sustainable energy by design

a TCPA 'by design' guide for sustainable communities

sustainable energy by design: a guide for sustainable communities

The Town and Country Planning Association (TCPA) is an independent charity working to improve the art and science of town and country planning. The TCPA puts social justice and the environment at the heart of policy debate and inspires government, industry and campaigners to take a fresh perspective on major issues, including planning policy, housing, regeneration and climate change. Our objectives are to:

- secure a decent, well designed home for everyone, in a human-scale environment combining the best features of town and country
- empower people and communities to influence decisions that affect them
- improve the planning system in accordance with the principles of sustainable development.

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TCPA HOMES AND COMMUNITIES FOR A SUSTAINABLE FUTURE
TOWN AND COUNTRY PLANNING ASSOCIATION

English Partnerships
The National Regeneration Agency

CABE

The Countryside Agency
Landscape Access Recreation

pilkington energy efficiency trust

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foreword

The aim of this guide is to show how sustainable energy can be integrated into the planning, design and development of new and existing communities. The guide is provided for local authorities, developers, investors and managers in the public and private sectors. It promotes opportunities for sustainable energy and considers the role of the planning system, communities, other stakeholders and delivery bodies.

The phrase ‘sustainable communities’ here brings together the need to tackle housing shortages or market failure by providing new housing and the necessary accompanying infrastructure while at the same time reducing dangerous greenhouse gas emissions. The TCPA first coined the phrase in 2001 when it called for a new programme to meet these varied needs of the country in terms of society, the economy, and the environment.

This is the second in this series of guides by the TCPA addressing different aspects of creating communities that, taken together, are aimed at ensuring that ‘sustainable communities’ will be genuinely sustainable[1].

Homes contribute around a third of the UK’s CO_2 emissions; all buildings contribute a half of emissions. When transport is also factored in, it becomes clear that energy demand and supply are, and can be, heavily influenced by the built environment. Rising to the challenge of meeting housing need, while reducing emissions of greenhouse gases, demands action from governments and their agencies and all players in the development process, including those who will eventually live in new housing.

There is a growing body of examples of low-carbon or carbon-neutral developments from across the UK and from abroad. Some focus on reducing energy demand, others include new or more established energy generating technologies. Often they include both. In other places, innovative mechanisms have been used to deliver low-carbon energy generation and supply networks on a citywide scale.

The public sector often takes the lead in initiating projects, but many excellent examples are led by developers. The most effective projects have been those where partnerships build capacity for sustainable development.

This guide demonstrates what is being, and what could be, done today. It focuses on the role of design, architecture and planning in the context of sustainable development and creating low-carbon communities. The case studies show how different low- and zero-carbon energy technologies can be integrated into different types of development and highlight the financial mechanisms that have made this possible. The guide also points to where more information can be found.

I would like to thank English Partnerships, CABE, the Countryside Agency and the Pilkington Energy Efficiency Trust for their support for this publication.

Robert Shaw, the TCPA’s Sustainable Development Policy Officer, has managed this project and contributed to some key aspects of the guide.

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what is climate change and sustainable energy?

This section introduces climate change and the benefits of sustainable energy.

1

introduction

Human activities are increasing the amount of carbon dioxide and other so-called greenhouse gases that are entering the atmosphere. This is leading to a warming of the planet and resulting in changes to the climate. One way to reduce the amount of greenhouse gases is to use low- or zero-carbon ‘sustainable’ energy sources. Sustainable energy networks can supply low-carbon, efficient energy to homes and communities.

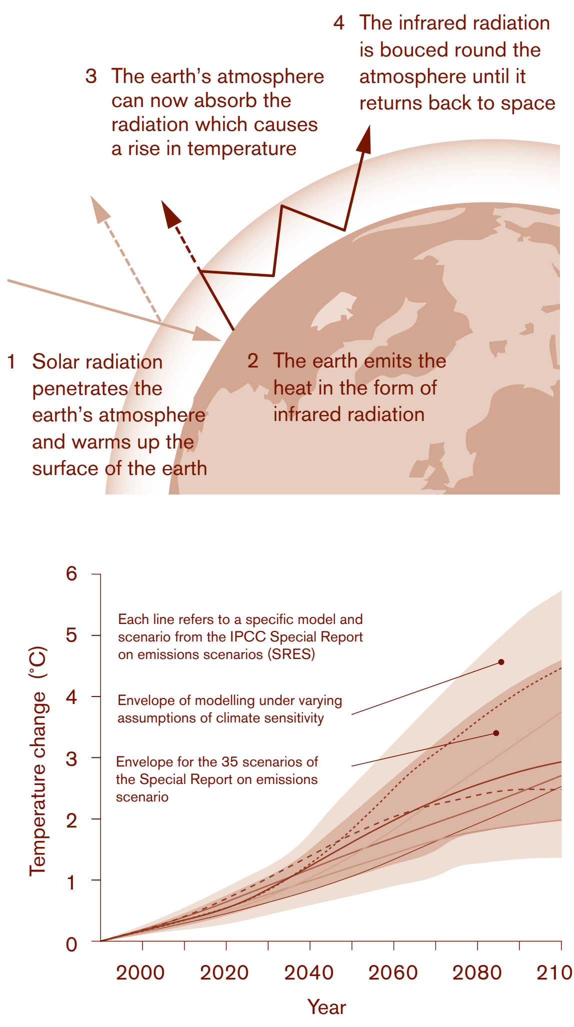
The climate change imperative

There is almost unanimous agreement among scientists that climate change is a fact; this is something the Government also accepts. Geological records show that our climate has changed greatly over time, but current concerns relate to quickening, human-induced change brought about mainly by burning fossil fuels.

Climate scenario models suggest that the likely impact of climate change on the UK will be average temperature increases of up to 5°C, while summer rain is likely to decrease. Incidences of extreme weather events, including flash floods and heatwaves, are likely to become more common[2]. It is now generally accepted that we have around ten years to make real progress towards reducing greenhouse gas emissions if we are to avoid catastrophic climate change.

Climate change is a consequence of what is commonly known as the ‘greenhouse effect’. Greenhouse gases (GHG) permit incoming solar radiation to reach the earth’s surface unhindered but absorb the outward flow, storing some of the heat in the atmosphere. This produces a net warming of the surface.

This heat will eventually return to space. However, the increasing atmospheric concentrations of gases, including carbon dioxide and methane, are causing the average temperature of the earth to increase, resulting in changes to the climate.



Climate change
Above top: The ‘greenhouse effect’.
Above: Scenarios for global average temperature change.

Source: Intergovernmental Panel on Climate Change

The case for sustainable energy

The standard form, location and density to which our homes and communities are constructed plays a crucial role in determining energy demand. While energy performance of new buildings is steadily improving, due mainly to successive revisions of the building regulations (see diagram opposite) and use of sustainability standards, it remains a long way from the zero-carbon goal required by the climate change imperative. On top of this, most of our energy is supplied in much the same way as it has been for the last century. Electricity is produced mainly by fossil fuels in large centralised power plants and distributed via national and local grids; this is a system which results in enough energy being wasted each year to power all the buildings in the UK.

Current building standards and the energy generation and supply system will not enable us to meet the requirements of government energy or sustainable development policy[3/4]. Short- and longer-term changes are needed to both. All stakeholders will benefit if the energy system is transformed from the current high demand, carbon intensive, constantly supplied system to one which is how demand, clean and decentralised (see box opposite for benefits of sustainable energy).

Benefits of sustainable energy

For the developer:

- more favourable response to development proposals from planners and development partners
- improved reputation with local authorities and other development partners leading to increased development opportunities
- reduced risk from future legislation (for example, through the EU Building Directive)
- economic benefits such as enhanced capital allowances.

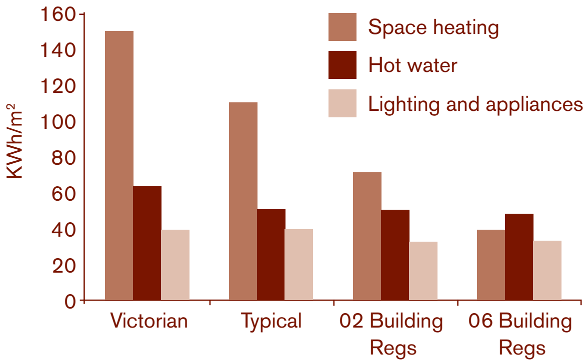
For the occupier:

- lower running costs for the occupants of buildings as heating, cooling and/or electricity bills decrease
- more natural light providing a greater sense of wellbeing
- warmer homes leading to fewer deaths from hypothermia, which kills thousands of vulnerable people every winter.

For the local community:

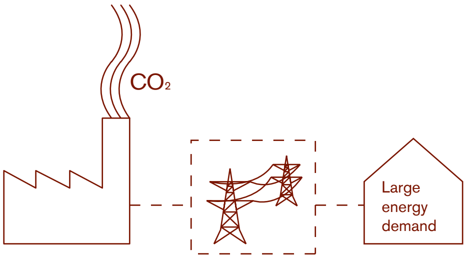
- economic benefits through the use of local materials and labour (for example, biomass)
- increased sense of community through the shared use of renewable technology
- assistance towards reaching local, regional and national carbon saving, air quality and renewables targets
- opportunity to invest in or part-own an energy company.

Source: London Renewables[5]

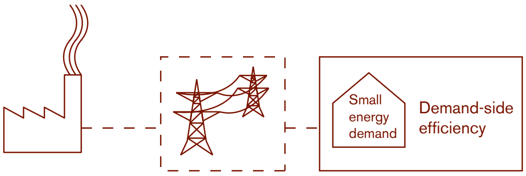


Energy consumption in the built environment

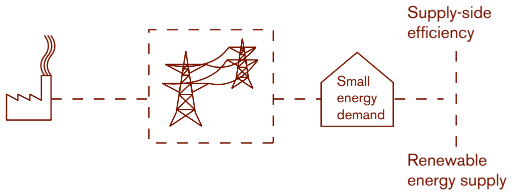
Source: XCO₂



1 Large centralised energy supply with vast distribution losses serving a large domestic energy demand.



2 Reduced energy demand using passive measures to increase energy efficiency and therefore a lower centralised energy supply.



3 A small centralised energy supply due to reduced energy demand and energy being supplied using renewables and efficient technology – sustainable energy.

What is sustainable energy?
The diagram above shows the steps to be taken to achieve a decentralised, more efficient and flexible energy infrastructure over the coming decades. Reducing energy demand through passive efficiency measures, such as better insulation or low energy lighting, is usually the most cost-effective strategy. It should be considered as the crucial first step towards reducing GHG emissions. Efficient and renewable supply of energy from a range of complementary low- and zero-carbon technologies reduces further the energy required from the inefficient national grid.

No generating plant operates 100% of the time. A system that relies on its energy from more than one source inherently has more stability of supply, regardless of the fact that the individual technologies within the system are intermittent. These steps are explained in greater detail in Section 4 of this guide.

Source: XCO₂

policy and legislation for sustainable energy

This section highlights the key policies and legislation that are encouraging the rapid increase in the use of sustainable energy.

2

policy background

Sustainable development is now an organising principle in decision making at all levels, from the global to the local. In the UK this is reflected in the preparation of the statutory strategies that guide all development. The private sector is also increasingly seeing that development based on sustainability principles makes sound business sense.

A range of policies and legislation are influencing the planning and development of sustainable communities, including implementation of sustainable energy.

International

Kyoto Protocol[6]

This is an international agreement to reduce greenhouse gas (GHG) emissions. The UK has committed to a 12.5% reduction by 2012.

EU Energy Performance of Buildings Directive[7]

Coming into force in early 2006, the European energy rating scheme for buildings requires an energy rating certificate to be displayed in all public buildings. The aim is to give building owners and occupiers an incentive to improve energy performance.

National

Securing the Future: UK Sustainable Development Strategy[3]

Published in March 2005, the strategy sets out five principles for sustainable development with a focus on environmental limits. It also identifies four priority areas: sustainable consumption and production, climate change, natural resource protection and sustainable communities.

Our Energy Future: Creating a Low Carbon Economy[4]

This 2003 energy white paper sets a target of generating 10% of UK energy by renewable technologies by 2010 and 15% by 2020. Other policies include creating an energy system that ensures security of supply and affordable warmth, as well as an aspirational target of a 60% reduction in CO_2 emissions by 2050.

UK Building Regulations, Part L[8]

Regulations control the quality and performance of new buildings. The recent revision to Part L (energy efficiency) will require a 20% improvement on current energy standards in buildings when it becomes live in mid-2006.

Sustainability standards[9]

A number of voluntary standards aim to raise the quality of new development. These include: EcoHomes/BREEAM, Z-Squared and energy standards from the Association for Environment Conscious Building (AECB) and the Energy Saving Trust (EST). The Government is currently preparing a national standard called the Code for Sustainable Homes. The code, due in early 2006, is likely to bring together many of the existing standards and will set the direction of future revisions to the building regulations.

Sustainable and Secure Buildings Act 2004[10]

Whereas previously the building regulations could only address sustainable development indirectly, for example via Part L (energy efficiency), this Act will allow future revisions to address this issue directly.

DTI Micro-generation Strategy[11]

This integrated strategy is being prepared and will replace and expand ClearSkies with subsidies and incentives.

Planning policy guidance and statements (PPG/S)[12]

PPS set out central government policy on a range of planning issues. Of particular relevance to sustainable energy are PPS1 and PPS22. The former sets out core planning objectives while the latter describes how planning should be used to deliver renewable energy.

Regional

Regional spatial strategies (RSS)

RSS are documents prepared by regional assemblies in England (a spatial development strategy is prepared by the Mayor in London). They draw on national policy and provide a broad development strategy for the region over a 15–20 year period. Together with local development frameworks (LDFs) they constitute the statutory Development Plan. A growing number of assemblies are including sustainable energy and climate change policies in their RSS (for example, see the case studies on London overleaf).

Local

LDFs, or unitary development plans (UDPs) in London, are prepared by local authorities and provide the framework for development at the local level. They are the principal consideration in determining planning applications. LDFs comprise statutory development plan documents (DPDs) and other advice and guidance, such as supplementary planning documents (SPDs) and area action plans. Local authorities must also set out how communities can become involved in the process through ‘statements of community involvement’.

Prescriptive development plan policies are increasingly being used to deliver climate change and sustainable energy objectives. The London Borough of Merton, for example, requires certain developments to incorporate on-site renewable energy generating capacity (see case study overleaf).

case studies

Planning for energy in London

London leads the way in planning for sustainable energy at regional level. Published in 2004, the Energy Strategy[13] adopts an approach to energy similar to that used in this guide: use less energy, use renewable energy and supply energy efficiently. Policies and targets include:

- 665GWh of renewable electricity and 280GWh of heat capacity by 2010
- every London borough to have at least one zero-carbon development by 2010
- use of energy service companies (ESCos) to deliver a more sustainable, decentralised energy network
- improve energy efficiency in housing by setting minimum SAP (standard assessment procedure) targets.

The spatial development strategy (the London Plan)[14] was adopted in February 2004. It provides the statutory framework for delivering targets set out in the energy strategy, including policies requiring major developments to show how they intend to generate a proportion of the site's energy needs from renewables. This will be supported by supplementary planning guidance (due 2006) which will set out broad guidelines to define locations for stand-alone schemes and set assessment criteria. It will also include work on feasibility.

A number of other bodies also support sustainable energy. London Renewables informs the adoption of targets and promotes action to meet them. A toolkit was published to help developers and their design teams to achieve these targets[5]. The independent London Energy Partnership brings together sectors and organisations to deliver energy action more effectively.

More information: www.london.gov.uk/mayor/strategies

London Borough of Merton

Merton's Unitary Development Plan (as amended by the Government Inspector and approved in November 2003) stipulates that 'the council will encourage the energy efficient design of buildings and their layout and orientation on site. All new non-residential development above a threshold of 1,000 sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements.'

In approving the policy the Government Inspector said that there was 'unambiguous national and regional support' for the approach adopted by Merton.

At least 50 other local planning authorities in England and Wales are now following suit with most, such as Croydon, also including residential development. Planners have so far found developers to be very positive towards implementing the policy.

More information: www.merton.gov.uk, www.croydon.gov.uk

Willow Lane Industrial Estate: London Borough of Merton

Developed by Chancerygate, this 4,500m^2 speculative commercial development comprises 10 units in a built-up suburban location. In order to comply with the Merton's on-site generation planning policy, the developer included 10 small-scale wind turbines and 5kWp of photovoltaic (PV) panels. This is the first timethat a developer has been compelled to respond to a prescriptive renewable energy policy.

London Borough of Merton and Cadogan (the developer's chosen consultants) established the proposal's baseline energy usage using Energy Efficiency in Industrial Buildings Sites Guide 18 and Benchmarking Tool for Industrial Buildings Guide 81. They then calculated a carbon footprint. The London Renewables toolkit[5] has subsequently been developed which can assist with this process.

CO_2 emissions have been reduced by 17.5% with renewable energy contributing over 7%.

