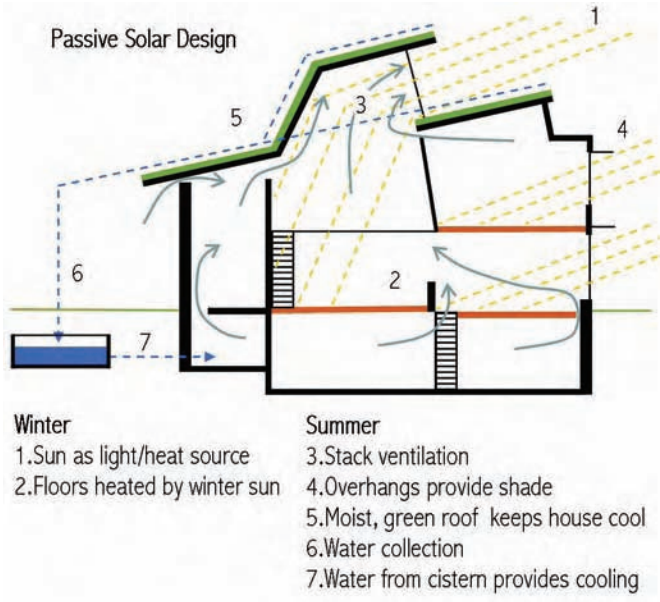
appendix

I	Passive Solar Design
II	Solar Water Heating
III	Heating From Biomass
IV	Geothermal Heating
V	Photovoltaic Panels
VI	Wind Turbines
VII	Increased Insulation
VIII	Earth Sheltering
IX	Improved Glazing
X	Passive Ventilation
XI	Water Management Systems
XII	Rainwater Harvesting

INTRODUCTION

Passive solar design tries to optimise the amount of energy that can be derived directly from the sun, by careful planning of buildings to collect the sun's heat, thus reducing the need for heating.

Simple features can be incorporated at the design stage such as large south-facing windows and building materials (thermal mass) that absorb and slowly release the sun's heat. Passive solar designs can also include natural ventilation for cooling with windows playing a large part in passive solar design.



KEY PRINCIPLES

The main orientation of the building should be within 30° of south - houses orientated east of south will benefit more from morning sun, while those orientated west of south will catch late afternoon sun delaying the evening heating period.

The thermal mass within the masonry walls should allow the sun to be 'soaked up' during daylight hours and then released into the building at night – suitable thermal mass prevents overheating during the summer and avoids cold conditions during the winter.

The most frequently used rooms i.e. those that require most sunlight, should be on the south side of the dwelling. Rooms that do not need to benefit from sunlight should be placed to the north of the building (i.e. hallways, bathrooms, utility rooms, stores). They should also have smaller windows to minimise heat loss.

A responsive, zoned heating system should be installed to automatically cut in when and where necessary – this can be more energy efficient than leaving heating on all day, or heating an unoccupied room.

Although the benefits of passive solar design can best be achieved in new houses, the installation of a conservatory on an older house could save up to 20% of annual heating bills - although this is strongly dependent on the size of the house, siting, design and materials used. A well-designed conservatory acts as extra insulation for the house, preheats the ventilation air and provides direct solar heating to the intervening wall, which is drawn into the house.

CONCLUSION

By incorporating passive solar design into new buildings, annual fuel bills can be cut by about a third, alongside environmental carbon dioxide savings.

DEFINITION

The term Solar Thermal Energy is most commonly applied to a system where solar energy is used to heat a fluid passing through pipes in roof mounted arrays. The hot fluid is circulated to the house's hot water cylinder where the heat energy is transferred to the domestic hot water system. Industrial and commercial applications also exist.

TYPICAL DOMESTIC SYSTEM

A typical domestic system is comprised of a roof mounted array for collecting the solar energy, a storage tank which often doubles as the normal domestic hot water cylinder and a pumped circulation system which includes sensors and a circulating pump.

