CE190

Meeting the 10 per cent target for renewable energy in housing – a guide for developers and planners

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Contents

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What is 'renewable energy'

Introduction

Home energy use is responsible for 27 per cent of all UK carbon dioxide (CO_2) emissions which contribute to climate change. By following the Energy Saving Trust's best practice standards, new build and refurbished housing will be more energy efficient – reducing these emissions and saving energy, money and the environment.

Renewable energy has a key role to play in reducing CO_2 emissions. The objective of this guide is to provide developers, planners and specifiers with guidance on meeting the 10 per cent target for the use of renewable energy sources on new housing developments, which are being set by a rapidly increasing number of local housing authorities.

The guidance summarises current national energy and planning policy, and goes on to consider passive solar design techniques that can be applied from an early stage in the design of housing developments, regardless of scale.

The various renewable energy technology options are then outlined in terms of their underlying basic principles and suitability for use in different size developments.

Pages 17-20 of the guide shows three fictional examples of how different renewable energy technologies might be used in large, medium and small-scale developments to achieve the 10 per cent target.

Using typical system sizes and indicative costs, estimates are made for each scenario regarding the number of renewable energy systems that would need to be installed in order to meet the target.

What is 'renewable energy'?

Renewable energy can be defined as the energy flows derived from natural sources that are continuously at work in our environment and are not depleted by being used.

Solar radiation is responsible for the majority of renewable energy sources; however, there are other sources where the energy generated comes from sources other than solar radiation.

This guide covers the following technologies which are capable of generating heat or electricity for use in dwellings:
- Solar thermal (solar water heating).
- Photovoltaics or 'PV' (solar electric).
- Biomass heating.
- Micro wind.

In addition to the above sources of renewable energy this guide will also highlight some of the other low carbon technological solutions that are available:
- Heat pumps.
- Micro combined heat and power.

National energy policy

- The Kyoto Protocol was developed In 1997 with countries agreeing to set legally binding targets for reducing greenhouse gas emissions.
- A target of 12.5 per cent below 1990 levels by 2008/2012 was set for the UK.
- The UK Government set a voluntary target of 20 per cent by 2010.
- UK is currently on target to meet the Kyoto commitment – but not the voluntary target.
- The Energy White Paper[1] was published in February 2003 with the aim that the UK would achieve CO_2 emissions of at least 60 per cent by 2050 (and real progress by 2020).
- The UK has a target of achieving 10 per cent of total electricity generation by renewable energy sources by 2010, set under the EU Renewables Directive[2].
- Aspirational target to double this to 20 per cent by 2020.

Planning policy

England

The planning system In England is underpinned by the statutory development plan system which replaces the previous system of regional planning guidance, unitary development plans, structure plans and local plans.

Under this new system, adopted development plans, regional spatial strategies, and local development documents, set out the planning policies against which planning applications are assessed.

Further information on these changes can be found in planning Policy Statement (PPS) 11[3] and 12[4] (see Contacts and references for more details).

Regional planning policies usually give advice to local planning authorities on what their plans should contain; they are informed by other strategies, such as regional economic strategies, as well as national Planning Policy Guidance (PPGs) and statements.

PPS 1[5] sets out the overarching planning policies on the delivery of sustainable development through the planning system. It requires regional planning bodies and local planning authorities to ensure that development plans address the causes and potential impacts of climate change – through policies which 'promote the development of renewable energy resources'.

Advice on renewable energy for regional planning bodies and local authorities is given in PPS 22[6]. This sets out requirements for regional targets which reflect the national aspiration, and includes guidance on other local considerations. It also requires planning authorities and developers to consider opportunities for including renewable energy in all new developments.

Practical advice on how policies can be implemented and more detailed information on the technology options can be found in the 'Companion guide to PPS22[7]. The guide also describes the roles of regional and local planning authorities in supporting and encouraging the use of renewable sources of energy.

Scotland

The current modernisation of the Scottish planning system seeks to reinforce the primacy of development plans with a focus on environmental implications. Renewable energy policy in the current over-arching structure plans is contained within NPPG 6[8] (National Planning Policy Guidance), and further advice is available in PAN 45[9] (Planning Advice Note).

Wales

The Planning and Compulsory Purchase Act 2004[10] has led to the statutory development planning system being reformed in Wales. Planning Policy Wales provides the strategic policy framework for the effective preparation of local planning authorities' development plans (known as Local Development Frameworks). This is supplemented by 20 topic based Technical Advice Notes (Wales) (TANs) Advice on the renewable energy content of the new local plans can be found in the recently revised TAN 8[11] (Technical Advice Note).

Northern Ireland

In Northern Ireland, the Regional Development Strategy – Shaping our Future[12], sets out the strategy for the development of Northern Ireland up to 2025. Renewable energy policy at a regional level is currently contained within PSU 12[13] (Planning Strategy for Rural Northern Ireland). It is expected that this will be replaced by a Planning Policy Statement. See Contacts and references for more information.

Planning policy

What role do planners have?

The Planning and Compulsory Purchase Act 2004 section 39 requires any person or body which exercises any function under Part 6 of the Act to exercise that function with the objective of contributing to the achievement of sustainable development.

The overarching planning policies on the delivery of sustainable development through the planning system are set out in PPS1 (for England) and SPP1 (for Scotland). Chapter 2 of Planning Policy Wales addresses planning for sustainability and key policies. These policies are reflected in the UK's shared framework for sustainable development. The framework has been agreed by Scotland's devolved government, the Welsh Assembly Government, the Northern Ireland administration and the UK government.

The framework sets out five common principles. They are:

- Living within environmental limits.
- Ensuring a strong, healthy and just society.
- Achieving a sustainable economy.
- Promoting good governance.
- Using sound science responsibly.

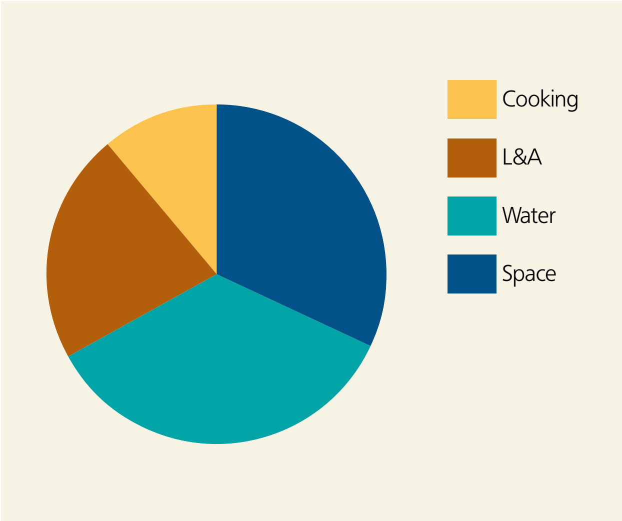
The UK planning system and those that work within it have an important role to play in ensuring that provision is made for implementing energy efficiency measures and renewable energy technologies in both new build developments, and refurbishment schemes.

Local planning authorities can also use planning obligations in order to require developers to make suitable provision for sustainable energy in their planning applications. These are effectively a set of conditions which are attached to a grant of planning permission and can enable developments to go ahead which might otherwise have been refused.

This is now known as the 'Planning Contribution' – formerly Planning Obligation or section 106 agreements. This is covered in sections 46 and 47 (and 48 in Wales) of the P&CPA. At the time of writing, this part of the planning system is under review. In Scotland this is covered in Section 75 of the Scottish Town and Country Planning Act 1997.

Energy efficiency before renewables

Before applying renewable energy technologies to new dwellings it is important to consider reducing the total energy requirement (for electricity, space heating and hot water). This can be achieved by using appropriate energy efficiency measures, passive solar and low energy design techniques.



