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# Sustainable Design & Construction Guidance

Presented to: Cleaner, Greener Energy Study Steering Group I

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# Contents

# 1 Sustainable Construction Guidance for Derby City

This document has been produced specifically for the partners to the Cleaner, Greener Energy Study (CGES) for Derby City Council, Erewash Borough Council, South Derbyshire District Council and Amber Valley Borough Council. The Cleaner Greener Energy Study aims were three-fold, resulting in three individual reports:

- Prepare an 'evidence base' for the partner authorities' Local Development Frameworks, establishing the potential for the decentralised and renewable or low-carbon sources of energy and recommending carbon standards for future development
- Prepare recommendations on key carbon reduction opportunities (responding to the NI 186 performance targets), including analysis of options for the delivery of renewable energy generation. This work has a particular focus on Derby City.
- Providing guidance on sustainable construction issues (for Development Control officers and the developer community)

This report focuses on the third of these aims. A range of sustainable construction issues are discussed, which should help educate and inform relevant authorities within the region. It should support responses to issues surrounding sustainability.

It should be noted that this document in its current form does not have statutory status. It is for guidance purposes only and primarily intended for use by development control officers. However, individual authorities may consider including a version in supplementary planning documents in the future.

# 2 What is sustainable construction?

There are a number of definitions of sustainable construction. Effectively it is building in a way that can be permanently sustained. Sustainable construction must consider the whole life of a project, from conception right through to the end of a developments useful life and land use beyond.

The aim of sustainable construction is to be financially, socially and environmentally sustainable. This means ensuring that a development not only makes financial sense, but that it provides a sufficient quality of life and has minimal impact on the environment.

Sustainability within design and construction should cover the following key areas:

- energy and CO2 emissions
- water use
- waste
- flood risk
- adapting buildings for climate change
- sustainable drainage systems
- transport
- pollution
- health and well being
- ecology and biodiversity
- local community and environment
- lifecycle impacts of materials and equipment

The focus of this document is the environmental side of sustainable construction, and most specifically the impact construction has on greenhouse gas emissions and ultimately climate change. Building regulations target demand from a building in-use, but there is also opportunity to reduce emissions from the construction process.

## 3 Why is it so important?

Companies and individuals involved in construction are increasingly aware of the need for sustainable construction. They are driven both by government legislation and public pressure for social responsibility.

Most people are well aware of the threat posed by climate change. We know that we can mitigate the effects of climate change by reducing our emissions of greenhouse gases. This is why the government has committed the UK to cutting greenhouse gas emissions by 80% of that emitted in 1990 by 2050. With the built environment representing around 40% of the total UK emissions, there is an opportunity through sustainable design and construction to contribute to meeting this target.

The UK government Department for Business, Innovation and Skills (BIS) also see a clear need for sustainable construction. They state that the business case for sustainable construction is based three things:

- Increasing profitability by using resources more efficiently;
- Firms securing opportunities offered by sustainable products or ways of working;
- Enhancing company image and profile in the market place by addressing issues relating to Corporate and Social Responsibility.

## 4 When should you start thinking about it

You need to start thinking about sustainable construction from day one. It should not be seen as an add-on to a development, but be an integrated part of the design and construction process. Every decision should consider the effect on the developments sustainability.

Within this report, we highlight the benefit that development layout and building orientation can have on eventual energy demand. Decisions made in the initial stages of design can greatly affect the potential of low and zero carbon technologies.

Site ecology is also an important aspect of sustainable construction. Without due consideration, it is easy for a development to impact on the natural ecology of a site. Working from an early stage with a trained ecology expert can actually result in improvements to ecological levels following development.

The Code for Sustainable Homes and BREEAM (discussed in section 5) offer a comprehensive list of considerations for sustainable construction, most of which need consideration early on in the design stage.

# 5 What is already available

Sustainable development has been a significant part of large construction projects for many years. It is now becoming much more mainstream, with changes to building regulations in 2006 requiring energy modelling of all buildings at the design stage.

Building regulations are a statutory requirement for all developments in England and Wales. In order to push the sustainability agenda forward, many planning departments and public sector funders are asking for greater levels of sustainability. These are specific to the authority in question, but usually focus on three things:

- Carbon emissions better than building regulations
- Generation of renewable energy to reduce emissions by a set amount
- Targets for achievement of ‘BREEAM’ and ‘Code for Sustainable Homes’ ratings.

Authorities within the Derby Housing Market Area are looking at introducing policies incorporating the above, to secure more sustainable buildings. The policies will apply to both residential and non-residential buildings. Developers looking to work in the sub-region should start thinking about these now and discussing potential targets with the relevant planning authority.

A wealth of information is available online from various sources to help developers meet these targets. The Carbon Trust[1], Energy Saving Trust[2] and the BREEAM[3] websites are particularly useful resources. In most cases it is also advisable to work with a specialist consultant to develop an appropriate energy strategy.

‘BREEAM’ and the ‘Code for Sustainable Homes’ (CSH) cover good practice criteria for environmental issues, which enables a development to be benchmarked and also certified to a level of compliance. Pre-assessment estimators are available on the BREEAM website.

**Proposed changes to building regulations**

Building Regulations Part L is set to be revised in October 2010. The most significant change is a 25% reduction in carbon emissions from new buildings compared to the current standard. For residential buildings, this is equivalent to the carbon emission standard for CSH level 3. The impact of the revisions should be carefully considered to ensure dwellings achieve planning and building control consent after October 2010. The next planned revision is in 2013, when emissions will need to be 44% below current levels (carbon emission standard of CSH level 4).