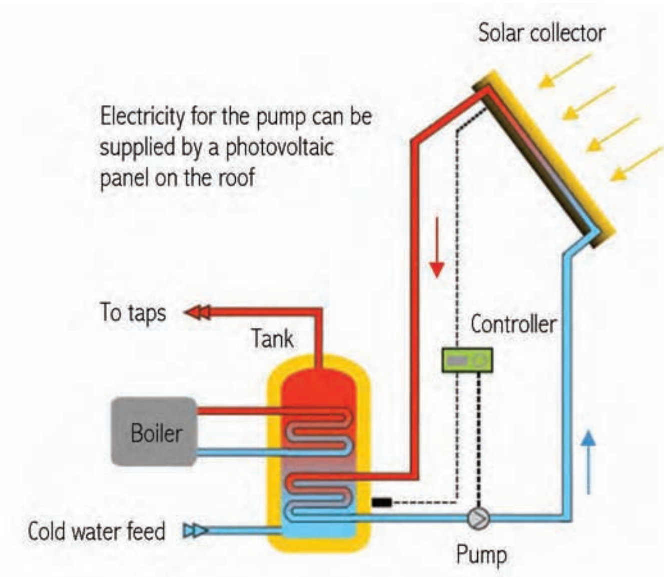
The hot water tank usually contains an electric immersion heater for winter use. The circulation system includes an electronic controller which switches the pump on or off depending on the temperature difference between the fluid in the solar collector and the water in the tank.

PRACTICAL CONSIDERATIONS

Ideally the roof should be south facing but the effects of orientation away from south are not particularly critical. For most solar heating applications, collectors can be faced anywhere from south-east to south-west.

A typical installation in the UK has a panel of $3m^2$ - $4m^2$ (depending on the size of house, type of collector, etc.).

For a family of four, a well designed Solar Thermal system should contribute between 1,500kWh and 2,000kWh, which will be equivalent to 40 - 50% of the household's water heating energy needs.



COSTS INVOLVED

The cost of installing a solar hot water system ranges from approximately £500 - £1500 for a DIY system, to £2000 - £5000 for a commercially installed system. These prices, however, are dependent on the size of the system.

INTRODUCTION

Bioenergy is the general term for energy derived from materials such as wood, straw, energy crops (such as rape, sugar cane, maize), and animal wastes. Bioenergy comes from materials that were living matter relatively recently – in contrast to fossil fuels. Such materials can be burned directly to produce heat or power. They can also be converted into biofuels.

WOOD BURNING STOVES

The most obvious way to make use of biomass at home is by using a wood stove. A stove is much more efficient than an open fire, and new clean burning appliances should mean that wood can be burnt even in smokeless areas. For a wood stove to be a source of renewable energy, the fuel should come from a sustainable source. The type of stove to install depends on what you want your system to do.

To heat your room only, most stoves will be suitable. To heat your room and provide domestic hot water and central heating you will require a stove with a boiler. Stoves with large back boilers can provide most of the hot water needed for a house as well.

The fuel can take the form of wood pellets, wood chips or wood logs. Automatic feed can be used with pellets. Generally such stoves have an output of 6-12 kW.

PRACTICAL CONSIDERATIONS

Legal aspects. You should check whether you are allowed to use a wood burning stove in your area (Clean Air Act and related legislation refers). The installation must comply with all safety and building and safety regulations. If the building is listed or in an area of outstanding natural beauty (AONB), then you will need to check with your Local Authority Planning Department before a flue is fitted.

Access to and storage of fuel. It is important to have a suitable storage space for the fuel, with appropriate access to the boiler for loading and a local fuel supplier.

Flue. The vent material must be specifically designed for wood fuel appliances and there must be sufficient air movement for proper operation of the stove.

COSTS INVOLVED

Capital costs. These depend on the type and size of system you choose, but installation and commissioning costs tend to be fairly fixed. Stand alone room heaters generally cost £1500 - £3000 installed. The cost for boilers varies depending on the fuel choice; a typical 20kW (average size required for a three-bedroom semi-detached house) pellet boiler would cost around £5000 installed, including the cost of the flue and commissioning. A manual log feed system of the same size would be slightly cheaper.

Running costs. Fuel costs generally depend on the distance from your supplier. As a general rule the running costs will be more favourable if you live in an area that doesn't have a gas supply.

