Distributed Energy

Sustainability Guidance for North East Buildings

Association of North East Councils & One North East

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This report is a modification of an original report carried out by the Building Research Establishment (BRE), CP Energy and Narec in 2007. The original document was named "Simplified Guidance Supporting Major Developments to have Embedded Generation within them a proportion of On Site Generated Renewable Energy". The original work was commissioned by the Regional Development Agency One North East and the North East Assembly. This updated version was commissioned by the One North East and the Association of North East Councils (ANEC).

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Contents

Figures

Tables

1 Glossary of Terms

BER	-	Building Emissions Rate
BG&A	-	Bobby Gilbert and Associates
BRE	-	Building Research Establishment
BREEAM	-	Building Research Establishment Energy Assessment Methodology
CHP	-	Combined Heat and Power
CIBSE	-	Chartered Institute of Building Service Engineers
CSH	-	Code for Sustainable Homes
DECC	-	Department of Energy and Climate Change
DER	-	Dwelling Emissions Rate
EPC	-	Energy Performance Certificate
EU27	-	The 27 member states of the European Union
FCERM	-	Flood and coastal erosion risk management
NI	-	National Indicators
ONE	-	One North East
PV	-	Photovoltaic
RSS	-	Regional Spatial Strategy
SAP	-	Standard Assessment Procedure for the energy rating of dwellings
SBEM	-	Simplified Building Energy Model
SEAP	-	Sustainable Energy Action Plans
TER	-	Target Emissions Rate

2 Executive Summary

Climate Change, Fuel poverty and Energy Security are currently at the top of the political agenda. Anthropogenic climate change is now probably reaching a dangerous point (1)(2)(3)(2)(4), the recession and ensuing austerity measures have plunged many additional households into fuel poverty, and there is a mounting political necessity to increase the United Kingdom's energy security.

Against this backdrop, a raft of new legislation, international, national and local, has been introduced to reduce the energy demands within local authorities. With the change in government in the UK in 2010, policy again dramatically shifted, with a new perspective on planning, and removal of regional strategy.

This document was originally created by a collaboration of CP Energy, BRE (Building Research Establishment), and Narec (National Renewable Energy Centre). However, since then many factors, both regulatory and technological, have changed. Not least of these is the removal of the Regional Spatial Strategies, and with them regional renewable energy targets. Therefore it was felt that a dramatic rewrite was necessary. Due to these changes, Narec was employed by the Association of North East Councils (ANEC) and One North East (ONE) to update and improve the original.

Within this document, the policy requirements on local authorities are discussed, and exactly what is expected of Local Authorities (LA). This document is intended to ensure that planners have a full understanding of present legislation.

There are many examples of low carbon developments, both within and outside of the UK. This document looks at some of these, and demonstrates the possibilities that are open when planning new developments. Some of these, such as Groundwork's Reed Street in South Shields and Gentoo's Racecourse Estate in Houghton-le-Spring, Tyne and Wear, are within the North East of England and show exactly what an exemplar project is capable of achieving.

Additionally, a new version of the Carbon Mixer® North East 2.0 software has been developed. This software offers a common language for planners, architects and developers, showing both the financial and carbon cost of new developments, ensuring that initial rough cuts of the sustainability of new developments can be assessed quickly, and so all developments are compared on the same system. Bobby Gilbert & Associates were responsible for the original version of the Carbon Mixer®, and therefore created the updated version. A sister project has developed a schools version of the software, as part of the long term strategy of low carbon development pursued by One North East and Narec. Together, this document and the Carbon Mixer North® East 2.0 form the Microrenewables toolkit. The toolkit can be found at www.microrenewables-toolkit.info.

Using this document, and the associated Carbon Mixer® North East 2.0, it is hoped that the North East will be able to follow all the relevant legislation with regard to energy, and make the region a world class exemplar on how a low carbon society can be created.

3 Introduction

3.1 Background

The world is currently facing the triple threat of climate change, energy security and fuel poverty. In response to this, a raft of new legislation has been passed at both the European and National level; these have filtered down to local authorities in the forms of national indicators and planning policies.

This document provides support to development control officers and planners in local authorities in the North East in reaching decisions on planning applications within the context of the spatial planning regime that emanates from a variety of compulsory and voluntary schemes and polices. The original document focused on the (now discontinued) Regional Spatial Strategy. However, recent policy changes have given a different range of issues for planners. It is important to stress that there are a number of sustainability criteria new build and retrofit projects must follow, this document exists to aid planners with that.

Alongside this document a new version of the Carbon Mixer®, known as the Carbon Mixer® North East 2.0 has been developed in association with Bobby Gilbert & Associates. This software allows for quick educated decisions to be made on the penetration of renewable devices in a new, or retrofitted, development. The Carbon Mixer® North East 2.0 offers a common language for architects, planners and council officers, speeding up the planning process and allowing for intelligent discussions between planners and developers.

It is hoped that this document, and the Carbon Mixer® North East 2.0, will assist planners when faced with the new high levels of legislation with regard to sustainability, and hence ensure the North East will become an exemplar low carbon economy.

3.2 Structure of Report

This report first details the importance of various national and European policies against the background of Climate Change, Fuel Poverty and Energy Security. The impact of these policies on planners in the North East is considered, and how they are integrated.

The implementation guide, moving through the energy hierarchy from energy conservation to renewables, demonstrates the different renewable and low carbon technologies available to developers, and the scenarios in which they would be applicable. This is completed with a serious of flow charts, to illustrate the decision making process.

Following the implementation guide there are examples of various developments are provided, showing how it is possible to follow current legislation.

3.3 About Narec

Narec (National Renewable Energy Centre) was set up by One North East in 2002 to be a Centre

of Excellence for renewable technologies. Since then it has become recognised worldwide as the UK's national centre for the research, development, commercialisation and implementation of renewable and low carbon technologies. The organisation operates as a not for profit company, and is involved in all aspects of renewable and low carbon technologies. Narec has various facilities, including a high voltage testing lab, blade test facility capable of testing blades up to 70m long, wave test facility, tidal test facility, low voltage lab, photovoltaic R&D centre and two dry docks. In recent years the centre has used the strong R&D background to give firm and detailed advice on implementation of renewables, producing energy strategies for both single buildings and whole towns.

4 Climate Change

The Earth's climate is changing. In 2009 the levels of atmospheric CO_2 were higher than they have been for the past 650,000 years. Temperatures have been steady increasing for several decades, and through thermal expansion and melt water the sea level is now increasing, which is already threatening low lying countries such as Tuvalu. It is now estimated that the Arctic will become essentially ice free well within this century (5).

The science of climate change is now approximately 200 years old, although it is only within the past few decades that any action of the problem has occurred. In 1900 Nobel Prize winner Svante August Arrhenius made predictions as to what the effect of increased atmospheric CO_2 would be on global average temperatures (6). However, it was only during the 1980s that the science moved into the political spectrum.

By 2007 the Intergovernmental Panel on Climate Change (IPCC) gave a 95% certainty human activities are changing the climate (4). A vast international effort over 200 years has shown the current temperature variations could not be explained by natural cycles alone. According to leading climate scientists, immediate dramatic cuts in greenhouse gas emissions are necessary to avoid dangerous climate change.

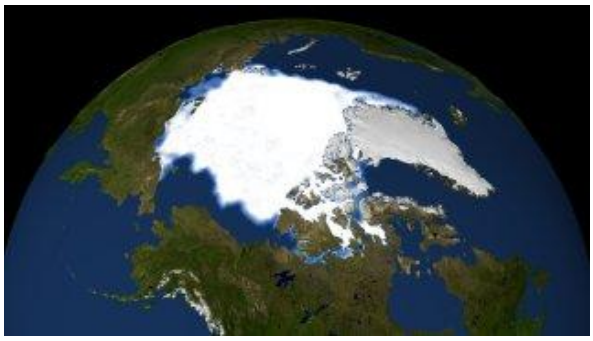

Figure 1: Arctic ice minimum, radar image, 1979 - image © NASA

It is now clear that as well as reducing effects of future climate change, the UK needs to adapt to climate change. For this reason the Adaption Sub-Committee has been formed, which is making plans as to how the UK will deal with increased flooding, heat waves, failing crops, and the other various issues associated with climate change. Additionally, local authorities must follow National Indicator 186 to make local plans for adaption.

Figure 2: Arctic ice minimum, radar image 2005 – image © NASA

In order to assist local authorities and the Adaption Sub Committee, Defra ran the UK Climate Projections project in association with the MET office. Their predications are based on the latest modelling of the Earth's climate, including anthropogenic interference, present day data and climatic feedback systems. It is however important to note that large feedback systems in the climate, such as the collapse of the Greenland ice sheet, or issues with the Gulf Stream are not included. Data can be found from ukcp09.defra.gov.uk.

5 Fuel Poverty

Fuel poverty is defined as "when 10% or more of a domestic household's available income is spent on heating". The most recent official figures from Defra are for 2007, in which it was estimated 2.8m households in England and were suffering from fuel poverty, and 586,000 households in Scotland (7). National Energy Action estimate there were 300,000 households in Wales suffering fuel poverty in the same year. To put this in perspective, there are 25m households in the UK in total. So this is a percentage of 15%.

Since 2007, the UK has suffered an unprecedented economic downturn, which will have exacerbated the fuel poverty issue. Even before the recession the numbers of households suffering was increasing. Unofficial estimates place current numbers much higher. In the North East it is estimated that just under 1 in 3 households now suffer from fuel poverty (8).

To put this in context, according to official figures there were 36,700 excess winter deaths reported in the UK for winter 2008/2009 (9).

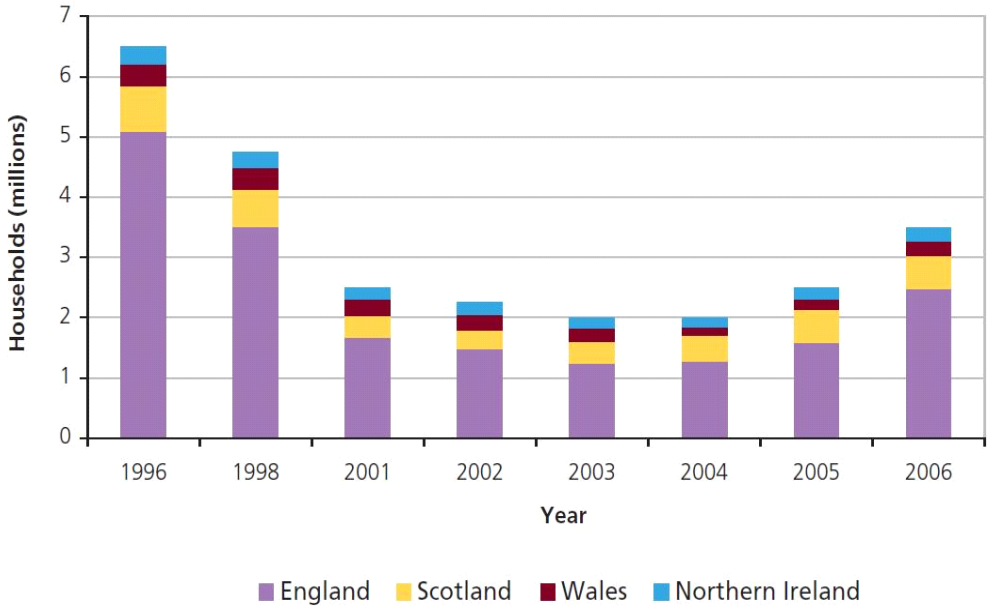

Figure 3: Fuel poverty figures for England and Wales in the period 1996 to 2006 - source: Defra

In order to save lives and alleviate suffering, Local Authorities must encourage the upgrading of poorly performing housing to ensure that the minimum of heating is required for a safe and comfortable domestic environment. As discussed later, National Indicator 187 deals with this issue, and hopefully will ensure the North East can improve the quality of life of the most vulnerable.

6 Energy Security

With regard to the national interest, there is growing concern over the energy independence of the UK. In 2008 the UK had an annual demand of 401TWh of electricity per year, of which 97% was produced in the UK and 3% imported from the European super-grid(10), and ~700TWh of heat. The UK relies on gas to provide electricity and heat more than any other primary energy source; in 2008 the UK imported around 25% of its natural gas. Projections suggest that by 2020 this could rise to around 60% as North Sea gas reserves decrease (11).

Looking to the future, global energy demand is forecast to increase by around 40% between 2007 and 2030(11). The UK will be forced to source gas from countries with which there is a less than strong relationship. The UK's nuclear base load (18% of UK electricity) will be decommissioned in 2020 (with the exception of Sizewell B which will run till 2035(12)). Issues between the Conservative and Liberal Democrat parties do mean there is some uncertainty over new nuclear build.

In the long term, lowering availability of oil and gas will impact of the UK's oil and gas powered power stations, thus meaning the UK will be more reliant on imported fuels, and further exposed to global energy price fluctuations

To summarise, the UK is no longer energy independent, and this will only become worse over the next hundred years. Therefore it is important that domestic methods of generating heat and electricity are found.

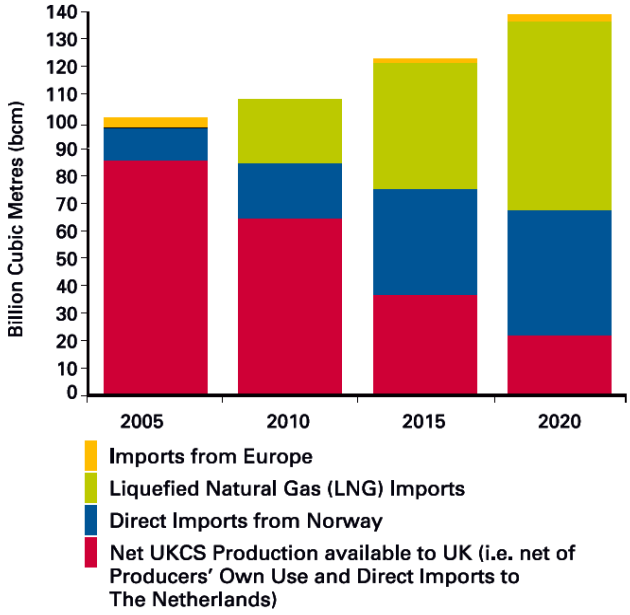

Figure 4: Predicted UK gas mix (11)

7 European Policy

This section details the background to this document and the requirements of various government planning and energy policies. It sets the regional planning strategy in the context of EU and UK legislation and provides examples of various UK districts which have taken action to follow these policies.

7.1 Targets

Within the European Union there are three major targets for the year 2020 – commonly referred to as the 20/20/20 target. These are the following;

- 20% European wide cut in emissions of greenhouse gases by 2020 compared with 1990 levels
- 20% increase in the share of renewables in the energy mix (heat, electricity and transport)
- 20% cut in energy consumption.

These aspirations affect all national policies within the EU27. The effects can be seen in the UK's Energy Bill, and the plans for zero carbon homes post 2016.

With regard to the EU wide target for 20% of all energy used (heat, electricity and transport) to originate from renewable sources by 2020, in the case of the UK 15% of all energy will come from renewables. To make up for this shortfall, other EU countries will generate over 20%. For example, Latvia will generate 42% of their energy from renewables in 2020.

In order for the UK to reach this 15% target, the energy breakdown will be (13):

- 35% of all electricity from renewables
- 10% of all transport energy from renewables
- 12% of all thermal energy from renewables

There are additional shorter term targets for member states of the EU. The Commission has an overall target of 12% of energy (and 22.1% of electricity) from renewables by 2010. The indicative target that the Directive sets for the UK was 10% of electricity from renewables by 2010, although clearly this was unsuccessful. The Commission monitors progress and proposes individual and mandatory national targets if needed.

The full EU27 targets for renewable energy by 2020 are set out below:

EU Member State	Actual 2006 Figure	2020 Target
Sweden	41.3%	49%
Latvia	31.4%	42%
Finland	28.9%	38%
Austria	25.1%	34%
Portugal	21.5%	31%
Denmark	17.2%	30%
Slovenia	15.5%	25%
Estonia	16.6%	25%
Romania	17.0%	24%
France	10.5%	23%
Lithuania	14.6%	23%
Spain	8.7%	20%
EU	9.2%	20%
Greece	7.1%	18%
Germany	7.8%	18%
Italy	6.3%	17%
Ireland	2.9%	16%
Bulgaria	8.9%	16%
United Kingdom	**1.5%**	**15%**
Poland	7.5%	15%
Netherlands	2.7%	14%
Slovakia	6.8%	14%
Belgium	2.6%	13%
Cyprus	2.7%	13%
Hungary	5.1%	13%
Czech republic	6.5%	13%
Luxembourg	1.0%	11%
Malta	0.0%	10%

Table 1: EU27 targets for 2020 compared withy 2006 actual renewable energy generation (14)

These targets build on the work from the European Commission White Paper(15) on Renewable Energy Sources and Green Paper on Energy Security of Supply (16) market.

7.2 EU Directive - The Energy Performance of Buildings

The EU Directive on the Energy Performance of Buildings(17) set requirements for improved energy efficiency and also requires consideration to be given to use of renewables, Combined Heat and Power, district heating or heat pumps for new buildings over 1,000m^2 floor area. The effects of this policy can be seen in the Code for Sustainable Homes, Planning Policy Statements and other national legislation as detailed in Chapter 14 on page 40. As this only informs the UK government on what policy must include, it is not necessary to go into detail here, rather those policies affected will be described. However, it is interesting to quote Article 5 – New buildings,

this states:

"For new buildings with a total useful floor area over 1 000 m^2, Member States shall ensure that the technical, environmental and economic feasibility of alternative systems such as:

- *decentralised energy supply systems based on renewable energy,*
- *CHP*
- *district or block heating or cooling, if available,*
- *heat pumps, under certain conditions,*

is considered and is taken into account before construction starts."

The full document can be downloaded from http://www.diag.org.uk and the vehicle for implementing this requirement is Part L of the Building Regulations (2010).

7.3 Covenant of Mayors

The Covenant is an EU wide project between 1843 local authorities to ensure councils reach beyond the targets set by the EU for carbon reductions, so greater than 20% for 2020.

In order to reduce emissions, councils are first expected to perform a CO_2 inventory of their area. They then must submit a Sustainable Energy Action Plan (SEAP) within one year of signing up, which is capable of hitting the targets of the Covenant. After this has gone through an iterative approval process, it must be implemented.

This is particularly relevant to the North East, as all the councils have signed up to this scheme. Therefore, the North East must exceed the 20/20/20 target on energy. Planners must therefore be aware that the city councils may expect them to go beyond UK local and national policies with regard to renewable energy in order to meet the requirements for the Covenant of Mayors. Planners should acquaint themselves with the Sustainable Energy Action Plan for their area to discover what relevance this have for themselves.

More information can be found at http://www.eumayors.eu.

7.3.1 VantagePoint

It is important to note that councils in the North East have been using the VantagePoint software to help with the development of the Sustainable Energy Action Plans (SEAP). This document does not advocate any specific commercial software purchases, however it is noted this appears to be the standard in the North East. The software essentially breaks up the SEAP into small targets. However, it is just that, targets. It breaks down the large problem of CO_2 reduction into many small problems, but it will still be necessary to do further work on a detailed energy masterplan and implementation plan.

8 UK Policy

8.1 Energy Act 2008

In the Energy Act 2008 the UK committed to a legally binding cut of 80% of CO_2 emissions by 2050 against 1990 levels. This is the third largest cut promised by any country, beaten only by the 100% commitment of Costa Rica for 2021 and the Maldives on a similar timescale. It should be stressed that the UK's promise is legally binding, and hence the largest legally binding percentage CO_2 cut in the world. This act is based on the targets and aspirations within the Energy White Paper 2007 and previous supporting documentation. The Act also established an independent body – the Climate Change Committee, to work with Government to reduce emissions over time and across the economy. It is the responsibility of the Climate Change Committee to show how the UK can reach the 80% target.

Additionally, the act created enabling powers to put in place new emissions reduction measures needed, and set out improved monitoring and reporting arrangements, including how the Government reports to Parliament.

8.2 Zero Carbon Homes

By 2016 all domestic new builds must be operationally zero carbon. Additionally, all new build commercial buildings must be opperationally zero carbon from 2019 onwards. It is important to note that this concerns the carbon footprint after build, and the "embedded carbon". Several houses following these standards are in existence, and the Groundworks Carbon Negative development in South Shields known as Reed Street) goes beyond these targets. An important consideration for planners in the North East is that any developer who claims current regional and national sustainability targets are too difficult to achieve, will have difficulty building anything legally post 2016. Therefore Narec do not recommend planners show any leniency on sustainability.

8.3 Planning and Energy Bill

The Bill, which received royal assent on the 13th November 2008, provides councils with the legal powers to force any developer to follow their own rules on renewable generation, as long as they are above government targets. These allow the local authority to specify "reasonable" requirements for developers including:

1. A proportion of energy used in development in their area to be energy from renewable sources in the locality of the development;
2. A proportion of energy used in development in their area to be low carbon energy from sources in the locality of the development;
3. Development in their area to comply with energy efficiency standards that exceed the energy requirements of building regulations.

8.4 National indicators

These have now been removed. National Indicators were a way in which various targets could be monitored on a local authority level, including targets on CO2 emissions, fuel poverty and adaption & mitigation of climate change.

So far nothing has been put in place to replace these.

8.5 Planning Policy Statement 1

This document is key to the Government's national policies for land use planning within England. Other polices exist for Scotland and Wales, but this is not relevant to North East planners. This document replaced *Planning Policy Guidance (PPG) Note 1, General Policies and Principles*, published in February 1997. This document looks at social and environmental impacts of good planning, and contains a number of options. With regard to sustainability there are recommendations to ensure optimum usage is made of available land, through using brown field sites, and high density of buildings. With regard to building materials it is recommended that developers make more efficient use or reuse of existing resources, this also applies to energy.

The document recommends the implementation of renewable and low carbon technologies. Community heating, combined heat and power and renewable energy are all recommended. Additionally, options such as car sharing and reducing freight are discussed.

8.6 Planning Policy Statement on distributed energy systems

On the 17th December 2007 the Government issued a PPS on Planning and Climate Change, which is a Supplement to PPS 1 Delivering Sustainable Development. Essentially this document commits Local Planning Authorities to set targets for renewable (and low carbon) technologies.

The full document can be downloaded from
http://www.communities.gov.uk/publications/planningandbuilding/ppsclimatechange.

8.6.1 Low Carbon/Renewable Technologies

PPS1 gives a number of instructions to planners. Importantly, there is the order that a certain amount of energy for a new development must come from renewable sources.

"Planning authorities should…set out a target percentage of the energy to be used in new development to come from decentralised and renewable or low-carbon energy sources where it is viable. The target should avoid prescription on technologies and be flexible in how carbon savings from local energy supplies are to be secured"

"[Planning authorities should] expect significant proportions of the energy supply of new development to be secured from decentralised and renewable or low-carbon energy sources"

In additional to regional targets set by planners, if it is felt there is greater possibility for a particular development to use renewable sources (such as if they are located on an old mine which could be used for water source heat pumps), then the planners can dictate a higher target. The document states that planners can;

(ii) "where there are particular and demonstrable opportunities for greater use of decentralised and renewable or low-carbon energy than the target percentage, bring forward development area or site-specific targets to secure this potential;
(iii) set out the type and size of development to which the target will be applied; and
(iv) ensure there is a clear rationale for the target and it is properly tested."