# 6 How to make developments more sustainable

## 6.1 Building design measures – the energy hierarchy

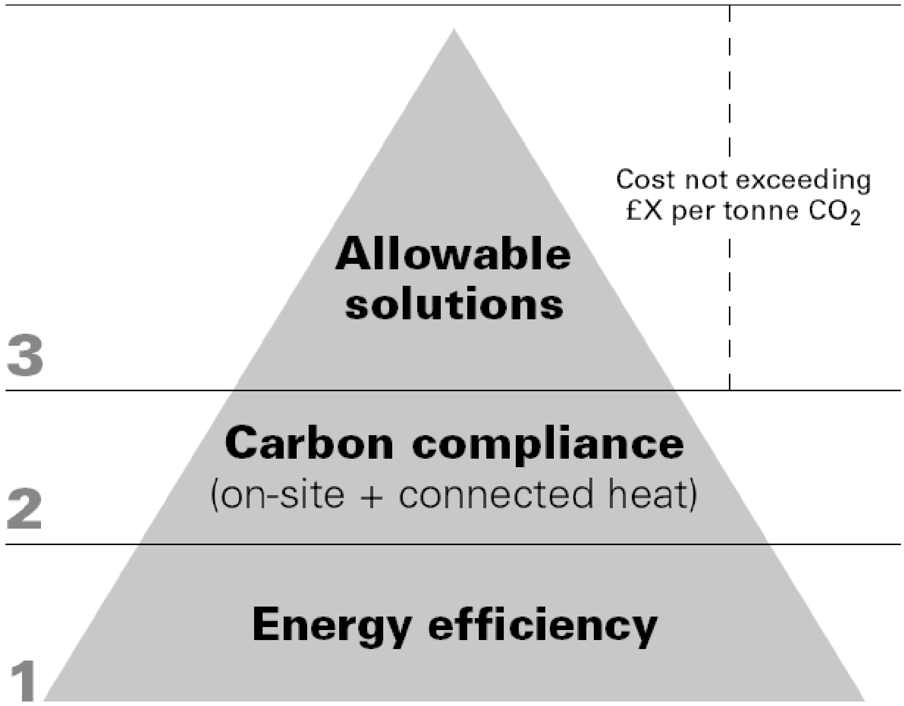
Sustainable urban design must first consider appropriate location, grouping, orientation and layout of buildings. Designers can then look at use of landscape features, thermal mass and natural ventilation. In order to maximise their effect, it is important that these measures are considered early in the design process.

Development should contribute to improving the sustainability and environmental performance of the built environment by reducing carbon dioxide emissions. It makes sense to do this first through

[1] *www.carbontrust.co.uk*
[2] *www.energysavingtrust.org.uk*
[3] *www.breeam.org*

improving energy efficiency, then generating energy services efficiently, and then implementing building integrated renewable energy technology. This is known as "The Energy Hierarchy".

Further carbon reductions can be considered through off-site solutions, particularly where site constraints limit on-site solutions. The definition of a "zero carbon building" is under consultation, but is expected to allow off-site measures. Off site measures might include the export of low carbon or renewable heat from the development to other developments, or investments in low and zero carbon community heating infrastructure and energy efficiency. The below diagram demonstrates the above, sourced from the "Definition of Zero Carbon Homes and Non-Domestic Buildings Consultation"[4]




The point at which it makes most sense to move up a level in the hierarchy is the source of much debate. In theory you should invest as much as possible in measures that improve energy efficiency, as these are most likely to provide long term carbon savings than renewable energy technologies. A solar panel output will reduce over time and suffer from inverter failure, but wall insulation will work effectively for the life of the buildings. However there is a point in every building design at which the cost of energy efficiency measures is difficult to justify in terms of long term carbon and cost payback. Improving a wall U-value from 0.15 $W/m^2K$ to 0.10 $W/m^2K$ will only save a few pounds per year (as heat loss through the wall is already very low), but could cost several thousand pounds for a new house.

With the proposed introduction of Feed in Tariffs and the Renewable Heat Incentive (see footnote 5), payback periods for renewable energy technologies have reduced significantly.

### 6.1.1 Orientation, massing and passive solar design

As a free resource, solar energy can make an important contribution towards minimising energy consumption in buildings. Passive solar design is designing and arranging a building's form, fabric and

[4] *http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition*
[5] *http://www.decc.gov.uk/en/content/cms/news/pn10_010/pn10_010.aspx.*

systems to capture and use solar energy, to provide heating and natural daylighting, and avoiding overheating. It should always be prioritised before considering forms of energy generation, and should be form part of the early design process.

Buildings should be orientated so that one of the elevations is facing within 30° of south. This typically results in streets orientated within 30° east-west. To make maximum use of this, the south facing elevation should have large windows to benefit from natural light and solar heat gain. It is also beneficial to have living spaces (kitchen, dining room, living room and study) on this south facing side as they tend to be used most during daylight hours. This ensures that passive solar heating in winter is maximised, though we must be careful to provide shade during the summer when excessive heat gains are unwanted. Sites located on south-facing slopes are preferable to those on north-facing slopes.

North West, North and North East facing facades should have reduced glazing levels. Overall, glazing performs 10 times worse than modern walls. 25% of the floor area is generally considered a maximum glazing level for dwellings. There is a need for natural light in all spaces, but smaller windows can reduce the overall emissions from lighting and heating on north facing sides.

North-south orientated streets are more suitable for detached buildings, or where storey heights change, allowing solar access to south-facing walls. In non-domestic buildings, easterly orientations may help provide solar heating in the morning, and avoid overheating in the afternoon. Garages should be located to the north of houses, and opening courtyards to the south.

Atria, conservatories and skylights can be used to bring light and warmth into buildings. Placement of rooms should be considered in conjunction with orientation, with requirement for sunlight in living rooms prioritised over kitchens and bedrooms.

Site layouts should take into consideration the overshadowing of buildings. For example, where possible, taller buildings should be located to the north of developments.

While passive solar gains are valuable during the heating season, it is equally important to ensure that excessive solar gains are minimised during the summer. This can be achieved through effective overhangs on southern facades, trees and landscaping for shading on lower levels of buildings.

For offices, an east-west orientation is preferable as the south façade only needs to be shaded – solar geometry makes this easier than East and West facades, and cheaper as it avoids having to shade two facades. For modern, highly insulated dwellings, south-facing windows should be shaded by exterior awnings or shutters.

In larger buildings, appropriate zoning of spaces with similar orientations should be ensured.

### 6.1.2 Building form

The depth and width of buildings will have a marked effect on the sustainability of a development in terms of the flexibility of the building (and the potential for it to adapt to future needs), as well as the way in which it performs in energy terms.

The depth of a building has a direct impact on daylighting, ventilation and robustness. A shallow building can reduce the need for artificial lighting and mechanical ventilation, therefore reducing energy demands. It is generally acknowledged that 9 to 13m is the optimum depth for non-domestic buildings.

### 6.1.3 Thermal mass

Thermal mass of building materials should be used to reduce peak daytime temperatures. This can be achieved through the use of exposed, heavyweight building materials, such as exposed concrete walls and soffits, which store heat during the day and release it at night. The use of other lightweight means of construction should not be dismissed as they can provide other benefits, for example, the reduced embedded carbon associated with timber frame construction.

