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WNDC - Technology Review
Review of technologies and approaches for new developments

West Northamptonshire Development Corporation
March 2010

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WNDC - Technology

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Table of Contents

1 **Introduction** 4
- 1.1 Purpose of Guide 4
- 1.2 Scope of Guide 4

2 **Environmental Benchmarking & Assessment Schemes** 7
- 2.1 Background 7
- 2.2 Code for Sustainable Homes 8
- 2.3 PassivHaus 10
- 2.4 BREEAM 11
- 2.5 CEEQUAL 14
- 2.6 Summary of Environmental Benchmarking & Assessment Schemes 15
- 2.7 Further Information 16

3 **Passive Design** 18
- 3.1 Background 18
- 3.2 Orientation 19
- 3.3 Building Form 19
- 3.4 Shelter Beds 20
- 3.5 Thermal Mass 20
- 3.6 Daylighting 20
- 3.7 Shading Systems 21
- 3.8 Natural Ventilation 23
- 3.9 Further Information 24

4 **Energy Efficiency** 26
- 4.1 Background 26
- 4.2 Insulation & Thermal Bridging 26
- 4.3 Air Tightness 26
- 4.4 Building Services 27
- 4.5 Further Information 32

5 **Low & Zero Carbon Energy** 34
- 5.1 Background 34
- 5.2 Combined Heat & Power (CHP) 35
- 5.3 Micro-CHP 36
- 5.4 Biomass 38
- 5.5 Solar Thermal 40
- 5.6 Solar Wall 41
- 5.7 Solar Electricity 42
- 5.8 Wind Technology 45
- 5.9 Air Source Heat Pumps 47
- 5.10 Ground Source 48
- 5.11 Waste to Energy 50
- 5.12 Site Suitability 51
- 5.13 Calculation of CO_2 savings 51
- 5.14 Revised CO2 Emission factors 54
- 5.15 Financial Incentives 54
- 5.16 Further Information 56

6 **Water and Drainage** 58
- 6.1 Background 58
- 6.2 Efficient Water Use 58
- 6.3 Water Reuse 62
- 6.4 Rainwater Harvesting Systems 69
- 6.5 External Water Use 73

6.6 Sustainable Urban Drainage ... 74
6.7 Reed Beds ... 77
6.8 Further Information ... 78

7 Materials ... 80
7.1 Background ... 80
7.2 Green Guide to Building Specification ... 80
7.3 Reclaimed Materials ... 81
7.4 Natural Material Selection ... 82
7.5 Natural Building Fabric Recommendations ... 83
7.6 Insulation Materials ... 84
7.7 Ozone Depletion ... 84
7.8 Cement Substitutes ... 84
7.9 Timber from Sustainable Sources ... 85
7.10 Modern Methods of Construction ... 85
7.11 Further Information ... 87

8 Waste & Recycling ... 89
8.1 Background ... 89
8.2 Sustainable Waste Management ... 89
8.3 Waste reduction ... 90
8.4 Solid Wastes ... 90
8.5 Waste Recycling ... 91
8.6 Construction Waste ... 91
8.7 Site Waste Management Plans ... 91
8.8 Demolition ... 92
8.9 Deconstruction ... 92
8.10 Further Information ... 93

9 Pollution ... 95
9.1 Background ... 95
9.2 Key Issues ... 95
9.3 Further Information ... 96

10 Health & Wellbeing ... 98
10.1 Background ... 98
10.2 Key Issues ... 98
10.3 Further Information ... 98

11 Transport ... 100
11.1 Background ... 100
11.2 Key Issues ... 100
11.3 Further Information ... 102

12 Landuse & Ecology ... 104
12.1 Background ... 104
12.2 Key Issues ... 104
12.3 Further Information ... 105

13 Construction Management ... 107
13.1 Considerate Constructors Scheme ... 107
13.2 Use of Local Labour and Materials ... 107

14 Strategic Scale LZC Technologies ... 109
14.1 Background ... 109
14.2 Large Scale Wind Generation ... 111
14.3 District Heating ... 115
14.4 Biomass ... 117
14.5 Large Scale Biomass CHP ... 120
14.6 Waste to Energy ... 121

15 Exemplar Scheme Review ... 125
15.1 Introduction ... 125
15.2 ProLogis Distribution Centre - Pineham ... 126

15.3 Oak Meadow, South Molton (Formerly Livarot Walk) 128
15.4 British Timken - Northampton 130
15.5 Innovate Green Office, Thorpe Park, Leeds 132
15.6 Upton Residential Development – Northampton 134
15.7 Queens Building - De Montfort University 136
15.8 Wind Turbine Example – Reading 138

16 Conclusion 140

Appendix A - Technology & Approach Matrix 142

Appendix B - Broad Principles for Site Suitability 159

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Introduction

Introduction

1.1 Purpose of Guide

West Northamptonshire Development Corporation (WNDC) is responsible for enabling and managing significant development growth in the areas of Northamptonshire, Daventry and Towcester. The purpose of this guide is to provide practical advice on the Sustainable Design and Construction in all new developments in the area. The guide provides an impartial and comprehensive review of sustainable and low carbon technologies and approaches to all types and scales of development.

This document forms one section of the Sustainability Manual that has been prepared for WNDC. However it has also been structured to be read as a standalone document if required.

Given the rapid speed in which the policy drivers and technologies are evolving in the UK, every effort has been made to provide up to date information for each technology and approach. Therefore the implications of issues discussed in this guide are correct at the time of writing.

1.2 Scope of Guide

The structure of the guide includes:

1. A review of sustainability benchmarking methods and assessment schemes which include: Code for Sustainable Homes; PassivHaus; BREEAM; & CEEQUAL.

2. A review of technologies and approaches appropriate to address the Sustainable Design and Construction (SDC) at a development scale. The Guide describes aspects of SDC that could be employed in developments in the West Northamptonshire region once the site has been selected. It therefore refers to the wide range of issues related to SDC within the boundary of a development site for all types of buildings (including domestic and commercial) such as:

   - Passive Design
   - Energy Efficiency
   - Low & Zero Carbon Energy
   - Water and Drainage
   - Materials
   - Waste & Recycling
   - Pollution
   - Health & Wellbeing
   - Transport
   - Land Use & Ecology
   - Construction Management

   These issues are generally covered in environmental assessment schemes such as Code for Sustainable Homes and BREEAM. The principles of these two schemes are discussed first followed by sections for each major issues listed above.

3. A review of LZC technologies and approaches appropriate at a strategic scale. The strategic scale options considered in this section are technologies and approaches that could support a larger portion of the community beyond the scope of a single development.

4. A review of a number of exemplar local, regional and national developments that provide information on a range of developments that have successfully implemented advanced sustainability standards.

The sustainability guide is followed by a technology and approach matrix in appendix A. This matrix has been designed to help both developers and WNDC officers identify the suitability of a particular technology and or approach for a development. The matrix therefore provides a quick overview of each technology and or approach that is covered in depth in the guide text. Reference to further information is also provided.

To understand the ever increasing number of acronyms and terms covering sustainable development a glossary of terms can be found at:

http://www.thenbs.com/topics/Environment/Glossary/index.asp

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Environmental Benchmarking & Assessment Schemes

Environmental Benchmarking & Assessment Schemes

1.3 Background

The environmental benchmarking and assessment schemes identified include Code for Sustainable Homes and PassivHaus standards for dwellings, BREEAM for non dwellings and CEEQUAL for infrastructure projects.

This section includes a summary of the following benchmarking and assessment methods:

- Code for Sustainable Homes (Code)
- PassivHaus
- Building Research Establishment Environmental Assessment Method (BREEAM)
- Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL).

1.4 Code for Sustainable Homes

The Code for Sustainable Homes is an environmental assessment system for new housing in England, which was introduced in April 2007 as a result of the UK Government's strategy for sustainable development – 'Securing the Future'.

Since May 2008 it has been a mandatory requirement for all new homes to include a Code certificate in the Home Information Pack when a property is marketed; although this doesn't require the developer to undertake a full Code assessment as a nil rating certificate is acceptable. At present, the Homes and Communities Agency (HCA) require new social housing to achieve a Level 3 Code rating – soon to be officially increased to Level 4. Consequently residential developers are applying Code to the affordable units within their developments in order to receive HCA funding support.

Some developers adopt Code for all dwellings, including private, either because of local policy requirements (usually level 3 or 4), or occasionally as a marketing opportunity.

The Code is based on the earlier Building Research Establishment's (BRE) EcoHomes scheme (new development) and assesses a development against a set of criteria under nine key categories.

The Code awards a rating to each dwelling type within the development based on a scale of Level 1 to 6 (denoted by stars) (Table 2.1). The rating depends on whether the dwellings meet a set of mandatory standards for each level, as well as an overall score (Table 2.1).

Table 2.1: Minimum requirements for the six levels under the Code:

	Minimum Entry Requirements		
Code Levels	Energy Improvement over Target Energy Rating	Water litres/person/day	Total Points Score out of 100
Level 1 (★)	10%	120	36
Level 2 (★★)	18%	120	48
Level 3 (★★★)	25%	105	57
Level 4 (★★★★)	44%	105	68
Level 5 (★★★★★)	100%	80	84
Level 6 (★★★★★★)	Zero Carbon	80	90

The Target Energy Rating is the requirement of the 2006 Building Regulations and the percentage improvement refers to the CO_2 emissions, excluding appliance use. Zero carbon for Level 6 means that the net CO_2 emissions of the dwellings over the year including all energy uses (appliances), is zero. Mandatory requirements exist under the following credits:

- Energy (see Table 2.1)
- Water (see Table 2.1)
- Embodied Impacts of Construction Materials
- Surface Water Runoff
- Construction Site Waste Management
- Household Waste Storage Space and Facilities.

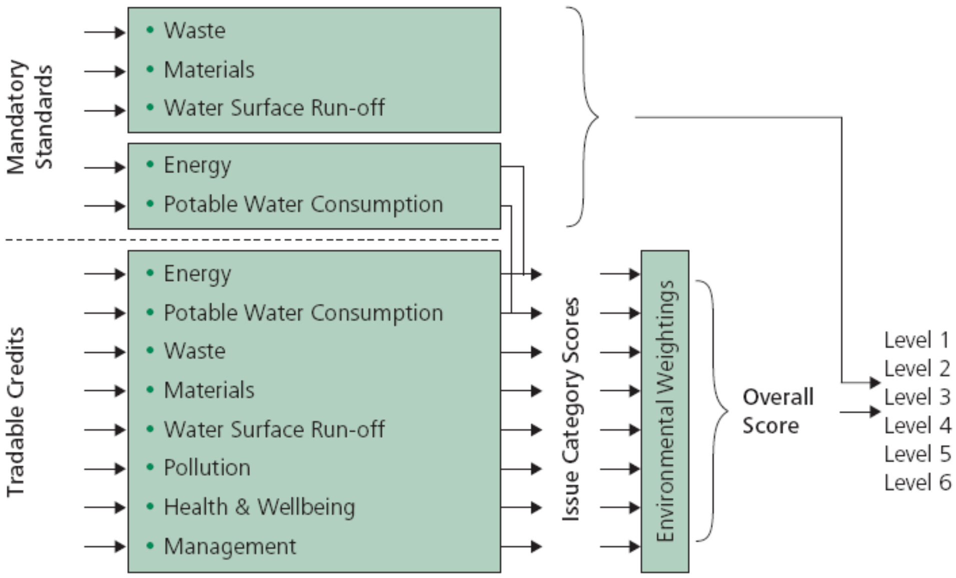
The credits achieved for each dwelling type are then multiplied by the environmental weighting factor for each category to calculate the number of points achieved (Table 2.2).

Table 2.2: Environmental Weighting Factors for each category under the Code

Environmental Impact Categories	No of Credits	Environmental Weighting Factor
Category 1 – Energy/CO2	29	36.4%
Category 2 – Water	6	9.0%
Category 3 – Materials	24	7.2%
Category 4 – Surface Water Run-off	4	2.2%
Category 5 – Waste	7	6.4%
Category 6 – Pollution	4	2.8%
Category 7 – Health & Wellbeing	12	14.0%
Category 8 – Management	9	10.0%
Category 9 – Ecology	9	12.0%

Non-mandatory credits are tradable and allows for some degree of flexibility when targeting credits to achieve the desired Code rating. See Figure 2.1 below.

Figure 2.1: Code from Sustainable Homes Weighting Process, Code for Sustainable Homes Technical Guide, March 2007, Department for Communities and Local Government.



The first stage of the process is for a qualified Code Assessor to register a housing site with BRE as soon as the requirement for the Code is known – this registration lasts for five years. This enables the version of the Code to be set such that even if the Code is updated (say every two years), the version of the Code used across the site will remain the same.

Code Assessments are carried out in two stages:

- The first part of the assessment is carried out at the design stage (called the Design Stage Assessment) and each 'Code Dwelling Type' is given an 'Interim' Code certificate.
- The second part is carried out after construction (called the Post Construction Stage) – and each 'Dwelling' is given a 'Final' Code certificate on completion of the assessment. Post construction stage assessments can be carried out on each dwelling as it is completed.

1.5 PassivHaus

The term PassivHaus refers to a voluntary, low energy building standard developed by Dr Wolfgang Feist of the PassivHaus Institute in Germany. The core focus of PassivHaus is to design buildings that have a minimal heating and cooling load without compromising the comfort and health of the occupants. The PassivHaus standard primarily focuses on reducing the energy demand of buildings through passive measures. Other sustainability considerations such as water and waste are not covered by this standard.

Although the PassivHaus standard has been developed in Northern Europe specifically for their climatic conditions, the standard is slowly becoming more prevalent in the UK.

Basic Principles

A dwelling which achieves the PassivHaus standard typically includes:

- Very good levels of insulation with minimal thermal bridges
- Well thought out utilisation of solar and internal gains
- Excellent level of air tightness
- Whole house mechanical ventilation system with highly efficient heat recovery

By specifying these features the design heat load is limited to the load that can be transported by the minimum required ventilation air with a 1kW peak heat output. The focus of reducing the heating and cooling demand of a building is to avoid the need of a traditional heating system or active cooling to be comfortable to live in – if designed accordingly the small heating demand can be typically met using a compact services unit which integrates heating, hot water and ventilation in one unit (although there are a variety of alternative solutions).

A dwelling is deemed to satisfy the PassivHaus criteria if:

- The total energy demand for space heating and cooling is less than 15 kWh/m^2/yr treated floor area; and
- The total primary energy use for all appliances, domestic hot water and space heating and cooling is less than 120 kWh/m^2/yr

Example outline specification for a Passivhaus in the UK:

Issue	PassivHaus standard
Compact form and good insulation:	Exterior shell achieves a U-value that does not exceed 0.15 W/m^2/K
Southern orientation and shade considerations:	Passive use of solar energy
Energy-efficient window glazing and frames:	Windows (glazing and frames, combined) should have U-Values not exceeding 0.80 W/m²/K
Building envelope air-tightness:	Air permeability value of less than 1 m^3/hr/m^2 @ 50 Pa
Passive preheating of fresh air:	Fresh air may be brought into the house through underground ducts that exchange heat with the soil.
Highly efficient heat recovery from exhaust air using an air-to-air heat exchanger:	Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air
Energy-saving household appliances:	Low energy refrigerators, stoves, freezers, lamps, washers, dryers, etc. are indispensable in a PassivHaus.
Total energy demand for space heating and cooling:	Less than 15 kWh/m^2/yr

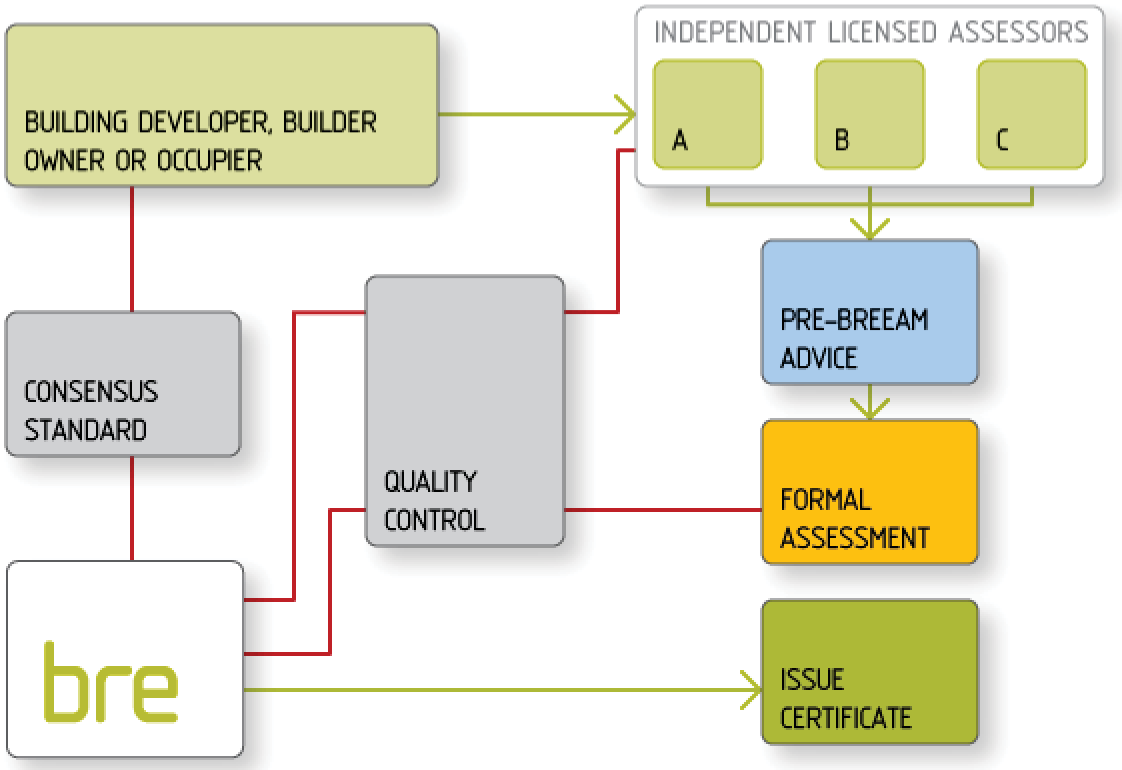
1.6 BREEAM

BREEAM (Building Research Establishment Environmental Assessment Method) is the world's longest established and most widely used environmental assessment method for non-domestic buildings. It sets the standards for better practice in sustainable development and demonstrates the level of achievement of a building's environmental performance.

The BRE is the certification and quality assurance body for BREEAM ratings. BREEAM assessments are carried out by professionals who have been trained by the BRE and hold a licence to deliver BREEAM ratings.

The process for delivering a BREEAM assessment is shown in Figure 2.4.

Figure 2.4: Process flow chart for BREEAM



Clients, planners, development agencies, funders and developers are using BREEAM to specify the sustainability performance of their buildings in a way that is consistent, comprehensive and visible in the marketplace.

Current building methods can result in unnecessary energy usage, large quantities of waste, poor occupancy comfort and low user satisfaction. BREEAM can address the environmental impact of these issues and provide a range of benefits to all involved with buildings. In general, BREEAM aims to:

- Reduce the environmental impacts of developments
- Enable developments to be recognised according to their environmental benefits
- Provide a credible, environmental label for buildings
- Stimulate demand for environmentally sustainable buildings.

BREEAM was originally developed in the early 1990s and since then it has undergone a number of changes to keep it up to date in line with Best Practice, Government Legislation, EU Directives and public pressure. With each revision the BREEAM assessment method has become more onerous, requiring developers to strive harder to achieve the environment ratings. The 2006 version is still current for buildings registered before 1st August 2008; however buildings registered after this date will be required to be assessed by the 2008 methods.

The 2008 assessment method has marked a distinct change from previous versions by adopting mandatory credits that must be achieved in order to obtain a given rating. This is similar to the method adopted by the Code for Sustainable Homes, which requires minimum standards to be achieved for targeted categories. The new 2008 BREEAM assessment process also only awards an interim certificate at Design and Procurement stage and there is now a requirement to carry out a Post Construction Review Assessment on the completed building to obtain final certification.

There are several Assessments types for BREEAM (listed below), each designed to cover common building types. For less common building types, 'bespoke' assessments can be produced by the BRE tailored to the specific functions of the building. For buildings outside the UK, assessments can be made using BREEAM International methodology. The various BREEAM versions are listed below:

- BREEAM : bespoke
- BREEAM : courts
- BREEAM : ecohomes (for retrofit dwellings only)
- BREEAM : ecohomesXB
- BREEAM : industrial
- BREEAM : multi-residential
- BREEAM : prisons
- BREEAM : offices
- BREEAM : retail
- BREEAM: schools
- BREEAM : further education
- BREEAM: healthcare.

In each assessment, issues are assessed under a number of categories with credits being awarded for attaining certain benchmarks. Credits are awarded in each of the categories below according to performance:

BREEAM 2006	BREEAM 2008
Management	Management
Health and Wellbeing	Health and Wellbeing
Energy	Energy
Transport	Transport
Water	Water
Material and Waste	Material
Land Use and Ecology	Waste
Pollution	Land Use and Ecology
	Pollution

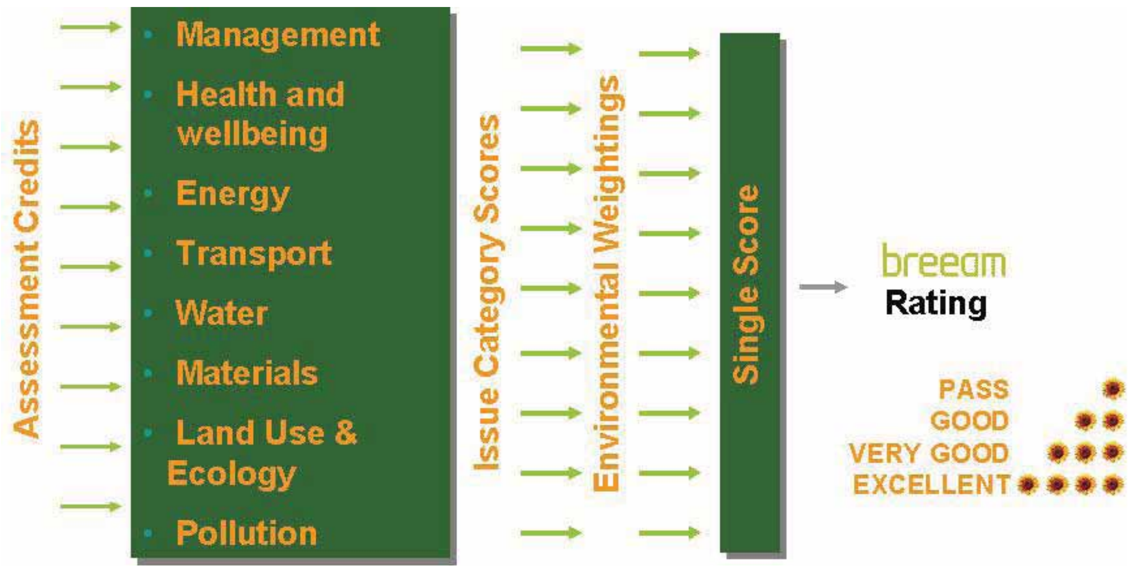
Developers and designers are encouraged to consider these issues at the earliest opportunity to maximise their chances of achieving a high BREEAM rating. The actual categories and their weighting as a component of the final score varies from building use to building use to reflect the way in which they are operated. The environmental weightings enables the credits to be added together to produce a single overall score (see Figure 2.3).

Credits are awarded in each area according to performance. The building is then rated on a scale of:

BREEAM RATING	% Score
UNCLASSIFIED	<30
PASS	≥30
GOOD	≥45
VERY GOOD	≥55
EXCELLENT	≥70
OUTSTANDING (2008 Scheme)	≥85

A certificate is awarded that can be used for promotional purposes.

Figure 2.3: BREEAM credits and scoring system



1.7 CEEQUAL

The Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) provides a methodology by which to assess the sustainability of infrastructure projects in a manner similar to the way BREEAM assesses retail or industrial developments, for example. The detail of CEEQUAL is very different and a single scheme has the capacity to assess a broad scope of infrastructure projects from stream bank stabilisation works to pipelines to major freeway or sewage treatment developments.

Similar to BREEAM and Code for Sustainable Homes, CEEQUAL assesses a range of environmental and social considerations. Currently, Version 4.1 assesses the following themes:

- Project Management
- Land Use
- Landscape Issues (rural and townscape)
- Ecology and Biodiversity
- The Historic Environment
- Water Resources and the Water Environment
- Energy and Carbon
- Material Use
- Waste Management
- Transport
- Effects on Neighbours
- Relations with the Local Community and other Stakeholders.

CEEQUAL has a number of awards available depending on the structure of the project team and the commitment of the client, design team and contractors.

The awards are:

- Whole Project Award: for a joint application by the Client, Designer and Principle Contractor
- Client & (Outline) Design Award: available as an interim award prior to detailed design for Whole Project Awards
- Client & Design Award: for a joint application by the Client and Designer
- Design Award: for principle Designers only
- Design & Build Award: for a joint application by the Contractor and their Designer
- Construction Award: for Principle Contractors only.

The Award thresholds based on the determination of the assessor and verifier for a particular project are as follows, based on exceeding minimum legal requirements:

CEEQUAL RATING	% Score
PASS	≥25
GOOD	≥40
VERY GOOD	≥60
EXCELLENT	≥75

1.8 Summary of Environmental Benchmarking & Assessment Schemes

BREEAM and Code are both schemes that could be considered for all large developments by Local Planning Authorities in West Northamptonshire when assessing the sustainability credentials of proposed applications. These schemes would be directly relevant to Development Control, as they provide an approved and impartial mechanism for assessing the sustainability issues.

The Government set out in its Building a Greener Future - Policy Statement (July 2007) that new homes will be net zero carbon from 2016. As steps to achieving this target, energy efficiency standards for new homes are to be improved by 25% in 2010 and 44% in 2013 relative to current 2006 standards.

These proposed targets are to be met through the revision of the Building Regulations Part L which is reflected by the Code credit Ene 1 - Energy and Carbon Dioxide Emissions. Anticipated changes to Part L will continue to be reflected in Ene 1 as part of the following trajectory:

- 2010 Code level 3 25% CO_2 reduction
- 2013 Code level 4 44% CO_2 reduction
- 2016 Code level 5 100% CO_2 reduction

Despite the proposed changes to Part L, achieving Code level 3 will not become a Government legislative requirement for new developments. This will only be a requirement if stipulated by local planning policy or a funding body, such as the HCA.

The PassivHaus standard has been provided more for information. Developments that aspire to meet, or achieve accreditation by the PassivHaus standards will exceed the minimum energy requirements at a local or national level. However it is currently very rare for planning policy to make any requirements for PassivHaus.

For large developments that require major ground works or infrastructure a CEEQUAL assessment could be used to assess the impact of ground works.

1.9 Further Information

Code for Sustainable Homes:

http://www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/

PassivHaus:

http://www.passivhaus.org.uk/

BREEAM:

http://www.breeam.org/

CEEQUAL:

http://www.ceequal.co.uk/

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Passive Design

Passive Design

1.10 Background

Passive Design involves consideration of the built form and its relationship with natural forces such as solar radiation and wind. Passive design strives to reduce energy demands as far as possible before using the more active technologies. There are a wide range of techniques and these will be very building specific.

Passive design should not be mistaken with energy efficiency (covered in chapter 4) which focuses on the energy efficient specification of plant and technologies. The distinction between some approaches, such as limiting heat loss through insulation and air tightness, could be included in either passive design and/or energy efficiency. For the purpose of this guide these issues are dealt with in the energy efficiency section.

The main aspects to consider are:

- Orientation
- Building shape, height and depth
- Landscaping e.g. use of trees for shading
- Thermal mass
- Window areas and external shading, balancing daylighting with heat loss/gain.

The importance of considering passive design is that there is a one-off opportunity at the early conceptual design stage to influence energy use of the building for its lifetime.

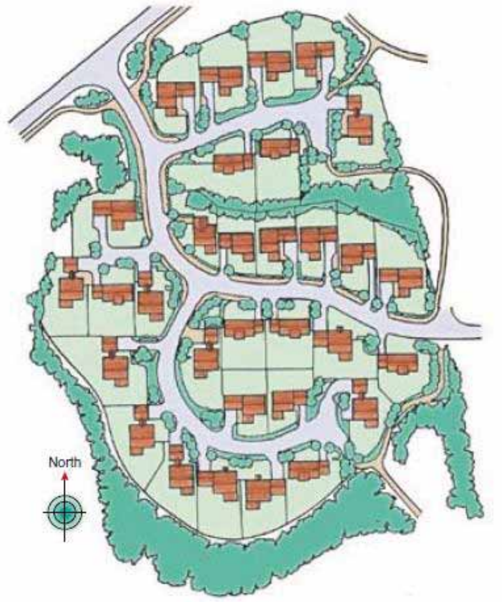
Designing individual dwellings/buildings that maximise the potential of solar gain during the heating season and limit solar gain during the cooling season requires careful daylight analysis. This can be undertaken using computer simulation software. A comprehensive understanding of how the sun path and trajectory will impact on the dwellings heating and cooling load, will help inform such things as building orientation, form and window design.

1.11 Orientation

"Passive solar" derives from the design of a building to maximise the benefits of natural elements, particularly solar energy, daylight, wind, natural ventilation and thermal mass, without relying on any "active" components such as fans or pumps. All new buildings can be designed, and existing buildings renovated, to improve their passive performance by understanding the principles and following simple rules.

Housing and road layouts should be designed to maximise the number of units with a north/south orientation. This will allow main living areas to face south and make maximum use of passive solar gains for heating. It will also allow the use, or at least the future use, of roof-mounted solar water heating or photovoltaic panels. The nearer the orientation is to due south, the greater the solar gains. Residential roads running east-west produce housing plots with good solar orientation. There are a number of ways that houses on roads running north-south can be given southerly orientation, such as placing larger detached houses one plot deep at intervals along the road and arranging houses in groups around parking courts or short cul-de-sacs off north-south roads.

Overshadowing by adjacent buildings or by trees should be avoided where possible as this will reduce access to solar energy for heating and daylight (this may be harder in high density developments but can be minimised through good design). For details about solar shading refer to section 3.7.



The BRE's Site Layout Planning for Daylight and Sunlight, and General Information Leaflet (GIR) 27 'Passive Solar Estate Layout, provides detailed guidance on these aspects. Image 3.2 sourced from the EST Guide GIR27 – Passive Solar Estate Layout.

Good practice suggests that sloping roofs should include a component that faces within 45% of south that will provide an appropriate location for the provision of solar water heating or photovoltaic systems now or in the future. The optimum slope for renewable energy generation in the UK is around 30^o from horizontal.

1.12 Building Form

Along with orientation the building form (shape height and depth) can achieve a significant impact on a building's heat loss/gain, ventilation and daylighting potential.

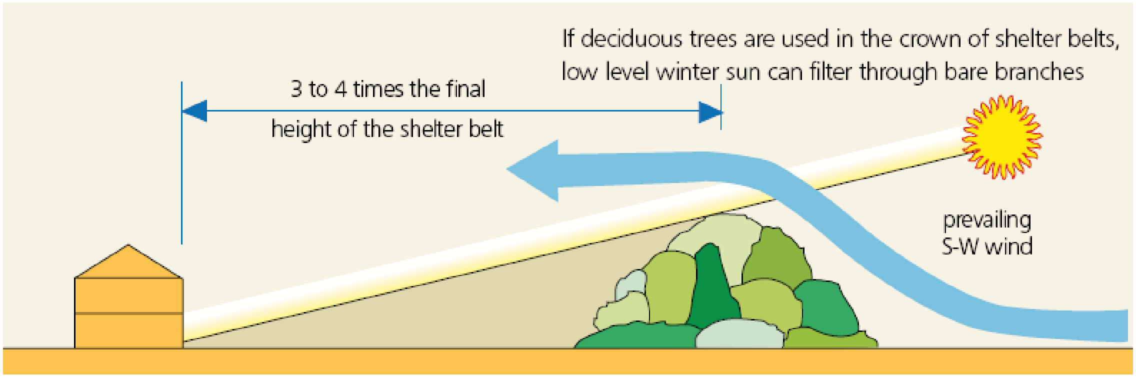
The effect of building form on heat loss is largely a function of the degree of envelope exposure to outdoor temperature and wind. The form will affect wind channelling and air flow patterns contributing to heat loss, and large facade areas will increase the amount of heatloss through the building fabric.

Opportunities for enhancing the use of natural daylight and ventilation require careful design especially in regard to depth of the floor plate. Shallow floor plates offer improved potential natural ventilation and daylighting. Care must be taken with complex geometric shapes and projecting wings as they tend to create overshadowing.

1.13 **Shelter Beds**

Planting should be considered where appropriate on developments (in advance of construction starting) to both screen the development and construction works from distant views, to provide shelter from prevailing winds and to provide habitat for wildlife. Shelter belts should be located 3 to 4 times the final height of the shelter belt away from development. Deciduous trees can be used to provide shade in summer, while allowing for solar gain in winter.

Image sourced from Energy Savings Trust GIR27 – Passive solar estate layout



1.14 **Thermal Mass**

There is still much debate regarding the benefits of thermal mass against the benefits of light-weight construction. Thermal mass is generally designed into buildings to prevent temperature fluctuations within a conditioned space. The mass acts as a thermal store by absorbing excessive internal gains in order to prevent overheating (such as in offices). For dwellings thermal mass provides an opportunity to harvest solar energy during the day that will temper the heating demand in the evening when occupants are generally home and heating is required.

Although thermal mass can provide a benefit in tempering temperature fluctuation, the building is less responsive than a light-weight construction and may create a higher heating demand for intermittent occupation in a dwelling if excessive mass is introduced. This is because the thermal mass will absorb the energy before the space is sufficiently conditioned, resulting in more energy being introduced to maintain comfortable internal temperatures.

Thermal mass has been introduced into the 2010 SAP methodology currently under consultation. If adopted the careful use of thermal mass within a dwelling will offer an improved SAP rating for dwellings.

1.15 **Daylighting**

Daylighting not only provides a sense of wellbeing for the occupant but can provide one of the largest energy savings in a development. This is especially true for offices, provided adequate control is incorporated to reduce glare and solar overheating. This energy saving is created by the reduction of daily usage of the artificial lighting systems, which can account for up to 40% of an office’s total electricity consumption.

The principle measurement to quantify the amount of daylight entering a building is a ‘daylight factor’. A daylight factor is a numerical ratio used to describe the relationship between indoor and outdoor daylight illuminances (typically under overcast sky conditions).

When incorporating natural lighting, design considerations will include floor plan depth, glazed façade area, glazing type and room surface reflectance.

Floor plan depth:
To provide adequate natural daylight it is essential that the floor plan is sufficiently shallow to allow good daylight penetration. Generally the rule of thumb guide for good daylighting would be a maximum floor depth of two and a half times the window height. This doubles if the room is daylit from two opposite facades. Where it is not possible to provide a suitable floor plan depth for natural lighting, sun pipes may be investigated providing the building is under 3 stories in height. Sunpipes are effectively a tube lined with a highly reflective inner surface that can direct daylight into the building.

Glazed façade/floor area ratio:
The benefits of natural lighting have to be weighed against other considerations such as heat loss and heat gain. Larger areas of glazing will provide increased natural lighting, therefore reduce the dependency on artificial lighting, providing glare and solar gains are controlled. Generally designs for offices will try to limit the amount of solar gain whilst providing optimal natural lighting. Designs for dwellings will try to harness the solar gain to reduce the heating demand, whilst also providing natural light to all rooms.

Discomfort glare can lead to an increase in internal blinds being used, which then puts extra demand on the artificial lighting system. Also with large areas of glazed façade the benefit of natural lighting can be lost due to the extra demand for comfort cooling. This is especially evident in UK offices where an increase in cooling is occurring throughout the country as a result of façade treatment and rising temperatures attributed to climate change.

Solar control glazing:
Special solar control glass can reduce the total rate of heat transfer by increasing either the absorbed or the reflected component. Glazing is available with a range of selective coatings that alter the properties of the glass; ideally office glazing should be selected with the highest light transmittance and the lowest solar heat gain factor. This will help provide daylight while reducing solar gains. All major glass manufacturers provide data on the properties of their products, including those with coatings as described here.

Reflectance of internal surfaces:
The Internal reflectance of room surfaces are governed by two primary surface characteristics - colour and texture. The importance of interior surface reflectance becomes greater with increased distance between the lit area and the source of light illuminating it (window). Surfaces with high reflectance values such as white plastered walls will provide maximum daylight distribution within the space. Other ways of improving the daylight distribution could be to introduce light shelves. Light shelves are usually placed two thirds the way up the window and work by bouncing light off a highly reflective surface on to the ceiling. They are generally used in offices and schools to improve the daylight distribution towards the centre of a room.