Key lessons:

- this successful development was achieved via a flexible, holistic and consultative approach from the council and the developer
- incorporating energy saving measures (condensing boilers, intelligent lighting and passive stack ventilation) significantly reduced the size of the renewable systems needed and therefore the cost of complying with the policy
- in line with ODPM thinking, it was agreed that the policy should be interpreted through carbon emissions rather than energy usage
- as a speculative development, it was difficult to establish a baseline energy/carbon footprint; this approach ruled out water heating technologies that might normally be used to preheat water for central heating, showers and so on.

More information: www.merton.gov.uk

how to fund and deliver sustainable energy

This section describes how to develop a sustainable energy plan and select the appropriate funding and delivery mechanisms.

3.1 creating a sustainable energy plan
3.2 funding sustainable energy
3.3 energy services
3.4 community input

3

3.1 creating a sustainable energy plan

The approach to implementing sustainable energy is broadly similar no matter where a site is, or the nature of the development. An energy plan, prepared by the local planning authority with the involvement of stakeholders, allows for energy options to be developed on an area-wide basis.

An energy plan can be prepared as part of a wider community, climate change or carbon reduction strategy, or as a stand-alone document. If given a spatial planning focus, and subject to appropriate community involvement, the aim should be to adopt it as part of an LDF or SPD. The objectives will be to: facilitate delivery of energy and GHG reduction targets, identify priorities for action and consider principal opportunities for sustainable energy.

Stage 1: Involve stakeholders

The lead is likely to be taken by the local authority planning department, bringing together other departments, elected members, developers, government offices, local authority support programmes, energy suppliers and communities.

Stage 2: Integrate the plan

Those co-ordinating the preparation of the plan should consider how energy fits in with and can contribute to other council objectives such as growth, raising construction standards, and GHG emission reduction or renewable energy targets. The plan should review demand and emissions of existing and proposed development, the potential to use existing infrastructure, and renewable energy sources[15].

Stage 3: Develop options

Partners should use this information to develop options, including consideration of financial implications, technical viability and implementation mechanisms (see Sections 4 and 5). They should also consider national tools such as landscape character assessments, and national landscape and other designations of material consideration.

The public sector, including agencies such as English Partnerships and the Housing Corporation, is increasingly setting development standards for its own buildings. This sector's strategies should be considered as part of developing an energy strategy.

Stage 4: Finalise strategy

Stakeholder workshops or similar events should be used to finalise the delivery-focused strategy. Arrangements for monitoring and reviewing the plan should be established and adequately resourced. As a minimum, the published strategy should have senior level support within the local authority.

case studies

Climate change strategy: Bristol City Council

Bristol's Climate Protection and Sustainable Energy Strategy and Action Plan contains a target of reducing GHG emissions by 60% on 2000 levels by 2050, with a range of actions for the council, local businesses, community groups and individuals. The target was set in Bristol's community strategy which was published in 2003. It identified tackling climate change as a priority for the city.

A number of factors supported development of the strategy:

- high level corporate support for tackling climate change, and involvement of as many departments as possible
- proper community and stakeholder consultation
- linkages with other council priorities and to regional strategies and national agendas
- identifying first the actions which would be the most cost effective and quickly deliverable, but also identifying longer term priorities and awareness-raising initiatives.

More information: www.bristol-city.gov.uk/climatechange

Energy action plan 2005 to 2020: Kirklees Council

The Kirklees Council Energy Action Plan addresses energy issues as part of the community strategy and directly supports its environment policy framework. The framework requires the council to implement actions to reduce GHG emissions, and to increase the proportion of energy generated by renewable sources. The action plan will be achieved by:

- raising awareness
- becoming more energy efficient
- providing more renewable energy through embedded generation or purchase
- trading emissions to enable contraction and convergence
- adapting and preparing for the impacts of climate change.

The action plan sets out what needs to be done in order to meet the targets. It also includes timescales, the partners involved and a set of performance indicators, as well as an analysis of the financial implications of different scenarios for meeting emission reduction targets. Scenarios range from buying carbon reductions on the international markets through to energy efficiency and procurement of renewable energy.

Once complete the aim is to adopt the relevant targets and actions contained within the action plan into the LDF. It will also consider preparing an SPD to provide best practice guidance to support planning policies.

More information: www.kirklees.gov.uk

3.2 funding sustainable energy

The cost of sustainable energy technologies is coming down, but they remain expensive to install. While funding sources are available, they are not significant. A whole-life approach to funding sustainable energy needs to be adopted so that some of the long-term financial benefits can be built into the planning stage.

There are many factors influencing which sustainable energy measures and technologies are suited to particular developments (these are discussed in Sections 4 and 5). Cost – both capital and revenue – will be a crucial factor. Information and advice is available to assist with costing sustainable energy options[5]. It is crucial that funding and project priorities are set from the outset through an energy action plan.

The capital costs for the inclusion of sustainable energy options can in part be off-set. Some grants are available and these are discussed below, as are options for commercial implementation. Higher sale prices for properties on the basis of lower running costs is another option. Introduction of the energy rating scheme for buildings will create a market for more energy efficient buildings and increasing inclusion of micro-generation technologies within buildings means that some contribution from purchasers could be expected.

However, many purchasers are already financially stretched due to high house prices and so alternatives should be considered. If development teams are aware from the beginning of the need to include sustainable energy as part of a proposal there will be more chance that this could be reflected in the price paid for the land. In cases where the sale of land has already been agreed, or a price fixed, a landowner may be flexible as to when they receive payments for the land. In both cases the burden of increased capital costs for the developer or purchaser is removed or significantly reduced. The remaining residual cost will need to be provided by stakeholders or the developer.

This section does not provide a comprehensive list of available funding; rather it gives examples and a flavour of where more information can be found. For a funding database visit the Energy Saving Trust website (www.est.org.uk/housingbuildings/funding/database).

Energy-specific funding sources

- Defra's Energy Crops Scheme (www.defra.gov.uk/erdp/schemes/energy/default.htm).
- The current Department of Trade and Industry (DTI) capital grant schemes (Clear Skies and the Major PV Demonstration Programme) are due to end in March 2006. They will be replaced by the Low Carbon Buildings Programme. This will focus on a smaller number of large-scale projects, together with some assistance for smaller-scale individual and community projects[16].
- Energy efficiency is supported through schemes such as Warm Front. The Carbon Trust and Energy Saving Trust also provide support programmes, such as Homes Energy Efficiency Schemes or Innovation Funding[17].
- The Enhanced Capital Allowance scheme (www.eca.gov.uk) provides businesses with tax incentives if they invest in certain low-carbon technologies[18].
- The Renewables Obligation (www.dti.gov.uk) requires power suppliers to purchase a proportion of energy from renewable sources. For each megawatt the producer receives a certificate (ROC), which can be traded.

Non energy-specific funding sources

- The European Union makes grants available for research and implementation. For example, Concerto is a major new EU initiative to help local communities demonstrate the benefits of integrating sustainable energy on a community scale. The Energie Helpline UK (www.dti.gov.uk/ent/energie) is part of an EU-wide network to assist in the delivery of a number of European funding programmes, including the Sustainable Energy Systems thematic priority of Framework Programme 6 and Intelligent Energy Europe.

Charitable and small grants for voluntary and community groups

- Lottery funding – Big Lottery Fund (www.biglotteryfund.org.uk).
- New Deal for Communities – Community-led regeneration programme (www.ndfc.co.uk).
- The Neighbourhood Renewal Fund provides support for projects tackling deprivation in the most deprived neighbourhoods (www.neighbourhood.gov.uk).

Sources of private finance, such as from banks or companies

- Triodos Bank only finances projects with social and environmental benefits (www.triodos.co.uk).
- The Co-operative Bank is a customer-owned UK bank with an ethical focus, and also runs a Community Dividend Investment Foundation (www.co-operativebank.co.uk).
- Shell Springboard funds commercially viable business ideas that tackle climate change (www.shellspringboard.org).

3.3 energy services

Energy services are a package of energy efficiency measures, advice, supply of energy and access to grants and finance. Ideally this should be provided by one company. Benefits can include increased capital investment in energy services and efficiency by levering in private finance, increased revenue, reduced bills, improved comfort or health for residents and reduced management costs.

These benefits are important because renewable energy can be expensive and grants are limited. In many cases it is unlikely that technology-specific funding will be available to help developers meet prescriptive planning policies or more stringent building regulations.

The Local Government Act 2000 created a power enabling local authorities to set up local energy service companies (ESCos) which, on their own or in partnership, can offer energy saving measures or low-carbon solutions to home owners or businesses. The use of energy services is increasingly demonstrating that sustainable energy projects can be delivered commercially (as outlined in the case studies in this section) as part of a co-ordinated strategy involving public, private and voluntary sectors. Any individual or organisation can seek funding for or implement sustainable energy. However, an ESCo can be useful for co-ordinating the whole process and is particularly suited to delivering sustainable energy on a larger scale or as part of a network.

Woking Borough Council uses an ESCo to design, finance, build and operate affordable, low-carbon, renewable power and heat sources, and to promote energy efficiency to the local community in ways that stack-up financially. The ESCo has responsibility for delivering energy services from the primary energy plant and infrastructure. The owners/occupiers of the properties become customers of the ESCo which meters, bills and collects revenue from them.

Less ambitious ESCo initiatives are also delivering significant energy efficiency and energy generation capacity. The Association of UK Energy Agencies (AUKEA) has been set up to support energy agencies around the country[19]. For example, the Leicester Energy Agency leases solar panels (photovoltaic and passive) to local residents through a ‘solar rental’ scheme.

There is a role for developers, supported by a local authority, and other public and private sector organisations to initiate the set up of an ESCo. Opportunities and partners should be identified as part of a local authority initiated energy plan or similar.

Energy services companies (ESCos)

In order to lever in private finance, some local authorities have begun to provide energy services by entering into a legal public/private joint venture ESCo, comprising the installation and operation of energy supply and demand reduction measures. Management models for ESCos can be based on community ownership, not-for-profit companies or private utilities.

Energy services are sub-contracted to a specialist ESCo for a fixed period for a set fee. The ESCo specifies, pays for, installs and runs power, heating, and cooling equipment over that time period. Once terms have been agreed, the ESCo organises and oversees all necessary works to the building(s) and the energy supply. Since the equipment remains the property of the ESCo there is no capital outlay for the customer. The capital, running and maintenance costs are subsumed into the customer's bills over the period of the contract.

The customer pays a guaranteed amount for the energy services, leaving the ESCo to focus on delivering those services as efficiently as possible to maximise profits and/or environmental benefits. They can be a powerful mechanism for meeting the requirements of planning and other policy and legislative requirements profitably.

ESCos are authorised to generate, distribute and supply electricity under the Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. They are increasingly being used by local authorities, but could also be used by regeneration companies and other organisations, to deliver sustainable energy and sustainable development objectives. Although still subject to central government capital expenditure controls, by keeping the public sector shareholding at less than 20% local authorities can avoid those controls imposed on purely local government companies.

ESCos are a useful mechanism for delivering one-off as well as long-term projects at small and community scales. They enable profits to be recycled to install more energy generation capacity or energy efficiency measures. They are particularly suited to delivering power and heat networks. While it is more expensive to produce and supply than centrally generated energy due to the higher cost of the plant it can usually be supplied cheaper to customers since it is supplied direct avoiding distribution and other costs.

Examples of energy services in the UK include the following:

- preferred supplier partnerships (also known as 'affinity deals') are set up between an energy supply company and a local authority or housing association to supply energy at an affordable rate. The local authority receives a 'finders fee' for each household it signs up (typically around £30) and invests the money in energy efficiency measures. For example, Aberdeen City Council receives around £60,000 per year with its scheme.
- social housing energy clubs offer similar benefits to preferred supplier partnerships, but focus more on low income groups. Typically they offer grants, discounts or interest-free finance on energy efficiency measures and appliances and energy advice on the use of existing heating systems. The Black Country Energy Services Club, comprising Dudley Metropolitan Borough Council and six housing associations, offers such services.
- ESCos can generate and supply energy services to one or more buildings. Energy generation by an ESCo, with profits recycled into a fund to provide capital and revenue funding for energy efficiency measures and further generating capacity, can remove upfront capital costs of energy infrastructure from the developer. ESCos can help to raise the importance of energy management where it may otherwise not be considered a priority.

More information (including a free consultancy service): www.est.org.uk

case studies

Titanic Mill CO_2 neutral development: Linthwaite, West Yorkshire

This Grade II listed textile mill is now being converted to provide 130 residential apartments, a spa/leisure facility, hotel and a restaurant. It is expected that the project will be completed in late 2006.

The developer, Lowry Renaissance Ltd working in partnership with Energy for Sustainable Development Ltd and Kirklees Metropolitan Council, has committed to making the apartments carbon-neutral (on a net annual basis) and to minimise carbon emissions from the ground floor spaces.

The development will incorporate high levels of insulation, high specification windows and mechanical ventilation with heat recovery. It will also feature a roof-mounted, 50kWp PV system (part-funded by the DTI Major PV Grants programme) and a biomass-fuelled CHP system, producing 100kW of electricity and 140kW of heat. This is expected to reduce annual CO_2 emissions by approximately 400 tonnes in residential areas and 200 tonnes in commercial areas. The site will be connected to the local electricity grid which will allow the development to export excess electricity from the biomass CHP system and to purchase electricity from an electricity supplier when demand on-site is high or the CHP system is not operating.

A not-for-profit ESCo (Mill Energy Services) has been set up to manage and supply energy and water systems. This is wholly owned by the building's management company which in turn is owned by the residents and the ground floor tenants. The vision is for this to be a ground-breaking, small-scale ESCo demonstrating that a holistic approach to energy demand and supply can lead to commercially viable carbon-neutral energy services for domestic customers.

After running costs have been deducted from the revenue, any surplus will be used to build up a reserve fund for the long-term renewal of the energy and water system assets.

More information: www.kirklees.gov.uk, www.lowryrenaissance.com/titanic.html

Thameswey Energy Ltd: Woking Borough Council ESCo

Woking's ESCo (Thameswey Energy Ltd) was set up in 1999 to participate in energy services projects and to enable expansion of the established private wire network.

Energy and water systems for a converted mill managed using an ESCo. *Source: ESD Ltd*

Fuel cell powered swimming complex operated by Thamesway Energy Ltd. *Source: Woking Borough Council*

This was initiated by the council's energy manager, with support of senior management and politicians. Woking is now the most energy efficient local authority in the UK, and has the largest installed solar PV capacity.

Thameswey Energy Ltd is a public/private joint venture bringing together Woking Borough Council and the energy company Xergi A/S. Projects are financed with shareholding capital and private finance, with development carried out jointly by Thameswey Energy and Xergi. Thameswey Energy has enabled Woking to increase its own energy generation by over 800% since 2000.

Key lessons:

- senior management, including local authority asset managers and politicians, need to back the project.
- Woking has opted for a very innovative model that creates genuine commercial partnerships. Other local authorities should use the full breadth of legislative powers (such as the Local Government Act 2000) to enable them to develop special financial vehicles and to develop relationships with energy companies and other commercial partners.

More information:
www.woking.gov.uk/environment/climatechangestrategy

HelpCo Energy Club: funding for sustainable energy

In partnership with ScottishPower, the Greater London Energy Efficiency Network (GLEEN) set up HelpCo with a £99,000 matched funding grant from the Energy Saving Trust (energy services programme). HelpCo is a not-for-profit community energy club offering a range of energy services to UK residents and communities to help reduce carbon emissions and incidences of fuel poverty.

Services include:

- fixed weekly or monthly payment plans and arrears management
- monthly energy efficiency statement including advice and feedback
- a free home energy audit
- loan finance for efficiency measures.

ScottishPower funds the scheme by paying a commission for every customer. It bills HelpCo for the energy and HelpCo bills the customers, which includes a monthly charge of £1.50 plus VAT. HelpCo has estimated that the average cost saving to households is approximately 7%.

Under the scheme nine local authorities have signed up tenants, saving customers £25,000 a year on their fuel bills and earning £60,000 in commission payments to local authority energy funds. HelpCo has awarded over 100 loans for energy efficiency measures and conducted more than 1,000 Warm Front surveys.

More information:
www.est.org.uk/housingbuildings/funding/innovative

3.4 community input

Community involvement in planning for sustainable energy can help to foster support for, and improve the quality of, development. It can raise awareness of the need for sustainable energy and help contribute to actual project delivery. It is therefore crucial that communities and other stakeholders are fully involved from the beginning.

There are different ways in which communities can be involved in developing and implementing sustainable energy projects. These range from participating in consultation during the preparation of an energy plan or the development plan process through to initiating community-owned projects as part of existing or new communities.

While participation in decision making is sometimes seen as an expensive impediment to the development process, in the long term it can reduce conflict and lead to outcomes that better reflect the aspirations of communities. Planners, developers and other partners should engage with communities as early in the development process as possible and provide genuine opportunities for communities to influence the outcomes.