8.6.2 Existing Infrastructure

Possibly the most important part of this is that is gives developers instruction to ensure existing renewable and low carbon infrastructure are used by developers (be this private wire or district heating or some variant).

"In considering a development area or site-specific target, planning authorities should pay particular attention to opportunities for utilizing **existing decentralised and renewable or low-carbon energy supply systems** and to fostering the development of new opportunities to supply proposed and existing development. Such opportunities could include co-locating potential heat customers and heat suppliers. **Where there are existing decentralised energy supply systems, or firm proposals, planning authorities can expect proposed development to connect to an identified system, or be designed to be able to connect in future.** In such instances and in allocating land for development, planning authorities can set out how the proposed development would be expected to contribute to securing the decentralised energy supply system from which it would benefit."

This is particularly relevant for development land that is not provided with a connection to the natural gas grid (See sections 14.4, 14.10 and Table 12).

8.6.3 Sustainable Design

Within this document, it is not just basic aspects such as fabric loss, but the very design of the building which must be optimised to use as little energy as possible. This means developers in the North East must accurately pay attention to sustainable design principles. There is high concern that a number of new North East developments have shown a significant failing in the understanding of basic sustainability concepts.

"planning authorities should expect new development to:

– take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption, including maximising cooling and avoiding solar gain in the summer; and, overall, be planned so as to minimise carbon dioxide emissions through giving careful consideration to how all aspects of development form, together with the proposed density and mix of development, support opportunities for decentralised and renewable or low-carbon energy supply;

– deliver a high quality local environment;
– provide public and private open space as appropriate so that it offers accessible choice of shade and shelter, recognising the opportunities for flood storage, wildlife and people provided by multifunctional greenspaces;
– give priority to the use of sustainable drainage systems, paying attention to the potential contribution to be gained to water harvesting from impermeable surfaces and encourage layouts that accommodate waste water recycling;
– provide for sustainable waste management…"

8.6.4 Monitoring

It is important to stress that Local Planning Authorities are monitored on their performance against this document.

8.6.5 Summary

This document, if used correctly, gives planners the ability to force developers to go over and above national and regional targets for renewable energy. Additionally, control is given to planners for ensuring sustainable design principles are correctly followed, and that existing renewable and low carbon infrastructure is correctly used by any new development.

8.7 Planning Policy Statement 22 Renewable Energy

At a national level PPS 22 has set out a means of encouraging renewable energy supply and this is supported by a detailed and comprehensive guidance document. The core of PPS 22 is that, as stated in paragraph 18;

"Local planning authorities and developers should consider the opportunity for incorporating renewable energy projects in all new developments."

This guidance document includes detailed case studies showing the economic and environmental benefits of renewable energy. Ensuring that it is clear to planners what developers are already capable of producing.

PPS22 paragraph 8 legitimises the use of policies in Local Development Frameworks requiring a percentage of energy for new commercial, industrial or residential development to come from on site renewables.

The statement does specify that undue burden should not be placed on developers. However, it must also be stressed that in the light of the rules on zero carbon homes for 2016 and zero carbon commercial buildings for 2019, any developer intending to be legally allowed to build anything within the next decade must be capable of implementing highly energy efficient buildings with renewable energy generation.

A number of key principles run throughout the document.

- Renewable developments must be sustainable environmentally, socially and economically
- Local development documents must promote and encourage all renewable devices.
- A criteria must exist for assessing application for permission of renewable energy projects. These MUST NOT rule out the possibility of any particular renewable technologies.
- The wider environmental and economic benefits of all proposals for renewable projects must be given significant weight when deciding if to grant planning permission.
- Planning authorities must not make assumptions over the environmental, social, economic or technological feasibility of renewable systems, as technology may change so that particular sites become more suitable.
- Devices must not be rejected purely on the fact they generate a low level of power
- Community involvement should be encouraged in renewable energy projects. This should both promote knowledge and acceptance of renewable energy.
- Development proposals should discus the environmental, economic and social benefits as well as how negative impacts have been minimised.

Additional points in this document include:

- When assessing planning applications for wind turbines, local authorities should recognise these impacts may be temporary if conditions are attached to planning permissions which require the future decommissioning of turbines.
- For biomass projects, planning authorities should ensure that generation plants are located in as close proximity as possible to the sources of fuel that have been identified. However, considerations such as connections to the Grid and the potential to use heat generated from the project may influence the most suitable locations for such projects more than fuel source.

More information can be found at:
http://www.communities.gov.uk/publications/planningandbuilding/pps22.

8.7.1 PPS 22 Companion Guide

The government have supplied a companion guide to PPS 22, this provides advice on how planners can hit the policies in practical and economically viable ways. It is highly recommended that planners read this document.

More information can be found at:
http://www.communities.gov.uk/publications/planningandbuilding/planningrenewable.

8.8 Building Regulations Part L –Conservation of Fuel and Power

Part L of the building regulations sets requirements for energy efficiency. There are two parts to this, L1 deals with domestic building, whilst L2 deals with the non domestic sector(18). These deal with rules on air permeability, U-values, water, lighting, ventilation, and other major energy related issues with buildings. These have recently been substantially revised to require a 25% improvement over the 2006 edition, as is discussed later in this document in section 14.

8.9 Nottingham Declaration

The Nottingham Declaration was launched in October 2000. Since then over 300 English councils have signed up, including all North East councils and all Scottish and Welsh councils. The first council after Nottingham to sign up was the North Tyneside Metropolitan Borough Council.

By signing the Declaration councils and their partners pledge to systematically address the causes of climate change and to prepare their community for its impacts. The full version can be read in Appendix A - Nottingham Declaration.

To support the Nottingham Declaration, there exists the Nottingham Declaration Partnership. This is made up of Carbon Trust; Energy Saving Trust; Environment Agency; International Council for Local Environmental Initiatives; Improvement & Development Agency; Local Government Association; Nottingham City Council; and UK Climate Impacts Programme. This exists to assist councils in following their commitments.

8.10 Merton Rule

The Merton Rule is a planning policy, originally developed by Merton Council, which gives a defined level of renewable generation to be included in a development (This is usually 10%, however some local authorities have promised above this). Over the past few years the rule has been voluntarily taken on by numerous planning agencies. Councils can now force developers to follow this rule using the Planning and Energy Bill 2008.

8.11 Permitted development rights for small scale renewable and low carbon energy technologies, and electric vehicle charging infrastructure

This consultation closed on the 9th February 2009. The consultation deals with implementation of microrenewables and both domestic and commercial buildings. This deals with, on a domestic setting, wind turbines and air source heat pumps. On a commercial level it givers planning guidance on; wind turbines, air source heat pumps, ground source heat pumps, water source heat pumps, solar panels, flues for biomass systems and combined heat and power (CHP) systems, structures to house anaerobic digestion systems and biomass boilers, as well as structures to house hydro-turbines and structures to house hydro-turbines. The consultation is mainly concerned with the noise emitted by wind turbines and heat pumps and places importance on the Microrenewable Certification Scheme. There is discussion on the sizing and

appearance of vehicle charging points, which with One North East's current drive for electric vehicles, this is of particular importance to North East planners. The results of the previous government's consultation are now overdue, so planners should be aware of this forthcoming change.

8.11.1 Summary:

There is a raft of legislation available on renewable energy within new developments. Legally domestic new build will have to be operationally zero carbon by 2016, and commercial buildings by 2019. Additionally, the 2010 version of Part L of the Building Regulations requires a 25% improvement in carbon emissions over the previous 2006 version. Therefore any claims by developers that low carbon buildings are unfeasible must be questioned. Councils in the North East have signed up to the Nottingham Declaration, Merton Rule and Covenant of Mayors, as well as facing stringent National Indicator targets

9 UK Renewable Energy Incentive Schemes

9.1 Introduction

The previous government introduced several measures to ensure long term grants for renewable energy installations. Some of these, such as the Feed in Tariff, were based on the successful German model. The Renewable Heat Incentive is a more experimental grant, but should have a high impact. These tariffs are important for planners to understand, as they will influence the types of installations they are likely to deal with in the next few years.

9.2 Feed In Tariff

The UK Feed in Tariff is designed to give a financial incentive to homeowners and communities to install renewable technologies. It is very important to stress that despite its name, this is not a Feed in Tariff, it is in fact a generation tariff.

With the Feed in Tariff every kWh of electricity generated, be it used by the homeowner or exported to the grid, will result in a payment to the homeowner. The payment will come from the electricity companies, and not the government. Additionally, there is a small export tariff of 3p per kWh for exported electricity.

The table below details the financial incentives, which when added to the money saved on electricity bills becomes a very attractive financial package. The Feed in Tariff became operational in April 2010, and is available for all devices which have undertaken testing under the Microgeneration Certification Scheme. The feed in tariff will give money to a device for 20 years (25 for photovoltaics).

The financial return for each specific device will be constant, but a digression will apply to when the device was installed. For example, a wind turbine installed in 2010 will receive more money than one installed in 2015.

Technology	Rating	Proposed Tariff [£/kWh]			Tariff lifetime [years]
		Year 1: 1.04.10-31.03.11	Year 2: 1.04.11-31.02.12	Year 3: 1.04.12-31.03.12	
Anaerobic digestion	≤500kW	11.5	11.5	11.5	20
Anaerobic digestion	>500kW	9	9	9	20
Hydro	≤15 kW	19.9	19.9	19.9	20
Hydro	>15 - 100kW	17.8	17.8	17.8	20
Hydro	>100kW - 2MW	11.0	11.0	11.0	20
Hydro	>2kW - 5MW	4.5	4.5	4.5	20
MicroCHP pilot*	≤2 kW*	10*	10*	10*	10*
PV	≤4 kW (new build)	36.1	36.1	33.0	25
PV	≤4 kW (retrofit)	41.3	41.3	37.8	25
PV	>4-10kW	36.1	36.1	33.0	25
PV	>10 - 100kW	31.4	31.4	28.7	25
PV	>100kW - 5MW	29.3	29.3	26.8	25
PV	Standalone system	29.3	29.3	26.8	25
Wind	≤1.5kW	34.5	34.5	32.6	20
Wind	>1.5 - 15kW	26.7	26.7	25.5	20
Wind	>15 - 100kW	24.1	24.1	23.0	20
Wind	>100 - 500kW	18.8	18.8	18.8	20
Wind	>500kW - 1.5MW	9.4	9.4	9.4	20
Wind	>1.5MW - 5MW	4.5	4.5	4.5	20
Existing microgenerators transferred from the Renewables Obligation		9.0	9.0	9.0	to 2027

*NB This tariff is available only for 30,000 microCHP installations. A review will take place when 12,000 units have been installed.

Table 2: Feed in Tariff values

Evidently, the values given in the Feed in Tariff will affect those renewable devices chosen by developers. Also, the emergence of the feed in tariff may lead to the creation of small Energy Service Companies (ESCos). This has direct relevance to the Planning Policy Statement on distributed energy systems.

Renewable systems will receive a payment index linked to the tariff in the year of installation. Each year this will decrease for new installations, in order to encourage early take up of the technologies and also reflects the expected fall in the costs of installation.

9.2.1 Forthcoming Changes to Photovoltaic Tariffs

The rules on large photovoltaic systems were changed in 2011 by the coalition, in an attempt to prevent large solar farms from being subsidised. This means that the tariffs for systems over 50kWp in size will soon be slashed. It is not yet clear by how much.

9.2.2 Worked example

An energy conscious, private householder in Newcastle consumes 2600kWh of electricity per year. They pay 10p per kWh for their electricity and the annual bill is £260 per year.

The householders want to invest in a PV system to reduce CO_2 and generate some income. So they have a 1.76kWp PV system installed in February 2010. This will take up an area of approximately 1.5m^2.

The installation costs £8000
Annual PV yield = 1200kWh
Approximately half of the electricity they generate is used in the house and the other half is exported
Annual export = 600kWh

Figure 5: Typical detached house with a PV system

Therefore;
Income from FIT = Generation + Export + Saved

Generation	1200kWh * 41.3p	=£496
Export	600kWh * 3p	=£18
Saved	600kWh * 10p	=£60

Total income from PV system =£574

This gives:
Simple "payback" = 8000 / 573.60 = 14 years
Simple rate of return = 7 %

Compared with alternative investments the rate of return is favourable and the income is tax free, and guaranteed for 25 years. The profit after year 14 = 11 * £573.60 = £ 6310

With regard to CO_2 avoided = 17 tonnes over the system lifetime.

9.3 Renewable Heat Incentive

9.3.1 Introduction

The Renewable Heat Incentive was originally designed in 2010 to come into law in April 2011. However, the Coalition made significant changes which were announced in March 2011, with a revised start date for the scheme of June 2011. The scheme essentially will operate is a similar manner to the Feed in Tariff, with payments given for every kWh of heat generated (measured with a heat meter), based on the figures given in Table 3. The major difference to the Feed in Tariff is that the RHI will be funded by central government as opposed to energy providers.

9.3.2 Phases

The scheme is designed to incentivise the use of low carbon technologies which generate heat, and is divided into two distinct phases.

Phase 1: This phase is intended for non domestic installations of renewable heat systems. By non-domestic the government means industrial and the commercial sector; the public sector; not-for-profit organisations and communities in England, Scotland and Wales. The incentives paid per kWh are given in Table 3.

Additionally, a scheme known as the Renewable Heat Premium Payment will be run, starting in June 2011. This is to give a payment to domestic installations of renewable heat systems, on the condition that these will be monitored to help inform phase 2 of the scheme. There are currently few details on the Renewable Heat Premium Payment, but they should be released in May 2011. This scheme will probably result in few installations, as there is only £15m allocated across the whole UK to fund it.

Phase 2: This will begin in June 2012 and will extend the Renewable Heat Incentive to the domestic sector. The details of this have not yet been released.

Levels of Support					
Tariff name	**Eligible technology**	**Eligible Size**	**Tariff rate [£/kWh]**	**Tariff Duration [years]**	**Support Calculations**
Small Biomass	solid biomass, municipal solid waste (incl. CHP)	<200kW$_{th}$	Tier 1: 0.076	20	Metering Tier 1 applies annually up to the Tier Break, Tier 2 above the Tier Break. The Tier Break is: installed capacity x 1,314 peak load hours, i.e.: kW$_{th}$ x 1,314
			Tier 2: 0.019		
Medium Biomass		≥200kW$_{th}$ and <1000kW$_{th}$	Tier 1: 0.047		
		≥1000kW$_{th}$	Tier 2: 0.019		
Large biomass			0.026		Metering
Small ground source	ground source heat pumps, water source heat pumps, deep geothermal	<100 kW$_{th}$	0.043	20	Metering
large ground source		≥100 kW$_{th}$	0.03		
solar thermal	solar thermal	<200 kW$_{th}$	0.085	20	Metering
biomethane	biomethane injection and biogas combustion, except from landfill gas	Biomethane all scales, biogas combustion < 200kW$_{th}$	0.065	20	Metering

Table 3: Renewable Heat Incentive Phase 1

9.3.3 Certification

All biomass, ground and water source heat pumps and solar thermal plants of 45kWth capacity or less, will need to be certified under the Microgeneration Certification Scheme (MCS) or equivalent schemes. This means that *both* the technology and the company or person installing it will need to be certified under the MCS scheme or equivalent. When applying for support, applicants will be asked for details of MCS or equivalent certification.

9.4 Renewables Obligation

The Renewables Obligation (RO) was introduced in April 2002, and is a requirement that electricity producers source a certain percentage of their electricity from renewable sources. This percentage is increasing up to 15.4% for 2015/2016, which it will then remain at until 2027. The levels on a yearly basis are given in Table 4, which are as set out in the Renewables Obligation Order.

Electricity generators receive 1 (or more) Renewable Energy Certificate (ROC) for each 1MWh of renewable energy they generate, which then become tradable credits. If a supplier does not reach the legal requirement for the Renewable Obligation, and they cannot buy ROCs from an overproducing supplier to make up the short fall, they must make "buy-out" payments. The system is set so it is financially a better option to generate renewable electricity, or buy ROC's from another electricity generator, than pay the "buy out" payment. With respect to energy from waste, the possible fuels to use under the renewables obligation are given in Table 5. The number of ROCs per MWh is not constant, and depends on the technologies used to generate the electricity. These are summarised in Table 6.

Currently the electricity industry is not keeping pace with the RO, for example at the end of 2007, eligible electricity generation from renewable sources only stood at 4.9% as opposed to 6.7%.

Obligation period	**Percentage of total supplies**
1st April 2006 to 31st March 2007	6.7
1st April 2007 to 31st March 2008	7.9
1st April 2008 to 31st March 2009	9.1
1st April 2009 to 31st March 2010	9.7
1st April 2010 to 31st March 2011	10.4
1st April 2011 to 31st March 2012	11.4
1st April 2012 to 31st March 2013	12.4
1st April 2013 to 31st March 2014	13.4
1st April 2014 to 31st March 2015	14.4
1st April 2015 to 31st March 2016	15.4
Each subsequent period of twelve months ending with the period of twelve months ending on 31st March 2027	15.4

Table 4: Renewables Obligation percentage variation over time

Type of Generating station	Mixed waste	Waste that is purely biomass	Energy crops, agricultural waste and forestry material
Incineration	Ineligible	Eligible [1]	Eligible [1]
Pyrolysis, gasification and anaerobic digestion	Eligible for the biomass fraction of waste	Eligible [1]	Eligible [1]
Combined Heat and Power (CHP)	Eligible for the biomass fraction of waste produced as good quality CHP [2]	Eligible [1]	Eligible [1]
Co-firing	Ineligible	Eligible [1] (There are no restrictions on the amount of co-firing a generator can undertake. However, suppliers can only meet 10% of their obligation from co-fired ROCs.)	Eligible [1]

Table 5: Available energy from waste options within the Renewables Obligation

[1] Subject to a maximum fossil-derived energy content of 10%.

[2] CHP stations must be accredited under the CHP Quality Assurance scheme to be eligible. For schemes that are fully compliant with the Good Quality benchmark, they receive ROCs on the electricity generated from the biomass fraction of the waste. For schemes that are partially compliant, this is scaled back depending on their efficiency.

Generation Types	No. MWh per ROC
Electricity generated from landfill gas	4
Electricity generated from sewage gas	2
Co-firing of biomass	2
Other	1
Electricity generated from landfill gas (Northern Ireland)	1
Onshore wind	1
Hydro-electric	1
Co-firing of energy crops	1
Energy from waste with CHP	1
Geopressure	1
Co-firing of biomass with CHP	1
Standard gasification	1
Standard pyrolysis	1
Offshore wind	2/3
Dedicated biomass	2/3
Co-firing of energy crops with CHP	2/3
Wave	1/2
Tidal-stream	1/2
Advanced gasification	1/2
Advanced pyrolysis	1/2
Anaerobic digestion	1/2
Dedicated energy crops	1/2
Dedicated biomass with CHP	1/2
Dedicated energy crops with CHP	1/2
Solar photovoltaic	1/2
Geothermal	1/2
Tidal impoundment – tidal barrage	1/2
Tidal impoundment – tidal lagoon	1/2
Enhanced wave (Scotland only)	1/3
Enhanced tidal stream (Scotland Only)	1/5

Table 6: ROCs for different technologies

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10 Knowledge Hubs and Resources

10.1 Zero Carbon Hub

The Zero Carbon Hub is a governmental organisation set up to facilitate the development of policy for Zero Carbon buildings. The organisation's website contains detailed information on example zero carbon developments and regularly leads on consultations for new low carbon legislation.

http://www.zerocarbonhub.org

10.2 Renewable Energy without the Hot Air

This book is a free downloadable resource on sustainable energy. It is written by Professor David MacKay of the University of Cambridge, who now works as the Department of Energy and Climate Change's chief scientific advisor. It is recognised as a detailed and accurate reference on low carbon and renewable technologies.

http://www.withouthotair.com

10.3 London Renewables Toolkit

The London Renewables Toolkit is a similar document to the one you are reading. The London document is several years older and so unfortunately some parts will now be out of date; however it is still a very useful resource on renewable energy. The document is focused on London, as opposed to this which is focused on North East England.

http://static.london.gov.uk/mayor/environment/energy/docs/renewables_toolkit.pdf

10.4 Renewables Network

Renewables Network is a One North East funded project carried out by Narec. The objectives are:

1. Provide support to existing businesses looking to diversify into low carbon technologies.
2. Inward investment: attract energy sector businesses to set up in the region.
3. Provide support to businesses in addressing the issues of climate change.
4. Support organisations looking to implement distributed site solutions.
5. Provide information on market intelligence and horizon scanning to organisations.
6. Provide a central resource to enhance both the profile of and the opportunities of low carbon projects.

www.renewables-network.co.uk

10.5 Community Energy Online

An online resource developed by the Department for Energy and Climate Change which includes information on technologies, funding and regulations for the implementation of low carbon technologies.

This has been put together by the following organisations:

- BRE
- The Carbon Trust
- Department of Communities and Local Government
- Community Heat and Power Association
- Department of Environment, Food and Rural Affairs
- UK Information Portal for Decentralised Energy
- Energy Saving Trust
- Homes and Community Agency
- National Energy Foundation
- Renewable Energy Association

http://ceo.decc.gov.uk

11 Local Development Frameworks

Local Development Frameworks (LDFs) are a folder of local development documents prepared by district councils, unitary authorities or national park authorities that outline the spatial planning strategy for a local area.

The Local Development Frameworks are split into the following sections:

- Statement of community involvement
- Annual monitoring report
- Local development scheme (LDS)
- Supplementary planning documents (SPD)
- Local development orders and simplified planning zones (LDO & SPZ)
- Development plan documents (DPD)
    - Core Strategy
    - Adopted Proposals Map
    - Area Action Plans
    - Other Development Plan Documents

This section of the Sustainability Guide will give a rough overview of how some local authorities have used the Local Development Frameworks to push sustainability in their local area. Specifically, the sustainability sections are held within the Supplementary Planning Documents. However, a large number of these as yet have not been adopted. It is worth noting that due to the Coalition government's recent decisions on Regional Spatial Strategies, a number of consultations of Local Development Frameworks are currently on hold indefinitely.