### 6.1.4 Energy efficiency

Buildings should be designed to avoid energy use where possible and minimise energy use where it can not be avoided. Many of the passive design measures described above will help to improve a building's energy performance. Effective natural daylighting will help to minimise lighting energy consumption, while passive solar design will reduce heating energy, and thermal mass will minimise cooling energy.

Further key areas that should be considered are:

- Thermal performance of fabric - improving the insulation of the building fabric is one of the lowest cost methods of reducing life cycle carbon emissions. Windows usually have a poorer thermal performance than walls and roofs, and therefore the area of glazing can have a considerable impact on the overall thermal performance of the building.
- High levels of air tightness - airtight buildings stop uncontrolled ventilation and loss of heat in the winter. Prefabricated panels require fewer joints and can be constructed to higher tolerances (under factory conditions) and therefore make this easier to achieve. In highly airtight buildings, a controlled ventilation system with heat recovery will be required to ensure a healthy supply of fresh air to the occupants.
- Low energy Heating, Ventilation and Air Conditioning (HVAC) design – efficient plant and equipment, such as condensing boilers, and variable speed drives on pumps and fans.
- Low energy lighting and controls, such as occupancy detection and daylight sensing.
- Provision of energy efficient appliances, such as 'A' and 'A+' rated fridge-freezers.

## 6.2 Wider site measures

By looking wider at a site and the surrounding areas, we can often identify potential for enhanced sustainability. A sites topography, natural features and existing buildings often dictate development layouts in terms of cost. A sustainable development will look at ways of utilising these existing features, both to improve the sustainability of the new buildings and existing ones.

### 6.2.1 Microclimate and the landscape

Buildings and cities should be designed in response to local climate conditions. Appropriate consideration of site microclimate can minimise the impact of the urban heat island effect, and ensure both comfortable buildings and a comfortable public realm.

Topography should be considered – sites should be well-sheltered from prevailing winter winds. Hilltop and coastal sites are usually most exposed. A south-facing slope will be warmer and provide better solar access. Solar access can be optimised by ensuring that sites are not heavily obstructed to the south.

Landscaping, such as large areas of vegetation, ponds and water features, can enhance microclimate by moderating temperatures through increased humidity and evaporation. Deciduous trees are ideal, as they provide shade during the summer, but allow passive solar gains during the winter.

Choice of materials and albedo should be considered – polished or lighter coloured materials increase the reflectivity of surfaces, resulting in a higher albedo. This means that building surfaces exposed to solar gains absorb less radiant heat, which helps to keep buildings cooler.

### 6.2.2 Adaptability

Buildings should be designed to adapt to changing climatic conditions. With warmer, wetter winters and hotter drier summers likely in the UK, key issues will be risk of flooding, limited water resources, increase in internal temperatures and risk of subsidence.

Consideration should be given to the following:

- **Location:** evaluate the flood risk of new developments, and consult industry guidance where necessary.
- **Site layout:** layouts should not increase the flood risk, but should help reduce the risk, through appropriate design. Natural ventilation and passive solar design should be optimised, including use of external shading. Where cooling is required, free cooling techniques should be considered, such as evaporative cooling and ground cooling. Allowance should be made for the increased risk of subsidence.
- **Outdoor space:** natural vegetation and planting, particularly species which can adapt to drier climates, should be maximised, with private outdoor spaces for homes, as well as public space. Outdoor space should be appropriately shaded, and where practicable consideration should be given to water features (with minimal net water consumption) to provide a cooling effect. This can help reduce the 'urban heat island effect' caused by high density developments.
- **Buildings layouts:** floor to ceiling heights and provision of thermal mass should be maximised to optimise natural ventilation, and limit mechanical cooling requirements. Buildings should be designed to withstand increases in wind speeds, rainfall and risk of subsidence, as a result of climate change. Consideration should be given to the durability of construction materials. Building structures should allow for maximum flexibility so that internal layouts can be altered in the future.
- **Water consumption:** this should be minimised through water efficiency and re-use of greywater and rainwater.
- **Drainage:** Sustainable Urban Drainage (SUDS) measures should be incorporated, where possible (see Derby HMA Water Cycle report[6]).

### 6.2.3 Sensitive locations

In this regard, sensitive locations are ones were any new development might struggle to get planning permission on visual grounds. Changes affecting listed buildings and world heritage sites will always have their own specific issues, as will development in green belt areas, or areas of outstanding natural beauty. Care must be taken to consult with the relevant stakeholders. Many of the suggestions made in this report will not be suitable in such locations. However, if development is given permission, it is highly unlikely that all opportunities for reducing emissions will be unavailable. Designers should consult with specialists who can advise on alternative solutions. In some cases planning applications in sensitive locations have been approved on the basis that it will contribute to the authorities other targets for low carbon development and overall reductions in emission levels.

[6] www.derby.gov.uk/Environment/Planning/Landuseplanning/watercyclestudy.htm

## 6.3 Low and zero carbon energy generation technologies

Low and zero carbon (LZC) generation technologies includes both renewable energy technologies and technologies which are either significantly more efficient than traditional solutions or which emit less carbon in providing heating, cooling or power.

In order for the UK to meet its 2020 15% renewable energy target, and its commitment to reduce $CO_2$ emissions 80% by 2050, the Government has proposed two new, key financial incentive schemes to help expand the LZC technology market (for further information see footnote 7):

- **Feed-in tariff (FIT)**: this is intended to encourage the uptake of small-scale low-carbon electricity energy technologies, up to a maximum limit of 5 MW capacity, and 50 kW in the case of fossil fuelled combined heat and power (CHP). The Feed-in-Tariff will be introduced through changes to electricity distribution and supply licences. Small-scale low-carbon electricity technologies include solar PV, wind turbines (including micro wind turbines), micro-hydro, CHP, including micro CHP.
- **Renewable Heat Incentive (RHI)**: it is expected that this will apply to the generation of renewable heat at all scales, whether it is in households, communities or at industrial scale, and will cover a wide range of technologies including biomass, solar hot water, air- and ground-source heat pumps, biomass CHP, biogas produced from anaerobic digestion, and biomethane injected into the gas grid. It is anticipated that the Renewable Heat Incentive will be banded, for example, by size or technology.

These incentives are expected to improve the business case for small to medium scale Low and Zero Carbon (LZC) technologies significantly.