1.16 Shading Systems

The traditional roles of shading systems are to improve thermal and visual comfort by reducing overheating and glare, and to provide privacy. Shading devices may perform one or all three roles. Shading devices may be designed to limit the amount of direct solar radiation entering the building by shielding the opaque as well as the transparent surfaces. A secondary role is to limit the diffuse and reflected radiation entering the building. The objectives of good shading can therefore be simply defined as:

- Moderating or blocking direct solar radiation at required periods
- Controlling diffuse and reflected radiation

- Preventing glare from external and internal sources.

Solar shading is usually grouped into one of three categories:

Fixed shading:
Fixed shading devices are usually external and highly visible and can provide important architectural opportunities. Typically they are in the form of horizontal overhangs, vertical fins or egg- crate (combined horizontal and vertical) devices. The recessed window is also a type of fixed shading device. They are relatively simple and inexpensive, and particularly effective at obstructing direct sunlight, but less effective against diffuse or reflected light. The horizontal overhang is the most common form of fixed shading device and is the simplest device for controlling high angle direct solar radiation. In the UK it is primarily used on the south façade. In fixed shading device design, the orientation of the aperture is the main determinant.

When correctly designed and used on the south-facing facade, the horizontal overhang can provide complete shading during midsummer and permit solar penetration in winter. To be most effective (i.e. to better control low-angled morning and afternoon sun) the overhang should extend sufficiently on both sides of the window aperture. Fixed devices do not generally provide effective protection from the low-angled sunlight of morning and afternoon, particularly on the east and west facades. Fixed vertical fins can give some protection, but tend to reduce internal illuminance. Carefully planned vegetation or moveable external devices give better control of the low-angled direct sunlight.

Retractable shading:
Retractable shading devices refer to those that are almost completely removable from the window area. They may be retracted to the upper or side portion of the window, or totally removed. Internal blinds and curtains fall under this definition, as do external devices such as fabric awnings, louvres and shutters. These devices avoid the compromise between adequate shading when required during the summer months and adequate sun access required during the winter months. They may however compromise ventilation requirements when providing full shading during periods of overheating. They can, however, be designed to minimise this effect.

Movable and adjustable shading:
Adjustable and moveable shading devices can be located externally, internally or between the panes of a double or triple glazed window. Adjustability is most often found in internal shading systems, where manipulation is readily achievable and relatively inexpensive. However, it can be applied to external systems in certain circumstances. An external adjustable device can be manipulated to exclude or admit sunlight when required, and is particularly effective in dealing with low-angled direct sunlight, diffuse and reflected light. Unlike fixed shading, it can be operated such that internal illuminance is not excessively reduced.

The success of movable and adjustable shading depends on robust construction and correct use and if automated, it can be expensive. Automation of adjustable external shading, if it is to be energy efficient, depends mainly on climate and the frequency of adjustment. Where adjustment is seldom, for instance on a seasonal basis only, automation could be considered.

The main concern with adjustable external shading systems, however, is durability: they require more maintenance and repair than fixed or internal systems.

1.17 Natural Ventilation

Where the measures listed above are implemented, it may be possible to reduce heat gains to the point where air-conditioning is unnecessary and where comfort conditions can be maintained through the use of natural ventilation. All development proposals should explore the use of natural ventilation and examine how the installed power of mechanical ventilation and air-conditioning systems can be reduced.

CIBSE Application Manual TM10 provides detailed guidance on the design of naturally ventilated buildings and helps to identify in what circumstances natural ventilation is likely to be effective. Good Practice Guide 237 provides similar information.

The most effective form of natural ventilation is cross ventilation, where air is able to pass from one side of a building to the other. For this to work effectively it typically dictates that buildings are no more than 15m in depth from façade to façade. However deeper plan spaces can be achieved by introducing central atria and making use of “stack effect” to draw air from the outer perimeter and up through the centre of the building.

Effective window design is essential in naturally ventilated buildings. Windows should allow ease of control by building occupants regardless of subsequent desk arrangements. They should also allow controlled ventilation that will not blow papers off desks, or cause draughts when background fresh air ventilation is required in winter.

Night ventilation can be an effective method of maintaining comfort conditions in summer. Where night ventilation is used, it is important that building occupants understand how the building is intended to be operated, or that effective control measures are introduced, as it is counter intuitive to open windows before leaving a building at night. Other factors to consider include maintaining security, and controlling wind and rain ingress. In some cases high external ambient noise levels or air pollution may prohibit the use of natural ventilation.

1.18 Further Information

CIBSE TM2351 sets out good and best practice air permeability rates for different building types; the best practice rates should be adopted for all buildings.

Energy Savings Trust has a number of useful best practice guides concerning passive design and energy efficiency in dwellings. The publications can be sourced from –

http://www.energysavingtrust.org.uk/housingbuildings/publications/index.cfm?mode=listing&selTopic=120&topicTitle=Best%20Practice%20archive

Some useful guides include:

- GIR27 – Passive Solar Estate Layout
- CE257 – Daylighting in Urban Areas: A guide for Designers
- GIL25 – Passive Solar House Designs: the Farrans study
- CE257 – Delighting in Urban Areas: A guide for designers
- Thermal Mass and Overheating, BRE, Jan 2005.

EST – Good Practice and Advanced Practice Standards

http://www.energysavingtrust.org.uk/housingbuildings/professionals/standards/goodandadvanced/

Site Layout Planning for Daylight and Sunlight - A guide to good practice. P J Littlefair BRE. 1991

SUNPIPES - http://www.sunpipe.co.uk/

Case Studies

OFFICES

National Energy Foundation Phase II building http://www.natenergy.org.uk/news-018.htm

DWELLINGS

- Integer House –

http://www.integerproject.co.uk/images/photos/achievments_and_future_objectives.pdf

- BedZed - http://www.peabody.org.uk/pages/GetPage.aspx?id=213

http://www.visionshutters.co.uk/

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Energy Efficiency

Energy Efficiency

1.19 **Background**

Once passive measures have been fully investigated, energy demand shall be reduced as far as possible and the efficiency of plant and controls optimised.

The following section covers technologies that can contribute to an energy efficient design. The technologies and approaches covered include:

- Insulation and thermal bridging
- Air permeability
- Building services
  - Lighting
  - Lighting controls
  - Ventilation systems
  - Boilers
  - Comfort cooling
  - Inverters

1.20 **Insulation & Thermal Bridging**

Insulation is incorporated into buildings in the UK to limit the heat loss through the building fabric. Targets for thermal efficiency are covered by the Building Regulations Part L, which require minimum standards be met regarding a building element's U value. It is strongly advised that insulation levels exceed the minimum requirements outlined in the Building Regulations and that attention is paid to a high level of detailing to limit thermal bridging. Insulation is a relatively inexpensive measure that can greatly reduce a building's heat loss throughout its life.

U-value standards stated in the EST Good and Advanced Practice Standards for the following elements are:

Table 4.1: EST Good and Advanced Practice U-values standards:

Element	Good Practice Standards	Advanced Practice Standards
	W/m^{2}K	**W/m^{2}K**
Roof	0.16	0.15
Walls	0.30	0.15
Exposed Floors	0.22	0.15
Windows & Doors	2.2	0.80

Insulation with a low global warming potential and zero ozone depletion potential should be specified. Also natural insulations are recommended. Typical insulation materials include: cellulose, fibreglass, rock wool, polystyrene, urethane foam and vermiculite.

1.21 **Air Tightness**

Air tightness or leakage is the amount of uncontrolled air flow through gaps and cracks in the fabric of building (sometimes referred to as infiltration, exfiltration or draughts). This is not to be confused with ventilation, the controlled flow of air into and out of the buildings through purpose-built ventilators that is required for the comfort and safety of the occupants. Excess air leakage leads to unnecessary heat loss, discomfort from cold draughts and increased energy costs.

Addressing detailing and placing contractual clauses with regards to meeting predetermined air leakage through testing, is a positive measure in reducing heat loss and associated CO_2 emissions. The building regulations require mandatory pressure tests on new buildings; reducing air leakage, or improving ‘air tightness’, is an important issue.

The Energy Savings Trust has published Good Practice Standards and Advanced Practice Standards for dwellings. The Advanced Practice standards are intended to produce a 60 per cent reduction in CO_2 emissions compared with Part L1A 2006 demonstrating exemplar housing developments.

Air permeability standards confirmed after construction (but prior to completion) by a pressure test include:

- Good Practice Standards = Less than 5 m^3/m^2hr @ 50 Pa
- Advanced Practice Standards = Less than 1 m^3/m^2hr @ 50 Pa

The benefit in reducing the heating demand by achieving such low air permeability will need to be balanced against the potential need for introducing mechanical ventilation and the associated fan power needed to achieve minimum requirements for ventilation. For dwellings with an air-tightness of less than 5, mechanical ventilation with technology is likely to be appropriate.

1.22 Building Services

The provision of energy efficient building services is traditionally associated with the conditioning of non-domestic buildings. Although this is still generally true, with the current trend towards energy efficient buildings, new dwellings are increasingly adopting building services to improve their environmental performance. Thus building services are becoming more commonplace in the domestic sector.

1.22.1 Lighting

Lighting in domestic buildings can account for up to 10% of the dwelling’s annual energy demand; therefore the introduction of energy efficient lights can have a considerable impact on the associated emissions.

Lighting in non-domestic buildings is often the largest end use of electricity and can account for up to 40% of the total electricity cost in a naturally ventilated building. In conventionally daylit commercial buildings the choice of lighting controls can result in a 30-40% reduction in lighting use, assuming appropriate means of control have been installed to turn the artificial lighting off when not required.

Where natural daylight is available around the perimeter of the office then more effective control will be introduced by the specification of dimmers. Suitable lamps can be smoothly dimmed down to 10% of their maximum light output as a series of photocells respond to the combined daylight and artificial illumination level to provide a constant level of illumination.

T5 technology provides the most energy efficient method of commercial lighting currently available. It is significantly more efficient than older technologies such as T8 systems, or switch start which is still widely used.

Luminaires should be specified with high frequency ballasts which enable them to operate at over 32,000Hz (32 kHz). At this frequency the flicker is totally undetectable (either consciously or unconsciously). Whilst it is the health benefits that are under consideration, luminaires with high frequency ballasts also result in significant energy savings and prolonged lamp life leading to environmental and financial benefits. Such an installation can, with careful selection, also provide an even ambient light on the ceiling surface and eliminate high contrast light, thus reducing eyestrain for office occupants.

1.22.2 *Lighting controls*

Lighting controls should be designed so that small groups of lights can be controlled individually with the controls provided adjacent to the work area. Perimeter lighting should be controlled separately from core lighting so that perimeter lights can be switched off when there is adequate daylight. Absence detection can be provided to rooms that are used intermittently. This will switch lights off automatically after a room or space has been unoccupied for a set period of time. Daylight sensors and timed switches can be used to prevent external lighting being left on unnecessarily. Daylight sensors can also be used to switch off internal lighting when daylight levels are sufficient. Advice on the design of lighting controls is provided in Good Practice Guide 160.

1.22.3 *Building Management Systems*

A Building Management System (BMS) is an effective way of monitoring and controlling environmental parameters of the building to optimise visual and thermal comfort and at the same time minimise the energy consumption within a building.

The system works through a series of sensors and controllers that have the ability to be linked together in a modular fashion by a network, and can communicate with each other with an optional central operator's terminal, which is often a conventional Personal Computer (PC).

Some of the plant and technologies that a BMS can control and monitor include: Indoor Air Quality Control, Lighting Control, Ventilation, Cooling and Heating plant optimisation, Smoke and Fire Detection, Access control and Solar. They can be expected to save 20% of the energy consumption of the plant being controlled with savings recurring year after year.

The benefits of a BMS system include:

- Energy saving
- Detailed reports on occupancy and energy use
- Enhanced operation scheduling
- The ability to share occupancy information with other building systems
- Diagnosis of lighting, HVAC, system problems
- A wide array of manual control options for building occupants and managers
- The ability to monitor and control lighting, heating, cooling, throughout a building or even throughout a multi - building facility
- The ability to minimise peak demand, thereby reducing energy costs where utility rate structures are based on peak demand and real-time pricing.

1.22.4 *Mechanical Ventilation*

Mechanical Ventilation with Heat Recovery
MVHR systems can be used in domestic or non-domestic applications. There are a number of methods of recovering energy in the ventilation system. If the building in question is deemed to need mechanical ventilation then there are further factors to take into consideration to decide whether MVHR would be beneficial. These include the local climate and therefore the likely difference in temperature between the external and internal air, the efficiency of the buildings' heating systems and the heating loads.

It is important to remember that the heat exchangers used in an MVHR system will put an extra load on the air flow, therefore increasing the fan power required to maintain a given flow rate. These are electrically powered, which is a more expensive and carbon intensive fuel source than gas which is likely to be used to power the main heating system. Because of this a substantial amount of heat needs to be recovered per unit of extra electrical energy required before the system starts to make any economical or environmental savings. However, installation of heat recovery will provide relatively fast payback as the incoming air will be preconditioned so there will be a reduction in the energy required to conditioning the air to the correct temperature.

Efficiency:

The performance of an MVHR system is largely dependent on the difference in temperature between the exhaust air coming from inside the building and the external air coming in which is being heated. The larger this temperature difference the greater the performance will be.

Flow rates will also have an impact on the overall efficiency of the unit as higher flow rates will cause higher resistances through the heat exchanger, therefore meaning more fan power will be needed. The effect from this can be minimised by proper sizing of the heat exchanger so that there is enough space for the air to flow through. This must be done correctly as, if the exchanger is too large, then heat transfer will not be as great but if it is too small then resistance to flow will be heightened.

Types of Unit:

There are several different types of heat exchangers which can be used within an MVHR system. The most commonly used ones are Plate Exchangers, Run Around Coils and Thermal Wheels. Each one is best suited to different situations.

The simplest of the three technologies is the Plate Exchanger. This heat exchanger works by passing the fluid through alternating gaps between plates of conducting material (usually metal). There is little cross contamination of the external and exhaust air in this system as the fluids are always separated by a plate. Another advantage of this technology is that it is passive and therefore needs no extra power. These heat exchangers are less suitable for high flow rates as the gaps between the plates must be widened to avoid high resistance to flow, which cause the units to become too large.

Run around coils (RACs) work by transporting heat between the exhaust and external air via an intermediate fluid such as water. This fluid is pumped around a loop between the two air flows with a heat exchanger at each end to transfer heat between the air and fluid. This system is useful in situations where the two air flows are situated too far apart for a plate exchanger or thermal wheel and is also less affected by flow rate than a plate exchanger. It avoids cross contamination as the two air flows are kept completely separate. The disadvantages are that the RAC requires a pump which must be powered and that some heat may be lost by the intermediate fluid during transit hence lowering the efficiency.

Thermal wheels work by means of a wheel containing a matrix of conducting material (usually metal) rotating between the two air flows. This system can provide the highest efficiencies out of all the three mentioned technologies in the right conditions and also has the advantage of not being affected as much by flow rates as a plate exchanger. The wheel needs to be powered to rotate which adds to the energy consumption so it is important that the gains in efficiency outweigh the energy used for this. There is also the problem of cross contamination between air flows. These systems are quite large and the shape of the unit is less flexible due to the wheel.

Earth Tubes

Earth tubes are another way of tempering air with limited need for mechanical intervention. Earth tubes works by drawing air into a building through tubes buried in the ground allowing the air to gain or lose energy (depending on the season) with the ground. The system's success will depend on a suitable temperature difference between outdoor air and the soil temperature at the tube depth. In the UK this system could potentially temper the ventilation air in winter and pre-cool the air in summer.

1.22.5 *Condensing boilers*

Condensing boilers use heat from exhaust gases that would normally be released into the atmosphere through the flue. To use this latent heat, the water vapour from the exhaust gas condenses on a larger heat exchanger, or sometimes a secondary heat exchanger to recover the heat. This process allows a condensing boiler to extract more heat from the fuel it uses than a standard efficiency boiler, by minimising the heat lost through the flue gases. Condensing boilers are now the minimum requirement to meet Building Regulations Part L - Conservation of Fuel and Power, for replacement or new gas or oil boilers.

1.22.6 *Comfort cooling*

Conventional air conditioning/cooling systems in the UK built environment are provided by centrally supplied air, refrigerant or water systems. Comfort cooling in the UK is typically limited to non domestic buildings with high internal gains or solar gains. The use of cooling in the domestic market is neither common nor necessary for a well designed dwelling.

There are many forms of air conditioning, all of which have varying energy intensities. Some innovative low carbon solutions include chilled beams and absorption chillers.

Chilled beams:
Use closed-circuit water-based systems as the heat transfer method. As water has a specific heat capacity four times that of air and has a much lower volume of fluid to displace (in systems of similar cooling/heating capacity), a chilled beam cooling/conditioning/ventilation system requires less fan power and therefore electrical input for an equivalent amount of heat transfer (compared with an all air system).

Absorption chillers:
Use heat instead of mechanical energy to provide cooling. Compared with mechanical chillers, absorption chillers have a low coefficient of performance (CoP)). However, absorption chillers can substantially reduce operating costs and CO_2 emissions if they are powered by low-grade waste heat. The cooling load does have to be significant to use absorption chillers.

EC fan coils with variable volume flow:
Use as a highly energy efficient method of cooling the room. These have to be designed carefully but can deliver substantial energy savings because the amount of air pushed by the system varies thus saving energy in conditioning and moving the air.

Super Efficient chillers:
Can be used in certain circumstances and can deliver electrical savings as the amount of energy required in cooling will be reduced. These chillers can have very high COP's reaching 6 or 7 and are reliant on very good controls.

1.22.7 *Inverter technology*

An inverter drive is an electronic device that is able to take the fixed characteristics of the mains electrical supply (in terms of frequency and voltage) and converts this supply to a variable voltage and frequency for use by a motor. This allows the speed of the motor that drives fans, pumps and compressors (used in refrigeration plant) to be varied, depending on the heating/cooling/ventilation load that needs to be met. Inverter drives can detect the change in load and quickly adjust the motor speed to match the required load at a given time.

The motors that drive the fans, pumps and compressors used in conventional heating, ventilation and cooling (HVAC) plant are sized to meet the maximum demand. However, this means that for most of the time, the motor will be running with a higher power rating than is needed to meet the HVAC demand.

The benefits of using inverters to control fans and pumps include reduced running costs and reduced CO_2 emissions; however, at an increased capital cost.

1.23 Further Information

CIBSE

Energy efficiency publications can be sourced from - http://www.cibse.org/index.cfm?go=cibse.search – Select Energy Efficiency from the Topic Search Tab on the top right corner of the page.

Mixed mode ventilation. CIBSE AM13:2000. www.cibse.org. Tel: 020 8675 5211

EST

Energy Efficiency Best Practice Programme for Housing - a range of free guides on reducing energy use in housing, these are available from www.est.org.uk/bestpractice/ such as:

- Leaflet 72: Energy Efficiency Standards: for new and existing dwellings
- Leaflet 59: Central Heating System Specification
- CE83: Energy efficient refurbishment of existing housing
- GPG268 – Energy Efficient Ventilation in Dwellings: a guide for specifiers
- GPG224 – Improving Air Tightness in Dwellings
- CE248 – Achieving Air Tightness in Dwellings
- Energy Efficiency Best Practice in Housing Reducing overheating – a designer's guide
- GPG160 - Electric Lighting Controls: a guide for designers, installers and users.

National House Energy Rating - www.nher.co.uk

The Government's Constructing Excellence Programme provides advice for construction companies wishing to adopt best practice. Free publications and advice are available from www.constructingexcellence.org.uk or T 0845 605 55 56

The Enhanced Capital Allowance Scheme lists recognised energy efficiency products that qualify for Enhanced Capital Allowances - www.eca.org.uk.

Limiting thermal bridging and air leakage: Robust construction details for dwellings and similar buildings. The Stationery Office. 2001.

Testing Buildings for Air Leakage – TM23: 2000. CIBSE. ISBN 1 903287 103

Energy Use in Offices. Energy Consumption Guide 19. Best Practice Programme. January 2000.

AIR TIGHTNESS IN DWELLINGS:

- http://www.attma.org/ATTMA_TS1_Issue_1_March_06.pdf
- CIBSE TM2351

HEAT RECOVERY - http://www.flaktwoods.com/products/air-handling-units/eu-ec-sting-and-marine/features/heat-recovery-solution/

INSULATION

- http://www.insulation.kingspan.com/index.htm
- http://www.hoben.co.uk/vermiculite/insulation.htm

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Low & Zero Carbon Energy

Low & Zero Carbon Energy

1.24 **Background**

Renewable energy is an integral part of the Government's longer-term aim of reducing CO_2 emissions by 80% by 2050. The Government has set a target of 40% of electricity from low carbon sources and 30% of electricity supply from renewable energy by 2020[1]. Currently 4% of the UK electricity comes from renewable sources allowing for considerable expansion of renewable energy.

This section of the guide sets out the range of low carbon technologies available to developers to guide the West Northamptonshire Development Corporation in assessing proposed developments. It is intended to inform decision makers and developers of the potential of each technology.

The low carbon technology areas discussed are:

- CHP (including absorption chillers)
- Biomass (boilers and CHP)
- Solar systems (thermal and PV)
- Wind energy (at a range of scales)
- Ground source systems
- Air Source Heat Pumps
- Energy from waste.

In each section the following issues are discussed:

- Principles of the technology
- CO_2 savings potential
- Implications for the design of the building and services.

This is followed by a brief summary of the suitability of the technologies for the development areas and projects and the methodology for calculating CO_2 emission reductions.

[1] HM Government. The UK Low Carbon Transition Plan, National strategy for climate and energy, July 2009

1.25 Combined Heat & Power (CHP)

1.25.1 *Principles of CHP technology for buildings*

A CHP plant is an installation where there is simultaneous generation of usable heat and power (usually electricity) in a single process. The basic elements of a CHP plant comprise one or more prime movers usually driving electrical generators, where the heat generated in the process is utilised via suitable heat recovery equipment for a variety of purposes including: industrial processes, community heating and space and water heating. More recently the heat generated has been used to drive absorption cooling as a way of utilising the heat throughout the year. This type of installation is often referred to as tri-generation or CCHP (Combined Cooling, Heating & Power).

Due to the utilisation of heat from electricity generation and the avoidance of transmission losses as the electricity is generated on site, CHP typically achieves a 30% reduction in primary energy usage compared with power stations and heat only boilers. This can allow the host organisation to make economic savings depending on the hours of operation over the year. Economic and CO_2 savings can be made from the supply of heat and displacement of electricity sourced from the grid. Maximising the number of hours the CHP can supply heat over the year is an important determining factor; however other factors such as the price of electricity being displaced is also an important factor in the system's viability. Buildings that are occupied for longer and have a high demand for domestic hot water throughout the year are therefore preferred on economic grounds. However it is technically possible to use CHP for buildings with a winter only heat demand and make CO_2 emissions savings. The running hours of a CHP unit can normally be improved by using thermal storage in the system to smooth the demand profile.

An important issue in the economic viability of CHP is the difference between the cost of electricity and gas, referred to as the "spark gap". The greater the cost of electricity over gas, the more likely a CHP installation is to be economically viable.

1.25.2 *Implications for the design of the building*

The CHP unit will operate in a similar way to a boiler, the main implications being the need for additional space in the plantrooms and an additional flue. Return temperatures need to be kept low under part-load conditions or the unit could trip out unnecessarily. Lower return temperatures would allow more of the heat to be recovered from the engine. Gas engines tend to be constant temperature devices, therefore there are likely to be design implications for variable temperature heating circuits.

1.25.3 *Site-wide CHP*

The main benefits of a site-wide approach are:

- Lower capital costs for the CHP plant
- Lower maintenance costs for the CHP plant
- A smoother demand profile (for both heat and electricity) due to a mix of buildings being supplied
- A central Energy Centre may make better use of the site than allocating valuable space for CHP within every building
- It may be easier to include thermal storage at a central Energy Centre.

The disadvantages are:

- The costs associated with district heating infrastructure
- The costs associated with a larger single electrical connection (e.g. to the site-wide HV system)
- The potential for higher costs for an Energy Centre building

- The need for a separate planning application for an Energy Centre building.

A possible compromise approach is to adopt a site-wide concept but incorporate a larger CHP installation within one of the new buildings.

A CHP system typically supplies 60-80% of the annual heat demand of the buildings and gas-fired boilers would be used for top-up in the winter and stand-by for periods when the CHP is being maintained. These boilers could be installed either centrally or more likely within each building.

1.25.4 CHP with absorption chillers

CHP can be used to supply heat to absorption chillers. This can provide additional CO_2 savings; however the level of savings depends on the electricity emissions factor and the CoP of the electric chillers displaced. The absorption chiller will require additional plantroom space and also space for heat rejection equipment.

If a site-wide approach is adopted for CHP then there are two possible designs:

- Install the absorption chillers within the buildings using heat from the district heating system as the energy source
- Install the absorption chillers at the Energy Centre and distribute chilled water through a District Cooling network.

The latter has the clear disadvantage of the additional costs for the district cooling network; however there would be economies of scale on the absorption chillers and release of space within the buildings.

1.25.5 Fuel Cells

Fuel cells are an emerging technology that are highly efficient energy conversion devices and can be used as stationary CHP units.

Most fuel cell CHP systems run on natural gas, although a variety of fuels can be used, including sewage and other hydrogen rich biogas. Systems vary in size from a few kWs to MWs and are suitable for a range of installations from single dwelling, networked residential units to multi-megawatt sized industrial/commercial/ utility support systems.

Figure 5.2: Fuel Cell CHP – MTU Hot Module (source: MTU CFC Solutions GmbH)

Fuel cell-based CHP systems have benefits in terms of cleanliness, reliability and maintenance over conventional CHP systems, but their main advantage is often seen as their particularly high electrical efficiency. This is superior to conventional and other newer CHP and microCHP technologies. These electrical efficiencies can reach up to 45%-50%. Currently the cost of the fuel cell is very high and the life of the stack is limited as it is an emerging technology.

Although the potential of fuel cells is very positive, there are a limited number of fuel cell CHP units that are commercially available.

1.26 Micro-CHP

1.26.1 Principles of the technology

Micro-CHP refers to CHP engines with a rated electrical output of 50kWe or less. Micro-CHP units are usually purpose designed spark ignition gas engines.

There are three main categories of Micro-CHP:

- **Internal combustion (IC)** - Most mature of the Micro-CHP technologies
- **Stirling engine** – Emerging technology that is less mature than an IC engine. (SE) have an electrical efficiency lower than IC. However, these systems benefit from a smaller, quieter engine with less moving parts, therefore offering an extended life than an IC engine. This makes SE the most suitable engine for domestic applications.
- **Fuel cell** – Early stages of development, commercial products still years away.

Systems incorporating an internal combustion engine or a Stirling engine are most common. In all cases except the fuel cell, an engine drives a generator to produce electricity. Waste heat produced is recovered for use within the building. The CO_2 benefit is derived from the electricity offset from the grid.

Micro-CHP systems are most appropriate for installation in large dwellings and small commercial buildings. To maximise the economic viability of the system, the system should be designed to operate for approximately 3,000-6,000 hours per annum. The systems should also be matched to a heat demand that limits the frequent starting of the engine as this will increase the maintenance costs and reduce the life of the engine.

1.26.2 *CO_2 savings potential*

Carbon Trust field trial demonstrated that the following CO_2 savings could be realised:

- **Small commercial properties**: 15-20% when installed as the lead boiler. Appropriate applications include: care homes; community housing schemes; and leisure centres
- **Domestic applications**: the systems are best suited to larger homes with 3 or more bedrooms and hard to treat homes such as solid wall properties where insulation measures are not feasible. In these homes a CO_2 saving of 5-10% could be reasonable
- For **new energy efficient dwellings** with a limited heat demand, micro CHP is unlikely to provide a significant CO_2 saving.

1.26.3 *Implications for the design of the building and services*

A slightly larger space consideration and similar ventilation/exhaust considerations will be needed when compared with a more conventional boiler system. The significant difference for micro CHP will be noise and vibration constraints imposed by an internal combustion engine. This may limit the systems from being housed in the living areas of a dwelling as a boiler currently is. The Stirling engine would be better suited for this application.

1.27 Biomass

1.27.1 Biomass Boilers

Biomass is normally considered a carbon neutral fuel, as the carbon dioxide emitted during burning has been (relatively) recently absorbed from the atmosphere by photosynthesis and no fossil fuel is involved. Biomass from coppicing is likely to have some external energy inputs, for fertiliser, cutting, drying etc. and these may need to be considered in the future. The carbon dioxide emission factors for biomass is substantially less than other fuel sources, see section 5.1.

Wood from forests, urban tree pruning, farmed coppices or farm and factory waste can be burnt directly to provide heat in buildings, although nowadays most of these wood sources are commercially available in the form of wood chips or pellets, which makes transport and handling on site easier.

Modern systems can be fed automatically by screw drives from fuel hoppers. Electric firing and automatic de-ashing are also available. Some boilers are designed to comply with the Clean Air Act.

The most common application of biomass heating is as one or more boilers in a sequenced (multi-boiler) installation where there is a communal i.e. block or district heating system.

Issues which can prevent uptake of biomass boiler technology are:

- On site access problems for large lorries delivering wood chip, especially for urban locations
- Lack of space for a large fuel storage area in the plant area of the building (and therefore a need for more frequent loads of fuel to be delivered by a lorry to the site)
- Lack of an adequate supply chain in place currently to provide a regular and cheap biomass supply
- Concerns over emissions of NOx and particulates.

1.27.2 Implications for the design of the building

The biomass boiler will produce heat in the form of hot water compatible with the existing heating systems. The main problem will be that the biomass boiler is less responsive and is best suited to meeting a steady base load demand. This is likely to mean that a thermal store will be needed and possibly a heat dump facility to protect the boiler. The biomass boiler may also need to be designed to meet only a proportion of the annual heat demand.

The main implication though is the additional space for the biomass boiler, fuel storage and fuel delivery facilities. These factors can add significantly to total costs.

1.27.3 Site-wide Approach

A biomass boiler could be used in a site wide approach with district heating and this would have the benefit of a more steady load, including a base demand from network heat losses. It will also be easier to design the fuel handling and storage facilities and a thermal store.

1.27.4 Biomass CHP

If biomass is used as a fuel for a CHP plant then the carbon benefits are increased. The cost of the plant is high; however there is potential for gaining financial benefits from the electricity. There are also benefits from the Renewable Obligation Certificates; currently biomass CHP receives double ROCs for every MWh produced. There may also be a possibility of entering the feed in tariff scheme if it is adopted (see section 5.15).

Technologies available include:

- **Biomass combustion with conventional steam turbine** (viable at a large-scale i.e. electrical output of greater than 2MW).

Steam turbines show very good part-load performance and technology has reached a good level of maturity for large installation (2MW). However, low electrical plant efficiency and high maintenance are some of the disadvantages. Also, due to high noise level (up to 95 dBA) an application of this technology is not possible without corresponding noise suppression measures.

- **Biomass combustion with externally-fired air turbine** (not well-proven but demonstrations exist).
- **Biomass combustion with Organic Rankine Cycle turbines** (commercially available in Europe; however limited experience and no proven track record yet exists in the UK. Also many products are still under development therefore the technology cannot be viewed as mature).

  ORC plants are offered as complete modules. The electrical output of an ORC module ranges between 200 kWe to 1 MWe. Higher plant output can be achieved by a parallel operation of modules; however this can prove to be impractical and costly. Like steam turbines ORC shows very good part-load performance. However, ORC plants are relatively silent (the highest noise emissions occur at the encapsulated generator and amount to 75 dBA in a distance of 1 m) and also due to low working pressures and temperatures, it is not subject to the regulations of the pressure equipment directive (PED). The main disadvantage of ORC is it is still in its technological infancy and incurs very high capital cost. This is especially true for small units.
- **Biomass gasifier and modified gas-engine** (operating experience is limited and not consistent)

  Gasification systems turn biomass into a gas. This is burned in a modified gas engine to produce electricity, and heat is recovered as part of the engine cooling. In the gasifier, woodchip is turned into a fuel known as synthesis gas or syngas. It is important to have a uniform product entering the gasifier. Gasification brings higher efficiencies due to gas engine technology having advantages over steam based systems.
- **Biomass gasifier with combustion of the gas for use in a Stirling** engine or externally fired gas turbine (as above)
- **Biomass gasification and pyrolysis with steam turbine** (proven on waste streams at a larger-scale) – also using organic rankine cycle
- **Liquid biofuel (biodiesel, bioethanol) with reciprocating engine** (more technically proven but liquid fuels are best used for transport applications and fuel has a CO_2 content from the processing energy use)

Biomass or biogas CHP systems are likely to be designed to meet a constant base load. At present the only technology that is well established is the combustion boiler and steam turbine system, which is most cost-effective at a scale of 10MWe or above. The other technologies are also likely to have improved economics at a larger-scale. Hence the opportunity for biomass CHP can be realised at a site-wide level much more readily in combination with district heating. As a result this technology is particularly important in the context of delivering a planning policy on energy.

Liquid biofuels can be used with reciprocating engines; however long-term guarantees or reliability may be hard to obtain for fuel that is 100% biodiesel as there is limited operating experience at present. There is also some concern that the net carbon benefit from biodiesel may be limited after processing energy is taken into account and that the environmental and social impacts of some energy crops used to produce biodiesel may be significant. It could be argued that the limited supply of biodiesel would be better used initially as a blend for vehicle applications, rather than in building energy applications where alternative biomass energy sources exist.

1.28 **Solar Thermal**

Solar water heating systems use the energy from the sun to heat water, most commonly in the UK for hot water needs. The systems use a heat collector, generally mounted on the roof or a south facing façade in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or more commonly a twin coil hot water cylinder with the second coil providing top up heating from a conventional boiler. Ideally the collectors should be mounted in a south-facing location, although south-east/south-west will also function successfully. The panels can be bolted onto the roof or walls or integrated into the roof.

There are two standard types of collectors used - flat plate collectors and evacuated tube collectors. The flat plate collector is the predominant type used in solar domestic hot water systems, as they tend to have a lower cost for each unit of energy saved. Evacuated tube collectors are generally more expensive due to a more complex manufacturing process (to achieve the vacuum) but manufacturers generally claim better winter performance.

	
Filsol flat plate system on Wedgewood Visitor Centre (photo courtesy of John Blower), serving washrooms	*Viessmann evacuated tube system, London Borough Of Camden (photo courtesy of LB Camden), serving washrooms for office accommodation, library and health centre.*

1.28.1 *Typical Performance*

The typical annual performance is 450kWh/year per m^2 of flat plate collector or 580kWh/yr per m^2 for an evacuated tube system. This will have a direct saving in gas costs.

1.28.2 *Implications for the design of building services*

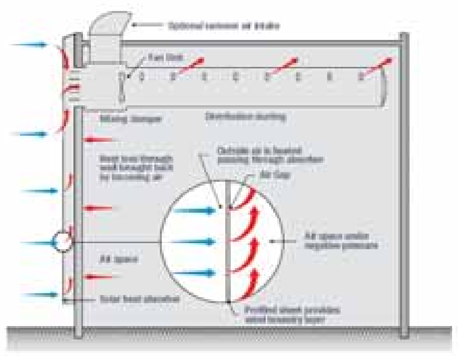
For domestic systems the main implication is the need for a larger hot water cylinder to incorporate the double coil and the need for orientation of the roof to obtain maximum benefit. For non-domestic buildings the issue will be whether the hot water service can be centralised without undue cost and whether the level of hot water demand justifies such a system.

1.28.3 *Site-wide*

As solar heat is a distributed resource there is little benefit in centralising the systems although there are a few schemes in Europe where such an approach has been used. It would depend on having a large area of land of low value which is unlikely in the UK context.

1.29 **Solar Wall**

Solar Wall is a novel technology that has been developed to harness the solar radiation incident on the cladding system of a building. The system works by incorporating a perforated aluminium or steel cladding system (solar collector) which is placed approximately 200mm away from the inner wall. When the sun warms the surface of the collector, the heated air is drawn through thousands of tiny perforations on the surface and ducted to the existing air intake. The solar heated air is then distributed throughout the building via the conventional ventilation system or dedicated fans and ducting.



A Sketch demonstrating the basic principles of how a Solar Wall works.

Photograph of the Solar wall system integrated in the Sainsbury's Distribution Centre at Pineham.

Solar ducting is a similar system to solar wall that incorporates a thermal ducting system that can integrate with a standalone PV system. The system works by drawing heat off the back of the PV modules and is ducted to the nearest rooftop air handler. The 'excess heat' is then channelled into the building's HVAC system where it is used to offset the heating load. This system would not only help reduce the buildings heating demand but could allow the PV array to operate at an improved efficiency by potentially reducing the temperature of the array.

1.29.1 Typical Performance

Manufacturers technical documentations suggest that Solar Wall panels can typically produce 500 watts/m^2 of thermal energy. However as the technology is relatively new to the market in the UK, relying on the manufactures' performance expectations could introduce an element of risk to a proposed development.