Proactive community-led initiatives, assisted by schemes such as the Countryside Agency's Community Renewables Initiative[15], enable active involvement in decision making and full- or part-ownership of installations. Community-owned green energy is the mainstay of German and Danish renewable expertise and has worked successfully in the UK since 1996.

Experience in the UK and abroad suggests that encouraging community development and ownership of sustainable energy projects, where benefits of developments to both individuals and communities are tangible, can be particularly useful in:

- increasing installed sustainable energy capacity
- promoting cheaper and better technologies through private investment
- helping overcome problems and conflicts
- providing an attractive financial return to those involved and creating economic benefits for the local area including job creation, services and production of affordable energy
- promoting individual commitments to low carbon.

There are a range of options for community ownership. In a co-operative model, heat and power is produced and used in or close to the community. Merchant supply is a similar model, although the electricity may be generated some distance away. In the case of wind power, this may be a more suitable option for high density urban developments. In both cases excess power can be sold to the national grid and money earned through accruing Renewables Obligation Certificates (ROCs).

case studies

Energy4All Limited: a co-operative future for clean green energy

Owned by Baywind Energy Co-operative Ltd, the UK's first community-owned wind farm, Energy4All was formed in 2002 to expand the number of renewable energy co-operatives throughout Scotland, England, Wales and Ireland. Energy4All provides a package of administrative and financial services to its clients in return for a share of income from the co-operatives.

The co-operative has so far generated enough green electricity to power 1,300 homes a year while paying an attractive return to its 1,350 members and supporting local initiatives such as the Baywind Energy Conservation Trust.

As additional co-operatives are established the aim is that they too will own a share in Energy4All. Energy4All is currently financed by the Baywind Co-operative and a grant from Co-operative Action.

Due to this financial structure Energy4All has only limited risk capital at its disposal, although management skills and time can be made available to community organisations. Site owners or developers are normally expected to meet the direct costs of the development process until planning consent is achieved.

In November 2005 Energy4All launched a new share issue for Westmill Wind Farm Co-op. This will be the first wind farm co-operative in the south of England and will consist of five 1.3MW (megawatt) turbines.

More information: www.energy4all.co.uk, www.co-operativeaction.coop, www.baywind.co.uk

Holsworthy Biogas Plant: community renewables initiative

Holsworthy Biogas power plant opened in 2001 and processes cattle slurry and food waste from local farms and businesses to make methane. This is used in turbines to create heat and electricity that is then sold to the national grid. The power plant has capacity to process up to 146,000 tonnes of waste per year. The electricity produced should be 14.4 million kW hours per annum from generators with a capacity of 2.1MW.

There are two main by-products to the process: fertiliser, which is distributed to local farmers, and heated water. The aim is to harness the heat to supply local community buildings. Although not yet implemented, the plant has recently received £600,000 from the Community Energy Programme to establish a heat network to supply the local hospital, school and housing. This amounts to 15 million kW hours.

The total cost of the project will be £7.7 million. Funding was secured with advice from the Countryside Agency's Community Renewables Initiative and Devon Association for Renewable Energy (DARE), combined with aid from Torridge District Council and the South West Regional Development Agency. The plant was built by the German company Farmatic Biotech Energy AG which originally held shares in the project. Shares will now be held by the local community and supplying farmers, together with other interested parties.

The heat distribution will be managed by a community group, which has been developed in consultation with DARE, with support from the district council and the regional development agency. The project will bring skills, expertise and value for money into the community.

More information: www.holsworthy-biogas.co.uk

Co-operatives are helping to expand sustainable energy.
Source: Energy4All Ltd

Local farmers and the community benefit from Holsworthy Biogas plant.
Source: Renewable Heat and Power Ltd

Merchant wind power: Ecotricity

Merchant wind power (MWP) is a commercially attractive method of providing green energy to organisations with an environmental agenda. Energy supplier Ecotricity builds, owns, operates and maintains wind turbines on a partner organisation's site, or in the case of off-site MWP, at a remote location.

MWP partners agree to purchase the electricity, typically over a 12 year period, in return for a competitively priced, dedicated supply of green energy. The desired amount of green energy is guaranteed to be available and the financial costs of the project are absorbed by the supplier leaving no financial or developmental risk to the partner.

In April 2004 construction of London's first wind park was completed at the Ford Motor Company's Dagenham site. Two 85m high turbines, with a combined capacity of 3.6MW, generate over 6.7 million kWh of electricity every year, providing all the electricity needed to power Ford's Dagenham Diesel Centre. This is equivalent to enough electricity to power over 2,000 homes (nearly seven million units per annum).

More information: www.ecotricity.co.uk

Co-operative culture in Denmark and Sweden

In Denmark and Sweden the energy systems are characterised by distributed power generation, with capacity located within communities. The culture change necessary to make this happen was brought about by distributing the benefits through co-operative ownership.

There are five models: community-led investment, consumer-owned utilities, farmer co-operatives, new ventures and trade associations. These models of ownership have been widely used in the UK, but not to deliver energy projects.

Consumer-owned district heating

Developed as a response to the 1970s energy crisis, district heating now accounts for over half of Denmark's space heating now comes from district heating, enabling efficient use of fossil fuels while increasing renewable energy and making communities more resilient to fuel price fluctuations.

Schemes have been delivered by local authority or co-operative-owned heating companies, with most using CHP from generators ranging from 1MW upwards.

Formed in 1992 as a not-for-profit organisation, Høje Taarstrup is one of 19 district heating co-operatives in greater Copenhagen. The co-operative's board of representatives, which approves the budget and accounts, is the main decision-making body. Each shareholder has voting rights, but there is also a general meeting once a year to elect the board and this is open to all consumers.

The relationship that is fostered between energy producers and suppliers, brought about by the co-operative, is seen as an effective model for the investment and management of community district heating. The local authority's planning powers and role as loan guarantor have been crucial.

The district heating co-operatives have similarities with the UK's community interest companies, with their assets dedicated in perpetuity for the benefit of the community. However, their co-operative nature provides consumers with the additional benefit of a democratic structure.

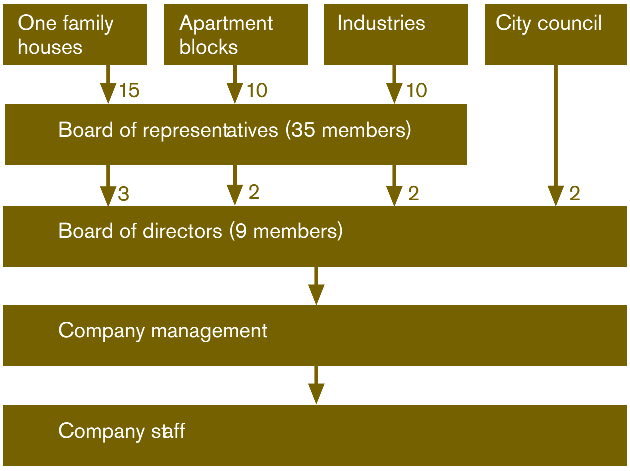
Employees: 14
Annual turnover: £13.7 million
Typical investment payback period: 20 years
Consumer members: 35 (elected board of representatives)
Consumer connections: 4,500
Heat supplied annually: 1,200 Tjoules
Peak load: 60 MWth
Heated floor area equivalent: 2.6 million m^2

Source: DTI Global Watch Mission.

Ford Plant in Dagenham.
Source: Ecotricity

Consumer-owned district heating in Denmark. *Source: Ecotricity*

District heating consumers:
Høje Taarstrup co-operative structure



Source: Urbed

how to implement sustainable energy through design and development

This section is structured around the design and development process, and shows how sustainable energy can be incorporated into new development.

4.1 reducing energy demand:
- at the neighbourhood/city scale
- at the street/block scale
- at the building scale.

4.2 efficient energy supply:
- at the neighbourhood/city and street/block scales
- at the building scale.

4.3 renewable energy generation:
- at the neighbourhood/city and street/block scales
- at the building scale.

4

design and development

This section considers the options for implementing sustainable energy strategies. Decisions will be influenced by the development's design strategy, location and scale.

Energy used in the built environment for thermal uses such as heating or cooling and electrical appliances or lighting, can be addressed in different ways. The guide deals generically with reducing demand across both, with particular approaches implied rather than specified in the different design and locational approaches.

Although the guide concentrates on technological, locational and design issues, rather than actual daily use and operation of buildings, such behavioural changes do have a significant impact on overall energy demand.

Design strategy

The design strategy will be influenced by the development scale and location. The objective should be to minimise a development's GHG emissions and therefore its contribution to climate change. However, in order to achieve value for money (for example, by minimising the cost per tonne of carbon saved) developments will often comprise a combination of demand reduction, efficient supply and renewable energy.

Reducing energy demand

Reducing the energy demand of a building or group of buildings through passive design techniques (such as massing, daylighting or form) will generally offer a sound basis for implementing low- and zero-carbon technologies cost effectively. In addition, choosing energy efficient heating systems can reduce carbon emissions.

Efficient energy supply

Greenhouse gas emissions can be significantly reduced by generating energy using conventional fossil fuels more efficiently, for example by using waste heat. Distributing this energy via heat, cooling or power networks improves the efficiency still further. Renewable energy technologies can also make use of the same infrastructure.

Renewable energy generation

Incorporating renewable energy technologies into buildings or as part of energy networks is increasingly being demanded by prescriptive planning policies. Technological innovation and rapid reductions in unit costs mean that even if renewable energy systems are not incorporated into a development or energy network, consideration should be given to their future role.

Location

Different approaches, technologies and combinations of technologies will be more or less suitable depending on the location. This should be considered as part of a masterplan or sustainable energy plan.

Urban locations

Higher densities create opportunities for reducing energy use from transport as well as from developments themselves. Higher densities are often ideal for developing community heat, cooling and power networks supplied by low- and zero-carbon technologies. Roof- or facade-mounted building-integrated technologies, such as solar and micro-wind, may be well suited to urban areas.

Suburban locations

These developments characteristically have lower densities which can, without careful planning, increase the energy used for transport and movement. Sustainable energy networks may still be viable and there is greater scope for more space-intensive technologies, such as biomass and medium to large wind turbines. Generally larger and more accessible roof space means that building-integrated technologies are easier to install.

Rural-urban fringe locations

Densities here are likely to be low. There will be great potential for building integrated renewables due to high solar and wind access. Availability of space and opportunities to provide biomass can generate income which may be an important factor in technology choice. Sustainable energy networks can supply groups of buildings or homes, although lower densities mean that the opportunities are likely to be less than in urban or suburban locations.

Development scale

How and what sustainable energy technologies are incorporated into a development will depend on the overall scale: from a few houses or buildings to a major development or regeneration project. Implementation that meets the seemingly competing aims of maximising value for money, while achieving environmental and social objectives, will require a diverse range of approaches and technologies. The remainder of this section is colour-coded to demonstrate what options are available at the three different scales which are set out below.

Neighbourhood/city scale

Sustainable energy incorporated at this scale will potentially serve the whole city or neighbourhood and is likely to include a full range of land uses. Opportunities for creating diverse and integrated networks cost effectively as part of an overarching masterplan or energy plan may be greatest at this scale.

Street/block scale

Developments of discreet groups of dwellings, including a mix of uses, offer similar opportunities as the city/neighbourhood scale for creating sustainable energy networks. Greater consideration will need to be given to site analysis and micro-climate. This scale can vary considerably in size from an individual block to a large estate.

Building scale

Smaller developments including individual dwellings, apartment blocks or commercial buildings provide opportunities for integrating sustainable energy into or around buildings. These can operate as stand-alone systems or feed into a national grid or local energy network. Small-scale sustainable energy networks can also work effectively at this scale. Detailed attention will need to be given to the design of buildings and their surrounds in order to maximise current and future sustainable energy potential.

4.1 reducing energy demand: neighbourhood/city scale

Reduce energy demand for large numbers of dwellings and other uses.

The current government target is to reduce CO_2 emissions by 60% by 2050. This should be the minimum that new development achieves, although it should ideally be capable of being carbon neutral. This requires a fundamental change in approach to masterplanning, especially at a neighbourhood or city scale – typically around 2,000 homes or 5,000 people and a full range of uses.

The new and growing focus on reducing GHG emissions in the built environment requires a rigorous holistic approach, from initial briefing and concept design, through to implementation and long-term management.

Larger-scale projects involving masterplanning are likely to be carried out by a number of development partners, from both private and public sectors. While the objectives of private housebuilders and registered social landlords (RSLs) may previously have been markedly different, the new sustainability agenda demands a shared vision, common goals and a commitment to long-term management of the public realm. It also demands a commitment to community consultation, integrated design, innovative funding and, above all, quality.

Large-scale development offers a unique opportunity to consider and plan for a robust infrastructure that will support the aspirations of a sustainable community in terms of energy supply, water and waste management, transport and biodiversity. All these issues need consideration from the earliest stage and will have a major influence on the masterplan concept. Performance targets need to be established and agreed as part of the masterplan, concept statement or development framework.

One example of this is the standards being proposed to guide sustainable development in Ashford, Kent[20] (see case study opposite). The approach by Ashford Borough Council has been to set four standards for energy, water, waste and materials, and to apply these to various types of development such as urban villages, regeneration and so on.

The project team should have sustainable development expertise in order to adopt a strategic and co-ordinated approach to engineering, architectural design and community development. The design approach requires a level of analysis not always carried out at such an early stage, including capacity studies, energy loads, CO_2 emissions, lifecycle costing and so on.

Integration of water, landscape and built form is essential in order to create a high quality environment and enhance local biodiversity. The masterplanning team should develop a clear green space strategy which makes a positive contribution to local biodiversity. It will also need to resolve a number of conflicting requirements, in particular the need for appropriate residential density[21], good practice in urban design (placemaking, connectivity and enclosure) and good access to daylight and sunlight. At densities over 100 dwellings per hectare the tensions between good urban design and solar access become more apparent. Built form will need to be manipulated and 'sculpted' to ensure adequate sunlight to amenity space.

Sophisticated design tools are now available and these need to be employed in a rigorous analysis of the microclimate[24].

A solar layout of 30 degrees either side of due south will enable 80% of dwellings to have access to unobstructed sunlight. This should not imply rigid layouts, but does present a challenge to designers.

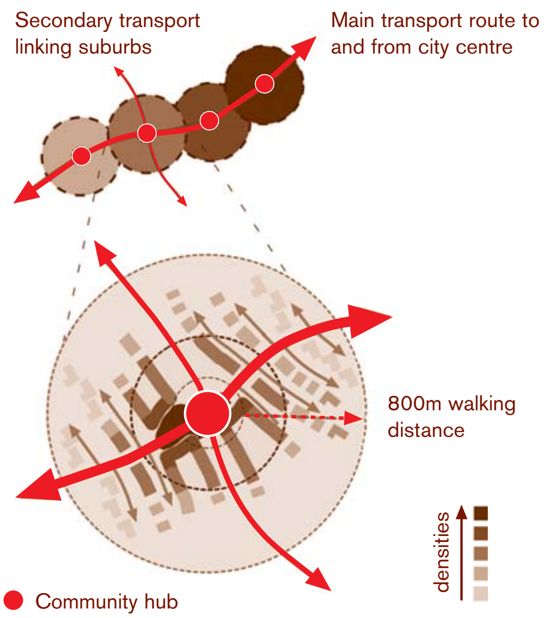
Design codes can be used to protect solar access. These have been used in American cities such as San Jose, California and Boulder, Colorado. A number of pilots are also being run in the UK[25]. Solar access can be defined as the unobstructed availability of direct sunlight for four hours at midday on 21 December – the winter solstice. Other definitions employ geometrical projections to describe a 'solar envelope'. However, future hotter summers may mean that overheating becomes an issue, and east-west orientations may be more appropriate for some sites. Use should also be made of deciduous trees to ensure adequate solar shading.

Concept statements[22]

A concept statement is a simple expression of the kind of place that new development should create. It is a positive document that sets out how the policies and objectives of the local plan, local development document or energy strategy should apply to a specific site in order to deliver the best possible economic, social and environmental benefits.

Concept statements are less detailed than development briefs but more informative for developers and the community than statutory plan policies. Most concept statements are no longer than two sides of A4 paper.

More information: www.countryside.gov.uk/LAR/Landscape/PP/planning/tools_technique.asp



Walkable communities: 'ped sheds'[19]
The planning of 'ped sheds' can reduce the energy consumed by the transport network. Main arterial public transport routes can be used to link together communities that are within easy walking distance of transport hubs.

Higher densities are used closer to the hub so as to reduce the average walking distance for members of the community.

Source: XCO_2

case studies

Green guide for sustainable development in Ashford

Between now and 2030 it is anticipated that 31,000 new homes will be built and 28,000 jobs created in the growth area of Ashford, Kent. The green guide will provide a set of standards for the energy and environmental performance of the new development.

The main objective is to combine a functional yet aspirational approach to sustainability with good urban design. Aimed principally at developers and design consultants, it is intended to be adopted as a supplementary planning document within the local development framework (LDF). The standards at present are restricted to residential development but will be extended to include non-residential buildings in due course.