The following Supplementary Planning Documents on sustainability have been adopted by Spring 2010(19)

Ashford Borough Council	Sustainable Design and Construction SPD, DRAFT Sustainable Urban Drainage Systems (SUDS) SPD, DRAFT Green Spaces and Water Environment SPD,
Bedford Borough Council	Climate Change and Pollution SPD
Chelmsford Borough Council	Sustainable Development SPD
Reading Borough Council	Sustainable Design and Construction SPD
Hinckley & Bosworth Borough Council	Sustainable Design SPD

South Tyneside	Sustainable Construction and Development SPD
Redbridge LB	Sustainable Design & Construction SPG (adopted 2005), Nature Conservation SPD, Trees and Landscaping SPD
Sutton London Borough	Interim Planning Guidance or IPG on 'Sustainable Design and Construction' which was adopted in May 2008
Swindon Borough Council	Sustainable Design and Construction SPD
Wokingham Borough Council	Sustainable Construction in preparation
North York Moors National Park Authority	Renewable Energy SPD
Plymouth City Council	Sustainable Design - SPD
Sheffield City Council	
Poole Borough	
Newcastle-under-Lyme Borough Council	
Harrogate Borough Council (North Yorkshire County Council)	Open Space in New Housing Development SPD (2007)
Milton Keynes	Sustainable Construction SPD
City of London Corporation	
Brent LB	Design, Construction & Pollution Control (adopted April 2003) SPG
Lincoln City Council	SPG Green Design in Planning
North Kesteven District Council	none found, Gillian's list said Sustainable Design SPD and Renewable Energy SPD
Kettering Borough Council	The Sustainable Design SPD is intended to provide guidance on policies within the North Northamptonshire Core Spatial Strategy
Brighton and Hove City Council	Sustainable Building Design SPD
Camden (London Borough of)	Camden Planning Guidance
Cheshire West and Chester	DRAFT Designing for Energy Efficiency - Renewable Energy SPD
Crawley BC	Sustainable Design SPG
Cumbria County Council	Onshore Wind Energy SPD

Hammersmith and Fulham London Borough	Sustainable Construction and the Recycling of Building Materials SPD Energy SPD, DRAFT Water Management (including SuDS) in New Development SPD
Guildford Borough Council	Sustainable Development and Construction SPD (also has a checklist)
Mid Sussex District Council	Sustainable Construction SPD
Oxford	Natural Resource Impact Analysis SPD
Richmond LB	Sustainable Construction Checklist SPD
Southampton	Environmentally Sustainable Design SPD in Spring 2010

Additionally, the following are currently not adopted:

Barnet Borough Council	Sustainable Design and Construction SPD
Basingstoke and Deane	Design and Sustainability SPD
Bexley (London Borough of)	Sustainable Design and Construction SPD
Bolton Metropolitan Borough Council	Sustainable Design and Construction SPD
Cambridge County Council	Sustainable Design and Construction SPD
Cherwell District Council	Building in Harmony with the Environment SPD (not adopted yet)
Chesterfield	Sustainable Design SPD
Chorley Borough Council	Sustainable Resources SPD
Eastleigh Borough Council	Environmentally Sustainable SPD and SPD on Storage and Collection of Domestic Waste and Recycleable Materials
Leeds City Council	DRAFT Sustainable Design and Construction SPD
North East Derbyshire District Council	Draft Climate Change SPD and Draft Climate Change and Renewable Energy SPD
North Devon	Onsite Renewable Technologies SPD and Sustainable Design and Construction SPD
North Tyneside	Sustainable development SPD
Oldham	Renewable Energy SPD
Preston City Council	Draft Energy Efficiency and Renewables SPD

Restormel BC (now Cornwall)	Sustainable Design and Construction SPD
Rochdale Metropolitan Borough Council	Energy and New Development SPD
Rugby	Sustainable Design and Construction SPD
Rushmoor Borough Council	Sustainable Design and Construction SPD
Salford City Council	Salford Greenspace Strategy, Trees and Development SPD, Sustainable Design and Construction SPD
Sefton MBC	Green Space, Trees and Development SPD
Solihull MBC	Vehicle Parking and Green Travel Plans SPD (2006)
Southwark Borough Council	Sustainable Design and Construction SPD
St Helens Borough Council	Carbon Renewables (Draft) SPD and Trees and Development SPD
Stockport MBC	Sustainable Design & Construction SPD
Stratford Upon Avon	Achieving Sustainable Low Carbon Buildings SPD
Tameside Metropolitan Borough Council	Sustainable Design and Construction SPD
Taunton Deane Borough Council	
Three Rivers District Council	Sustainable Communities SPD (2007)
Warwick District Council	Sustainable Buildings SPD
West Dorset	Design and Sustainability Development Planning Guidelines
Windsor and Maidenhead (Royal Borough of)	Sustainable Design and Construction SPD
Wolverham Council	Planning for Sustainable Communities SPD - Adopted
Worcester Council	Contributions to Sustainable Travel SPD, Water Management SPD, Biodiversity and Trees

11.1.1 South West

The South West Low Carbon Housing and Fuel Poverty Strategy and Action Plan (SWCCAP) looks at integrating the twin domestic sector priorities of low carbon housing and fuel poverty alleviation. This action plan includes reference to the incorporation of both energy efficiency measures and embedded generation technologies in housing. More information can be found at

http://www.oursouthwest.com/lowcarbon.

11.1.2 Uttlesford District Council

Uttlesford District Council introduced a Supplementary Planning Document (SPD) to mitigate the greater use of energy resulting from the provision of house extensions. The SPD applies to households when an application for planning permission for an extension is submitted. The guidance was the first of its kind in the UK and will require energy efficiency measures such as loft and cavity wall insulation, draft stopping and improved heating controls to be installed where appropriate and practical.

Supplementary Planning Document – Home Extensions

"The Council will require simple, cost effective energy efficiency measures to be carried out on the existing house if possible and practical. These measures could include upgrading loft insulation, insulating cavity walls, improving draught proofing, improving heating controls, installation of reflective panels behind radiators, installation of low energy lighting or upgrading the boiler. As part of your application you will be expected to complete and submit a home energy assessment form. This will be provided with your application form. The Council will notify you of the cost-effective measures that may reasonably be included as conditions of your planning permission (if it is granted) and provide information on where to go to get the work carried out."

11.1.3 The London Plan

For authorities within London, such as the Borough of Hammersmith and Fulham or Croydon, the Supplementary Planning Document uses the policies on energy contained in the London Plan (consolidated with alterations since 2004), as published in February 2008. This covers the following subjects:

- 4A.4 Energy assessment
- 4A.5 Provision of heating and cooling networks
- 4A.6 Decentralised Energy: Heating, Cooling and Power
- 4A.7 Renewable Energy
- 4A.8 Hydrogen Economy
- 4A.9 Adaptation to Climate Change
- 4A.10 Overheating
- 4A.11 Living Roofs and Walls

One particularly interesting point is that it requires all new developments to have 20% renewable energy unless it can be demonstrated that such provision is not feasible[1]. Also, for

[1] Although if the developer is not capable of hitting this target, it is unlikely they would be capable of

heating and cooling, new developments should evaluate possible solutions in the following order:

1. Connection to existing CCHP/CHP distribution networks
2. Site-wide CCHP/CHP powered by renewable energy
3. Gas-fired CCHP/CHP or hydrogen fuel cells, both accompanied by renewables
4. Communal heating and cooling fuelled by renewable sources of energy
5. Gas fired communal heating and cooling.

Another interesting point within the London Plan is the requirement for large developments to have living roofs and walls where feasible. These are walls and roofs where vegetation is partially or completely covering the outside on top of a waterproofing membrane.

Full information can be found at:
http://www.london.gov.uk/thelondonplan/climate/sustainable_energy.jsp

11.1.4 Oxford City Council

In 2006 Oxford City adopted a Supplementary Planning Document on natural resource impact analysis (NRIA) (20). The guidance addresses sustainable energy within the broader context of sustainable construction and covers:

- Energy efficiency.
- Renewable energy.
- Choice of materials and embodied energy.
- Recycled materials.
- Water resources.

The document is intended to ensure Oxford plays a part in the target for 2026 of the South East producing 16% of its electricity from renewable energy. Unlike other regions which have a set percentage of renewable energy from new developments, this has a checklist which sets the required percentage to be produced from on-site renewables and low carbon technologies. Within this checklist a score of at least 6 must be achieved and all the minimum targets must be hit. This is reproduced below in Table 7. Information on SAP and SBEM can be found in section 14.

building anything legal post 2016. Therefore planners should be very dubious of any claims this is unfeasible.

			Minimum standard		Preferred standard		Target standard		Score achieved
Energy efficiency	C1	**Residential uses:** What is the SAP rating? (See table 1)	SAP "good" (GS1)	1 pt	SAP "best" (BS1)	2 pts	SAP "advanced" (AS1)	3 pts	
		Non-residential uses: Under criterion 1 of SBEM: what is the relationship of the Building Emissions Rating (BER) to the Target Emissions Rating (TER)?	BER = TER	1 pt	BER is 2% better than TER	2 pts	BER is 5% better than TER	3 pts	
Renewable energy	C2	What percentage of energy requirements will be produced by on-site renewables?	20%	1 pt	30%	2 pts	40%	3 pts	
Materials	C3	What score is achieved in table 2?	4	1 pt	5-7	2 pts	8-11	3 pts	
Water resources	C4	What score is achieved in table 3?	1	1 pt	2	2 pts			
								Total checklist score:	/11

Table 7: Oxford NRIA Checklist

11.1.5 The London Borough of Merton

The London Borough of Merton was the first authority to adopt planning policies requiring all new commercial developments to incorporate renewable energy supply. A requirement for 10% of predicted energy requirements to be met on-site was set. (Merton Unitary Development Plan, October 2003). Merton also follows the London Plan as detailed earlier, which has replaced substantial parts of their Unitary Development Plan.

Policy E.11: Environmental Improvements from Employment Development

"to achieve environmental benefits, employment developments will be expected to be of a high quality and layout. All new industrial, warehousing, office and live/work units outside Conservation Areas and above a threshold of 1,000m^2 will be expected to incorporate renewable energy equipment to provide at least 10% of predicted energy requirements…"

Policy PE 13: Energy Efficiency Design and Use of Materials

"The Council will encourage the energy efficient design of buildings and their layout and orientation on site. All new non-residential development above a threshold of 1,000m^2 will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. The use of sustainable building materials and the re-use of materials will also be encouraged, as will the use of recycled aggregates in the construction of buildings. This will be subject to the impact on the amenity of the local environment, taking into account the existing character of the area."

Over 100 other local authorities are following Merton's lead.

11.1.6 Milton Keynes Council

The Milton Keynes Core Strategy, released in 2010, contains policy C14 which deals with Sustainable buildings. According to this, developments of over 5 dwellings or 1,000 sq m of non-residential floorspace will be expected to achieve at least the following standards unless not

technically or financial viable;

	Area	Older Town Centres	City estates, including CMK	Strategic Development Areas	Rural Area	Conversion or alteration of existing buildings
A	**Code for Sustainable Homes**	Code Level 4	Code Level 4	Code Level 4	Code Level 4	EcoHomes Very Good
	BREEAM	Very good	Excellent	Excellent	Very good	Very good
B	**Minimum carbon dioxide reduction through renewable energy and/or low carbon technologies**					
		10%	20%	20%	10%	10%

Table 8: Milton Keynes Core Strategy requirements for buildings

Additionally, all new development exceeding 5 dwellings (in the case of residential development) or incorporating gross floor space in excess of 1000 sq m will be required to make a contribution into the Milton Keynes Carbon Offset Fund.

The Milton Keynes Core Strategy requires the following for large housing developments:

- For developments of more than 100 homes, applications should show that the potential for community energy networks has been explored
- For development of more than 200 homes, applications will require community energy networks, unless it can be proven that this is not feasible on technical or economic grounds
- Regardless of the number of homes in a proposal, where an existing local energy network is established, developments will be expected to connect to the network, if feasible

Supporting guidance on how Policy CS 14 will be delivered and managed will be set out in a revised Sustainable Construction SPD, which at the time of writing this document was unpublished (21).

11.1.7 Barnsley Metropolitan Borough Council

Barnsley is far ahead of government targets. By 2008 the council had on their own estate reduced it's CO_2 emissions by 40% on 1990 levels, and by 2015 are expected to have reached the 80% emission cut on 1990. The carbon reduction policies began in 1986 where, as with Woking, they began with a range of energy efficiency measures, such as under floor heating. After which, they looked to the opportunities of biomass. Using only locally grown woodchip, the majority of coal boilers in the municipal buildings have been converted to biomass.

Barnsley has the following policy on renewable energy in new build:

CSP 5 Including Renewable Energy in Developments

"All development (either new build or conversion) of 10 or more dwellings or 1000m^2 of non-residential floorspace will be expected to incorporate decentralised, renewable or low carbon energy sources sufficient to reduce the development's carbon dioxide emissions by at least 15% for applications submitted up to 2015 rising to 20% for applications submitted thereafter.
Where it is not appropriate to incorporate such provisions within the development, an off site scheme, or contribution to such may be acceptable "

11.1.8 Ashford Borough Council

The major policy for sustainability in the built environment within Ashford is C10, which has changed slightly since the last version of this guidance document (22).

POLICY CS10: Sustainable Design and Construction

All major developments (as defined in paragraphs 9.57 and 9.58) must incorporate sustainable design features to reduce the consumption of natural resources and to help deliver the aim of zero carbon growth in Ashford.

Unless it can be demonstrated that doing so is not technologically practicable, would make the scheme unviable or impose excessive costs on occupiers, developments are expected to:-

A) Achieve the standard set out below or specified in a later DPD, or an equivalent quality assured scheme, with a strong emphasis on energy, water and materials. These requirements will be met through:

(a) Energy and water efficiency,

(b) Sustainable construction materials, and,

(c) Waste reduction.

B) Reduce carbon dioxide emissions through on-site sustainable energy technologies at the percentage set out below or at such other level as may be specified in a subsequent DPD.

C) Be carbon neutral which can be met through a combination of (A) and (B) above, with any shortfall being met by financial contributions to enable residual carbon emissions to be offset elsewhere in the Borough.

Ashford LDF 2007 - 2014						
			(CS3) Town Centre & (CS4) Brownfield Urban Sites	(CS5) Urban Extensions & (CS4) Greenfield Urban Sites	(CS6) Tenterden, the Villages	Existing and refurbishment
(A)		Residential	Code Level 3	Code Level 4	Code Level 2	EcoHomes 'Very Good'
	BREEAM	Overall level	Very Good	Excellent	Good	Very Good
		Energy Credits	Excellent	Excellent	Excellent	Excellent
		Water Credits	Maximum	Maximum	Excellent	Excellent
		Material Credits	Excellent	Excellent	Very Good	Very Good
(B)		Minimum Carbon Dioxide Reduction				
			20%	30%	10%	10%

Table 9: Ashford Borough Council LDF Code Level requirements

11.1.9 Summary

This section shows the range of policies currently used in the Local Development Frameworks of various Local Authorities across the UK. They are all attempting to reduce CO_2 emissions levels in similar yet slightly different ways. Probably the most confusing issues are the range of measurement methods, which some councils measuring in carbon emissions and others using overall energy usage. It would make sense for all councils to take the same approach, but this does not currently appear likely. Having an understanding of this will help planners see local policy in relation to the rest of the UK.

12 Implementation

Having explained the various levels of policy and legislation affecting planners on the North East, and why they exist, this document will now discuss how to implement these various requirements.

First, the energy hierarchy will be discussed as the optimum way to produce a low carbon development. Having put in place this initial concept, then the following issues will be discussed:

- Baseline assessment – SAP, SBEM
- Energy Efficiency & fossil fuel CHP
- Renewable Energy Technologies

Having looked at these, the document will move into looking at the options given by the Carbon Mixer® North East 2.0, and detail some case studies of low carbon developments based in the North East.

13 Energy Hierarchy

When producing an energy strategy for a development, the energy hierarchy provides the most practical and cost effective methodology to achieve a low carbon development. This is a five stage process as detailed below:

1. Energy Reduction

Reduce the amount of energy used. In the simplest form this means turning off equipment which is not needed. Looking at intelligent lighting systems, timing the heating system for optimum operation, ensuring air conditioning does not turn on at the same time as heating.

↓

2. Energy Efficiency

Using energy efficient systems, such as A rated electrical appliances and insulating the building as much as possible. Additionally, it means looking at passive design elements such as south facing windows and overhangs to capture solar energy efficiently.

↓

3. Renewable Energy

Having reduced the energy demand of a building as much as possible, the remander of power must be generated. This phase involves generating heat and electricity from renewable generators. This includes photovoltaic panels and wind turbines for electricity, solar thermal for water heating.

↓

4. Low Carbon Energy

For the energy which can not be generated through renewables, low carbon technologies can be used. These include ground/air/water source heat pumps.

↓

5. Conventional Energy

With no other options left, the final part of a building's energy demand will be generated through using conventional polluting options. In an optimum development this final phase will not be reached.

14 Baseline Assessment

14.1 Carbon Mixer® North East 2.0

The Carbon Mixer® North East 2.0 is a major part of the Microrenewables Toolkit. This software is based on the Carbon Mixer®, a commercial software package developed by Bobby Gilbert & Associates. The North East specific version has been developed between Narec and BG&A.

The original version of the Carbon Mixer® North East was released in 2007. Version 2.0 was released in 2010 with this document. The software has a large array of CIBSE approved benchmark buildings, on which various energy efficiency, low carbon and renewable technologies can be tested for environmental and economic sustainability. The software will allow the user to carry out multiple scenarios. Looking at the CO_2 savings, capital costs, payback times and running costs. Thus the ideal solution can be made. One of the major strengths of the software is that it offers a very quick calculation on the percentage of energy a particular renewable system will give to a development. Hence developer's plans can quickly be checked for accuracy.

14.2 Calculating the amount of energy used in a development

In order to ensure that a minimum of 10% renewable energy is provided by a development, the total energy demands of the development must be calculated. The two most common methodologies that are used to calculate the energy demand are SAP for domestic buildings and SBEM for non-domestic buildings.

14.2.1 SBEM – Simplified Building Energy Model

SBEM calculates monthly energy use and carbon dioxide emissions for a range of non-domestic building types.

14.2.2 SAP - The Standard Assessment Procedure for Energy Rating of Dwellings

SAP only calculates annual energy use and carbon dioxide emissions for single family dwelling houses.

Both calculation procedures are mainly used to show compliance with building regulations Part L and also to produce Energy Performance Certificates (EPCs). They can be used to model proposed buildings from plans/specifications and for existing buildings from measurements/inspections.

It is important to note that these methodologies only consider energy used in the building services for heating, hot water, air conditioning, pumps, fans, lights and cooling equipment. They do not consider energy consumed by building-specific appliances such as refrigerators in domestic properties and, for instance, the ovens in a food processing factory. Therefore when the total energy use is presented from these calculations it is probably not the whole picture for

the building or site being assessed, but it is a good indicator to satisfy the calculation required by planning obligations as it is not "occupier specific".

The targets set by the latest edition of Part L of the building regulations are stringent but renewable energy targets for developments are still required as the domestic case study later in this chapter shows that the latest edition of building regulations sets targets that can still be met without some degree of renewable energy if the fuel used by the space heating is mains gas.

14.3 Performing an energy calculation using SAP or SBEM

To perform a SAP or SBEM energy calculation details of the building need to be entered into the accredited software package covering:

- **Geographical location** (to determine temperature and solar irradiation weather data)
- **Orientation** (for solar heat gains & potential to capture solar irradiation)
- **Degree of exposure/shelter** (for uncontrolled air infiltration and solar shading)
- **Geometry** (floor area and volume)
- **Zoning** (how the property is sub-divided)
- **Construction** (U'Values of heat loss elements and details of thermal bridging etc.)
- **Solar heat gain** (areas of windows/rooflights and solar control devices)
- **Daylighting levels** (to ensure artificial lighting is not used unnecessarily)
- **Thermal mass** (to determine the effect on the heating & cooling loads)
- **Air tightness** (the extent of draught proofing and the control of air permeability)
- **Ventilation** (natural ventilation and the type/extent of mechanical ventilation)
- **Heat recovery**
- **Fuel used in the various building services**
- **Type of heating & how it is controlled** (boilers, room heaters, community heating, CHP)
- **Type of hot water system & how it is controlled** (direct or indirect with cylinder)
- **Type of cooling equipment (if any) & how it is controlled**
- **Type of lighting installation & how it is controlled** (internal and external lights)
- **Renewable energy** (solar thermal, wind turbines, heat pumps, photovoltaics etc.)

The results from the calculation models are provided in two main formats – the amount of energy demand for the building (kWh/m^2/year) and the Dwelling or Building Emissions Rate (kg of CO_2/m^2/year) where the m^2 figure represents the floor area of the building. The energy demand figure can be further sub-divided to show where the energy is consumed i.e. heating, hot water, lighting, ventilation etc. This is useful when considering the most appropriate type of renewable technology for a particular type of building – see further discussion in the non-domestic case studies later in the chapter.

14.4 Building Regulations Part L

All new buildings, some extensions and certain changes of use to existing buildings, require an energy calculation (using SAP or SBEM) to be submitted to building control with the design plans and specifications. These "as designed" calculations are known as the "Predicted Energy Assessment" and they show that the design is *capable* of complying with Part L of the building regulations when taking into account the data described in section 14.3 above.

The drawback of this procedure in planning terms is that building control applications are normally made after the granting of planning permission. Therefore parts of the design that can have a significant influence on the energy performance of the development are already decided – such as site location, orientation, degree of shelter/overshadowing, roof designs and their potential to support solar technologies etc. An example of the most serious of these is the availability of mains gas for the heating services. When a developer is scouting for a potential site the availability of mains gas supply is unlikely to be high on any list of priorities. However, the lack of a supply of mains gas for a development has serious implications on the result of the energy calculation as shown in Table 10 below.

14.5 Target Emissions Rate

Part L of the building regulations sets Target Emissions Rate (TER) based on CO_2 emissions for all types of buildings. The target uses a "notional" building design and sets "improvement factors" for the developer to demonstrate that their designs are within the targets. The latest 2010 edition uses the 2006 level with an improvement factor of around 25%. By definition the TER remains the same for a given building. The Dwelling Emissions Rate or Building Emissions Rate, for non-domestic situations, is dependent on the factors listed in section 14.3.

The DER & BER are building specific – therefore two "identical" buildings can have different emissions rates. An example of this would be two "identical" houses, one facing north the other facing south – the solar heat gains through the windows would alter the heating demand of the house. Another more significant difference would be if one of the houses were heated using mains gas and the other used heating oil as the fuel, this would alter the energy costs and carbon emissions. There are thousands of connotations for the differences; therefore it is impossible to give an energy demand figure for say a "typical" apartment, bungalow, workshop, hotel, school etc. Each building needs to be modelled individually using SAP or SBEM.

As with most regulatory systems, the devil is in the detail and with Part L (2010) at first glance the amendments do not seem too complicated. However, it should be borne in mind that the methodologies for the SAP and SBEM have also been amended to coincide with the changes to the regulations and it is the changes to the data and algorithms where designers will notice a further tightening of the requirements. To ensure that buildings are within the Part L targets, the construction details need to be more accurate, the building services equipment needs to be more efficient, the controls need to be more effective and commissioned more thoroughly. When all of these improvements are realised, it will be more common for renewable technologies to be required to make up the shortfall in the designs to achieve the 2010 Target Emissions Rates especially for buildings that are not using mains gas as the main heating fuel.

14.6 SAP ratings and Environmental Impact Ratings for dwellings

The SAP rating is based on the **energy costs** associated with the heating, hot water, ventilation and lighting less cost savings from energy generation technologies. The Environmental Impact Rating is based on the annual **CO_2 emissions** associated with space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies. Both are adjusted for floor area so that they are essentially independent of dwelling size for a given built form. They are expressed on a scale of 1 to 100, the higher the number the lower the running costs & better the EI standard.

The data to calculate these ratings is being constantly revised and updated. The tables below indicate that a dwelling with a gas fired heating system achieving a score of 80 under the 2001 edition of the calculation would only achieve a score of 71 under the 2005 edition and this would reduce again, to 68 under the 2009 edition of the calculation.