1.29.2 Implications for the design of building services

The system is mainly applicable to buildings with a large façade area with minimum fenestration such as warehouses and distribution centres.

The system could be integrated into a conventional ventilation system and requires little maintenance as it uses no liquids; fans are its only moving parts. Integration into a building HVAC system should be relatively straightforward.

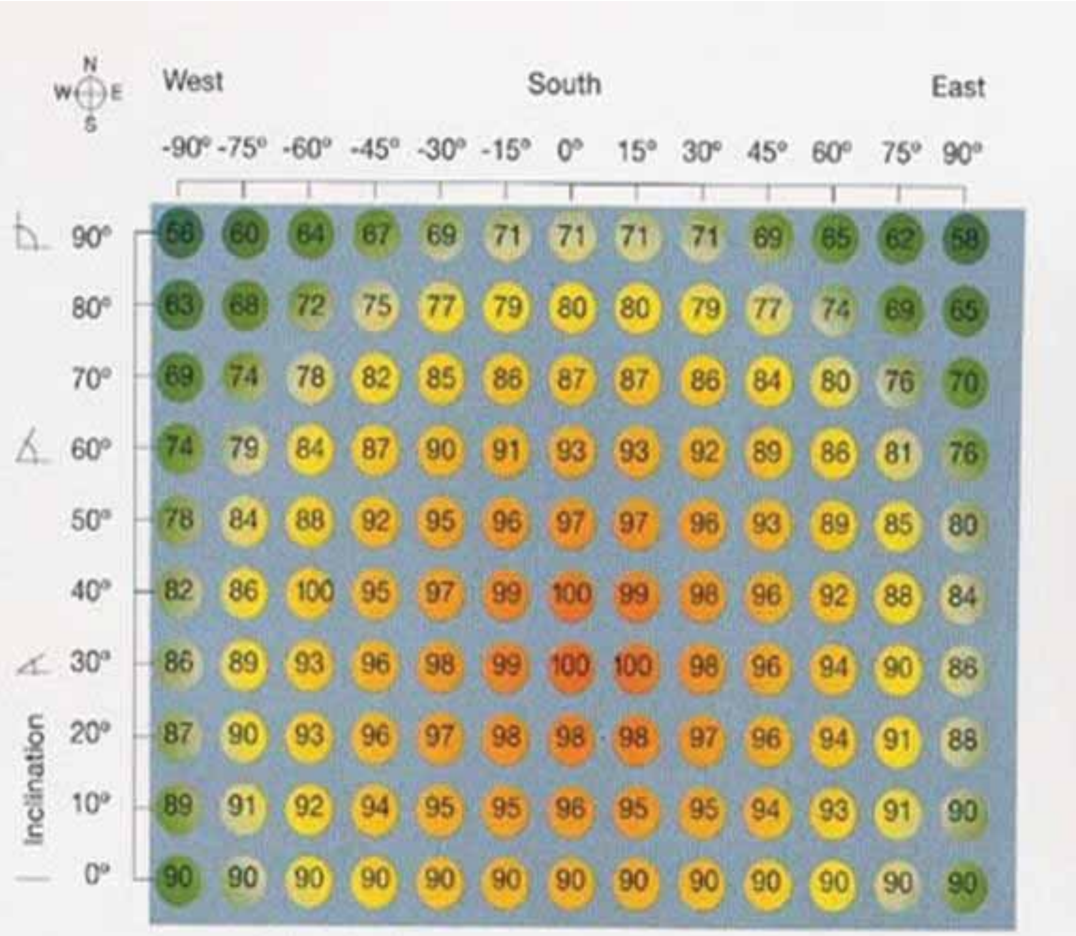
1.29.3 Site-wide

As with solar thermal a site wide distribution system is unlikely to offer any benefit over a simple building integrated system.

1.30 **Solar Electricity**

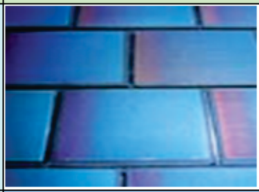
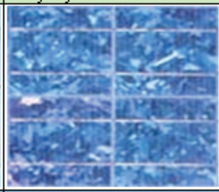
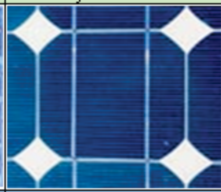
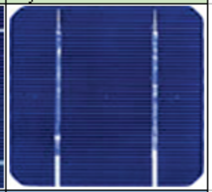
Photovoltaic (PV) systems convert energy from the sun into electricity through semi conductor cells. Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn their direct current (DC) in to alternating current (AC), which is usable in buildings. PV can supply electricity either to the buildings they are attached to or, when the building demand is insufficient, electricity can be exported to the electricity grid.

For PV to work effectively it should ideally face south and at an incline of 30º to the horizontal, although orientations within 45º of south are acceptable. It is essential that the system is unshaded, as even a small shadow may significantly reduce output. The figure 5.4 below shows how PV efficiency varies depending on panel orientation and pitch.



Solar Sundial showing energy yield relative to the inclination and orientation of your roof

PVs are available in a number of forms including monocrystalline, polycrystalline, amorphous silicon (thin film) or hybrid panels that are mounted on or integrated into the roof or facades of buildings. The table below from PV supplier Solar Century shows carbon savings per metre squared or output of panel for all the various forms, which is useful for comparing the various PV technologies currently available.

	'Thin Film'	Polycrystalline	Monocrystalline	'Hybrid'*
Appearance				
Description	The most efficient in poor light conditions. An extremely sturdy, vandal-proof PV.	Also highly efficient in good light conditions. Less embodied energy than monocrystalline.	The most efficient of the PV technologies in good light conditions	A combination of monocrystalline and thin-film technologies, this has high peak output coupled with excellent performance in poor light conditions
Efficiency at STC**	Good 7 - 8%	Very good 11 - 13%	Very good 14 - 16%	Excellent 17 - 19%
Efficiency in overcast conditions	Excellent	Good	Good	Excellent
Area needed per kWp***	Kaneka module: 15.5m2 Unisolar modules: 16m2	Sharp modules: 8m2	Sharp modules: 7m2	Sanyo modules: 6.5m2
Area needed per kWp	Solar metal roofing: 23.5m2 Glass-glass laminate: 25m^2	C21 tile: 10m2 Glass-glass laminates: 10m^2 - 30m^2	Sunslate: 10m2 Glass-glass laminates: 8m^2 - 30m^2	n/a
Annual energy generated per kWp	900 kWh/kWp	750 kWh/kWp	750 kWh/kWp	900 kWh/kWp
Annual energy generated per m^2	55 - 60 kWh/m^2	90 - 95 kWh/m^2	105 - 110 kWh/m^2	125 - 135 kWh/m^2
Annual CO_2 savings per kWp	390 kg/kWp	325 kg/kWp	325 kg/kWp	390 kg/kWp
Annual CO_2 savings per m^2	25 kg/m^2	40 kg/m^2	45 kg/m^2	55 - 60 kg/m^2
Annual Carbon savings per m^2	6.8 kgC/m^2	10.90 kgC/m^2	12.27 kgC/m^2	15 - 16.36 kgC/m^2

* 'Hybrid' PV combines both monocrystalline and thin-film silicon to produce cells with the best features of both technologies
** Standard Test Conditions are: 25 °C, light intensity of 1000W/m2, air mass = 1.5
*** kWp = kilowatt 'peak'. Solar PV products and arrays are rated by the power they generate at STC

PV system size is measured in kWp. A 1kWp polycrystalline system will cost around £5,500 and will generate around 750kWh of electricity a year. The size of the PV systems can be varied to match the carbon saving required.

There are a number of mounting systems available on the market that can provide a neat solution for flat roofs without requiring any roof penetrations, so will not interfere with the integrity of the roof.

1.30.1 *Implications for the design of the building*

There is relatively little impact on the design of the services as the electrical production is likely to be very small in relation to the total demand. The main implication is architectural, although the range of products available means that the panels can be used in place of other architectural elements.

The impact of buildings on the performance of PV can be significant. PV performance deteriorates considerable when they panels get hot, or when overshading occurs. It is therefore vitally important that PV panels are mounted with sufficient space around the panel for air to ventilate and cool the panels. Also, that the panels are positioned so that overshading does not occur.

Grid Connection

In order to connect PV systems to the grid G83/1[2] standards must be met. Most small PV inverters are designed to comply with this standard. Under this standard you can connect up to 16Amps (approx 3.68kW) per electricity phase under a “connect and notify” arrangement, without having to go through the expensive grid connection survey process. In practice this means that domestic and small business installations should be sized below 3.68kW for single phase electricity supplies, or 11kW for three phase supplies.

Installations above this size will need to consider the recommendations of G59/1[3] standards; this will require a more costly grid connection survey process.

1.30.2 *Site-wide approach*

As solar energy is a distributed resource there is little benefit in centralising the systems, unless it’s to increase the economies of scale on larger sites.

[2] Engineering Recommendation G83/1:Sept 2003, ‘Recommendations for the connection of Small-scale Embedded Generators (up to 16A per phase) in parallel with Public Low-Voltage Distribution Networks’ Energy Networks Association, 2003.
[3] Engineering Recommendation G59/1, ‘Recommendations for the connection of Embedded Generating Plant to the Regional Electricity Companies Distribution Systems’, Electricity Association, 1991.

1.31 **Wind Technology**

1.31.1 Principles of technology

The UK has the largest wind resource in Europe accounting for approximately 40% of the total European wind resource. Wind energy is also one of the most cost effective methods of renewable power generation with a wide range of sizes available from a few kW to 2MW or more. The large wind resource and relatively low cost (compared with other forms of renewable energy) make it one of the fastest growing renewable technologies in the UK, It is anticipated that 33GW of wind capacity will be installed to meet about 30% of UK's total electricity demand, by 2020[4].

Turbines are categorised into 2 categories:

- Micro wind
- Large scale wind

1.31.2 Micro wind

The small scale or micro turbines have a diameter of around two metres and require mounting on a mast which increases the turbine overall height to at least 4m. Typically these turbines are mounted above roof level, as the increased height usually means greater wind speeds. Micro turbines of 1 to 6 kW can be mounted on buildings as well as independent masts.

1.31.3 CO_2 Saving Potential

Care must be taken when assessing the performance of building mounted wind turbines. Surrounding topography can affect output, leading to lower wind speeds and more turbulent flow, thus reducing the overall out-put of the system. The predominant wind direction in the UK is from the south-west. Therefore, when deciding on potential areas where a wind turbine can be located, checking that the south-westerly direction upstream of the turbine is free from obstructions is important.

The Warwick Urban Wind Trial Project identified that wind speed and power curve data available to predict performance of micro wind turbines in urban areas were not very accurate, with predictions falling within an error margin of +/- 25%[5].

1.31.4 Design Implications

Wind turbines on buildings are usually very visible and can have implications on planning especially in conservation areas. The energy produced is generally relatively small for most micro turbines, therefore this should have little impact on the building service design.

Building mounted turbines will need to have the structural implications full investigated to ensure wind loading and vibration does not affect the structural integrity of the building.

1.31.5 Large Scale Wind Turbines

The most cost-effective wind energy systems will generally be those using the largest wind turbines in the locations with the best wind speed regime. Hence there is the possibility that sites outside the immediate building location could be used and the power generated attributed to the building energy demand.

This approach raises the issue of proving additionality, i.e. would the wind turbine capacity still have been built without the planning requirements for renewable energy.

1.31.6 CO_2 Saving Potential

The potential CO_2 savings for large wind turbines will be determined by the electrical energy generated. The output of the turbine is affected by a number of factors, the most significant of

[4]HM Government. The UK Low Carbon Transition Plan, National strategy for climate and energy, July 2009
[5]Encraft, Warwick Wind Trial – Final Report, 2009.

these being the average wind speed of the site at hub height; the swept area of the turbine; and the amount of turbulence.

Wind speed varies considerably around the UK. For large schemes it would be wise to monitor the wind speed in advance of installing the turbine(s) to avoid disappointment.

1.31.7 Design Implications

Wind turbines will always have implications on planning especially in conservation areas, such as:

- Visual impact
- Noise
- Shadow Flicker and Reflected Light

1.31.8 Location Of Turbines

The energy output of a wind turbine is extremely sensitive to wind speed and characteristics. The predominant wind direction in the UK is from the south-west. Therefore, when deciding on potential areas where a wind turbine can be located, checking that the south-westerly direction upstream of the turbine is free from obstructions is important. Two other rules of thumb for locating turbines are to locate the turbine hub so that it is:

- Either twice the height of an adjacent obstruction, or
- A horizontal distance of 10 times the height of the nearest obstruction away from the obstruction.

1.32 Air Source Heat Pumps

1.32.1 Background

Air Source Heat Pumps (ASHPs) are similar to a GSHP except they use the air as a source of energy as opposed to energy from the ground. By extracting energy from an external air source using the refrigeration cycle, the heat output can be several times the purchased energy input. This makes ASHPs a very energy efficient method of heating when compared with other forms of direct electric heating.

Air source heat pumps have only recently been accepted as a LZC technology by the Code for Sustainable Homes. Generally they are not considered a LZC in non-domestic applications. Therefore this section is biased towards the domestic applications.

ASHPs can be configured in a number of ways, such as air to air or air to water:

Air to Air systems:
Air to air systems are the most efficient heat pump application in terms of CoP. These systems require an all air delivery system either ducted or isolated to a particular room. This is the most appropriate solution if cooling is also being provided. Many ASHP units can be used to provide both heating and cooling by reversing the heat pump cycle. However, these units may not be the most efficient option if cooling will only be required occasionally as they are usually slightly less efficient than units designed purely for heating.

Air to Water systems:
Air to water systems are most appropriate when incorporated in a low temperature heat distribution system. The optimal efficiency is achieved if the water temperature does not exceed 45C. This makes them ideally suited for under-floor heating systems.

An added benefit of an ASHP is that the same system can also provide domestic hot water. However, achieving the temperatures required to eradicate Legionnaires disease greatly reduces the CoP of the system, often requiring an additional electric element to raise the temperature to above 60C.

As higher heating loads have a negative impact on the CoP of an ASHP system, heat losses are an important factor to consider when deciding whether an ASHP would be the right choice for a project. Highly insulated buildings with small areas of glazing are likely to be better suited for heat pumps.

1.32.2 CO_2 savings potential

The CO_2 saving potential of an ASHP is affected by three issues. The temperature the heat pump is trying to deliver, the external ambient air temperature and the carbon dioxide intensity of the electrical source.

Assuming an average season COP of 2.5 under the current CO_2 emission factors an ASHP will provide a 25% CO_2 reduction over a gas condensing boiler (86% efficient). If the proposed CO_2 emission factors (see section 5.14) are adopted an ASHP with the same COP will incur a 3% CO_2 penalty against a gas condensing boiler of 90% efficiency. It may be reasonable to take a long term view on the potential change to the CO_2 emission factors for the grid; however, caution will need to be shown not to over-estimate the reduction in emission factors. The fuel mix, and subsequent CO_2 emission factors for the grid, is influenced by many factors and is difficult to predict future trends.

When assessing the predicted performance of any heat pump, it is important to use the average seasonal COP, sometimes documented as the seasonal performance factor (SPF). Using an optimal COP will overstate the CO_2 benefit of the system.

1.32.3 Implications for the design of the building and services

The only real implication to a building design is where to place the outdoor unit and connection to the outdoor unit. The compressor and fan can cause considerable noise and vibration; therefore the outdoor unit should be located away from sensitive areas. Also the refrigerant pipe work will need to be carefully routed through the fabric of the building in a way that does not impact on the air tightness and insulation levels of the building.

1.33 Ground Source

1.33.1 Background

Ground source heat pumps incorporate many different technologies and configurations. Essentially they consist of a heat pump coupled with either a ground heat exchanger which utilises the grounds thermal mass or an open loop system which directly utilises the thermal properties of an underground aquifer.

Both systems convert low grade heat from the earth into high grade heat through the vapour compression cycle also known as a heat pump. Heat pump technology is a tried and tested technology underlying the refrigeration industry. The benefit of a GSHP over a conventional air sourced heat pump or chiller, is that the temperature of the ground is generally more stable than that of the air and this stability of the ground leads to higher efficiencies (Energy Savings Trust, 2004).

The efficiency of the system is specified as a coefficient of performance (CoP) which represents the number of thermal units (kWh_{TH}) as delivered heat for every unit of electricity consumed; thus a CoP of 4 would equate to an efficiency of 400%. Efficiencies vary greatly between each system and care must be taken not to overestimate the potential CoP.

The systems can provide both heating and cooling by reversing the cycle of the heat pump. GSHPs can be configured in a number of ways. The systems are defined by the type of heat exchanger used to collect or reject heat to the ground. They are always one of two system types; an open loop or closed loop system.

Open loop systems consist of direct extraction of a water source to deliver energy to the heat pump. Configurations can include:

- Open loop - Open Loop System works by extracting water form an underground river, aquifer or artesian basin and using the energy of the water. Generally water can be found in areas of porous rock such as chalk.
- Aquifer thermal energy store – Similar to an open loop system described above, however with a balanced heating and cooling demand throughout the year. This system effectively uses the earth as a thermal store or heat sink, by locking away warm water underground for use in winter and cool water away for use in summer.
- Canal or pond loop - Canal and pond loops can either be configured in an open loop configuration – by pumping water directly from a canal or pond or closed loop configuration by submerging a polyethylene pipe.

Closed loop systems consist of a sealed loop of pipe buried under the ground in a horizontal or vertical configuration. Typical systems include:

- Horizontal loop - Horizontal Loops currently come in three configurations, parallel tubes, a slinky coiled tube or stacked pipes to reduce excavation. The coil is buried at a depth of approximately 1.2 - 1.8m. These systems require a large parcel of land adjacent to the building.
- Vertical loop - Vertical collectors take up less space than horizontal installations and are generally used on larger developments. Installation involves the insertion of a u tube into a pre-drilled borehole. Typically the pipes range from 100-150mm in diameter 15-120m deep spaced 5-15m apart.
- Energy piles – Incorporate the ground loop into the structural concrete piles; if well programmed it can make them more cost effective than a separate array of piles. However, they are usually adopted on sites with limited land area to increase the yield of the system.
- Direct Exchange systems - Direct exchange systems (DX) contain refrigerant rather than brine in the ground loop. Although higher efficiencies can be achieved, this needs to be balanced against the environmental risk of refrigerant leakage.

1.33.2 CO_2 savings potential

GSHP are most effective when designed to meet a balanced heating and cooling demand throughout the year. This ensures the ground is recharged and avoids diminishing returns in performance. CoPs for GSHPs are marketed at around 3.5 in heating mode and 4/5 in cooling mode, which could be a sensible efficiency with a balanced system. For heating or cooling only systems the CoP may be lower, reducing the realised potential CO_2 savings. Monitoring data of a horizontal closed loop system suggest a CoP of 2.7 may be a realistic efficiency. To provide a true account of the potential CO_2 savings, seasonally adjusted CoPs must be used when assessing the savings along with any auxiliary power used for pumping and controls.

The electrical energy required must be accounted for when assessing the environmental impact. Although the system can be very efficient, if the electricity powering the system is sourced from the grid, then the CO_2 emission savings provided through a heat pump are susceptible to fluctuations in the carbon intensity of the grid. The CO_2 emission factors are currently under review and are likely to increase in 2010 for grid supplied electricity (see section 5.14).

The real difficulty in assessing the potential CO_2 saving of a GSHP at the design stage is that each system is effectively a bespoke system. Care must be taken not to over emphasise the potential CO_2 saving, especially given the costs associated with drilling and excavations.

View down a ground source energy pile

Ground level view – ground source energy pile

1.33.3 Implications for the design of building services

GSHP can be easily designed into the plant room and offer potential for space savings if designed to provide both heating and cooling. Heat delivery is best through an all air system or underfloor heating. The biggest impact on the building services design is coupling the heat pump to the ground.

1.33.4 Site-wide

Ground source systems are less suited to a site wide approach as the energy source is distributed. In addition, the temperature difference available for heating or cooling circuits from ground source systems is very limited making energy distribution infrastructure very costly.

1.33.5 Permits

If ground water is to be extracted then a licence will be required from The Environment Agency. This is only likely to be given if the water is re-injected into the aquifer.

1.34 Waste to Energy

Waste to energy schemes are increasing in their feasibility/viability at a large scale. Therefore this section provides a brief description of four approaches, with more in-depth information in the following section – Strategic Scale Technologies. All technologies would be most beneficial if integrating a CHP system as opposed to heat only.

1.34.1 Incineration

The most established technology for waste to energy plant is mass incineration coupled to a steam boiler and turbine system. Examples include the SELCHP plant in London and the Sheffield plant. This technology is large-scale (>200,000 tonnes p.a.).

1.34.2 Gasification/Pyrolysis

The newer technology of gasification/pyrolysis is employed for waste disposal at Avonmouth (Compact Power). This plant takes clinical waste with typical annual waste of 5,000 tonnes p.a. Net electricity generation is about 300kWe. There is still limited operating experience at the moment. Typical scales for municipal waste using this technology would be 32,000 tonnes to 64,000 tonnes p.a.

1.34.3 Anaerobic Digestion

This process uses organic waste to produce a methane rich gas which can be used to generate electricity from reciprocating engines. Some of the heat recovered from the engines is used for the process; the remaining would be available for heating buildings. Most plants have been built on farms where the waste is generated and again the quantities of waste needed for a viable plant are significant (e.g. 8,000 tonnes of farm slurry and 30,000 tonnes of food waste p.a.).

1.34.4 Mechanical Biological Treatment – Plus Combustion/Gasification

A new method of treating municipal solid waste is to shred it and dry it and extract valuable materials such as metals and glass. The remaining waste is then high in calorific value and can be used as a fuel typically in industrial processes such as cement manufacture.

1.35 **Site Suitability**

There is the opportunity for all developments to consider the use of low carbon and renewable sources of energy (once building energy use has been minimised, see section 3 & 4 for details) to decrease overall carbon dioxide emissions.

Each site should be assessed for its suitability for each technology. Each site will have different characteristics so it is not advisable for the WNDC to recommend one particular technology over another. Solar water and photovoltaic installations can generally be applied to any site but the installed capacity may be limited by roof areas. Ground source heat pumps, wind turbines biomass and CHP are much more site-specific depending on scale and resource available.

A matrix demonstrating the site/development features suitable for each technology and the opportunities and constraints that influence the selection of appropriate technologies is provided in Appendix B.

1.36 **Calculation of CO_2 savings**

The technologies discussed previously produce heat, electricity or cooling, with a lower CO_2 emission than using conventional technology. To calculate the CO_2 reduction it is therefore necessary to first establish the CO_2 production that would result from the building energy demands if supplied by conventional means. The efficiency of the conventional systems therefore needs to be determined.

1.36.1 Heat

For heat, it is assumed that boilers fired on natural gas would be used as the conventional supply option. In new buildings it is unlikely that electricity for heating would be used, as passing the Building Regulations would be made much more difficult. If domestic hot water service is small, local electric hot water heating may be used as this avoids distribution losses of a centralised HWS service. If a natural gas supply is available then this is preferred to oil which has a higher CO_2 emissions factor. The efficiency of gas boilers is typically 80-86% with higher figures possible if maximum condensing conditions are obtained through the design of heating circuits using very low return temperatures.

It would be reasonable to assume that gas boilers at 86% efficiency are used. The CO_2 emission factor for gas is given in the Building Regulations as 0.194kg/kWh[6].

Gas Boiler: Hence 1kWh of heat requires 1.163kWh gas which results in 0.226kg CO_2.
CO_2 emission factor for heat from gas boilers = 0.226 kg/kWh

(or 0.226 tonnes /MWh)

Heat Pump: For an air sourced heat pump assuming default COP from SAP of 2.5. The CO_2 emission factor for electricity is given in the Building Regulations as 0.422kg/kWh[2].
1kWh of heat requires 0.4kW of electricity which results in 0.169 kg/kWh

CO_2 emission factor for heat from gas boilers = 0.169 kg/kWh

Under this scenario the air sourced heat pump would have a 25% improvement over the boiler.

Most renewable energy sources will involve some additional electricity use to deliver the energy or result in lower or higher heat losses from the circuits within the buildings. Examples are:

- Pumping energy needed for district heating systems
- Solar thermal circulating pumps

[6] Table 2 – ADL2A Part L - Building Regulations 2006

In addition, the ancillary electricity used in the heating system of the building may also change as a result of introducing renewable energy sources and this will need to be considered. Examples are:

- Heat pumps using low heating circuit temperatures may require additional pumping energy as a result of higher flow rates
- Solar thermal systems would need to use a centralised hot water service with additional circulating pump energy and heat losses

A full calculation of emissions should take account of these ancillary energy uses.

1.36.2 Electricity

The CO_2 emission factors associated with electricity are a more complex issue. Electricity is produced by a wide range of different power stations each with emissions rates determined by the type of fuel and the conversion efficiency. In addition, as there are losses on the national grid and the local distribution network the emissions from a delivered unit of electricity at a building are higher than the emissions at a power station. As the mix of power stations operating varies over the day and over the year the emissions factor varies with time. In addition, a large number of power stations will be decommissioned over the next 15 years and the future mix of fuels is uncertain.

The average emission factor for electricity can be estimated from the data published on power station operation and the losses in the national grid and local distribution systems. Nationally this is approximately 0.508kg/kWhe. However, the average emissions factor includes the nuclear element and it is unlikely that the amount of nuclear electricity generated will be influenced by renewable energy or CHP generation. A more reasonable approach might be to use the average emissions factors from fossil fuel electricity generation which is much higher at 0.663kg/kWhe.

A number of sources quote a lower figure of 0.43kg/kWhe e.g. the Defra guidelines for the UK Emissions trading system.

(http://www.defra.gov.uk/environment/climatechange/trading/uk/pdf/trading-reporting.pdf).

The Building Regulations gives two emission factors:

0.422kg/kWhe for imported electricity

0.568kg/kWhe for electricity generated on site

In view of the above range of values it is recommended that calculations are made using the CO_2 emissions factors given in the Building Regulations as this ensures consistency with the other calculations needed for Building Regulations compliance. However there are two technologies where it would be useful to analyse the emissions for a range of electricity emissions factors partly to predict how the benefit might change in the future if emission factor reduce as a result of a change of power station mix. These technologies are:

- Absorption chillers supplied from CHP compared with electrically driven chillers
- Ground source heat pumps compared with boilers (and CHP)

The graphs below show how the benefits could be very different depending on the electricity emissions factor assumed.

Figure 5.13.2: CO_2 emissions per kWh of cooling provided

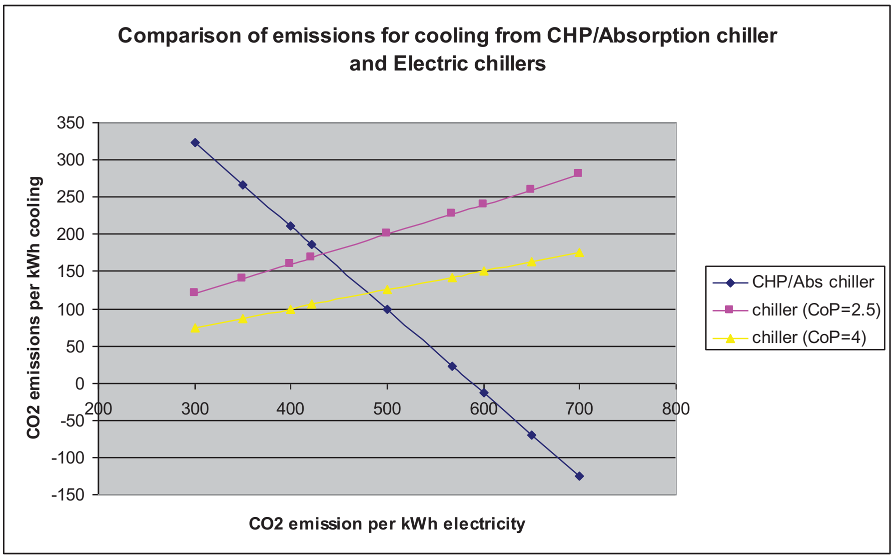
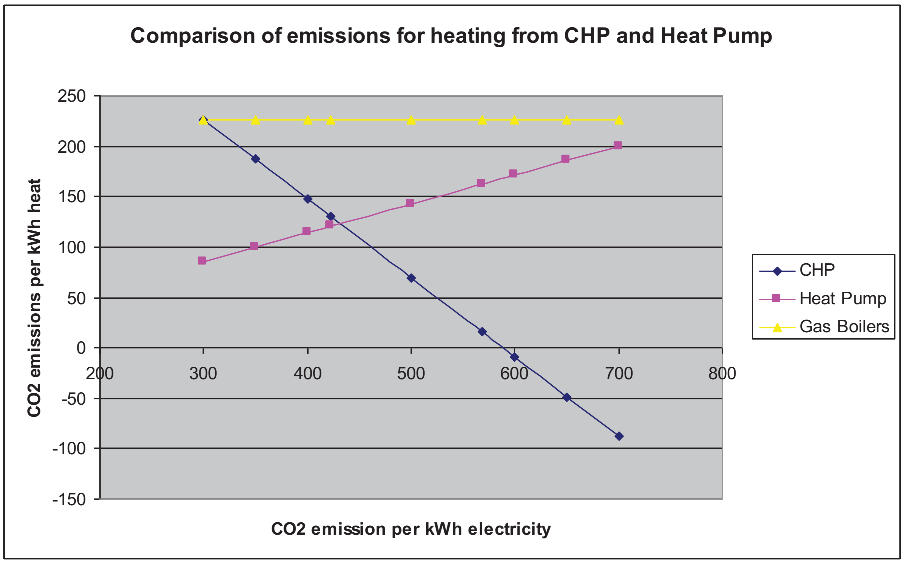


Figure 5.13.3: CO_2 emissions grams per kWh of heat provided (Boilers 85%, CHP 33%/78%, Heat Pump CoP 3.5)



1.36.3 Cooling

As for heating it is important to consider the CoP of the conventional chillers that would be installed, so that the saving from a low carbon energy source can be determined. CoPs for chillers depend on size, refrigerant type, and the temperatures at which the heat is rejected. If cooling towers are used for example then CoPs will be higher than for air-cooled chillers. It is likely that for any given building the renewable cooling source will not supply all of the demand and there will therefore be a need for conventional chillers as well. The selection of these chillers needs to be determined so that the correct comparisons and CO_2 saving calculation can be made.

1.37 **Revised CO2 Emission factors**

As part of the Building Regulations Part L consultation for 2010, the CO_2 emission factors are being reviewed based on a revised methodology. If adopted, the revised emission factors will change the CO_2 emissions associated with each technology.

As the emission factors for electricity are likely to increase proportionally more than other fuels, technologies that are electrically driven such as heat pumps, lighting etc will incur a greater CO_2 penalty than under the current emission factors. Technologies utilising natural gas such as CHP will see a benefit from the revised emission factors. Table 5.14 provides a comparison of current CO_2 emission factors compared with those proposed under the current consultation.

Table 5.14: Building Regulations Current & Proposed CO_2 Emission Factors

	Carbon dioxide Emission Factors	
	2006 – Adopted	**2010 - Proposed**
	$KgCO_2/kWh$	$KgCO_2/kWh$
Gas – mains	0.194	0.206
Gas – LPG	0.234	0.251
Oil – Heating	0.265	0.284
Oil – Biodiesel any source	-	0.098
Oil – Biodiesel used cooking oil	-	0.019
Rapeseed oil	-	0.058
House Coal	0.291	0.382
Anthracite	0.317	0.365
Manufactured smokeless fuel	0.392	0.402
Wood logs	0.025	0.018
Wood pellets	0.025	0.037
Wood chip	0.025	0.015
Electricity – grid	0.422	0.591
Electricity – Displaced from grid	0.568	0.591

1.38 **Financial Incentives**

The government has a raft of financial incentives to support the capital cost of LZC technologies. These incentives go beyond the scope of this guide, as they are generally short term incentives; however it would be useful to keep informed of current and proposed schemes by visiting Government websites.

Long term financial incentives that reward the generation of renewable and low carbon energy can also significantly improve the viability of selected technologies. These incentives are covered in the guide and include a summary of the following:

- Renewables Obligation
- Proposed Feed in Tariff
- Proposed Renewable Heat Incentive

1.38.1 Renewable Obligations

The Renewables Obligation (RO) is the Government's main mechanism for supporting the generation of renewable electricity. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewable Obligation Certificate (ROC) is awarded to each generator for each MWh of renewable energy produced. ROC are currently valued at £52 per ROC, however this price can and does fluctuate.

In June 2009 the BERR (Now BIS) Reform of the Renewable Obligations proposed a number of changes to the scheme. Currently the scheme awards 1 ROC only per MWh of renewable electrical produced for all types of generation. One of the proposed changes that could benefit some technologies includes the allocation of a banding system, whereby each technology will receive an allocation of ROCs proportional to the capital investment necessary for implementation. For instance technologies such as PV and Anaerobic Digestion may receive 2 ROCs per MWh of generation. This is anticipated to help stimulate the growth of the more costly technologies.

1.38.2 Feed in Tariff

The 2008 Energy Act contains powers for the introduction of Feed-in Tariffs (FITs) in Great Britain for renewable electricity installations up to a maximum capacity of 5MW. In July 2009 the DECC Consultation paper, Consultation on Renewable Electricity Financial Incentives was published outlining the government's proposals for the introduction of a FIT. This will provide a financial support scheme for renewable electricity aimed at small-scale installations. It is intended that the implementation of FITs will be brought in by April 2010.

For all systems of 50kW or less it is proposed that a fixed tariff will be paid for a fixed number of years. The actual tariff will depend on the actual generating technology (the highest tariff of 36.5 p/kWh for retrofit PV, the lowest being 9 p/kWh for biomass CHP)[7].

For larger systems (50kW to 5 MW) a choice will be available to join either the RO scheme or FIT scheme. Both schemes cannot be entered into simultaneously.

Systems larger than 5MW will have to continue with the RO scheme.

1.38.3 Renewable Heat Incentive

The aim of the renewable heat incentive (RHI), is to support the generation of heat from renewable sources. Currently approximately 50% of the UK CO_2 emissions derive from the production of heat. The incentive is likely to focus on: biomass installations; air & ground source heat pumps; solar thermal water heaters; and combined heat and power (CHP) from renewable sources. The details of the scheme are yet to be finalised, however the scheme is scheduled for introduction in April 2011.

[7]DECC, Consultation on Renewable Electricity Financial Incentives, July, 2009.

1.39 Further Information

The Energy Savings Trust has guidance on renewables that can be sourced at -

http://www.energysavingtrust.org.uk/resources/publications

Solar Trade Association www.solartradeassociation.org.uk/

National Energy Foundation http://www.nef.org.uk/actonCO2/renewableenergy.htm

Solar Wall http://solarwall.com/en/products/solarwall-air-heating.php

British Photovoltaic Association www.pv-uk.co.uk

Photovoltaics in Buildings: A Design Guide Report No ETSU S/P2/00282/REP. Available from DTI Photovoltaics in Buildings: Testing, Commissioning and Monitoring Guide Report No ETSU S/P2/00290/REP

Best Practice Guidelines for Wind Energy Development, British Wind Association, http://www.bwea.com/noabl/

Domestic Ground Source Heat Pumps, Energy Efficiency Best Practice Programme Good Practice Guide 339. www.est.org.uk/bestpractice

Renewable Energy Association http://www.r-p-a.org.uk/home.fcm?subsite=1

http://www.berr.gov.uk/energy/sources/renewables/

CIBSE – AM12 – Small-scale CHP in Buildings

Combined Heat and Power Association - http://www.chpa.co.uk/

Micro CHP
http://www.carbontrust.co.uk/technology/technologyaccelerator/small_scale_chp.htm
http://www.carbontrust.co.uk/publications/publicationdetail.htm?productid=CTC726

Renewable Obligations
http://www.berr.gov.uk/energy/sources/renewables/policy/renewables-obligation/page15630.html

BERR, REFORM OF THE RENEWABLES OBLIGATION Statutory Consultation on the Renewables Obligation Order 2009 JUNE 2008

Feed in Tariff
http://www.berr.gov.uk/energy/sources/renewables/policy/feed-intariffs/page50362.html
www.decc.gov.uk
DECC, Consultation on Renewable Electricity Financial Incentives 2009

Renewable Heat Incentive
http://www.berr.gov.uk/energy/sources/renewables/policy/renewableheatincentive/page50364.html

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Water and Drainage

Water and Drainage

1.40 **Background**

The Hadley Centre's research into climate change has predicted that by 2080, average summer rainfall could be reduced by up to 50% and winter rainfall increased by up to 30% in the South East. The East of England is the driest region in the UK with an average annual rainfall of just 600mm (24 inches), so it is particularly vulnerable to water shortage. Northamptonshire has an average annual rainfall of between 570-630mm. In addition, increased population size and changes in demography, resulting in more houses being built and more urbanisation has affected the hydrology of river catchments so that more water runs off into rivers and less percolates through the soil. This can lead to localised flooding and water pollution. The implications for buildings are that we will need to adopt sustainable urban drainage strategies to help combat the increased risk of flooding in winter and we will need to make more effective use of water to avoid shortages in summer.