Under Permitted Development rules most small-scale renewable energy technologies do not require planning permission (within certain restrictions). This applies to Solar PV and Solar Thermal systems, Wood burning stoves and CHP and Ground/Water Source Heat Pumps. Air Sourced Heat Pumps and micro-wind energy systems do not currently come under Permitted Development rules but are expected to do so in the near future.

### 6.3.1 Combined heat and power

Combined heat and power (CHP) is a form of local electricity generation where heat is recovered from the generator engine and exhaust flue and usually fed into a heating system. These systems have total efficiencies of up to 90% compared with an efficiency of around 35% for grid generated electricity. CHP is recognised by the UK government and local planning authorities as a potential major contributor to help reduce carbon emissions. Types of engine include traditional reciprocating engines (as in a car), gas combined cycle gas turbines, and fuel cells. The power produced is either used at source or fed into the national grid. The heat energy is used to provide hot water and space heating in the building or can be delivered locally via a district heating infrastructure. Where there is sufficient cooling demand, absorption chiller units can be added to provide cooling to refrigeration appliance or air-conditioning systems.

The acknowledged best practice way to size CHP is to run the engine for as much of the year as possible in order to realise economic value and reduce payback. CHP is typically sized to meet either the heat or electrical base load to maximise the total operating hours, carbon savings and economic benefit. Therefore, an important factor in its viability is the availability of a base heating load, particularly during the summer. Swimming pools, buildings with high domestic hot water demands, such as hotels, or developments with a mix of building type are ideal candidates. CHP may also be suited to other situations but generally the smallest size is in the order of 26 kWth. Metering and billing systems will need to be in place to charge for the heat and power delivered to the on-site consumers, and the electricity exported to the grid.

[7] *http://www.decc.gov.uk/en/content/cms/news/pn10_010/pn10_010.aspx.*

| Combined heat and power – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| £1,000 to £2,250 / kW | Hotels, hospitals, leisure centres, large, high density mixed use developments and some industrial premises. With biomass or bio-fuels CHP can provide significant savings | • High and consistent heat loads are required<br>• Where biomass / bio-fuels are used is fuel constraints identified in the biomass / biofuels section are relevant<br>• Space for storage and boiler plant<br>• 'Spark price' (difference between fuel and electricity costs can negatively affect economics | • 20 years + lifetime<br>• Annual maintenance<br>• Regular site supervision and/or remote monitoring<br>• Moderate reliability (with effective maintenance) |

### 6.3.2 Biomass and biofuels

Biomass refers to the burning of wood or plant material to provide heat, and is a generic name for either solid biomass, such as woodchips and pellets, liquid biofuels, such as bioethanol or biodiesel, and biogas.

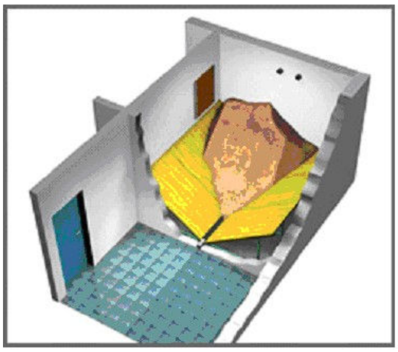
Solid biomass fuels are becoming more commonplace, and the technology is becoming more mature, and is the most common types of fuel for use in biomass boilers are wood chips and wood pellets. Wood chip is produced from the chipping of wood, commonly from forestry thinning. Pellets are produced by extruding sawdust under pressure. Pellets are supplied in standard sizes, which make the plant operation more consistent, while wood chip systems require some manual intervention.

The cost of solid fuel biomass boilers range between £600 and £1000 per kW installed. However, costs vary depending on the complexity of the installation and storage systems required. Wood pellet boilers are low maintenance requiring annual servicing similar to that of traditional gas heating systems. Running costs are largely dictated by the fuel source, with wood chip generally costing around 3 pence per kWh less than wood pellets. However, the total fuel cost is very much dependent on delivery costs and location. The cost of biomass may also rise as gas and oil become more expensive. A reliable fuel supply is crucial to a successful biomass installation and since biomass markets (in comparison for other solid fuels) are relatively immature it is important to develop a fuel procurement strategy at the early stages of design / development. For example, identifying a number of possible suppliers, using local suppliers (which will encourage the development of local supply chains) and securing a longer term contracts will mitigate the risks.

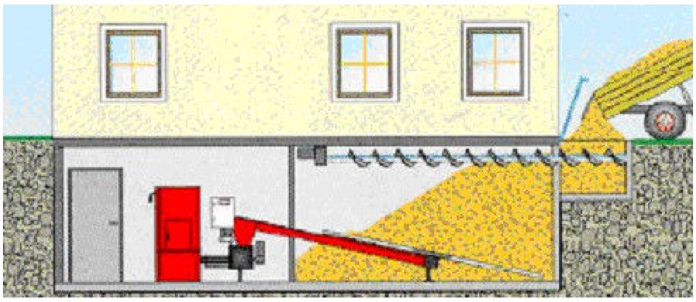
Biomass CHP is an emerging technology, with suppliers concentrating on either combustion and waste heat turbine units or gasification and reciprocating engine systems. As gasification is a more complex process than combustion, the systems generally require a higher quality, and therefore more expensive, fuel source leading to higher life cycle costs than for combustion. Biomass CHP is still in its infancy with only a few pilot schemes in the UK and a limited range of units available.

Liquid biofuels, such as sustainably sourced biodiesel, have could also be considered as a fuel source for a biomass heating or CHP installation, as combustion is generally more efficient than solid fuels. However, biodiesel has the potential for competition with the growth of food crops, and there are difficulties and costs associated with the procurement of sustainably sourced biodiesel.

Biogas is obtained from the breakdown of various organic materials, such as farm wastes and putrescible kitchen waste, by anaerobic digestion. The gas generated can be used for burning and may be used in CHP engines and boilers. Whilst some pilot plants are operating in UK and abroad, this technology may not yet be currently suitable for building applications.



*Possible Storage System*



*Possible Supply System*

| Biomass heating (woodfuel) – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| £600 to £1000 per kW | Hotels, hospitals, leisure centres, large, high density mixed use development and some industrial premises. | • High and consistent heat loads are required<br>• Access to reliable competitively costed fuel<br>• Space for storage and boiler plant<br>• Transport access for fuel deliveries<br>• Possible concerns with air quality<br>• Comparative reliability may require redundancy / back-up e.g. with gas boilers | • 20 years + lifetime<br>• Annual maintenance<br>• Regular site supervision and/or remote monitoring<br>• Fuel delivery management<br>• Fuel procurement<br>• Moderate reliability (with effective maintenance) |

### 6.3.3 Solar water heating

Solar water heating is a simple and low cost technology, with minimal maintenance requirements, and is appropriate for most homes, provided a space facing predominantly south can be found and can be easily integrated in roof spaces or façades.