Domestic new build energy consumption

Source: Information gathered from Summary of Specifications for New Housing (CE12)

New dwellings also need to comply with the thermal performance standards set out in the relevant building regulations, however this should be seen as only the minimum specification. Constructing dwellings to higher levels can make compliance easier. In addition, reducing the total energy requirements of an individual dwelling or a development as a whole means a smaller and therefore cheaper renewable system can be used.

Building regulations across the UK are increasingly adopting a holistic approach to improving energy efficiency for new dwellings as part of ensuring compliance. This is seeking to tackle all areas where dwellings consume energy.

This approach will allow design flexibility within certain limits (for example; maximum fabric U-values, minimum efficiencies for heating systems, specifications for controlled ventilation systems), however it is possible that the target could be met by using building integrated renewables (technologies that are built into the building fabric and that utilise renewable energy sources).

Planning policy

Potential areas for consideration when seeking to improve the energy efficiency of buildings and thereby reducing CO_2 emissions are:

- Increased fabric insulation.
- Reduced thermal bridging.
- Improved air-tightness.
- Controlled ventilation.
- Efficient heating and hot water systems.
- Responsive heating and lighting controls.
- Efficient lighting and fittings that do not permit the use of non-efficient lighting.
- Efficient electrical appliances.

Importance of low energy/passive solar design

Passive solar design

The energy performance of dwellings can be improved by the careful use of passive solar design (for example increasing the proportion of south facing glazing, to maximise gains, whilst reducing heat losses to the north) – this helps to reduce the need for heating during winter months, and can make heating systems employing renewable energy sources more cost-effective.

Simple design techniques can be employed at both the individual dwelling and estate planning stages of a housing development. A well designed passive solar dwelling will save energy and also provide a warm, naturally lit environment for occupants. Passive solar design can also be incorporated relatively easily (depending upon site limitations) and does not add to build costs.

When considering the layout of any new development, opportunities exist for maximum advantage to be taken from passive solar gains entering a dwelling, in addition to increasing levels of natural daylight and providing protection from the prevailing wind. These gains are generally welcome but need to be controlled otherwise there will be a tendency for the dwelling to 'overheat' (see section on 'controlling overheating').

Some of the main considerations to bear in mind at the design stage of a new dwelling or development are shown in the box below.

Tips for integrating passive solar design into new developments:

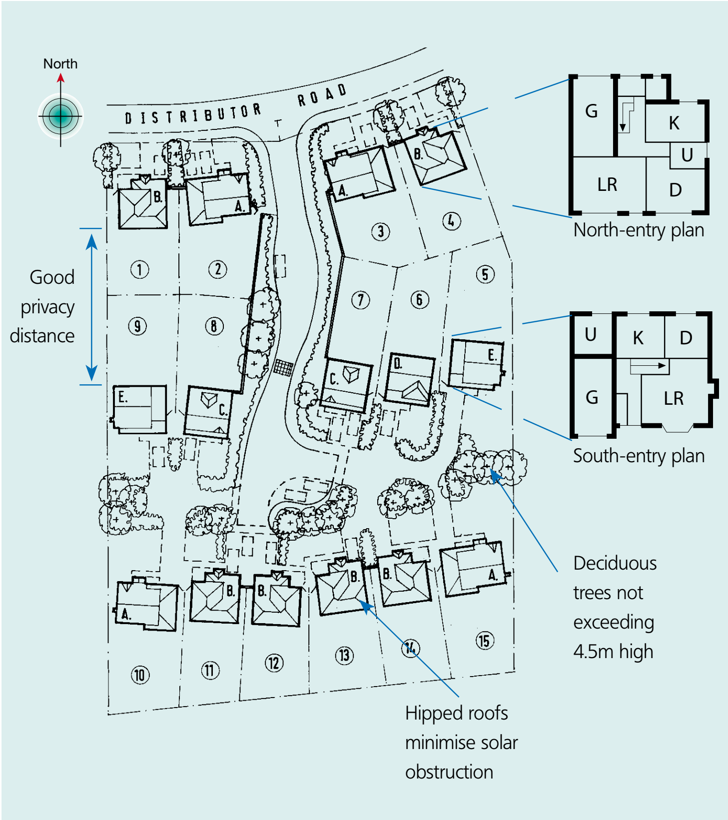
- Space dwellings at least twice their height apart (north to south).
- Orientate houses so that their main glazed elevation faces within 30° of south.
- Arrange dwellings so that main living areas and bedrooms are within 45° of south.
- Avoid over-shading within 30° of south.
- Use garages to shelter north elevations.
- Increase the proportion of the total glazed area that is south facing, and aim for a window area approximately 15 per cent of total south facing window area.
- Avoid large ventilated entrances and stairs in block of flats which can introduce cold areas into the middle of the block.
- Specify heating and ventilation systems and controls which respond well to solar gain. Areas subject to high solar gain should have their own zone temperature control (e.g. thermostatic radiator valves or 'TRVs').
- Use materials such as exposed concrete, ceramic tiles and stone to build in thermal mass. This allows buildings to absorb excess heat during the day and release it slowly during the night when the ambient temperature is cooler.

Controlling overheating

If adequate provision and consideration is not given to passive solar design at the design stage, then the absence of controlled solar gains can give rise to overheating. This can not only cause discomfort to occupiers, but if it occurs regularly can lead to them installing domestic air conditioning equipment. This in turn is likely to lead to increased overall energy consumption and a subsequent rise in CO_2 emissions.

For more information on overheating see 'Reducing overheating – a designer's guide' (CE129).

An example of permanent shading to reduce solar gains. Greenwich Millennium Village Phase 2a, Proctor & Matthew (photo: David Churchill)



An example of a possible estate layout showing north-entry and south-entry plans

Renewable technology options

Why use renewable energy?

Only once energy efficiency measures have been implemented should we consider generating energy from building integrated renewable energy sources. These can help reduce our dependence on fossil fuels and substantially cut down our emissions of CO_2 and other greenhouse gases.

Renewable energy technologies have become an increasingly mainstream and familiar source of energy, and are a key part of the UK Government's energy policy. The technologies that are described in this guide offer virtually free energy in return for an initial capital outlay.

By using renewable energy technologies it is possible, not only to provide a proportion of a dwellings' or developments' total heat and electricity requirements, but also in the future the home owner has potential to generate income by selling surplus electricity back to the national grid.

Solar thermal (solar hot water)