SAP 2001	SAP 2005 for main heating fuel as:				
	Mains gas	LPG	Oil	Solid fuel	Electricity
1	1	(-5)	(-5)	3	3
10	10	5	5	13	13
20	20	16	16	23	22
30	30	26	26	33	32
40	40	36	36	43	41
50	50	45	45	52	50
60	58	54	54	59	58
70	65	61	61	66	64
80	71	67	67	71	69
90	76	72	72	75	72
100	80	75	76	78	75
110	83	77	78	80	77
120	85	79	80	82	78

Table 10: Relationship between SAP 2001 ratings and SAP 2005 ratings (23)

SAP 2005	SAP 2009 for main heating fuel as:					
	Mains gas	LPG	Oil	Electricity	Solid mineral	Biomass
1	1	10	1	6	12	9
10	9	20	9	16	21	18
20	19	31	19	26	31	28
30	29	41	29	37	41	37
40	39	50	39	46	50	47
50	48	59	50	56	59	56
60	58	68	60	65	68	65
70	67	76	70	74	77	74
80	76	84	80	82	85	83
90	85	92	90	91	93	92
100	94	99	100	99	100	100

Table 11: Relationship between SAP 2005 ratings and SAP 2009 ratings(24)

14.7 Energy Performance Certificates for all types of property

When a new building is completed and the exact specification for its construction, the air permeability test result and the building services commissioning results are known, its "on construction" Energy Performance Certificate (EPC) needs to be produced and lodged on the national Landmark register under its Unique Property Reference Number (UPRN). This procedure is carried out using the "as built" SAP or SBEM calculation results.

For domestic properties, the higher the number the better the EPC, but confusingly, for non-domestic properties the higher the number the worse the energy rating.

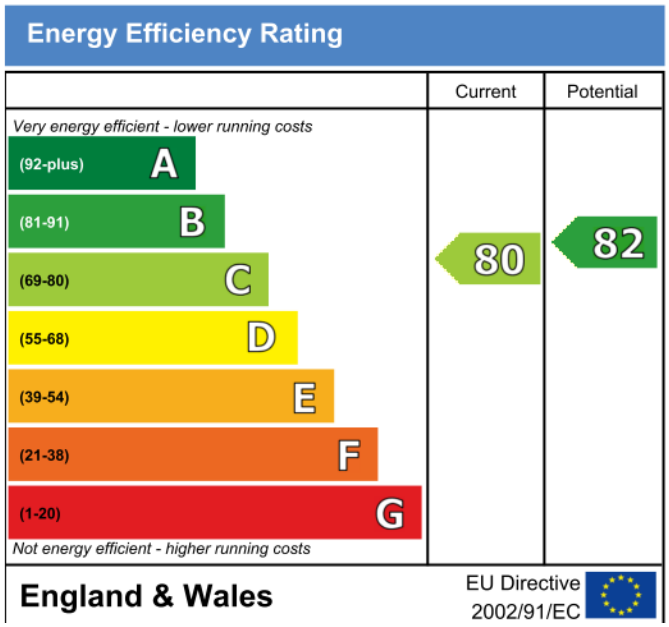


Figure 6: Energy Performance Certificates for domestic property

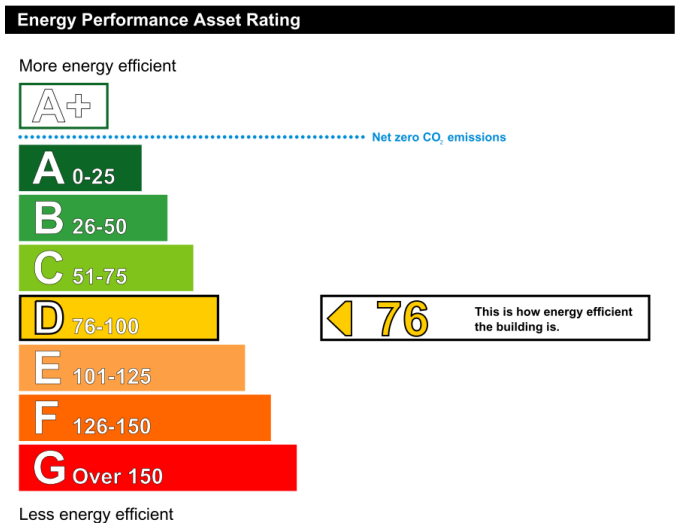


Figure 7: Energy Performance Certificates for commercial property

14.8 Carbon Content of fuel used

The Building Emissions Rate (and eventually its Environmental Impact Rating) is significantly influenced by the type and source of fuel used in the building services, particularly those for space heating and hot water. The table below indicates the unit costs and carbon content of typical fuels for buildings. The figures provided here are a sample of the most common types of fuels and energy tariffs.

These figures demonstrate that mains gas performs well overall when considering cost and CO_2

emissions, whereas alternative fuels such as LPG, oil and electricity are more costly and emit more CO_2 per kWh. Therefore any building on a site that is not connected to the mains gas supply is at an immediate disadvantage for the emissions section of the SAP and SBEM energy calculations.

The figures in brackets in the table represent the equivalent figures from the 2005 edition of the SAP guidance. It can be seen that the CO_2 emissions have been re-categorised, with mains gas and wood logs reducing and all the other fuels increasing. This is one of the subtle changes in the most recent building regulations and of course makes it more challenging for designers to meet the targets set by Part L as the "notional" building used to set the target is always deemed to be heated using mains gas.

Fuel type	Unit price (p/kWh)	Emissions (kg CO_2 /kWh)
Mains gas	3.10	0.198 (0.194)
Bulk LPG	5.73	0.245 (0.234)
Bottled LPG	8.34	0.245 (0.234)
Heating oil	4.06	0.274 (0.265)
House coal	2.97	0.301 (0.291)
Anthracite	2.86	0.318 (0.317)
Wood logs	3.42	0.008 (0.025)
Dual fuel appliance (mineral and wood)	3.21	0.206 (0.187)
Electricity (standard tariff)	11.46	0.517 (0.422)
Electricity 7 – hour tariff	12.82(high) 4.78 (low)	0.517 (0.422)
Electricity 10-hour tariff	11.83 (high) 6.17 (low)	0.517 (0.422)

Table 12: Fuel prices and carbon emissions factors. Source (24)*. (figures in brackets represent the equivalent figures from the SAP2005)*

14.9 Code for Sustainable Homes and BREEAM Assessments

It is difficult to discuss building regulations and energy performance of buildings in today's climate without mentioning the role played by the Code for Sustainable Homes and the BRE Environmental Assessment Method (BREEAM). Both of these are environmental assessment tools that go beyond simply looking at the energy use of a building. The methodologies offer a very broad appraisal of all the environmental implications of a development from land reclamation through transportation and waste management issues to approaching the subject of the embodied energy of the building materials and water conservation features.

More details can be found at www.breeam.org and www.communities.gov.uk.

The assessments are carried out using a weighting scale and the most significant influence on both of these scales is the energy use of the building being assessed.

For the CSH the energy assessment is based on a percentage improvement over the minimum

standards required by Part L of the building regulations. So a level 2 CSH property roughly complies with the 2006 edition of Part L and a level 3 CSH property roughly complies with the 2010 edition of Part L and so on up to a level 6 CSH property that should be close to a "zero carbon home" as discussed in previous chapters.

For BREEAM assessments it is not so simple to describe the relationship with building regulations as there are many different versions of BREEAM to select from depending on the type of non-domestic building being assessed. Suffice to say that the BREEAM assessor uses the buildings Energy Performance Certificate figure and this needs to be calculated using SBEM and, in general the lower the EPC figure the more "points" scored in the "energy" section of the assessment with buildings aiming to achieve an "Excellent" or "Outstanding" result needing to achieve a very low EPC number.

Both of these assessments can be carried out at any time during the design of a development to assist the designers in their desire to achieve sustainable design (refer to Section 8.6 for discussion on this and its relationship to the relevant Planning Policy Statement). In fact the earlier these assessments are carried out the better chance there is of avoiding the pitfalls described in section 14.4 above as leaving the SAP and SBEM calculations to the detailed design stage could be too late to take advantage of beneficial opportunities for low carbon design.

14.10 Case Study of Domestic energy calculation under Part L 2006 and Part L 2010

The following pages provide a case study of a typical detached dwelling that demonstrates the level of specification required to pass the TER test for both the 2006 edition of Part L and the 2010 edition. The dwelling is initially assessed with mains gas as the space heating fuel and the study demonstrates that, with enhancements to the specification, the dwelling can comply with the 2010 TER without the need for renewable energy technology to be introduced.

When mains gas is not available for the space heating fuel, the dwelling is unlikely to be able to achieve the TER without the need for more challenging improvements to the construction specification and / or the introduction of renewable technology.

Case Study demonstrating how changes to the specification of a dwelling affect the energy rating calculation

Description of dwelling that complies with the Target Emissions Rate of the **2006** Part L of Building Regulations using **SAP2005**:

- A detached, two-storey house, sheltered on two sides from adjacent buildings with an average amount of overshadowing.
- Ground floor area 100m^2, first floor area 85m^2, window area is 46m^2 (approximately 25% of the total floor area).
- The windows are on all four elevations - south = 20m^2, east = 7m^2, north = 5m^2 and west = 14m^2.
- The windows have a U'Value of 1.8 W/m^{2}k and their design has average light/solar transmittance and a normal ratio of frame:glass.
- The U'Values of the external elements are as follows: External walls – 0.27 W/m^{2}k, Main roof – 0.11 W/m^{2}k, Ground floor sunroom roof – 0.19 W/m^{2}k, Ground floor – 0.18 W/m^{2}k, external doors 2.2 W/m^{2}k, and the thermal bridges at the junctions and openings are average.
- The air permeability of the house when tested at 50 pascals is 5.5 m^3/hour/m^2
- The heating and hot water are provided by a **mains gas** fired, 90.1% efficient, regular boiler via radiators. The boiler has a programmer and full thermostatic zone controls. All the pipes are insulated and the hot water cylinder is 180 litre capacity with 50mm of foam insulation and full thermostatic / timer controls.
- The secondary heating in the lounge is a condensing gas fire with an efficiency of 85%.
- The house is naturally ventilated with extractor fans in the rooms as required by building regulations Part F.
- The electricity supply to the house is standard tariff. One in four of the lights in the house are low energy type.
- The house has a medium thermal mass (i.e. it is constructed with a concrete ground floor, masonry external walls and partitions internally).

Description of Dwelling	**SAP**	**EPC**	**TER** $KgCO_2/m^2/yr$	**DER** $KgCO_2/m^2/yr$	**Energy kWh**	**Energy cost £/year**	**New/ Renewable Energy**	**Comments**
Detached two-storey house as described above (2006 compliant)	79	C	20.83	20.79	17988	416.15	None	This is a typical house designed to comply with the 2006 edition of Part L of the building regulations.
Same house as above but assessed using the SAP 2009 methodology to comply with the 2010 edition of Part L of the building regulations	80	C	16.37	20.53	16113	718.06	None	The same design does not pass the 2010 TER/DER test – which is to be expected as Part L has been revised to require a 25% improvement for new build dwellings.

Description of dwelling that complies with the Target Emissions Rate of the **2010** Part L of Building Regulations using **SAP 2009**:

- A detached, two-storey house, sheltered on two sides from adjacent buildings with an average amount of overshadowing.
- Ground floor area 100m^2, first floor area 85m^2, window area is **56m^2** (approximately 30% of the total floor area).
- The windows are on all four elevations - **south = 25m^2**, east = 7m^2, north = 5m^2 and **west = 19m^2**.
- The windows have a U'Value of **1.4 W/m^{2}k** and their design has average light/solar transmittance and a normal ratio of frame:glass.
- The U'Values of the external elements are as follows: External walls – **0.23 W/m^{2}k**, Main roof – 0.11 W/m^{2}k, Ground floor sunroom roof – **0.17 W/m^{2}k**, Ground floor – **0.16 W/m^{2}k**, external doors **1.8 W/m^{2}k**, and the thermal bridges at the junctions and openings are **better than average.**
- The air permeability of the house when tested at 50 pascals is **4.5 m^3/hour/m^2**
- The heating and hot water are provided by a **mains gas** fired, **91%** efficient, regular boiler with a **load compensator device** via radiators. The boiler has a programmer and full thermostatic zone controls. All the pipes are insulated and the hot water cylinder is 180 litre capacity with **80mm** of foam insulation and full thermostatic / timer controls.
- The secondary heating in the lounge is a condensing gas fire with an efficiency of 85%.
- The house is naturally ventilated with extractor fans in the rooms as required by building regulations Part F.
- The electricity supply to the house is standard tariff. **50%** of the lights in the house are low energy type.
- The house has a medium thermal mass (i.e. it is constructed with a concrete ground floor, masonry external walls and partitions internally).

Description of Dwelling	**SAP**	**EPC**	**TER** $KgCO_2/m^2/yr$	**DER** $KgCO_2/m^2/yr$	**Energy kWh**	**Energy cost £/year**	**New/ Renewable Energy**	**Comments**
See full amended description above with changes highlighted in **bold.**	83	B	16.16	16.15	13453	587.96	None	The house can be designed to comply with the new 2010 Part L by improving many parts of the energy related elements and **without the need for renewable energy to be installed.**
Same description as above but with LPG as the heating fuel for boiler and secondary heating.	76	C	16.16	19.31	13453	850.20	Solar thermal?	With LPG the emissions are higher than the target and more improvements will be required.

14.11 Case Study of Non- Domestic energy calculations under Part L 2006

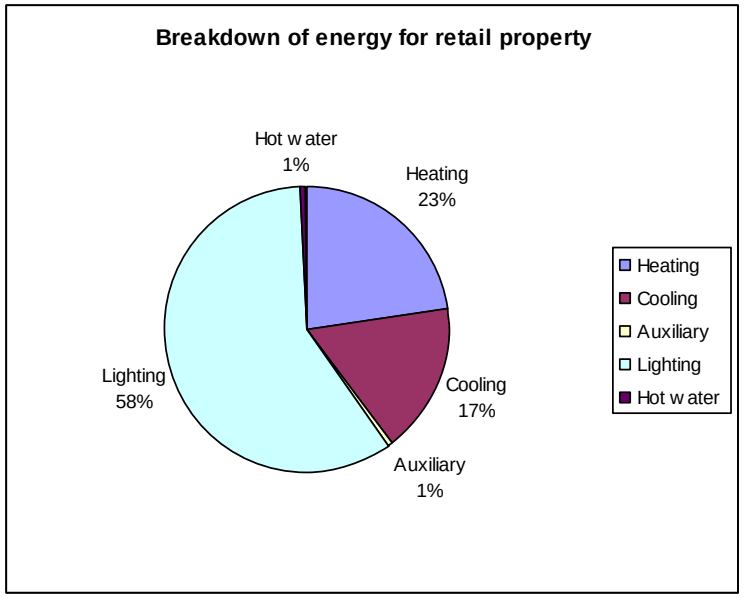
The current SBEM calculation tool is version 3.5 (May 2010 version) which has not been updated to take into account the revisions to Part L (2010). Therefore the following Case Studies are for illustration only. The aim is to demonstrate how the use of a non-domestic building affects the total energy consumption and the pattern of energy use. These subtle differences should be taken into account when considering whether to use renewable technology and if so what type of technology – that which produces electricity such as PV and wind power or that which produces heat such as solar thermal, biomass, heat pumps etc.

The properties presented here are all built in the North East of England. They have all been modelled in SBEM and they cover a wide variety of building uses, a range of typical building services and are either new-build developments or change of use.

- Non-Domestic Case Study One - New build, detached Retail Store
- Non-Domestic Case Study Two - 1990's Sports Centre with Swimming Pool
- Non-Domestic Case Study Three - New Build Vehicle Maintenance Depot * see special note in case study regarding this type of development
- Non-Domestic Case Study Four – Change of Use project from public house to House in Multiple Occupation
- Non-Domestic Case Study Five – Large extension to an existing Residential Care Home
- Non-Domestic Case Study Six – Children's Nursery
- Non-Domestic Case Study Seven – Change of Use retail (A1) to a Café/coffee shop (A3) * see special note in case study
- Non-Domestic Case Study Eight – Naturally Ventilated, new-build Office
- Non-Domestic Case Study Nine – 1990's Naturally Ventilated Office
- Non-Domestic Case Study Ten – Typical high street Retail premises

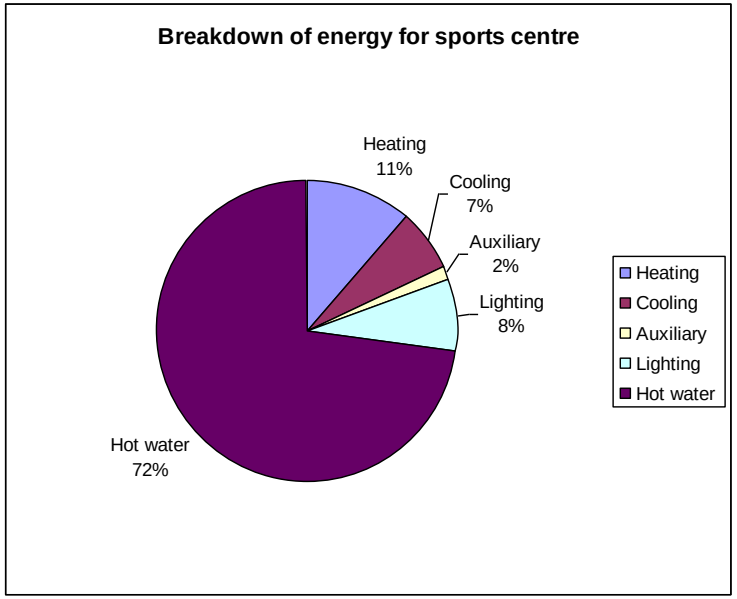
14.11.1 Non-Domestic Case Study One - New build, detached Retail Store

Description of Building	Floor area m^2	EPC	TER $KgCO_2/m^2/yr$	BER $KgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
New build, single storey, detached convenience store located in Newcastle upon Tyne. Designed in 2010 to meet the requirements of Part L 2006	239	53	103.4	93	52,687	220	Air source heat pumps	For retail premises the lighting is the highest energy user. Therefore IF renewable energy were considered for this project it would be prudent to focus on technology that produces renewable electricity such as PV or wind power.



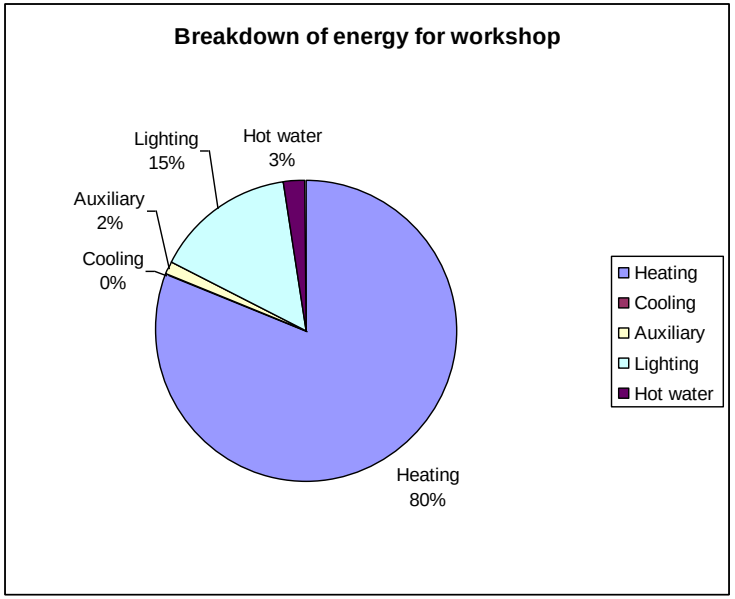
14.11.2 Non-Domestic Case Study Two - 1990's Sports Centre with Swimming Pool

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
Purpose built in 1999, two storey, detached sports centre located in Sunderland with a swimming pool.	2290	51	142	140	1,341,321	585	Air source heat pumps to most areas	For sports premises the hot water is the highest energy user. Therefore IF renewable energy were considered for this project it would be prudent to focus on technology that produces hot water such as solar panels or a biomass boiler.



Non-Domestic Case Study Three - New Build Vehicle Maintenance Depot

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
New build, detached vehicle maintenance workshop located in North Tyneside. Designed in 2010 to meet the requirements of Part L 2006	691	29	28.5	26.7	79,596	115	None	For workshop premises the space heating is the highest energy user. Therefore IF renewable energy were considered for this project it would be prudent to focus on technology that produces heat such as biomass heater.

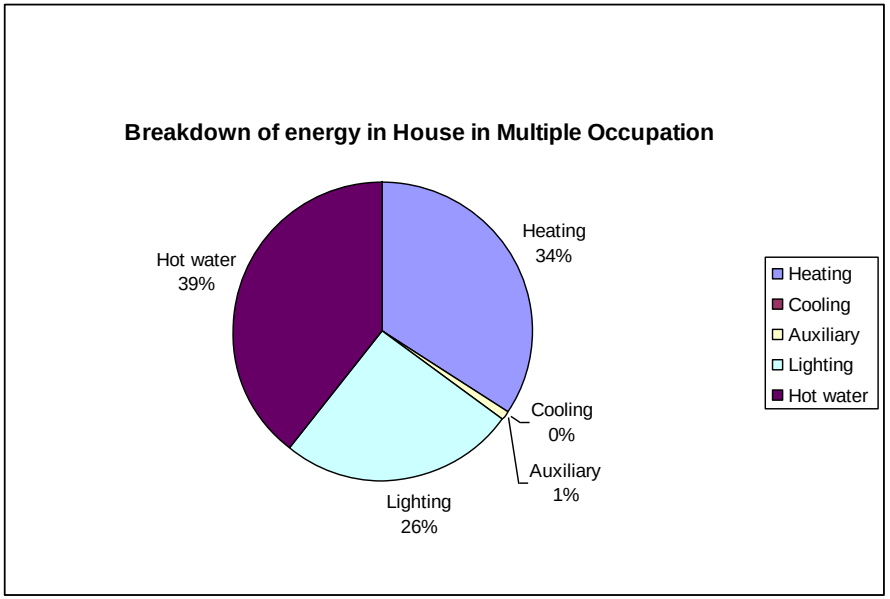


SPECIAL NOTE FOR WORKSHOPS ETC

It is worth noting that, with this type of property and others such as distribution depots, warehouse/storage premises, farm buildings etc. the use of the building dictates that the vehicle access doors are open during the occupied times of the day. Therefore although the buildings are modelled as if they are fully heated (for reasons of employment laws), it is unlikely that a full space heating system would be used when the building is in use. So these buildings, in practice, use far less energy than the models indicate and there are serious limitations when considering installing the full building regulations levels of insulation and any renewable technology. The amount of energy actually saved is very small and therefore the payback periods are very long. This should be borne in mind when requesting any 10% renewables target at the planning application stage.