All new development in the Greater Ashford area will be carried out in accordance with a masterplan and will have to comply with a set of design codes. The guide sets four standards covering four key topics: energy, water, waste and materials. In addition, it includes aspirational qualitative requirements for biodiversity and transport. The highest standard, which requires a carbon-neutral solution, is set for 2015.

More information: www.ashford.gov.uk, www.cabe.org.uk

Z-squared: Thames Gateway

An infrastructure-led concept design has been produced for a 2,000 home mixed-use, mixed-tenure development using proven technologies to achieve a zero-carbon, zero-waste masterplan.

The consultants developed a zero-carbon plan for the site and made estimates for a range of energy demand scenarios using benchmarks, assumptions and daily peak load profiles. They chose the following technologies:

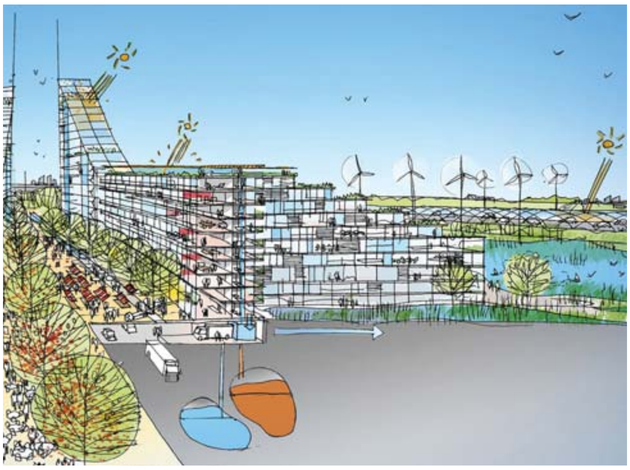
- space heating through inter-seasonal thermal storage (ITS), which is an effective way of providing heating and cooling in harmony with the seasons
- hot water from CHP fuelled by biomass, biogas and residual waste, with gas as a back-up
- electricity from CHP and larger wind turbines, which will also power the ITS system at times when electricity is not needed.

Preliminary cost calculations suggest that the net incremental cost of building to Z-squared standards is an 8% increase on a base case built to 2002 building regulations. This comprises a 6% increase for site-wide utilities infrastructure and 5% to meet EcoHomes 'excellent' standard, offset by a 3% saving in carparking and other support infrastructure. This cost differential will reduce to 3% compared to a base case with the new Part L building regulations.

The integrated nature of the Z-squared infrastructure suggests that a multi-utility waste water and ESCo will be required. Discussions with utility companies and ESCos indicate a willingness to provide this service for Z-squared. This will reduce the risk for the developer and enable it to focus on construction.

Sustainability Specialist: BioRegional Development Group
Infrastructure engineer: KBR
Architect: Foster and Partners
Cost consultant: Cyril Sweett
Engineer: Fulcrum Consulting

More information: www.bioregional.com



Concept design for a zero-carbon, zero-waste development.
Source: Foster and Partners

reducing energy demand:
street/block scale

Reduce energy demand for discreet groups of dwellings and other uses.

Sustainable design at street/block scale must be based on a more detailed analysis of the site and its microclimate. The starting point for this will be incorporating the daily and seasonal movement of the sun, as well as assessing local wind speed and direction.

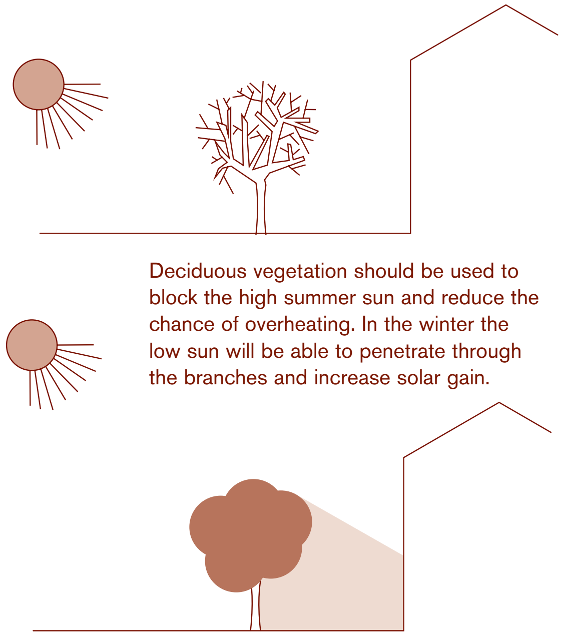
Daylighting and sunlighting criteria need to be established in order to inform the design process. Increasing density will limit the amount of natural light available. One useful benchmark is to calculate the annual solar radiation falling on the horizontal surface of the site and to compare this with the predicted annual energy demand of the development.

The guiding principles of 'bioclimatic' design – solar orientation, wind sheltering, compact built form – then need to be weighed up against the principles of good urban design including the need for placemaking, space and to create a sense of identity and character. Conventional urban design thinking, based on the notions of permeable street patterns and perimeter blocks, will not necessarily generate the most sustainable solutions.

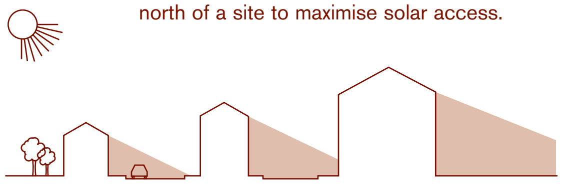
The objectives of sustainable urban design are to provide attractive sunlit amenity spaces at ground level (whether private or public), to ensure good levels of daylighting within dwellings at every floor level, to optimise passive solar gain while minimising risk of summer overheating, and to maximise the potential for collecting solar energy at roof level.

In contrast to the symmetrical street/block relationships illustrated in the Urban Design Compendium[26], solar-influenced design will tend to generate asymmetric relationships, with taller buildings positioned to the north to minimise overshadowing. Block proportions will tend towards rectangular shapes, for example 100 x 50m rather than 60 x 60m square; there will be an east-west emphasis.

From an architectural point of view the design of the roofscape will be critical so as to maximise the potential for south-facing solar panels. Flexibility is another key issue, with framed structures allowing more scope for change in the layout and size of dwellings to respond to changing needs in the future.



Deciduous vegetation should be used to block the high summer sun and reduce the chance of overheating. In the winter the low sun will be able to penetrate through the branches and increase solar gain.



Taller buildings should be located to the north of a site to maximise solar access.

Impact of height and aspect on solar gain

Source: XCO_2

case studies

Planning gain at BedZED: Sutton, London[27]

Completed in 2001, BedZed consists of 82 dwellings in a high density development. It was built as an example of low-carbon design and to promote a zero-carbon lifestyle.

Planning gain was used to boost densities without sacrificing design quality. The added revenue that this achieved (around £208,800 for each 6-plot development) helped fund the higher building specification. Some local authorities, such as the London Borough of Merton, allow the option of building at higher densities subject to a specified level of green credentials being met. This allows carbon-neutral proposals to compete for land without unduly burdening councils or the developer.

The site was originally put on the market with planning permission for 85 habitable rooms per acre and a limit of three storeys. The scheme has increased in value by achieving 271 habitable rooms, over 2,500m^2 of live/work units and space for offices, studios and community facilities.

This high occupation density is made attractive through the unique design where workspace roofs are used as gardens. In this way, most units get a private garden at densities that would normally allow only a balcony.

BedZED properties achieved premium values, some 17–20% above conventional new homes in the area, with buyers paying extra for the 'green' credentials.

More information: www.bedzed.org.uk, www.bioregional.com

Slateford Green: Edinburgh

Slateford Green is a mixed tenure development designed by Hackland & Dore Architects for Canmore Housing Association. It consists of 69 flats for social rent, 39 for shared ownership and 12 for outright sale through Malcolm Homes Ltd. The 'urban village' sits on 6ha of former railway goods yard in the suburb of Gorgie. The traditional Scottish enclosed tenement of 120 apartments is wrapped around a tear-shaped green space.

The project was completed in 2000 and showcases many of the key principles of sustainable living including a low $C0_2$ energy strategy. Using waste heat from the local distillery, the district heating system borders the site and each flat is connected using stairwell ducts. This is complemented by rainwater collection, reed beds, winter gardens and Passivent ventilation.

The project is significant because it also demonstrates the financial viability of housing for sale that is car-free and that incorporates sustainable construction methods.

Energy saving is achieved mainly by super-insulation. The structure is clad in a breathing wall with 175mm of Warmcel with panel-vent sheathing. Most flats have conservatories oriented into the south-facing courtyard, providing passive solar gain to living spaces. A district heating system had to be abandoned as a result of legal obstacles, and gas-fired boilers – previously planned as a back-up – were installed instead. Natural ventilation is encouraged by passive stack ventilation and there is provision for retrofitting of photovoltaic panels to power lighting if and when practical cost-effective products become available.

Key features:

- community heating
- close to transport nodes
- high levels of insulation
- solar buffer zone to each dwelling
- stack effect in communal stairwells
- materials low in embodied energy
- grey water recycling
- car club
- live/work units.

More information: www.canmore-housing.org.uk

Energy efficient layout at Coopers Road.
Source: ECD Architects

Coopers Road: Southwark, London

Coopers Road involves the regeneration of a 1960s council estate in Southwark. In 1999 the council made the decision to demolish the existing high rise buildings and appointed Peabody Trust as a development partner. ECD architects were appointed in 2000 and worked closely with existing residents to develop a concept for the new masterplan. This is based on four courtyards, each providing 35–40 homes with a mix of townhouses and flats. A total of 154 dwellings are planned for the 1.7ha site (90 dwellings per hectare). The layout creates a clear hierarchy of private, semi-private and public space. The houses have small private patio gardens which open onto an attractive landscaped courtyard measuring 21 x 35m.

From the outset the project team was keen to establish a clear set of sustainability targets which could be delivered within the project budget, including enhanced standards of thermal insulation, high performance timber windows, accessible riser ducts, community heating and CHP, low-flush WCs, recycling facilities and bicycle storage. In addition, the design offers the opportunity of retrofitting roof-mounted solar thermal collectors or photovoltaics in the future. The scheme achieved an EcoHomes 'very good' rating.

Orientation and solar access were primary considerations in the planning of the courtyards. Heliodon studies, which simulate the path of the sun, were carried out using physical models to optimise the design. The lower three storey houses are to the south of the four storey flats to ensure good sunlight within the courtyards. Daylight within the dwellings is maximised to reduce the need for artificial lighting.

A gas-fired CHP plant has been installed providing approximately 11% of the heat demand and 12% of the electricity demand; there is a 10 year payback period. Average CO_2 emissions for each dwelling are estimated to be less than $25kg/m^2$ per year.

All flats above ground level have balconies and all flats and houses have access to the gated landscaped courtyards. Access roads are designed as Homezones with 50% on-street parking. Phase 1 was completed in December 2004. The second and last phase commences in early 2006.

More information: www.ecda.co.uk

reducing energy demand:
building scale

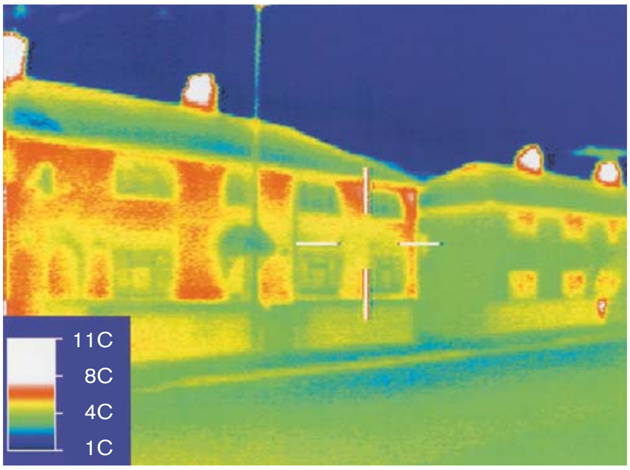
Reduce energy demand for individual buildings.

Numerous energy and sustainability standards have been published which set out how buildings can be designed to be more energy efficient, and how they can make greater use of low- and zero-carbon energy technologies.

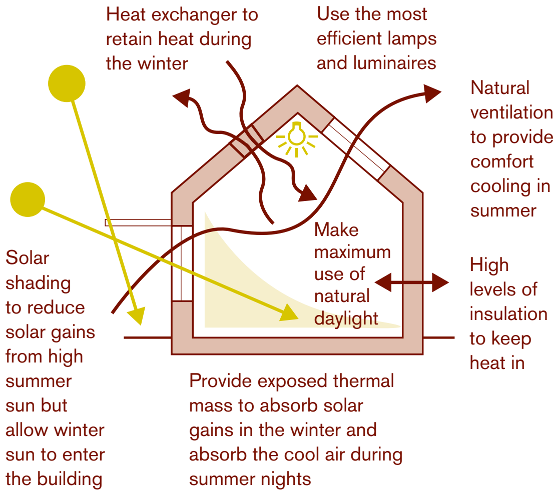
There are currently a large number of benchmarks and checklists that can help ensure buildings are energy efficient and contribute towards all aspects of sustainable development (see box below). These include the Millennium Communities Standard, Building for Life, SPeAR, AECB standards, EST Energy Efficiency Best Practice in Housing, BREEAM/EcoHomes and the Government's forthcoming Code for Sustainable Homes.

High levels of insulation in the walls, roofs, floors, doors and windows are paramount in reducing winter heat loss and therefore energy demand. It also helps keep buildings cool during summer, an increasingly important issue as the climate changes. In addition to energy saving, consideration should be given to the materials used. For example, while windows should be at least double-glazed with low emissivity coatings, PVC frames use harmful chemicals in their manufacture and are unlikely to be suited to national parks or conservation areas.

Airtight construction and ventilation are important. Care must be taken in the construction detailing to avoid thermal bridges where heat can find an easy route through the fabric. The 2006 revision to Part L of the building regulations will require airtightness and pressure tests. Wherever possible natural ventilation[28], such as passive stack ventilation allowing natural movement of air in the building, should be preferred over energy intensive mechanical means. Where this is not possible, mechanical ventilation should include heat recovery to reduce heat loss.



Thermographic image showing the heat loss through a typical building fabric. *Source: XCO2*



How passive measures can reduce the energy consumption of buildings

Source: XCO2

Energy standards

A variety of standards exist that can be used to raise the environmental, and sometimes social, performance of buildings.

The Association for Environment Concious Building (AECB) energy standards set best practice levels of energy efficiency performance (www.aecb.net). The two standards ('silver' and 'gold') both represent a considerable improvement on today's practice. The 'gold' standard is based on the German 'passive house' (www.passive.de) and the silver is based on several other international standards such as the Swiss MINERGIE.

Others include:

English Partnerships Millennium Communities Standard (www.englishpartnerships.co.uk).

CABE Building for Life (www.buildingforlife.org).

Arup SPeAR (www.arup.com/environment/home.cfm).

EST Energy Efficiency Best Practice in Housing (www.est.org.uk/housingbuildings).

BRE BREEAM/EcoHomes (www.breeam.org).

Code for Sustainable Homes (www.odpm.gov.uk).

Thermal mass should be exposed internally to absorb solar radiation received during the winter months. During the summer it helps to store cool air absorbed during the night. Summer temperatures are predicted to increase significantly over the next few decades and so thermal mass, cooling and ventilation should be increasingly important considerations.

Glazing is important for solar gain and for allowing light into a building. The greatest heat loss is through windows and so larger areas of glazing should be on the south-facing side of the building. Again, consideration should be given to the potential for overheating now and in the future, and to the suitability of large areas of glazing in design and locational terms. In some cases sun/light pipes may be useful, particularly since a growing number of flats now have no windows in kitchens and bathrooms.

Increasing use of higher efficiency appliances and lighting is reducing energy consumption in buildings. However, it is happening at a slower rate than for space heating and hot water. This is mainly due to the higher insulation levels demanded by the building regulations.

A control system should be used to prevent excessive use of artificial lighting when natural light is available. All artificial lighting should use the most efficient globes. Appliances installed in new buildings should be of the highest energy efficiency rating, currently the EU 'A' rating.

case studies

The Wintles: Living Villages, Bishops Castle

The Wintles is a development by Living Villages, a company set up to create sustainable eco-friendly communities. Located in rural Bishops Castle, each house is individual and positioned for maximum solar gain. Consideration of the effects of light and shade and the climatic conditions have also been taken into account.

The walls, floors and roofs have thick insulation (some 400% over present UK standards) and high specification construction standards ensure that buildings are airtight. As well as gas condensing boilers for central heating, heat recovery systems have been installed. Solar water heaters have been installed on south-facing roofs and solar PV panels and water recycling systems are available as optional extras.

The use of toxic materials has been avoided wherever possible and local and recycled building materials are used where feasible to reduce environmental damage.