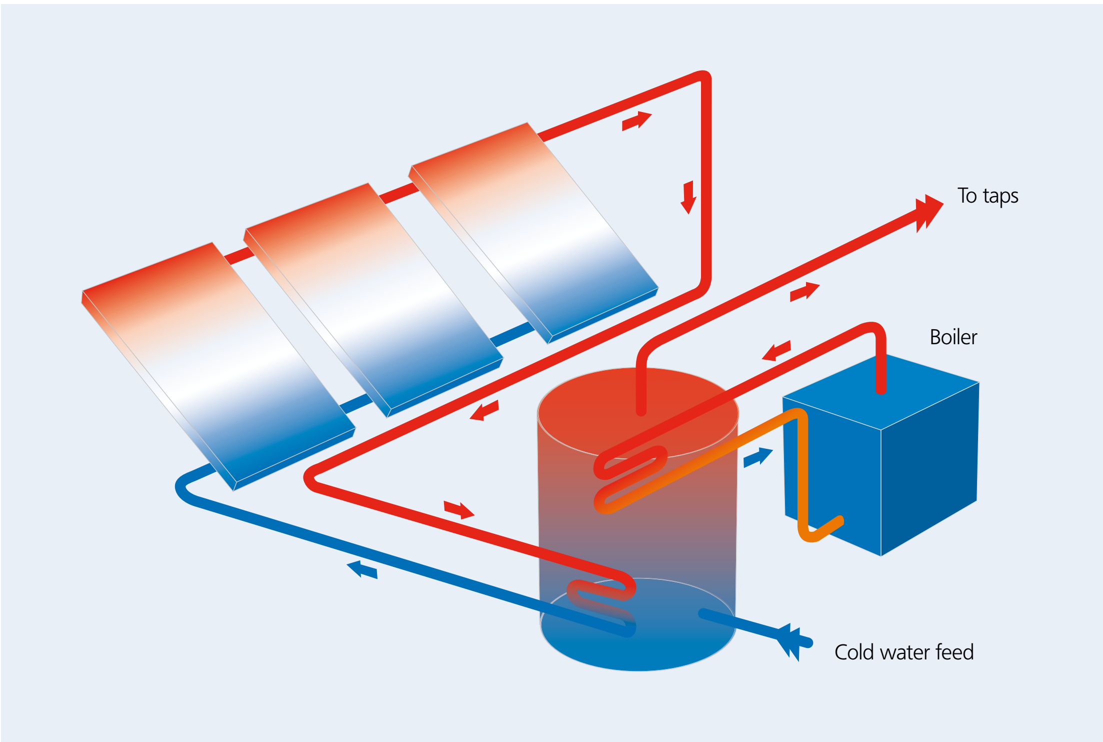
Key principles

Solar thermal or solar hot water (SHW) systems for use in dwellings, use a heat collector which is generally mounted on a roof, and contains a fluid (usually water with glycol) which is heated by the sun.

The heated liquid is then passed through a coil in a hot water storage cylinder. The water in the cylinder may then be supplied directly, or raised to a higher temperature (if required) by a boiler or electric immersion heater.

In this way the 'free' energy obtained from the sun can be used to offset the amount of energy required for providing domestic hot water, and will reduce both running costs (due to the fuel being displaced – electricity, natural gas, Liquified Petroleum Gas (LPG) or oil) and the associated CO_2 emissions.

These systems do not generally provide space heating, and are among the most cost-effective renewable energy systems that can be installed on dwellings in rural or urban environments.



Schematic of a solar hot water (SHW) system

Technology and costs

There are two main types of collector for use in SHW systems:

- Flat plate; these consist of a flat plate with a surface coating which absorbs heat. They are insulated to reduce heat loss, and a glass panel which helps to retain heat in the collector.
- Evacuated tube; these use a series of glass heat tubes which are grouped together. Heat loss is reduced as there is a vacuum inside each tube.

Evacuated tube collectors are generally more expensive than flat plate types, but are more efficient, and may be more appropriate where roof space is limited.

A SHW system for a typical three bedroom semi-detached house would require around $4m^2$ of roof area for the collector and provide the majority of the domestic hot water requirement during the summer months.

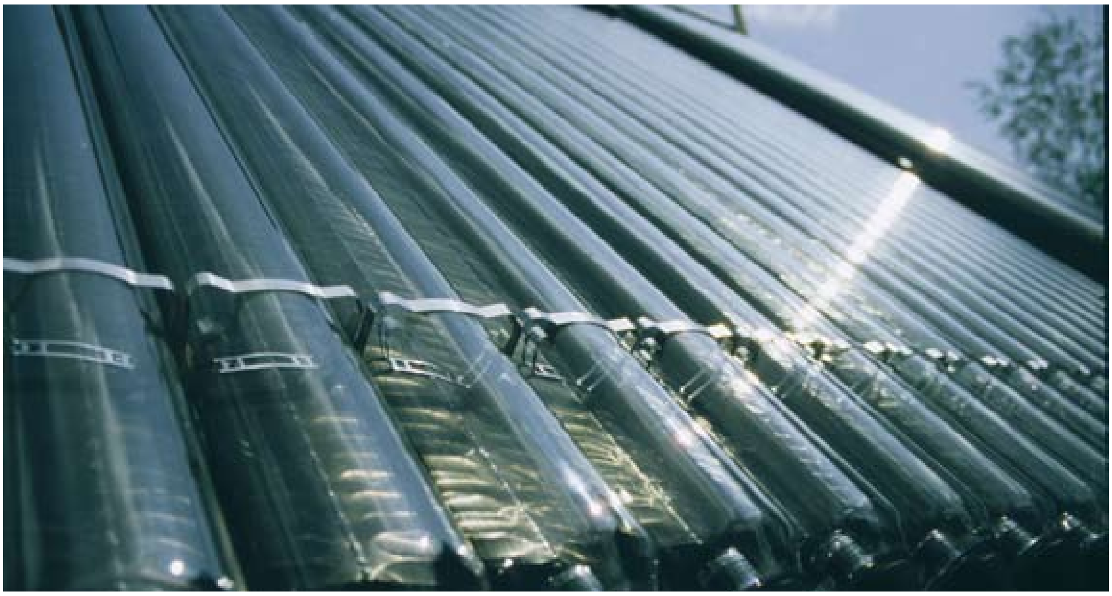
Overall, a SHW system could provide up to 60 per cent of the total hot water requirement. Factors such as the level of occupancy, and when the water is actually used will mean that this range can vary widely.

- This size of system could be expected to cost between £2,000 and £5,000 installed.
- The cost per tonne of CO_2 saved for a typical $4m^2$ system would be between £130-£600.

Developer tips – solar thermal

The following practical issues will be of use to designers and developers when considering implementing SHW into new build developments:

- To maximise the efficiency of systems, larger hot water storage cylinders than would normally be installed for gas or oil-fired systems are usually required. (Airing cupboards will need to be designed to allow for this.)
- Check that sufficient roof space will be available for mounting the collector (usually $2\text{-}5m^2$) in a southerly orientated direction (this may require reorientation of some properties or the use of hipped roofs).
- The intended location for the collector will not be shaded by any obstructions (such as trees and other buildings).



Evacuated tube collector Photo courtesy of the Centre for Alternative Technology

Renewable technology options

Solar electricity (photovoltaics or 'PV')

Key principles

PV systems convert energy from the sun into electricity through semi-conductor cells. A cell consists of a junction between two thin layers of dissimilar semiconducting materials, usually based on silicon.

When light shines on the junction, a difference in energy is created – otherwise known as 'voltage' or 'potential difference'. This voltage is used to produce an electrical current or direct current (DC), which can be used directly or converted into alternating current (AC) depending upon the application.

AC is most appropriate for household use or for exporting to the local electricity network/national grid.

The brighter the sunlight, the more power is produced – although PV cells still produce a reduced level of power when the sun is hidden by clouds. Shading from other objects (such as nearby buildings and trees) is a key issue, as PV cells are more likely to show a drop in system output than solar thermal panels. Ideally panels should face as close to due south as possible, and be unshaded for most of the day.