There are two key types of solar thermal energy collectors: flat plate and evacuated tubes. While the flat plate collectors are simpler and cheaper per square metre, the evacuated tubes have a higher efficiency, but only of the active components, and in practice performances is similar on a per square metre basis. They are normally supplied in fixed array sizes and specified in square metres of collector area. They are generally linked to the domestic hot water system via a closed water loop feeding a twin coil storage cylinder, and have an independent pump and control system. In larger commercial premises, solar collectors can be used to pre-heat water, which is then boosted by conventional boilers.

Systems can be mounted on the façade, roof or at floor level. The optimum yield can be achieved in an un-shaded location where the panels are south facing at an inclination of 30 degrees. Vertically mounting panels reduces annual energy yield by 11% compared to the optimum angle and horizontally mounted panels produce 30% less energy. Similarly, East or West facing panels reduce yield by 17% (assuming optimum inclination). A four square metre panel will produce around 2000kWh of hot water per year, which is around 50% of the requirement for a standard three bedroom house.

| Solar water heating – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| £625 - 1,000/m$^2$ | Any premises with hot water load (very modular technology allowing wide size range) | • Access to sunlight: avoid over shading from trees and buildings<br>• Sloped roofs with orientation between SSE and SSW<br>• Not compatible with CHP | • 15 year + lifetime<br>• Annual checks / re-pressurisation otherwise generally low maintenance<br>• Moderate reliability |

### 6.3.4 Wind energy

There are three main classifications of wind turbine; micro, medium, and large. In general, micro turbines comprise those that can be building mounted, while medium scale turbines are tower mounted rated from around a few kilowatts to a few hundred kilowatts. Large scale turbines are those that are greater than a megawatt, and are more cost effective than micro turbines, with some building mounted units operating at capacity factors below 10%. However, building mounted micro turbines in suitably windy locations can be very effective with reasonable payback periods in both investment and embodied energy.

The United Kingdom has some of the greatest wind potential in northern Europe. Of all the renewable energy technologies, wind is the most cost effective, but also the most controversial. However, studies undertaken by Ipsos on behalf of the British Wind Energy Association revealed that 74% of the people surveyed were in favour of wind turbines.

Within the CGES study a detailed analysis of the potential for wind energy was conducted and this identified that each authority has the potential shown in the table below, based on consideration of a range of technical and planning constraints.

In general, average wind speeds of more than 5-6 m/s are required for wind turbines to be viable. The Department of Business Innovation and Skills (BIS) provides access to the NOABL wind speed database which can be used to gain an indication of energy production at a given location. Medium and large schemes should undertake site analysis for a minimum of one year as part to gain an accurate assessment of the available resource. Small schemes in urban environments may suffer from increased levels of turbulence, and therefore consideration should be given to adjacent obstructions. Some types of micro turbine, such as vertical axis, may be more effective in this type of environment.

| Estimated wind energy potential (2020) – *elevated case* | | |
|---|---|---|
| | **% of electricity demand** | **Est. no of large scale turbine (2MW)** |
| Amber Valley | 10% | 12 |
| Derby City | 1.3% | 3 |
| Erewash | 4% | 4 |
| South Derbyshire | 45% | 44 |

The integration of building mounted wind turbines requires a very early commitment to deal with architectural and structural integration. Consideration should also be given to shadow flicker and noise, where medium and large scale turbines are located in close proximity to residential buildings.

Although the size of most development sites may preclude the use of medium and large scale turbines, consideration could be given to off-site solutions, whether sufficiently close to the site to be connected by a private wire network, or further away.

| Wind energy – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| Micro / Small (under 1kW to 50kW) | | | |
| £2,000-£4,600 / kW | • Tower installations within grounds of the existing buildings<br>• Appropriate roof locations | • Planning permission (although likely to become Permitted Development in the future).<br>• Requires good non-turbulent wind speed, through effective siting | • 5-10 year<br>• Annual checks<br>• Moderate reliability |
| Large (above 1 MW) | | | |
| £1,000 - 1,500/kW | Around the boundary of large development sites within the large property estates, e.g. Ford Dagenham. | • Planning permission required with possibility of public opposition<br>• High, consistent wind speeds required<br>• Access to suitable electricity network connection point<br>• Buffer zone of 400-600m from residential buildings (to avoid noise concerns)<br>• Shadow flicker which could<br>• Good road access and sound ground conditions for very large construction elements | • 15 year + lifetime (typically with major replacement of motor / gearbox)<br>• Remote monitoring<br>• Regular maintenance and emergency troubleshooting<br>• High reliability |

### 6.3.5 Photovoltaics

Photovoltaic cells (PV) are semi-conductor panels that convert electricity directly from sunlight. In simple terms, when light falls on the front of the panels, direct current (DC) power is generated, which flows out of the wires at the back of the panels. This DC power is then normally passed through an inverter which converts it into alternating current (AC) power, which can be used to power the normal range of domestic appliances, exported to the local electricity network, or used in off-grid situations with batteries.

PV is an established straightforward renewable technology in the UK. It has similar solar access constraints as solar water heating panels, except that they are more critically affected by shading. Therefore panels should not be located in areas that could experience significant shading. They can be easily integrated in roof spaces or façades, and do not require direct sunlight, although the sunnier, the better.

There are a number of PV cell technologies with different efficiencies and prices: thin film, poly-crystalline, monocrystalline, and hybrid. Solar PV panels can be purchased in a variety of sizes and an installation will comprise of one or more panels mounted externally on roofs, walls, or on the ground. In the UK panels should ideally face south and be mounted at an inclination of 30 degrees. Vertically mounting panels reduces annual energy yield by 11% compared to the optimum angle and horizontally mounted panels produce 30% less energy. Similarly, East or West facing panels reduce yield by 17% (assuming optimum inclination).