There is a hierarchy of approaches to water conservation similar to that for energy conservation presented above. For water conservation the priorities are:

1. Demand reduction through efficient water use

2. Installation of water efficient technologies

3. On-site collection, re-use and recycling

4. Supply/consumer related measures

1.41 **Efficient Water Use**

As with energy efficiency it is important to reduce the building occupants' utility demand and the mantra

'Reduce, Reuse, Recycle' can be applied to water use within buildings. Water efficiency is not necessarily a technological solution that can be used to promote the 'green' credentials of a development; nevertheless it is certain that efficiency is by far the best method of saving water in any building.

Water efficiency should always be the first approach when seeking to reduce water consumption on any site and is a pre-requisite before considering a water reuse system.

Substantial savings can usually be achieved in new buildings by installing carefully selected water efficient sanitary ware and appliances. Examples of these include:

- Low volume dual flush WCs
- Aerating showers with reduced flow rates
- Reduced bath sizes
- Aerating or spray taps with reduced flow rates
- Efficient appliances.

1.41.1 *Dual Flush WCs*

Dual flush WCs use two different volumes for flushing that can be selected by the user. The smaller volume is selected when the WC is required to flush only liquid rather than solid waste. Dual flush 6/4 litre WCs account for upwards of 80% of sales in the toilet market. Toilets with even lower flushes (for example, 4/2.6 litres) are becoming more widely available and are able to contribute towards significant reductions in the internal water consumption.

1.5 litre flush Propelair toilet

4/2.6 litre dual flush Twyfords Galerie toilet

4.5 litre flush Ifo Cera ES4 toilet

It is important when specifying toilets with reduced flows to ensure that the drainage gradients have been designed correctly to ensure systems work effectively.

The specified toilets must comply with the appropriate legislation (Water Supply Fittings Regulations 1999) and standards (BS EN 997:2003). The three toilets given as examples in Figures 6.1-3 have been designed to meet these standards.

1.41.2 *Low Flow Showers*

The BRE water consumption calculation methodology assumes that where both a shower and bath are installed, the shower is used 60% of the time for an average of 5 minutes. Water-saver showers with aerating shower heads typically operate at a flow rate of between 4 and 9 litres per minute, and produces a good perception of a high flow rate. Simple flow restrictors can also be fitted to normal shower models (either in the supply pipework or the shower head) to bring the flow rate of the shower down.

Currently there are no upper limits on flows in the UK, while in the US the maximum flow rate is 9.5 litres per minute. It should be noted however that showers with flow rates reduced to less than 3 litres are susceptible to replacement by the occupant, which would negate their purpose.

Some examples of showers with their flow-rate and overall daily water consumption in litres per person per day are shown in Table 6.1 below.

Table 6.1: Product options for low flow showers.

Flow rate	Litres / person / day	Product Examples
9 litres/minute	27.00	Mira Rada R105, Flowpoint FH242
8.5 litres/minute	25.50	Motion Flow N2143, Aeroflow N2144
8 litres/minute	24.00	Auteau Tonic 010, Oxygenics X-Stream
7.5 litres/minute	22.50	Oxygenics Guardian, Earth Showers N2920
7 litres/minute	21.00	Flowpoint FH655

1.41.3 *Reduced Bath Size*

Surveys carried out by UK water utilities have discovered that the average capacity of a standard bath is 225 litres, but the average amount of water used when bathing was 88 litres. There is therefore a significant potential to reduce the average capacity of a bath. Alterations can often be achieved without reducing the physical size of the bath. Tapered or peanut-shaped baths may provide more space for bathing with less water. Table 6.2 indicates the product options for reduced capacity baths.

Table 6.2: Product options for reduced capacity baths. Please note that bath volume is not necessarily an indicator of price.

	Litres / person / day	Product Examples
225 litres to overflow	36.00	Various
160 litres to overflow	25.60	Armitage Shanks Tiffany
140 litres to overflow	22.40	Armitage Shanks Nisa

1.41.4 *Low Flow Taps*

Wash basins in bathrooms tend to be mainly used for hand washing. This makes them ideal for fitting with spray or other types of low water use taps. Reduced flow taps are generally less appropriate for kitchen taps, as they can significantly increase the time taken to fill the basin.

Modifications to ordinary taps allowing variable flow rate taps (those with a 'brake' of flow between water efficient and standard flow rates) should be considered. For example, the Tap Magic device2 has two modes of operation; an economical spray and a 'full flow' mode that activates as the tap is turned on further. This may be more practical for a kitchen sink tap, where it is more likely that the basin will be filled.

BRE has confirmed that for variable flow rate taps, the flow rate used for water consumption calculation purposes should be "the maximum flow rate of the lower range before the water break". For the Tap Magic products, this results in a flow rate of 2.2 litres/minute, making them one of the most efficient water-saving tap modifiers currently available on the market. It should also be noted that where a dishwasher is present, the number of occasions when the kitchen basin will be filled will be substantially reduced.

Lower flow rate taps currently available on the market include spray taps, aerated taps and variable flow rate taps. There are a few points to consider when installing low flow taps in residential properties. The principle concern is that flow rates may be too low to initiate the firing of gas fired combi boilers. Modern modulating combis should be compatible with all but the lowest flow fittings. It is recommended that the client and their contractors ensure that the heating system selected for the proposed dwellings is compatible with low flow taps.

Additionally, in hard-water areas, sprays may need regular de-scaling to make sure that they do not become blocked. To avoid long delays while water runs hot, pipes to spray taps should be no longer than 1m from a point-of-use water heater or pumped loop.

Sample cost and product information for low flow taps is provided in Table 6.3.

Table 6.3: Product options for low flow rate taps

Product Name	Flow rate
Tap Magic M24[8]	2 – 7.6 litres/minute
Aqualogic (M22 Female) Tap Aerator AQT59144	2.5 litres/minute
Performa 159 Water Saving Basin Tap[9]	4 litres/minute
Kaja KA-35020 Kaja Disk basin tap with Ecotop cartridge and pop up waste	3 litres/minute

For standard taps an additional adapter can be installed which will enable the fitting of a pressure compensating aerator to most circular tap outlets.

1.41.5 *Efficient Appliances (Washing Machines and Dishwashers)*

The BRE water consumption calculation assumes a standard washing machine will use approximately 49 litres per cycle and a standard dishwasher approximately 13 litres per cycle. Achieving the CSH Level 4 mandatory requirement of 105 l/p/d or less is extremely difficult without using water efficient appliances. Some examples of efficient appliances are listed in Tables 6.4 and 6.5. Further details of efficient appliances can be found on the WaterWise website.

Table 6.4: Options for water efficient washing machines, based on full-sized models as listed by Waterwise [10]

Water use per wash	Litres / person / day	Product Examples
49 litres/cycle	16.66	(various)
45 litres/cycle	15.30	AEG L86810, Miele 2209, Gorenje WA74163, Hover
43 litres/cycle	14.62	AEG LL1620, Siemens 1435GB, Bosch 15SLogix
42 litres/cycle	14.28	Miele 1512
39 litres/cycle	13.26	AEG 88810, Gorenje WA65205

Table 6.5: Options for water efficient dishwashers, based on full-sized models as listed by Waterwise 'Water efficiency ranking of UK Dishwashers Nov 2006'[4]

Water use per wash	Litres / person / day	Product Examples
13 litres/cycle	3.90	(various)
12 litres/cycle	3.60	Bosch SGS46E, Neff S54T59, Siemens SE65T390GB
10 litres/cycle	3.00	Miele G2570/2870/1530

[2]Tap Magic - http://www.tapmagic.co.uk/index.html
[3]Performa Taps http://www.pegler.co.uk/prod/products_brand.aspx?FolderID=42&SubFolderID=82
[10] 'Waterwise - http://www.waterwise.org.uk/

1.41.6 *Additional Internal Water Consumption*

We have assumed that additional sanitary ware or appliances that could also contribute to the internal water consumption, such as bidets or water softeners, will be excluded from dwellings as these tend not to be part of the standard specification for residential dwellings.

1.41.7 *Building Drainage Implications*

The following excerpt from a BRE report[11] on the effect of reduced water use on drainage for domestic dwellings highlights potential impacts which must be considered when planning high density developments. The technology is still in its early development in the UK and subsequently there is currently very little existing design guidance to refer to at this stage. However, experts in this area are confident that the existing European Standard and experience will be incorporated into drainage design in the UK without difficulty.

'*Current and predicted future pressure on existing water resources, coupled with a growing emphasis towards designing for sustainability, are drivers behind the increasing use of water-efficient appliances in buildings. However, some of the many advantages associated with water-saving techniques and practices in buildings may be negated if the drainage systems malfunction and block. At present, the environmental and economic cases for reduced water usage are made with little information about the possible implications for drain and sewer systems.*

Drainage systems must be able to cope with the reduced effluent flows that are associated with the current trend towards water conservation. All pipes should be laid at gradients that are sufficient to prevent the build-up of blockages in drain and sewer systems.'

1.42 **Water Reuse**

Water reuse systems have a higher financial cost than the basic water efficiency measures described in the previous section. Consequently, they should be considered as an additional measure once appropriate steps have been taken to increase water efficiency.

1.42.1 *Greywater Recycling*

Greywater usually refers to wastewater from wash basins, baths and showers. It does not include waste from toilets, which is defined as black water. Kitchen waste water is also considered to be black water, due to the high levels of grease and food particles. There are a number of emerging technologies in development for the reuse of greywater. Most large scale greywater systems are essentially scaled down sewage treatment systems and have the potential to handle large quantities of greywater and treat it to a very high level. Systems are often designed to store the treated water underground, as the cold dark environment reduces the speed of deterioration of the water.

Greywater that has been collected from the wash basin taps, showers and baths can be used to provide the water required to flush the toilets. Domestic consumption of water for flushing toilets is well matched to the daily production of greywater, and as a result the volume of water required to be stored is dramatically reduced. Greywater can potentially also be used within washing machines.

Biological greywater treatment systems located within an enclosed building require some degree of ventilation to deal with the off-gases from the biological treatment process. The level of ventilation is dependent on the size and type of system.

The appropriate guidance should be used when sizing and designing a greywater system in order to ensure it is of adequate size to serve all included units. Due to the changing market the guidance can become out of date relatively quickly; however existing guidance includes CIRIA Rainwater and greywater use in buildings. Best practice guidance (C539 2001), BSRIA Water

11 *Drainage design for buildings with reduced water use,* BRE Information paper 1/04.

Reclamation Guidance Technical Note (TN 6/2002) and CIBSE Knowledge Series Reclaimed Water (2005).

Some examples of greywater recycling systems for residential use are described below. It should be noted that if there is no treated water available, the control units for all systems will automatically switch to mains water back-up via an air gap, ensuring a continuous supply of water. All of the systems have intelligent controls which notify the user of problems with the system. They are also designed to revert to mains water back up in the event of any system failure.

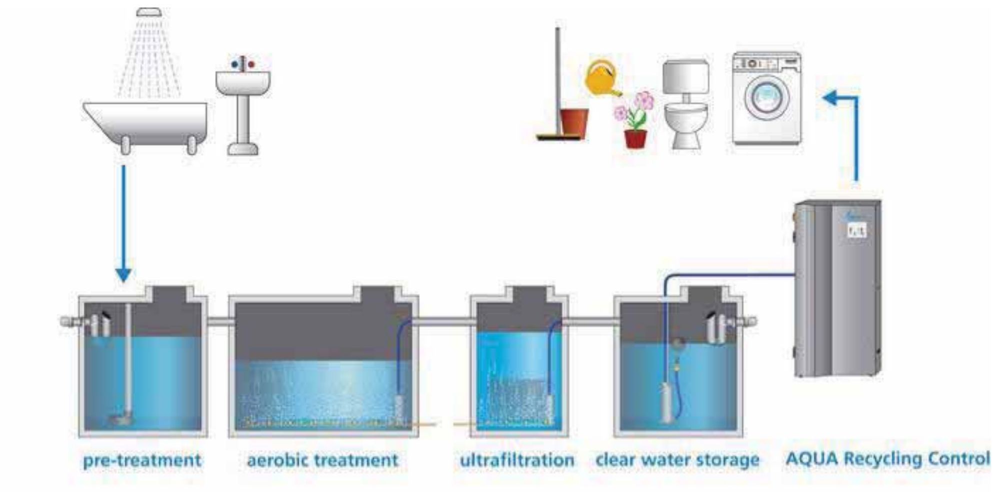
1.42.2 *Communal Greywater Recycling Systems*

Large communal greywater recycling systems can benefit from economies of scale in terms of storage, treatment and pumping and thus are likely to have a shorter payback period. Maintenance contracts can be arranged with the majority of suppliers, enabling them to undertake regular maintenance visits. However, as with all communal systems, ownership and management need to be defined.

AQUA-Recycling Biological Membrane Filter
The greywater from showers, baths and hand wash basins is treated in a four stage process, after which it can be used for flushing toilets. This process includes:

1. Pre-treatment - larger dirt particles are taken out of the process by sedimentation
2. Aerobic treatment - bio-degradable substances are degraded by cleaning bacteria
3. Membrane filtration - all particles larger than 0.00005mm are retained by the membrane
4. Clear water storage - the end water is stored for future reuse

Figure 6.4: Diagram of the operation of the AQUA-Recycling Control unit[12]



The advantages of a Biological Membrane Filter System are:

- Permanent high water quality due to membrane filtration
- Automated processes and cleaning effect
- Operating safety due to monitored water quality and plant operation with the ability to connect to a building management system
- No chemical additives needed
- The only energy requirements in use are for pumping

Disadvantages of a Biological Membrane Filter System are:

- Costs for annual maintenance requirement are relatively high and vary between £500-£2000, depending on whether the membrane needs to be replaced. If the membrane only needs to be cleaned the cost is a maximum of £500 (based on quotes for the London area);
- High level of chlorinated or chemicals flushed through the system may affect the membrane life length;
- User/resident education will be necessary to prolong membrane life length (i.e. some hair dyes, chemicals, etc. should be prohibited);
- Ventilation requirements for the plant/treatment room;
- Ownership and management of the communal system must be defined.

[12] Aqua-lity - http://www.aqua-lity.co.uk

Aquaco Media Filter System – (Deep Bed filtration)
The Spruce multi-layer filter provides a system for the elimination or reduction of pathogenic micro-organisms from water and wastewater. The filter bed comprises four layers of inert particulate material. The top layer of the filter contains coarse particles which decreases in coarseness in size through the 4 layers. The final layer uses a fine magnalite media which is naturally charged and attracts the bacteria in the water, reducing or eliminating the pathogenic micro-organisms. There is an optional, final stage of treatment involving UV disinfectant.

The advantages of a Media Filter System are:

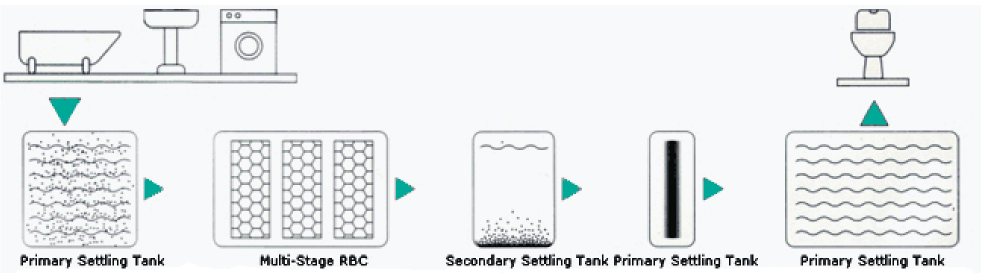
- Permanent high water quality due to the ultra filtration;
- The filter is easy to install and supplied as a skid mounted unit, assembled ready for inlet/outlet connections;
- Long service life with low maintenance due to automated back wash processes and cleaning effect. Multi Media guaranteed for thirty years;
- No chemical additives needed;
- The only energy requirement in use is for pumping.

Disadvantages of a Media Filter System are:

- Annual Maintenance requirements are approximately £1750. The maintenance involves back washing the system with an alkaline substance at a pH 8/9 annually. Other annual checks include checking pumps, cleaning tanks and replacing UV bulbs
- Each system will require a header tank, this will usually be a small tank within each home
- The systems cannot be scaled down for smaller developments at this stage, although work is being undertaken by companies to develop this. These types of system often only become financially viable for very large developments.

FreeWater UK Rotating Biological Contactor (RBC)
The greywater is cleaned with a biological wastewater treatment system. Characteristic wastewater bacteria consumes the biologically degradable waste particles. Oxygen is supplied by the revolving rotors to provide the optimal environment for the aerobic process. The surplus biological sludge is then allowed to settle in a secondary settling tank. The biologically treated greywater is disinfected by the means of UV-radiation and stored in a treated water tank.

Figure 6.5: Biological treatment with the Rotating Biological Contactor (RBC)[13]



[13]Free Water - www.freewater.co.uk

Figure 6.6: Typical Rotating Biological Contactor (RBC) System Installation (Courtesy of Freewater Ltd.)

The advantages of a RBC System are:

- Permanent high water quality due to the biological treatment and filtration
- Long service life with low maintenance due to automated processes and cleaning effect
- The system can treat highly polluted levels of water
- No chemical additives needed

Disadvantages of a RBC System are:

- Annual Maintenance requirements. Specialist staff would need to be trained
- Has a continuous energy consumption
- Ownership and management of the communal system must be defined
- Plant room space must be available
- Ventilation requirements for the plant/treatment room

1.42.3 Individual Grey Water Treatment Systems

Aqua Cycle
The Aqua Cycle is a stand alone, greywater treatment unit comprising a biological treatment, UV micro-organism reduction and storage tanks for use in individual dwellings. The system comprises of three modular tanks, each of 300 litre capacity. The greywater is gravity fed into the Aqua Cycle, and the clarified clean water is direct pressure fed to toilet and washing machines.

The Aqua Cycle 900 uses a patented Smart Clean System. The treatment is in 4 main stages:

1. Pre-Filtration - Larger particles such as hair and textile fragments are collected. The filter is automatically flushed by a special spray pump - sediments are washed away into the main wastewater drain

2. Two-fold Biological Treatment - In the main and secondary recycling chambers the dirt particles are decomposed by bio-cultures. The water is pumped to the next station in three hour intervals.

3. Sediment Disposal - The organic sediments which are produced during the recycling process are regularly sucked out from the chambers and diverted into the wastewater drain.

4. UV-Sterilisation - On the way to the storage chamber the recycled water flows through a UV-light lamp, which disinfects it. The high quality of the water conforms to the E.U. Directive 76/160/EWG for recreational water.

Figure 6.7: Photograph showing Aqua Cycle 900 Smart Clean System

In order to collect the shower and bath water, the unit should be installed below the points at which shower and bath water is accumulating, otherwise additional pumps will be required. The location for the unit must be frost-proof, dry, well ventilated and weather-proof.

The advantages of the Aqua Cycle system are:

- Long service life with low maintenance due to automated processes and cleaning effect
- Simple system with no or little maintenance requirements (air pump membrane Exchange recommended every four years)
- Treatment is 100% bio-mechanical therefore free of odours
- No chemical additives needed
- The only energy requirement in use is for pumping.

Disadvantages of the Aqua Cycle system are:

- Plant room/internal space required for the treatment and control units, complete unit is size of small wardrobe
- Additional ventilation may be required in the storage room
- Potential buyer perception issues related to health and maintenance – they may need to be educated of the benefits and details of the system.

Table 6.6: Details of Aqua Cycle greywater recycling system

Manufacturer	Aqua Cycle 900[14]
Type	Individual unit systems
Capacity	300 litres/system
Dimensions	H 1.88m W 1.35m D 0.60m

[14] AquaCycle 900 - http://www.freewateruk.co.uk/domestic-greywater-IV.htm

Ecoplay

The Ecoplay is a self contained greywater recycling system that can be installed in bathrooms behind the conventional WC. The system is basically an oversized cistern, with a greywater cleaning tank and a cleaned recycled water storage tank. Water from baths and showers is captured and fed into a cleaning tank, where soap suds and hair are skimmed off and heavier particles such as grit and sand sink to the bottom. Cleaned water from the middle of the cleaning tank is then taken to a storage tank, where it is used to refill toilet cisterns when flushed. The Ecoplay system has the capacity to run up to two toilets in a dwelling, although if a second WC is specified it needs to be a specialised system with water storage and controls. The Ecoplay system requires no separate filters that have to be maintained or replaced regularly so maintenance requirements are very low.

If electric showers are to be installed in the dwellings, a heat exchanger system can be fitted to the top of the Ecoplay unit to increase the cold water feed temperatures to the shower. The result of this is a predicted rise in temperature from 3 -5 degrees to 20 -22 degrees and an equivalent energy saving in the region of 10 KWh.

The advantages of the Ecoplay Systems are:

- Relatively small size, complete unit is similar in size to an ordinary cistern
- Only short lengths of pipe work are needed within the dwelling
- Low maintenance due to automated processes and cleaning effect
- Simple system with no or little maintenance requirements
- No chemical additives needed.

Disadvantages of the Ecoplay Systems are:

- Low/no level treatment of water
- Potential resident perception issues related to health and maintenance – Residents should be educated of the benefits and details of the system
- The system only provides around a third of the water needing for WC flushing and is therefore not as efficient as other greywater systems.

Figure 6.8: Ecoplay greywater recycling system.

Table 6.7: Details of Ecoplay greywater recycling system

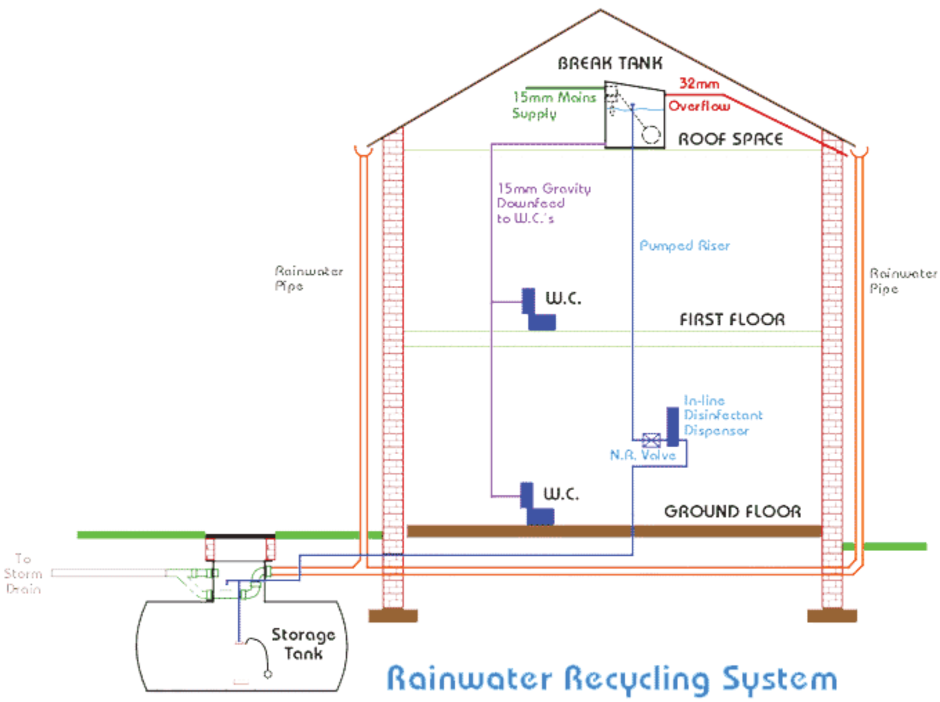
Manufacturer	Ecoplay
Type	Individual unit systems
Capacity	100 litres/system
Dimensions	H 2.30m W 0.85m D 0.24m

1.43 **Rainwater Harvesting Systems**

Rainwater storage has provided a source of water for communities around the world for millennia. The collection and use of rainwater in Northamptonshire could prove an effective method of reducing the growing water demand.

Potentially, rainwater can be used internally for the flushing of WCs and within washing machines, or externally for irrigation and vehicle washing. Collection from roofs is the standard method, where dissolved and suspended particles from the roof are passed into a collection chamber. These may include anything that has fallen onto the roof since the last rain i.e. bird droppings or leaves. It is essential that these are filtered out to avoid contamination of the collected rainwater.

Figure 6.9: Example of a rainwater recycling system



Collection from permeable paving or other hard standing areas, such as parking areas, requires additional filtration, interceptors/oil traps and further treatment. Systems collecting from flat or green roofs are also likely to require further filtration as well as more sophisticated and regular maintenance regimes. Flat roofs tend to lose more water to evaporation and have increased puddle formation, encouraging the growth of algae and bacteria in any rainwater harvested. The filter system should be designed to accommodate this.

Rainwater tanks are usually sized to meet approximately 5% of the total average annual rainfall yield, which will then provide for 10-20 days storage and supply. Estimated efficiencies of up to 90% are feasible within 10 days' storage, rising close to 100% with 20 days storage. .

Tanks should be located as close as possible to the building it serves to avoid extended pipe runs. Typically communal tanks could be located under hard or soft landscape. Locating tanks underground ensures that the temperature of the water remains low allowing the water to be stored for longer periods. The tanks are also then protected against frost. Communal tanks can be constructed using concrete, plastic or metal. However the choice of different materials will depend upon the nature of the ground and the cost of the system.

With storage tanks at ground level or below, pumps will be necessary to extract and deliver the water. The water can be run to a header tank or can be provided at pressure directly from the pump. The amount of electricity needed to run the pumps is negligible relative to typical annual consumption.

1.43.1 Communal Rainwater Harvesting Systems

There are many different rainwater systems available on the market, a small selection of which have been described below.

Aquaco Communal Rainwater System:

The system simply involves the collection of water from surfaces on which rain falls, and subsequently storing this water for later use. Normally water is collected from the roofs of buildings and stored in rainwater tanks. All that is necessary to capture this water is to direct the flow of rainwater from roof gutters to a rainwater storage tank. By doing this, water can be collected and used for various uses. In summary:

- All the roof rainwater is collected at a general point and distributed to the GRP collection tank
- Prior to the rainwater entering the collection tank it is filtered via a ground filter.
- The rainwater is then pumped to the header tank
- Prior to reaching the building it is disinfected via the ultra violet process
- The rainwater is distributed to the WCs via the header tank which incorporate mains water back up, riser connection and overflow.

Table 6.8: Details and example system - Aquaco communal rainwater harvesting systems

Manufacturer	Aquaco
Tank Volume	5000 litres
Tank Dimensions	H 1.225m W 4.700m

Prices quoted above include an in-line filter assembly located within the rain water collection tank and a submersible pump to distribute the water. The Aquaco system price also includes a UV disinfection unit.

Rainman Standard T

In this system design, rainwater falling onto the roof flows along the gutter through the down pipe into the tank, via an integrated filter that ensures unwanted particles are removed. The filtered water is fed to the bottom of the tank through a calmed inlet, where it is deflected upwards, oxygenating existing tank water and ensuring a further natural biological cleaning process takes place. On demand, the submersible pump delivers the clean rainwater to toilets and washing machines. The system also has an automatic mains water tank top up facility, ensuring a constant water supply is guaranteed even when tank rainwater levels are low.

Maintenance requirements are very low. For dwellings with flat roofs it is recommended that the pump filter is changed regularly for the first year, to ensure that it is operating correctly.

As the development has flat roofs it may be recommended that this system is fitted with a UV disinfectant system.

Advantages of the Rainman T systems are:

- The in-tank filter does not obstruct maintenance access and captures almost 100% of the incoming rainwater
- 'Elite' system will flag up leaks and other system errors, and has setting to switch system off if irrigation hosepipe is left on for longer than 45 minutes.

Disadvantages of the Rainman T systems are:

- Low/no level treatment of water
- Potential buyer perception issues related to health and maintenance – they may need to be educated of the benefits and details of the system.

Table 6.9: Details for Rainman T rainwater harvesting system

Manufacturer	Rainman Standard T
Tank Volume	3300 litres
Tank Dimensions	H 2.23m W 1.40m D 2.40m

For all systems, costs quoted would include the delivery, installation, testing and commissioning costs but do not include costs for excavation and additional pipe work costs. The building pipework and excavation must be completed before the systems can be installed.

Generally the costs that have been quoted include the actual system but would be in addition to the cost of providing the necessary water efficient sanitary ware and appliances, as well as the costs associated with installation as described in Table 12.

Table 6.10: Table outlining additional costs involved in installing a domestic rain water system

Additional Developer Costs Can Include:
Civil design and construction
Digging of the hole and installation of the tanks
Supply and installation of the service duct (DN100 pipe)
Supply of 32mm black MDPE pipe within service duct
Mains electrical 230v on/off spur connection
Associated Plumbers Work Costs:
Installation of the pump within the tank
Supply and installation of the water collection pipe on the roof
Supply and installation of the rainwater collection pipe and drainage pipe work
Supply and installation of the water feed pipe to the WCs within the house

1.43.2 *Combined Greywater and Rainwater systems*

Rainwater harvesting systems can be combined with greywater recycling fairly simply in circumstances where the greywater is being stored in an external, underground tank. Rainwater can then be collected and stored in the same tank, avoiding the need for two separate holding tanks.

1.43.3 *Water quality standards and regulations*

One of the major barriers facing the use of greywater and rainwater systems is the lack of a statutory requirement for the quality of reused water. This makes adequate specification of the system very difficult, and leads to confusion as several different standards have been proposed by different organisations.

One of the main actions for the DEFRA Market Transformation Programme (MTP) is to:

"Progress the review of water quality standards for recycled and rainwater use in the home. At present, there are no specific standards. MTP is currently undertaking a review of water quality standards and recommendations for the UK for rainwater and greywater. The objective of the study is to publish a consensus-based action plan that lays out policy and stakeholder actions over a period of 10 to 20 years to ensure deployment of rainwater and/or greywater recycling technologies as mainstream in the construction sector."

Existing regulations for waste water reuse systems, which apply to both rainwater and greywater systems, are based around maintaining human health and safety. In England, the main statutory instrument is the Water Supply (Water Fittings) Regulations 1999. This specifies the need for backflow protection such as air gaps, which vary in type depending on the quality of water stored in the tank, and the need for approved materials to be used for all components. The issue of backflow prevention for the protection of the mains supply should be a fundamental consideration in the design of all water reuse systems. It is also vital to avoid cross contamination of the potable and non-potable water systems where two systems exist. In order to ensure that this is not done accidentally, all non-potable pipework must be labelled clearly, as recommended by the Water Regulations Advisory Scheme (WRAS).

WRAS has produced a document on the subject of 'Reclaimed Water Systems,' which recommends different levels of treatment depending on the use of the water. The types of use are classified as Class A (potable) and Class B (non-potable) as in the Water Supply (Water Quality) Regulations 1989. The classification is summarised below:

- Class A – supplies to kitchen taps, drinks machines etc, basin taps, baths, showers or jacuzzis, any spray systems such as cooling towers, pressure jetting etc.
- Class B – Other water uses including WC flushing, irrigation and laundry.

All of the systems discussed in this report fall under the Class B standards. The two classes of use will require different treatment, with Class A systems being subject to the Private Water Suppliers Regulations 1991 and requiring much more stringent treatment and checking of water quality. We do not recommend treating greywater or rainwater to Class A standards (i.e. for bathing or even for drinking) for residential use. Besides the significant expense, the impact of all the equipment needed outweighs the environmental benefits of reducing mains water use. Small-scale water treatment systems use lots of energy in manufacture and use, and the filters need to be regularly replaced (creating waste).

Like all water systems, greywater and rainwater systems involve the transmission and storage of water, and therefore the risk of Legionnaire's Disease should be assessed for each system. In particular, the Health & Safety Executive's (HSE) Approved Code of Practice and Guidance (ACoP) , and CIBSE's Technical Memorandum 13 should be complied with. The BISRIA Buildings that Save Water project consulted a variety of microbiologists to investigate the maximum acceptable concentration of bacteria in stored water (see Table below). The project report states:

"There are currently no standards in England and Wales relating directly to domestic greywater and rainwater recycling systems. Subsequently, in order to meet the needs of the increasing number of domestic recycling systems available in the country, the Building Services Research and Information Association (BSRIA) published proposed water quality criteria for recycled greywater and stored rainwater (BSRIA 1997), although these have no statutory obligation. These requirements were recently reassessed and a less stringent water quality criteria for greywater for toilet flushing was proposed but was subject to further research (BSRIA 1999)."

1.44 **External Water Use**

Outdoor water use accounts for around 7% of the total water use in the UK, although in the summer this can rise to over 50% of peak demand. Mains quality water is treated to a much higher standard than is necessary for irrigation and car washing so this represents a significant waste of energy and cost.

A domestic rainwater recycling system for external use can be as simple as a water butt, with a down pipe connector to collect surface water running from the roof of the dwelling. The water can be removed either by connecting a hose to the butt, or by using a watering can. No special treatment is required, although ideally water butts should be fitted with a removable lid to enable them to be cleaned regularly and this lid should be well fitted, to keep out unwanted debris and insects.

If greywater is to be diverted for external use, consensus implies that this is acceptable without treatment other than basic filtration, which is necessary to remove hair, soap and other debris that would clog up the system. There are a number of caveats that accompany this use, for example, the irrigation should always be sub-surface to exclude the possibility of contact with people. Also, greywater should not be used to irrigate crops that could be eaten uncooked. If reusing water from a washing machine, a low sodium detergent should be used; as sodium damages plants and degrades soil (liquid detergents usually contain less salt than powders). Phosphorus should also be avoided, as this causes algal blooms if it collects in ponds or rivers. The main disadvantage of the use of untreated grey water in irrigation is that the water cannot be stored for any length of time and therefore is impractical on a large scale.

On a larger scale for communal grey water treatment systems, irrigation systems can comprise water storage tanks, which are often located underground as they are large, cumbersome and heavy vessels. Such irrigation systems are often 'sub-surface;' water is delivered below the ground directly to the plant roots, enabling a smaller volume of water to be used, and reducing the risk to members of the public coming into contact with the water. This type of system can also be used for manual watering systems, using a simplified pump and tap system.

There are a number of features that can be incorporated into an irrigation system to make it more efficient in terms of water used. These include controls which water plants only when required, using moisture sensors or time clocks. Some systems include 'rainwater sensing' systems that shut down the device during rainy spells.

1.45 Sustainable Urban Drainage

Planning policy guidance (Planning Policy Guidance Note 25 (PPG25)) outlines how flood risk issues should be addressed. In most circumstances built development tends to extend the area of impermeable ground from which water runs off rather than percolating into the ground; this can increase total and peak water flows, leading to flooding. At its worst flooding can lead to substantial damage to property and loss of life, more often it results in erosion and pollution of water courses damaging their ecology. The assumption in PPG25 is that SUDS will be used unless it is proven that they are not possible or applicable. SUDS aims to reduce flooding by managing urban water run-off in a way best suited to the development. A SUDS Interim Code of Practice, issued in July 2004[15] has been developed to provide support for developers in promoting and implementing SUDS and to ensure their long-term viability.

SUDS can save money in the following areas:

- Reduced excavation costs during drainage system construction
- Reduced requirement to negotiate wayleaves and easements
- Differential charging to owner/occupiers leading to reductions in sewerage charges
- Simpler building techniques with lower costs involved
- Simpler maintenance techniques.

1.45.1 Examples of SUDS

Pollution prevention and reduction:
The first stage of the SUDS approach is to prevent or reduce pollution and reduce runoff quantities. Examples of these techniques may include:

- Not paving areas unnecessarily
- Draining to lawns
- Preventing or containing spills
- Good housekeeping
- Storage
- Sweeping of paved areas and roads.

Pervious surfaces:
Surfaces that allow inflow of rainwater into the underlying construction or soil. Car parks, car parking areas, patios and garden paths can all be considered. Permeable paving such as Grasscrete[16] can provide the structural loading necessary for HGV's.

Photograph of a Grasscrete System of permeable paving.

[15] http://www.ciria.org/suds/pdf/nswg_icop_for_suds_0704.pdf
[16] http://www.grasscrete.com/docs/pdfs/02grasscrete.pdf

Filter drains:
These are linear drains consisting of trenches filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage; to store and conduct water, but also may permit infiltration.

Filter strips:
Vegetated areas of gently sloping ground designed to drain water evenly off impermeable areas and filter out silt and other particulates.

Swales:
Shallow vegetated channels designed to conduct and retain water, but may also permit infiltration; the vegetation filters particulate matter. The conservation benefits of SUDS can be achieved early in the system with swales and filter strips that can be colonised by a variety of wetland plant and animal species. However, the presence of pollutants in water draining into swales and filter strips means that they are likely to support only relatively robust and common pollution-tolerant species. Swales and filter strips should be allowed to vegetate naturally wherever possible.