INTRODUCTION

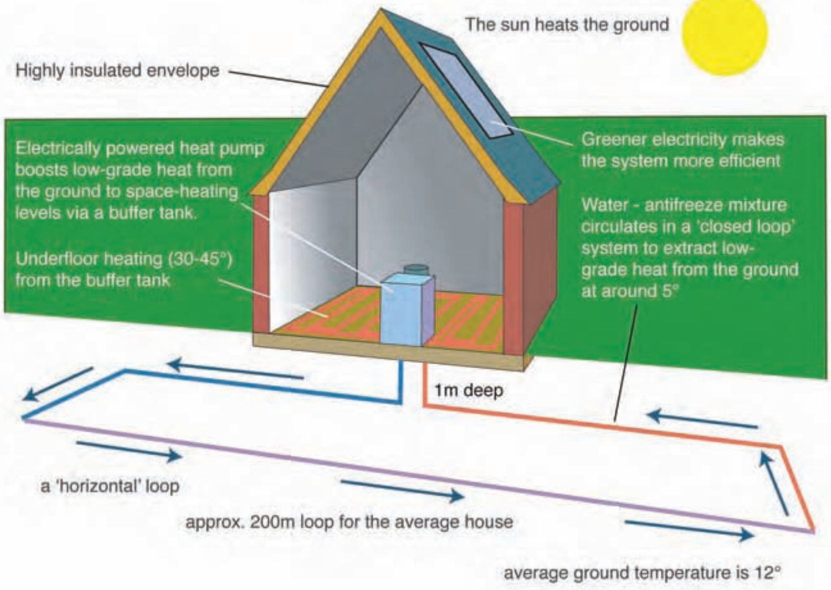
Geothermal energy is usually thought of as heat energy derived from the depths of the earth. Heat and electricity can be generated by circulating water deep underground, where it is heated naturally by hot rocks. There are only certain places in the world where this heat energy provides a practical option for generating electricity, for example in parts of the USA, Kenya and the Philippines – but not, at least at present, in the UK.

However, the term geothermal energy is also used to describe heat energy from the ground near the earth's surface warmed by the heat of the sun. This can be exploited in the UK using a Ground Source Heat Pump [GSHP]. Although the pump does require an electrical input the energy gain from the ground should be several times greater than the electrical energy needed to drive the pump.

GROUND SOURCE HEAT PUMP SYSTEM

GSHPs can be used to extract heat from the ground and pump it into a building to provide space heating and to pre-heat domestic hot water. In the summer months this process can be reversed to meet the cooling requirements of a building.

GSHPs take advantage of the fact that a few metres below the surface the ground maintains a constant temperature throughout the year. In the UK this temperature is 11-13°C. In winter this temperature is warmer than the air above ground. GSHPs are used to extract this heat and transfer it to a building where heat is required.



THE THREE MAIN ELEMENTS TO A GSHP SYSTEM

The ground loop. Normally made up of lengths of plastic pipe buried in the ground, either in a borehole or a horizontal trench. Horizontal trenches are drilled to a depth of 1 to 2 metres; boreholes are drilled to a depth of between 15 and 100 metres. The pipe is a closed loop, which is filled with a water and antifreeze mixture.

The heat pump. This works on the same principles as a refrigerator. A heat exchanger transfers heat from the water/antifreeze mixture in the ground loop to the refrigerant which evaporates. A compressor is then used to increase the pressure and so raise the temperature until the refrigerant condenses. A condenser gives up heat to a hot water tank which then feeds the distribution system.

Heat distribution system. GSHPs are most suitable for underfloor heating systems which require temperatures of 30 to 35 °C.

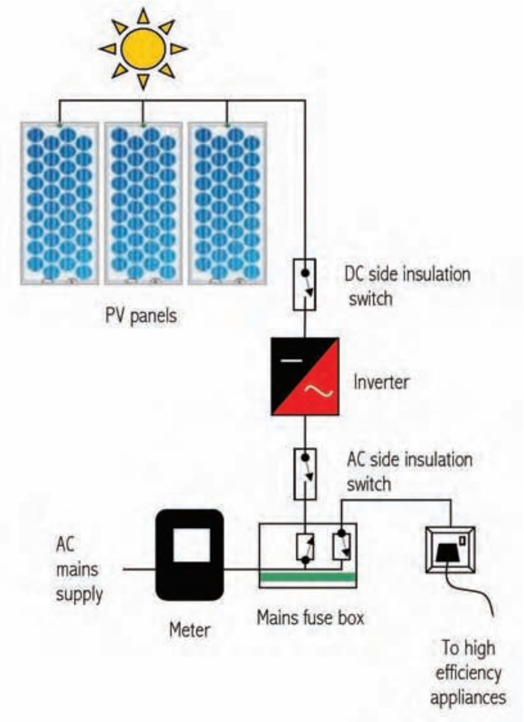
COSTS INVOLVED

The cost of a professionally installed GSHP is about £1000 per kW. A typical 8kW system therefore costs about £8,000. The actual cost will be very dependant on property and location.

photovoltaic panels

WHAT IS PV ENERGY?

Photovoltaic means electricity from light. PV cells (or solar cells) convert sunlight to electricity. Since the electrical power that can be obtained from a single solar cell is very small, for most practical applications they are combined into modules which can themselves be combined into larger arrays.