*Example domestic installations*

| Solar Photovoltaics – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| £4,500 to £6,500 kWp | Most premises with flat or sloped roofs also the facades of buildings (with reduced efficiency) | • Access to sunlight: avoid over-shading from trees and buildings<br>• Sloped roofs with orientation between SSE and SSW<br>• Limited roof area on high density urban development will limit the carbon reduction possible | • 20 year + lifetime<br>• Annual checks<br>• High reliability<br>• Replacement of power conditioning elements during lifetime. |

### 6.3.6 Ground source energy

Heat pumps are electrically powered systems that use the refrigeration cycle to remove heat from a source and deliver it to an output. Traditional heat pumps use air as the source of heat. However, the ideal source for maximum efficiency is one which has a stable temperature, warmer than the air temperature in winter and cooler than the air in summer, and the ground provides such a source.

Ground source heat pumps tap into the stored energy of the earth to achieve high seasonal efficiencies. Their input energy must be subtracted from the energy supplied in order to calculate the renewable component. Furthermore, the operation of the heat pump requires electricity and unless linked to a source of renewable energy production such as hydro, wind or solar PV, will require grid electricity, and its associated carbon emissions.

Heat can be extracted from the ground using either closed loop vertical or horizontal ground collectors, in which refrigerant is usually circulated, or by abstracting ground water directly, known as open loop systems. Vertical boreholes are most appropriate in high density developments, since the horizontal loops require a greater amount of free space. A prerequisite to the installation of GSHPs is a geological survey. Abstraction of water may require a licence from the Environment Agency.

Ground source heat pumps can be used to deliver space heating and domestic hot water in the range of 35 to 50°C, which is relatively low, and are therefore best used in conjunction with under-floor emitters.

The key factor for heat pumps is the coefficient of performance (CoP). This reflects the ratio of electricity supplied to the heat produced. For example, a heat pump with a CoP of 3.5, would consume 1kW of electricity and deliver 3.5 kW of heat. The CoP reduces as the temperature output of the heat pump is increased. Therefore it is best to use the unit with the lowest temperature output possible. In particular ground source units may be unsuitable for providing stored hot water as the temperatures required to protect against legionella result in low efficiencies from the heat pump.

The system should be designed so that the annual heat removed from the ground is matched to the heat flow back. If too much heat is removed, the ground temperature may drop, resulting in lower system efficiency.

A major factor in favour of heat pumps is future plans for grid decarbonisation. Currently UK electricity generation results in 523 $gCO_2$ per kWh generated. This means heat pumps are in some cases have only marginally lower emissions than modern gas boilers. The UK energy strategy is aiming to reduce this to 300 $gCO_2$ per kWh by 2020 and 70 $gCO_2$ per kWh by 2030. As heat pumps use electricity, the emissions from these will also drop. Increased use of heat pump technology is part of the government's vision for a low carbon energy network in the UK.

| Ground source heat pumps – key data | | | |
|---|---|---|---|
| **Costs** | **Key Opportunities** | **Key Constraints** | **Operational issues** |
| £1,200-1,500/kW | Range of technologies enable use in most building applications (both residential and non-residential) | • Low cost horizontal devices restricted to properties to gardens / grounds (leaving vertical systems as an option)<br>• Ground conditions can restrict installation<br>• Requires underfloor heating (because of the low operating temperatures), which is generally in appropriate for apartments<br>• Generally requires direct electrical heating for 'top-up' and hot water leading to higher carbon emissions<br>• The running costs can be higher than conventional gas heating. | • 10 year + lifetime<br>• Annual checks<br>• High reliability |

### 6.3.7 Emerging technologies

Fuel cells can be used as CHP systems in buildings. There are currently several different systems under development using different chemical processes, which operate at different temperatures. They currently use natural gas as the fuel, which is reformed to produce hydrogen, the required fuel for the fuel cell. If and when hydrogen becomes available from renewable sources, for example, as the storage medium for wind, PV, or wave and tidal-generated energy, fuel cell CHP from renewable sources may be a viable means of reducing carbon emissions.

## 6.4 Community heating and energy services

A community heating provides heat from a central heat source to more than one building or dwelling via a heat distribution network. The network may serve a handful of flats in a small block, a large tower block or possibly several streets of buildings. However, when retrofitted, high density schemes are required to be cost effective. Some systems only provide space heating, and not hot water. Some have a large central hot water tank with direct supply to flats, while others use a separate heat exchanger with controls and heat meter for each flat, which is called a Hydraulic Interface Unit.

Community heating can make use of a wide number of heat sources, such as a gas boiler, biomass boiler or CHP unit, and these can be changed more easily than for individual systems according to availability and price. For example, switching to a biomass boiler is relatively straight forward and cost effective. It is this ability to provide centralised low carbon technologies serving a number of developments, or to switch to alternative technologies in the future which has the potential to generate carbon savings, rather than community systems themselves.

Community heating also often involves the local production and distribution of electricity, which is sometimes termed 'embedded generation'. This is usually delivered as part of a CHP scheme.

Community energy schemes have higher up-front capital costs compared with individual heating systems, whether gas central heating or electric heating, although whole life costs may be lower. This is primarily due to the cost of pipe work, central plant space and the plant itself. It is highly dependent on density and densities of below 30 dwellings per hectare may well find costs prohibitive. However, running costs should be lower due to simplified inspection and maintenance, longer system life, bulk purchase of fuels and the economic value of CHP (where included). The development of community energy requires capital funding, and installation and management of the asset over a period to recover the additional up-front costs. This is often done using an Energy Services Company (ESCO).

ESCOs are financial and legal vehicles for delivering centralised heat and/or electricity to a number of users. They can take responsibility for billing, management and maintenance of the system, and can take many forms - the market is a complex one as it is in its early stages. Business case analysis should be carried out to ensure that appropriate commercial terms can be agreed, commensurate with the level of risk that the ESCO is being asked to manage and the value that will be obtained from the project. In return for bringing revenue to projects, ESCOs usually have the right to sell heat and/or power to a development. Resultant savings in energy costs are usually used to pay back the capital investment of the project over a five- to twenty-year period, or reinvested into the building to allow for capital upgrades.

## 6.5 Checklist

First consider the energy demand of the building and ways it can be reduced through design:

- East-west orientation is generally best to take advantage of passive solar heating
- Careful sizing of windows with respect to orientation
- Access to daylight
- Protection from winds
- Proximity to landscape features
- Use of thermal mass, where possible
- Topography

Once all energy efficiency options have been considered and value assessed, start to look at Low and Zero Carbon (LZC) technologies?