More information: www.livingvillage.com

Hockerton Housing Project: Nottinghamshire

The Hockerton Housing Project was the UK's first self-sufficient housing development. Completed in 1998 it consists of five terraced units with glazed conservatories to the south side and high levels of insulation and thermal mass on the northern side. The project, which represents an aspiration more than an easily replicable model, promotes low energy building design as well as a low-energy lifestyle.

While success depends largely on the commitment of residents, it does demonstrate what can be achieved when environmental goals are prioritised. It also shows how individual buildings can operate within a multi-functional environment which utilises biomass, grey water treatment and reuse.

Key features:

- zero carbon emissions
- passive solar heating through solar orientation and earth shelter, and 70% heat recovery from extracted air
- wind turbines and photovoltaics
- black water recycling using reed beds
- high levels of insulation to reduce heat loss
- £90,000 build cost per home.

More information: www.hockerton.demon.co.uk

Homes in Shropshire built to high environmental standards.
Source: Living Villages

Self-sufficient community in Nottinghamshire.
Source: Hockerton Housing Project

4.2 efficient energy supply: neighbourhood/city and street/block scale

Supply energy efficiently to large developments or discreet groups of buildings.

Developing sustainable energy infrastructure can often be easiest, most flexible and cost-effective in larger developments or in discreet groups of buildings. The aim should be to create a robust network for heating, cooling, and/or powering local homes and buildings which can respond to future changes.

In a community energy system heat, refrigeration or electricity is generated from a central source or sources and distributed via a network (of pipes or private wires for example) to buildings.

Community heating and cooling enables more efficient creation of heat and power from primary energy sources. Heat, usually in the form of hot water produced by a centralised boiler or more commonly combined heat and power (CHP), is distributed to customers via super-insulated underground pipes.

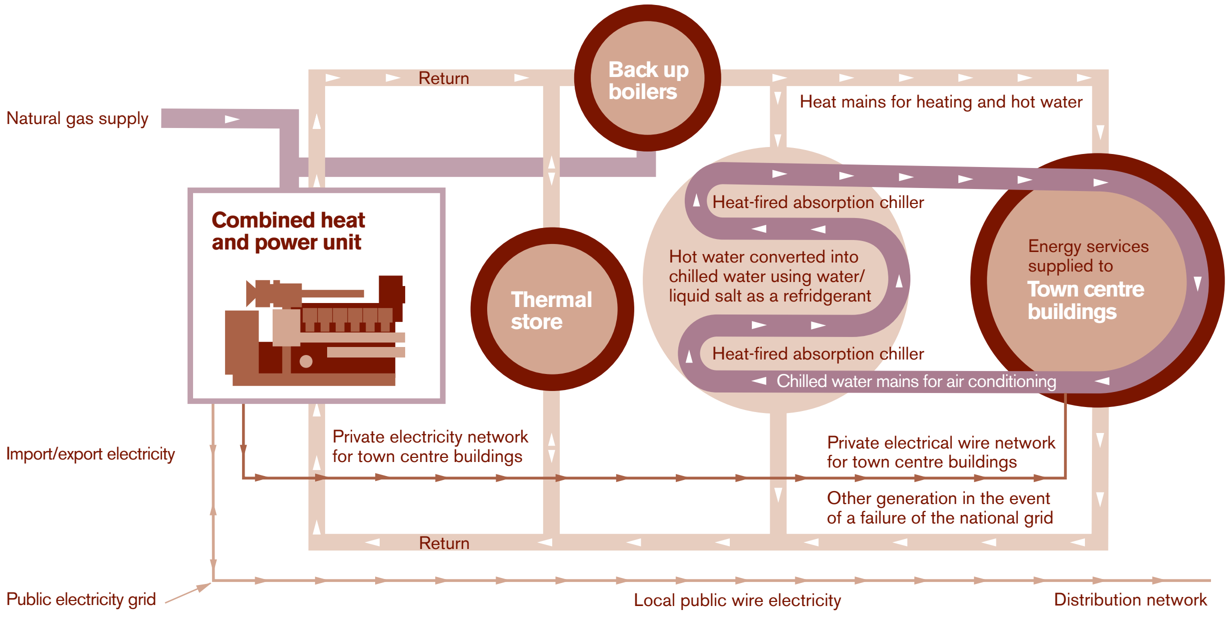
Private wire networks (PWNs) distribute electricity and can utilise the same generating plant and infrastructure as community heating or cooling. Local supply of power, delivered independently from the national grid, minimises the energy that is lost via distribution, leading to greater energy efficiency and lower CO_2 emissions.

The potential for utilising power and heating networks in new and existing developments is significant; schemes range in size from one building to city-wide links connecting residential, public and commercial buildings. They can be developed relatively swiftly using technologies currently available. Well-configured modern systems can significantly reduce a development's carbon emissions in cost-effective ways. They should therefore be considered as part of a local authority's energy plan as well as being utilised as part of any masterplanning process.

Community energy and PWNs can make use of a wide range of energy sources, including conventional boilers using traditional fossil fuels, CHP, energy from waste, geothermal, fuel cells and renewable energy (see Section 5 for a description of these technologies). The most efficient and lowest carbon technologies should be prioritised to maximise CO_2 reduction. However, networks are flexible and allow conventional energy technologies to be replaced by renewable sources as fossil fuels become less viable. Community energy and PWNs can also be linked together to provide a greater security of supply. PWNs also allow for export and import of electricity.

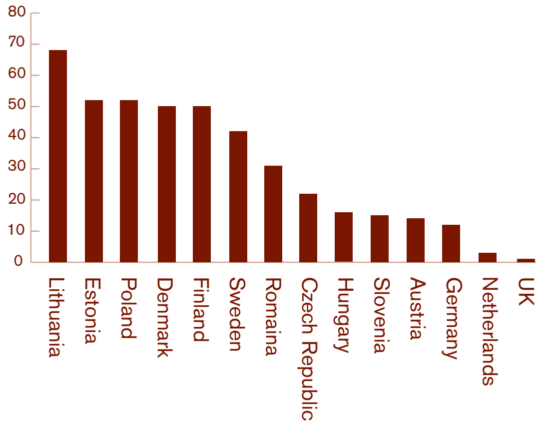
For communal heating and cooling networks to be viable in cost and efficiency terms, they need to supply dwellings which have been built to a minimum density of at least 30 dwellings or 100 people per hectare. A quarter of the UK population lives in such densities, while current government planning policy stipulates densities of between 30 and 50 dwellings per hectare for new housing.

At the early stages of a development the fluctuations in demand for energy (that is, the 'demand profile') for heat, cooling and power is unlikely to match supply capacity. This will mean significant initial capital costs with little return. Options include obtaining bridging finance or securing a grant



Private wire and community heating system, Woking.

Source: Woking Borough Council



Community heating as a proportion of the domestic heating market (%)

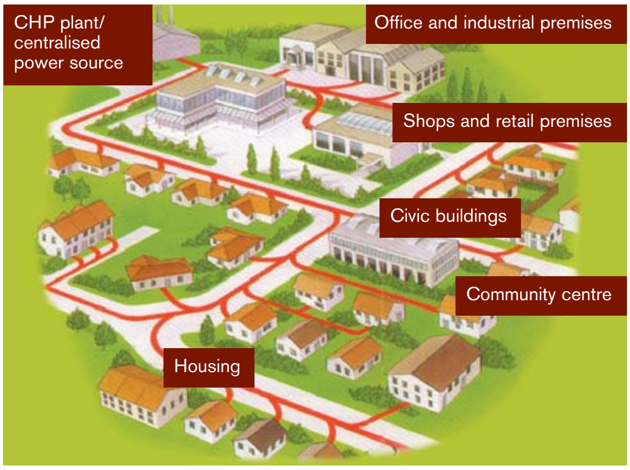
Source: XCO$_2$

(see funding under Section 3.2), or setting up a dedicated ESCo to develop and manage the system (see Section 3.3).

To assess whether a community heating network is financially and technically viable for a particular development, the relevant parties should carry out an appraisal through the masterplanning process.

Although CHP systems cost more up-front than conventional energy systems they will generate ongoing revenue. If CHP systems are implemented using an ESCo, they can also maximise the financial return on generating plants by guaranteeing consumer sales at a higher rate than they would by selling electricity to the grid.

Developments that include higher base heat loads (or basic heating demand), such as hospitals, swimming pools, or those including a diversity of users, enable a greater economic return for energy technologies. However, CHP can still be economic over its lifetime without these heat demands. This makes it one of the most cost-effective ways of reducing CO$_2$ emissions.



Community heating network.
Source: CHPA

case studies

Geothermal and CHP district heating and chilling scheme: Southampton City Council

In response to dramatic rises in oil prices in the 1970s Southampton embarked on one of the UK's first district heating and cooling schemes. Elements of the scheme include:

- a geothermal aquifer providing 15–20% of the system's heat and a CHP engine supplying the remainder
- 30,000MWh of heating and 1,200MWh of cooling each year
- 4,000MWh of electricity that is generated from CHP and sold to the national grid each year
- a saving of 11,000 tonnes of CO$_2$ per annum
- an initial cost of £6 million.

The council's private sector partner is Utilicom which financed and developed the scheme. It also owns and operates the scheme under a subsidiary ESCo called Southampton Geothermal Heating Company (SGHC). The cornerstone of this partnership is the joint co-operation agreement between Southampton City Council and Utilicom.

Competitively priced heat supply is guaranteed because costs are linked to national fuel prices. Customers can also choose to have air conditioning provided by chilled water circulated via a separate chilling mains. Since 1987 the network has expanded and now has over 40 commercial and public sector customers including a hospital, academic and civic buildings, offices, a leisure complex, hotels and a shopping centre, as well as housing.

Electricity from the scheme is sold to the energy supplier Scottish and Southern Energy on a long-term contract. Ideally, SGHC would sell directly to those on the CHP grid but to do this it would need to install a PWN.

The profit-share from the scheme generates £10,000–15,000 of income for the council each year.

CHP plant serving Southampton's community heating network.
Source: Southampton City Council

Key lessons:

- ensure agreements with companies and developers are binding so they cannot avoid their obligations
- watch out for consultants who know nothing about, and may therefore advise against, community heating
- emphasise the triple bottom line (reduced costs, reduced emissions and improved relations with the community)
- use planning powers to put pressure on those submitting planning applications to consider linking up to the district heating system (this may need to be through a Section 106 agreement)
- get political support.

More information: www.southampton.gov.uk/environment/energy

Energy effective estates: Strathclyde University

This project aimed to identify the key factors required for making a large estate more 'energy effective'. Based on an analysis of several case studies, researchers determined some key factors that are responsible for success: the effectiveness of energy management, the selected financial structure to support investments, the availability of trustworthy data, energy efficiency measures and effective supply technologies, availability of funds and grants, and a strong evaluation method across all factors.

Based on those key factors, researchers created a framework of considerations about energy management, creating a financial structure and seeking funding. This framework also included tools/methods to evaluate several selected measures (based on energy efficiency and energy supply technologies) under different criteria (best payback, best CO_2 savings and so on).

More information: www.esru.strath.ac.uk

Greenwich Millenium Village: London

Development of the 1,400 home masterplan on the Greenwich peninsula is still in progress, although the main infrastructure and most residential units are now completed. The landowner (English Partnerships) stipulated an 80% reduction in primary energy use compared to new-build developments benchmarked in 1998. This is likely to be achieved through a combination of community heating (CHP), solar PV, highly energy efficient buildings and resident education about using energy efficiently.

CHP provides space heating and instantaneous unlimited hot water to each dwelling.

The scheme is managed on behalf of the developer and the residents by an ESCo, Utilicom Ltd. The electricity generated is at present sold for use off-site but the potential to utilise it in the common parts of the development is being explored. In due course electricity may be sold directly to tenants.

Key features:

- community energy (CHP)
- brownfield redevelopment
- high densities
- green 'corridors'
- increase in biodiversity
- use of sustainable materials (low embodied energy)
- grey water recycling
- ecohomes 'excellent' rating
- passive solar design
- high levels of insulation.

More information: www.greenwich-village.co.uk

Private wire and community heating network: Woking Borough Council

The Woking town centre CHP station is the first commercially operated energy station of its kind in the UK. It is the first project of Thameswey Energy Limited (see Section 3.3).

80% reduction in energy use at Greenwich Millenium Village.
Source: Chris Henderson, English Partnerships

CHP plant, Woking.
Source: Woking Borough Council

Thameswey also aims to finance, build and operate small scale CHP stations (up to 5MW) to provide energy services by private wire and distributed heating and cooling networks to institutional, commercial and residential customers.

Woking has the largest proportion of solar PV in the country. The PV roof on the Brockhill sheltered housing development, installed by BP Solaris, is one of the UK's largest domestic installations and the first to combine solar and CHP energy. Both technologies feed into the borough's private wire and district heating networks. Using the combined technologies enables the housing scheme to receive energy from the CHP plant in the winter and from the PV roof in the summer, with the potential of achieving 100% sustainability in electricity supply.

The Woking Park Fuel Cell was opened in June 2003 as part of the Woking Park CHP system that supplies energy to Woking Park and the nearby pool complex. Hydrogen gas is chemically re-formed from natural gas, and oxygen is extracted from outside air to fuel the 200kWe fuel cell.

Key features:

- district energy network powered by CHP
- private wire network
- first commercial fuel cell CHP in the UK
- an 'energy efficiency recycling fund' which has enabled annual investment of nearly £1 million
- photovoltaics installed throughout Woking, especially in highly visible locations
- reduced energy consumption in local authority corporate and housing stock of 48.6%, and reduction in CO_2 emissions of 77.4% on 1990 levels (by 2004)
- reduced CO_2 emissions for whole borough of 17% on 1990 levels (by 2004)
- proposed use of domestic waste-to-energy to power CHP incorporating technologies of in-vessel composting, anaerobic digestion and pyrolysis.

More information: www.woking.gov.uk

CHP: Aberdeen City Council

Aberdeen City Council's primary objectives were to achieve affordable warmth for tenants and reduce CO_2 emissions in cost-effective ways. A report was prepared examining the main issues, feasibility and available funding for a group of properties in the Seaton area of the city.

The most attractive option was CHP with overcladding of the buildings. However, due to the prohibitive capital costs of the overcladding the council chose to only implement the CHP scheme. This reduced CO_2 emissions and tenant's heating bills by about 40%.

A not-for-profit company was set up to develop and manage CHP schemes across Aberdeen. The council successfully applied to the Community Energy programme for grant funding and also secured a favourable rate of interest on a bank loan to cover the remaining capital. The council is also accessing Energy Efficiency Commitment funding.

An energy centre was built close to one of the multi-storey blocks, housing a 210kWe gas-fired reciprocating engine CHP unit and 2 x 700kW gas-fired boilers for peak load and back-up. The heat is distributed via pre-insulated underground pipes which comprise the heat network, with each unit having a new internal distribution system. It is anticipated that 47% of the electricity produced by the CHP unit will be sold to dwellings served by the heat network, with the remainder being sold to other customers.

Key lessons:

- need to approach a process like this strategically
- whole-life costing is the best way to establish the real cost and overall contribution to 'best value'
- external specialist assistance is essential
- an individual needs to champion the project
- an arm's-length company arrangement enables acceleration of refurbishment plans.

More information: www.aberdeen.gov.uk

CHP, Woking.
Source: Woking Borough Council

CHP installed as part of an affordable warmth programme, Aberdeen.
Source: EST

efficient energy supply:
building scale

Supply energy efficiently to individual buildings.

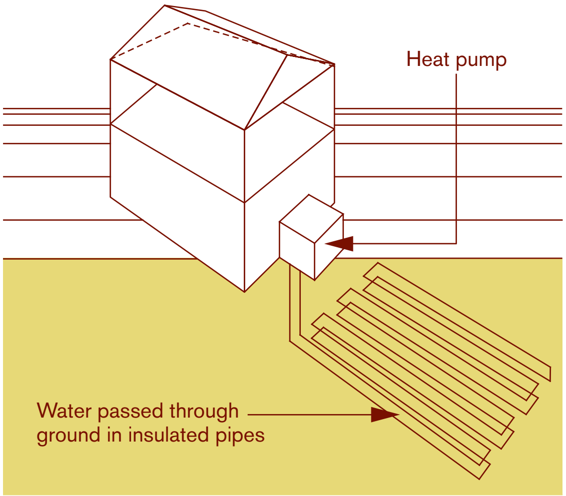
Micro-scale stand-alone systems of energy supply and heat recovery often offer the most effective way to supply energy efficiently. Consideration will need to be given to issues such as the demand for heat and power, the availability of space within the development and alternative fuel sources.

Micro-generation is the generation of heat and power using low- or zero-carbon technologies at the smallest of scales. Many of the technologies for doing this are renewable (see Section 5 for more explanation).

Ground source heat pumps (GSHP) can be used to replace conventional boilers in domestic buildings or blocks of flats, but multiple systems will be needed for larger non-domestic developments.

The two forms of GSHP – horizontal or vertical – have different design implications. For example, a horizontal system for a large individual house will require an area of up to 100m^2 to accommodate the pipes. More area will be required for larger buildings, however the pipes can be located under carparks, open spaces, or even access roads.