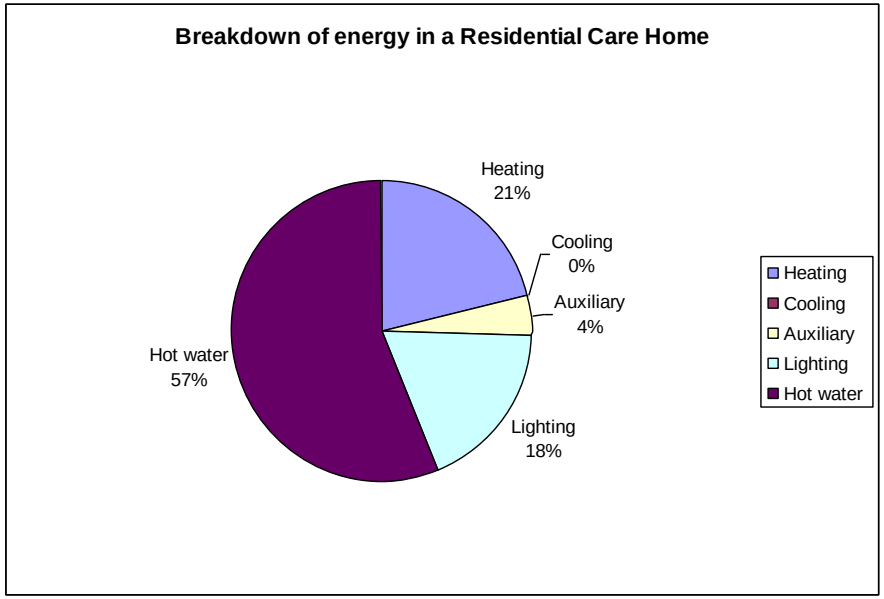
14.11.3 Non-Domestic Case Study Four – Change of Use project from public house to House in Multiple Occupation

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
Three-storey Victorian Public House in Northumberland converted to HMO with managed areas and hot water provided by mains gas and rented rooms heated with electric room heaters.	493	88	55	112	196,214	398	None	Given that most of the heating and all of the lighting would be using grid supplied electricity photovoltaics would be most suitable for this project especially when considering the fuel poverty aspect of the development (refer to section 5 for discussion)



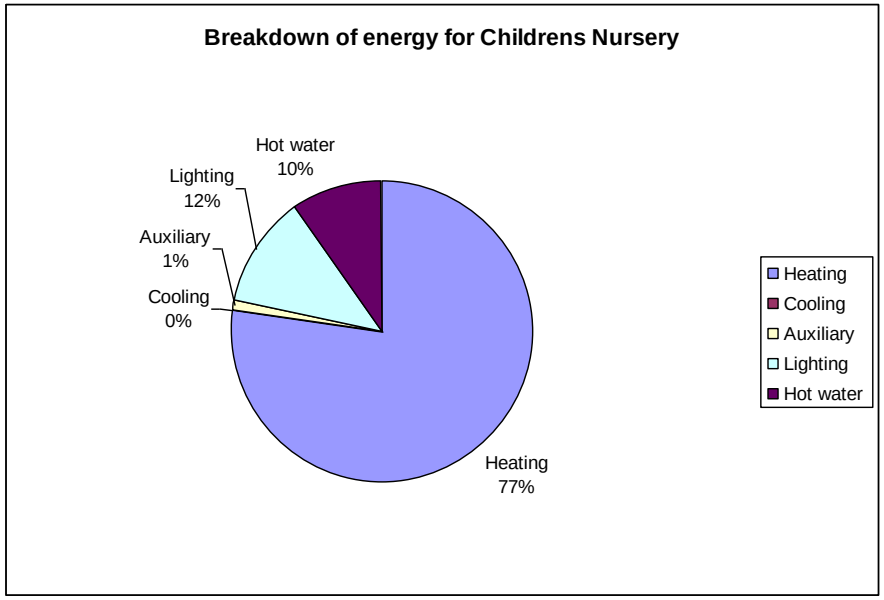
14.11.4 Non-Domestic Case Study Five – Large extension to an existing Residential Care Home

Description of Building	**Floor area m^2**	**EPC**	**TER** $kgCO_2/m^2/yr$	**BER** $kgCO_2/m^2/yr$	**Energy kWh**	**Energy kWh/m^2**	**New/ Renewable Energy**	**Comments**
Extension designed for existing care home in Middlesbrough during 2008 to meet the 2006 building regs. The extension has its own heating & hot water services.	1,507	42	34.3	33.8	207,483	138	None	The heating and hot water services are the highest energy consumer so a solar hot water system could well provide a 10% renewables obligation on a development like this. Installing a biomass boiler for heating and hot water would go further than the minimum requirement and could be viable as these buildings are heated 24/7 for 365days/year.



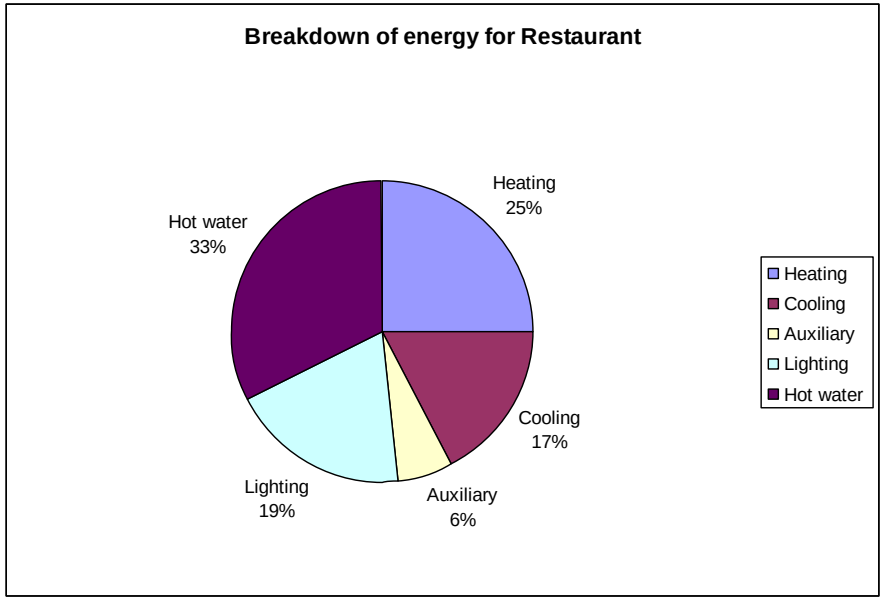
14.11.5 Non-Domestic Case Study Six – Children's Nursery

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
New build, single storey nursery with good daylighting levels, efficient lighting and a mains gas heating and hot water system	614	36	24.3	24.2	66,674	109	None	Changing from mains gas to biomass would be one possibility for this type of building.



14.11.6 Non-Domestic Case Study Seven – Change of Use retail (A1) to a Café/coffee shop (A3)

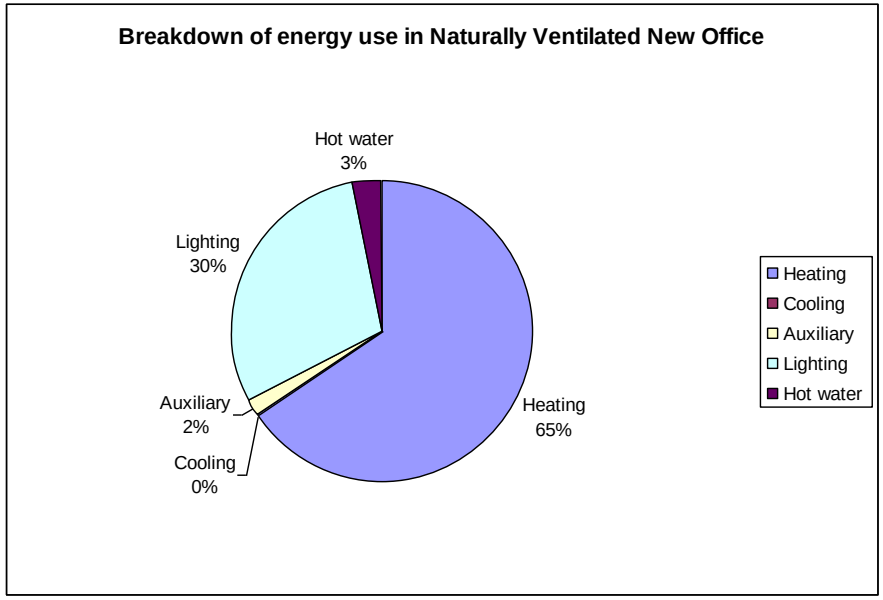
Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
Existing building in an established shopping street with no gas supply.	361	82	112	137	117,325	325	Air source heat pump	As all of the heating, cooling, hot water, fans and lights in this building use grid supplied electricity with a high carbon content, the 10% renewables obligation is perhaps more important.



SPECIAL NOTE FOR RETAIL CHANGE OF USE
The important point about this development is that it is not a change of use as defined by building regs, only planning law. Therefore the amount of energy improvements able to be enforced by building control are very limited and perhaps this should mean that the "10% renewables" planning requirement is applied more rigorously. This is doubly emphasised in this particular project as it is in an "off gas" location.

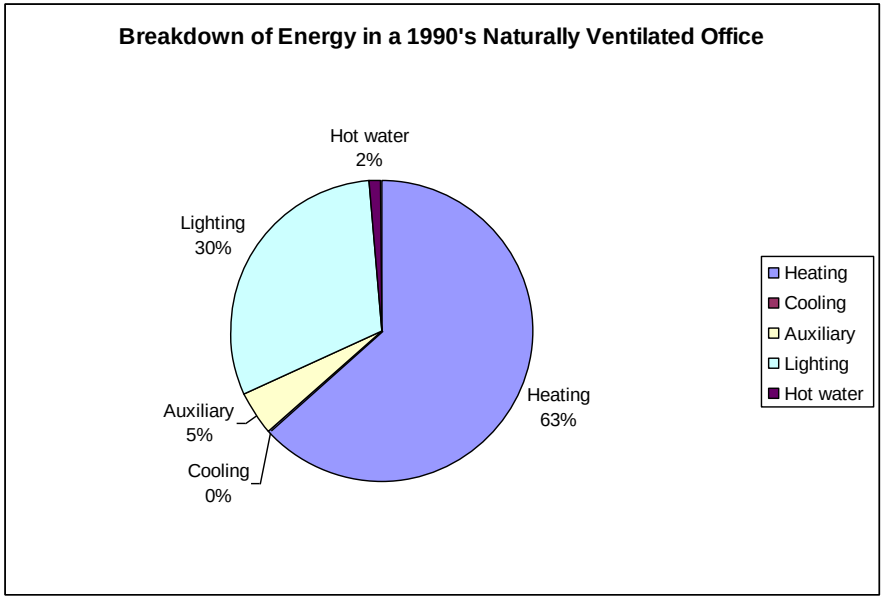
Non-Domestic Case Study Eight – Naturally Ventilated, new-build Office

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
Two storey office building, new build (2009) on an out of town business park in South Tyneside. Good day lighting levels, solar control glass, narrow plan, efficient mains gas boiler and low energy lights.	412	35	33.3	33.3	51,615	125	None	Although heating is the largest energy use in this building it is provided by a high efficiency boiler with mains gas as the fuel so it would be more beneficial in carbon reduction terms if any renewable energy for this project targeted the grid supplied electricity for the lights – i.e. photovoltaics.



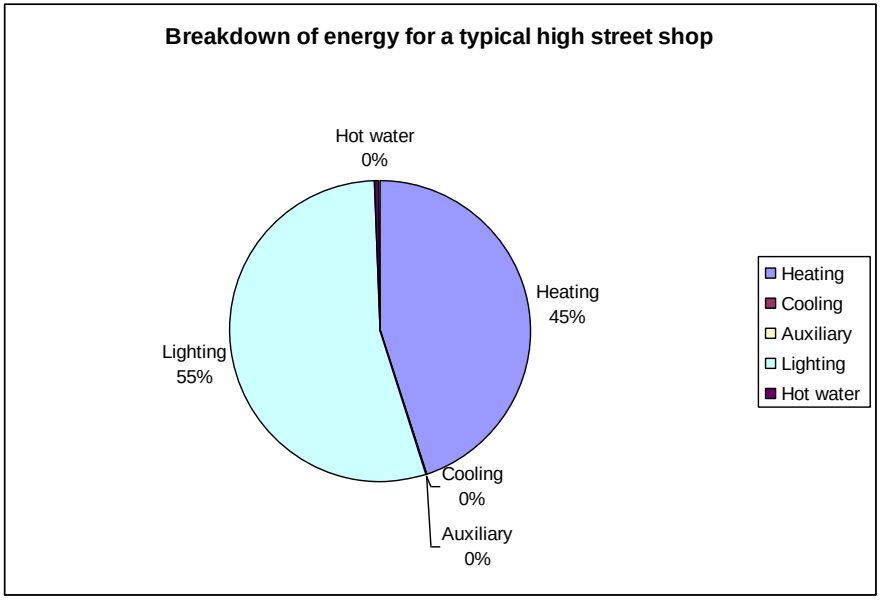
Non-Domestic Case Study Nine – 1990's Naturally Ventilated Office

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
Purpose built two-storey office building on a business park location in Northumberland. Designed to the 1995 building regulations with poor day lighting levels, average artificial lighting standards and an 81% mains gas boiler.	1,230	73	28	51.5	221,400	180	None	This building was designed at a time when energy conservation requirements were not particularly stringent even though it is only 11 years old. Its energy use / m^2 is therefore 30% more than the building in case study nine above. This stresses the importance of energy conservation measures prior to installing renewable energy technology.



Non-Domestic Case Study Ten – Typical high street Retail premises

Description of Building	Floor area m^2	EPC	TER $kgCO_2/m^2/yr$	BER $kgCO_2/m^2/yr$	Energy kWh	Energy kWh/m^2	New/ Renewable Energy	Comments
High street clothing shop with gas supply but tenant chooses to use oil filled radiators for heating. Poorly performing general lighting. Single glazed display window and display lighting discounted.	166	66	64	118	46,712	281.4	None	Retail tenants often choose to use electric heaters in their premises and landlords rarely provide a connection to the gas supply. This leads to high electricity usage. It is difficult to install renewable energy if upper floors of property in different ownership/control. Contrast these results with Case Study One



15 Energy Generation Technologies

15.1 Introduction

Renewable energy technologies convert energy that is not particularly concentrated – sunlight, biomass, wind, etc – into heat or electricity. Most renewable energy technologies can be deployed in the built environment with the probable exception of wave and tidal power conversion devices.

In order to ensure the correct technologies are implemented, a full survey of the energy requirements and resource availability must be carried out. This section discusses the various renewable and low carbon energy generating technologies which will be relevant in the North East.

An important point to make is that renewable and low carbon energy systems are very cheap to run, as they generally get their fuel, or a portion of it, effectively for free. However, they are extremely capital intensive, requiring a large initial investment.

Narec would like to make clear that any changes to energy generation systems should only be considered after all reasonable energy saving measures have been carried out, as detailed in the energy hierarchy. This approach is the most sensible with regard to economic and environmental sustainability.

15.2 Combined Heat and Power

15.2.1 Introduction

The consumption of fuels (gas, coal, oil, peat, wood & other biomass, uranium & other radioactive fuels, etc) to generate electricity involves processes where there are a significant amounts of heat generated. When the power stations are not co-located with the load they are supplying, they waste the heat generated. Generally this heat is wasted as steam coming from the cooling towers. The following table gives the average conversion of fuel to electricity efficiencies of large UK power stations in 2008. It is interesting to note that the total thermal energy wasted in the UK by large power stations is roughly equivalent to the total domestic space heating of the UK.

Plant Type	Thermal Efficiency
Combined Cycle Gas Turbine	51.9%
Coal Fired Stations	36.0%
Nuclear Stations	37.9%

Table 13: Source: Dukes table 5.10 – 2008 Data.

Instead of wasting this heat, it can be captured and used. Clearly, the steam captured is too cool to generate electricity with (unless using an Organic Rankine Cycle system). It can be used to provide either space heating or domestic hot water. A system which does this is called a Combined Heat and Power (CHP) system. Additionally, absorption chillers can be used, which provide cooling from heat. These systems are referred to as Trigeneration.

CHP systems can run on a variety of fuels, although generally they will run on natural gas or some form of biofuels.

CHP and Trigeneration systems come in various sizes, from domestic to large district heating system. This document will now look at large and domestic CHP systems, and the applications of both.

15.2.2 Large Scale CHP

Large scale CHP systems can be integrated into district heating systems. This means that the waste heat from a large system, around 1MW, will be distributed through underground pipes which contain water at approximately 70°C. Generally such systems are managed by ESCos, and are considered one of the best ways to reduce CO_2 emissions in an urban environment.

For more information, read Energy Service Companies (ESCos) on page 115

15.2.3 Medium Scale CHP

These are systems for large buildings, preferably buildings with a constant heat load. For example, these are particularly useful for swimming pools, which will have a constant heat demand throughout the year.

15.2.4 Domestic CHP

Domestic CHP systems are becoming increasingly popular.

15.2.5 Performance

Overall efficiency of CHP units is around 75-90%, dependant upon the technology employed. The selection of technology depends upon the thermal requirements and the size of the units. An example of unit efficiencies is shown in the following table:

System	Heat	Electricity	Efficiency
WhisperGen (Stirling Engine)	8kW	1kW	85-90%
Baxi Dachs (Internal Combustion Engine)	12.5kW	5.5kW	79%
Turbec T100 Gas Turbine	170kW	100kW	80%
Cummins QSV81G	2066kW	1570kW	88%
Conventional Solution (90% efficient gas boiler, 40% efficient electrical supply)	170kW	100kW	62%

Table 14: performance of CHP systems

15.2.6 Costs

Typical costs for CHP systems are shown in the table below. CHP installations are more expensive that conventional installations, however they have the capacity to reduce carbon emissions and provide economic paybacks over time. Not every installation will provide an economic payback, however the following features of the expected load could provide pointers to where CHP systems are economically viable:

- Large electrical loads and large thermal loads
- Duration of simultaneous need for heat (or space cooling) and electricity is greater than 4000 hours per year (i.e. over 50% of the year)
- Cost of electricity is relatively high compared to gas (known as the 'spark gap').

Typical installations where CHP proves economically viable include the following:

- Hospitals; Nursing Homes, sheltered housing
- Greenhouses
- Hotels; Health Clubs; Swimming Pools
- Industrial/chemical plants; Manufacturing; Food Processing
- Commercial facilities; Government facilities
- Colleges & Universities; District heating
- Land fill & sewage treatment plants
- Mining & Oil fields

Type & Model	Installed Price
WhisperGen 8kW$_{heat}$ 1kW$_{elec}$ Grid Connected CHP unit	£3000 inc VAT
Baxi Dachs	£9725 + VAT
75kW system (not including installation)	£135,000

Table 15: costs of CHP systems

15.2.7 District Heating

District heating systems bring large costs for the laying of pipes. Additionally, large accumulator tanks will be necessary to ensure the system can cope with large surges in heating demand. A high rise apartment block may cost around £2,500 per flat, whereas a row of terraces about £5,000 per dwelling and a semi detached street around £8,500 per dwelling.

15.2.8 Building Design Considerations

While there are no specific building design considerations that need to be made to fit a CHP system, consideration should be given to district heating to maximise the opportunity for a lead boiler(s) to be a CHP boiler with support from other boilers to meet peak heat demand.

15.2.9 Planning Considerations

It is unlikely that issues for CHP systems will require special handling in a planning application. Potential applications include:

- Visual impact, especially the chimney and storage area.
- Noise from the system
- Emission authorisation (400kW-3MW local authority authorisation, 3MW+ Environment Agency authorisation)
- Building regulations re safe accommodation, sufficient air supply, good ventilation, flues, chimneys, safe access etc
- Electrical connection to the appropriate standard for CHP applications

With regard to district heating systems, these may involve the digging up of both the roads and pavements. Clearly this will have to be taken into account within the planning application.

15.2.10 Integration issues

Integration of the CHP to the electricity network will have been studied as part of the connection and potential issues addressed. Demand for CHP systems may be reduced by Solar Thermal systems and other renewable energy systems so their impact should be considered on CHP systems.

15.2.11 Supply chain

There is a directory of the CHP association members at the following address:

http://www.chpa.co.uk/directory.htm

Local system integrators include PB Power and ARUP and the region has CHP power stations operated by SembCorp and Teesside Power Ltd designed for export of electricity onto the grid, as well as some on the industrial process plants around the Tees.

15.2.12 Rules of thumb and templates for site evaluation

This is included in section 17.

15.3 Biomass

15.3.1 Introduction

Biomass fuels are generally derived from wood, crops and wastes. Biomass can be burnt to provide heat, or further processed to provide liquid or gaseous bio-fuels. The heat can in turn be used to generate electricity. In the North East there exists opportunities for farm based anaerobic digestion schemes to extract energy from manure or waste; the growing of energy crops – oil seed rape and short rotation coppice for example; and for heat from the processing of municipal waste. However, the majority of biomass derives from burning wood for heat, either in the form of logs, chippings or pellets.

15.3.2 Evaluation of biomass resource

There is a large biomass resource in the North East region, however it must be noted that there is not enough for the entire region to move over to using biomass, and that it can only play a part in an energy mix.

Fuel	Weight [tonnes]	Moisture Content [%]	Energy [GWh]
Forestry timber	550,000	30	1700
Co-products from the wood industry	170,000	50	382
Wood Waste	80,000	20	320
Energy coppice	4,300	30	15

Table 16: biomass in the North East

15.3.3 Performance

The output of wood burning biomass systems is influenced by the following items

- The type of wood
- The moisture content of the wood
- The efficiency of the burner

For most biomass systems considered, logs, wood chips or pellets will be the fuel source. Wood chips and pellets are usually manufactured in a way such that the moisture content can be controlled by the supplier. This should be specified by the operator when sourcing fuel. For logs, they should be air dried under cover outside, and then dried inside (by the fire for example) before being burnt.

Wood burning boiler efficiencies are similar to gas boiler efficiencies, at 60-90% depending on the boiler design efficiency, quality of the wood input and the duty cycle.

400 Tonnes of wood chip fuel is sufficient to heat two large buildings, such as schools, replacing 200,000L of fuel oil for non-gas connected schools.

15.3.4 Cost

A standalone biomass stove will cost in the region of £5,800 including installation. A typical automatically fed boiler for an average home costs around £11,500 including installation and installing a suitable flue, and VAT at 5%. Manually fed log systems are slightly cheaper.

Wood fuel can cost between 1-4p/kWh depending upon the delivery size and local availability.

15.3.5 Building Design Considerations

Wood burning stoves will require a storage area for the logs / pellets / chippings. This will need to be identified in the building design phase, and depending on the system employed, automatic handling systems also included in the building design. Delivery systems should also be identified such that access for delivery lorries is catered for in the service road design. A chimney will be needed to remove the combustion products that is of sufficient diameter and height so that it is effective and does not cause a nuisance to people inside or outside the property.

15.3.6 Planning & Other Considerations

The planning and other requirements for a wood burning system will revolve around the following items:

- Visual impact, especially the chimney and storage area.
- Noise from the system
- Delivery – particularly impact on traffic
- Smokeless zone issues (either a bigger chimney or clean up technology)
- Emission authorisation (400kW-3MW local authority authorisation, 3MW+ Environment Agency authorisation)
- Building regulations re safe accommodation, sufficient air supply, good ventilation, flues, chimneys, safe access etc
- Electrical connection to the appropriate standard for CHP applications

15.3.7 Integration issues

Biomass boilers can be connected together with boilers burning other fuels in large systems. Water pre-heat from solar thermal systems is also possible. Electricity from CHP systems should be compatible with electricity from other systems; however the generation levels should be checked with the local electricity distribution network operator (NEDL) to ensure connection is possible.

15.3.8 Supply chain

It is vital from a planning and grant/incentive perspective that any installer of a microgen biomass system is accredited under the Microgeneration Certification Scheme and it is also vital that the products themselves are accredited under the same scheme.