HOW PV SYSTEMS WORK

The system provides a DC output and, of course, will only provide electrical energy during daylight hours. It is often used to charge a set of batteries so that a continuous DC supply can be maintained.

When photovoltaics are installed for the home then the DC output is normally converted to AC using an inverter. The AC supply augments the National Grid supply and any excess is exported back to the grid.

PV modules come in a variety of shapes and colours, ranging from grey `solar tiles' that look like roof tiles, to panels and transparent cells that can be used on conservatories and glass. These can provide shading as well as generating electricity.

COSTS INVOLVED

A typical 2 kWp system generates around 1500kWh per year, which is roughly 50% of the electricity consumption of an average household. The manufacture of PV cells requires the use of very sophisticated production techniques so costs are still high at £6000-£9000 per kWp. However, prices are coming down year by year as the market develops and the cost of electricity from fossil fuelled power plants becomes more expensive, so PV will eventually become more competitive.

NECESSARY MAINTENANCE

Owners of grid connected systems must ensure that the panels are kept relatively clean and that shade from trees does not become a problem. The wiring and components of the system should also be checked regularly by a qualified technician.

WHAT IS A WIND TURBINE AND HOW IS IT USED?

The UK is the windiest place in Europe and wind power is one of the most promising renewable energy technologies. A wind turbine is a set of aerodynamically designed blades mounted on a tall mast. The blades rotate as the wind blows past them and drive a DC generator.

Systems can stand alone or be connected to the National Grid. In stand alone systems, the DC output may be used directly to supply DC lighting or electrical equipment, or it may be used to charge batteries so that the turbine can provide a continuous supply of electricity. It is also common to combine this system with a diesel generator for use during periods of low wind speeds.

In a grid based system a special inverter and controller converts the DC output to AC at a quality and standard acceptable to the grid. No battery storage is required. Any unused or excess electricity can be exported to the grid and sold to the local electricity supply company.

PREFERRED LOCATIONS FOR WIND TURBINES

Every time you double the wind speed, the energy increases eight times. This indicates why high wind speed regions are chosen to site wind turbines. Some of the best places in the UK are the north west of Scotland, north and south west Wales and Cornwall. However, as technology has developed and system costs have reduced it has become more feasible to locate wind turbines in less windy sites.

Knowledge of the local wind is critical to designing a wind energy system and predicting output. For domestic installations a good source of information on local wind speeds is the NOABL database which can be accessed from the British Wind Energy Association.

PRACTICAL IMPLICATIONS OF INSTALLATION

Small scale turbines are now becoming available which are intended for domestic applications. Planning permission must be sought before installation and it would be valuable to talk to a planning officer at your local district council.

You should try to minimise the environmental impact of the turbine and it will be helpful to inform your neighbours of your plans at an early stage.

The turbine should be mounted as high as possible and well clear of obstructions.

Ideally there should be a clear, smooth fetch to the prevailing wind, e.g. over open water, smooth ground or on a smooth hill.

Electromagnetic interference with television reception is not usually a problem and any remedial action is simple and cheap.

COSTS INVOLVED

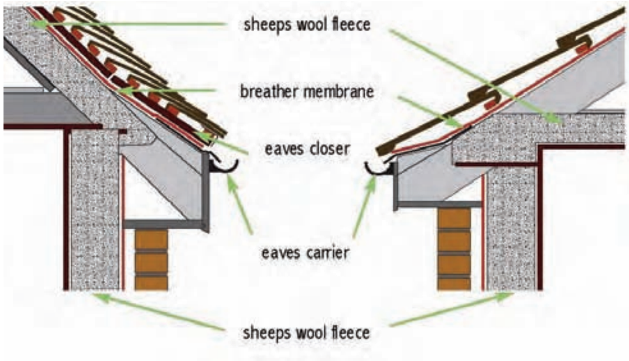
The cost of small scale wind systems for up to 1kW is about £3000. Larger systems between 1.5kW and 6kW can cost £4000-£18000 installed. For battery storage systems, a typical battery lasts around 6-10 years before a replacement is needed.

INTRODUCTION

To minimize heat loss in a building it is necessary to consider all interfaces between the inside and the outside, that is, the walls, roof, windows, doors and the ground floor. The 1995 Building Regulations required minimum U-values of 0.25W/m²/°C for the roof and 0.45W/m²/°C for the walls and floor. However to achieve the goal of a house which requires little or no space heating, insulation to prevent heat loss needs to be far more effective. In addition it is most important that the building is airtight – otherwise other efforts to insulate the building will be wasted.