Basins, ponds and wetlands:
These are areas that may be utilised for surface runoff storage. A balancing pond is designed to attenuate flows by storing runoff during the storm and releasing it at a controlled rate during and after the storm. Detention basins, and extended detention basins, are designed to be free from water under dry weather flow conditions, while balancing, attenuation and retention ponds, lagoons and wetlands are designed to retain some water all year round. Balancing ponds, and also watercourses and surrounding landform, can be designed and constructed where appropriate to introduce ecological features. The preferred design of the attenuation ponds is that they permanently contain water to encourage flora and fauna. These can be used to enhance recreational areas in the public open space and could be planted with reeds to improve water quality.

Soakaways:
Sub-surface structures to promote the infiltration of surface water to ground.

Infiltration trenches: These are trenches, usually filled with granular material, designed to promote the passage of surface water to the ground.

Ditches:
Existing ditches can be utilised in some areas to drain localised roads, individual properties, and carry runoff from the attenuation ponds to main rivers.

Pipes and accessories:
These are a series of conduits and their accessories normally laid below ground and designed to convey surface water to a suitable location for treatment and/or disposal. They are sustainable systems where the use of other SUDS devices is not practicable.

Rainwater re-use:
Such systems can be used even where other SUDS devices may be considered unsuitable and so should always be considered as a “first line”.

Green roofs:
A green roof is one with plants growing on its surface. The vegetated surface provides a degree of retention and treatment of rainwater, and promotes evapotranspiration.

There are some instances when SUDS may not be suitable, in particular:

- The surface structures that may be needed can take more space than conventional drainage systems
- The use of infiltration devices may be limited where the soil is not very permeable (clay), the water table is shallow, the groundwater under the site may be put at risk, or infiltration of water into the ground may adversely affect ground stability.

1.46 **Reed Beds**

Traditionally, domestic wastewater has either been disposed of using a mains drainage system or cesspool, or treated by using a septic tank with an infiltration system to the soil or by using a packaged plant. However, reed bed systems are increasingly being considered for use in various situations in the UK for treating effluent waste. Guidance on good practice can be found in BRE documents GBG 42 part 1 & 2 Reed Beds: Design Construction and Maintenance, good building guide.

1.47 Further Information

PPG 25 Development and flood risk (DTLR 2001)

CIRIA publish the following documents which are relevant to SUDS and rainwater and grey water http://www.ciria.org.uk/suds/ :

- Sustainable Drainage Systems – Design Manual for England and Wales. C522
- Sustainable Drainage Systems – Best practice. C523
- Source control using constructed pervious surfaces. C582
- Infiltration drainage – Manual of good practice. C156
- Rainwater and grey water use in buildings – best practice guide. C539
- Review of the design and management of constructed wetlands. C180

Interim Code of Practice for Sustainable Urban Drainage can be sourced at:

http://www.ciria.org/suds/pdf/nswg_icop_for_suds_0704.pdf

The Environment Agency publishes the following, which are relevant to SUDS and rainwater and grey water: http://www.environment-agency.gov.uk/

- Harvesting rainwater for domestic uses: an information guide, July 2003 - http://www.environment-agency.gov.uk/commondata/acrobat/rainharvest_june04_809069.pdf
- Policy and practice for the protection of groundwater, (1998)
- SUDS – Guide for Developers,
- Framework for Sustainable Urban Drainage Systems (SUDS) in England and Wales, 2003
- Conserving water in Buildings, Guidance sheet 3: Grey water recycling
- SUDS policy, http://www.environment-agency.gov.uk/business/444304/502508/464710/464884/?lang=_e
- Interim code of practice for Sustainable Urban Drainage - http://www.environment-agency.gov.uk/commondata/105385/icop_final_0704_872183.pdf

Reclaimed Water Systems, WRAS Information and Guidance note, August 1999 No. 9-02-04. www.wras.co.uk

UK Rainwater Harvesting Association: www.ukrha.org

The Enhanced Capital Allowance Scheme lists recognized water efficiency products that qualify for Enhanced Capital Allowances – www.eca-water.gov.uk

Envirowise (Practical Environmental Advice for Businesses) www.envirowise.gov.uk

GG067 Cost-Effective Water Saving Devices and Practices

The Bathroom Association provides information on suppliers of water saving devices – www.bathroom-association.org - T: 01782 747123

BSRIA Water Reclamation Guidance Technical Note (TN 6/2002)

CIBSE Knowledge Series Reclaimed Water (2005).

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Materials

Materials

1.48 **Background**

The production, use and disposal of building materials consume energy and non-renewable resources, resulting in emissions to air and water and leaving significant quantities of solid waste. The UK construction industry uses 420 million tonnes of resources every year[17]. Resource extraction processes such as mining and forestry can have additional local impacts, such as loss of habitat and biodiversity. Any contribution to the built environment will have an impact on the natural environment; therefore taking a more environmentally responsible approach to the selection and specification of materials is essential in providing a sustainable solution to new developments.

There are many issues that need consideration when assessing whether a material has been sourced or manufactured in a sustainable way; some of the key considerations include:

- Embodied energy – The energy spent on the extraction, production and delivery of the material
- Resource Degradation – Consideration should be given to both resource scarcity and impact on the natural environment (habitat loss, waste disposal, water extraction and acid deposition)
- Toxicity – Refers to the potential pollution to the environment during extraction and processing plus the toxicity of finished products that may impact installers and occupants of the buildings.

In order to reduce the impact of materials and the use of resources a strategy must be developed that will:

- Make use of materials with the lowest impacts over their lifecycle
- Use existing materials or procure reclaimed and recycled materials
- Use local materials to reduce their transportation impacts
- Reduce waste in design and at construction
- Assist residents to reduce and recycle waste in occupation.

1.49 **Green Guide to Building Specification**

The principal guidance document on specifying sustainable materials is the BRE Green Guide to Specification – used to determine the relative performance of different materials. The Green Guide has recently been updated, which now contains more than 1200 specifications used in common building types. The Building Research Establishment has examined the relative environmental impacts of the construction materials commonly used in six different generic building types which include:

- Commercial buildings, such as offices
- Educational
- Healthcare
- Retail
- Residential
- Industrial.

[17] http://www.environment-agency.gov.uk/commondata/acrobat/susmats_factsheet_1365397.pdf
[17] http://www.thegreenguide.org.uk/page.jsp?id=2

The guide provides a rating of 'A' to 'C' for each element of a building and for each of the common construction types commonly used to build that element. Materials and construction methods with a rating of 'A' have the lowest impact overall compared with the alternative construction methods available.

The Green Guide assesses the materials and construction elements against the following criteria[18]:

- Climate change
- Water extraction
- Mineral resource depletion
- Stratospheric ozone depletion
- Human toxicity
- Ecotoxicity to freshwater
- Nuclear waste
- Ecotoxicity to land
- Waste disposal
- Fossil fuel depletion
- Eutrophication
- Photochemical ozone creation
- Acidification.

Examples of 'A' rated construction types (please note there are many more examples in the guide) include:

External walls

- Brickwork outer leaf, insulation, steel frame, plasterboard, paint
- Concrete tiles, battens, timber frame with insulation, plaster board, paint
- Brickwork outer leaf, insulation, aerated block work inner leaf, plasterboard/plaster, paint

Roofing

- Concrete tiles, battens, sarking felt, battens on timber roof structure with insulation between rafters
- Plywood decking on timber joists with insulation, polyester-reinforced bitumen felt

Internal walls

- Aerated block work partition, plasterboard/plaster, paint
- Timber studwork partition, plasterboard, paint
- Aerated block work cavity wall with isolated plasterboard panels.

Windows

- Pre-treated softwood frame, double glazed, painted inside and out

1.50 **Reclaimed Materials**

Recycled materials are considered to be any materials that have been taken from the waste stream and reprocessed and remanufactured to form part of a new product.

Construction materials account for:

- 420 million tonnes of material consumption (7 tonnes per person)
- 20% of the UK's total ecological footprint
- 19% of the UK's total greenhouse gas emissions
- 30% of all UK road freight.

The embodied environmental impacts of these large quantities of material are generated during:

- Extraction of raw materials
- Processing and manufacture
- Transportation.

Direct substitution of reclaimed materials for new in any construction or building work will radically reduce the environmental impact of that particular item. It removes the need to extract more raw materials and it largely removes the need for processing and manufacture. Transportation impacts are usually reduced too as reclaimed materials tend to be sourced locally (although not always).

1.51 **Natural Material Selection**

Natural products have many advantages over conventional materials. They are low impact, made from renewable, organic resources and have low embodied energy. They can be reused and recycled and are fully biodegradable. They are non-toxic, allergen-free and can be safely handled and installed. They also allow for a building to breathe by regulating humidity through their absorbent properties therefore reducing problems of condensation. This keeps the indoor environment comfortable and protects any timber structures from rot. The optimal material selection would be to choose natural produced that can be locally sourced.

Materials that can be used in place of conventional building materials include:

Timber:
Timber offers one of the most sustainable construction resources available provided sufficient plantations and forestry management is in place to protect forests from exploitation. Selecting exotic timbers from ancient rainforests in Malaysia, Indonesia and the Amazon should be avoided, with preference given to locally sourced timber and timber products.

Bricks:
Fired bricks are produced using a mixture of clay and water. Units are moulded, dried and fired. Brick kilns use a large amount of energy. The clay used in ‘stocks’ often requires extra firing. ‘Mud’ bricks require very little generated energy to manufacture but large amounts of water. The embodied energy content of mud bricks is potentially the lowest of all building materials but additives, excessive transport and other mechanical energy use can increase the 'delivered' embodied energy of all earth construction.

Straw:
Straw bale construction uses baled straw from wheat, oats, barley, rye, rice and others in walls covered by stucco. Straw bales are traditionally a waste product, which farmers do not till under the soil but do sell as animal bedding or landscape supply due to their durable nature. In many areas of the country, it is also burned, causing severe air quality problems. It is important to recognise that straw is the dry plant material or stalk left in the field after a plant has matured, been harvested for seed, and is no longer alive.

1.52 Natural Building Fabric Recommendations

External walls:
Hempcrete - Is being marketed as an eco-friendly alternative to concrete. Hempcrete is a generic term for a hemp-based building material that can be used in place of concrete. It consists of a mixture of hemp, lime, sand, plaster, and cement, and can be used in the same way as concrete.

Produced mainly from renewable sources, Hempcrete has excellent performance characteristics for durable, healthy, sustainable and ecologically sound buildings. It also delivers excellent application and aesthetic performance characteristics combined with economic comfort.

Rammed earth - Rammed earth walls (aka pise) are constructed by the compacting (ramming) of moistened subsoil into place between temporary formwork panels. When dried, the result is a dense, hard monolithic wall.

In recent years, rammed earth has become popular amongst environmentally-conscious architects as well as those seeking an element of exoticism. Contemporary examples include:

- The Eden Project visitors' centre in Cornwall
- The AtEIC building at CAT in Powys.

Although there are a growing number of buildings including rammed earth in the UK, its prospects of entering mainstream construction as a structural material are limited due to formwork and labour costs involved together with a climate that has relatively high humidity and moderate external temperatures.

The likely future for the application of rammed earth is as:

- Thermal mass
- Internal load-bearing non-stabilised walls
- External load-bearing stabilised walls.

Green roofs:
Life cycle costing indicates that green roofs cost the same or less than conventional roofing and they are an investment which provides a significant number of social, environmental and economic benefits that are both public and private in nature.

They have been standard construction practice in many countries for hundreds, if not thousands, of years, mainly due to the excellent insulation qualities of the combined plant and soil layers (sod).

Green roofs are usually categorised into two groups, Intensive and extensive[19]:

Intensive Green Roofs composed of relatively deep substrates and can therefore support a wide range of plant types: trees and shrubs as well as perennials, grasses and annuals. As a result they are generally heavy and require specific support from the building. Because of their larger plant material and horticultural diversity, intensive green roofs can require substantial input of maintenance resources – the usual pruning, clipping, watering and weeding as well as irrigation and fertilization.

Extensive Green Roofs are composed of lightweight layers of free-draining material that support low-growing, tough drought-resistant vegetation. Generally the depth of growing medium is from a few centimetres up to a maximum of around 10cm. These roof types have great potential for wide application because, being lightweight, they require little or no additional structural support from the building, and because the vegetation is adapted to the extreme roof top environment (high winds, hot sun, drought, and winter cold) they require little in the way of maintenance and resource inputs.

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[19] http://www.thegreenroofcentre.co.uk/pages/what.html

1.53 **Insulation Materials**

Unfortunately, natural insulation materials are currently up to four times more expensive than conventional materials, which can be prohibitive to builders, architects and developers. But the environmental and health benefits of natural insulation materials far outweigh their costs, and growing consumer demand combined with government regulation and rising oil prices will inevitably drive prices down. Despite the high price, natural insulation is an energy-efficient, healthy and sustainable choice for a better indoor and outdoor environment.

There is a wide array of insulating materials for the Specifier to select from. They range from the familiar polystyrene and mineral wool through to alternatives now entering the market such as sheep's wool and hemp.

When selecting an insulation material, primacy should be given to performance in the construction context. Very few insulation materials are capable of performing all the functions called for e.g. sheep's wool is perfectly suitable for ventilated wall construction but not in unventilated cavities. The choice of insulation will be governed by choice of construction and vice-versa.

Selection by performance continues to be the most important consideration; however the current evolution of the market in 'green' products will complicate the choice for Specifiers. Life cycle data is available for some products; however other often newer products have not had their claims verified by third party research, leaving some manufacturers claims open to contention.

1.54 **Ozone Depletion**

In the EU, CFC production and import was banned in 1995. HCFCs have been used as temporary replacements for CFCs as they have a much lower 'ozone depletion potential' (ODP); however EC Council Regulation 2037/2000 banned the use of HCFCs in all foam plastic insulation materials from 1st January 2004. Stocks of some materials may still exist and products should be selected that are known not to contain HCFCs.

The same regulation also banned the use of HCFCs in any new refrigeration or air-conditioning equipment from 1 January 2004 and CIBSE have provided guidance to their members that HCFCs should no longer be used in new equipment.[20] Any energy-efficient white goods supplied or offered to purchasers should exclude the use of fridges and freezers using ozone-depleting substances either as refrigerants or in their insulation. Alternative products are now widely available. Care must be taken when specifying insulation materials that they have an ODP rating of zero.

1.55 **Cement Substitutes**

The production of cement is a significant contributor to global warming. In addition to optimising the energy efficiency of Portland cement production plants, the amount of cement used in concrete mixes can be reduced by using cement substitutes.

Data on the use of Portland cement indicates[21]:

- Cement production is the third ranking producer of CO_2 in the world after transport and energy generation
- Cement production is responsible for 7-10% of the world's total CO_2 emission and 2% of that produced in the UK (according to the BCA)
- For every tonne of cement produced, approx. 1 tonne of CO_2 is produced from chemical reaction and the burning of fossil fuel
- The UK produces around 12,000,000 tonnes of cement per annum
- Cement production is increasing worldwide by approx. 5% per annum.

[20] http://www.berr.gov.uk/sectors/sustainability/fgases/page28889.html
[21] http://www.greenspec.co.uk/html/materials/cementsub.html

All cement substitutes have the dual benefit of replacing energy-intensive Portland cement, and of using material that would otherwise be landfilled.

1.56 **Timber from Sustainable Sources**

Forest management can be environmentally appropriate and socially beneficial, but it can also be environmentally and socially damaging. Preference should be given to timber and timber products that have been independently certified from well-managed and licensed European sources to reduce transport energy requirements. Where available and where it does not significantly increase costs, timber should be selected from suppliers certified by the FSC or PEFC. Timber from unknown origins should not be used. Significant credits can be obtained under CSH and BREEAM schemes by specifying FSC or PEFC certified timber for internal and external timber uses.

If independently certified timber proves to be unavailable, contractors should as a second resort only, use timber from a known source. They should also attempt to gain as much assurance as possible that the forest is well-managed and seek documentation of proof. Documentation must be provided to prove that every attempt has been made to obtain certified sources before exploring alternatives - flexibility in terms of species specification should be pursued.

1.57 **Modern Methods of Construction**

Modern method of construction (MMC) involves the manufacture and pre-fabrication of structural building parts offsite ranging in size from walls to full room units.

A key component of MMC is in reducing the environmental footprint of construction by utilising three areas:

- Energy savings: Buildings constructed using MMC are built to a high standard of detail as systems are constructed under factory conditions. Air tightness, insulation and thermal bridging can be better controlled than traditional construction methods. Providing installation is in accordance with the specification, buildings should require less energy to heat due to increased levels of thermal insulation and air tightness from the building.
- Resource Efficiency: The Environment Agency identified approximately 13 million tonnes of construction and demolition waste (9% of all UK construction sector waste) is material delivered to sites but never used. The amount of total waste produced using MMC is reduced because factory materials are ordered to exact specifications and thus operate with a lower risk of on-site non-use or spoilage.
- Transport Impacts: Building major house elements in factories may reduce the total number of trips to a building site. This is of growing importance as more house building takes place on ‘brownfield’ sites in inner-city areas.
- On-site construction time can be reduced by over a half and for dwellings it should be possible to build up to four times as many homes with the same on-site labour.

Typical Forms of MMC

The National Audit Office in their report: 'Using Modern Methods of Construction to Build Homes More Quickly and Efficiently'[22] defines the different MMC forms as the following:

Volumetric construction:
The whole dwelling is prefabricated off site in modules, which are then assembled on site. Modules may be constructed in a variety of forms from a basic structure to fully finished and serviced units.

Panelised construction:
Flat panels are produced off-site and assembled on site to produce a three-dimensional structure. The most common approach is to use open panels, consisting of a skeletal structure. More complex, or closed panels involve more prefabrication typically including lining materials and insulation. Services, windows, doors, internal finishes and external cladding may also be incorporated.

Hybrid:
A method also referred to as semi-volumetric that combines both the panelised and volumetric approaches. Typically, volumetric units for highly serviced areas such as kitchens and bathrooms (sometimes referred to as "pods") are used with the remainder of the dwelling or building constructed using panels.

Modern methods of construction can make significant improvement to:

- Reducing construction time by simplifying the construction process
- Improving quality and reducing defects by moving operations from site to factory conditions
- Speeding achievements of a weathertight envelope
- Improving safety by reducing the number of site operations
- Improving predictability for the project and productivity for the workforce
- Contributing to innovation
- Mitigating effects of skill shortages

However, these advantages are not automatically achieved. Careful and early consideration of all aspects of design, procurement, quality, site management and commissioning is needed for the improvements to be realised.

Barriers

MMC is still a relatively new concept in the UK; therefore teething problems currently exist. A high level of management is required to avoid problems associated with late deliveries and out-of-sequence deliveries. Also close supervision of workforce on site will ensure correct installation and prevent poor quality on site. Also the large up-front payments may leave little room for financial penalties if delays or inferior quality products are supplied.

[22] http://www.nao.org.uk/publications/nao_reports/05-06/mmc.pdf

1.58 Further Information

MATERIALS

The Green Guide can be found at http://www.thegreenguide.org.uk

BRE Green Guide to Specification (2002), Green Guide to Housing Specification (2000). The National Green Specification is developing a readymade specification of 6000 Green construction products and methods of construction, 1900 recycled, with product information, issues, design guidance, sustainability checklists, image bank, links, bibliography, etc.www.greenspec.co.uk

BRE: British Research Establishment: www.bre.co.uk

Sustainable Build: http://www.sustainablebuild.co.uk/InsulationMaterials.html

CAT: Centre for Alternative Technology: http://www.cat.org.uk/index.tmpl?refer=index&init=1

NNFCC: National Non-Food Crops Centre: www.nnfcc.co.uk

RECYCLED MATERIALS

Architectural salvage dealers – SALVO, www.salvo.co.uk

TIMBER

Forestry Stewardship Council, http://www.fsc-uk.info/

Pan European Forestry Council, www.pefc.co.uk

See chapter 10 sources of further information for recycled products

Environmental Goods and Services East of England, www.ecodirectory.org. This has 2500 companies listed with descriptions of activities and specialisms. Searchable by broad categories or specific keywords. Find local companies of consultants by postcode or county.

ZERO OZONE DEPLETING MATERIALS

CFCs, HCFCs and halons: professional and practical guidance on substances that deplete the ozone layer. Guidance Note GN1:2000. CIBSE. 2000. ISBN 0 9000953 99 3.

Cement substitutes can be found at http://www.civilandmarine.co.uk/10/ggbs.html

A source book for green and sustainable buildings - http://www.greenbuilder.com/sourcebook/

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Waste & Recycling

Waste & Recycling

1.59 **Background**

There are two areas of waste reduction and recycling to consider – waste produced during construction and waste produced during the life of the development. The East of England produces approximately 21.5 million tonnes of waste per annum[23]. The UK currently produces domestic waste at a rate of over 500kg per person per year (an increase from 106kg in 1983/4).

Statistics on current waste production and management allow the potential improvement in recycling rates to be estimated. One study suggests that 62.5% of UK waste is biodegradable. Another analysis shows general agreement, suggesting 69.8% of the household waste stream is recyclable or can be composted. Burying biodegradable waste in landfill results in emissions of the greenhouse gas methane.

A target to recycle or compost 25% of household waste by 2005 was set in the UK's Waste Strategy 2000. The Northamptonshire Waste and Recycling improvement plan has a target of increasing the amount of household waste that is recycled/composted to 40% by 2004 and 60% by 2007.

A significant proportion (76% in 1998-99) of construction and demolition (C&D) waste in England & Wales is already reused or recycled in some way. However the remaining 24% is still 17.5 million tonnes a year. WRAP, a government sponsored waste programme has set up AggRegain to support the use of sustainable aggregates. At the time of writing the AggRegain supplier database listed 130 companies offering recycled aggregates in the East of England.

Widespread use of recycled aggregates for appropriate uses in developments would drive demand and tend to increase the proportion of C&D waste processed into aggregates. AggRegain case studies on use of recycled aggregates demonstrate potential cost savings to developers. The extent of any savings on particular developments will depend on circumstances. Decreasing use of materials and waste will also decrease the traffic volume and resulting pollution, congestion and noise required to transport it from/to point of use.

1.60 **Sustainable Waste Management**

Waste is increasingly becoming an important consideration in design of new developments. The government produced in 2007 a waste strategy for England, which sets out its vision and key objectives for sustainable waste management; setting targets and increasing taxes on waste. The waste hierarchy (left) was developed to be applied not only for its environmental benefits but to increasingly save money. Waste is a major contributor to pollution in the UK, which is increasingly becoming more expensive to dispose of. Landfill tax is currently £24 per tonne and will increase by £8 per year starting 1st April 2008 until at least 2011.

The EU Waste draft directive from the European Commission is currently under consultation and will put forward binding targets for reducing waste. This has been driven by the increasing mountain of waste going to landfill. It is estimated that landfill void space in the UK will run out in 20-30 years.

According to the UK Department for the Environment, Food and Rural Affairs, in England and Wales alone the combination of industry, commerce and household waste amounts to over 100 million tonnes annually and is growing at around 3% each year. Most of this currently ends up in landfill, where biodegradable waste generates methane, a powerful greenhouse gas.

[23] http://www.environment-agency.gov.uk/

1.61 **Waste reduction**

It is expected that all developers will develop a waste minimisation plan. This should consider issues such as:

- Segregation of demolition waste into separate waste streams and where appropriate, incorporated within the new development. Where this is not practical demolition waste should be sent for re-use on other sites or for recycling or other secondary uses
- Identification of areas for reducing waste in the construction process
- Recycling.

Prefabrication could be considered in order to reduce waste, to improve quality of the build, to reduce construction times on site and to reduce nuisance to neighbours from deliveries.

Buildings should be designed to be flexible for changes in use to prevent wastage of materials in the future. Loft spaces should be considered as living accommodation or designed so that they can be converted at a later date, i.e. insulation included in the plane of the roof and necessary structural strength in joists and rafters. This will reduce land take and is economic in terms of the costs of the space and materials used. The structural design of homes and other buildings layouts to be adapted more easily in future prolonging building life.

Detailed designs should be based around standard sheet material dimensions and planed thicknesses to reduce the amount of waste and cutting required. Timber I beams can be considered in place of conventional timber joists and studs as these use around 60% less timber than standard beams.

Buildings should be designed with deconstruction in mind, so that construction materials from the building can be recovered. This may entail avoiding composite materials or using mechanical fixings in place of adhesives.

A commitment should be made to minimising the social and environmental impacts of the construction process by joining or confirming membership of the Considerate Constructors Scheme (see section 12) and conforming to its guidelines including measures for minimising waste. This will have financial benefits with landfill taxes increasing sharply over the next few years.

The incentives to reduce waste include reducing costs, increasing efficiency and reducing environmental impact.

These can be identified through the waste benchmarking process that can quantify the costs of waste in terms of:

- Cost of product wasted
- Cost of time to produce waste and clear it up
- Cost of disposal
- Environmental impacts associated with wasted product (including transport)
- Environmental impacts associated with waste management (including transport)
- Social impacts to local populations.

1.62 **Solid Wastes**

The only time at which the design team is likely to have any influence on the generation of solid wastes is during the construction phase. However, the design team can contribute to sustainable housekeeping practices on the part of the occupants by planning safe and adequate storage for different categories of waste. This is the preliminary to recycling or to safe and efficient disposal.

1.63 **Waste Recycling**

It is generally recognised that the construction industry has not investigated the possibilities of recycling and recovery to the fullest and could save significantly in terms of reduced disposal costs and avoidance of landfill tax. Part of this is due to the focus of a construction site being to construct rather than manage waste; part is due to lack of data surrounding the cost of waste. A major factor is also the constant relocation of the construction site resulting in new waste management contracts and varying facilities each time.

Work carried out by BRE on several construction projects has demonstrated the importance of requiring sub-contractors to participate in site segregation schemes as part of the tendering process if recycling is to be promoted. Where the requirement to segregate for recycling is introduced after the tendering process extra payment is typically demanded for the extra effort (perceived rather than actual). The materials that can often be segregated for recycling include metals, timber, inert, paper and cardboard. In addition some of the material suppliers offer take-back schemes for packaging, especially pallets, and material off cuts. A good example is that of British Gypsum, Lafarge and Knauf, who all provide a take back recycling scheme for plasterboard off cuts. Additional take-back schemes for mineral wool and polystyrene have also been identified. Where materials are being delivered continuously through the construction process these schemes reduce waste management costs significantly and resource recovery is increased with minimal transport impact.

1.64 **Construction Waste**

Design for standard sizes to reduce on-site cutting, require the contractor to use off cuts to the feasible maximum, and plan for re-usable formwork. Enforcing the standard specification clauses on the handling, storage and protection of material is one of the most effective ways of reducing site waste. Careful estimating and ordering procedures by the contractor can have a big impact. Surplus concrete and mortar, for example, are particularly difficult to dispose of.

Clauses requiring the separation, storage and collection of recyclable materials and the containment and disposal of other materials, can be written into the specification. Only eco-friendly cleaning material should be used during construction and at final clean up. Good waste management practice will involve additional labour costs but should cut material costs, and will certainly contribute to site safety.

Re-use building material or components where possible and, when specifying products, favour those which incorporate recycled material. Tiles, bricks, slates, joinery, scrap metal, kitchen and bathroom fixtures all have a market.

Re-using an existing building is one of the most effective sustainable strategies the client and design team can adopt. In addition to the saving in materials, and in the energy and pollution costs of production and transport arising from construction of a new building, there are savings on the services and infrastructure which would be needed for a building on a virgin site.

1.65 **Site Waste Management Plans**

Waste should be minimised from any development through the implementation of a number of measures during the construction and operation of the site. On the 6th April 2008, site waste management plans (SWMP) became compulsory on all construction projects in England worth more than £300,000[24]. Further information on SWMP can be found in DEFRA publication, Non-statutory guidance for site waste management plans April 2008[25].

[24] http://www.netregs.gov.uk/netregs/legislation/380525/1555007/?version=1&lang=_e
[25] http://www.defra.gov.uk

1.66 **Demolition**

If the development has a demolition phase, a 'waste demolition audit' should be undertaken (for example by using the SMARTwaste methodology[26] - see useful tools below for details). Materials can then be sorted and reused or recycled as appropriate. Materials can include brick, concrete, hardcore, subsoil and topsoil, timber and steel frames. Some of these materials could be reused for similar purposes or used for lower quality purposes such as concrete aggregate or footpaths.

1.67 **Deconstruction**

It is commendable that each year 3.3 million tonnes of architectural & ornamental components are salvaged, 24 million tonnes of aggregates are recycled, and an unknown quantity of steel and timber is recycled back into production. However, there are large volumes of potentially reusable components that are currently landfilled and lost to the system only to be replaced with similar components. Ultimately, each building could be designed to take into consideration the refurbishment and demolition that will occur at some point. Often the components used in buildings are highly durable and are replaced or disposed of before their predicted lifespan expires. The ideal scenario would be for materials and products to be reused in a construction application. DETR has sponsored BRE to promote further waste reduction and reuse by way of deconstruction. A fundamental part of this study is to undertake pre-demolition and pre-refurbishment audits using the BRE SMARTWaste tool, and to use these results to set targets for reuse and recycling.

[26] http://www.smartwaste.co.uk/

1.68 Further Information

An informative website on all things waste related - www.wrap.org.uk/

"A Report on the Demolition Protocol", commissioned by London Remade prepared by EnviroCentre Ltd. (www.ice.org.uk)

DEFRA provides information and associated guidance on the Site Waste Management Plan Regulations 2008: www.defra.gov.uk/constructionwaste

For information and further advice on Site Waste Management Plans and to freely download BRE's new SMARTWaste Plan tool visit: www.smartwaste.co.uk

Environment Agency guidance on waste: www.environment-agency.gov.uk/subjects/waste/ and www.netregs.gov.uk

For help in finding local waste management companies and opportunities to reuse and recycle materials try BREMAP free of charge at: www.bremap.co.uk

Both WRAP and Envirowise can provide advice and guidance on SWMPs: www.wrap.org.uk/construction and www.envirowise.gov.uk

Bank Recycling Locator - http://www.recycle-more.co.uk/banklocator/banklocator.aspx

Waste Watch is the leading national organisation promoting and encouraging action on the 3Rs - waste reduction, reuse and recycling. They work with community organisations, local and national government encouraging the environmental benefits of waste minimisation and recycling. www.wastewatch.org.uk

Recycling product guide. www.recycledproducts.org.uk/

Sustainable aggregates. www.aggregain.org.uk/aggspecifier_info.asp

Pollution

Pollution

1.69 **Background**

According to Sustainable Build[27], the construction industry "is a major source of pollution, responsible for around 4% of particulate emissions, more water pollution incidents than any other industry, and thousands of noise complaints every year". The key issues relating to construction impacts are air quality, water quality, and noise pollution.

On any individual construction project, these impacts are generally relatively small; however, they can amount to significant local impacts, particularly where the site is adjacent to sensitive receptors.

The construction period is relatively short compared with the operation of the development and pollution from this stage must also be considered. Primary sources of pollution derive from generating the electricity consumed onsite, and as such a key consideration in assessing the proposal is the energy efficiency of the development.

Large scale developments will likely require an Environmental Impact Assessment (EIA), or at the very least a scoping EIA.

1.70 **Key Issues**

1.70.1 Air quality

Air quality impacts are considered in three main areas: Nitrous Oxide (NO_x) emissions, Carbon Dioxide (CO_2) emissions and refrigerant leaks.

- NO_x emissions are a major element of photochemical smog, generated through the combustion of fossil fuels, particularly from vehicle and power generation. Onsite power generation using Combined Heat and Power (CHP) technology creates local NO_x emissions through the combustion of fuels but at a significantly lower rate per kWh than large scale power stations. Large developments may consider CHP, but as discussed this should be secondary to maximising energy efficiency.
- CO_2 emissions. The operational stage of any development will increase the amount of CO_2 emissions into the environment, primarily through energy consumption and potential generation of additional traffic. The effects of increased CO_2 emissions, as widely publicised, are detrimentally linked to climate change. To address this, policies have been developed by many local planning authorities that require new developments to generate up to 20% (depending on the authority) of their energy demand on site through renewable energy sources. Technologies that may be included in the development are discussed in Section 5.
- The third key air quality issue is the potential for refrigerant leaks from heating, ventilation and air conditioning (HVAC) systems, which can leak ozone depleting and greenhouse gases into the atmosphere. The Carbon Trust[28] state that one kilogram of the refrigerant R134a, for example, has a global warming potential 1,300 times greater than 1kg of CO_2, highlighting the importance for leak detection systems where HVAC systems are present.

1.70.2 Water quality

Surface water runoff from developments can be contaminated with pollutants such as silt, heavy metals, chemicals and oil which can impact on the health of streams and groundwater. All activities have the potential to pollute watercourses through run-off, including agriculture, transport, mining and any hardstanding areas, and may derive from planned or unplanned

[27] Sustainable Build: http://www.sustainablebuild.co.uk/PollutionFromConstruction.html
[28] Carbon Trust: http://www.carbontrust.co.uk/energy/startsaving/tech_refrigeration_leaks.htm

releases of water. The Environment Agency[29], as the referral agency for discharge to watercourses, has developed a policy on Sustainable Drainage Systems or 'SUDS' to protect water resources by requiring the removal of pollutants prior to the final offsite discharge. Please refer to Section 6.5 for further information on SUDS.

1.70.3 Nuisance

Nuisance to neighbours may be subjective, but there are guidelines and laws against it if it is deemed to be excessive or likely to be detrimental to a neighbour's quality of life. Noise, dust and light are forms of pollution that can be generated from on-site activities that can cause nuisance. NetRegs[30] define statutory nuisances as including noise and vibration, smoke, fumes, gases, dust, steam, smell, vermin, animals kept onsite, waste deposits and general state of the site. Ensuring the developer employs good practice during construction, such as signing up to the Considerate Constructors Scheme (see Chapter 13.1 of this report), and implementing mitigation measures to limit nuisances during operation should reduce the likelihood of complaints.

1.71 Further Information

Nuisance: http://www.netregs.gov.uk/netregs/275207/275504/?version=1&lang=_e

Environment Agency: http://www.environment-agency.gov.uk/business/444304/502508/464710/?version=1&lang=_e

[29] Environment Agency http://www.environment-agency.gov.uk/business/444304/502508/464710/?version=1&lang=_e
[30] NetRegs: http://www.netregs.gov.uk/netregs/275207/275504/?version=1&lang=_e

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Health & Wellbeing

Health & Wellbeing

1.72 **Background**

The health and wellbeing of the building users of a development are not strictly planning issues; however WNDC should be aware that this is an important aspect of the ultimate usability of the building, particularly those which are non-domestic.

Building users will prefer good working conditions and are more likely to maintain better health if their environment is well managed through the provision of fresh air, constant temperatures, daylight and low noise levels. Poor delivery of these factors can place strain on the users and deteriorate their health and general wellbeing. In the case of buildings such as offices, poor working conditions can also affect the productivity of building users.

Other aspects of this, for example good levels of daylighting, will decrease the need for artificial lighting during the day, reducing the overall energy consumption of the development.

1.73 **Key Issues**

The key issues for occupant comfort in non-domestic buildings can include lighting, ventilation, view out and glare control, and temperature.

- Lighting: People prefer daylight to artificial light. In regards to the workplace, the *Workplace (Health, Safety and Welfare) Regulations 1992* require that minimum light levels be provided, and that where possible this be from natural light. Artificial lighting should to be fitted with high frequency controls to minimise the potential flickering that occurs with fluorescent lighting. As an energy efficiency measure, artificial lighting could be zoned such that only the occupied areas of the building are lit.
- Ventilation: The air inside a building needs to be regularly changed to dilute contaminants such as CO_2 to acceptable levels. Ventilation may be provided mechanically and/or naturally through openable windows or passive ventilation systems.
- View out and glare control: A view of a landscape or adjacent building encourages occupants to reduce eyestrain and focus on an object at a greater distance. The potential for glare due to the close proximity of a window could be managed through the installation of occupant controlled blinds.
- Temperature: Maintaining a constant and comfortable temperature is required under CIBSE Guide A (Environmental Design)[31], and forms an energy saving measure. The heating system should be designed such that only the occupied areas are heated to prevent unnecessary heating and energy consumption through allowing individual areas to be separately heated. The occupant controlled blinds installed to control glare can also reduce the dependence on mechanical cooling systems and associated energy consumption through directly reducing solar heat gain in summer.

1.74 **Further Information**

See CIBSE Guide A: Environmental Design (refer footnotes below).

[31] http://www.cibse.org/index.cfm?go=publications.view&item=1

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Transport

Transport

1.75 **Background**

According to the Environment Agency[32], road transport accounted for 92 per cent of UK passenger travel in 2006.

Transport and access during construction and after completion are key considerations, given the likely increased pressure and congestion on the road network, and the knock-on impacts this can create. Congestion caused by construction traffic can be limited through measures such as logistics planning, which would limit the number of unnecessary journeys. Other good site management practice that could reduce the need for vehicle access to site include the re-use of existing aggregates and construction materials, efficient procurement (i.e. to prevent over-ordering), sorting construction and recycling waste onsite and providing minimal onsite car-parking for construction staff.