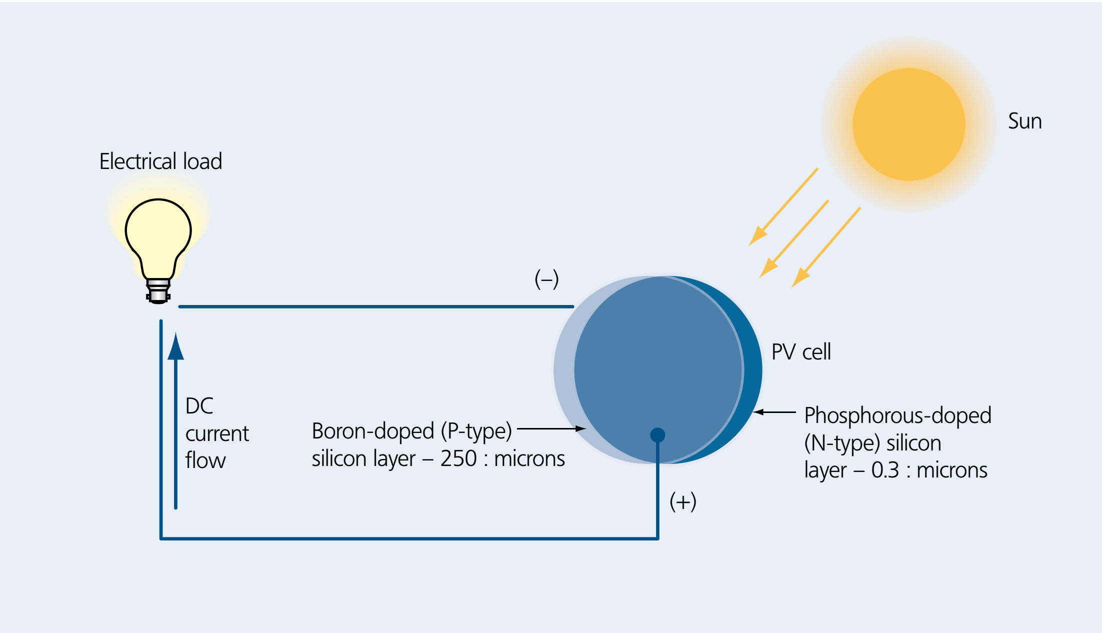
Individual PV cells only produce a small amount of power, so are usually connected together to form a module. Modules can then be linked to form an array and sized to meet a particular load.

Technology and costs

There are three main types of solar cells readily available in the UK:

- Monocrystalline – very thin wafers of silicon cut from a small seed crystal. More efficient than polycrystalline, but more expensive due to the manufacturing process.
- Polycrystalline – instead of one crystal, several different crystals are used for producing the slices. The result is cheaper PV cells than monocrystalline but lower efficiencies.
- Amorphous silicon – silicon is made into a continuous strip of film. Cells can be produced more quickly and hence cheaply than mono or polycrystalline, but with substantially lower efficiencies.

A variety of solar cells based on materials other than silicon, such as cadmium telluride (CdTe) and copper indium diselenide (CIS) are also starting to appear in the UK market as they are easier and cheaper to manufacture.



Generating electricity using PV

Renewable technology options

Hybrid solar cells are also available which usually incorporate a combination of monocrystalline and thin-film technologies. This approach can help to balance the costs and qualities of the cell types.

The table below shows typical conversion efficiencies of silicon based PV modules; cells with lower efficiencies would require a greater surface area of PV modules in order to produce the same electricity output.

Efficiency (per cent)	Module type	Durability (years)
12 – 15	Monocrystalline	25 – 30
10 – 13	Polycrystalline	20 – 25
3 – 6	Amorphous	15 – 20

A full domestic system may well have several modules, together with other system components such as an AC/DC inverter, batteries (for storing the energy until it is needed), a central control unit, mounting structure or materials for fixing the array, wiring, fuses and isolator.

A typical domestic system will usually be around 2kWp (kilowatt peak), which would be large enough to supply around a third of the average family's electricity consumption annually. To produce this amount of electricity an array would need to cover approximately 16-40m^2 of roof area depending upon the technology employed.

The installed cost of a PV array for residential use is high in relation to other renewable energy technologies such as wind power and solar thermal. In addition the total cost will vary significantly according to the type of module, the actual application and the overall efficiency of the system.

- A 2kWp system could be expected to cost between £9,000 and £18,000 installed.
- The cost per tonne of CO_2 saved for this size of system would be between £550-£1,100.

Developer tips – PV

- For optimum results, PV arrays should face between south-east and south-west and at an elevation of between 30-40°.
- Systems should only be situated where they are completely unshaded. Panel performance can be significantly affected if only partially shaded.
- PV arrays need to be adequately ventilated to prevent overheating and a subsequent drop in panel efficiency.
- A key advantage of PV in high density urban environments is their potential to be integrated into fabric of the building.
- PV panels can suffer power reduction of up to 10 per cent if they are not regularly cleaned to prevent dust and other debris from accumulating. If the array is tilted by at least 15°, the panel should be able to self-clean and maintain optimum efficiency.
- PV systems are ideally suited for use in conjunction with wind turbines (see page 14). The wind turbine is likely to produce the greatest contribution during the winter when output from the PV array will be at its lowest. In summer months this would reverse with PV providing the greater proportion of the total system output.


A domestic PV array

Heat pumps

Key principles

A heat pump extracts heat from the ground, air or water and transfers it to a heating distribution system, such as underfloor heating, using an electric pump.

Ground source heat pumps (GSHP) are currently the most common type of heat pump used for domestic space heating in the UK, and use technology which is essentially the same as that in a typical domestic refrigerator.

A typical GSHP system will comprise a ground heat exchanger (for extracting heat from the ground), the heat pump itself and a heat distribution system.

Technology and costs

The overall efficiency of a heat pump is determined by the difference in temperature between the heat source itself (the ground, air or water) and the temperature of the area or environment to be heated that is supplying heat to the dwelling. The smaller the temperature difference the higher the coefficient of performance (COP) will be. Typical COPs will be in the range 2 – 4 depending upon operating conditions.

Heat pumps can be designed to supply 100 per cent of a dwellings heat requirements, but it will usually only pre-heat domestic hot water, so an auxiliary form of heating hot water (for example an immersion heater) will be needed.

In comparison to conventional forms of central heating, a GSHP system will usually have a higher capital cost; a significant proportion of the total cost will be attributed to the ground heat exchanger and its installation.

- A typical GSHP system could be expected to cost between £4,500 and £14,000 installed.
- The cost per tonne of CO_2 saved would be between £30-£350 (depends upon the fossil fuel that is displaced).

Vertical heat exchangers can be used where ground space is limited, but will require boreholes typically 15-150m deep, and are consequently more expensive to install than horizontal systems.

Developer tips – heat pumps

- GSHP systems will be at their most cost-effective in locations where mains gas is not available, and high levels of energy efficiency have already been integrated into the dwelling(s).
- Heat pumps are at their most efficient when supplying heat continuously, so it is more cost effective to size them for less than 100 per cent of the heating load.
- In dwellings, GSHPs are capable of supplying the majority of the total space heating and hot water requirements.
- GSHP systems cannot be seen from the outside of a dwelling so aesthetic design is not usually an issue for planners to consider.
- A license may be required to drill vertical systems in most locations.

Ground loop collector for a GSHP © Geoscience 2002

Biomass

Key principles

Biomass is a term used to define all plant and animal material and has been used as an energy source for centuries. Although there are a number of different technologies available that extract heat from biomass, wood burning systems are most likely to be appropriate for use in individual dwellings. Wood is an extremely versatile energy source and can be burned in a number of different forms and appliances. Biomass or wood burning systems differ from other renewable energy sources in that CO_2 is emitted when it is burned to produce heat. However the amount of CO_2 released is only the same as the amount of carbon absorbed by the tree whilst it was growing.

Using biomass as a fuel is essentially a carbon neutral approach, however the fuel can only be called a true renewable energy source if the fuel has come from a sustainable source (i.e. it is processed and replenished). It should also be used close to where it was originally grown to reduce secondary CO_2 emissions incurred through transportation.

Technology and costs

Wood fuel can be sourced in three main forms, logs, pellets and woodchip. Logs are one of the simplest, quickest and cheapest forms of using wood fuel, although their energy density is half that of pellets, and a quarter of the energy density in woodchip. The graph below shows the approximate amount of wood fuel required to meet the total space and hot water energy requirements of a new dwelling.