CHOICE OF INSULATION MATERIALS

There is a wide range of materials available for insulation. Several factors need to be taken into account in selecting which material to use. These include: cost, availability, thermal properties, fire resistance, health issues, ability to be recycled and 'embodied energy' (the energy used up in the collection, manufacture and distribution of the material).



Types of renewable insulation that are available include:

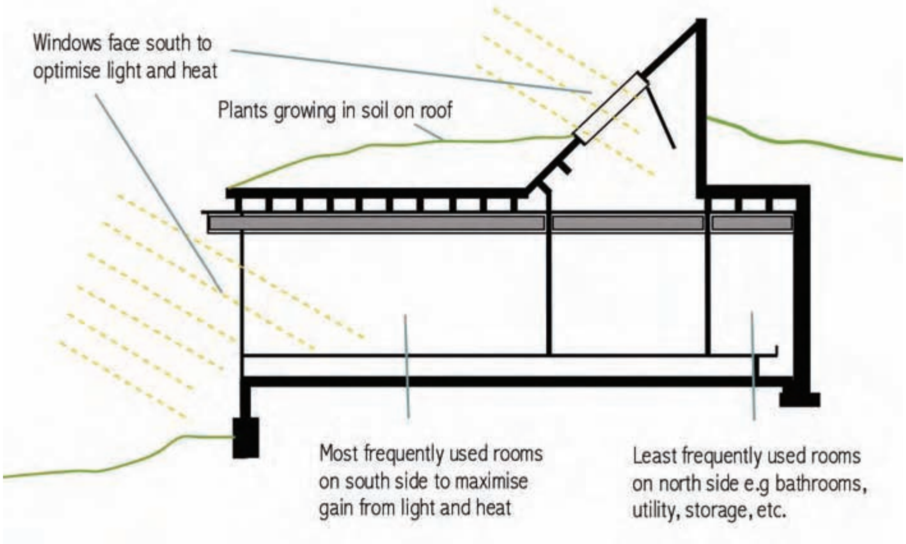
Cellulose	Currently the most common renewable insulation material in the UK. Made from waste paper. The cheapest option.
Sheep's wool	Ideal for use in breathable roofs and timber framed walls as it can absorb (and release) more than 1/3 of its own weight in moisture. It can therefore control condensation in the insulated cavity. It has low embodied energy and is completely biodegradable.
Flax	Flax is mainly used in the production of linseed oil but the short fibres of the plant can be used for insulation.
Hemp	Thought to have great potential as an insulation product. Increasingly used in the car industry as a superior product to synthetic materials. Hemp is a fibre crop well adapted for cultivation in the UK.
Cork	Has been available for some time as an insulation product, mainly in the form of floor or wall tiles. However cork insulation boards are still not widely available at building supply firms in the UK.
Cotton	Not suitable for growing in the UK. However, using waste cotton and other fibres as an insulation product is a possibility.
Straw Bale	An excellent insulator and gaining in popularity, straw bales are cheap to buy and easy to build with. Stacked like huge bricks, straw bale wall systems can be erected quickly without much building experience and few power tools. Soundproof and breathable, they allow a gradual transfer of air through the wall.

INTRODUCTION

Earth Sheltering basically means covering a building with a layer of earth which acts as a kind of blanket. This has two main advantages. Buildings can be covered in plants, helping to conserve the countryside around, and secondly the earth covering acts as a massive insulator, allowing huge savings in energy.

METHOD OF CONSTRUCTION

The easiest method is to build into a hillside, so that three sides and the roof of a building are buried whilst the fourth side is mainly glass to gain maximum sunlight.