Once a building becomes operational the transport issues associated with the use of that site can pose the largest challenge, since these are more likely to have a long term impact. Congestion linked to a building or site's operation is largely attributable to the dependence on private vehicles for single occupancy trips. However this can be addressed through a number of measures deriving from suitable site selection, including:

- Improving the public transport network to service the development; and
- The development of a green travel plan for site users.

The Department for Transport[33] has reported that currently, transport accounts for approximately 25% of man-made greenhouse gas emissions within the UK. Cars account for 13%[34]. The dependence on cars is highlighted by the fact that approximately a quarter of all trips made by cars are less than two miles[35]. Alternative modes of travel, such as public transport, cycling and walking are realistic alternatives and need to be encouraged and promoted throughout the community.

1.76 **Key Issues**

1.76.1 Public transport

Proximity of the development site to high frequency public transport nodes increases the likelihood of site users commuting to and from the site by these means. This tends to be dependent on site location and therefore not always possible to achieve. However, this is a key consideration of sustainable site selection and the existing public transport should be exploited as far as practicable to prevent increasing congestion on the local road network.

BREEAM guidance states that ideally, public transport should be within 500m of the main entrance to the building, and be serviced as follows:

- At least every 15 minutes during peak times; and
- 30 minutes during the day (8:00am to 7:00pm).

The local node should connect the site to a major transport node (i.e. train station or bus terminal) on a regional or national transport network. Such connectivity to public transport is rewarded by BREEAM with maximum credits. Where the site is not in proximity to existing public transport services, the size of the development may justify rerouting existing or establishing new services.

[32] Environment Agency: http://www.environment-agency.gov.uk/yourenv/eff/1190084/people_lifestyles/transport/
[33] Department for Transport: http://www.dft.gov.uk/pgr/sustainable/climatechange/climatechangeandtransport?page=1#a1001
[34] Sustrans (2007). 'Low Carbon travel': http://www.sustrans.org.uk/webfiles/info%20sheets/ff44.pdf
[35] Sustrans: http://www.sustrans.org.uk/default.asp?sID=1148643072078

1.76.2 Cyclist facilities

Cycling and walking are the two most sustainable forms of transport, with no greenhouse emissions attributable to their use. In addition, these forms of transport can reduce both air and noise pollution and ease traffic congestion, and improve the fitness of building users. As a quarter of trips made by car are less than two miles, cycling is a feasible alternative provided suitable facilities are available at the destination. These may include secure cycle racks, a shower and changing room, dedicated drying room for wet clothes and lockers for storing cycling clothes and helmets.

Cycle rack

Cycle shelter

Cycle lockers

Cycle storage systems from falco cycle parking systems

BREEAM promotes a ratio of one cycle rack for every 10 occupants for non-residential developments, with appropriate change facilities for each (i.e. reasonably sized locker and drying room) and 1 shower per 10 cycle racks. In residential developments, the Code for Sustainable Homes (CSH)[36] requires adequately sized and secure cycle spaces at the following minimum ratios:

- One space for every two studio or one-bedroom dwellings
- One space for every two and three-bedroom dwelling; and
- Two spaces for every dwelling containing four or more bedrooms.

Across BREEAM and CSH, adequate facilities are encouraged at the origin and destination of most cycle trips.

1.76.3 Travel plan

For commercial developments, a travel plan could be produced by the site owner/landlord to encourage site users to adopt alternate modes of transport to single-occupancy car use. A well structured and comprehensive travel plan can benefit not only the organisation and its employees but the neighbouring community, particularly in urban areas, through easing congestion and pressure on parking.

A travel plan should encourage alternatives to single occupancy car use, such as car-sharing, public transport, cycling and walking, and even the provision of video-conferencing and remote working to limit car journeys. In addition they should detail the facilities provided to assist with these alternatives (such as showers and changing rooms, restricted car parking, maps to public transport). This should not only reduce the environmental impact of travelling to and from work but also improve the health of employees.

Travel plans can also be prepared for residential communities, both encouraging and providing residents with alternatives to single-occupancy and car ownership.

Travel plans are not a requirement under legislation; however a policy requirement at a local level will ensure that all feasible travel alternatives are considered and promoted to users of the development.

[36] Code for Sustainable Homes: http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf

1.77 Further Information

Public Transport:

- Traveline East Midlands: http://www.travelineeastmidlands.org.uk/

Cyclist facilities:

- Sustrans Northamptonshire: http://www.sustrans.org.uk/default.asp?county=1093009155380

Travel plan:

- The Department of Transport: http://www.dft.gov.uk/pgr/sustainable/travelplans/
- British Council for Offices: http://www.bco.org.uk/research/researchreports/detail.cfm?rid=35&cid=0

Cycle storage systems

- http://www.falco.nl/uk/
- http://www.mackay.co.uk/mss/acatalog/Sheffield_Stand.html

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Landuse & Ecology

Landuse & Ecology

1.78 **Background**

It is evident that natural terrestrial and aquatic environments are subject to increasing pressures from a combination of pollution and nuisance, including noise and contaminated storm water run-off. In addition, the cumulative impacts of development, such as land take and destruction of habitats and green corridors (land that links two habitats of ecological interest), can also have a detrimental impact on an area's biodiversity. In fact, *Planning Policy Guidance 2: Green Belts* designates significant green belts and outlines the policy in place to protect them from inappropriate development. Development on such land should be avoided where possible.

Actively minimising impacts on species, particularly native, can assist in complying with relevant wildlife legislation in addition to increasing and maintaining the visual aesthetics of a development.

1.79 **Key Issues**

1.79.1 Site Selection and Re-use of Land

The Environment Agency[37] states that reusing brownfield sites "can help to make the best use of existing services such as transport and waste management. It can encourage more sustainable lifestyles by providing an opportunity to recycle land, clean up contaminated sites, and assist environmental, social and economic regeneration". With increasing demand to develop greenfield sites to meet national housing targets, reusing previously developed land will assist to protect the agricultural and ecological values of greenfield land, discussed below.

As mentioned previously, "some brownfield and derelict land can represent important wildlife habitat, public green space or a core part of urban green networks. These are important in providing good quality of life and brownfield reuse must strike an appropriate balance in the interests of sustainable development" (Environment Agency[37]).

Development on brownfield sites are likely to be nearer public transport nodes encouraging use of these services as an alternative to private vehicles, which in turn has environmental benefits. Additionally, brownfield development will not only reduce the pressure on greenfield sites, but can regenerate activity and financial investment in previously defunct industrial sites or areas of low economic activity. This in turn can help create socially and environmentally sustainable communities, which is an aspiration of the UK government.

1.79.2 Contamination

Development on a brownfield site may require remediation of contaminated soil which should be considered favourably provided remediation works are undertaken in accordance with Environment Agency requirements[38]. The use and remediation of land contaminated by previous industrial or other uses removes the hazard to the general environment through preventing it dispersing further into the wider environment.

Use of brownfield sites also significantly reduces the potential for contamination of greenfield areas, as any contaminants released in a brownfield development are less likely to affect areas of ecological significance.

[37] Environment Agency – Brownfield land redevelopment: http://www.environment-agency.gov.uk/aboutus/512398/289428/655750/

[38] Environment Agency – Contamination: http://www.environment-agency.gov.uk/subjects/landquality/113813/

1.79.3 Ecology

While developing brownfield sites is preferred, development on sites recognised as having low ecological significance also assists in protecting local ecological features through minimising removal or disturbance of significant ecological features.

The ecological value of the site is classified on the basis of the number of flora and fauna species present (particularly native species) and their legislative protection status, if applicable. The habitat value of the species on site and its context within the local area are also considered when assessing a site's ecological value. On this basis, it is possible that brownfield sites have ecological significance if, for example, bats, golden crested newts or large old trees are present.

Careful site selection could help avoid development on land regarded as having ecological value. Where such development is unavoidable, its impact could be minimised by implementing ecological protection and enhancement measures, as determined by a suitably qualified ecologist. Recommended mitigation measures will be site specific and dependent on the site and its surrounding area. Applying careful management when clearing a site for development and incorporating ecological features in the design, can also significantly reduce the impact on the site's ecological value. In any case, ecological features should be incorporated into the design of the development to enhance site ecology. Examples of this may include gardens of native vegetation to provide habitat for native species. Such measures should be made on recommendation by an appropriately qualified ecologist and be managed through a long term ecological management plan.

1.80 Further Information

Reuse of land: Environment Agency [37]

Contamination: Environment Agency [38]

Ecology: UK Biodiversity Action Plan for Northamptonshire website[39]

[39] UK Biodiversity Action Plans for Northamptonshire: http://www.ukbap.org.uk/lbap.aspx?ID=387

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13 Construction Management

Construction Management

1.81 **Considerate Constructors Scheme**

Measures should be taken to reduce the impact of the construction phase on the environment and the community, for example by signing up to and being monitored by the Construction Industry Board's Considerate Constructors Scheme[40]. This scheme establishes measures for reducing nuisance to neighbouring homes and premises due to noise, dust and other factors. The construction process will be monitored at appropriate intervals and feedback provided on any areas for improvement.

The recent changes to BREEAM Offices 2008 have introduced mandatory credits for certain levels of accreditation. The Considerate Constructors credit is now mandatory to achieve a score of between 24 and 31.5 to achieve an excellent rating. To achieve an outstanding the development must score between 32 and 35.5 in an accredited scheme.

1.82 **Use of Local Labour and Materials**

In order to promote the development of local economic growth, developers should use local labour and materials wherever possible. Materials should be sourced from a 50 mile radius of the development if available, to cut down on the embodied energy of the products (in terms of transport mileage). Local labour should be recruited where possible to contribute towards local economic growth and decrease commuting distances (and associated transport emissions) to the site.

[40] http://www.considerateconstructorsscheme.org.uk

14 Strategic Scale LZC Technologies

Strategic Scale LZC Technologies

1.83 **Background**

Renewable and low carbon energy solutions are increasingly becoming an important area of consideration in response to the UK's commitment to climate change mitigation and subsequent EU directives. Please refer to the accompanying policy review document for details.

WNDC and the Local Planning Authorities are responsible for assessing the planning application for any energy scheme less than 50MW of installed electrical capacity. Schemes over 50MW will be referred to the secretary of state under Section 36 of the Electricity Act 1989.

The technology matrix in the Appendix is based on an assessment of approaches at an individual development scale. Some technologies are more suited to development at a strategic level. The following section provides WNDC with an overview of some of the technologies that may be proposed within West Northamptonshire in terms of zero and low carbon strategic energy options. A strategic scheme for the purpose of this report is any scheme that shall benefit a larger portion of the community beyond the scope of a single development.

The technologies that have been identified as suitable for strategic scale include:

- Large scale wind
- District heating
- Biomass
- CHP
- Waste to energy
- Transport.

1.83.1 National Targets

The UK Renewable Energy Strategy: Consultation Document released on the 26th June 2008 sets out the UK's targets for renewable energy generation in order to meet its European commitment of providing 15% of its energy from renewable sources by 2020. One option suggests that renewable contribution will need to include 10% renewable energy from the transport industry, 14% from heat and 32% from electricity.

The consultation document indicates that in order to achieve this electricity target the UK would need to install approximately 14 GW of onshore wind, compared with the current installed capacity of 2GW today in addition to off-shore wind and other sources. This equates to approximately 4,000 new 3 MW onshore turbines in addition to the 2,000 turbines already installed[41].

1.83.2 Northamptonshire RSS8 Targets

The growth option areas present an opportunity to investigate sites that could contribute to the energy demands of the proposed urban expansions from wind power generation. Appendix 6 of the Regional Spatial Strategy for the East Midlands RSS8[42], highlights the targets for electrical generation from renewables for the region. The overall target for the region is by 2010 a total of 2.5TWh per year of electricity to be produced from renewables with a total installed capacity of 671 MW_e. Targets that could be reached through a strategic approach for the region include:

[41] UK Renewable Energy Strategy: Consultation Documment. BERR, 2008.
[42] Appendix 6 of the Regional Spatial Strategy for the East Midlands RSS8, March 2005.

Table 14. 1 – Renewable energy targets for Northamptonshire

Renewable Energy Technology	Capacity	Electrical
	MWe	**GWh/year**
Onshore Wind	12	31
Biomass – Wet Agricultural Waste	0.6	5.3
Biomass – Poultry Litter	15	118.3
Biomass – Energy Crops	10	75
Landfill Gas	14	116
Anaerobic Digestion	3.6	20.5
Total	**55.5**	**366.4**

The target of 300kW of installed capacity of Solar Thermal and PV would be met on a development by development basis and therefore should be expected to be considered in all developments with sufficient hot water/electrical demand and sufficient roof space. Solar thermal and PV have been covered in section 5.6 & 5.7 and in the technology and approach matrix in the appendix.

On the following pages is a review of the potential energy projects that WNDC may need to consider to deliver their sustainability aspirations or that they may require assessment as part of a planning application for a renewable or low carbon strategic energy scheme. These are:

- Large scale wind turbines
- Large- scale district heating
- Biomass and biomass CHP
- Energy from waste.

The graph below highlights the cost effectiveness of zero and low carbon technologies sourced from a study undertaken by the Element Energy for the Renewables Advisory Board. This study highlights that large-scale wind and large to medium-scale biomass CHP is the most cost effective technology currently available in terms of reducing CO_2 emissions in the built environment.

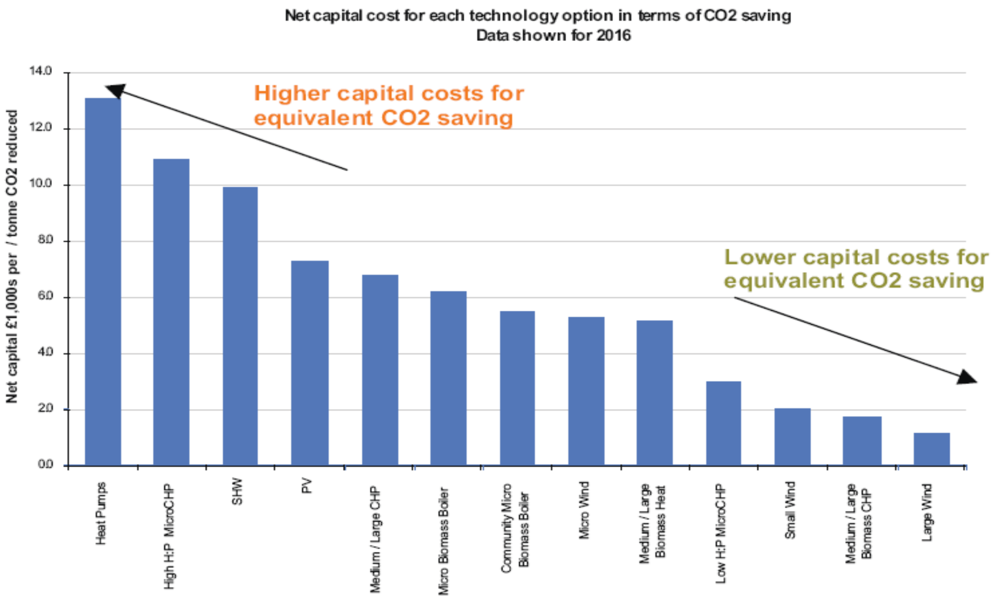


Figure 14.1 - Cost Implication for Zero and Low Carbon Technologies[43]

[43] RAB. The Role of Onsite Energy Generation in Delivering Zero Carbon Homes. (2007)

1.84 Large Scale Wind Generation

Wind turbines are available in a wide range of sizes; from small battery charging units with rotor diameters of less than a metre to very large wind turbines with rotor diameters greater than 100 metres with a capacity of several megawatts. Larger turbines have improved economies of scale and access to increased wind speeds when compared to smaller turbines; however locating suitable sites is more difficult and there may be high grid connection costs. The following is a review of the considerations that will need to be undertaken for the installation of a large scale wind turbine(s).

Currently there are 2033 onshore turbines in operation in the UK with an installed capacity of 2547 MW[44]. The largest installation in Northamptonshire is the Burton Wold Wind Farm consisting of 20 MW of installed capacity.

Table 14.2 – Bolton Wold wind farm specification

Burton Wold Wind Farm	
Location	Northamptonshire
Wind Turbine	2MW Enercon E70
Number of Turbines	10
Installed Capacity	20 MW
Hub Height	60m
Rotor Diameter	80m
Developer	Your Energy
Annual homes equivalent	12,180

For a wind turbine development to be successful a detailed analysis must be undertaken to assess the following considerations:

- Planning
- Extent of site
- Access
- Wind speed
- Grid Connection
- Proximity to dwellings, Air safeguarding and Electromagnetic Interference (EMI)
- Landscape and ecological designations.

1.84.1 Planning

Wind turbine developments with a rated capacity of 50MW or less are subject to local planning conditions. If an array of turbines is to exceed this capacity the planning application will be referred to the Secretary of State for Energy. The Regional Spatial Strategy for the East Midlands has produced a list of priorities in Policy 41 that local authorities must adopt when assessing renewable energy applications. It states that in establishing criteria for onshore wind energy, Development Plans and future Local Development Frameworks should give particular consideration to:

- Landscape and visual impact, informed by local Landscape Character Assessments
- The effect on the natural and cultural environment (including bio-diversity and the setting of historic assets)
- The effect on the built environment (including noise intrusion)
- The number and size of turbines proposed
- The cumulative impact of wind generation projects, including intervisability
- The contribution of wind generation projects to the regional renewables target

[44] http://www.bwea.com/ukwed/index.asp

- The contribution of wind generation projects to national and international environmental objectives on climate change.

Given that the UK's wind resource is generally good, which is the case for Northamptonshire, gaining planning permission is an equally if not more important factor in determining the viability of a development.

1.84.2 Size and Scale

The capacity of a turbine is a function of the size of the swept area and the average wind speed at the site. As the output of a turbine is proportional to the cube of the wind speed and the wind speed increases with height above the ground, it is desirable to use the tallest mast feasible. The majority of the onshore 2 MW turbines in the area have been mounted on 60m masts.

The image below sourced from the *Planning for renewable energy, a companion guide to PPS22*[45] indicates the scale and possible output of a range of turbines based on an average capacity factor of 0.3; the figure for the number of homes supplied is based on the average UK household consumption of 4100 kWh/year (OFGEM). Some discretion must be used when assessing the number of homes that a particular turbine capacity can meet as the electrical consumption of new dwellings could be considerably less than the UK average.

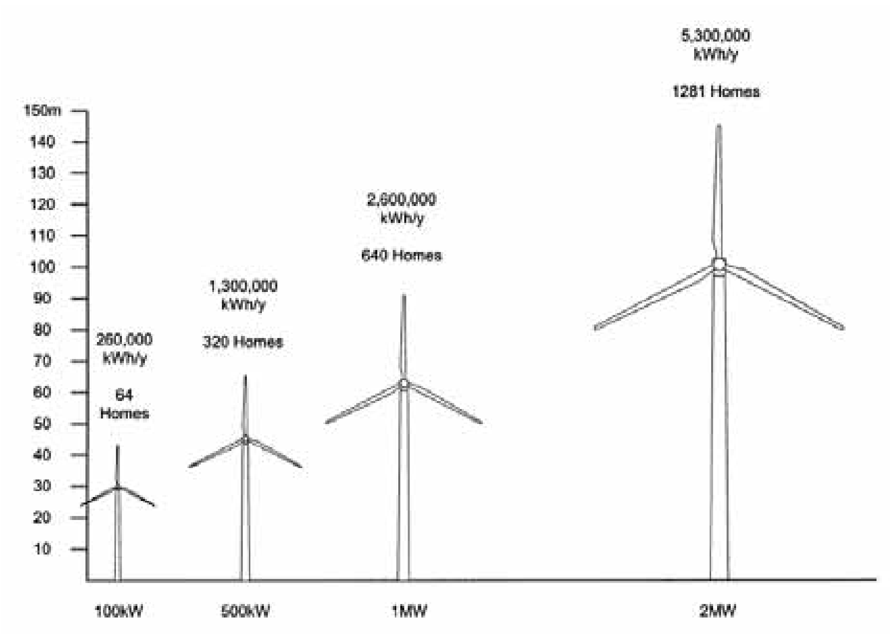


Figure 14.2 – Wind turbine size and capacity

1.84.3 Wind Farms

Wind farms are groups or clusters of wind turbines on a single development site. Factors that may influence the size of a wind farm development include the physical nature of the site, the capacity of the local electricity distribution network and the organisation undertaking the development.

1.84.4 Capacity

Based on these consumption figures Northamptonshire would require approximately 15 to 20 x 2 MW turbines to meet the entire proposed residential developments electrical demand by wind alone. The smaller 100 and 500 kW turbines could play an important role on individual developments, subject to space availability. Larger 2 MW turbines could be proposed to supply renewable energy to the grid as at the Burton Wold Wind Farm or a single large urban expansion development of industrial area. Large scale wind turbines should be encouraged at all suitable sites.

[45] OPDM. Planning for renewable energy, a companion guide to PPS22. ARUP 2004

1.84.5 Spacing of Turbines

Wind turbines need to be positioned so that the distances between them are around 3 – 4 rotor diameters apart when adjacent to the prevailing wind direction. When inline with the prevailing wind direction they should be spaced 6 – 10 rotor diameters apart. This spacing represents a compromise between compactness, which minimises capital cost, and the need for adequate separations to lessen energy loss through wind shadowing from upstream machines. The required spacing will often be dependent on the prevailing wind direction of south westerly winds.

1.84.6 Operation and Maintenance

Large scale turbines are often equipped with a central monitoring system. Multiple turbines operational status must be regularly checked through a central monitoring system and remote link.

1.84.7 Wind Resource

The energy produced by a wind turbine depends on the strength of the wind to which it is exposed. The simplest indicator of the wind resource available at a given location is the annual mean wind speed at the site. The British Wind Energy Association (BWEA) database of wind speeds can be used for a guide to the predicted average wind speed for any site in the UK accurate to 1 km^2. However these wind speeds have been assumed using computer modelling and do not take into account built structures and other obstacle such as trees. For accurate wind speeds, on-site monitoring using an anemometer should be undertaken for at least 12 months. Planning permission is required to erect a temporary mast to support an anemometer. The effect of wind shear and turbulence must be minimised by locating the turbines away from tall buildings, trees and built structures. The higher the hub height the less shear and turbulence will affect the performance of the turbine.

Generally an average wind speed of 6metres/second is the minimum wind speed required to ensure the viability of a large scale turbine. Wind farm developers such as Ecotricity will expect this as a minimum if they are to become involved with a wind farm development.

1.84.8 Environmental Impact Assessment

Wind turbines are projects which are listed under Schedule 2.3(i) to the EIA Regulations. Local planning authorities are required to screen applications for the need for EIA where the development involves the installation of more than 2 turbines or the hub height of any turbine or height of any other structure exceeds 15 metres. This condition may lead to most applications being liable to undertake an EIA assessment at the council’s discretion.

1.84.9 Noise

The advisable distance of a wind turbine from existing dwellings will depend on a number of factors such as local topography, the character and level of background noise and the size of the development. Given that concerns over the effect of noise can be an obstacle to acquiring planning permission, turbines should be located in areas away from existing dwellings. For new dwellings that will directly benefit from a proposed wind turbine(s) the minimum distance could be reduced. Guidance on noise can be sought from ETSU 1997 ‘the assessment and rating of noise from wind farms’.

A wind turbine at 350m will generate approximately 35-45 dB(A); the equivalent of rural night-time background noise Therefore it is recommended that wind turbines are sited at least 350m from existing dwellings. For turbines in urban areas a background noise assessment should be undertaken to determine the ambient noise levels. The proposed turbine(s) should be sited at a sufficient distance so that the ambient noise levels are not increased as a result of the development.

1.84.10 Safety

Well designed and maintained wind turbines are a safe technology. The minimum desirable distance between wind turbines and occupied buildings should be calculated by the fall over distance (i.e. the height of the turbine to the tip of the blade) plus 10%. However the need to limit noise and visual impact will require a further separation than the prescribed safety distance. Location near main roads may be subject to this constraint.

1.84.11 Specialist Consultation

OFCOM will need to be consulted to identify any radio installations relevant to a wind farm site that may be affected by the installation. In addition, it may be necessary to consult the local water company, gas companies, electricity companies, and also emergency services such as the police and ambulance service.

1.84.12 Interference with Electromagnetic Transmissions

Wind turbines can potentially affect electromagnetic transmissions in two ways: by blocking or deflecting line of sight radio or microwave links, or by the ‘scattering’ of transmission signals.

Specialist organisations responsible for the operation of the electromagnetic links typically require a 100m either side of a line of sight link to be kept clear from the swept area of turbine blades, although individual consultations would be necessary to identify each organisation’s safeguarding distance. Effects on such links can usually be resolved through careful siting of individual turbines.

1.84.13 Shadow Flicker and Reflected Light

Under certain combinations of geographical position and time of day, the sun may pass behind the rotors of a wind turbine and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as ‘shadow flicker’. Only properties within 130 degrees either side of north, relative to the turbines can be affected at these latitudes in the UK.

1.85 **District Heating**

A community heating (district heating) scheme enables multiple buildings to be heated from a single energy source. Irrespective of the overall system size and fuel type, community heating schemes comprise of three common components

- Heat source
- Heat distribution network
- Customer connections.

1.85.1 Heat Source

Heat can be provided from a number of sources, (CHP, Biomass, gas boilers) typically housed in a single, centralised plant room, containing the heat source(s) and district heating pumps. In many cases there will be benefits from using a thermal store.

There are capital cost and space implications of installing a single centralised system (usually housed within an 'energy centre') over individual boilers (in every dwelling for example), due to required pipework distribution routes across the site and within each apartment riser, and for the centralised plant room, pumps, thermal store and flues.

Centralised boilers are sized to cover peak heat load requirements for the development, which in a residential development are generally early morning and late afternoon. As such multiple heat sources are needed so the system can respond to changes in residents' requirements, occupancy levels and unit sizes.

1.85.2 Distribution Network

In community heating schemes, heat (normally as hot water), is distributed from a central boiler plant to customers via well insulated distribution pipes. These pre-insulated pipes are fitted with automatic leak detection equipment and 'zoned' isolation valves to enable local maintenance without disrupting the whole system. The cost of the distribution system will vary depending on the level of difficulty encountered in an excavation process. Providing district heating to old inefficient homes in existing urban areas can have the greatest impact in reducing carbon emissions; however the associated capital costs may be prohibitive.

1.85.3 Residential heating interface unit

The heating and hot water use within each dwelling is normally provided via heat exchangers (known as a Hydraulic Interface Unit (HIU)). The heat exchanger unit is a similar size to a conventional combi boiler although with the benefit of not requiring a flue. These units maintain a separation between the central distribution system and the systems within the dwelling. This ensures that any problems remain within an individual dwelling so as not to affect the whole network.

Figure 14.3 - Aqua Mini Heat Exchanger

1.85.4 Energy Service Contracts

Large-scale district heating systems are frequently developed by Energy Services Companies (ESCOs) which may be wholly private sector or a public private partnership. Examples include district heating companies in Sheffield, Southampton, Woking and the City of London.

1.85.5 Maintenance

Centralised heating and hotwater systems have maintenance and operational requirements that will require specialist knowledge and expertise. CHP units will require ongoing regular routine maintenance.

1.86 Biomass

Biomass is normally considered a carbon neutral fuel, as the carbon dioxide emitted during burning has been (relatively) recently absorbed from the atmosphere by photosynthesis and no fossil fuel is involved. The wood is normally seen as a by-product of other industries and the energy for drying, sawing, pelleting and delivery is relatively small. Biomass from coppicing is likely to have some external energy inputs, for fertiliser, cutting, drying etc. and these inputs need to be considered.

Wood from forests, urban tree pruning, farmed coppices or factory clean wood waste can be burnt directly to provide heat in buildings; although nowadays most of these wood sources are made commercially available in the form of wood chips or pellets, which makes transport and handling on site easier.

Modern systems can be fed automatically by screw drives from fuel hoppers. This typically involves daily addition of bagged fuel to the hopper, although this process can also be automated with use of augers, conveyors or walking floors. Electric firing and automatic de-ashing are also available and systems are designed to comply with the Clean Air Act.

The most common application of biomass heating is as one or more boilers in a sequenced (multi-boiler) installation where there is a communal i.e. block or district heating system.

Issues which can prevent uptake of biomass boiler technology are:

- On site access problems for large lorries delivering wood chip, especially for urban locations
- Lack of space for a large fuel storage area in the basement plant area of the building (and therefore a need for more frequent loads of fuel to be delivered by a lorry to the site)
- Lack of an adequate supply chain in place currently to provide a regular and low cost biomass supply
- Concerns over emissions of NOx and particulates.

1.86.1 Site-wide Approach

A biomass boiler could be used in a site wide approach with district heating and this would have the benefit of a more diversified load. It will also be easier to design the fuel handling and storage facilities and a thermal store.

1.86.2 Fuel

Fuels that may be used in a biomass boiler or CHP facility include:

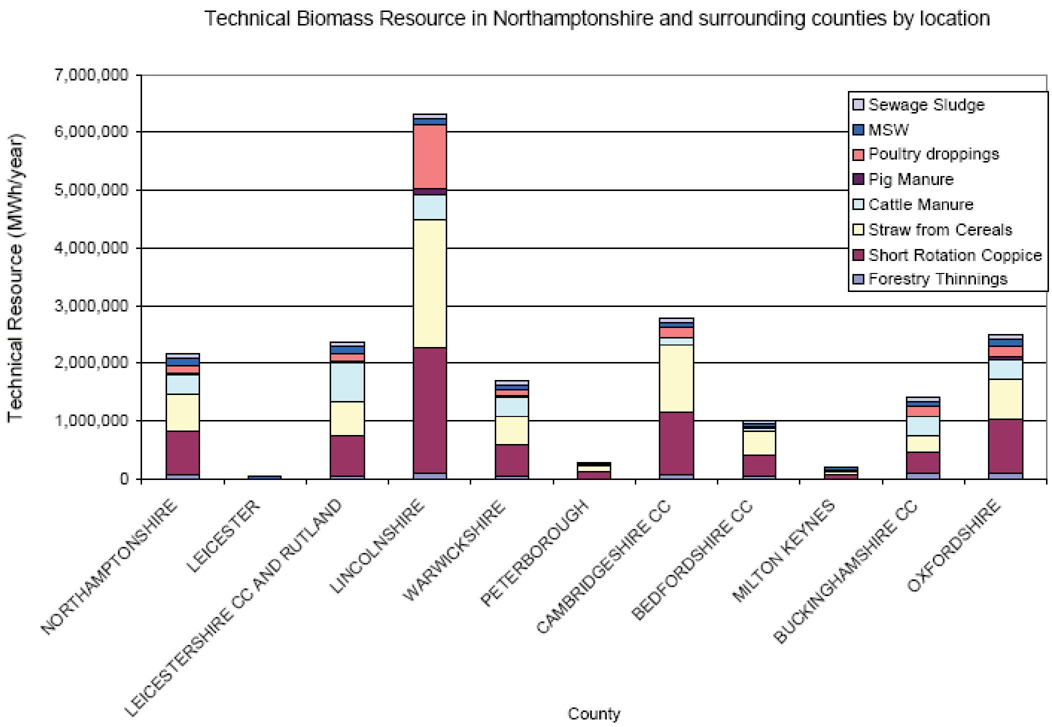
Forestry Residue	- Forrest thinning
Timber Processes	- Timber off cuts from industry
Agricultural Residues	- Straw
	- Chicken litter
Energy Crops	- Short rotation coppice: Willow
	- Grasses: Miscanthus.

In order to improve the security of fuel supply more than one fuel source may contribute to the mix.

1.86.3 Local Fuel Supply

The RSS8 identifies that the local biomass resource for Northamptonshire includes approximately 800,000 MWh/year of straw from cereals and 800,000 MWh/year from short rotation coppice. Cattle manure could also contribute approximately 200,000 MWh/year.

Figure 14.4 – Biomass Resource in Northamptonshire[46]



1.86.4 Implications for the design of the building

The biomass boiler will produce heat in the form of hot water compatible with the existing heating systems. Although biomass boilers can be modulated to meet a dynamic heating demand the biomass boiler are less responsive than a conventional gas boiler and is therefore best suited to meeting a steady base load demand. A thermal store would also be recommended increasing the space requirements of the plant room. Fuel storage will also be required adjacent to the plant room and located so that suitable access for fuel deliveries can be achieved. Fuel delivery facilities will require that sufficient access and turning circles are provided for lorries.

The flue will also need to be integrated into the building design. Typical flue heights SENTENCE TO BE COMPLETED

[46] Renewable Energy Feasibility Study for Daventry District Council. MWH, Appendix 3. 2008.

1.86.5 Fuel Supply

General rule of thumb guidance on fuel supply and delivery implications assume two 38 tonne trucks per MW of installed capacity based on thermal continuous output:

Table 14.3 – Relationship between installed capacity and fuel deliveries

Installed Capacity	Utilisation factor	Deliveries	Tonnage
250kW	50%	1 or 2 per week	60
10MW	100%	20 per day	750
40 MW	100%	80 per day	3,000

1.86.6 Emissions

Emissions and waste products from biomass energy production fall into three categories:

- Airborne Emissions
- Emissions to Watercourses
- Ash
- Dust.

The Environment Agency (EA) has responsibility for the control of water quality, water abstraction and all emissions.

1.86.7 Maintenance

For biomass systems, fuel delivery and ash removal will need to be supervised, including periodic ash removal from fire tubes and regular inspection of the boiler, fuel supply and ash removal systems.

1.87 Large Scale Biomass CHP

The RSS8 sets out the requirement for the region in the adoption of Combined Heat and Power (CHP) and district heating infrastructure, which requires planners to provide the necessary policy to achieve the regional target of 511 MWe by 2010 and 1120 MWe by 2020.

If biomass is used as a fuel for a CHP plant then the carbon benefits are increased. The cost of the plant is high; however there is the potential for gaining benefits from the electricity and heat produced and also from the Renewable Obligation Certificates. There are a number of technologies available:

- Biomass combustion with conventional steam turbine (viable at a large-scale)
- Biomass combustion with externally-fired air turbine (not well-proven but demonstrations exist)
- Biomass combustion with Organic Rankine Cycle turbines (limited experience)
- Biomass gasifier and modified gas-engine (operating experience is limited and not consistent)
- Biomass gasifier with combustion of the gas for use in a Stirling engine or externally fired gas turbine
- Biomass gasification and pyrolysis with steam turbine (proven on waste streams at a larger-scale) – also using organic rankine cycle
- Liquid biofuel (biodiesel, bioethanol) with reciprocating engine (more technically proven but liquid fuels are best used for transport applications and fuel has a CO_2 content from the processing energy use).

At present the only technology that is well established is the combustion boiler and steam turbine system, which is most cost-effective at a scale of 10MWe or above. The other technologies are also likely to have improved economics at a larger-scale. Hence the opportunity for biomass CHP can be realised at a site-wide level much more readily in combination with district heating. As a result this technology is particularly important in the context of delivering a planning policy on energy.

Liquid biofuels can be used with reciprocating engines; however long-term guarantees or reliability may be hard to obtain for fuel that is 100% biodiesel as there is limited operating experience at present. There is also some concern that the net carbon benefit from biodiesel may be limited after processing energy is taken into account and that the environmental and social impacts of some energy crops used to produce biodiesel may be significant. It could be argued that the limited supply of biodiesel would be better used initially as a blend for vehicle applications, rather than in building energy applications where alternative biomass energy sources exist.

1.87.1 Site and Capacity Space Requirements

The space requirements for a biomass CHP is similar to that of a biomass boiler providing heat only; however extra space requirements may be needed for fuel storage.

1.88 Waste to Energy

1.88.1 *Incineration*

The most established technology for waste to energy plant is mass incineration coupled with a steam boiler and turbine system. Examples include the SELCHP plant in London and the Sheffield plant. This technology is large-scale (>200,000 tonnes p.a.).

The majority of Municipal Solid Waste (MSW) incinerators burn the waste stream essentially in the form it is collected. The combustion gases are filtered to remove particulates, acid gases and trace organic compounds. The ash created by the system includes bottom ash and fly ash. Bottom ash is the ash that falls to the bottom of the incinerator; after the heavy metals have been removed it can be used as aggregate or disposed of in landfill. Fly ash is ash separated from the flue gas; it should be disposed of in controlled landfill.

Site and Capacity Space Requirements:

Table 14.4 – Relationship between installed capacity and building requirements

MSW	Site	Building	Chimney
10-35 MW	2 -3 hectares	30 - 40m	80m

Fuel Supply:

Table 14.5 - Relationship between installed capacity and fuel deliveries

Installed Capacity	Utilisation factor	Deliveries	Tonnage
10-35 MW	100%	30 per day	400,000

1.88.2 *Gasification/Pyrolysis*

The newer technology of gasification/pyrolysis is employed for waste disposal at Avonmouth (Compact Power). This plant takes clinical waste with typical volume of 5,000 tonnes p.a. Net electricity generation is about 300kWe. There is still limited operating experience at the moment. Typical scales for municipal waste using this technology would be 32,000 tonnes to 64,000 tonnes p.a.