- Is there sufficient roof space and solar access to allow roof-mounted technologies, such as solar PV or solar water heating?
- Is there sufficient domestic hot water demand for solar water heating to be viable?
- Could heating be supplied by a biomass heating system?
- Are ground conditions suitable for ground source heat pumps? Are lower hot water temperatures suitable for the development to meet its requirements for space heating?
- Could wind energy provide a significant carbon reduction for the development?
- Is there scope to provide a communal energy network, sourced by a LZC technology, such as CHP or biomass heating?

# 7 Other sustainability considerations

## 7.1 Waste

### 7.1.1 Waste hierarchy

With ever increasing pressure on waste disposal capacity in the UK's landfill sites, the Council's priority is sustainable disposal of waste, from demolition to construction to operation. Priority should be given to waste disposal according to the following hierarchy:

| Most preferred | |
|---|---|
| Reduce | Prevention |
| | Minimisation |
| Re-use | On-site re-use |
| | Off-site re-use |
| Recycle | On-site recycling |
| | Off-site recycling |
| Disposal | Energy from waste disposal |
| | Waste to landfill |
| Least preferred | |

Adequate and easily accessible storage for recyclables and compostable waste should be provided for developments, both internally within units and externally. In communal developments, the facility for communal composting should be investigated.

### 7.1.3 Construction waste

Re-use of existing buildings should be prioritised wherever possible, whether through refurbishment, conversion, or simply repair. For listed buildings and buildings in Conservation areas, this approach may be required.

Where re-use is not possible, new developments should minimise their use of new materials through good construction management and re-use and recycling of materials on-site. The use of new materials can be minimised through careful planning and the use of pre-fabricated elements which reduces on-site wastage of materials. Site Waste Management Plans and WRAP (Waste Resources Action Plan) assessments should be used to ensure resource efficiency.

## 7.2 Materials selection

The construction industry is the largest consumer of materials in the UK, and therefore consumes significant amounts of energy in both production and transportation. In order to minimise this energy, the use of new materials should be minimised, and developers should re-use existing materials wherever possible. Where this is not possible, the use of reclaimed materials should be investigated.

The specification of new materials should take into account the impact of a range of environmental impacts, such as material extraction, processing, manufacture, transport, use and disposal. This should include all new building elements and finishes, such as insulation materials, windows, flooring, paints and landscaping. Guidance is available to assist in the selection of materials' environmental ratings, such as the BRE Green Guide to Specification.

Materials should be responsibly sourced, particularly non-reclaimed timber which be sourced from a Forest Stewardship Council (FSC) accredited source and compliance will be achieved with the UK Government Timber Procurement Policy.

The use of substances that have a significant Global Warming Potential or Ozone Depletion Potential should be avoided, such as insulating materials. The Volatile Organic Compound content of materials should be minimised.

## 7.3 Pollution

The design of new developments should mitigate all sources of pollution that could impact on the health and wellbeing of residents:

- **Air pollution** - pollution of both construction sites and completed developments should incorporate measures to limit pollution and to reduce exposure to it. Air quality assessments will demonstrate the impact of a new development on the existing level of air quality. On-site energy generation plant and space heating or domestic hot water systems should be specified with low $NO_x$ emissions. Air intakes should be located away from sources of pollution. Areas of recreational and pedestrian/cycling access should be separated from traffic.
- **Noise pollution** - to mitigate noise effects, acoustically absorbent surfaces, such as dense vegetation and soft ground, should be specified, mechanical plant and equipment should be located appropriately and fans provided with attenuation, and separating walls and floors should be detailed carefully to maximise sound reduction across them, beyond minimum Building Regulation standards. Specialist advice from an acoustic specialist may be required.
- **Lighting pollution** –external lighting should be designed to minimise light lost to the sky, with a high downward component, and with appropriate lighting controls such as PIR detectors and daylight sensors. A useful guide for avoiding this is available from the Institute of lighting engineers[8].
- **Construction impacts** – contractors should participate in the Considerate Constructors scheme to ensure sites are managed to minimise impacts on the local community and the environment. This includes the control of dust, emissions and pollution from construction and demolition.

## 7.4 Biodiversity and ecology

Biodiversity is an essential consideration for sustainable development. Issues, such as wild species and their habitats, the natural quality of open spaces and enhancing access to natural places should be addressed as part of development design. Open and green spaces can also help to enhance urban areas in many respects - educationally, socially, culturally, and visually. In green spaces, biodiversity is an important issue.

Developments will ideally be located on sites which are classified as having a low ecological value. However, where this is not possible, key considerations are:

- Protecting existing features of ecological value
- Enhancing the ecological value of sites through measures such as the planting of native species, installation of bird and bat boxes,
- Provision of green roofs and green walls, including proper design and maintenance – in addition to the enhancement of biodiversity, green roofs also help to mitigate the urban heat island effect, reduce surface water run-off, provide improved thermal insulation to buildings, and assist in mitigating the effects of air pollution.

[8] *Guidance on the Reduction of Obtrusive Light (2005)*

Guidance from a specialist ecological consultant is likely to be required to demonstrate that these objectives have been met.

## 7.5 Management

In order to ensure that new dwellings are operated appropriately, efficiently and effectively, home user guides should be provided to occupants to provide adequate information and guidance on their dwelling.

## 7.6 Water

### 7.6.1 Water demand

Getting fresh drinking water into our homes results in relatively low carbon emissions, compared to other utilities. However, water can be a scarce resource, especially in hot summers, which we are likely to see more of in the future. Water is also quite an expensive utility. Often called “the forgotten utility”; in the UK we cannot switch suppliers of water and often pay as much for water as we do for gas or electricity. Hence reducing water demand is often more cost effective than energy efficiency.

Water demand can be reduced significantly at little or no cost by specifying low flow appliances, such as dual flush toilets and aerating taps. Rainwater recycling can also be installed, which is more costly but usually provides a reasonable payback period. In addition, where very high standards of water conservation are sought, Greywater recycling can be included, directing waste water from sinks or showers for use in toilets.

The Code for Sustainable Homes (CSH) contains mandatory credits for water use. To achieve levels 3 and 4, water use must be reduced to 105 litres per person per day (based on a standardised calculation of estimated demand). In most cases, this can be achieved with low flow appliances. To achieve CSH levels 5 and 6 requires further reductions in demand, meaning rainwater recycling is usually required. BREEAM also awards credits for reducing water demand, both internally and externally.