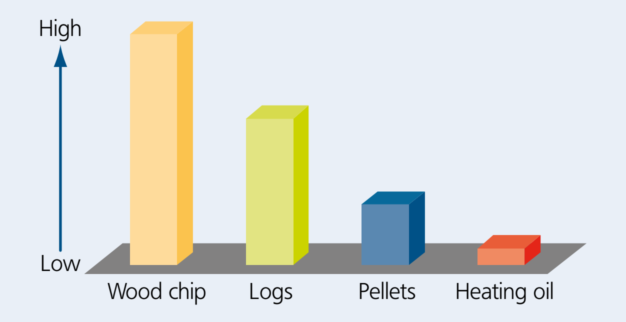
Technology options for burning wood fuel and producing heat will usually involve the use of room heaters or stoves, larger boilers and automatic wood chip boilers for larger applications. Smaller domestic applications with a typical heat requirement of between 2-12kW are ideal for traditional room heaters or stoves. These will usually require fuel in the form of logs or pellets and can provide direct space heating, or be used in conjunction with a fossil fuelled central heating system.

Boilers fed by logs pellets or wood chip are likely to be more appropriate for use in larger households where the heating requirement is more than 15kW. Boilers at this scale will often provide fully programmable space and water heating as they can be installed with a separate hot water tank to act as a thermal store.

- A typical 15kW pellet boiler system could be expected to cost between £4,000 and £12,000 installed.
- The cost per tonne of CO_2 saved for this size system would be between £30-£230 (depends upon the fossil fuel that is displaced).

Developer tips – biomass

- Biomass boilers are likely to require more frequent cleaning than gas or oil boilers and provision needs to be made for auxiliary heating when maintenance is required.
- If a biomass or wood burning system is to be integrated as part of a dwellings heating system, consideration needs to be given at an early stage as to the potential for local supply and space for the storage of fuel. This is likely to be an important factor in the running costs of the system and in the long term may influence the decision of occupants whether to retain the system or switch to a conventional fossil fuelled central heating system.
- The system proposed will need to be able to be managed by the occupants, particularly in terms of managing fuel supply and removing and disposing of ash. The system may not be suitable if the development is intended for the elderly unless maintenance contracts are entered into.



Graph showing comparative volumes of fuel required to supply annual space heating and hot water energy requirement

A pellet stove with back boiler
(Source: Centre for Sustainable Energy)

Wind

Key principles

The UK has the largest potential wind resource in northern Europe with approximately 40 per cent of the total supply available. This potential is recognised by the UK Government which sees wind energy as making a significant contribution to its renewable energy target of supplying 10 per cent of total energy requirement by 2010.

Wind turbines can have outputs ranging from a few watts to several megawatts and produce electricity without emitting CO_2. Energy is extracted from the wind using a rotor generally consisting of two or three blades which have a profile similar to that of an aeroplane wing. If the diameter of the rotor is doubled, the power output from the turbine is quadrupled at a given windspeed.

Technology and costs

Correct assessment of the resource and siting is critical before considering the installation of a turbine. Potential sites generally need average wind speeds of greater than 4.5m/s at hub height to be economically viable in the UK, although small roof mounted wind turbines (typically 1.5kW) can work at wind speeds as low as 3.5m/s.

- A typical 2.5kW small scale wind turbine could be expected to cost between £11,000 and £12,400 installed.
- The cost per tonne of CO_2 saved for this size system would be between £195-£220.

Wind energy availability varies on a seasonal basis and peaks during the winter months, which matches well with the seasonal variation in energy requirements in dwellings. If a wind turbine is viable it is likely to be one of the most cost effective solutions for integrating renewable energy into a new build dwelling or development. In direct-connected systems, the turbine output is connected directly to the load. An example could be a wind-heating system, where heater(s) run directly from the turbine as and when wind energy is available.

Further information on direct-connected; grid-connected and battery wind energy systems can be found in 'Installing small wind-powered electricity generating systems' (CE72).

Although best suited to rural environments, modern wind turbines are becoming increasingly cost-effective in low density areas where there is often the opportunity to connect them immediately to the grid, or use the electricity generated directly in a dwelling. For higher density housing, they are not as cost-effective as their output will be affected by lower and disrupted average wind speeds.

Rooftop mounted turbines are becoming increasingly available. The higher average windspeeds available at increased hub heights will contribute to improved performance compared to turbines mounted at ground level.

Developer tips – small scale wind turbines

- Determine the average windspeed on site as this will have a significant impact on feasibility.
- Local planning authorities will normally need to give formal planning permission for the installation of wind turbines, especially in urban areas.
- The height and location of the turbine will have a big impact on whether planning consent is given, and in addition the planning authority may impose restrictions on the siting of a turbine with regard to the expected noise output or the visual impact on the landscape.
- For grid-connected systems assistance will be needed from the appropriate Distribution Network Operator (DNO) in order to meet relevant electrical connection requirements.

Renewable technology options

Combined heat and power (Micro-CHP)

Key principles

Micro-CHP systems can replace domestic heating boilers for space heating and hot water, whilst at the same time generating electricity for use in the dwelling or exporting to the national grid.

These systems generally use gas as the main fuel and therefore cannot be considered as a renewable technology. However it is clear that they have a significantly reduced impact on the environment compared to conventional fossil fuelled heating systems, not least because of the reduced losses associated with distribution of heat, and have the benefit of generating electricity as well.

- A typical micro-CHP system* costs approximately £3,000 installed.
- The cost per tonne of CO_2 saved for such a system is £660.

*Calculations based on the Powergen 'WhisperGen' system

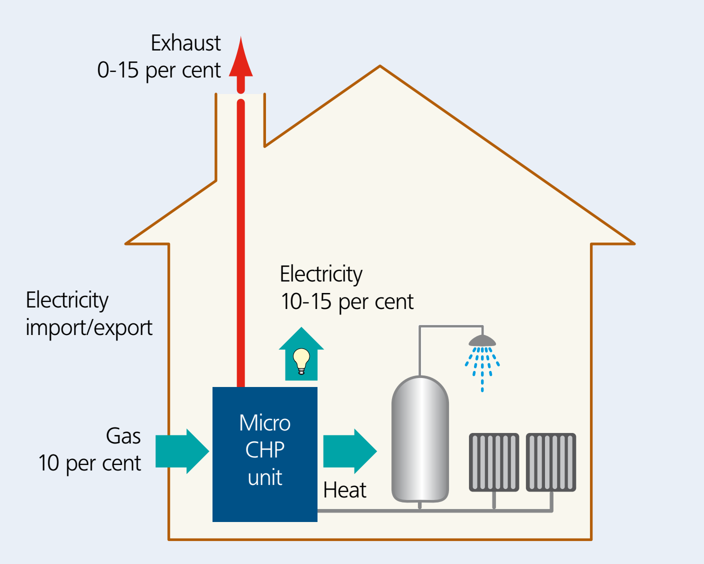
Developer tips – micro-CHP

- With the UK's increasing reliance on fossil fuel imports, security of supply will become an important issue for prospective purchasers.
- Micro-CHP offers the opportunity to generate power 'locally' in the event of a power supply failure.