Pyrolysis
Pyrolysis is the process of heating fuel in the absence of air to produce charcoal and a gaseous fuel (‘syngas’). These can then be burned in boilers, engines or turbines to generate heat and power. Plants with pyrolysis only are less common than those where pyrolysis is combined with gasification.

Gasification
Gasification is a process of partial combustion, which enables operators to effectively control the temperature of the process, with consequent mitigation of pollutants. A gas is formed when the fuel reacts with sufficient oxygen to maintain a high reaction temperature but with insufficient oxygen to complete combustion. This gas can then be used in engines, boilers or turbines to generate power.

For all these processes the useful energy in the waste is generally released by combustion. The ash resulting from pyrolysis and gasification followed by combustion has also been found to be more stable and less polluting than that from conventional incineration.

Site and Capacity Space Requirements:

Table 14.6 - Relationship between installed capacity and building requirements

Gasification	Site	Building	Chimney
1.5 MW	0.5 hectares	tbc	25m +
40 MW	5 hectares	tbc	tbc

1.88.3 *Anaerobic Digestion*

This process uses organic waste to produce a methane rich gas which can be used to generate electricity from reciprocating engines. Some of the heat recovered from the engines is used for the process; the remaining would be available for heating buildings. Most plants have been built on farms where the waste is generated and again the quantities of waste needed for a viable plant are significant (e.g. 8,000 tonnes of farm slurry and 30,000 tonnes of food waste p.a.). Sewage sludge can also be used in the Anaerobic Digestion (AD) process. The gas produced from sewage is of a similar composition to that from farm waste, the only difference being the size and scale of the digestion plant as sewage waste treatment is generally centralised covering towns and city populations. Thus sewage sludge digesters are usually much larger than farm waste digesters.

1.88.4 *Fuel Sources*

Sewage sludge.

This is the sediment that is removed from foul sewage during the course of treatment by a process of settlement. AD of sewage sludge currently takes place at many sewage treatment works in the UK, and some schemes already include energy recovery. The raising of sewage treatment standards, together with tighter controls on the disposal of sludge, has lead to greatly increased arisings, particularly in coastal areas where sludge dumping at sea ceased to be an option in 1998. Water companies are placing a priority on finding alternative methods of safe disposal. Energy recovery will potentially become more economically attractive where AD is the chosen waste treatment measure.

If Gas from sewage sludge digestion contains 55-65% methane this is suitable for CHP systems. For every 1 m^3 of sewage water, the amount of gas produced is sufficient to generate 1 kWh of electricity plus 1 kWh of heat in a CHP operation.[47] Based on this assumption the predicted total daily electrical generation for a city of 200,000 residents is 30 MW per day if all of the effluent waste was processed by AD and used to fuel a CHP facility. By introducing a district heating scheme a further 30MW of thermal energy could also be recovered.

Typical sewage output per person is indicated below:

Table 14.7 - Relationship between sewage throughput and tank volume[48]

Population	Daily sewage throughput	Total Digester Volume	Potential Electrical Generation
	m^3/day	m^3	MWh per day
21,000	3,000	380	3
60,000	9,000	1,350	9
200,000	30,000	3,400	30

[47] Renewable Energy Feasibility Study for Daventry District Council, MWH, May 2008.
[48] An introduction to Anaerobic Digestion of Organic Waste. Remade Scotland. 2003

Farm slurry.
The intensive rearing of livestock, particularly cattle and pigs, produces large quantities of slurry manure in liquid form which is not only odorous but which can also present pollution problems if it is not carefully disposed of. Silage effluent can cause similar problems. Farmers can face stiff penalties for causing these substances to pollute watercourses.

Municipal Solid Waste (MSW).
Municipal refuse contains large quantities of food, garden waste, paper and packaging with a high organic content, and is therefore suitable for energy extraction via AD. With the introduction of the Enhanced Renewables Obligation, the potential contribution from AD plant, utilising 100% food processing waste for example, is large and is likely to grow still further.

1.88.5 *Digestion Equipment*

An anaerobic digestion plant typically comprises a digester tank, buildings to house ancillary equipment such as a generator, a biogas storage tank, a flare stack and associated pipework. Plants can vary in scale from a small scheme treating the waste from an individual farm, or a medium-sized centralised facility dealing with wastes from several farms, to a sizeable industrial plant handling large quantities of MSW.

Digestion takes place in a tank, which is usually cylindrical or egg-shaped. The size of the tank will be determined by the projected volume and nature of the waste to be handled and the temperature and retention time in the digester. Some indicative tank dimensions are given in Table 14.8. Digesters with a volume of less than 250m^3 can operate successfully on farms. Whereas most tanks are constructed from glass-coated steel, these small digesters are often made of glass fibre-reinforced plastic.

Table 14.8. – Digester size and the volume of organic waste processed[49]

Organic Waste	Digester Volume	Height	Area
tonnes per day	m^3	m	m^2
50	800-1,500	8-10	75-150
150	2,200-3,500	10-12	180 - 360
350	4,700	10	470
450	7,700	15	513

1.88.6 *Mechanical Biological Treatment – Plus Combustion/Gasification*

A new method of treating municipal solid waste is to shred it and dry it and extract valuable materials such as metals and glass. By pre-treating the waste the combustion efficiency is improved and extracted recyclable materials such as metal and glass can be recovered.

Treatments include shredding, sorting and separation, and drying. The equipment used for sorting waste will typically include rotating and vibrating screens, magnetic separators, air separators and manual picking belts and high temperature washing.

The end product is a dry fuel which can be sold as a fuel with a high biomass content in such applications as cement works.

[49] An introduction to Anaerobic Digestion of Organic Waste. Remade Scotland (2003)

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15 Exemplar Scheme Review

Exemplar Scheme Review

1.89 **Introduction**

In assessing the exemplar projects a number of local, regional and national developments have been reviewed. A range of developments have been chosen in order to provide a comparison of building types at the varying scales that will be typical for the developments to be assessed by WNDC. The following developments have been chosen due to their innovative approach to addressing a range of sustainability issues. These schemes are deemed to be forward thinking exemplar development that could be replicable in the WNDC area.

This section is intended to provide both developers and WNDC with information on a range of development types and scales that have successfully implemented advanced sustainability standards.

Table 15.1 – Development case studies

Development	Location	Primary Land Use(s)	Size
ProLogis/Sainsbury's	Pineham	Distribution Centre	60,000 m^2
Oak Meadow	South Molton	Residential	35 homes
British Timken	Northampton	Residential	480 homes
Innovate Green Office	Thorpe Park	Office	46,000 sq ft
Upton	Northampton	Residential Retail Space Commercial Offices	1,020 homes 700 m^2 3,400 m^2
Queens Building	De Montfort University	Education	10,000 m^2
Green Park	Reading	Commercial Offices	200,000m^2

1.90 **ProLogis Distribution Centre - Pineham**

The ProLogis Distribution Centre at Pineham occupies a site covering 150 acres (61 hectares) of which about 112 acres (45 ha) are developable. In addition to the distribution space, ProLogis' planning consent allows for 200,000 sq ft (18,580 m^2) of offices, which will act as a buffer between the warehousing and 40 acres (16 ha) of homes. The site accommodates a 60,000 m^2 Sainsbury distribution centre, which has achieved a BREEAM rating of 'Very Good'

1.90.1 Building Details

Architect	RPS Burks Green

Building Type	Distribution Warehouse
Gross Floor Area	60,000m^2

U – Values	$(W/m^{2o}C)$
- walls	0.29
- floor	0.14
- roof	0.14 - 0.18
- glazing (centre of pane)	1.50 - 1.70

1.90.2 Strategy

The building has been designed to significantly reduce energy consumption and carbon emissions through a number of initiatives including innovative solar technologies, high levels of sky lighting and minimal efficient electric lighting.

1.90.3 *Summary of the Sustainability Credentials*

Passive Design

- Solar shading to glazed elevations
- Office initiatives include a narrow floor-plate, to give better natural lighting; solar shading

Energy Efficiency

- Energy efficient lighting systems
- Air-tight construction that minimises energy loss through the external fabric of the building exceeding Part L Building Regulations.
- The provision of 15% roof lights, which will provide more natural light, in conjunction with low energy lighting and intelligent lighting control
- Renewable energy is provided in the form of solar wall heating which, in conjunction with photovoltaic panels, will provide extra heating to the warehouse area. This is achieved through the integration of 950 m^2 of Solar Wall panels with a projected energy delivery of 343,000 kWh/year

Low and Zero Carbon Energy

- Wall-mounted photovoltaic panels that generate electricity
- Solar walls that produce heat from sunlight
- Combined heat and power (CHP) with absorption chiller

Water/Drainage

- Rain water system will harvest 16 million litres of water per annum which will be utilised in a variety of processes by Sainsbury's, and the creation of an ecological corridor will enable plants and animals to form a natural habitat
- Water conservation measures provide water savings of 200,000 litres per annum
- SUDS drainage for external works

Materials

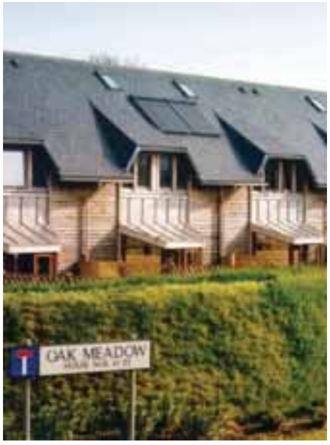
- Off-site prefabrication of materials
- Carpets from recycled materials
- Low Volatile Organic Compound (VOC) emission paint

Waste

- An on-site recycling facility

1.91 **Oak Meadow, South Molton (Formerly Livarot Walk)**

Oak Meadow in South Molton is a sustainable neighbourhood development of 35 Ecohomes, which have been built for the Devon & Cornwall Housing Association. The development was completed in September 2004.



1.91.1 Building Details

Architect	Gale & Snowden
M & E Consulting Engineers	Faber Maunsell
Structural Engineer	Faber Maunsell

Building Type	**Residential Dwellings**
Number of dwellings	35

U – Values	**(W/m^{2}°C)**
Walls	0.13 W/m^{2}K
Floor	0.14 W/m^{2}K
Roof	0.13 W/m^{2}K
Windows and doors	1.00 W/m^{2}K

1.91.2 Strategy

The architect designed the development to demonstrate and maximise the sustainability features of the dwellings, and achieved an Ecohomes rating of Very Good. SAP calculations were undertaken which determined the average SAP rating across the site as 118/120, achieved through a combination of passive design features and high quality building materials to control internal temperatures.

The residents have actively been involved since completion through completing questionnaires on the operation of the dwellings and the performance of the sustainability measures, and have monitored water use, energy and household waste.

The key structural design features incorporated in the design of the houses were the use of double skin timber frames manufactured by local timber frame manufacturer Frame Homes UK, using FSC certified timber. This allowed the wall, floor and roof construction to be prefabricated offsite in panels. These were then delivered to site and erected in sequence providing a quick method of construction and adding to the overall sustainability of the project by helping reduce traffic movements with respect to both material deliveries and site personnel. The panels were then filled on site with cellulose insulation blown into the 300mm and 350mm wide cavities to the walls and roofs respectively. This provided very high levels of insulation and reduced the level of thermal bridging.

The architect designed the houses to contain a room-in-the-roof space and, as the roofs are better insulated than the walls, the room-in-the-roof design maximises the use of space in the building, and reduces the area of wall and heat loss. Externally the panels are finished with sustainable timber cladding and lined internally with plasterboard.

1.91.3 *Summary of the Sustainability Credentials*

Passive Design

- The site layout & house terracing faces south & southwest to benefit from passive solar gain
- Maximisation of natural day light, through rooflights and windows to give the homes a light & airy feel
- Naturally ventilated
- Terrace houses reduce heat loss by sharing party walls.

Energy Efficiency

- High efficiency and low energy compact fluorescent lighting where required
- Thermal mass has been incorporated in the internal walls & solid ground floors to reduce fluctuations in internal temperatures
- The units were designed so that there will be a minimum requirement for space heating. The buildings as designed, do not require space heating except for exceptionally cold periods. An energy efficient gas condensing boiler and a wet radiator system has been installed but is only normally used when outside temperatures are below -1C.

Low and Zero Carbon Energy

- A special design feature is a naturally ventilated 'cool larder', a highly insulated space inside each house which is kept very cool by air drawn in through clay pipes, laid deep underground. The airflow is assisted by low voltage fans supplied with electricity from photovoltaic panels. The cool larder should eliminate the need for a refrigerator.
- Solar thermal panels were also installed to meet part of the domestic hot water demand.

Water/Drainage

- Water efficiency within the homes is ensured by the incorporation of low water use appliances. These include 3/6 litre dual WCs and pressure reduction valves. Low water use showers & taps have also been installed
- Rainwater is collected from the south facing roofs of the homes and stored in 6 underground tanks (1 for each terrace) which are located primarily under the car parking areas. The rainwater collected is used in all WCs
- By using the water saving appliances & rainwater collection, domestic demands on the mains water supply can be reduced by over 65%.

Materials

- Terraced houses also ensure greater efficiency for timber frame prefabrication as repetitive units enable quicker & cheaper construction than individual houses
- Traditional strip foundations and ground bearing slabs were used, but with concrete mixes using a 70% proportion of ground granulated blast-furnace slag (GGBS) as replacement for Portland Cement
- Timber and other materials from sustainable sources.

1.92 British Timken - Northampton

The former British Timken bearing factory site comprises approximately 67 hectares, and originally contained factory buildings, car parking, sports fields and a recreation club with associated playing areas. The brown field site to the north west of Northampton comprises a complex of 480 homes, sports pitches and offices on a 67-acre site. Developers Bellway Homes & David Wilson Homes plan to develop the site in four Phases.

1.92.1 *Building Details*

Developer	Bellway Homes

Building Type	Number of Dwellings/Gross Floor Area
Residential Recreation facilities, mixed use commercial and community development	480 dwellings

1.92.2 *Strategy*

The developers have demonstrated their commitment to sustainability by providing a sustainability and energy statement to accompany their planning application. The sustainability and energy statement included an Ecohomes pre-assessment used to demonstrate a commitment to sustainable development. The Ecohomes pre-assessment highlighted the minimum measures needed to achieve an EcoHomes rating of Very Good. SAP calculations were undertaken on a number of dwelling types in order to predict the annual CO_2 emissions associated with the dwellings and determine the predicted number of credits that could be achieved for Ene1 - Carbon Dioxide. The developers have also committed to undertaking a post construction review for 20% of the dwellings to ensure sustainability measures have been implemented during the construction stage and that the Very Good rating has been fully achieved.

Additionally all homes will be within 300m of an open amenity space and all houses and 75% of flats to have access to secure external (semiprivate) space, i.e. terrace, balcony or garden. The site is to be designed to Secured by Design standards. All home owners/occupiers will be provided with a comprehensive information pack detailing the specific sustainability features of their home.

1.92.3 *Summary of the Sustainability Credentials*

Passive Design
- Increased use of daylighting for living and dining rooms
- Natural ventilation

Energy Efficiency
- All homes to achieve an average reduction in regulated energy consumption (heating, hot water and lighting) by 10% on a Part L 2006 compliant dwelling
- Improved insulation levels
- Commitment to achieve a minimum air leakage rate of $5m^3/hr/m^2$
- Energy efficient lighting

Low and Zero Carbon Energy
- All homes to be supplied through a renewable energy tariff
- 10% of the site wide energy use will be generated through the application of solar thermal hot water systems
- Class 5 Condensing Gas Boilers

Water/Drainage

- All homes to achieve a reduction in mains water consumption of 20% compared with an average of 153.5 litres/day taken from Anglian Water, through the provision of low water use sanitary ware
- All homes with a garden to be provided with rainwater collection facilities
- Incorporation of attenuation ponds to increase both water attenuation and biodiversity

Waste

- Each dwelling to be provided with a minimum of $0.8m^3$ storage overall for household waste management, to include provision of $0.3m^3$ internal recycling bins in line with EcoHomes requirements and kerbside collection
- All insulation materials to have zero Ozone Depleting Potential and a Global Warming Potential of less than 5
- A target value of 15% recycled content per dwelling has been committed. This will be measured in line with the process developed by the Waste & Resource Action Programme (WRAP) document 'Opportunities to use Recycled Materials in House Building' and the WRAP recycled content toolkit
- A site waste management plan shall be produced with a commitment to producing no more than $35m^3$ of construction waste per dwelling.
- Waste management strategies to be adopted shall include segregation, reuse and recycling of construction waste on site
- Homes with a garden to be provided with composters or wormeries

Materials

- 80% of all materials used in the major elements during construction will be sustainably sourced
- All windows on the development will be timber framed
- The Developers are committed to sourcing materials for the British Timken development to an overall level of 15%
- 4 green roofs provided

Transport

- All homes within 600m of a public transport node – 80% within 500m

1.93 Innovate Green Office, Thorpe Park, Leeds

The Innovate Green Office, Thorpe Park is a newly built office with a shallow plan. It has no wind turbines or solar panels, yet it was awarded the highest ever BREEAM rating of 87.55%. Its concrete shell and large glass panes give it a unique look. The office emits 80% less CO_2 than a typical, conventionally air-conditioned office resulting in only 22kg of carbon dioxide per m^2 per year produced, saving 350 tonnes of CO_2 per year.

1.93.1 Building Details

Architect	Rio Architects
M&E Consulting Engineers	King Shaw Associates
Structural Engineers	Scott Wilson

Building Type	Gross internal area
Office	46,000 sq ft

U – Values	($W/m^2 {}^oC$)
- walls (concrete)	$0.15 W/m^2 {}^oC$

1.93.2 Strategy

The Innovate Green Office uses a strategy based on harnessing 'sustainable first principles' rather than adding renewable energy systems and sources to a conventional office design. The building is designed as a thermal store with the concrete structure and 'ThermoDeck' floor and roof planks playing an important role in maintaining a constant temperature.

The building fabric utilised a high percentage of recycled aggregate and cement replacement, and the specification of sustainably sourced timber. Stormwater run-off is managed in an extensive sustainable drainage system comprising an onsite wetland and swales, coupled with permeable hard landscaping and rainwater harvesting for toilets. These measures effectively result in no runoff from the site

The innovative design of the building and the materials it contains, coupled with the range of sustainability measures summarised below have resulted in a BREEAM rating of Excellent.

1.93.3 *Summary of the Sustainability Credentials*

Design

- Designed to passive solar principles
- Optimises orientation for controlling solar gain – utilise in mornings, block it in evenings
- Large windows – natural daylight avoiding need for electric lighting most of the year
- Thermal mass – heat store in winter recovering heat from people and computers

Power and heating

- Combined Heat and Power (CHP) providing electricity and heating and hot water
- Heat from CHP used for cooling in summer through an absorption chiller
- CHP reduced CO_2 emissions by 30 tonnes per year

Ventilation

- Enhanced mechanical ventilation using 'TermoDeck' to distribute and temper air supply to the floor plates through a network of hollow cores
- Stack effect for ventilation in central atrium along the length of the building

Water efficiency and SUDS

- Vacuum toilet system – 1.2 litre flush as used in marine/aircraft design
- Rainwater used for flushing toilets with surplus delivered to onsite lake. No mains water used for sewage
- Permeable carpark paving. Site designed so that no storm water is discharged from the site

Ecology

- Indigenous landscaping and planting, and wetland areas to encourage wildlife
- Green-roof

Materials

- 40% materials used in the structure have been recycled

Transport

- Extra cycle bays and showers

1.94 **Upton Residential Development – Northampton**

The Upton urban extension development promotes best practice in sustainable urban growth under the guidance of a Design Code applicable for the whole site. The development, particularly those publicly funded elements (through English Partnerships), demonstrates a range of sustainable technologies depending on the location within the site and the orientation of parcels of dwellings. The development has been split into four different areas: urban boulevard, neighbourhood spine, neighbourhood central and neighbourhood edge. The key for delivering sustainable urban growth is having design codes linked to an urban framework plan.

1.94.1 *Building Details*

Master Planning	EDAW
Developer - Site A (210 dwellings)	Paul Newman New Homes
Developer - Site B (204 dwellings)	Cornhill Estates, Fairclough Homes
Developer - Site C (30 large homes)	David Wilson Homes
Developer – Site D1 (345 dwellings)	Metropolitan Housing Partnership
Developer - Site D2 (165 dwellings)	Barratt Developments
Developer – Sites F, G	*To be confirmed*

Building Type	No. of Dwellings / Gross internal area
Dwellings	1,020 No.
Convenience Store / Retail units	1,000 m^2
Office	3,200 m^2
Café / restaurant	450 m^2
Nursery	70 spaces

1.94.2 *Strategy*

The design code strategy was key to achieving sustainable urban development. The design codes provide clarity as to what corresponds to acceptable design quality. Key features of the design code include ensuring that there is a wide range of affordable housing throughout the site. As well as this the design code ensures that every building will be assessed at the design and post construction stage to ensure that a BREEAM rating of excellent is achieved for non dwellings and a Code for Sustainable Homes minimum rating of 3 achieved for all dwellings.

1.94.3 *Summary of the Sustainability Credentials*

Design
- Passive solar design

Power and heating
- Micro CHP – utilising a small energy conversion unit instead of a conventional boiler, the heat produced is used for space and water heating, while the electricity is fed into the grid
- Photovoltaic panels and solar water heating
- CO_2 emissions less than 25kg/m^2 per year

Water efficiency and SUDS
- Rainwater harvesting for re-use on site
- Green roofs
- Sustainable Drainage System to reduce flood risk, in particular water butts, swales shallow wetlands and permeable paving

Ecology
- Green roofs

Materials
- 80% of material used ‘A rated’ in accordance with Green Guide to Housing Specification
- Locally sourced
- Zero construction waste to landfill

Transport
- Zero parking standard
- Group car share scheme

1.95 **Queens Building - De Montfort University**

The four-storey 10,000m^2 Queens Building, designed for the new School of Engineering and Manufacture at De Montfort University in Leicester incorporates teaching, laboratory and research facilities. Short Ford Associates were the project Architects responsible for the building design whilst Max Fordham Associates were responsible for the building service strategy.

1.95.1 Building Details

Architect	Short Ford Associates
M & E Consulting Engineers	Max Fordham Associates
Structural Engineer	YRM – Anthony Hunt

Building Function	Education
Gross Floor Area	9,850m^2
- teaching/lab spaces	6,390m^2
- computer suite	1,600m^2
- offices	1,400m^2
- concourse	300m^2
- amenity & dining	1,60m^2
Occupancy	2,000

U – Values	(W/m^{2o}C)
- walls	0.29 to 0.36
- floor	0.19 to 0.45
- roof	0.20 to 0.31
- glazing (centre of pane)	2.50 to 3.60

Lighting Levels	Lux
- offices	300
- circulation areas	150/200

- mechanical laboratories	1000
- general laboratories	750

1.95.2 *Strategy*

The building has been designed to make maximum use of daylighting and natural ventilation in order to reduce its energy consumption and running costs. The building utilises thermal mass in combination with night cooling allowing the building to avoid the need for comfort cooling.

Lighting

The need for electric lighting has been reduced through a combination of windows, rooflights and light shafts. Windows have been provided with solar shading through deep reveals, overhanging eaves and articulated facades. Multiple small windows have been used in preference to large glazed areas to provide daylighting without the penalties of increased heat loss in winter and excessive heat gain in summer. North lighting has been used extensively throughout the building that provides both lighting to the space whilst also integrating into the ventilation strategy.

The deep plan areas have benefited form a full height concourse that allows daylight to penetrate the centre of the building. High efficiency T8 flourescent lighting supplements the daylighting which is controlled through both zoned manual switching and a building management system. The switching strategy operates in two modes; during the core occupied periods the BMS system energises the lighting circuits allowing manual controlling of the zones, however outside of this period the BMS will de-energise the lighting circuit when the PIR sensors do not detect movement for longer than 5 minutes.

Heating & Ventilation

High standards of insulation have been achieved in floors, walls, roof and windows. In the summer the narrow sections of the building are cooled by cross ventilation. Other areas with a deeper floor plan incorporate purpose-made ventilation openings. Honeycombed brickwork was used to allow air into the seven buttresses supporting the external wall and gantry crane track. North lights and roof vents open automatically to create a through draught allowing a means of escape for the passive stack ventilation. In the central area where there are deep-plan classrooms and lecture theatres, tall extract stacks terminating in metal and glass extend well above the roof level. The stacks open to extract stale warm air while fresh replacement air is allowed in through low-level louvres and windows.

1.95.3 *Summary of the Sustainability Credentials*

- 38 kW_e CHP unit
- Natural Ventilation
- No comfort cooling
- Daylighting
- High efficiency T8 flourescent lighting
- Room thermostats and thermostatic radiator valves
- Building Management System (BMS) to control heating, lighting & ventilation
- Manual switching linked to BMS
- BMS control linked to passive infrared detectors
- BMS controls to allow night cooling

1.96 **Wind Turbine Example – Reading**

The Reading turbine located at Green Park was undertaken in a partnership between Ecotricity and Prudential Property Investment Managers Ltd (PRUPIM), close to Junction 11 of the M4 motorway. The 2MW turbine generates approximately 3,500 MWh of electricity per year providing power for up to 1,500 local homes and businesses.

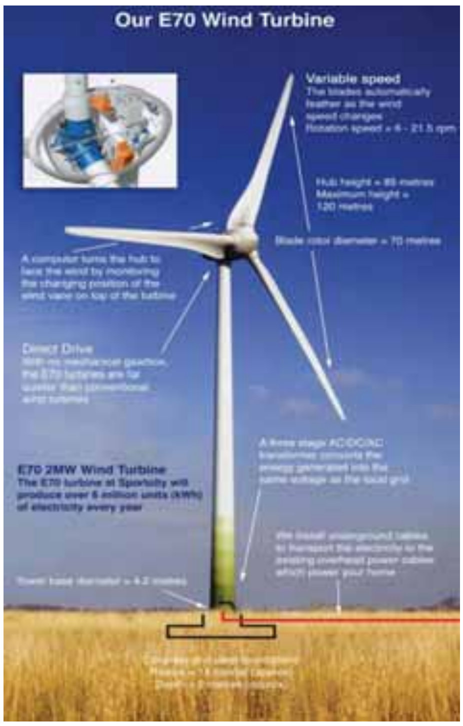
This equates to a reduction of carbon dioxide emissions of more than 2,000 tonnes, when compared with the average carbon dioxide emissions associated with the fossil fuel element of the grid supplied electricity.

Table 15.1 – Wind Turbine Specification: Enercon E-70

Ecotricity Turbine - Reading	Enercon E-70 Specification
Installed Capacity	2 MW
Height	85m
Rotor Diameter	71m
Blade Tip Height	120.5m
Swept Area	max - 3,959m^2
Cut-in Speed	2.5m/s
Rated Wind Speed	13.5m/s
Cut-out Speed	28-34m/s
Rotation Direction	Clockwise
Rotation Speed	Variable, 6-21.5 rpm
Tower Diameter at Base	4.2m
Tower Diameter at Top	2.0m
Area of Base	13.8m2
Concept	Gearless, variable speed, pitch regulated
Design Life	25 + Years

Importantly local contractors and suppliers were used for most of the building work, including the construction of access roads and turbine foundations.

Greenpark 2MWe wind turbine – Ecotricity



Enercon E-70 turbine

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16 Conclusion

Conclusion

The purpose of this guide is not to be prescriptive about the technologies or approaches that should be used for a particular development. Instead it offers potential solutions and identifies where these might be appropriate for a particular development type, scale and/or approach.

It is envisaged that this guide shall be used as a reference tool for WNDC, Local Authorities and developers to facilitate the understanding and appropriateness of technologies in different development scenarios. It is also intended that this document form part of the Sustainability Manual.

In regards to energy, waste and water, the approach to achieving sustainable design and construction will be firstly to minimise resource use. In regard to energy and water this will involve careful design to minimise consumption both during construction and operation, before applying technologies to generate energy or harvest water onsite. Applying technological solutions to a poorly designed, energy and water intensive development would be counterproductive and generally more expensive.

It must be stressed that each development will need to be assessed on its own merits, as there is never a single solution in the design of sustainable, resource efficient buildings. Where a particular technology or approach may be suitable for one development, site constraints, orientation, access, etc. may prohibit the same approach on another similar development.

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Appendix A

Appendix A - Technology & Approach Matrix

This section provides a summary of technologies and approaches suitable for investigation for developments within Northamptonshire based on building type. The matrix has been designed to help both developers and the WNDC officers to identify the suitability of a particular technology and or approach for a development. The matrix therefore provides a quick overview of each technology and or approach with references to further information if more in-depth clarification is necessary. Each topic references back to the sustainability guide with reference to further information and technical guidance also provided.

The matrix is separated into 3 sections covering Detached & Semi detached Dwellings, Flats and Non-Dwellings. Each technology or approach is assessed to indicate whether it is likely to be applicable to the development type and the level of priority the technology or approach should be given.

The table identifies if a technology or approach is applicable to the building type. Applicability is separated into 3 categories:

✓ Directly applicable: This technology or approach should always be given consideration

? Applicable under certain circumstances: Under the appropriate circumstances this technology or approach will have a considerable CO_2 benefit to the scheme

✗ Not applicable: The technology or approach is not appropriate for the given building type

3 levels of priority have been identified for each technology:

- High: Technology or approach should always be considered as a considerable CO_2 reduction is likely to be achieved
- Med: Technology or approach may provide a considerable CO_2 reduction
- Low: Technology or approach is unlikely to proved a meaningful CO_2 reduction

Key:

✓ – Directly applicable ? – Applicable under certain circumstances ✗ – Not Applicable **S.G.** – WNDC Sustainability Guide

Residential Detached & Semi Detached			Priority				Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Passive Design	Orientation	✓	●			Orientation of the building should make optimal use of solar gain	EST. GIR27 – Passive solar estate layout
	Shelter Beds	✓		●		Shelter bed could be incorporated where sufficient land is available to limit heat loss from northerly winds	EST. GIR27 – Passive solar estate layout
	Thermal Mass	?		●		Thermal mass provides an opportunity to harvest solar energy during the day that will temper the heating demand in the evening when occupants are generally home and heating is required. However dwellings designed to incorporate thermal mass are less responsive than a light weight design. Therefore either strategy could be appropriate in the reduction in CO_2 emissions and will generally be influenced by the predicted occupancy of the dwellings and heating source provided.	CIBSE. Guide L – Sustainability. 2007
	Daylighting	✓	●			Dwellings must strive to provide sufficient daylighting, sunpipes could be utilised in areas that do not have an external wall. Daylight factors of 2% in living rooms / 1.5% in kitchens should be achieved in line with CSH requirements.	EST. CE257 – Daylighting in urban areas: a guide for designers
	Shading Systems	✓		●		Should be investigated to limit excessive solar gains especially if large south or west facing areas of glazing are incorporated into the design	EST. CE129 – Reducing overheating: a designer's guide CIBSE TM37 - Designing for improved solar shading control (2006)
	Natural Ventilation	?	●			Must be incorporated, however if air tightness exceeds $3m^3/m^2/hr$@ 50 Pa, mechanical ventilation with heat recovery should be investigated	EST. CE124/GPG628 – Energy efficient ventilation in housing: A guide for specifiers on requirements & options
Energy Efficiency	Insulation	✓	●			Developers should always aim to exceed the minimum area-weighted Building Regulation Standards for thermal insulation.	EST. CE23 – Effective use of insulation in dwellings EST. CE71 – Insulation materials chart: thermal properties and environmental ratings
	Air Tightness	✓	●			Building Regulations ADL1A require a minimum air tightness of $10m^3/m^2/hr$@ 50 Pa, EST good practice of $5m^3/m^2/hr$@ 50 Pa, reducing further to $1m^3/m^2/hr$@ 50 will comply with passiv haus standards	EST. CE248 – Achieving air tightness in new dwellings CIBSE TM - Testing buildings for air leakage (2000)
	Lighting & Controls	✓	●			A minimum of 70% dedicated low energy light fitting should be installed	EST. CE80/ADH001 – Domestic lighting innovations EST. CE61 - Energy efficient lighting: guide for installers and specifiers EST. GIL20/CE188 – Low energy domestic lighting

Residential Detached & Semi Detached		App.	Priority High	Priority Med	Priority Low	Explanation	Further Information & Technical Guidance
Energy Efficiency	Heat Recovery	✓		●		Heat recovery should always be installed where whole house ventilation is incorporated. Heat recovery could also be investigated on the waste energy, to recover thermal energy from the hot water discharge.	EST. CE124/GPG628 – Energy efficient ventilation in housing: A guide for specifiers on requirements & options
	Building Management System (BMS)	?			●	A BMS is not generally applicable for detached dwellings that incorporate passive design measures. For dwellings that are built to high levels of air tightness and incorporate a MVHR system and other LZC technologies, a user friendly BMS may be appropriate.	BSRIA. The effective BMS (2001)
Renewable and Low Carbon	District Heating	?		●		Losses associated with the distribution pipework and costs limit the viability of district heating for low density developments. District Heating should be investigated with developments with a density greater than 50 dwellings per hectare as the viability increases with density. District heating should be considered a priority for such schemes.	EST. CE13 - Benefits of best practice: community heating EST. CE91 – Rural biomass community heating case study EST. CE55 – Community heating guide
	Combined Heat & Power (CHP)	?		●		CHP is generally not viable at an isolated domestic level, however it could be investigated in conjunction with district heating. A general rule of thumb for CHP to be feasible is a residential density > 50 units. CHP should be considered a priority for such schemes.	CIBSE – AM12 – Small-scale CHP in Buildings Combined Heat and Power Association - http://www.chpa.co.uk/
	Biomass	?		●		Dwellings with clear access and sufficient space to incorporate a biomass store could integrate a biomass boiler to meet the heating and hot water demand, the technology is more suited to larger dwellings or a central system for a number of dwellings. Biomass is compatible with DH, however potential barriers include issues with NOx and particulates emissions.	EST. CE69 – Renewable energy sources for homes in urban environments EST. CE70 – Renewable energy sources for homes in rural environments EST. CE91 – Rural biomass community heating case study CIBSE. KS10 - Biomass Heating
	Solar Thermal	✓	●			50% of a dwelling's hot water demand can typically be met by solar thermal, designers must ensure roofs are designed to optimise their solar aspect (45^{O} from south and 30^{O} pitch) and that over shading is avoided	EST. CE131 – Solar water heating systems EST. GIR88 - Solar hot water systems in new housing : a monitoring report
	Solar Photovoltaics (PV)	✓		●		1 kWe of installed electrical capacity would generally meet 25% of the electrical demand of a 3 bed house designed to good practice standards. Potential barriers for PV include the relatively high initial capital cost. As above, designers must ensure roofs are designed to optimise their solar aspect (45^{O} from south and 30^{O} pitch) and that over shading is avoided	CIBSE TM25 - Understanding building integrated photovoltaics (2000) DTI Photovoltaics in Buildings: A Design Guide
	Wind: building integrated	✗				The performance of building integrated turbines are very site specific and generally under-perform due to turbulence associated with obstructions from buildings and trees. Unless sufficient height can be achieved (very unlikely for a detached dwelling) turbines should be viewed with caution. Planning constraints should also be taken into consideration.	EST. CE72 - Installing small wind-powered electricity generating systems British Wind Association. Best Practice Guidelines for Wind Energy Development http://www.greenspec.co.uk/html/energy/windturbines.html