A full list of suppliers and technologies can be found at:

http://www.microgenerationcertification.org

Biomass fuel suppliers in the north east can be found at http://www.biomassenergycentre.org.uk

15.3.9 General Web sites

Wood fuel heating in the North of England: A practical Guide, downloadable from http://www.energynortheast.net/page/biomass.cfm

CHP association: http://www.chpa.co.uk/

15.3.10 Rules of thumb and templates for site evaluation

See Section 17

15.3.11 Case Study - Kielder Wood Fired District Heating

The Kielder district heating scheme utilises locally grown wood that is chipped for use in a 300kW Austrian Köb boiler. The hot water is distributed through insulated pipe work to surrounding buildings where heat exchangers transfer the energy to provide domestic hot water and heating. The system supplies hot water and heat to the Kielder Castle visitor centre, six new 3-bedroom homes, Rivermead Workshops, Kielder Community First School and Kielder Youth hostel.

Annual consumption of wood chip is around 350 tonnes with the main fuel store providing 450m^3 of wood chip (80-120 tonnes). Moisture content of the delivered wood chip is in the range 25-35%. The fuel is delivered by trailer with a capacity of 16m^3 of wood chip (80-120 tonnes).

Heat meters at each property monitor usage and enable monthly billing. All heat requirements for the properties are met by this system.

The boiler produces very little noise, smoke or ash whilst the wood fuel is 'carbon neutral' since it is of local supply from managed woodland where felled timber is replaced with new growth, absorbing CO_2 from the atmosphere and balancing that emitted during combustion.

15.4 WIND – Large scale

15.4.1 Introduction

Wind turbines convert kinetic energy in the wind into electrical energy. Aerofoil shaped blades create a differential pressure from the wind flowing over them, resulting in a lift force that causes motion. This motion is used to drive a wind turbine generator and generate electricity. These aerofoil blades have the same physical properties that are harnessed to cause an aircraft or helicopter to fly, where the 'wind' is caused by engines pushing the wings/blades at speed.

Figure 8: Blyth Harbour Wind Farm outside Narec's headquarters in Blyth was the seventh wind farm built in the UK under the Noffo scheme, having been built in 1992 and commissioned in January 1993

Large wind turbines have had several decades of development and their designs are now honed to efficiently and cost effectively harness wind energy. A wind turbine installation briefly comprises the following steps:

- Evaluation of the wind resource and selection of correct turbine
- Landowner agreements, electrical network connection offer, planning permission, commercial energy contracts.
- Civil foundations and access roads.
- Turbine purchase, erection and commissioning
- Electrical connection and commissioning – G59 etc
- Maintenance contracts

Unless the developer has experience of wind turbine/farm development, it is recommended that a specialist company is contacted to support the development of these opportunities.

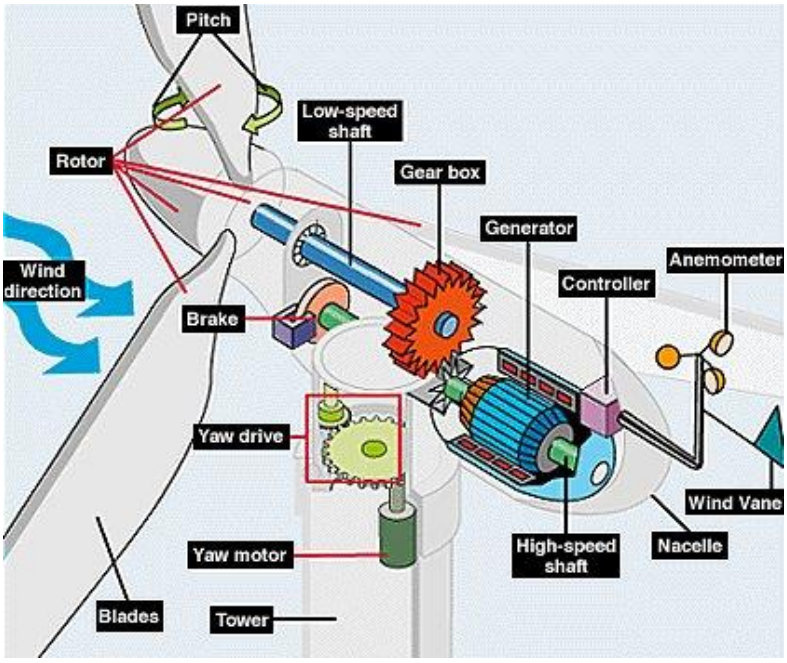


Figure 9: Simplified diagram of the workings of a wind turbine

15.4.2 Evaluation of wind resource

The only fuel for a wind turbine is the wind. Output from the turbine depends upon the wind resource available. For a large wind turbine it is critical to site the turbine in the correct location. This is best done by a specialist company identifying the correct location. They should take into account the following items:

- Terrain roughness & wind shear
- Escarpments (to avoid)
- Development of a roughness rose (to understand the levels of obstruction all around the turbine)
- Wind obstacles and its shading effect
- Turbine wake and park effects
- Tunnel and hill effects (to exploit)
- Offshore winds (to exploit)
- Selection of the site
- Measurement using an accurate anemometer for 6 months – 3 years, erected at the hub height and location of the prospective wind turbine/farm.
- Wind rose development
- Engineering Recommendation G59

The wind rose will provide data on the availability of the wind resource from a number of different directions. It is critical to have this information to select the correct turbine.

15.4.3 Performance

Large wind turbine manufacturers will generally provide two wind curves – one which is measured to a standard to demonstrate the performance of their turbine, and one which is a guaranteed by contract. The

second curve will only be available when the manufacturers have been given a copy and processed the wind data. Some wind turbines are particularly suitable for lower wind conditions and sometimes more energy will be captured by a smaller rated wind turbine (perhaps with oversized blades) than a larger wind turbine.

Large Wind turbines do not provide their rated output until they get to high wind speeds. A capacity factor in theory of between 0-100% is possible. However, economic turbines have capacity factors of between 20-70% and are generally in the 25-30% range. This means that a 2MW turbine with a capacity factor of 25% will on average generate 500kW whereas at 30% it will generate 600kW. Currently the largest wind turbines under development in the world are the Clipper 7.5MW systems, being developed in Blyth in association with Narec.

15.4.4 Costs

Wind turbine costs for on-shore turbines break down as follows(25):

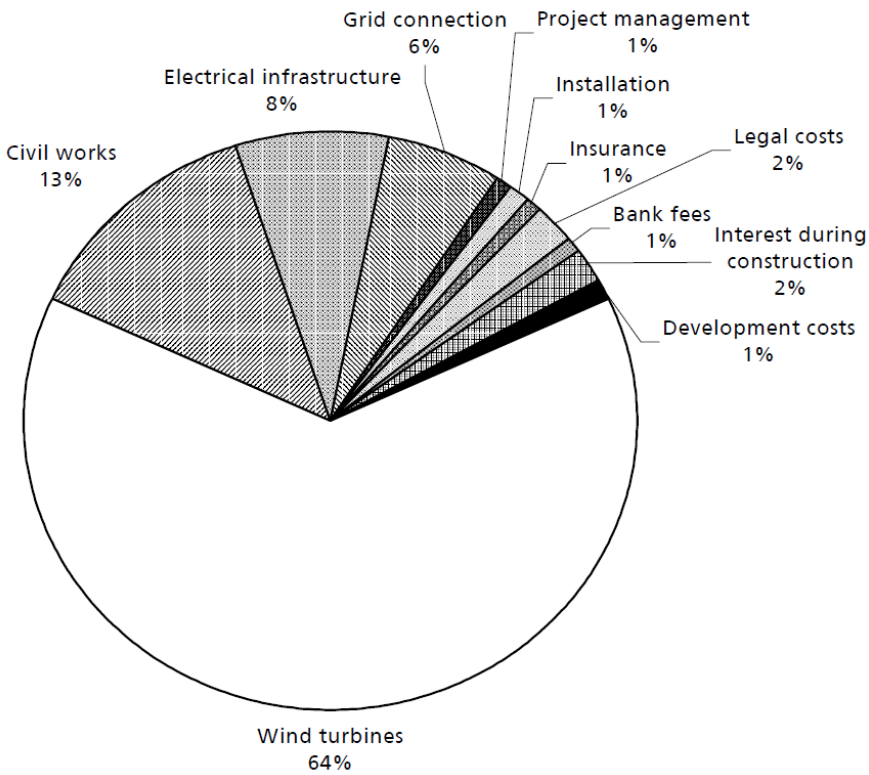


Figure 10: Breakdown of costs of a wind turbine installation

Some of these costs are fixed – Development, legal and project management fees. The others do not rise directly in proportion to the power output – it is generally cheaper per megawatt to install farms of turbines and larger turbines. There are of course discontinuities that need to be identified – for example the point where the electrical grid cannot export more power without being reinforced.

A Single 20kW wind turbine could cost £5000/kW whereas a sizable on-shore wind farm may cost £700/kW.

15.4.5 Building Considerations

Large wind turbines create noise as the blade tips cut through the air. This is regulated by blade design and

the maximum rotational speed (i.e. tip speed) of the turbine. A modern multi-megawatt wind turbine/farm will generate noise such that it measures only ~35dB at 500m. 35dB is the noise level you can hear in a quiet bedroom. At a distance of 500m a multi megawatt wind turbine will be inaudible.

There are issues of disinformation with regard to the levels of noise produced by wind turbines, and therefore it is advisable for planners to go to one of the many operating wind turbine sites in Northumberland to understand for themselves how low the level of noise is.

Adding buildings to sites will generate wind obstacle and wind shading effects. These need to be factored into the wind source evaluation.

15.4.6 Planning Considerations

A large wind turbine or farm will need planning permission. The planning permission can be included with the overall development of the site, up to a point. Large wind farms, over 50MW, are handled by central government. The planning policies have an inbuilt bias towards supporting on-site generation, hence this guide, however they will also want to consider other aspects of the wind turbine part of the development including impacts on:

- Preserved landscapes: National Park, Heritage coast & Areas of Outstanding Natural Beauty footprints.
- Preserved nature areas: Special Protection Areas, Special Areas of Conservation, Sites of Specific Scientific Interest, RAMSAR (Wetlands) and ASN Woodland footprints.
- Preserved Cultural Heritage Sites: World heritage sites [Hadrian's Wall & Durham Cathedral], historic parks & gardens, Listed Buildings and Scheduled Ancient Monuments.
- Environmental impact including the effects on nature conservation features, biodiversity and geo-diversity, including sites, habitats and species. Migratory birds, birds of prey and bats can be particular issues.
- Safety topple distances of 150m from motorways, Class A roads, Railways carrying passengers and electricity pylons
- Visual amenity & noise – a separation of 400m from settlements
- MoD Tactical Training Areas – subject to MoD objection
- MoD Radar (within 74km of radars at Brizlee Wood, Boulmer, Brunton or Fylingdales) unless developers can prove it will have no impact on the radars in question (topology)
- Civil Airports (within 30km of Newcastle or Durham Tees Valley airports) – need to consult with the airport.
- Proceed with caution in greenbelt.

15.4.7 Wind Turbine Myths

Renewables UK, formally the British Wind Energy Agency, have collated the top myths related to large wind turbines. As these arguments will probably come up in the planning process for wind turbines in the North East, the most relevant ones are reproduced here:

Myth: Wind farms won't help climate change

Fact: Wind power is a clean, renewable source of energy which produces no greenhouse gas emissions or waste products. The UK currently emits 560 million tonnes of carbon dioxide (CO_2), the key greenhouse gas culprit, every year and the Government target is to cut this by 80% by 2050. Power stations are the largest

contributor to carbon emissions, producing 170 million tonnes of CO_2 each year(26). We need to switch to forms of energy that do not produce CO_2. Just one modern wind turbine will save over 4,000 tonnes of CO_2 emissions annually (based on RenewableUK Calculations at http://www.bwea.com/edu/calcs.html).

Myth: Wind farms are ugly and unpopular

Fact: Beauty is in the eye of the beholder, and whether you think a wind turbine is attractive or not will always be your personal opinion. However, studies by RenewableUK show that most people find turbines an interesting feature of the landscape. On average 80% of the public support wind energy, less than 10% are against it, with the remainder undecided. Surveys conducted since the early 1990's across the country near existing wind farms have consistently found that most people are in favour of wind energy, with support increasing among those living closer to the wind farms(27).

Myth: Wind farms negatively affect tourism

Fact: There is no evidence to suggest this. The UK's first commercial wind farm at Delabole received 350,000 visitors in its first ten years of operation, while 10,000 visitors a year come to take the turbine tour at the EcoTech Centre in Swaffham, Norfolk. A MORI poll in Scotland showed that 80% of tourists would be interested in visiting a wind farm. Wind farm developers are often asked to provide visitor centres, viewing platforms and rights of way to their sites.

Myth: Wind farms harm property prices

Fact: There is currently no evidence in the UK showing that wind farms impact house prices. However, there is evidence following a comprehensive study by the Scottish Executive that those living nearest to wind farms are their strongest advocates(28).

Myth: Wind farms kill birds

Fact: The RSPB stated in its 2004 information leaflet *Wind farms and birds*(29), that "*in the UK, we have not so far witnessed any major adverse effects on birds associated with wind farms*". Wind farms are always subject to an Environmental Impact Assessment and RenewableUK members follow the industry's Best Practice Guidelines and work closely with organisations such as English Nature and the RSPB to ensure that wind farm design and layout does not interfere with sensitive species or wildlife designated sites. Moreover, a recent report published in the journal *Nature* confirmed that the greatest threat to bird populations in the UK is climate change(30).

Myth: Wind farms are dangerous to humans

Fact: Wind energy is a benign technology with no associated emissions, harmful pollutants or waste products. In over 25 years and with more than 68,000 machines installed around the world(31), no member of the public has ever been harmed by the normal operation of wind turbines. In response to recent unscientific accusations that wind turbines emit infrasound and cause associated health problems, Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects(32), says: "*I can state quite categorically that there is no significant infrasound from current designs of wind turbines. To say that there is an infrasound problem is one of the hares which objectors to wind farms like to run. There will not be any effects from infrasound from the turbines*."

Myth: Wind farms are noisy

Fact: The evolution of wind farm technology over the past decade has rendered mechanical noise from turbines almost undetectable with the main sound being the aerodynamic swoosh of the blades passing the tower. There are strict guidelines on wind turbines and noise emissions to ensure the protection of residential amenity. These are contained in the scientifically informed ETSU Working Group guidelines 1996(33) and must be followed by wind farm developers, as referenced in national planning policy for renewables(34). The best advice for any doubter is to go and hear for yourself!

15.4.8 Supply chain

There are a range of specialist and turbine suppliers available from the websites of RenewableUK and the European Wind Energy Association (EWEA). Regional support can be obtained from the following companies

Manufacturers:

- Gazelle Wind Turbines http://www.mkw.co.uk/about/Gazelle.php

Developers:

- AMEC Wind http://www.amec.com/wind/index.asp?pageid=8000
- TNEI http://www.tnei.org.uk/
- Wind Prospect http://www.windprospect.com/index.html
- North Energy http://www.northenergy.co.uk/

Electrical Connection Specialists:

- Narec http://www.narec.co.uk
- Econnect http://www.econnect.com/
- PB Power http://www.pbpower.net/
- SKM http://www.skm.com/

Associations:

- RenewableUK http://www.bwea.com
- EWEA http://www.ewea.org

15.5 Cassop Primary School - Case study

This primary school in County Durham has been benefiting from wind-generated electricity since 1999.

The wind turbine has an output of 50kW at a wind speed of 12m/s (26.8mph) and provides a 415v, three-phase output. The turbine is mounted on an 18.5m high tower with 7.2m blades.

Data from Durham County Council provides the following operational data:

Year	Turbine Production	Turbine production used by school	Exported electricity to grid	Imported grid electricity
1999/2000	57,560 kWh	16,336 kWh	41,222 kWh	33,863 kWh
2000/01	54,497 kWh	14,795 kWh	39,701 kWh	33,385 kWh
2001/02	56,655 kWh	16,356 kWh	40,299 kWh	32,550 kWh
2002/03	46,723 kWh	14,214 kWh	32,509 kWh	31,953 kWh
2003/04	17,937 kWh	5,175 kWh	12,762 kWh	40,933 kWh
2004/05	28,966 kWh	9,995 kWh	18,971 kWh	39,605 kWh
2005-06	34,348 kWh	12,188 kWh	22,160 kWh	42,301 kWh

Table 17: Cassop primary school data

Figure 11: Cassop school wind turbine

The wind turbine is accredited with Ofgem as a generator, is allocated Renewable Obligation Certificates and Climate Change Levy Certificates which are sold as part of the contract with the electrical supplier. Surplus electricity is sold through this contractual arrangement.

The revenue is used to maintain the turbine with a small surplus used for environmental projects.

The school is a substantial brick building dating from around 1912, however the interior was completely refurbished in 1972 providing a solid and spacious building with modern facilities. The Assembly Hall was built in 1972. A programme to make its use of energy more sustainable started in 1995, when light bulbs were replaced with compact fluorescents. This was followed by a recycling drive and the installation of cavity wall insulation. In 2003, the old oil boiler was replaced with an automated wood-pellet boiler, which burns pellets produced locally from recycled waste wood. Suspended ceilings in classrooms were then replaced, and more efficient lighting provided. A photovoltaic (PV) array was installed on a south-facing roof in 2005, with safety rail and stairs to allow access for visitors.

15.6 Small Wind Turbines

15.6.1 Introduction

Small wind turbines are defined as anything smaller than 50kW. So this covers everything from the turbines on the sides of houses (less than 1kW) to systems owned by farmers (50kW). As with large scale wind turbines, horizontal small wind turbines convert kinetic energy in the wind to electrical energy. They work in the same way (mechanically at least) as large turbines, where aerofoil shaped blades create a differential pressure from the wind flowing over them, resulting in a lift force that causes motion. There are two types of small wind turbine, horizontal axis and vertical axis. Both use aerofoils to capture the energy of the wind, with horizontal axis operating in a similar way to traditional large wind turbines, and vertical using the same basic principles but in a different way.

Horizontal Axis: Horizontal axis small wind turbines look very much like traditional large wind turbines. There are a few differences; they often have a tail(s) to align them into the wind flow although downwind designs (where the wind hits the tower before the blades) are also available. Unlike the large wind turbines where three is the usual number of blades, at the small wind level two, three, five and many bladed designs are available.

Vertical Axis: There are many different types of vertical axis turbine, the aspect they all have in common is that the main rotor shaft runs vertically. This means the gearboxes and generators can be kept on the ground, as opposed to at the top of the wind turbine tower as is the case with horizontal axis turbines. The main types of vertical axis turbines are known as Savonius and Darrieus.

Horizontal Axis	
	**Ampair** 3 Bladed design with tail, on a tower.
	**Proven** Two bladed design with tail, on a secured pole. These turbines are well known for being exceptionally rugged.
	**Renewable Devices Swift** Building mounted, 5 Bladed turbine with twin tails. The rim round the blades is designed to reduce noise.

Figure 12: Horizontal axis wind turbines

Vertical Axis	
	**Windside wind turbine** Savonius Style (drag) turbine incorporating a helix twist to even out the energy capture.
	**Quiet Revolution wind turbine** Darrius style (Lift) wind turbine incorporating a twisted blade for even energy capture.
	**Ropatec Wind Turbine** Darrius style (Lift) wind turbine incorporating an internal blade for self starting

Figure 13: Vertical axis wind turbines

15.6.2 Comparison

The two types, horizontal and vertical, are suited to different uses. In general, vertical axis wind turbines are better for the urban environment. This is because the wind in an urban environment is very chaotic and turbulent. Hence a horizontal axis wind turbine would continuously be facing in different directions and actually generate little power.

Vertical axis micro wind turbines do not need to align themselves with the wind flow and so are ideally suited to cope with rapidly changing wind directions found in built up areas.

Unfortunately, as was the case in 2007 with the original release of this document, there is still no peer reviewed quantitative research into the way vertical axis and horizontal axis turbines compare in a turbulent environment, and hence it is still not quantified what the advantage of using vertical axis turbines is. However, Narec has measured very significant reductions in the energy output from horizontal axis wind turbines when sited in a turbulent environment.

Although vertical axis wind turbines are better in a turbulent environment, in general they do not appear as efficient at converting the available wind resource into mechanical energy. By comparing the conversion efficiency of various turbines, it can be seen that at wind speeds where there are sensible levels of energy (7m/s onwards) in ideal wind conditions the horizontal axis turbine has a far better conversion factor. For

low speeds as found in the urban environment, again vertical axis appears to be the best choice.

Therefore, based on the above, Narec do not recommend the use of horizontal axis wind turbines in an urban environment, as they will not give optimum performance. If a turbine is to be placed in an urban environment it should be a vertical axis model. Conversely, Narec do not recommend the usage of vertical axis turbines in rural settings, as when in a non-turbulent environment horizontal axis turbines perform best. It is important to note that the planning authority has no control over the type of turbine a consumer may decide to use. However, these recommendations can be made to ensure the best choice of machine is made.

15.6.3 Performance

Small wind turbine manufacturers must now put forward their turbine for testing under the Microgeneration Certification Scheme. Although this is not mandatory, a turbine will not be eligible for the Feed in Tariff if it is not approved, and there are also planning considerations.

As part of this testing, a performance curve will be drawn for the turbine, showing the output produced at various different wind speeds. As the present time there are few turbines which are fully tested, however, large numbers of turbines are undergoing testing at either TUV NEL or Narec. The tests take around 9 months for Class II and 18 months for Class I. So it will take some time for all small wind turbines to have independently tested performance curves.

15.6.4 Evaluation of wind resource

The approach to wind resource evaluation for large wind turbines would ideally be followed for small turbines. Realistically however, the cost of the analysis would prove prohibitive in most practical situations.

For rural settings, the Carbon Trust Wind Power Estimator will give an indication of the average wind speed at a site, and the power generated by a specific device and tower height. In general, the approach should be to find area where clean winds are available (i.e. locations which are free of obstructions) and put the turbine on the largest tower affordable. Wind speed curves are available from some manufacturers, which can be fed into the Carbon Trust calculator.

The estimator is available for free at: http://www.carbontrust.co.uk/windpowerestimator

In urban settings, the wind speed database is prone to larger errors, as it does not take into account the levels of turbulence experienced in these environments.

15.6.5 Cost

Horizontal micro wind turbines are available for a variety of prices. The following table gives some prices (and their currency) to give an idea of the range of prices available.

Type & Model	Installed Price	Source & Date
Renewable devices SWIFT 1.5kW	£7,000	www.bettergeneration.com 2010
Ampair 600	£3,300	www.bettergeneration.com 2010
Proven 6kW	£25,000	www.bettergeneration.com 2010

Table 18: Horizontal axis small wind turbine prices (installed)

Type & Model	Installed Price	Source & Date
XCO2,QR5 6000W	£36k – £40.75k	Quiet Revolution web site May 10
Ropatec Simply Vertical Hotmax 3000	£19,260	Private communication 2010, exchange rates 13/07/2010
Maxi Vertical Hotmax 6000	£24,453	Private communication 2010, exchange rates 13/07/2010

Table 19: Vertical axis small wind turbine prices (installed)

Clearly the selection of a wind turbine depends therefore on the design, cost, and achieved load factor (a function of wind speeds & turbulence).

The payback of small wind turbines has been dramatically altered by the introduction of the Feed in Tariff. For example, if a householder in a rural environment near Newcastle who consumes 2600kWh in electricity were to spend £10'000 on a 1.4kW wind turbine, then they could expect a payback of their investment in around 13.5 years. After that the feed in tariff would provide a profit.