Technology and costs

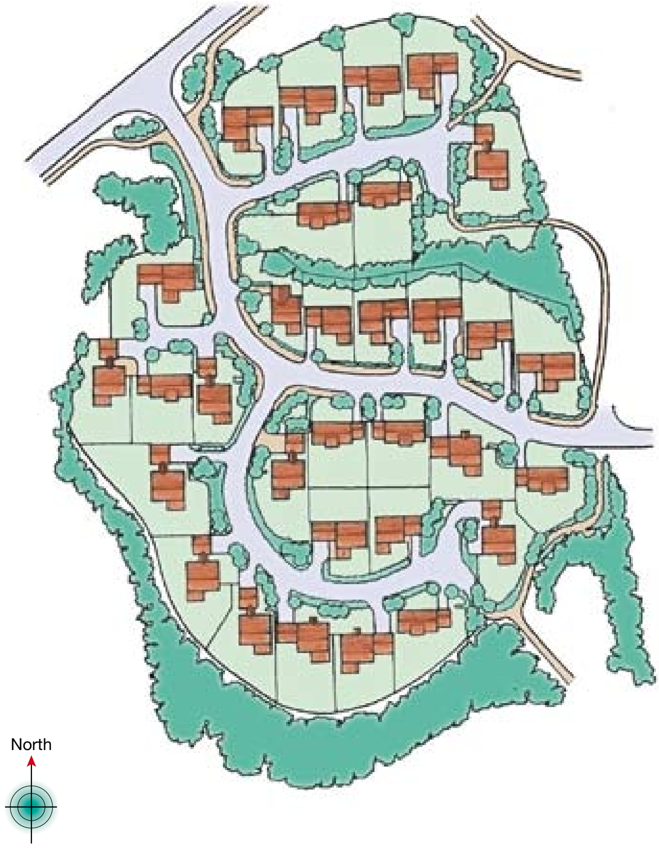
Micro-CHP systems are similar in appearance to a floor mounted boiler or domestic refrigerator. They function as a boiler supplying heating and hot water, but in addition also incorporate a 'sterling-engine' which produces electricity whilst the boiler is firing. These systems can deliver space heating via hot water to radiators, and domestic hot water via a conventional indirect storage cylinder.

As micro-CHP is a relatively new technology, capital and maintenance costs are high in comparison with conventional heating systems. However, since April 2005, the UK Government has introduced a reduced rate of VAT (5 per cent) which has been introduced in order to stimulate demand for the technology.



A typical micro-CHP unit

Renewable energy examples



A theoretical site plan

The following examples demonstrate potential scenarios to cut CO_2 emissions by 10 per cent using renewable energy sources.

The scenarios below are based upon achieving a CO_2 reduction target of 10 per cent. However, some local authority planning targets are set in terms of contributing 10 per cent of a development's predicted energy requirements using renewable energy. The information is given in tables 1 and 2 to allow correct combinations of renewable technologies to be calculated for meeting a target energy requirement.

The examples shown are indicative only. They assume a specific number and type of dwellings, which is not necessarily reflective of current new build developments. The information shown demonstrates the possibilities for meeting the target using different combinations of technologies.

For each scenario, two solutions are offered, but there will be many other combinations that would meet the 10 per cent requirement. The reference data for the following examples is shown in Table 1.

Table 2 provides likely CO_2 savings and renewable energy contributions for the different renewable technologies used in each scenario. These figures are approximate and serve as a guide only. There are many factors to be considered when sizing renewable energy systems accurately, and these factors will vary according to type.

Reference data calculations
The figures shown have been calculated using the Building Research Establishment Domestic Energy Model (BREDEM12), which permits the total energy requirement (including emissions associated with lights, appliances and cooking) to be calculated. The CO_2 emissions can then be calculated assuming a fuel and heating system efficiency. Any assumptions made have been shown where appropriate.

The scenario calculations use default figures, which provide a short cut in the calculation process. In some instances, using default figures for carbon emissions reductions will not be appropriate and other information tools such as the London Renewables Toolkit should be consulted as they are more comprehensive and use the baseline emissions for a whole development instead.

Renewable energy examples

Table 1 Reference data

	Dwelling type	Top floor flat	Mid-terraced	End-terraced	Semi-detached	Detached
	Total floor area (m^2)	60.9	78.8	78.8	88.8	104.0
Energy requirements (kWh/yr)	Space	2,270	2,232	2,893	3,423	4,451
	Water	2,813	3,228	3,228	3,412	3,762
	L&A	2,201	2,719	2,719	3,057	3,635
	Cooking	1,173	1,264	1,264	1,314	1,386
	Total	**8,456**	**9,443**	**10,103**	**11,205**	**13,233**
CO_2 emissions ($kgCO_2$/yr)	Space	440	433	561	664	863
	Water	546	626	626	662	730
	L&A	929	1,147	1,147	1,290	1,534
	Cooking	227	245	245	255	269
	Total	**2,142**	**2,452**	**2,580**	**2,871**	**3,396**

Notes:

- Standard total floor areas (TFA) have been assumed per dwelling type.
- The figures provided are calculated for dwellings built to the Approved Document L1A 2006 regulatory standards.
- The CO_2 emissions assume that the heating, hot water and cooking fuel is mains gas for all dwelling types.
- It is assumed that no secondary heating is provided and that all of the space heating and hot water requirement is met by the main heating system (86 per cent efficient).
- The energy requirement figures provided do not include production, delivery and appliance conversion losses.
- The CO_2 emissions incorporate production, delivery and appliance conversion losses.

Table 2 Indicative CO_2 saving, renewable energy contributions and costs

Renewable energy technology	CO_2 saving ($kgCO_2$/yr)	Renewable energy contribution (kWh/yr)	Cost installed per unit (£)
SHW ($4m^2$)	230[1]	1,200	2,000 - 5,000
PV (2kWp)	680	1,600	9,000 - 18,000
Wind turbine (2.5kW)	1,800	4,300	11,000 - 12,400
GSHP	580[2]	4,500	4,500 - 14,000
Biomass boiler	1,300[2]	6,800[3]	4,000 - 12,000

Notes:

The renewable energy contribution figures are the useful contributions which each technology can make towards meeting the energy requirements of a typical semi-detached dwelling.

1 Assumes mains gas is used for water heating, savings will be higher when offsetting electricity, oil or solid fuels.

2 Assumes typical semi-detached dwelling, savings will vary for other dwelling types dependant upon their heating and hot water requirements (table 1 permits these to be calculated).

3 It is assumed that the biomass boiler provides 100 per cent of the space heating and domestic hot water requirements, so this figure represents the sum of the space heating and domestic hot water energy requirements for the semi-detached dwelling (table 1 permits renewable energy contributions to be calculated for different dwelling types). CO_2 emissions and energy expenditure produced as result specifying an over sized system have been ignored.

The target in the following tables could be achieved using a combination of technologies. Two different scenarios are suggested for each development. The actual figure is of course an estimate only, but demonstrates the approximate number of renewable energy installations required to meet a 10 per cent target.

More information on this can be found in 'Renewable energy sources for homes in rural environments' (CE70) and the 'London Renewable Toolkit' (see Further information for details).

Renewable energy examples

Large development scenario – 100 dwellings

For a development of this size, it is likely that there will be a mix of dwelling types. This will obviously vary from development to development, but for the purposes of this example the numbers indicated below in Table 3 have been assumed. A large development such as this is likely to be located close to, or in, an urban environment rather than a rural setting, and this may have an influence on the type of renewable energy technologies that would be suitable.