Residential Detached & Semi Detached		App.	Priority High	Priority Med	Priority Low	Explanation	Further Information & Technical Guidance
Renewable and Low Carbon	Wind: stand alone	✓	●			Large to medium scale stand alone turbines should be encouraged especially in large developments in excess of 1000 dwellings.	PPS22 Renewable Energy British Wind Association. Best Practice Guidelines for Wind Energy Development
	Ground Source Heat Pumps (GSHP)	?			●	GSHP could be investigated, although sufficient land availability may limit their feasibility. Generally they offer little carbon benefit over a gas condensing boiler for space heating and should only be considered if there is no mains gas supply to the site. The cost of installing a ground loop or borehole system can be prohibitive.	EST. GIR72 - Heat pumps in the UK – a monitoring report EST. CE82/GPG339 - Domestic ground source heat pumps: design and installation of closed loop systems
	Air Source Heat Pumps (ASHP)	?			●	Again in the absence of mains gas an ASHP could provide a viable solution providing the electrical supply is from a renewable source (such as a large wind turbine), heat pumps provide a low grade heat therefore underfloor heating would also be recommended for the distribution system.	HVAC. TR30 - Heat Pumps: A good practice guide (2007)
	Waste to Energy	?		●		There is little an individual dwelling can do to provide waste to heat unless a collective scheme is incorporated. For developments in rural sites effluent systems that could process effluent sludge into methane to supply a CHP unit could be investigated. Provision for organic waste storage and collection should also be included	IEA Bioenergy. Biogas Upgrading and Utilisation
Water	Efficient Sanitaryware	✓	●			All dwellings should strive to reduce water consumption to at least 105 l/p/day through the installation of water efficient sanitaryware.	DCLG. Analysis of consultation responses for water efficiency in new buildings (2007)
	Rainwater Harvesting and Reuse	✓	●			Rainwater harvesting should be incorporated, storage tanks above or below ground sized to meet the dwellings non-potable uses with a minimum 14 day coverage would be advised. Water butts should be adopted as a minimum	UK Rainwater Harvesting Association (UKRHA) http://www.ukrha.org
	Greywater Recycling	✓		●		Greywater recycling could be considered to collect the waste water from baths, showers and wash basins for reuse in WC flushing. Either individual or communal systems are available. Greywater recycling could be considered where rainwater is planned for reuse in landscape irrigation rather than internal use.	CIBSE. KS01 – Reclaimed Water
Drainage	Sustainable Drainage Systems (SUDS)	?		●		Individual dwellings should maximise permeable surfacing as opposed to hard surfacing especially for drive ways and car parks. Community developments should investigate swales, trenches and holding ponds to deal with surface water run off.	CIRIA. C697 - The SUDS Guide (2007) BRE. Digest 365 – Soakaway design (1991)
	Green Roofs	✓			●	Green roofs are not generally adopted on detached and semi detached dwellings. However they could be considered along with green walls, however priority should be given to solar technologies.	CIBSE. KS11 – Green Roofs BRE. Green roofs & facades (2006)

Residential Detached & Semi Detached		Priority					Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Materials	Green Guide Rating	✓	●			A+ - D Rated materials as stated in the Green Guide to Housing Specification should be sought where feasible.	CIBSE. KS11 – Green Roofs BRE. Green roofs & facades (2006)
	Reclaimed	✓	●			Reclaimed materials, such as bricks, roof tiles and other materials from any existing buildings due for demolition, should be considered where suitable materials are available.	Waste and Resources Action Programme (WRAP) Reclaimed Products Building Guide Institute of Civil Engineers (ICE) Demolition Protocol
	Locally Sourced	✓	●			Locally sourced materials should be considered first over imported materials. This would not only benefit the local economy, it would also help to preserve local character, as well as reducing the embodied energy associate with material transportation. Material sought and fabricated within a 30 mile radius would be encouraged.	
	Natural	?		●		Natural materials can readily be adopted into detached dwellings.	
	Timber	✓	●			Timber construction has the lowest embodied energy when compared to steel or concrete construction. Also timber is a renewable material providing plantations are well managed, whereas concrete, steel and masonry are finite. Timber should be sourced from a certified and legal sustainable source such as the Forest Stewardship Council (FSC).	GLTA. Glulam specifiers guide (2001) TRADA. Timber frame construction. 4th edition (2008) http://www.fsc.org/
	Materials with High Recycled Content	✓		●		Many standard construction products are available at no extra cost from alternative suppliers that use a high percentage of recycled materials in their manufacture. Ideally developers should seek to measure the % recycled content in their projects but as a minimum, they should audit their supply chains in an attempt to find suppliers with high recycled content products.	WRAP Choosing Construction Products
	Modern Methods of Construction	?		●		If a modern approach is to be taken, modern methods of construction could benefit especially if local industries are created to meet the demand. Local labour and materials should be given precedence.	CE139 Building energy efficient buildings and modern methods of construction. EST
Waste	Site Waste Management Plan	✓	●			SWMP's are mandatory for all projects over £300K. The minimum requirements should be exceeded to include commitments and procedures to sort and divert waste from landfill	EA. Guidance for waste destined for disposal in landfills. Version 2 (2006) DEFRA. Non-statutory guidance for site waste management plans (2008) NatRegs. A Simple Guide to SWMP. (2007)
	Reduction	✓	●			Developers should seek to reduce waste generated on site through good design and careful procurement' i.e. only ordering what you need. Prefabrication, room dimensions matching standard materials sizes etc can help to reduce waste.	WRAP. Achieving effective waste minimisation through design
	Recycling	✓	●			Ensure sufficient storage is provided both internally in the dwellings and externally, with appropriate separation.	http://www.wrap.org.uk/index.html

Residential Detached & Semi Detached		Priority					Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Waste	Deconstruction	✓		●		Dwellings should be designed to be deconstructed and reused/recycled at the end of their useful life. Alternatively the buildings must be designed to provide flexile uses of occupancy, i.e. through the use of the Lifetime Homes standard.	Institute of Civil Engineers (ICE) Demolition Protocol
Transport	Public Transport	✓	●			Developments that can integrate with existing public transport infrastructure should be encouraged. Those in rural sites should either provide safe pedestrian access to public transport nodes where they exist. Where public transport is insufficient the developer should be encouraged to liaise with the relevant bus operators to increase capacity frequency or include a new stop on existing routes, or provide a new service altogether.	TFL. Transport Assessment Best Practice; Guidance Document (2006.)
	Cycling Facilities	✓	●			As a minimum cycle storage should be provided at each dwelling in compliance with the CSH standards. For large rural sites cycle ways should be incorporated within the site linking up to existing cycle ways.	Code for Sustainable Homes – Ene8 cycle storage. BRE Sustrans/cyclists' Public affairs group/CTC. Providing for cyclists - A code of practice (1997).
	Travel Plan	✓	●			Developers should provide a green travel plan ranging in detail depending on the scale of the development.	BCO. A good practice guide to green travel plans. (2004) DfT. Transport Energy Best Practice : A Guide on Travel Plans for Developers (2005)

Residential – Flats			Priority				Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Passive Design	Orientation	✓	●			Orientation of the building should make optimal use of solar gain.	EST. GIR27 – Passive solar estate layout
	Shelter Beds	✓		●		Shelter bed could be incorporated where sufficient land is available to limit heat loss from northerly winds.	EST. GIR27 – Passive solar estate layout
	Thermal Mass	✓		●		Thermal mass should be integrated if passive solar design is achievable.	CIBSE. Guide L – Sustainability. 2007
	Daylighting	✓	●			Flats must strive to provide sufficient daylighting, sunpipes could be utilised in areas that do not have an external wall. However this may be easier to achieve in low-rise flats as opposed to high-rise flats.	EST. CE257 – Daylighting in urban areas: a guide for designers
	Shading Systems	✓		●		Should be investigated to limit excessive solar gains especially if large south or west facing areas of glazing are incorporated into the design. Balconies could be designed to provide solar shading.	EST. CE129 – Reducing overheating: a designer's guide CIBSE TM37 - Designing for improved solar shading control (2006)
	Double Aspect and Duplex	✓		●		Developers should avoid single aspect apartments where possible and certainly apartments with only access to northlight. Double aspect and duplex apartments provide more efficient cross and stack ventilation and will improve summertime comfort.	
	Natural Ventilation	?	●			Must be incorporated, however if air tightness exceeds $3m^3/m^2/hr$@ 50 pa, mechanical ventilation with heat recovery should be investigated.	EST. CE124/GPG628 – Energy efficient ventilation in housing: A guide for specifiers on requirements & options
Energy Efficiency	Insulation	✓	●			Developers should always aim to exceed the minimum area-weighted Building Regulation Standards for thermal insulation.	EST. CE23 – Effective use of insulation in dwellings EST. CE71 – Insulation materials chart: thermal properties and environmental ratings
	Air Tightness	✓	●			Building Regulations ADL1A require a minimum air tightness of $10m^3/m^2/hr$@ 50 Pa, EST good practice of $5m^3/m^2/hr$@ 50 Pa, reducing further to $1m^3/m^2/hr$@ 50 will comply with passiv haus standards. Potential barrier to high air tightness is the risk of condensation. Air tightness in excess of $3m^3/m^2/hr$@ 50 Pa may need to incorporate mechanical ventilation.	EST. CE248 – Achieving air tightness in new dwellings
	Lighting & Controls	✓	●			A minimum of 70% dedicated low energy light fitting should be installed.	EST. CE80/ADH001 – Domestic lighting innovations EST. CE61 - Energy efficient lighting: guide for installers and specifiers EST. GIL20/CE188 – Low energy domestic lighting
	Heat Recovery	✓	●			Heat recovery should always be installed where the flats are ventilated mechanically.	EST. CE124/GPG628 – Energy efficient ventilation in housing: A guide for specifiers on requirements & options
	Building Management System (BMS)	?		●		A BMS could be considered for developments where a centrally managed system would be beneficial, such as social housing.	BSRIA. The effective BMS (2001)

Residential – Flats			Priority			.	Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Renewables and Low Carbon	District Heating	?		●		District Heating (DH) should be investigated for all blocks of flats. Possible barriers include the cost of the user interface especially if DHW is centralised. Larger blocks of flats could benefit from economies of scale increasing the viability of DH, and this issue should therefore be considered a priority in these circumstances.	EST. CE13 - Benefits of best practice: community heating EST. CE91 – Rural biomass community heating case study EST. CE55 – Community heating guide
	Combined Heat & Power (CHP)	?		●		CHP could be investigated in conjunction with district heating. The system would need sufficient space to accommodate a thermal store. CHP should be investigated especially if the flats are to be part of a mixed use development or at a site surrounded by existing buildings with high thermal energy demands. The feasibility of installing a district heating network is increased for developments with ground/basement level car parking as the costs of excavation for the distribution pipework is reduced. This issue should therefore be considered a priority in these circumstances	CIBSE – AM12 – Small-scale CHP in Buildings Combined Heat and Power Association - http://www.chpa.co.uk/
	Biomass	✓		●		Flats with clear access and sufficient space to incorporate a biomass store could integrate a biomass boiler to meet the heating and hot water demand. Biomass is compatible with DH, however potential barriers include issues with NOx and particulates emissions.	EST. CE69 – Renewable energy sources for homes in urban environments EST. CE70 – Renewable energy sources for homes in rural environments EST. CE91 – Rural biomass community heating case study
	Solar Thermal	✓	●			50% of a dwelling's hot water demand can typically be met by solar thermal, designers must ensure roofs are designed to optimise their solar aspect (45^{O} from south and 30^{O} pitch) and that over shading is avoided. Flats above 3 stories may need to consider an alternative hot water strategy as due to extended pipe runs. In large blocks where the roof space is insufficient to meet all of the flats hot water demand a solar thermal array size to pre heat a thermal store for a centralised scheme could also be investigated.	EST. CE131 – Solar water heating systems EST. GIR88 - Solar hot water systems in new housing : a monitoring report
	Solar Photovoltaics (PV)	✓		●		PV could be investigated to meet the demand for the communal elements of the flats, such as corridor lighting and lifts etc. Potential barriers for PV include the relatively high initial capital cost. As above, designers must ensure roofs are designed to optimise their solar aspect (45^{O} from south and 30^{O} pitch) and that over shading is avoided	CIBSE TM25 - Understanding building integrated photovoltaics (2000) DTI Photovoltaics in Buildings: A Design Guide
	Wind: building integrated	?				The performance of building integrated turbines (BITs) are very site specific and generally under perform due to turbulence associated with obstructions from buildings and trees. Large blocks of flats may be of a sufficient height to accommodate BITs although turbulence created by the building itself can limit performance.	EST. CE72 - Installing small wind-powered electricity generating systems British Wind Association. Best Practice Guidelines for Wind Energy Development
	Wind: stand alone	✓	●			Large to medium scale stand alone turbines should be encouraged especially in large developments in excess of 1000 dwellings.	PPS22 Renewable Energy British Wind Association. Best Practice Guidelines for Wind Energy Development

Residential – Flats			Priority			.	Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Renewables and Low Carbon	Ground Source Heat Pumps (GSHP)	?			●	GSHP could be investigated, though sufficient land availability may prevent to systems feasibility. Generally they offer little carbon benefit over a gas condensing boiler for space heating and should only be considered if there is no mains gas supply to the site. The cost of installing a ground loop or borehole system can also be prohibitive.	EST. GIR72 - Heat pumps in the UK – a monitoring report EST. CE82/GPG339 - Domestic ground source heat pumps: design and installation of closed loop systems
	Air Source Heat Pumps (ASHP)	?			●	ASHPs could provide a viable solution providing the electrical supply is from a renewable source (such as a large wind turbine), heat pumps provide a low grade heat therefore underfloor heating would also be recommended for the distribution system.	HVAC. TR30 - Heat Pumps: A good practice guide (2007)
	Waste to Energy	?		●		There is little an individual dwelling can do to provide waste to heat unless a collective scheme is incorporated. For developments in rural sites investigation into effluent systems that could process effluent sludge into methane to supply a CHP unit. Provision for organic waste storage and collection should also be included.	IEA Bioenergy. Biogas Upgrading and Utilisation
Water	Efficient Sanitaryware	✓	●			Flats should strive to reduce water consumption to at least 105 l/p/day through the installation of water efficient sanitaryware.	DCLG. Analysis of consultation responses for water efficiency in new buildings (2007)
	Rainwater Harvesting and Reuse	✓	●			Rainwater harvesting should be incorporated, storage tanks above or below ground tanks sized to meet the dwellings non potable uses with a minimum 14 day coverage would be advised.	UK Rainwater Harvesting Association (UKRHA) http://www.ukrha.org EA. Harvesting rainwater for domestic uses: an information guide (2003)
	Greywater Recycling	✓		●		Greywater recycling could be considered to collect the waste water from baths, showers and wash basins for reuse in WC flushing. Either individual or communal systems are available. Greywater recycling could be considered where rainwater is planned for reuse in landscape irrigation rather than internal use.	CIBSE. KS01 – Reclaimed Water
Drainage	Sustainable Drainage Systems (SUDS)	?		●		Flats should maximise permeable surfacing as opposed to hard surfacing especially for access roads and car parks. Community developments should investigate swales, trenches and holding ponds to deal with surface water run off.	CIRIA. C697 - The SUDS Guide (2007) BRE. Digest 365 – Soakaway design (1991)
	Green Roofs	✓	●			Flat roofs not supporting solar technologies should include green roofs. Intensive green roofs or walls should be investigated in built up urban areas where open green space is limited. Extensive roofs can be incorporated into most roof designs.	CIBSE. KS11 – Green Roofs BRE. Green roofs & facades (2006)
Materials	Green Guide Rating	✓	●			A+ - D Rated materials as stated in the Green Guide to Housing Specification should be sought where feasible.	BRE. Green Guide to Housing Specification
	Reclaimed	✓	●			Reclaimed materials, such as bricks, roof tiles and other materials from any existing buildings due for demolition, should be considered where suitable materials are available.	Waste and Resources Action Programme (WRAP) Reclaimed Products Building Guide Institute of Civil Engineers (ICE) Demolition Protocol

Residential – Flats			Priority			.	Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Materials	Locally Sourced	✓	●			Locally sourced materials should be considered first over imported materials. This would not only benefit the local economy, it would also help to preserve local character, as well as reducing the embodied energy associate with material transportation. Material sought and fabricated within a 30 mile radius would be encouraged.	
	Natural	?		●		Natural materials can readily be adopted into detached dwellings.	
	Timber	✓	●			Timber construction has the lowest embodied energy when compared to steel or concrete construction. Also timber is a renewable material providing plantations are well managed, whereas concrete, steel and masonry are finite. Timber should be sourced from a certified and legal sustainable source such as the Forest Stewardship Council (FSC).	GLTA. Glulam specifiers guide (2001) TRADA. Timber frame construction. 4th edition (2008) http://www.fsc.org/
	Materials with High Recycled Content	✓		●		Many standard construction products are available at no extra cost from alternative suppliers that use a high percentage of recycled materials in their manufacture. Ideally developers should seek to measure the % recycled content in their projects but as a minimum, they should audit their supply chains in an attempt to find suppliers with high recycled content products.	WRAP Choosing Construction Products
	Modern Methods of Construction	?		●		If a modern approach is to be taken, modern methods of construction could benefit especially if local industries are created to meet the demand. Local labour and materials should be given precedence.	CE139 Building energy efficient buildings and modern methods of construction. EST
Waste	Site Waste Management Plan	✓	●			SWMP's are mandatory for all projects over £300K. The minimum requirements should be exceeded to include commitments and procedures to sort and divert waste from landfill	EA. Guidance for waste destined for disposal in landfills. Version 2 (2006) DEFRA. Non-statutory guidance for site waste management plans (2008) NatRegs. A Simple Guide to SWMP. (2007)
	Reduction	✓	●			Developers should seek to reduce waste generated on site through good design and careful procurement' i.e. only ordering what you need. Prefabrication, room dimensions matching standard materials sizes etc can help to reduce waste.	WRAP. Achieving effective waste minimisation through design
	Recycling	✓	●			Ensure sufficient storage is provided both internally in the dwellings and externally, with appropriate separation.	http://www.wrap.org.uk/index.html
	Deconstruction	✓		●		Dwellings should be designed to be deconstructed and reused/recycled at the end of their useful life. Alternatively the buildings must be designed to provide flexile uses of occupancy, i.e. through the use of the Lifetime Homes standard.	Institute of Civil Engineers (ICE) Demolition Protocol

Residential – Flats			Priority			.	Further Information & Technical Guidance
		App.	High	Med	Low	Explanation	
Transport	Public Transport	✓	●			Developments that can integrate with existing public transport infrastructure should be encouraged. Those in rural sites should either provide safe pedestrian access to transport nodes where they exist. Where public transport is insufficient the developer should be encouraged to liaise with the relevant bus companies to increase capacity frequency or include a new stop on existing routes or provide a new service altogether.	TFL. Transport Assessment Best Practice; Guidance Document (2006.)
	Cycling Facilities	✓	●			Communal cycle storage should be provided in compliance with the CSH standards. For large rural sites cycle ways should be incorporated within the site linking up to existing cycle ways	Code for Sustainable Homes – Ene8 cycle storage. BRE Sustrans/cyclists' Public affairs group/CTC. Providing for cyclists - A code of practice (1997).
	Travel Plan	✓	●			A travel plan should be undertaken, ranging in detail depending on the scale of the development, and displayed in a common area or provided to each flat upon occupation.	BCO. A good practice guide to green travel plans. (2004) DfT. Transport Energy Best Practice : A Guide on Travel Plans for Developers (2005)

Non-Residential			Priority				Further Information & Technical Guidance
Category		App.	High	Med	Low	Explanation	
Passive Design	Orientation	✓	●			Orientation of the building should make optimal use of daylighting whilst minimising excessive solar gain during the summer months. High heat gain spaces such as offices and classrooms should be north facing whilst low heat gain spaces such as circulation, canteens and toilets should be south facing.	DFES. Schools for the future - design of sustainable schools (2006)
	Shelter Beds	✓		●		Shelter bed could be incorporated where sufficient land is available to limit heat loss from northerly winds.	
	Thermal Mass	?		●		Depending on the services strategy a construction incorporating high levels of thermal mass could be appropriate, this would usually be associated with night ventilation and heat recovery on an the AHU. This approach has demonstrated a low energy design such as the Innovate Green Office, Thorpe Park, Leeds. The massing (usually concrete) will need to be left exposed or rendered with an equally highly conductive material. Lightweight construction can also provide carbon savings therefore should not be discounted. Industrial buildings will tend to be lightweight highly insulated	CIBSE. Guide L – Sustainability (2007)
	Daylighting	✓	●			Good daylighting can greatly reduce a commercial/educational building's CO_2 emissions. Consideration should be given to minimising floor plate depth, providing floor-to-ceiling windows and sufficient glare control through occupant controllable blinds. For industrial, warehouse and distribution buildings the use of northlights and roof lights should be investigated. The level of daylighting must be optimised against excessive heat loss and/or heat gain that could lead to higher heating and cooling demands. Daylight modelling and thermal modelling should be undertaken to verify the optimal daylight balance.	MCRMA. Recommended good practice for daylighting in metal clad buildings (2004) BRE BR305 – Designing with innovative daylighting (1996)
	Shading Systems	✓	●			Shading systems, such brise soleil, should be designed to limit excessive solar gains especially for highly glazed facades. Any building provided with comfort cooling must have first demonstrated that shading alone is insufficient.	CIBSE TM37 - Designing for improved solar shading control (2006)
	Natural Ventilation	?		●		Natural ventilation may be incorporated, however mechanical ventilation or full air-conditioning will usually be specified for large offices especially if high internal heat gain is expected from high occupancy or electrical equipment such as IT. Natural ventilation should always be encouraged for educational buildings however mechanical ventilation with heat recovery can also be designed to be a low carbon solution. Industrial buildings could include a series of roof mounted turbine ventilators.	BSRIA. Making Natural Ventilation Work (2000)

Non-Residential			Priority				Further Information & Technical Guidance
Category		App.	High	Med	Low	Explanation	
Energy Efficiency	Insulation	✓	●			Developers should always aim to exceed the minimum area weighted Building Regulation Standards for thermal insulation. One exception to this rule would be for buildings with high internal gains, the thermal efficiency of the façade could be relaxed where comfort cooling is introduced.	EST. CE71 – Insulation materials chart: thermal properties and environmental ratings
	Air Tightness	✓	●			Most buildings, with the exception of those with extremely high internal gains such as dealer floors and retail spaces, will benefit from higher levels of air-tightness than stipulated under building regulations. The following best practice air-tightness standards (m^3/m^2/hour) should be aimed for: Factories, warehouses 2.00 Naturally ventilated office 3.50 Schools 3.00 Air-conditioned buildings 2.00 Retail stores, superstores 2.00 Museum and archival storage 1.25 Cold storage 0.40 Air tightness will again come down to the level of internal gains and the services strategy adopted.	CIBSE TM 23. Testing Buildings for Air Leakage BRE. Airtightness in commercial and public buildings BRE. Achieving airtightness: General principles GBG 67
	Lighting & Controls	✓	●			High efficiency fluorescent lighting should be installed with high frequency ballasts. Lighting controls would be expected to be included such as manually operated zoning control, daylight sensors connected to dimming ballasts, occupancy sensors for circulation spaces and toilets.	BRE BG498 – Selecting lighting controls (2006)
	Heat Recovery	✓		●		Heat recovery via a thermal wheel or cross-flow heat exchanger should always be installed where spaces are mechanically ventilated.	ASHRAE Handbook. SI - Heating ventilation and air conditioning applications (2007)
	Building Management System (BMS)	✓	●			A BMS would be recommended to monitor and control lighting, plant and equipment and provide real-time information on energy use. Systems should be simple to use with appropriate training given where relevant..	CIBSE. KS04 Knowledge Series: Controls BSRIA. The effective BMS (2001)
Renewables and Low Carbon	District Heating	?		●		District heating should be investigated especially for mixed use developments. New buildings should be encouraged to connect to existing energy networks where they pass close to the site.	
	Combined Heat and Power (CHP)	?		●		CHP should be investigated especially if the building is to be part of a mixed use development or on a site surrounded by existing buildings with high thermal energy demands. The feasibility of installing a district heating network is increased for developments with ground/basement level car parking as the cost of excavation for the distribution pipework is reduced. Existing buildings with a high, regular thermal demand could benefit from a district heating scheme, however the carbon benefit would need to be weighed against the cost of introducing a heat distribution network in an existing urban area.	CIBSE – AM12 – Small-scale CHP in Buildings Combined Heat and Power Association - http://www.chpa.co.uk/

Non-Residential			Priority				Further Information & Technical Guidance
Category		App.	High	Med	Low	Explanation	
Renewables and Low Carbon	Trigeneration	?		●		Buildings with a large continuous requirement for cooling may benefit from trigeneration where heat from a CHP plant is turned into cooling via an absorption chiller.	BSRIA. BG1 – The illustrated guide to renewable technologies. 2008
	Biomass	✓		●		Biomass boilers could be investigated for all non dwellings with sufficient storage space for the biomass fuel store. Delivery of fuel will require access to the site and to the fuel store. In practice this technology is best suited to edge of town or rural buildings.	BSRIA. BG1 – The illustrated guide to renewable technologies. 2008
	Solar Thermal	?		●		Solar thermal can be integrated into non-residential schemes however the hot water demand in many developments will generally be limited to hand washing therefore contributing to a relatively small carbon reduction for the total scheme. Nevertheless solar thermal can still contribute to a reduction in emissions and should be investigated. Designers must ensure roofs are designed optimise their solar aspect (45^{O} from south and 30^{O} pitch) and that over shading is avoided.	BSRIA. BG1 – The illustrated guide to renewable technologies. 2008
	Solar Photovoltaics (PV)	✓		●		PV could be well integrated into non-residential developments as electrical demand will match the generation supply, designers should optimise the solar aspect (45^{O} from south and 30^{O} pitch) and ensure over-shading is avoided. Although technically PV is well suited for applications in non dwellings, the high capital costs may be prohibitive. As a minimum, space should be provided on south-facing roofs and spare ways provided on switch boards for the future installation of PV when costs come down.	CIBSE TM25 - Understanding building integrated photovoltaics (2000) DTI Photovoltaics in Buildings: A Design Guide
	Wind: building integrated	?		●		The performance of building integrated turbines are very site specific and generally under perform due to turbulence associated with obstructions from buildings and trees. Unless sufficient height can be achieved these turbines should be viewed with caution. Providing the office/industrial development is significantly higher than local obstructions and the turbines can be located close to the south/western façade building integrated turbines could be feasible.	PPS22 Renewable Energy British Wind Association. Best Practice Guidelines for Wind Energy Development
	Wind: stand alone	✓	●			Large to medium scale stand alone turbines should be encouraged especially in large developments. Although wind turbines offer one of the most cost effective renewable energy solutions, barriers include the risk of rejection through the planning process and difficulty is siting large turbines. It is advisable to undertake an in-depth feasibility study early on in the process.	PPS22 Renewable Energy British Wind Association. Best Practice Guidelines for Wind Energy Development
	Ground Source Heat Pumps (GSHP)	✓			●	GSHP could be feasible if a balanced heating and cooling load has been identified for the development. Buildings with limited plant and roof space could benefit from this technology. Land availability will need to be investigated when sizing the system since it is most cost effective to place closed loop boreholes in landscaping away from the building. A vertical open-loop system could be adopted where land is limited however the cost of drilling the boreholes can be prohibitive.	BRISA. TN18 - Ground Source Heat Pumps. 1999.

Non-Residential			Priority				Further Information & Technical Guidance
Category		App.	High	Med	Low	Explanation	
Renewables and Low Carbon	Air Source Heat Pumps (ASHP)	✓			●	ASHP could be investigated for non – dwellings. The basic principles of an ASHP system is the same as for a GSHP although the system use the air as a source of energy rather than the ground and are generally quoted as having slightly lower coefficient of performance (CoP)	HVAC. TR30 - Heat Pumps: A good practice guide (2007)
	Waste to Energy	✓		●		Food production and/or food retail buildings could be incorporated into a district-wide waste to energy scheme. Storage of suitable waste and access for collection would need to be incorporated into the design. Also any industrial processes that incur a high amount of waste that could either go to incineration of bio digestion / anaerobic digestion should also be investigated.	IEA Bioenergy. Biogas Upgrading and Utilisation CIWM. Energy from Waste: A good practice guide (2003)
Water	Efficient Sanitaryware	✓	●			All buildings providing WC and washrooms should strive to reduce water consumption through the installation of water efficient sanitaryware.	CIRIA. Sustainable water management in schools (2007)
	Metering and Leak Detection	✓	●			To ensure water consumption can be monitored and managed a water meter with a pulsed output should be installed on the mains supply to each building. In addition, the development should consider installing a leak detection system capable of identifying major leaks both within the building and between the building and its site boundary.	CIBSE TM39 Building Energy Metering (2006)
	Rainwater Harvesting and Reuse	✓		●		Rainwater harvesting should be investigated, its feasibility will depend on the size of the roof collection area and available space for water storage tanks. Rainwater could be utilised for toilet flushing or irrigation.	BSRIA. Rainwater and greywater in buildings: project report and case studies (2001)
Drainage	Sustainable Drainage Systems (SUDS)	?	●			Permeable surfacing could be considered for access roads and footpaths. For larger developments, swales, trenches and holding ponds should be investigated to deal with surface water run off.	CIRIA. C697 - The SUDS Guide (2007)
	Green Roofs	?	●			Green roofs could help increase water attenuation for developments reducing stress on the storm water drainage system. Extensive green roofs are suitable for many expansive roofs with a low pitch. Intensive green roofs should be considered a priority in built up urban areas where open green space is limited.	CIBSE. KS11 – Green Roofs BRE. Green roofs & facades (2006)
Materials	Green Guide Rating	✓	●			A+ - D Rated materials as stated in the Green Guide to Housing Specification should be sought where feasible.	BRE. Green Guide to Housing Specification
	Reclaimed	✓	●			Reclaimed materials, such as bricks, roof tiles and other materials from any existing buildings due for demolition, should be considered where suitable materials are available.	Waste and Resources Action Programme (WRAP) Reclaimed Products Building Guide Institute of Civil Engineers (ICE) Demolition Protocol
	Locally Sourced	✓	●			Locally sourced materials should be considered first over imported materials. This would not only benefit the local economy, it would also help to preserve local character, as well as reducing the embodied energy associate with material transportation. Material sought and fabricated within a 30 mile radius would be encouraged.	I
	Natural	✓		●		Natural materials can readily be adopted into detached dwellings.	

Non-Residential			Priority				Further Information & Technical Guidance
Category		App.	High	Med	Low	Explanation	
Materials	Timber	✓	●			Timber construction has the lowest embodied energy when compared to steel or concrete construction. Also timber is a renewable material providing plantations are well managed, whereas concrete, steel and masonry are finite. Timber should be sourced from a certified and legal sustainable source such as the Forest Stewardship Council (FSC).	GLTA. Glulam specifiers guide (2001) TRADA. Timber frame construction. 4th edition (2008) http://www.fsc.org/
	Modern Methods of Construction	?		●		Although generally associated with dwellings MMC could be adopted for commercial premises on a scale envisaged within Northamptonshire.	WRAP. Choosing Construction Products BRE. Modern methods of construction (MMC) in housing: drivers and barriers to their use (2007) NHBCFOUNDATION. Guide to modern methods of construction (2006)
Waste	Site Waste Management Plan	✓	●			SWMP's are mandatory for all projects over £300K. The minimum requirements should be exceeded to include commitments and procedures to sort and divert waste from landfill	EA. Guidance for waste destined for disposal in landfills. Version 2 (2006) DEFRA. Non-statutory guidance for site waste management plans (2008) NatRegs. A Simple Guide to SWMP. (2007)
	Reduction	✓	●			Developers should seek to reduce waste generated on site through good design and careful procurement' i.e. only ordering what you need. Prefabrication, room dimensions matching standard materials sizes etc can help to reduce waste.	WRAP. Achieving effective waste minimisation through design
	Recycling	✓	●			Ensure sufficient storage is provided for storage of recyclable waste, with appropriate space and facilities for separation.	http://www.wrap.org.uk/index.html
	Deconstruction	?		●		Where feasible, buildings should be designed to be deconstructed and reused/recycled at the end of their useful life.	Institute of Civil Engineers (ICE) Demolition Protocol
Transport	Public Transport	✓	●			Developments that can integrate with existing public transport infrastructure should be encouraged. Those in rural sites should either provide safe pedestrian access to public transport nodes where they exist. Where public transport is insufficient the developer should be encouraged to liaise with the relevant bus companies to increase capacity frequency or include a new stop on existing routes or provide a new service altogether.	TFL. Transport Assessment Best Practice; Guidance Document (2006.)
	Cycling Facilities	✓	●			Cycle storage should be provided in compliance with BREEAM standards. Showering facilities and lockers should also be incorporated into the design.	Sustrans/cyclists' Public affairs group/CTC. Providing for cyclists - A code of practice (1997).
	Travel Plan	✓	●			A travel plan should be developed for the whole site for use by site users.	BCO. A good practice guide to green travel plans. (2004) DfT. Transport Energy Best Practice : A Guide on Travel Plans for Developers (2005)

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Appendix - B

Appendix B - Broad Principles for Site Suitability

Technology	Development		Broad principle for site suitability		
	Type	Scale	Key Site/Development Features for Suitability	Opportunities	Constraints
District Energy Networks	Urban Extension	Large	Green field sites Large brown field sites	Planned urban extensions or estates offer the least technically challenging situation for delivering the energy infrastructure Lower installation costs than in the existing urban fabric Potential revenue stream through metered heating and hotwater	New developments may not achieve the density necessary to provide a viable solution New energy efficient dwellings may have limited heat load, reducing the effective CO_2 reductions
	Existing Urban fabric	Large	Residential: Areas with hard to treat homes such as solid walled properties	Opportunity of significant CO_2 reductions Potential revenue stream through metered heating and hotwater	Providing the energy network may be technically difficult and financially prohibitive
	Existing Urban fabric	Large	Commercial: Inner city locations that could potentially offer both heating and cooling to commercial premises	Opportunity of significant CO_2 reductions, especially if heating and cooling is provided Meeting the demands of local authority buildings offer the greatest potential for getting schemes off the ground Potential revenue stream through metered heating and hotwater	Providing the energy network may be technically difficult and financially prohibitive Long contracts will be necessary to ensure the network is viable

	Flats >50 Houses >= 50 homes per hectare	Medium to Large	New blocks of flats or high density housing	Potential CO_2 savings On demand Heating and hot-water, through the inclusion of a hydraulic interface unit Potential revenue stream through metered heating and hotwater	Billing options can be complex and undesirable Requires a centralised energy centre New energy efficient dwellings may have limited heat load, reducing the effective CO_2 reductions
CHP	All developments with a large heating or cooling load	Large	District heating	Potential CO_2 savings Centralised energy centre	Provision would need to be made in the boiler room for the CHP engine Requires a constant heat demand to limit frequent starting of the engine
		medium	Mixed use developments Commercial developments (hotels, leisure centres, hospitals etc)	Potential CO_2 savings Centralised energy centre	Provision would need to be made in the boiler room for the CHP engine & thermal store Requires a constant heat demand to limit frequent starting of the engine Maintenance costs can be prohibitive
		Micro	Large Dwellings > 3 bedrooms & small commercial buildings	Potential CO_2 savings	Noise and vibration issues Maintenance costs can be prohibitive
Biomass	All developments with a relatively constant heat load	Medium to Large	Sites with good access for fuel deliveries by lorries	Potential high CO_2 savings Rural or out of town developments	Smoke control areas may limit the technologies available & a dispersion model may be necessary for planning. On-site fuel storage will be necessary Lorry access and frequency will need consideration. Boilers are less responsive than a traditional gas boiler.

		Micro	Ideally suited to residential and small commercial sites	Potential CO_2 savings Rural developments	Smoke control areas may limit the technologies available On-site fuel storage will be necessary Boilers are less responsive than a traditional gas boiler
Solar Thermal	All developments that have a hot water demand	All	Require un-shaded south facing aspect	CO_2 Savings Off grid applications	East & West facing aspects can work though at a reduced effectiveness Will only meet approximately 50% of the total hot water demand for a year, therefore requires a secondary
Solar PV	All	All	Require un-shaded south facing aspect	CO_2 Savings Long life guaranteed Low maintenance Off grid applications	Cost East & West facing aspects can work though at a reduced effectiveness
Wind Energy	All	Micro	High wind speeds Sites with low levels of turbulence are preferred Suitable position for mounting a mast either on the ground or building mounted	Potential CO_2 Savings Off grid applications Provide a visual statement of sustainability	Low wind speeds and turbulence reducing yield
	All	Large	High wind speeds Sites with low levels of turbulence are preferred	High CO_2 saving potential per £ invested Provide a visual statement of sustainability	Suitably positioned away from dwellings in existing estates Can offer a complex planning route

GSHP: Horizontal Loop	Manly used for dwellings or small commercial units with a heating load only	Small	Large vacant sites Best suited to rural sites off the gas grid	Lower excavation cost when compared to other GSHP configurations	Lower efficiencies than other GSHP configurations Requires large amounts of ground adjacent to the building. Often larger than building footprint itself.
GSHP: Vertical Closed Loop	All	Medium to large	Requires vacant land adjacent to site. Energy piles can reduce the amount of land necessary for the ground heat exchanger.	For best performance requires a balanced heating and cooling load It is possible to integrated into the structural piles of a building	Drilling costs can be prohibitive Existing services and underground structures will need to be considered Requires the ability to core drill
GSHP: Open Loop	All	Medium to large	Requires a water source to be present, such as: • Aquifer • Pond • River Requires the ability to core drill if exploiting an aquifer	Higher CoPs can generally be achieved than from a closed loop system	Drilling costs can be prohibitive Risk of not achieving designed flow rates from aquifer. Requires an extraction licence issued by the Environment Agency
Waste to energy	Non specific	Large - generally strategic scale	Best suited to compliment a district energy network.	Suitably positioned to avoid conflict with neighbouring properties.	Conflicts may arise from smoke, smells and high levels of deliveries from heavy goods vehicles.