Vertical systems require pipes placed in boreholes that extend to depths of 15 to 150 metres. This makes them ideal for developments where space is at a premium. Consideration will need to be given to access for drilling rigs and to whether or not drilling permits are required from the Environment Agency.



Ground source heat pump

Source: XCO$_2$

Heat recovery ventilation involves the exchanging of heat from warm extracted air into fresh incoming air using a heat exchanger. In domestic situations this commonly takes the form of a plate heat exchanger. These can recover up to 70% of the extracted heat and therefore significantly reduce heating bills and CO$_2$ emissions.

A number of micro-CHP products are now on the market. These are around the same size as a large domestic boiler and don't make any more noise.

In summary, GSHP and heat recovery ventilation operate better as stand-alone systems rather than as part of heat or power networks. Micro-CHP installations, however, may be able to sell surplus power back to a local or national grid.

Ground source heat pump at IKEA's distribution centre, Peterborough.
Source: EarthEnergy Ltd

Gamblesby village hall.
Source: CLAREN

case studies

IKEA distribution centre: Peterborough

Inclusion of a ground source heat pump (GSHP) system in Ikea's 130,000m^2 distribution centre and office accommodation was part of a strategy to reduce running costs and CO_2 emissions.

Heat pumps (ETT Catt 385D) were connected to an EarthEnergy borehole system providing 250kW of heating and cooling from over 8km of underground pipework installed in 45 vertical boreholes drilled to 70 metres each. The maintenance-free pipework has been laid underneath the car park.

The developer faced no planning obstacles in proposing this system; a biomass boiler is also due to be installed.

More information: www.earthenergy.co.uk

Case study credit: London Renewables, now part of the London Energy Partnership

Gamblesby Ground Source Heat Pump: Cumbria

In order to attract funding for the renovation of the hall in a remote village in the North Pennines, the project needed to be innovative. Since the hall was off the gas mains a ground source heating system was selected. The project, including renovation of the hall, cost £42,000 with grants from North Pennines Leader+ Programme, Northern Rock Foundation, Eden District Council, Shell Better Britain Campaign and CLAREN.

Electrical heating demand has been reduced from 12kW to 3kW, cutting CO_2 emissions by 75%. This made the village hall accessible throughout the year and increased the environmental awareness of the villagers to a point where many are considering installing their own renewable technologies.

The system is cheap to run, reliable and low maintenance. Planning permission and most of the funding is now in place for phase two, which includes a wind turbine and PV.

More information: www.feta.co.uk/hpa, www.ukleader.org.uk, www.claren.org.uk

The Way: Beswick, East Manchester

Beswick is being developed jointly by Lovell and urban regeneration company New East Manchester. The 550 home mixed-tenure scheme will create 447 homes for open market sale, 76 homes for Northern Counties Housing Association and 27 homes for shared ownership. The scheme forms part of the first phase of a major regeneration plan including new community facilities and green space.

The Kingspan Tek off-site manufacture system achieves a U-value of 0.2 W/m^2.K for walls, 0.2 W/m^2.K for roofs and an air leakage rate of approximately 1m^3./hr/m. Powergen's WhisperGen micro-CHP systems are being installed in each home. They are capable of cutting energy bills by around £150 and CO_2 emissions by 20% annually per home. The CHP units convert the excess heat that normally escapes through the exhaust flue of a conventional boiler into electricity. Any electricity generated by the system and not used by the householder can also be sold back to Powergen.

Mechanical ventilation with heat recovery (MVHR) systems are also being installed which can halve heating energy demand compared to a 2002 standard building.

More information: www.lovell.co.uk, www.powergen.co.uk

GSHP has reduced CO_2 emissions from Gamblesby village hall by 75%. *Source: CLAREN*

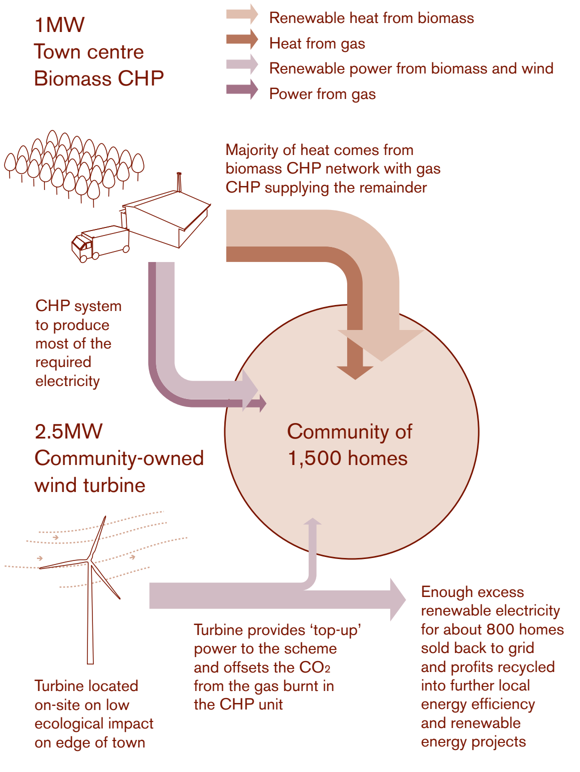
Energy efficiency and micro-CHP in new housing in East Manchester. *Source: Lovell*

4.3 renewable energy generation: neighbourhood/city and street/block scale

Supply renewable energy to large developments or discreet groups of buildings.

Large-scale renewable energy technologies can be cost effective and contribute significantly to the energy needs of new and existing communities. When choosing a technology (or combination of technologies) consideration will need to be given to the location and scale of the development.

Renewable energy technologies, located either on-site or close by, are sufficiently developed to make a significant contribution to the energy needs of existing and new communities. The cost of technologies is reducing rapidly (see Section 3.2 and 3.3 for innovative models for cost-effective delivery). Commercial viability can be increased still further by integrating renewables with low-carbon technologies as part of networks of heat and power (see page 26).



A decentralised hybrid energy system supplying energy to a 1,500 home community and selling the excess electricity to the national grid

Source: XCO$_2$

Technologies suited to integration into the planning of new communities include biomass, wind, hydroelectric and solar. Each will have particular attributes that make them more or less suited to different situations; their application, and combination of applications, should be considered accordingly.

Biomass heating is a simple and proven technology, widely used across Europe. It can be easily implemented at the larger scale, through community energy systems, where the economies of scale are likely to be greater. The technology to make biomass CHP available at scales smaller than a power station is developing fast.

Delivery and storage of biomass may be more manageable at this scale rather than at the level of individual buildings. The capital costs will also be lower.

Green spaces on and around a site should be considered to be multi-functional: they can operate as potential fuel sources, sustainable drainage systems, habitat areas and as places for leisure. This will be particularly important around the urban fringe. The planning and masterplanning processes should be used to identify such uses. Management and use of resources could be undertaken as part of the operation of an ESCo.

Wind turbines on or close to buildings, or along landscape corridors, could provide cost-effective and efficient energy. Different sizes of turbine will be suited to different developments. However, they should be sited carefully given the sensitivities around their appearance. Adhering to principles of good design and community involvement in planning and operation of turbines may help to overcome opposition and foster support (see Section 3.4).

PV and solar thermal arrays are playing an increasingly important role in delivering renewable energy targets and should be seen as a key part of a neighbourhood- or city-wide energy network. This helps to overcome problems of insufficient roof space on individual buildings and offers the opportunity for high impact schemes with a large solar canopy in visible locations.

This scale of development can also benefit from inter-seasonal storage: summer heat can be stored in underground aquifers for use in winter for space heating and domestic hot water. However, this depends on the availability of such underground reserves. A site geology survey can reveal the potential.

Vertical axis wind turbine, Bristol.
Source: XCO$_2$.

Although not strictly zero-carbon, producing energy from waste using either direct combustion or anaerobic digestion has great potential. Tapping into an abundant resource flow reduces use of fossil fuels, demand for space and methane emissions from landfill. Old-style incineration has been controversial but, in combination with CHP, new energy from waste technologies, such as pyrolysis, is clean and can make a valuable contribution to meeting energy needs.

Consideration will need to be given to how energy from waste fits in with a local authority's overall waste and recycling strategy since important resources may be redirected. As with biomass, transport of fuel from transfer stations to the power plant will need to be fully considered. Community involvement in the decision-making and management processes will be crucial to success.

case studies

Swaffham wind turbines: Norfolk

Swaffham I was the UK's first multi-megawatt wind turbine and one of a new generation of direct drive, variable speed wind turbines. It was installed at the Ecotech Centre in Swaffham, Norfolk, in October 1999 and produces enough electricity for around 3,000 people – over a third of the population of Swaffham.

In 2003 Ecotricity sent over 100,000 leaflets to households in Breckland and surrounding districts asking residents to vote 'yes' or 'no' to a second turbine. Around 89% of the almost 9,000 respondents voted in favour.

A second, larger turbine turbine was installed in 2005. With a capacity of 1.8MW it saves around 3,500 tonnes of CO_2. Swaffam I incorporates a viewing platform at the hub of the turbine (65m high) which offers unprecendented views of the Norfolk countryside and has made the turbine a tourist attraction as well as the main source of the town's electricity.

More information: www.ecotricity.co.uk

Quiet Revolution wind turbine: Temple Meads Circus, Bristol

Temple Meads Circus is the proposed site for a novel small-scale vertical-axis wind turbine, called Quiet Revolution, bringing together renewable energy, public art, and public information.

The turbine will be located at a key focal point in the city to increase awareness of renewable technologies. It will generate 10,000kWh annually, enough to power three typical homes, while also displaying full-colour video and still images on the swept surface of the turbine.

More information: www.quietrevolution.co.uk

Bo01 sustainable district: Malmö, Sweden

A derelict industrial zone in the western harbour is being redeveloped into a new urban quarter with a range of employment and a college. Once completed, up to 10,000 people will live and work in the area supplied entirely by locally generated renewable energy. Planning for this demonstration development began in 1997 with the energy system and 50,000m^2 of residential development in place by 2001.

Energy is generated by 120m^2 PVs, 1400m^2 solar collectors, a 2MW wind turbine, aquifers and a heat pump, and biogas produced from 1000 households. The biogas will be produced in a plant just outside Malmö and used in the existing natural gas network or for car fuel.

The vision behind the project was to build a city according to ecological principles. The project is based on the 'Kvalitetsprogrammet', a comprehensive document communicating visions, goals, targets and management tools.

During the project much has been learned about how to combine technologies in an integrated system.

More information: www.ekostaden.com, www.sydkraft.se, www.malmo.se

Large wind turbine, Swaffham.
Source: Ecotricity

Wind farm.
Source: npower renewables

Malmö, Sweden.
Source: Nicole Collomb, CABE

renewable energy generation: building scale

Supply renewable energy to individual buildings.

Roofs, facades, gardens and open space in urban and suburban locations offer opportunities for renewable technologies. Rural areas, where densities are lower and the possibility of connecting to energy networks is limited, provide different opportunities.

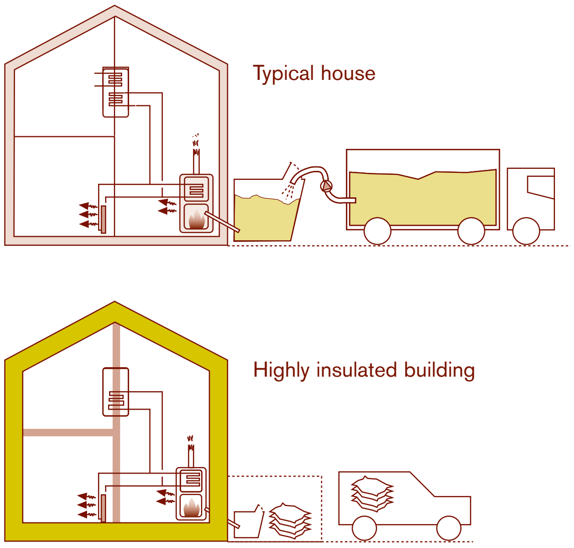
Most micro-generation technologies can either operate connected to a national or local grid or as stand-alone systems that power buildings directly or feed into an energy store, such as a battery. Micro-generation is suited to rural locations where mains connectivity may not be available, as well as urban and suburban areas.

There are concerns about the intermittency of renewable systems and the need for backup. However all systems, renewable or otherwise, are to some extent intermittent. It is therefore important to have a diverse energy supply, irrespective of source.

Large wind turbines are now commercially viable in many locations, while small scale (500W to 25kW) turbines are also becoming increasingly cost-effective. As a result the market for urban wind turbines is now growing. As with all visible technologies, turbines should be sensitively sited and the local community should be involved in these decisions.

Photovoltaic (PV) panels are ideally suited to the urban environment since they utilise roof space and have little or no visual impact. They can be easily integrated into buildings at different urban scales as outlined in Section 5.

Solar thermal hot water systems can be retrofitted into existing houses or integrated into the design of a new building. They require direct access to sunlight. They are suited to flat or pitched roofs on individual buildings or groups of houses.



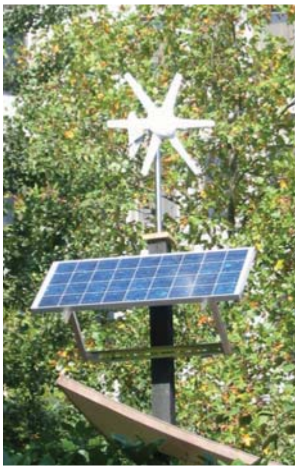
Biomas heating system in insulated and uninsulated buildings
The illustration above shows that a typical house requires significant storage (a hopper) and frequent deliveries during the heating season, whereas a low-heat building needs little storage for biomass fuels.

Source: XCO$_2$

For individual buildings, a biomass heating system can consist either of a room-heating stove or a boiler system supplying space heating and hot water. Consideration should be given to availability of fuels, space required for storage and access for deliveries.

Where opportunities exist, gravity flow of rivers can be harvested using small or micro-hydro schemes. This is a robust technology, especially in remote areas.

Hydrogen fuel cells store and transport energy. This emerging technology will play an increasingly important role in the design of sustainable energy systems.



Small-scale 500W wind turbine with a PV array. *Source: XCO$_2$*

Biomas boiler, Kingsmead School. *Source: Cheshire CC*

Kingsmead Primary School, Cheshire. *Source: Cheshire County Council*

case studies

Kingsmead Primary School: Northwich, Cheshire

Completed in July 2004, Kingsmead Primary School has been built as part of a new housing development. Core costs were met by Cheshire County Council and the land was provided through a Section 106 agreement with housing developers. The project has attracted several grants including £200,000 from DfES, £100,000 from North West Development Agency and £15,000 PV demonstration programme grant.

The 50kW Talbott C1 Biomass Boiler cost approximately £30,000 and is expected to provide around 60% of the school's heat demand. The building management system co-ordinates the energy from the boiler and solar PV. The boiler uses woodchip supplied from a local joint venture of two private companies. This is expected to require around 35 tonnes per year of woodchip, and the school contains a 10m^3 storage bunker for monthly deliveries.

More information: www.kingsmead-school.co.uk, www.talbotts.co.uk

The Core, Eden Project: Cornwall

The Core is the education centre at The Eden Project in Cornwall. It incorporates extensive use of PV modules on the roof, which also provides a cover for the centre's 'solar terrace', offsetting building material costs.

The roof generates enough electricity annually for seven average three-bed houses, saving over nine tonnes of CO_2 emissions.

Major sponsors included the Millennium Commission Lottery, South West Regional Development Agency and the European Regional Development Fund (Objective One).

More information: www.solarcentury.co.uk, www.edenproject.com

Beaufort Court: Kings Langley

Beaufort Court is a 2,500m conversion of an old egg farm into an office headquarters for Renewable Energy Systems (RES). It contains a mix of renewable energy strategies that provide the building with all of its power and heating requirements.

The triangular site comprises 7ha of farmland located in a metropolitan green belt. In order to provide for the new uses the existing buildings had to be radically altered and extended. However, the local planning authority required that the views of the outside of the building must remain largely unchanged. Both the coach house and 'horseshoe' buildings had to be converted for modern office use with additional exhibition, catering, conference, meeting and main plant spaces.

The site is self-sufficient in energy and uses:

- a 225kW wind turbine
- a 170m^2 solar array (54m^2 PV, 116m^2 solar thermal)
- ground water cooling
- a 100kW biomass boiler
- inter-seasonal heat storage.

There are zero CO_2 emissions.

In order to minimise the need for energy the development uses a combination of active systems (mechanical ventilation, artificial cooling, heating and lighting, building management systems) and passive systems (solar heating, natural ventilation and lighting, solar shading and a well-insulated building envelope incorporating thermal mass). A monitoring programme will show whether energy predictions prove to be correct.

RES actively encourages staff to use public transport, bicycles and car sharing for travel between home and office. A green travel plan includes subsidised season ticket loans for rail travel, a hybrid fuel pool car, pool bikes, interest free loans for bike purchase and bicycle mileage allowance.