15.6.6 Building Design Considerations

It is not advisable to place a small wind turbine in an urban environment. Various work, such as Encraft's Warwick Wind Trials, and the Energy Saving's Trust small wind research, has shown this. Turbulence causes large issues, leaving turbines continuously attempting to face the wind. Therefore, small wind turbine are more suited for properties in a rural environment.

With regard to placing wind turbines on buildings, vibration from the turbines must be considered, and could cause serious damage to the property. Therefore it should not be recommended, although there is nothing the planning authority can do to prevent it.

With regard to bedrooms, close proximity to bedrooms should be avoided unless the noise in the bedroom is under 45dB(A). The impact of light flicker (blades casting moving shadows in certain sun positions) should also be considered and controlled or eliminated.

15.6.7 Planning Considerations

According to the new rules on permitted development, small wind turbines must be installed and certified through the Microgeneration Certification Scheme (to ensure industry standards), have a maximum noise level (no more than 45dB), and follow restrictions relating to sensitive areas (e.g. Conservation Areas, World Heritage Sites).

15.6.8 Wildlife impact

As stated in the section on large wind turbines, a recent report published in the journal *Nature* confirmed that the greatest threat to bird populations in the UK is climate change(30). Additionally, according to the RSPB 2004 information leaflet *Wind farms and birds*(29), that "*in the UK, we have not so far witnessed any major adverse effects on birds associated with wind farms*".

Small wind turbines have smaller blades, and hence even less likely to cause deaths to birds. There are known issues with badly placed large wind turbines killing bats. However, this is mainly through the creation of vortices behind the blades, which cause bats internal organs to explode, this is known as

barotraumas. Small wind turbine blades are not capable of creating a vortex which could kill a bat.

Clearly, turbines should not be placed on migratory routes, and advice should be sought from the RSPB and Bat Conservation Trust when planning small wind turbines.

15.6.9 Supply Chain

It is vital from a planning and grant/incentive perspective that any installer used for the installation of small wind systems is accredited under the Microgeneration Certification Scheme.

It is also vital that the products themselves are accredited under the same scheme.

A full list of suppliers and technologies can be found at:

http://www.microgenerationcertification.org

15.6.10 Further Information

There are lists of small wind turbine suppliers available from the British Wind Energy Association and the European Wind Energy Association web sites. Regional support can be obtained from the following companies

General Web sites
http://www.bwea.com/members/CompanyDirectory.asp and select small wind
http://www.ewea.org/index.php?id=99

15.6.11 Rules of thumb and templates for site evaluation

This is included in Section 17.

15.7 Photovoltaics

15.7.1 Introduction

Photovoltaic panels (PV panels) are a type of solar panel which convert light into electricity. They do this using semiconducting materials to induce an electrical flow in a circuit. They are generally made of silicon, the second most common element in the Earth's crust, however there are also other semiconducting materials now being used.

Solar panels have the advantage that as they have no moving parts, there is very little on them to fail. They generally have lifetimes of 25 to 40 years, although as with small wind turbines, the inverter they are connected to will need replacing in around ten years.

15.7.2 Types of Panel

Photo	Technology
	**Mono-crystalline Silicon** Each photovoltaic cell is made from a slice of a single crystal of silicon. This means they are the most efficient type of photovoltaic cell, however they also require the most energy to build in the first place, hence have a longer CO_2 payback time.
	**Multi-crystalline Silicon** With these, each photovoltaic cell is made up of multiple smaller crystals. This is a cheaper method of producing panels, however it also is less efficient. The production process is also less energy intensive.
	**Amorphous Silicon** Amorphous Silicon is made as a thin film; it has a poorer conversion efficiency compared to crystalline silicon but can absorb more of the visible light spectrum.
	**HIT (Heterojunction with Intrinsic Thin layer)** This is a combination of mono-crystalline and amorphous silicon technologies that provide the highest conversion efficiencies of all the available technologies.
	**CIGS (Copper Indium Gallium Selenide)** This is one of several thin film non-silicon based semiconductors which it have poorer conversion efficiencies compared to crystalline silicon but can absorb more of the visible light spectrum.

Table 20: Photovoltaic panels

15.7.3 Site Conditions

The most important thing to consider when installing photovoltaic panels is to ensure they are sited correctly. PV is an expensive technology, and so it should be connected up in a way to ensure the maximum energy yield. The things that must be dealt with are:

Shading:
Shading is very important. With a solar thermal panel, shading 10% of the panel will result in loosing 10% of the available energy. However, with a photovoltaic panel, because they are connected up in circuits, then shading 10% of the panels could result in losing 50% of the energy. Therefore any potential shading issues should be carefully considered.

Orientation:
PV panels should be installed facing south. Panels facing east or west will only produce around 75% of the energy of a south facing system. There is little point installing a system which is north facing.

Inclination:
In order to produce the most energy possible, the light from the sun should be perpendicular to a PV panel. What this means in practice is to gain the maximum energy in winter a panel should be arranged at a steep angle. In summer it should be at a shallow angle. To gain the maximum energy over a whole year, the panel should be set at 39 degrees in the North East. This will vary for other regions.

15.7.4 UK Solar Resource

The average available solar resource at an optimum angle in the North East of England is around 1000kWh per year per square meter. Clearly this varies by time of day and time of year.

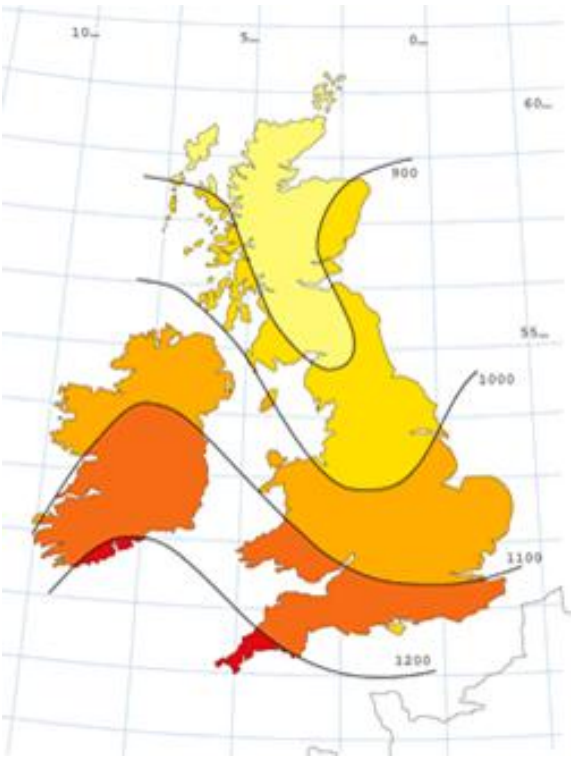


Figure 14: Total solar energy available in the UK per annum

15.7.5 Costs

The costs of a photovoltaic system installation will be decreasing as production increases. Currently companies such as Tesco and Sainsbury's are getting into the market, as well as the traditional installers. For a full installation of a typical domestic system of around 1.76kWp a cost of approximately £8,000 is reasonable (including around £1000 - £1500 for an inverter). Prior to the Feed in Tariff, photovoltaic systems were unlikely to pay for themselves within a typical photovoltaic system operational lifetime. However, due to the Feed in Tariff, the paybacks of PV systems are for Newcastle are now around 14 years, and hence they will then generate an income for the householder thereafter.

15.7.6 Photovoltaic Geographical Information System

The energy from a particular photovoltaic system can be estimated using a free online resource funded by the European Commission; this can be found at http://re.jrc.ec.europa.eu/pvgis. The website uses a Google Maps interface to locate a site, and then uses weather data to provide an estimate of the energy from a system at a particular orientation and power output rating. This is very good for an initial first pass at estimating energy yield from a photovoltaic system. However, for a more exact idea shading from other buildings and diffuse radiation should be heavily considered.

15.7.7 Planning Considerations

Solar systems are generally not subject to planning restrictions, and are mostly included as "permitted development". If the building is to be built in a conservation area or it is a development of a listing building or the site is in an area of outstanding natural beauty then the local planning department should be contacted. Likewise, if the panels are mounted directly facing a highway, permission will need to be sought.

15.7.8 Installation

PV panels should be mounted such that they are ideally orientated due south, or at least within 45º of south, and (in the North East) at an angle of 39° from horizontal, and without any shading of the panels. On flat roofs they can be mounted on frames. Additionally, it should be ensure that the panels are placed somewhere that will be difficult for thieves to access, as the market grows so will theft.

15.7.9 Supply Chain

It is vital from a planning and grant/incentive perspective that any installer used for the installation of photovoltaics is accredited under the Microgeneration Certification Scheme and that the products themselves are accredited under the same scheme.

A full list of suppliers and technologies can be found at:

http://www.microgenerationcertification.org

For photovoltaic feasibility study the following companies offer consultancy:

Narec	-	www.narec.co.uk
ARUP	-	http://www.arup.com
TNEI	-	http://www.tnei.org.uk

North Energy	-	http://www.northenergy.co.uk
PB Power	-	http://www.pbpower.net
SKM	-	http://www.skm.com

15.7.10 Rules of thumb and templates for site evaluation

See Section 17

15.7.11 Case Study - The Solar Office – Doxford

Located at Doxford Park, Sunderland, this office development comprises a three storey building, of 4,600m^2 total floor area oriented and designed in terms of relative positions of windows and walls to incorporate passive solar gain. Electricity is supplied from a 642m^2 photo-voltaic array inclined at 60° to form the south facing wall of the building. The PV cell pattern using glass:glass modules provides shading to the interior of the building.

The PV system is rated at 73kW peak and uses 352 PV modules generating 56,500kWh per annum.

Figure 15: Doxford Park

15.8 Solar Thermal

15.8.1 Introduction

As well as converting incoming solar radiation into electricity using photovoltaic cells, energy from the sun can be harnessed to provide domestic hot water. These systems do not generally provide space heating (although they can), and are known as solar thermal systems.

In a typical system, a heat transfer medium (generally a water/antifreeze mixture) travels through a series of heat conducting tubes known as a heat collector. During its circulation through the tubes, the fluid picks up heat which is then transferred to the domestic hot water supply as it passes through a coil in an appropriate storage cylinder.

Commercially available systems are either indirect (closed loop) or direct (open loop). With the more common indirect system, circulating fluid flows through the collector and transfers the heat to a hot water tank.

A typical closed loop solar water heating system is shown in Figure 16.

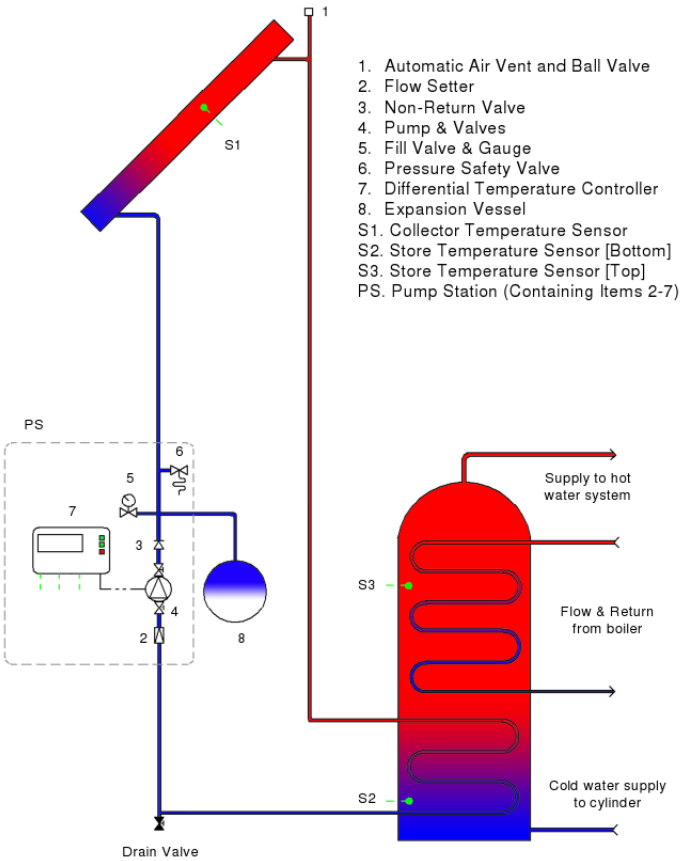


Figure 16: Solar thermal system - image courtesy of AES (www.aessolar.co.uk)

With direct systems, water is heated as it is passed directly through the collector, and flows to the building where it can be used for bathing, washing etc. Direct systems can have higher efficiencies than indirect systems, but will have higher running costs, as the potential for scaling and corrosion of the internal surfaces can lead to increased servicing and maintenance.

Solar hot water (SHW) systems can be either active or passive in terms of the circulation method. Active systems use an electric pump to circulate the heat transfer fluid (some installations use a small PV module to generate electricity to power the pump). In a typical system a controller will compare the temperature of the solar collectors with the temperature of the water in the storage cylinder(s).

If the collector temperature is hotter than in the storage cylinder, the controller will switch on the pump. The circulating fluid will then start to flow through the collectors and heat exchanger, thus heating the water in the cylinder.

The circulating fluid in a SHW system tends to expand and contract as it warms and cools; therefore allowance needs to be made for expansion. Systems also need to incorporate a method of protecting the

circulating fluids from freezing during winter months.

Most domestic systems are pressurised (sealed) and require an expansion vessel and air vents. These systems rely on (a) the fact that the circulating fluid is under pressure to prevent the fluid from boiling, and (b) an appropriate anti freezing agent to protect the system from damage.

Drain back systems use a tank to store the circulating fluid when the system is not in use. Whenever the system is not collecting solar radiation from the sun or the ambient temperature is very low, a temperature sensor can switch off the pump and allow the fluid to drain back into the tank automatically. This helps protect the system from freezing and potential damage due to extremes of temperature during the summer months.

When considering the options for expansion and freeze protection for a specific application, always seek advice from a specialist consultant/installer. This will ensure that components such as the expansion vessel (where appropriate) are sized for use in all anticipated conditions, including stagnation under full sunlight.

A basic solar thermal collector comprises of a translucent cover, an absorption plate, and the heat transfer system. In the UK, there are two main types of collector, known as evacuated tube and flatplate.

	**Evacuated tube systems** Evacuated tube collectors consist of rows of parallel transparent glass tubes, each containing an absorber tube covered with a selective coating. Selective coatings are made of materials which reduce radiation heat losses from the collector. This can significantly boost the efficiency of the collector. Sunlight enters through an outer glass tube and strikes an absorber tube, at which point it converts into heat energy. This heat is then transferred to a liquid flowing through the absorber tube. During the manufacturing process air is evacuated from the space between the two tubes, forming a vacuum. This vacuum greatly reduces heat loss from the system because there is no air to conduct the heat away. Evacuated tube collectors have the benefit of the sun shining directly on the absorber for most of the day. Also, by adding or removing tubes, systems can be modified at a later date to fit in with potential changes in the hot water requirement. They perform well in both direct and diffuse solar radiation, which is why they are especially effective in the UK climate. Whilst more efficient than the flatplate type, evacuated tube collectors are inherently more expensive due to the complexity of their design and manufacture.

Flatplate systems

Flatplate collectors are the most common systems for domestic water heating. They generally consist of an insulated metal box with a glass or plastic cover and a dark or black coloured absorber plate. The transparent cover allows the light to strike the absorber plate whilst reducing the amount of heat that can escape. To further minimize heat loss, the sides and base of the collector are usually insulated. The absorber plate is usually black because dark colours absorb more solar energy than light colours. Sunlight passes through the glazing and strikes the absorber plate. As with the evacuated tube collector, this has the effect of changing the incident solar radiation into heat energy. This in turn is transferred to the liquid passing through the collector. The tubes are arranged in parallel and attached to the absorber plate so that heat absorbed by the absorber plate is readily conducted to the liquid. Absorber plates are often made from copper or aluminium, being good heat conductors. Copper is more expensive, but is a better conductor and less prone to corrosion than aluminium.

In common with evacuated tubes, many flatplate collectors now have selective coatings to increase the temperature and efficiency attained compared to simple matt black absorber plates.

15.8.2 Evaluation of solar resource

See photovoltaic section

15.8.3 Performance

A DTI sponsored project tested eight solar thermal panels in a side by side test from January to July 2001. A summary of the results is shown below:

Name	System Type	Other info	Panel size m2	Annual Output MJ	Panel output kWhpa/m^2	Panel Efficiency %	Absorber Efficiency %
Suntube	Evacuated Tube	Electronic controls	2.653	3931	415	39	56
Solarmax	Evacuated Tube	Conventional	2.816	4142	412	38	54
ZEN Type D	Flat Plate	Drain back	3.100	4018	363	34	39
Solar Twin	Flat Plate	pv driven pump	3.187	3624	318	33	33
AES Type H	Flat Plate	Conventional	3.384	4461	369	34	39
Filsol	Flat Plate	Conventional	3.998	4864	341	32	38
Fieldway	Flat Plate	Conventional	4.114	4346	296	27	30
Energy Engineering	Flat Plate	Conventional	4.594	3853	235	22	28

Table 21: DTI project results

The results support many other studies and the manufacturer's claims that around 50-70% of a home's hot water requirements can be met from hot water produced in a suitably sized solar thermal system.

15.8.4 Costs

Typical domestic systems will cost around £3,500. It has been recently noted that some companies are attempting to charge up to £20,000 for domestic systems, there is no justification for such costs. Most panels come with a 20 year warranty and an expected 35 year life. It is very important to note that with the introduction of the Renewable Heat Incentive in April 2011 the payback of a solar thermal system will be of the order of six years. This will give approximately 6% rate of return on investment.

15.8.5 Building Design Considerations

Solar thermal panels are almost always mounted onto sloped roofs or on frames on flat roofs. Integrated solar thermal roof tiles are available, however these require large numbers of connections, which mean the system has many failure points.

15.8.6 Planning Considerations

Solar systems are generally not subject to planning restrictions, and are included as "permitted development". If the building is to be built in a conservation area or it is a development of a listing building or the site is in an area of outstanding natural beauty then the local planning department should be contacted. Likewise, if the panels are mounted directly facing a highway, permission will need to be sought.

It is important to note that if the property does not already have one, a hot water tank will need to be installed. This is a large weight and the building needs to be structurally sound to hold it. Additionally, the panels themselves are heavy and so the roof must be structurally sound to take this extra weight.

Solar installations should always be carried out by a trained and experienced installer. There will be a system, possibly an extension of MCS, set up soon.

15.8.7 Integration issues

Like PV systems, solar collectors provide optimum performance when positioned in direct sunlight and located on sloped roofs with a southerly orientation. Unlike PV cells however, the degree of offset from due south is not so critical, enabling correctly sized systems within approximately 45° of due south to provide a significant contribution to hot water demand. Again, panels should be angled 30°-40° from horizontal (Latitude less 20°C). During the summer months a typical SHW system can achieve between 80-100 per cent of hot water demand, although this will be considerably less in winter. High efficiency boilers should be used where applicable to provide auxiliary 'top up' heating of the domestic hot water supply.

15.8.8 Supply Chain

It is vital from a planning and grant/incentive perspective that any installer used for the installation of SHW is accredited under the Microgeneration Certification Scheme and that the products themselves are accredited under the same scheme.

A full list of suppliers and technologies can be found at:

http://www.microgenerationcertification.org

Regional support can be obtained from the following companies

Developers:

- Narec http://www.narec.co.uk
- ARUP http://www.arup.com/feature.cfm?pageid=299
- TNEI http://www.tnei.org.uk/
- North Energy http://www.northenergy.co.uk/

15.8.9 Rules of thumb and templates for site evaluation

See Section 17

15.8.10 Case Study

Solar thermal installations have been applied to many buildings in the North East, both domestic and commercial. At the Newcastle Great Park development solar hot water panels have been offered as an option to purchasers. Such installations provide up to 60% of the domestic hot water requirement over the year. The installations are neat and fit well to the roofline, particularly on new build.

Figure 17: House with solar thermal panel installed

15.9 Micro Hydro

15.9.1 Introduction

Of the total renewable energy generated in the UK, 0.8% is from small scale hydro (<5MW), and 6.7% from large scale hydro (>5MW). Within the large scale hydro pumped storage schemes are included which are used to compensate for large disturbances on the network by providing back up power, and also to provide time shifting of demand. Of course pumped storage systems are also users of energy, consuming 1% of the UK's supply in the pumping process.

The main advantage of hydro schemes is that they provide a relatively constant and predicted able output of energy, as opposed to the more weather dependent forms of renewable energy, although obviously drought and flooding will effect the systems.

Hydro schemes have provided energy for the milling of flour and in the early part of the industrial revolution for driving machinery. These sites may well be suitable for the fitting of modern micro-hydro schemes

15.9.2 Evaluation of hydro resource

The power in a moving body of water can be easily worked out using the equation

$$P = \rho g Q h$$

Where;

P	=	Power [Watts]
P	=	density of water (1000 kg/m^3)
g	=	acceleration due to gravity (9.81 m/s^2)
Q	=	volume of water passing per second [m^3/s]
h	=	height between inlet and outlet of system [m]

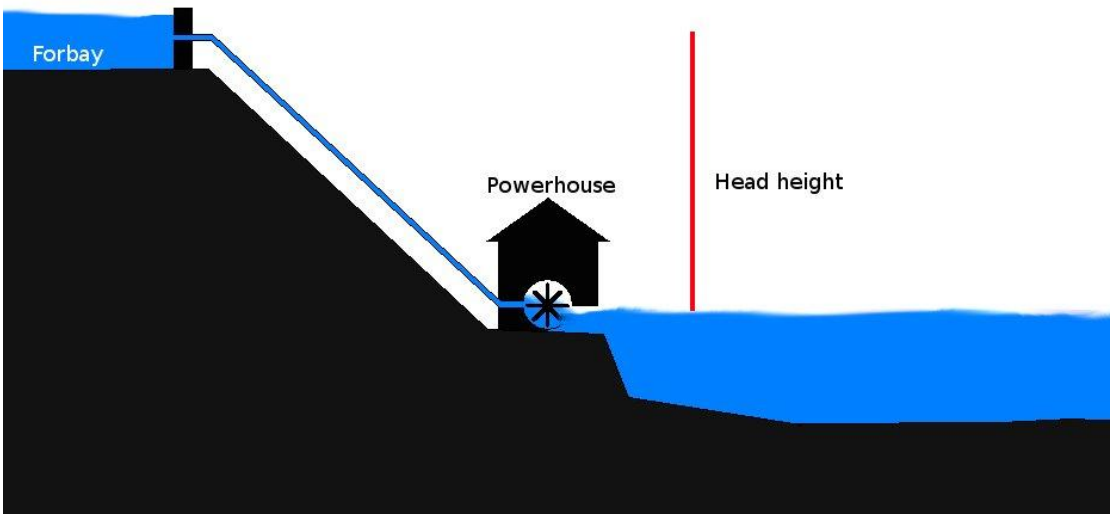


Figure 18: Hydroelectric system

So, for example, a flow rate of 1m^3/s dropping a height of 5 meters would result in a power output of;

P = 1000 * 9.81 * 1 * 5 = **49kW**.

So assuming this output is constant, over a year this would generate **430MWh**.

When evaluating the available resource, the flow rate will be influenced by rainfall, so an annual evaluation of flow rates would be beneficial, and while estimating the volume, knowledge of the river contours is essential. It should also be considered how much of the river can be diverted for the generation of electricity. If the river is tidal, this should also be considered in the evaluation of flow rates.