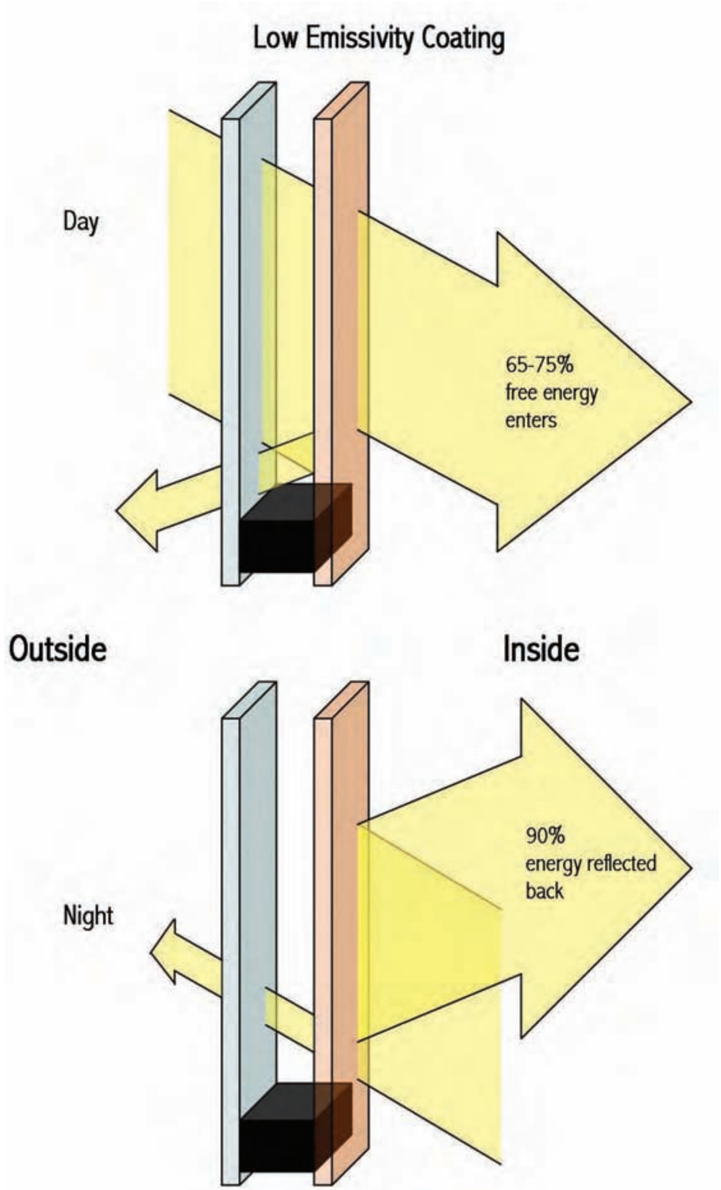


INTRODUCTION

Energy efficient glazing contains more than one pane of glass, with air gaps between each pane. Windows are double, triple or even quadruple glazed primarily to reduce heat loss – although these features will also assist in sound proofing. To further enhance these effects, the space between the glass panes may be filled with a heavy gas or the air may be evacuated.

LOW EMISSIVITY COATINGS

To meet the Building Regulations, low emissivity (low E) double glazed windows must now be fitted whenever you replace an existing window. Low E glass has a special invisible metallic coating that reflects heat back into your room, conserving more heat.



INTRODUCTION

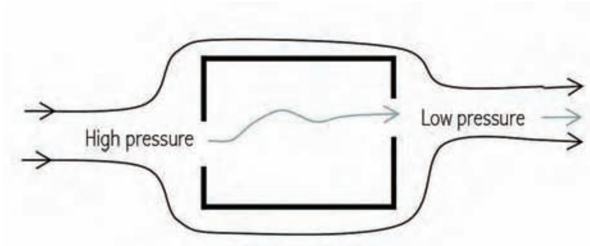
In general terms, ventilation has not been considered a significant design issue for the average house. The only places in the house where we are normally likely to need ventilation are the kitchen and the bathroom/WC areas.

Adequate ventilation can normally be achieved by opening a window, and possibly a door, to create a through draught. The movement of the air can also be assisted by running a small extractor fan.

However, ventilation becomes an important issue in the design of larger buildings used for schools and other places of learning, commercial office blocks, large stores and supermarkets. Passive ventilation in such buildings means making use of building shape and design to produce sufficient natural ventilation without the use of electrically powered fans.

PASSIVE VENTILATION PRINCIPLES

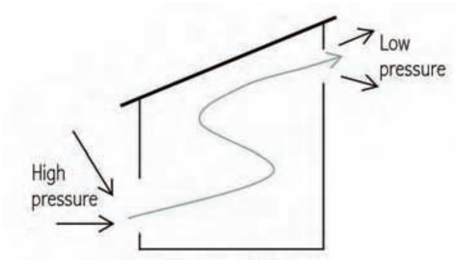
There are two basic ways of achieving effective natural ventilation: cross ventilation and stack ventilation. Of the two, stack ventilation is generally more predictable and reliable. This is because, unlike cross-ventilation, stack ventilation is not dependent on wind speed and direction.



Cross ventilation

Cross ventilation occurs when openings are placed on opposite sides of a building so that wind pressure pushes air through the room spaces. It is clearly dependent on there being some wind, and wind in a certain direction.