More information: www.beaufortcourt.com

Solar PV array replaces traditional roof materials.
Source: Solarcentury

Zero-energy converted egg farm, Kings Langley.
Source: Fusion/Renewable Energy Systems

technologies

This section provides an overview of the low- and zero-carbon technologies that are available, including information on costing.

- combined heat and power (CHP)
- wind
- biomas and biofuel
- photovoltaic (PV) panels
- solar themal hot water collectors
- energy from waste
- ground source heat pumps (GSHP)
- wave and tidal power
- micro-/small-scale hydroelectric
- fuel cells

5

combined heat and power (CHP)

CHP is the production of electricity and useful heat from a single plant. Conventional electricity generation is very inefficient as only a small part of the input energy is converted to electricity (typically 25–35%), with the remainder lost via cooling towers as waste heat.

In a CHP system, energy can be produced in the same way as conventional electricity, but the heat is retained for heating, hot water and cooling, and is distributed to customers via highly insulated pipes. This improves the overall efficiency of energy conversion to around 85%.

A conventional CHP system uses natural gas to drive an internal combustion engine. It reduces CO_2 emissions compared to conventional distributed gas or electricity by 20-40%. Some of the heat can also be used to provide cooling via absorption chillers.

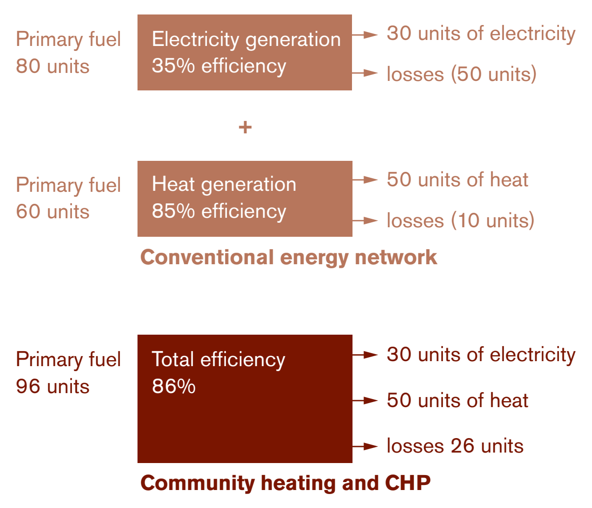
CHP is applicable on a variety of scales, from city-wide development down to individual buildings. Steady heat and power loads will improve the economics of CHP and so systems should be designed to allow a suitably sized engine to run at or near maximum capacity for as much of the day as possible.

Electricity generated by CHP can be sold in three ways:

1 It can be made available to energy supply companies. Until recently only low prices could be obtained on the energy market. However, recent rises in the cost of energy has improved the economics for CHP operators.

2 It can be transported over the wires of the local distribution network operator and sold directly to other users. This incurs a 'distribution use of system' charge.

3 The best prices can be obtained by selling directly to domestic customers over a private wire network (PWN). When building a community heating system it is sensible to install a private distribution network at the same time. It will be necessary to establish or employ an energy services company (ESCo) at the same time to operate and manage the business (see Section 3.3).



The increase in efficiency of a CHP sustainable energy network over conventional energy supply

Source: XCO_2

Micro-CHP refers to small scale CHP, which is most commonly used for individual buildings. Two suppliers – WhisperTech and Baxi31 – have recently launched a gas heat engine (stirling engine) in the UK. Units are becoming smaller and quieter and have the potential to be used in place of traditional boilers within homes.

Technology analysis

Analysing the cost effectiveness of low- and zero-carbon technologies in relation to carbon saved and other environmental benefits, can be complex. In the following section the key technologies are presented with a cost analysis chart. The first bar shows the initial capital cost of a system, while the second shows the potential lifetime earnings. This takes into account any savings over procurement of conventional energy. The third bar shows the likely CO_2 saved per annum. The typical energy demand per dwelling has been assumed as 70kWh/m^2 per year for heating, 40kWh/m^2 per year for hot water and 50kWh/m^2 per year for electricity.

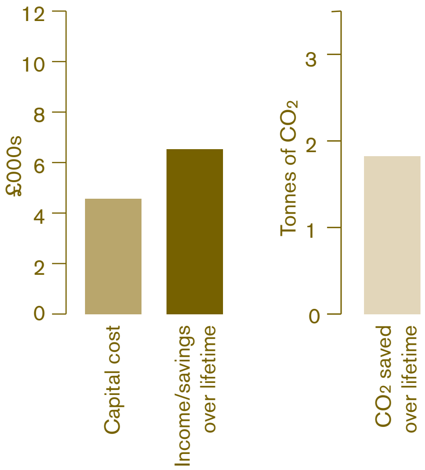
A table summarising all technologies is included on page 48.

Summary: CHP

- Increases efficiency over conventional grid supply by up to 50%.
- Reduces CO_2 emissions by up to 40%.
- Can be used at all scales but most efficient when used as part of a sustainable energy network.
- Lifespan of around 15 years.

More information: www.dti.gov.uk/renewables

CHP costs
3.9kg of CO_2 saved per £ of capital cost



wind

Wind turbines convert the power in the wind into electrical energy using rotating wing-like blades which drive a generator. They can either be connected to the national grid to export electricity, used directly for electricity or used to charge batteries for on-site use.

Wind turbines can range from small domestic turbines producing hundreds of watts of energy to large offshore turbines with a capacity of 3MW and a diameter of 100m.

Wind velocities are the key factor in the location of wind turbines. Care must be taken with site selection, particularly for larger turbines. A feasibility study should take into account wind speed and turbulence and constraints such as radar stations, airports, landscape designations and proximity to special wildlife areas or bird migration corridors.

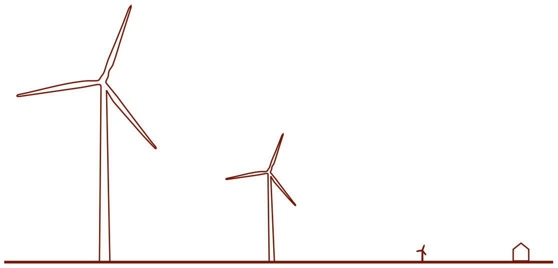
While horizontal axis wind turbines (HAWTs or 'propeller type') are the most common, there is growing interest in vertical axis wind turbines (VAWT) particularly in urban locations where they are thought to be able to cope with more turbulent winds. Turbines have a cut-in (around 3m/s) and shut-down (around 25m/s) wind speed, between which the turbine is able to generate power. The optimum output is at around 12–15m/s.

The UK has a huge potential wind resource. However, site constraints mean that the 'recorded capacity factor' for onshore turbines in the UK is around 27%[32].

Typical energy output in different average wind speeds per m² of swept area include:

kWh/m²/year	4.5m/s	5m/s	5.5m/s
Small turbine	320	450	550
Large turbine	450	600	720

Varying scales and types of wind turbines.
Left: a 6kW VAWT Right: a small 500W HAWT. *Source: XCO₂*



CO₂ emissions offset and the number of homes powered by different sized turbines
These figures are based on standard assumptions and will vary depending on site-specific features.

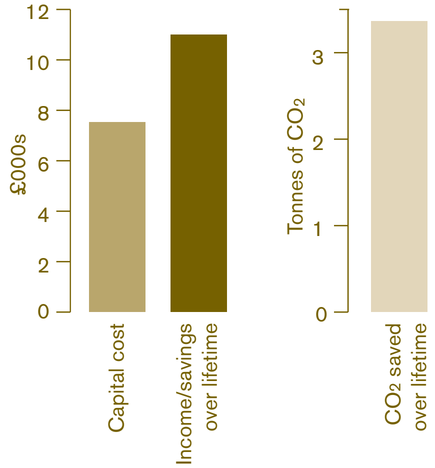
Source: XCO₂

Summary: wind

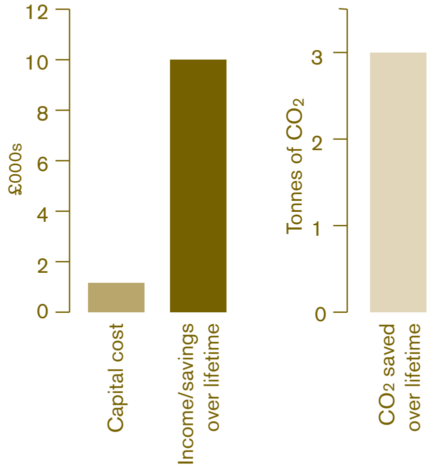
- Care should be taken in chosing turbine types and location to take advantage of available wind, but also to avoid or minimise visual impact.
- Developments will normally require planning permission.
- Larger turbines require suitable infrastructure.
- Can be stand-alone or integrated into a network.
- Lifespan of around 25 years, or less if connected to a battery.

More information: www.dti.gov.uk/renewables

Small wind costs
4.5kg of CO₂ saved per £ of capital cost



Large wind costs
26.8kg of CO₂ saved per £ of capital cost



biomass and biofuel

Biomass is a generic term that describes the use of organic matter to produce energy. Biomass heating is a simple and proven technology, widely used across mainland Europe.

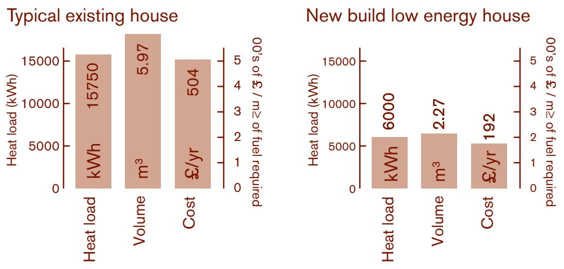
Biomass can be processed to produce either solid or liquid energy. Biomass fuels are virtually carbon-neutral. This is because the growing plant or tree absorbs CO_2 in its lifetime, and the same amount is released upon conversion to energy.

Biofuel is diesel or ethanol replacement derived from plant matter or natural feedstocks via a chemical or biological process. Biomass or biofuels are currently being produced from a variety of plant types such as short rotation willow coppicing as well as from waste materials like cooking oil or waste wood.

Biomass can be used in space heating, for hot water and in CHP units.

Biomass heating needs space for storage of fuel, but this requirement is reducing as houses become better insulated under tighter building regulations, as illustrated in the table below.

The production of biofuels offers a new economic opportunity for farmers.



Assumptions: 75m≤ house, 85% efficiency of heating system, £130 a ton of wood pellets

Source: XCO_2

The biomass process from field to boiler

Short rotation coppice for fuel for a biomass boiler. *Sources: www.coppiceresource.co.uk and www.engext.ksu.edu/biomass*

Small-scale biomass energy generation: annual fuel requirements

Size	Properties served	Annual fuel requirement	Physical size comparison	Technology
15kWth	One family house	5odt	Large suitcase	Boiler
350kWth	School	100odt	Garage	Boiler
1MWe	200 houses	500odt	Garden shed	Boiler
250kWe	250 houses	1,500odt	Small barn + fuel store	Gasifier/ pyrolyser/ engine
1MWth	1,000 houses	500odt	Medium barn + fuel store	Gasifier/ pyrolyser/ engine
1MWth	1,000 houses	8,600odt	Medium barn + fuel store	Boiler

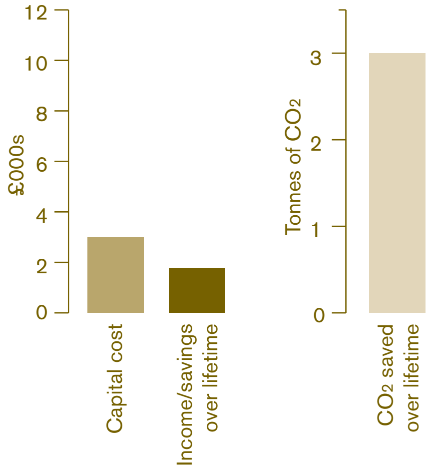
kWth = 1,000W of thermal power i.e heat
MWe = 100kW of electrical power
Odt = oven dry tonnes: dry weight of the fuel

Summary: biomass and biofuel

- Virtually carbon neutral (CO_2 emissions associated with transportation).
- Cost of fuel is comparative with conventional heating fuel, and will improve as fossil fuel prices increase.
- Can operate at a variety of scales.
- Storage of fuel and disposal of ash are considerations.
- Biomass can be processed as low moisture content pellets or burned in situ.
- Lifespan of approximately 20 years.

More information: www.dti.gov.uk/renewables

Biomass costs
9.8kg of CO_2 saved per £ of capital cost



photovoltaic (PV) panels

Photovoltaics are materials capable of converting daylight into direct current electricity. In principle they are the ideal source of renewable energy as they harness the most abundant source of energy on earth: the sun. They also produce electricity which is the most useful form of energy.

PVs are silent, have no moving parts and a long life with zero maintenance levels. PV systems can either be connected to the national grid or used as stand-alone systems which are more suited to remote locations. Grid-connected systems consist of PV arrays which use a charge controller and an inverter to convert the direct current into the more useable alternating current.

PV cells are more efficient at lower temperatures so they ideally require good ventilation. Overshadowing will reduce energy production; however, direct sunlight is not necessary for energy output and they will operate throughout the year. The orientation and angle of the arrays also affects the output (see table below).

Outputs are measured using kilowatts peak (kWp), which refers to the maximum output a module will have under standard test conditions. Typically, the area required per kWp is 6.5–16m^2; approximately 2.5 kWp is needed to supply all the electricity for a typical three-bedroom house. Usual maintenance involves a site inspection every year with a more comprehensive check every five years.

Currently efficiencies are only around 18% but recent advances in technologies and economies in the manufacturing process are likely to see efficiencies increase and prices fall.

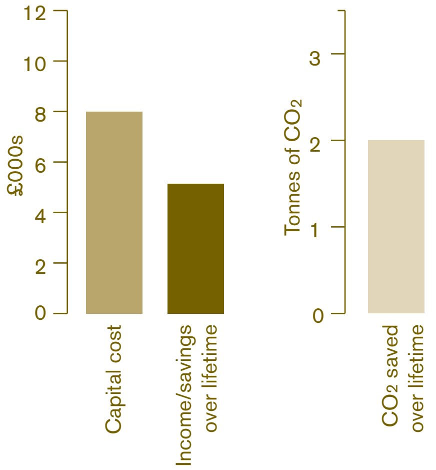
A building-integrated roof tile PV system and a conventional roof-mounted PV array. *Source: XCO_2*

Summary: PV

- Silent operation with no moving parts, leaving minimal operational or maintenance costs.
- Can be integrated into the building fabric, thereby offsetting costs such as solar shading, roofing or cladding.
- Does not require direct sunlight, though care must be taken to avoid overshadowing.
- May have implications for load capacity of the roof or structure of a building.
- Lifespan of at least 15–20 years.

More information: www.dti.gov.uk/renewables

Photovoltaic costs
2.4kg of CO_2 saved per £ of capital cost



Orientation of PV array	Angle of PV array: 0°	45°	90°
0°	-12%	Optimum 750KWh/yr	-30%
15°	-12%	-1%	-30%
30°	-12%	-3%	-30%
45°	-12%	-6%	-32%

Actual optimum: 35-37° inclination
south orientation

Assumptions: 4m≤ array
18% efficiency

Optimum orientation for PV
The table shows the varying scales of output from a 4m^2 solar array depending on orientation and angle of the PV cells.

Source: XCO_2

solar thermal hot water collectors

Solar water heating harnesses the sun's rays to heat water that can then be used for either space heating or, more commonly, domestic hot water heating. The system consists of solar collectors that are often roof-mounted. Water or oil is passed through the collectors to a heat exchanger in the hot water cylinder, which will also have a top-up heat source from a conventional system.

Solar thermal collectors fall into two broad categories: flat plate and evacuated tube collectors.

Flat plate collectors are usually glazed (though unglazed versions are also used). They work by exposing a broad, flat expanse of absorber to the sun. This transfers its heat directly to water, while the glazing creates a greenhouse effect and rear insulation reduces unwanted heat loss. They are less expensive than evacuated tube collectors but also slightly less efficient and subject to convective and conductive losses.

In an evacuated tube collector the absorber surface is placed inside a glass tube. The air is removed to stop nearly all convective and conductive losses. These collectors either directly heat water or use a liquid that boils when heated and condenses to transfer heat energy to water. Evacuated tubes are more efficient and expensive than flat plate collectors.

Solar thermal collectors can still produce energy with diffused sunlight and are therefore ideally suited to the UK climate.

A typical domestic installation will be 4–6m^2 of flat plate or 2–3m^2 of evacuated tube, costing around £3,500–4,000 and meeting 50–70% of hot water demand. A solar thermal array acts in a similar way to PV arrays in terms of their orientation and inclination. The best performance comes from south-facing arrays with an inclination of 30° to 45° (see the table on the previous page).

Solar thermal competes against the viability of CHP and community heating because it reduces the demand for heating which is needed to make CHP and community heating efficient and economic. Solar thermal arrays can also work on a larger scale but care must be taken to minimise the distance between the solar thermal collectors as long pipe runs increase the heat loss.