Table 3 Dwelling mix and total CO_2 emissions

Dwelling type	No of dwellings	Total CO_2 emissions ($kgCO_2/yr$)
Flat (mid-floor)	16	34,300
Mid-terraced	20	49,000
End-terraced	8	20,600
Semi-detached	36	103,300
Detached	20	67,900
Total	100	275,100

Table 4 Meeting the target – option 1

Technology	No of dwellings	CO_2 saving ($kgCO_2/yr$)	Total cost (min) £	Total cost (max) £
SHW	50	11,500	£100,000	£250,000
PV	16	10,800	£144,000	£288,000
GSHP	9	5,220	£40,500	£126,000
	Total:	27,600	£284,500	£664,000

Table 5 Meeting the target – option 2

Technology	No of dwellings	CO_2 saving ($kgCO_2/yr$)	Total cost (min) £	Total cost (max) £
SHW	17	3,910	£34,000	£85,000
PV	8	5,440	£72,000	£144,000
Biomass	14	18,200	£56,000	£168,000
	Total:	27,550	£162,000	£397,000

In the two options shown (Tables 4 and 5), two different technology combinations have been illustrated in terms of the number of dwellings that would need to be installed with each technology in order to meet the ten per cent target overall. Developers may also wish to adopt a blanket approach to reach the same target by specifying cheaper renewables on every dwelling.

SHW and PV are well suited as complementary technologies. SHW is one of the most cost-effective renewable energy technologies available, but PV is still relatively expensive despite costs falling substantially over the last few years. Therefore a higher number of SHW installations compared to PV would be recommended here. Ground source heat pumps which have a CO_2 saving similar to PV but at a lower cost would be suitable for a number of houses and would help this development meet the target.

This combination of technologies would therefore provide savings on overall heating running costs, as well as electricity consumption. In addition, during winter months when there is less solar resource available and a higher demand for heating, the GSHP systems will still be making a useful contribution. However this would 'double count' the savings and so it has been assumed that SHW and GSHP are not combined on a single dwelling.

Table 4 shows that the target for this development could be met by installing:

- SHW systems on fifty of the dwellings (not including flats) to provide water heating.
- PV systems on all sixteen of the flats to provide electricity.
- GSHP systems on nine of the dwellings to provide space heating and hot water.

In comparison to the technologies discussed above, biomass has the potential to provide higher CO_2 savings per typical domestic installation. This can be seen in Table 5 where a combination of SHW, PV and biomass technologies could also achieve the ten per cent target. The higher CO_2 saving potential of biomass can be seen here, in terms of the number of total installations needed (39 in Table 5, compared to 75 in Table 4) and by way of the total capital expenditure required, which would be significantly reduced.

Although the CO_2 saving benefits of biomass are obvious, factors such as location and local impact need careful consideration. Locations which have convenient transport access to suppliers of biomass fuel will be most suitable, and storage facilities at the point of use also need to be available.

Table 5 shows that the target for this development could also be met by installing:

- SHW systems on seventeen properties (not including flats) to provide water heating.
- PV systems on eight of the flats to provide electricity.
- Biomass boilers to serve fourteen semi-detached or detached properties.

Renewable energy examples

Medium development scenario – 50 dwellings

For a medium size development of approximately 50 dwellings, a mix of different dwelling types has again been assumed. This scenario would consist of a block of flats (typical energy consumption figures for a mid-floor flat have been assumed), two rows of terraced housing (each comprising 5 mid-terrace and 2 end-terrace), and a number of semi-detached and detached dwellings.

In Table 7, an example is shown whereby a combination of solar water heating and a biomass boiler are used to meet the target. A single PV system and wind turbine could additionally be employed to meet a proportion of the annual electricity requirement and enable the development to meet its target.

For this option, location is again an important consideration, and good access to solar radiation is crucial to the site in general, and the specific dwellings to which SHW systems or PV arrays are to be fitted. Rural and suburban locations are more likely to have good access to solar radiation for longer periods than urban locations where other buildings can cast shadows and reduce output.

PV systems and wind turbines complement each other since high solar radiation levels usually occur at times of lower wind speeds. The number of locations where a wind turbine of this size (2.5kW) is suitable may be limited but corner plots may be one option. Alternatively it could be part of a community facility if these exist on a site.

Table 7 shows that the target for this development could be met by installing:

- SHW systems on forty three of the dwellings to provide water heating.
- A PV system on one property to provide electricity.
- A biomass pellet boiler on one property to provide space heating and hot water.
- A wind turbine to provide electricity on one property.

Table 6 Dwelling mix and total CO_2 emissions

Dwelling type	No of dwellings	Total CO_2 emissions ($kgCO_2$/yr)
Flat (mid-floor)	11	23,600
Mid-terraced	10	24,500
End-terraced	4	10,300
Semi-detached	16	45,900
Detached	9	30,600
Total	**50**	**134,900**

Table 7 Meeting the target – option 1

Technology	No of dwellings	CO_2 saving ($kgCO_2$/yr)	Total cost (min) £	Total cost (max) £
SHW	43	9,890	£86,000	£215,000
Biomass	1	1,300	£4,000	£12,000
PV	1	680	£9,000	£18,000
Wind turbine (WT)	1	1,800	£11,000	£12,400
	Total:	**13,670**	**£110,000**	**£257,400**

Table 8 Meeting the target – option 2

Technology	No of dwellings	CO_2 saving ($kgCO_2$/yr)	Total cost (min) £	Total cost (max) £
Biomass	11	14,300	£44,000	£132,000
	Total:	**14,300**	**£44,000**	**£132,000**

An alternative option could simply be to use biomass heating to meet the target without supplementary help from other technologies. Table 8 shows that this would be possible by installing eleven wood pellet boiler systems to detached or semi-detached properties. These properties are more likely to have sufficient space available for fuel storage and access to this for lorries unloading the wood fuel.

Table 8 shows that the target for this development also be could be met by installing:

- Biomass pellet boilers on eleven detached or semi-detached properties to provide space heating and hot water. This would easily achieve the target.

Small development scenario – 10 dwellings

For this size of development, a combination of semi-detached and detached dwellings has been assumed in a rural or semi-rural environment. This would potentially permit the adoption of technologies (such as wind and GSHP) which might have a limited contribution to make in more urban environments. A smaller development such as this might also allow the orientation and layout of individual dwellings to be arranged to optimise the contribution from the solar technologies.

GSHP can provide hot water as well as space heating and should not be included on the same dwellings as SHW systems in order to avoid 'double counting'. The capital costs of GSHP systems are generally higher than those of conventional heating systems because of the cost associated with installing the ground loop, however the total costs will vary with local conditions, and this technology will be particularly cost-effective where there is limited availability of gas and oil.

Table 9 Dwelling mix and total CO_2 emissions

Dwelling type	No of dwellings	Total CO_2 emissions ($kgCO_2/yr$)
Semi-detached	4	11,500
Detached	6	20,400
Total	**10**	**31,900**

Table 10 Meeting the target – option 1

Technology	No of dwellings	CO_2 saving ($kgCO_2/yr$)	Total cost (min) £	Total cost (max) £
SHW	4	920	£8,000	£20,000
GSHP	4	2,320	£18,000	£56,000
	Total:	**3,240**	**£26,000**	**£76,000**

Table 11 Meeting the target – option 2

Technology	No of dwellings	CO_2 saving ($kgCO_2/yr$)	Total cost (min) £	Total cost (max) £
Wind turbine	2	3,600	£22,000	£24,800
	Total:	3,600	£22,000	£24,800

Table 10 shows that the target for this development could be met by installing:

- SHW systems on four of the dwellings to provide water heating.
- GSHP systems on four detached properties to provide space and water heating.

As an alternative to the scenario outlined in Table 10, a small scale wind turbine could also be used to achieve the ten per cent target as a development of this size may be located in a more rural environment.

A rural environment which has a more exposed site, and therefore high average wind speeds (typically 4.5m/s or higher) will improve the economic viability of wind turbines. The rural setting also makes it more likely that the dwellings will have larger plots of land allowing a small scale turbine to be sited away from the dwelling.