Stack ventilation relies on the fact that as air becomes warmer, its density decreases and it becomes more buoyant. As the name suggests, stack ventilation involves the creation of stacks or atria in buildings with vents at high level. As air becomes warmer due to internal and solar heat gains, it becomes more buoyant and thus rises up the stacks where it is exhausted at high level. In doing this a draught is created which draws in fresh air at low level to replace the warm air that has been displaced. Stack ventilation has the beauty of being self regulating - when building heat gains are at their largest, the ventilation flow rate will also be at its largest, due to the large buoyancy forces.



Stack ventilation

INTRODUCTION

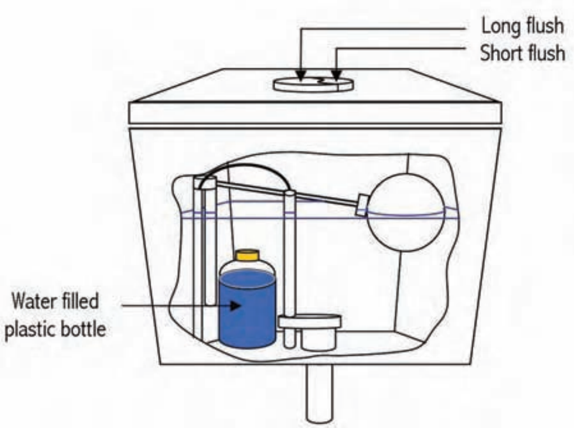
Due to higher standards of hygiene and cleanliness, domestic water use has doubled from 75 litres/person/day in 1960 to 150 litres/person/day in 2006. On average we use water in the home in the following proportions:

Flushing the toilet	33%
Washing machines	21%
Baths and showers	16%
Wash basin	9%
Other uses	4%

Every household uses about 50 litres of water per person per day for WC flushing. In the past, standard UK toilet cisterns generally used 9 or 7.5 litres per flush. The 1999 Water Regulations limited all newly installed cisterns to 6 litres. Water efficient toilets use even smaller volumes which can potentially reduce the average daily water usage in a toilet from 50 to 20 litres per person (60% reduction).

THE SIMPLEST WAY OF ACHIEVING LOW FLUSH

By placing a suitably sized plastic bottle filled with water in the cistern, it has been estimated that household water consumption can be reduced by 10-15%.

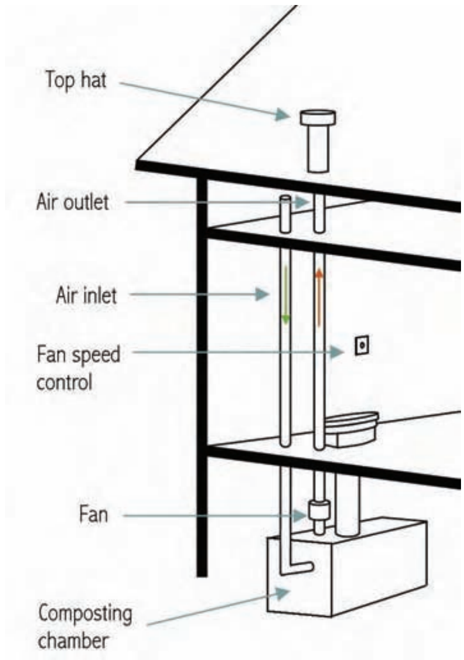


DUAL FLUSH TOILETS

These toilets have two buttons, allowing users to select a reduced or full volume flush depending on the material to be flushed away.