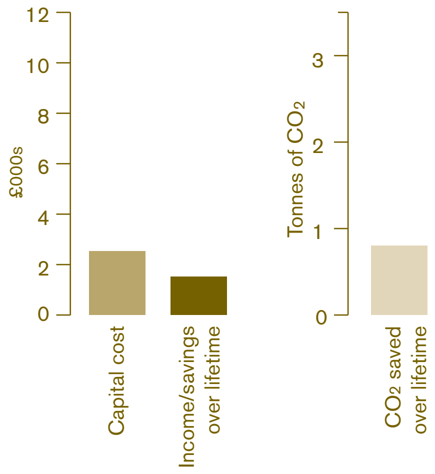
Solar thermal collectors are relatively simple to install by any suitably trained plumber, although a specialist installer is recommended. An annual maintenance check should be carried out to ensure there is no corrosion and the collectors are clean.

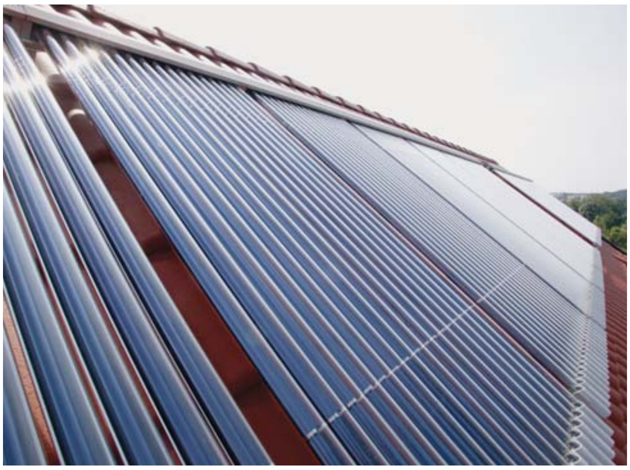
Summary: solar thermal

- Can be either flat plate (cheaper) or evacuated tube (more efficient) collectors.
- Does not require direct sunlight, though care must be taken to avoid overshadowing.
- Can be used with combination boilers.
- Lifespan of at least 20 to 25 years.

More information: www.dti.gov.uk/renewables

Solar thermal
3.0kg of CO_2 saved per £ of capital cost





Evacuated tube collectors.
Source: Rayotec Limited

Flat plate collectors.
Source: Solarcentury

energy from waste

Harnessing the energy in waste can reduce both carbon emissions and the pressure on landfill sites and sewage treatment plants. Any organic matter can be used to produce energy through the processes described below.

Anaerobic digestion (AD)

Around 90 million tonnes of waste is produced in the UK each year, of which 62% is biodegradable.[33]

AD replicates the natural process that occurs in landfill sites. Organic waste can be placed in an oxygen-free environment, causing the waste to be reduced into a digestate that can be used for a high quality fertiliser similar to compost. During this process methane can be siphoned off and used as fuel. Alternatively, although less efficient, the methane produced in landfill sites can be used directly as a fuel.

After taking into account efficiencies and the energy content of the gas methane, AD could supply the UK with 1.9% of its current energy demand.

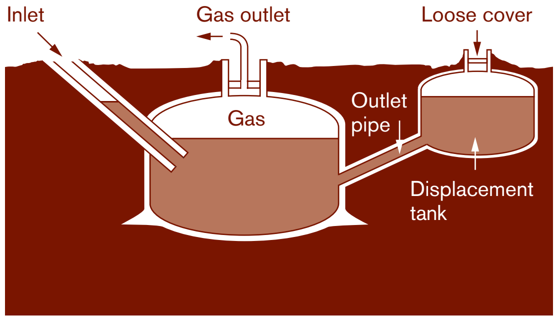
Waste incineration

Although mass waste incineration has been used for decades, tighter regulations on pollution have meant that capacity has fallen. New cleaner technologies mean that direct incineration of municipal waste is now viable in urban areas. Using the same calculation method as AD, direct incineration of waste could provide 5% of the UK's energy demand, reducing waste to landfill by over 60%.

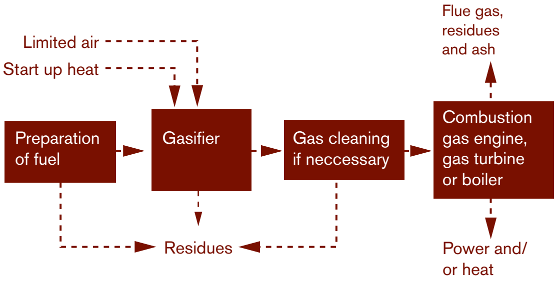
Pyrolysis/gasification

Pyrolysis and gasification (P&G) are very similar technologies. They involve the processing of waste in an oxygen-free (pyrolysis) or oxygen-reduced environment (gasification). Pyrolysis produces a rich oil and a solid residue known as 'char', which can be burnt as a fuel. Gasification only produces gas from the waste. The flow diagram above shows the gasification process.

Gasifier plant.
Source: www.dsiaq.ing.univeq.it



A simple AD system



The gasification process

The main advantage of P&G over direct incineration is that the process retains any pollutants. Efficiencies are also higher (approximately 35%) making it feasible to provide up to 9% of the UK's energy demand. P&G can also work at smaller scales where direct incineration is neither viable nor economic (less than 150,000 tonnes of waste a year).

The main drawback with P&G is the need to prepare the waste: fuel needs to be shredded or broken down before entering the gasifier, and this involves extra cost. Public opinion still opposes large-scale incinerators for reasons of visual intrusion and possible harmful emissions. Therefore, the absence of any emissions should be seen as an important benefit.

Summary: energy from waste

- Energy can be obtained from waste through anaerobic digestion, direct incineration, pyrolysis or gasification.
- Reduces the amount of waste sent to landfil, but may conflict with recycling objectives.
- Modern technologies are clean and very efficient.
- Can be used at the large and small scales.
- Cost will depend on the technology used. However, as it is possible to offset some of the costs of waste disposal against energy from waste it can cost as little as £0.05 per kWh generated.

More information: www.managenergy.net, www.dti.gov.uk/renewables

ground source heat pumps (GSHP)

Ground source heat pumps (GSHP) harness energy from the ground. Ambient air temperatures vary widely throughout the year, however ground temperature is stable.

Stable ground temperatures make it possible to use the heat in the ground during the winter months to provide for some heating needs. Conversely, in the summer months it is also possible to cool buildings using the relatively lower ground temperatures.

A typical system consists of a ground-to-water heat exchanger (often called the 'ground loop' or 'ground coil'), a heat pump and a distribution system. Water passes around the system and 'absorbs' heat from the ground. This heat is relayed via the heat pump into the building. The heat exchanger can either consist of a bore hole, where long pipes are driven deep into the ground, or trench system, which operates at shallower depths. A heat pump is a device that can take low grade heat and raise it to a usable higher temperature. Using a compressor, it works in much the same way as a fridge.

Underfloor heating is the most efficient way to distribute the heat. A GSHP has little or no maintenance costs. The pump can be replaced without having to replace the rest of the system.

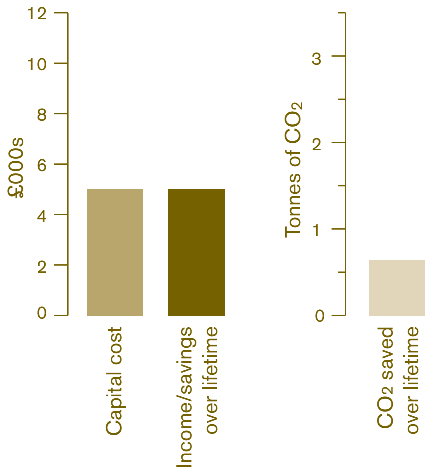
The overall efficiency of the system depends on factors including the type of system used, the geology of the site and the performance of the heat pump.

Summary: ground source heat pumps

- Provide either heating or cooling.
- Trench systems require a large area.
- Borehole systems need access for drilling, a geological survey and possibly a permit from the Environment Agency.
- Life span for heat pump – around 15 years; for the coil system – around 30 years.
- A typical borehole system costs around £1,000 per kilowatt.
- Trench systems cost around £500–700 per kilowatt.

More information: www.dti.gov.uk/renewables

GSHP costs
1.3kg of CO_2 saved per £ of capital cost



wave and tidal power

Harnessing the energy in waves and tides, this technology is restricted to locations where the resources are available, such as coastal towns.

Marine energy can be harnessed using several different technologies such as tidal stream turbines and reciprocating tidal stream devices, and oscillating water columns and point absorbers (wave) that can harness the power in moving ocean currents.

Summary: wave and tidal

- Restricted to coastal locations, but a variety of technologies are available.
- An emerging technology though it is proving to be robust and durable.
- High capital costs, but wave generators have the potential to generate more power than wind turbines.
- Output depends on wave height, tidal power and technology choice.
- Care must be taken to avoid damage to the marine environment and conflict with navigation.
- As an emerging technology the costs are hard to predict. Individual suppliers should be contacted.

More information: www.bwea.com/marine, www.dti.gov.uk/renewables

Pelamis Wave Energy Converters (www.oceanpd.com).
Source: www.dsiaq.ing.univeq.it

micro-/small-scale hydroelectric

Hydroelectric generation captures energy from flowing water. It most commonly involves the construction of a dam and a reservoir. Water is released from the reservoir and, as it falls, turns a turbine which generates electricity. The amount of power generated is related to the flow of water and the distance the water falls.

It is also possible to harness power from flowing streams – this is known as 'micro-hydro'. Current technology limits efficiencies at 'head heights' of less than three metres. Care has to be taken with the environmental impact of hydroelectric systems as the creation of dams and reservoirs can have an adverse impact on wildlife and can flood land that might be of use for farming.

Currently the UK generates about 2% of its power from hydroelectric, but there is potential to increase this by up to 40%.

Summary: micro-/small-scale hydroelectric

- Harnesses the energy in flowing water courses.
- A range of technologies are available.
- Visual and water ecology impacts need to be considered.
- Small reservoirs may be required.
- A robust and durable technology that generally produces high outputs with low very running costs.
- Capital costs will be generally high, but will vary according to the scale and may need to cover site-specific issues.

More information: www.dti.gov.uk/renewables

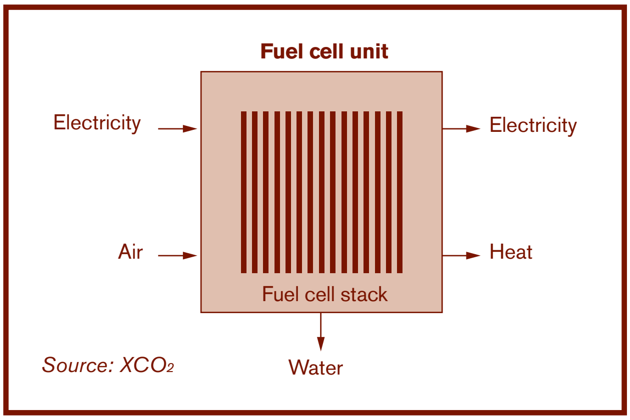
Micro-hydro.
Source: Hydroplan and Glen Kinglas Hydro, Strone Estate, Argyll

fuel cells

Fuel cells convert hydrogen and air into heat and power with the only by-product being water.

Fuel cells require hydrogen to power them. This has to be manufactured using primary energy (fossil, solar or wind), and there is an efficiency loss in the conversion process.

There is interest in the potential of fuel cells to power vehicles as well as to provide a store for heat and power in buildings. They are almost silent in operation, have few or no moving parts, and require little maintenance. Efficiencies are around 60%, almost double that of an internal combustion engine. They are currently relatively expensive.



Source: XCO_2

Summary: fuel cells

- Efficiencies of around 60%.
- Pollution free: by-product is water.
- Fossil-fuel energy is required to produce hydrogen fuel.
- No moving parts, silent operation and little or no maintenance.
- Can be used at micro up to very large scales.
- Lifespan is at least 20 years.
- Cost of about £1,000 per kilowatt is often cited.

More information: www.fuelcelltoday.com, www.fuelscellsuk.org

Hydrogen fuel cell.
Source: www.hydrogen.org.au

references and further information/ glossary

references and futher information

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Other useful organisations

- BRE – centre of expertise on buildings, runs BREEAM/EcoHomes (www.bre.co.uk).
- The Carbon Trust – a government-funded independent company, helps businesses and the public sector to cut carbon emissions (www.thecarbontrust.co.uk).
- CIRIA – improves the performance of the construction industry (www.ciria.org.uk).
- Department of the Environment, Food and Rural Affairs (www.defra.gov.uk).
- Department of Trade and Industry (www.dti.gov.uk).
- The Energy Saving Trust – a government-funded independent company which aims to helps cut carbon emissions across the residential sector (www.est.co.uk).
- The Housing Corporation – funds and regulates Registered Social Landlords in England (www.housingcorp.gov.uk).
- Office of the Deputy Prime Minister (ODPM) – administers the building regulations and the planning system, and will be responsible for the Code for Sustainable Homes (www.odpm.gov.uk).
- Royal Town Planning Institute – the professional body representing planners (www.rtpi.org.uk).
- Sustainable Homes – runs a searchable EcoDatabase with 1,500 best practice examples, which includes a description of the development, environmental features and payback times (www.sustainablehomes.co.uk).
- The UK Climate Impacts Programme – publishes scenarios showing how the UK's climate might change and co-ordinates research (www.ukcip.org.uk).
- WWF-UK 'One million sustainable homes campaign' (www.wwf.org.uk/sustainablehomes).
- XCO_2 – an engineering and design studio providing low carbon solutions in the built environment (www.xco2.co.uk).

glossary

Energy terms used in this guide

Airtight: buildings that minimise the uncontrolled flow of air through gaps and cracks in its fabric.

Carbon-neutral: development achieving zero net carbon emissions from energy use on site, on an annual basis.

Daylighting/sunlighting: amount of natural light that a building and its interior can receive.

Demand profile: details the energy demand of a building or group of buildings according to time of day, season and so on. This can help inform energy supply options and design solutions.

Embedded generation: electricity generation plant connected directly to the local distribution network rather than to the national grid (also referred to as 'distributed generation').

Energy network (also community or sustainable energy network): privately owned and operated heating, cooling or power circuit that can operate independently of the national grid.

Greenhouse gases: a group of gases that absorb solar radiation, storing some of the heat in the atmosphere, resulting in global warming.

Heat recovery: a system for maximising efficiency by recovering and reusing heat that would otherwise be lost through a ventilation or exhaust system.

Low- or zero-carbon technologies: technologies that produce energy with low or zero net carbon emissions, compared with energy produced by standard fossil fuel generation.

Passive ventilation: the controlled flow of air into and out of a building through purpose-built non-mechanical ventilators.

Planning gain: Section 106 of the Town & Country Planning Act 1990 sets out the arrangements whereby local authorities, in granting planning permission, can require developers to pay for planning and other community gains related to the particular development. Also known as 'planning obligations'.

Renewables Obligation Certificates (ROCS): Certificates granted under the Renewables Obligation, which requires power suppliers to supply a percentage of their energy from renewable sources. For each megawatt of energy generated the producer receives an ROC which can be traded on the free market with generators unable to reach their target. The scheme can improve the cost effectiveness of renewable energy generation.

Standard Assessment Procedure (SAP): the Government's recommended system for the energy rating of buildings.

Thermal mass: the effect of high thermal mass (heavier or thicker walls for instance) is to even out variations in temperature, thereby keeping a building cooler in summer and warmer in winter.

U-value: the rate of transfer of heat through materials of the building. The lower the U-value, the better the insulation.

Measures used in this guide

GWh	Gigawatt hours
ha	Hectare
kg/m^2	Kilograms per metre square
kW	Kilowatt
kWe	Kilowatts electricity
kWh	Kilowatt hours
kWp	Kilowatt peak
m	Metres
m^2	Metre squared
m^3	Metre cubed
m/s	Metres per second
MW	Megawatt
MWh	Megawatt hour
W/m K	Measure of the U-Value (watts per metre squared expressed on the Kelvin scales)

Technology analysis summary table

This table summarises the technology analysis data in Section 5. All costs are shown per dwelling and should be used as guides only. Compliance with prescriptive planning policies and increasingly the building regulations, will require more in-depth analysis. Tools such as the London Renewables Toolkit[5] and organisations such as CIBSE[30] and BRE[28] can assist with this process.

	Capital cost per dwelling (£)	Financial saving per dwelling (£)	CO_2 saved over lifetime (tonnes)	Kg CO_2 per £ over lifetime
CHP	4,600	6,610	17,808	3.9
Large wind	1,125	10,063	30,100	26.8
small wind	7,400	11,059	33,080	4.5
PV	8,000	5,175	19,350	2.4
Solar thermal	2,500	1,400	7,600	3.0
GSHP	5,000	4,900	6,533	1.3
Biomass	3,000	1,797	29,260	9.8

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