Wind characteristics are specific to each location, and although initial evaluations of the wind resource available can be made relatively quickly (for example using the Department of Trade and Industry's NOABL wind energy model), a more detailed local assessment to establish the specific effects on site of aspects such as obstructions, trees, local topography is recommended.

Table 11 shows that the target for this development could also be met by installing:

- Two small scale wind turbines on the site to provide electricity.

Key considerations for developers

Developers will normally have to consider a number of different factors when deciding upon the right renewable energy technology for a development. Some of these factors are listed below:

- Potential for reducing carbon emissions.
- Cost-effectiveness.
- Technological risk.
- Visual impact/promotional value.
- Intermittency (reliability).

As the fictional examples in this guidance indicate, renewable energy offers differing carbon saving potential for typical domestic installations. The UK Government has set statutory national obligations which must be met, and in addition, local planning authorities may require developments to achieve more challenging targets. It is therefore important to consider the carbon saving potential of each technology as accurately as possible in relation to the actual conditions likely to be encountered on site.

As the cost data in the three development examples shows, meeting the statutory targets for renewable energy generation will require a considerable amount of investment. Financial return is one of the most important factors in influencing a decision to make a commercial investment, and it is therefore important to consider cost effectiveness of any technologies which appear appropriate at an early stage in the design process. The cost effectiveness is likely to depend upon a number of factors such as building type, location, orientation and these should all be considered very carefully.

Most of the renewable energy technologies considered in this guidance are technically proven and established, and therefore present a low level of risk. However, some systems will need to be designed carefully to fit in with the requirements of the specific site, whereas others such as PV for example, are essentially 'off the shelf' items which can be more easily integrated into a dwelling or development.

Technologies such as PV, wind turbines and SHW can influence the visual impact of a dwelling or development. In some cases this can lead to problems with obtaining planning consent because of opposition from local residents. However, there can also be a positive effect in that it can increase the 'saleability' of an individual dwelling or development as a whole.

Intermittent generation is an issue. Wind and solar technologies, only achieve peak electricity outputs when the wind is blowing or the sun is shining. As the energy supplied by these technologies will not match directly with the load profile for typical dwellings (i.e. there will not always be demand for the energy when it is generated).

Some wind turbine and PV systems can accommodate this problem if batteries are employed to store the surplus electricity for when it is required. Such systems are called 'stand-alone' and operate completely independently of the grid. The size of the battery array connected to the system will dictate the amount of energy that can be stored and hence the time that appliances will run for if there is no wind or solar radiation. Another, more common approach to help match the renewables output to the load profile would be to specify a mixture of technologies and ensure that any electricity generated can be fed back into the national grid.

What's the future for renewables?

The effect of improving standards

The UK's implementation of the EU Energy Performance of Buildings Directive (EPBD) will require reviews of the building regulations to be carried out every five years.

This will have the effect of driving emissions down, and in order to achieve this, overall standards of energy efficiency will have to increase. As the minimum regulatory requirements become progressively tougher, the gap between regulations and what is practically and technically possible will become smaller.

This will help to develop renewable energy technologies as a method to achieve lower target carbon emission rates. Considering renewable energy alongside energy efficiency measures at the design and planning of a new build development will not only make it easier to achieve statutory requirements, but also to go further in terms of reducing CO_2 emissions.

Successive reviews of the building regulations in the UK together with more stringent planning requirements and guidance will help to cut down emissions from the new build sector, and develop technologies, construction details and strategies for widespread use in new dwellings. However existing housing has potentially the biggest contribution to reduce emissions – in 2050, only 30 per cent of the existing stock will have been built from 2005 onwards, meaning that the majority of the housing expected to be standing in 2050 has been built already. Developments in the new build sector therefore, will have an important role to play in improving standards in existing dwellings.

Renewable energy technologies now represent a viable alternative to traditional forms of energy production in the home. Whilst their initial cost is still currently quite high, they can reduce energy costs in the long term and can also deliver a wide range of benefits: affordable warmth, reduced environmental impact, increased asset value and demand for the property.

There is a wide range of support available including case studies, training and guides. This, combined with feasibility and capital grant funding and a well-established supply and installation industry, makes it easier to integrate renewable energy technologies into new housing.

Microgeneration

Microgeneration, in this context, is the production of heat and/or electricity on a small (or domestic) scale from a low carbon source such as those considered in this document. It has the potential to reduce CO_2 emissions by providing low carbon sources of electricity and heat to dwellings, and helps to ensure reliable energy supplies by reducing the load on the national distribution network and associated transmission losses.

Microgeneration could also contribute towards alleviating fuel poverty. Although it is currently an expensive option in comparison to conventional energy efficiency measures, the lower fuel and running costs from these technologies could help reduce fuel poverty if the substantial capital costs of installing them can be covered by Government incentives and grant schemes.

However, barriers such as the lack of demand; absence of a widely understood accreditation system for products and installer and inadequate metering arrangements are just some of the obstacles which will need to be overcome in order for microgeneration to be successful.

Contacts and references

Websites for additional information

London Renewables Toolkit
www.london.gov.uk

Department of Trade and Industry
www.dti.gov.uk

Renewable Energy Association
www.r-p-a.org.uk

Combined Heat and Power Association
www.chpa.org.uk

National Energy Foundation
www.nef.org.uk

British Wind Energy Association
www.bwea.com

Routes to Sustainability
www.routestosustainability.org.uk

Sustainable Homes
www.sustainablehomes.co.uk

INREB Faraday Partnership
www.inreb.org

The Countryside Agency
www.countryside.gov.uk

Information on planning

More information on the Planning system, including Planning Policy and guidance can be accessed through the following websites:

Department for Communities and Local Government
www.communities.gov.uk

Welsh Local Government Association
www.wlga.gov.uk

Department for Regional Development in Northern Ireland
www.drdni.gov.uk

Scottish Executive Planning and Building
www.scotland.gov.uk

References

1 Energy White Paper 'Our Energy Future – Creating a low carbon economy', February 2003

2 EU Renewables Directive (2001/77/EC), October 2002

3 Planning Policy Statement (PPS) 11 – Regional Spatial Strategies, ODPM

4 Planning Policy Statement (PPS) 12 – Local Development Frameworks, ODPM

5 Planning Policy Statement (PPS) 1 – Delivering Sustainable Development, ODPM, 2005

6 Planning Policy Statement (PPS) 22 – Renewable Energy, ODPM, 2004

7 Planning for renewable energy – A companion guide to PPS22, ODPM, 2004

8 National Planning Policy Guidance (NPPG) 6, November 2000

9 Planning Advice Note (PAN 45), 2002

10 Planning and Compulsory Purchase Act, 2004

11 Technical Advice Note (TAN) 8, 2005

12 Regional Development Strategy 2025, DRD, September 2001

13 Planning Strategy for Rural Northern Ireland, DOE, September 1993

Further information

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools, are available to help meet these standards.

The following publications may also be of interest:

- Energy efficiency in new housing – summary of specifications for England, Wales and Scotland (CE12)
- Innovative Social Housing – Alpine Close, Maidenhead, Berkshire, (CE37)
- Renewable energy in housing – case studies (CE28)
- Community heating – a guide (CE55)
- Renewable energy sources for homes in urban environments (CE69)
- Renewable energy sources for homes in rural environments (CE70)
- Installing small wind-powered electricity generating systems (CE72)
- Domestic ground source heat pumps: design and installation of closed-loop systems (CE82/GPG339)
- Rural biomass community heating case study (CE91)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

Other publications

Generating Solar Homes 'Pathways to PV' (2002). Nottingham Energy Partnership. www.nottenergy.com

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