WATERLESS TOILETS

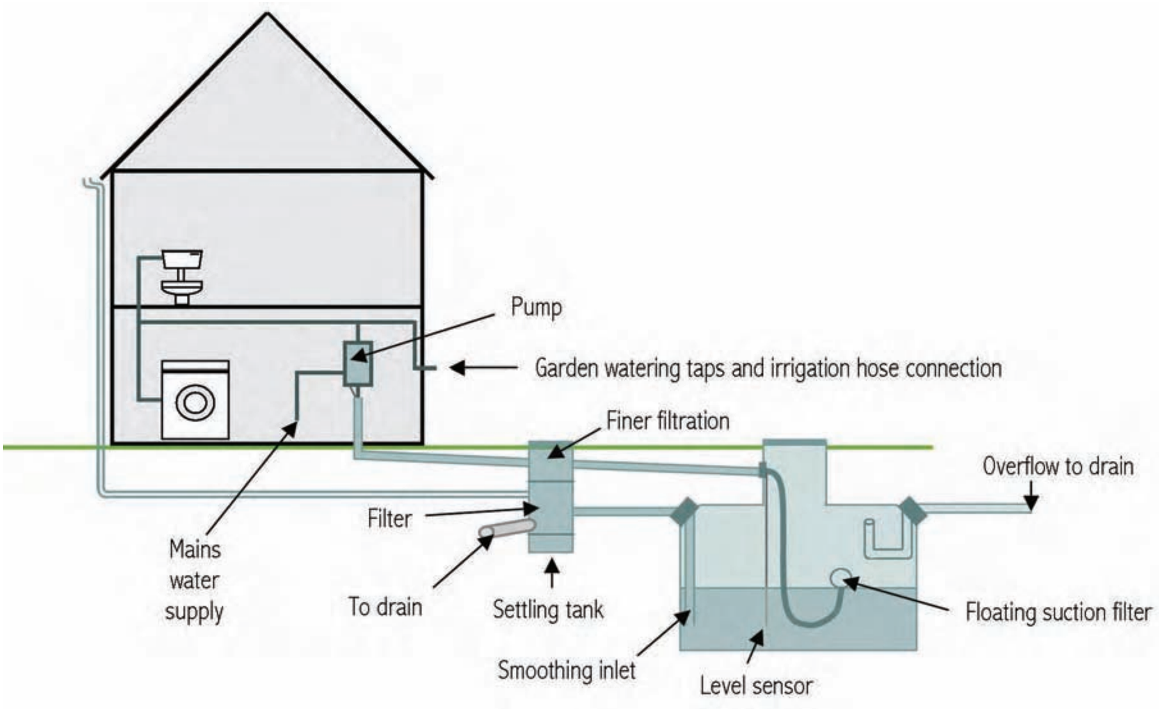
If you wanted to reduce water consumption still further you are probably looking at installing a waterless toilet – this could be a composting toilet or a vacuum toilet (as used on trains and in aeroplanes). However these are not practical for normal domestic use due to their size and expense.



COLLECTION OF RAINWATER

Collecting rainwater can be as simple as positioning a water butt underneath a roof gutter down pipe. Water can be collected and used in the garden or for household chores.

More complicated systems are also available that can be used to collect rainwater from larger roof areas, paved and hard landscaped areas.



MAKING USE OF RAINWATER

One can easily collect enough rainwater to meet normal gardening needs, but to meet all your household needs it estimated that a household of four could use around 240m^3 of water per year and require a rain collection area of about three times the area of the average house roof and storage capacity of 30m^3. Less ambitious schemes would be more practical.

In most schemes a pump is required to transport the stored water to the point of use. A settling tank collects silts and ensures that they do not block distribution pipes and pumps. Finer filtration is used prior to draw off points such as garden watering taps and irrigation hose connections.

The rainwater can also be distributed to sinks and WCs via a header tank which would incorporate mains water back up.

RENEWABLE ENERGY is within everyone's reach. This final example is a story from an ordinary street in Norfolk and demonstrates the opportunities available to us all.

VISITING FRIENDS IN GERMANY inspired Sally and Chris Wilson-Town to think seriously about how they could make their home more energy efficient. In response to Smart Energy's leaflet, they had a solar installation fitted in April 2001 to heat their water.

THE HOUSE HAS NO SOUTH FACING ROOF, so two panels were placed on the front and back of the house to maximise solar gain. These are connected to a 150 litre storage tank in the loft and the system is operated by a control box in the airing cupboard.

ON SUNNY DAYS, the solar tank provides hot water for the whole house with temperatures reaching 70°C or higher from around mid morning until the end of the day. During the night, the water remains warm enough to be used for the washing machine. On very cloudy days, water from the solar tank may only reach 25°C and so will be fed into the main boiler tank. Even in this east-facing property, where hot water from the solar system cannot be stored, the benefits have been noticeable.

SALLY POINTS OUT "As most people's gas bills have been going up, ours have been going down." Since installing the system they have saved considerably on their gas bills and received regular reimbursements from their suppliers. Chris concludes, "I firmly believe that if every new house in Norfolk was built with solar panels, it would make a significant difference to the cost of people's energy usage. And it's not difficult to do."

47 SANDY LANE

Use	Private Residence
Location	47 Sandy Lane, Taverham, Norwich, NR8 6JT
Installers	Smart Energy
Contact	0800 026 6999
Features	Solar Water Heating

THANK YOU

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