### 7.6.2 Sustainable urban drainage systems (SUDS)

The aim of SUDS is to reduce peak pressure on drainage systems during heavy rainfall. Heavy rainfall can result in flooding, pollution and damage to property and the local environment. SUDS systems work by either diverting water away from main drainage systems, or storing the water and letting it drain away slowly over a 24 hour period. If ground conditions are right, soakaways and permeable paving can be used that let water flow directly to the ground. “Green roof” or “Brown roof” systems may also contribute to the attenuation of water. If none of these options are possible, rainwater holding facilities are required. Rainwater can be held below ground in oversized pipes (with a bottleneck to the main drain), or in swales/ponds to create a landscaped water feature.

The environment agency has comprehensive online maps covering the UK which show flood risk from rivers. They can be searched by postcode from their website, and show areas defined as being at high risk from flooding. The strategic flood risk assessments for each authority will update the Environment Agency flood risk maps, once published.

To achieve any level of the CSH, developments must “ensure that run-off rates and annual volumes of run-off post development will be no greater than the previous conditions for the site”. This is a mandatory requirement for CSH, with credits also awarded under BREEAM. New developments are often also set run off limits by the water utility provider, which can be more stringent than the CSH/BREEAM requirements.

## 7.7 Checklist

- Has the waste hierarchy been adhered to?
- Has a Site Waste Management Plan been used to ensure resource efficiency?
- Has a WRAP assessment been carried out?
- Have materials been selected on the basis of their environmental impacts?
- Are materials sustainably and responsibly sourced?
- Have all sources of pollution been mitigated?
- Have developments enhanced the ecological value of the site?
- Are green roofs and walls proposed?
- Will Home User Guides be provided to occupants?
- Has consideration been given to water demand?
- Is a Sustainable Urban Drainage system appropriate?

# 8 Sources of further information

Code for Sustainable Homes, e.g.
*http://www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/*

TCPA - Sustainable Energy by Design
*http://www.tcpa.org.uk/pages/sustainable-energy-by-design.html*

Urban Design Compendium
http://www.urbandesigncompendium.co.uk/

BRE guidance – e.g. Environmental Site Layout Planning -
*http://www.brebookshop.com/details.jsp?id=29619*

Energy Saving Trust guidance, e.g.
http://www.energysavingtrust.org.uk/business/Business/Building-Professionals

Carbon Trust guidance, e.g.
http://www.carbontrust.co.uk/policy-legislation/Business-Public-Sector/Pages/building-regulations.aspx

CIBSE guidance, e.g.
*http://sustain.cibse.org/*

Environment Agency
*http://www.environment-agency.gov.uk*

WRAP
*www.wrap.org.uk*

NISP
*www.nisp.org.uk*

# Glossary

The following glossary explains some of the key technical terms used in this guidance.

| | |
|---|---|
| Code for Sustainable Homes (CSH) | The UK government administered process by which the sustainability of homes is assessed. CSH has replaced Ecohomes. |
| BREEAM | BREEAM, in this context, is the assessment tool used to assess the sustainability performance of non-residential properties. BREEAM is privately administered by BRE Ltd. |
| Heating, Ventilation and Air Conditioning (HVAC) | HVAC is the generic term applied to the systems incorporated into building to provide thermal comfort and fresh air. |
| Zero Carbon Homes (ZCH) | ZCH is the term used to describe UK government's goal of achieving homes that create no carbon emissions from energy use within the home (including those not regulated under existing Building Regulations). The definition of zero carbon has yet to be fully resolved, particularly with respect to allowing off-site carbon reduction measures to be considered as carbon reduction measures for individual properties. |
| Sustainable Urban Drainage (SUDS) | A range of drainage measures designed to reduce overall water volumes and maximum flow rate into sewers our other discharge points from development sites. Examples are described in the report. |
| Low and zero carbon (LZC) technology | LZC refers to any technology designed to achieve an overall carbon reduction. It is largely used to refer to energy efficiency and the renewable energy measures but also includes a lower carbon generation technologies which may not be wholly utilise renewable energy sources, e.g. heat pumps which use electricity as the primary energy source. |
| Combined heat and power (CHP). | Any device that generates both thermal and electrical call energy. Combustion engines, turbine devices and fuel cells are the most common systems available. |
| Biomass and Biofuels | Any fuel that is derived from organic materials. There are a range of specific definitions with a set of standards in development for biomass (CEN/TC 335). Biofuels refer to biomass energy produced in liquid form, e.g. Biodiesel, bio ethanol |
| Renewable Heat Incentive (RHI): | The new tariff structure introduced in the UK Climate Change Bill 2009 that we provide revenue for the generation of the heat from renewable sources. The rules for RHI are due to be formalised by 2011. |
| Feed-in tariff (FIT) | The new tariff structure introduced in the UK Climate Change Bill 2009 that we provide revenue for the generation of the electricity from renewable sources. The rules for RHI are due to be formalised by 2010. |
| Coefficient of performance (CoP). | CoP is a standard term used to describe the performance of Heat Pump devices. It describes the units of energy delivered from the primary energy used, i.e. kWh of electricity in for kWh of thermal energy out. |

| | |
|---|---|
| Hydraulic Interface Unit. | The unit that which connects a buildings internal thermal distribution network to the external heat mains of a community /district heating network |
| Photovoltaics | An electrical generation devices that converts solar energy |
| Energy Services Company (ESCO). | An organisation that manages (and may own) the energy supply infrastructure |
| Rainwater recycling | Collection of re-use of rainwater as opposed to diverting it to drainage infrastructure. |
| Greywater recycling | Collection of re-use of water from sinks, baths and showers often for use in toilets. |
| Shadow Flicker | Shadow Flicker is the phenomenon caused by sunlight being ‘chopped’ by wind turbine blades as they spin. This can cause a distracting flicker of light where the wind turbine sits between the line of sight between the sun and the viewpoint. Where it exists it is an intermittent problem (due to the nature of the moving position over the sun across the day and the across the year). Winter is most problematic as the sun is lower in the sky and the more significant impacts occur in residential living spaces or offices. The likely impact of shadow flicker can be assessed by modelling. |
| Private Wire Network | Private wire systems are localised electricity grids, which although connected to the local distribution networks have privately owned central plant that produces electricity. This enables it to operate a stand-alone supply in the event of the national grid failing. This provides localised energy security and offers the opportunity of tying consumers with the electricity producers |

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