There are a number of different water take off configurations, including; dams, pipes, penstocks, weirs, canals, reservoirs. The effects of energy losses due to; bends, friction, turbulence, contraction/expansion and valves all need to be evaluated.

15.9.3 Cost

It is difficult to define the cost of hydro systems as simply as the other renewables in this document, as it is incredibly site specific. However, according to the Energy Savings Trust for low head systems (not including the civil works), costs may be in the region of £4,000 per kW installed. For systems greater than 10kW peak output the cost per kW would be less.

Medium head systems cost about £10,000 and then about £2,500 per kW up to around 10kW. Therefore it can be said a typical 5kW domestic scheme might cost £20-£25,000. Clearly larger systems will cost less per kW.

15.9.4 Building Design Considerations

Small hydro schemes, as would be encountered in the North East, are likely to be integrated into existing water mill structures. The main considerations of the system are the noise, the safety implications and the implications of flood water damaging the building. All of these items should be considered by the system designer.

15.9.5 Planning Considerations

A micro-hydro scheme will need a number of different permissions, including planning (from the local authority) and water extraction/return permits (from the Environment Agency).

General points to look for are:

- Water extraction licence
- Wildlife [fish, plant, birds, wildlife] issues – How much will be extracted & what mitigation is being made to protect the local wildlife, in particular change of habitat, noise. loss of vegetation downstream sediment deposition. If the planning authority considers the system to have a significant impact on the environment the planning application must be accompanied by an Environmental Statement.
- Extraction rights & land ownership (i.e. who owns the river bed & the rights – this need not be the mill owner)
- Water quality & potential contamination (or mitigation) issues
- Agriculture & forestry if new dams are built
- Landscape (visual amenity) impacts

- Planning permission for the new structures
- Public opposition
- Environmental impact - CO_2 savings
- Its demonstration & educational value

15.9.6 Supply chain

The best source of information is probably http://www.british-hydro.org/mini-hydro/listing.asp?infoid=388 for micro hydro suppliers. Regional support can be obtained from the following companies

Developers:

- ARUP http://www.arup.com
- Entec http://www.entecuk.com

15.9.7 Rules of thumb and templates for site evaluation

See Section 17

15.10 Heat Pumps

15.10.1 Introduction

A heat pump moves heat. It can either move heat from outside to inside (to provide heating inside a building) or from inside to outside (to provide cooling inside a building). Fridges and freezers are heat pumps that move heat from inside to outside the appliance.

This is how they work:

When a gas is compressed, it will heat up, when it expands it will cool down. A heat pump uses this property on a gas called a refrigerant, which *is chemically unreactive and has a boiling point and condensing point close to the temperatures the heat pump operates at.*

The system works thus:

1) Refrigerant is compressed, hence heating it up. This is done by a compressor, which uses electricity.
2) The gas is cooled in a heat exchanger, which takes the heat from the refrigerant to heat the building. Generally the heat exchanger will heat water to pump around the building.
3) The refrigerant goes through an expansion valve and is cooled by expanding
4) This cooled refrigerant goes to a another heat exchanger, where it takes heat from a gas/air heat exchanger (air source heat pump) or a gas/liquid [water/glycol mix for ground/water] heat exchanger. The air or glycol heats up the refrigerant gas to around 9ºC or so, prior to it being compressed again.

For ground/water heat pumps, the glycol is pumped round a buried pipe either in the ground [ground source heat pump] or in a river/lake/sea [water sourced heat pump]. For an air source heat pump, outside air is blown over the heat exchanger. This represents the other 75% of the energy used to heat the building and is a form of stored solar energy and thus is completely renewable.

Because heat pumps generate low temperature hot water (35ºC-55ºC) compared to the 60ºC-70ºC normally found in building heating systems, a large surface area is needed for the radiators. This can be achieved using under floor heating, or large radiators. Additionally, fan assisted radiators can be used to ensure there is adequate heat transfer.

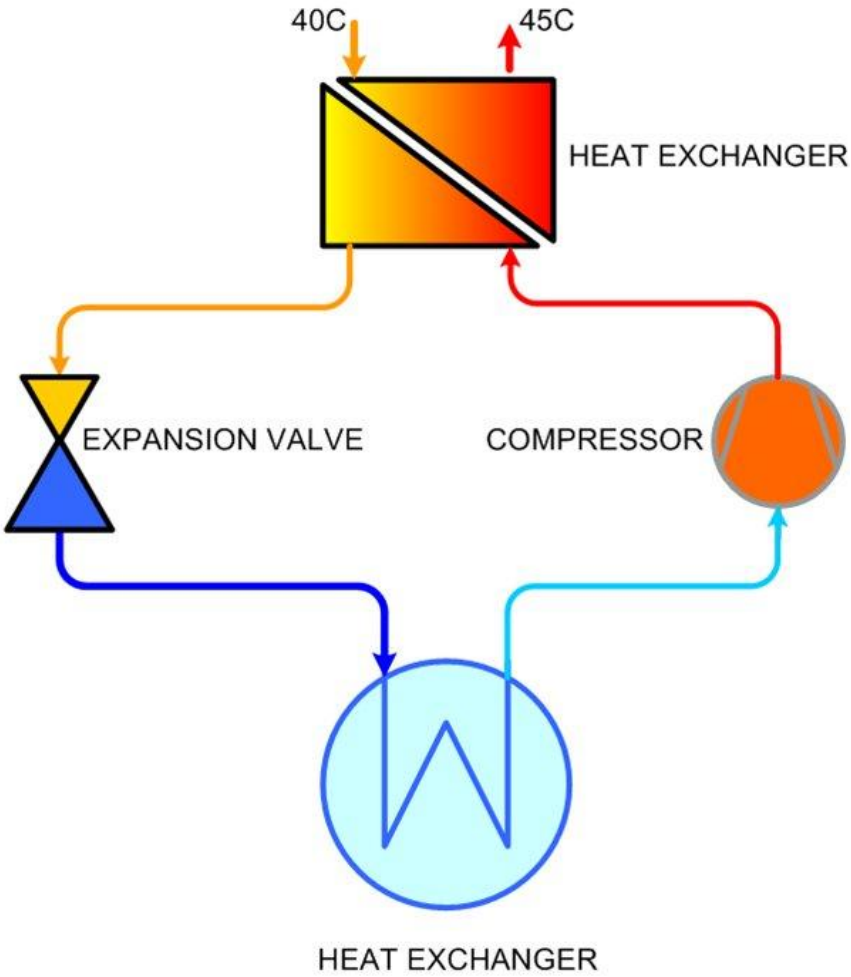


Figure 19: Basic operation of a heat pump

15.10.2 Performance

As explained above, heat pumps will use energy for pumping refrigerant and water, as well as for the compressor. This will be in the form of electricity. To measure the performance of a heat pump, the energy it extracts from outside (be it air, ground or water) is compared with the electricity used. For example, if a heat pump takes twice as much energy from outside as it uses, then it is said to have a Coefficient of Performance of 2. This is not efficiency, as it is taking energy from outside of the system.

15.10.3 Flow Temperatures

System efficiencies are affected by the output temperature of the hot water (the lower the better) and the input temperature of the external heat source (the higher the better). While the air temperature used as the input to the heat pump can vary say between +15°C and -15°C, ground source heat pumps have a nearly constant input temperature of +10°C. This makes them more efficient. Air source heat pumps have typical a COP of 2-3.5. The variation of COP against ambient temperature and flow temperature is shown below.

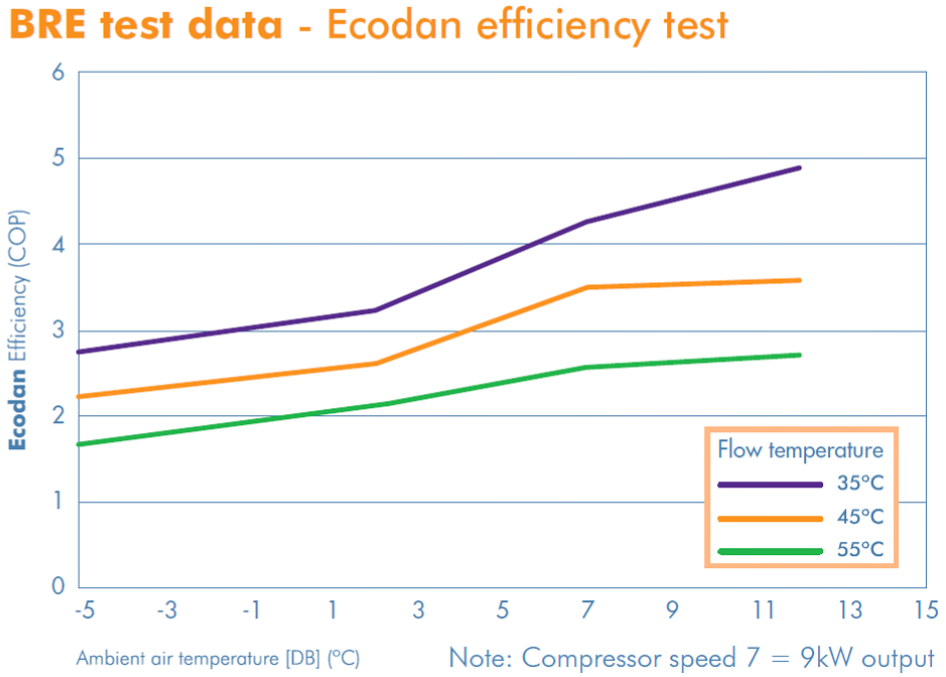


Figure 20: BRE test data for a Ecodan Air Source Heat Pump

15.10.4 Heat Pump Vs Gas

It is very important to ensure the right choices are made when installing a heat pump. One of the most traditional mistakes is to put in a badly designed heat pump system which could cost the consumer more than their previous heating system. Specifically, this document will now talk about comparing using gas with a heat pump.

There are questions over the suitability of heat pumps in comparison to gas boilers. According to SAP 2009, the carbon emissions from using electricity are 0.568kgCO_2/kWh, whereas the carbon intensity of natural gas is 0.209kgCO_2/kWh. Therefore for a heat pump systems to be more carbon efficient than gas it must have a COP of greater than 0.568/0.209=2.72. This is around the value of the COP of a large number of Air Source Heat pumps, and above that of a badly installed heat pump. Therefore, this shows that ASHP are not a good idea in an urban environment when compared to an efficient gas combi-boiler. In such cases perhaps gas fired micro-CHP should be considered for improvements, or solar thermal. However, when looking at homes off the gas grid heat pumps are a good idea.

Ground Source have much higher levels of COP, however, they are extremely expensive to install, so probably only a good idea if there is already building work being in process, and therefore less initial groundworks necessary.

15.10.5 Types of Heat Pump

Air Source Heat Pump
An air source heat pump looks very much like an air conditioning system. Essentially it is simply cooling the air near the building by taking the heat inside, so acting as an air conditioner in reverse. The devices have a fan outside to suck air inside, from which the heat is taken.

Ground Source - Open Loop System
A groundwater-based open loop system is one whereby groundwater is extracted from a source. This is typically a drilled water well, but can also be a spring, a flooded mine, a dug well, or a groundwater-fed lake. A main consideration for this type is the disposal of the water afterwards, which despite no changes occurring to the water beyond temperature, is subject to a large amount of government legislation because of issues around possible discharging of contaminated water into open water courses.

Ground Source - Vertical Closed Loop System
Vertical closed loop schemes involve sinking loops ("u-tubes") of polyethene pipe into drilled boreholes. A thermal contact between the pipe and the walls of the borehole is provided either by (a) a natural column of groundwater, (b) a granular backfill or (c) most commonly, by a thermally enhanced "grout". This grout may be a specially formulated mixture of bentonite and silica sand, or it may be a thermally enhanced cementitious grout. A well formulated cementitious grout usually possesses better frost resistance than a noncementitious bentonite-based grout. A chilled "carrier fluid" (usually a solution of antifreeze) is circulated through the buried pipe. This fluid extracts heat from the soil and conveys it back to the heat pump.

Ground Source - Horizontal Closed Loop System
Horizontal closed loop schemes typically involve burying lengths or coils ("slinkies") of polyethene pipe underground at depths of 1.2 to 1.5 m. A chilled "carrier fluid" (usually a solution of anti-freeze) is circulated through the buried pipe. This fluid extracts heat from the soil and conveys it back to the heat pump.

15.10.6 Prices

For GSHPs, borehole costs would likely be of the order £40 per linear metre including pipe and grouting, but the costs do vary enormously (£25 - £80 according to ground conditions). The GSHP units themselves are a few thousand pounds. The costs for a system are given in Table 22. The heat pump requires 10m of slinky per kW and therefore the length of trench to be dug can be easily calculated. Trenches should be 2m deep and 5m apart – 50m^2/kW. Bore holes cost between £500 and £2000 each, and will provide 3-7kW for bore holes at a depth of 30-70m with a temperature at 50m depth of 13ºC. Boreholes should be 1.5m from buildings and 5m from each other – 3–8m^2/kW

System Type	Ground coil costs [£/kW]	Heat pump costs [£/kW]	Total system cost [£/kW]
Horizontal	250-350	350-650	600-1000
Vertical Indirect	450-600	350-650	800-1250

Table 22: Indicative capital costs from ground-to-water heat pump systems(35)

Cost wise, to give an idea, a 5kW Mitsubishi ASHP is £1800 but this does not include a hot water cylinder and some of the controls you would need, so it would be best to allow another £800 on top of this figure. Installation cost would be similar to a gas boiler.

15.10.7 Cost

Typical costs for heat pump systems are as follows:

Type & Model	Price (Plus VAT)	Source & Date
Heat King 8kW Air Source Heat Pump	£2,800	Quote dated June 06
Kensa 8kW Ground source heat pump inc slinky/manifold	£4,509	Kensa web site – March 07 (2006 price list)
Kensa 300kW Ground source heat pump inc slinky/manifold	£65,800	Kensa web site – March 07 (2006 price list)
8kW Ground Source Heat Pump without slinky/manifold	£3,579	Kensa web site – March 07 (2006 price list)
300kW Ground Source Heat Pump without slinky/manifold	£36,100	Kensa web site – March 07 (2006 price list)

Table 23: Heat pump costs

Estimated installed costs are as follows:

Size	Trenching/ bore holes	Pipes & manifolds	Heat Pump	Total	Area needed for installation
8kW Slinky	£500	£930	£3579	£5,009	400m2
8kW Bore Holes	£2,000	£270	£3,579	£5,849	50m2
300kW Slinky	£12,000	£29,700	£36,100	£77,800	15,000m2
300kW Bore Holes	£21,500	£5,000	£36,100	£62,600	1,075m2

Table 24: heat pump installation costs

15.10.8 Building Design Considerations

Heat pump systems produce low temperature hot water, so heating system need to be designed to ensure adequate heat transfer into the building. In practice, this means under-floor heating systems; fan assisted or oversized radiators.

Air source heating systems have a small foot print and can be floor or wall mounted. They are available in sizes up to 12kW. Multiple systems could be used to heat larger buildings, however massing of these devices may lead to noise issues and adequate air flow across devices must be maintained.

Ground/water source heat pumps based on slinky technology can be installed wherever the bed-rock allows a trench 2m deep to be dug to bury the slinky. Water based heat pump installations do not need to bury the slinky this deep. Slinkies should not be buried where tree roots or other land disturbance types will take place.

Bore hole systems rely on the water table refreshing the heat around the buried heat exchanger, so the bore hole must be of sufficient depth to reach the water table. It is also important that the bore hole does not allow contamination of water from below or above. Clearly bore hole installation and design is a specialist topic and support should be sort prior to embarking on this sort of design.

Heat pumps can be a significant electrical load and so this must be factored into the building services design.

15.10.9 Planning and Regulatory Considerations

Air Source
Planning permission is required for Air Source Heat Pumps, however the exact requirements are under review, and so unclear. It is thought that it will be necessary for Air Source Heat Pumps to be MCS approved for planning purposes.

Ground Source
There are a large number of regulatory issues faced by Ground Source systems, however, very little which falls within the remit of the planning authority. As part of the permitted development planning rules in the Microgeneration Strategy, no planning permission is required for Ground Source Heat Pumps. The regulatory issues include potential health and safety risks, environmental risks and risks to third parties. Essentially, any planned Ground Source Heat Pump installation should contact the Environment Agency as soon as possible in order to receive advice on what permissions need to be sought.

Additionally, the potential Ground Source Heat Pump operator should contact the appropriate local authority, the Health and Safety Executive or a legal professional. If it looks to be breaking a coal seam advice must also be sought from the coal authority, as it may possibly be mined in the future. Finally, advice should be sought from the British Geological Survey (in the spirit of Section 198 of the Water Resources Act 1991).

15.10.10 Integration issues

Heat pumps, on start-up can draw significant levels of electrical power. This should be factored into the electrical supply design, and may cause within building voltage dips on start-up. These dips could trip G83 protection on other electricity generating renewable devices such as wind turbines, PV panels and CHP units.

15.10.11 Supply chain

There are a range of specialists and micro hydro system suppliers available from the hydro trade association web site http://www.heatpumpnet.org.uk/. Region based support can be obtained from the following companies:

- McQUAY (UK) LTD http://www.mcquay.com
- Geowarmth http://www.geowarmth.co.uk

15.10.12 Rules of thumb and templates for site evaluation

See Section 17

15.10.13 Safety Issues

A further issue to consider, which also applies to solar thermal systems, is that of Legionella. This bacteria leads, amongst other things, to Legionnaires Disease. The bacteria is in all drinking water, but only becomes an issue when water is left to stand at certain temperatures. In order to kill off the bacteria water must be heated above 60°C on a regular basis to pasteurise it. This will reduce the effective COP of the whole

system. An alternative would be to use a system with two water tanks and a heat exchanger, acting like a combi-boiler.

15.10.14 Case Study – Groundwork South Tyneside and Newcastle Eco Centre in Hebburn

The Eco-Centre at Hebburn uses a ground source heat pump operating in the basement using water drawn from a 100m borehole to provide all the space heating requirements for the building. Underfloor heating is used since this is a more effective means of transferring heat from the relatively low temperatures generated by heat pump systems. The Groundwork installation forms part of an integrated approach to low energy demand that includes passive solar design through building orientation and construction, use of solar thermal, PV and wind energy with the result that the complex is a net exporter of energy.

15.10.15 Case study: Bede Academy, Blyth

Bede Academy is an Emmanuel Schools Foundation school and provides secondary education for up to 1150 pupils. Specialising in Engineering and Enterprise, the school focuses on extending conventional perceptions of engineering by providing specialist insights into aspects of biotechnology, environmental science and recycling technologies, sound and computer network engineering, medical and animal science, and naval and automotive systems and design. Bede Academy is a new build and opened in September 2009.

Figure 21: Bede Academy ground source heat pump system installation

The school has 2 x Dimplex SI 75 TER+ heat pumps, serviced by vertical ground collectors in 40 boreholes.

The scheme involves two reverse cycle heat pumps in separate roof top plant rooms serving air handling units providing either heating or cooling. The heat pumps are switched on by the Building Management System which also signals whether they are to provide heating or cooling. The heat pumps are not weather compensated and run at a fixed return set point in heating mode of 40°C. In cooling mode the return temperature is 10°C which creates a flow temperature of around 7°C.

Each heat pump is served by its own ground loop array consisting of 20 x 90 metre boreholes, each with a single loop of 32mm pipe. Two manifold chambers on the edge of each borefield reduce the 20 separate circuits into a single 90mm flow and return pipe which routes to the plant room. Because of varying distances from each borehole to the manifold chambers, flow regulators on the pipework balance the flow to ensure equal flow rates through each borehole.

The design and installation work for the project was carried out by the regional ground source heat pump experts Geowarmth.

15.11 Hydrogen

It is very important to state that hydrogen is not an energy source, it is merely a method of energy storage, much in the same way that batteries are not energy generators, they just store energy. So hydrogen power can be considered simply as very special types of batteries.

15.11.1 What is Hydrogen?

Hydrogen is the most common element in the universe, and also the lightest. It is abundant in many compounds, especially organic ones. It is a highly flammable gas with no taste, smell or colour. However, it is also extremely energy dense, 143 MJ/kg, allowing large amounts of energy to be kept in a small volume.

15.11.2 How is it produced?

Currently, most hydrogen used worldwide is produced from natural gas, a fossil fuel. There is much talk of using hydrogen within the low carbon economy, for which producing it from fossil fuels does not make sense. It can also be produced from water, which is made up of hydrogen and oxygen atoms. Water molecules are split using an electrolyser. When hydrogen is reacted to release energy it combines with oxygen to procure water as a waste product

15.11.3 How is it used?

Fuel Cells: Fuel cells strip protons and electrons from hydrogen atoms provide a battery style electro-chemical reaction which generates heat and electricity. To supply the hydrogen, fuels rich in hydrogen (e.g. natural gas) are usually processed at the fuel cell to deliver the hydrogen. Fuel cells are currently expensive but receiving substantial R&D investment so could well reduce in cost soon. As the heating requirements for buildings reduce, the hot water demand and electrical demand may be best met by fuel cell CHP units. Most fuel cells are quite small although there are examples over 1MW.

Hydrogen Engines: Hydrogen can also be burnt as a fuel in a hydrogen engine.

Transport: Hydrogen is thought to be increasingly important in the future as a transport fuel. Therefore planners may come up against large hydrogen storage facilities for this fuel. Possibly co-located with electrolysers and renewable energy systems.

Table 25: hydrogen systems

15.11.4 What are the safety aspects?

Hydrogen must be treated very carefully. It is a gas with no smell and burns with an invisible flame. However, there should be no problems if it is treated correctly.

It should be noted that hydrogen is lighter than air, so any leak will release gas upwards. Therefore it should

not be stored underground, as this would trap the gas to a point where it may concentrate into an explosive density.

As hydrogen installations are still a new thing, the safety legislation is evolving around them. There are minimum clearances in the BCGA CP33 guide for the bulk storage of hydrogen. However, clarification must be sought as to if a particular development should adhere to these rules.

HSE should be contacted for hydrogen installations, giving them information on the storage pressure and quantity. Additionally, thought must be placed on security of the site. For installations in the North East, it would be wise to seek advice from the Centre for Process and Innovation (CPI).

15.12 Wave and Tidal

Wave and Tidal energy devices are currently only in the prototyping and demonstration stage. This means there are many different technologies being developed which operate in a multitude of ways. It is unlikely that planners will find any developments with intentions of using wave or tidal devices in the next few years. Any installations which do occur in the North East are most likely to be demonstration projects, not fully commercial systems.

With regard to offshore devices, the Crown Estates own the ocean floor around the UK, so many planning considerations will be dealt with by them as opposed to regional planning authorities. However there may be issues with laying electrical cables onto land, or possibly the development of new substations.

There may be options for tidal and wave devices in the Tyne. This would clearly be under the remit of planning authorities in the North East.

16 Important Regulation for Renewables

16.1 Microgeneration Certification Scheme

The Microgeneration Certification Scheme (MCS) exists to ensure that microrenewable technologies are of a reasonable standard and installed by competent installers. Although the scheme is not compulsory, devices which are not MCS accredited and installed by MCS accredited installers will not be allowed to claim with the Feed–in Tariff or the Renewable Heat Incentive. Additionally, the planning rules for MCS accredited devices are different to those for other microrenewables.

http://www.microgenerationcertification.org/

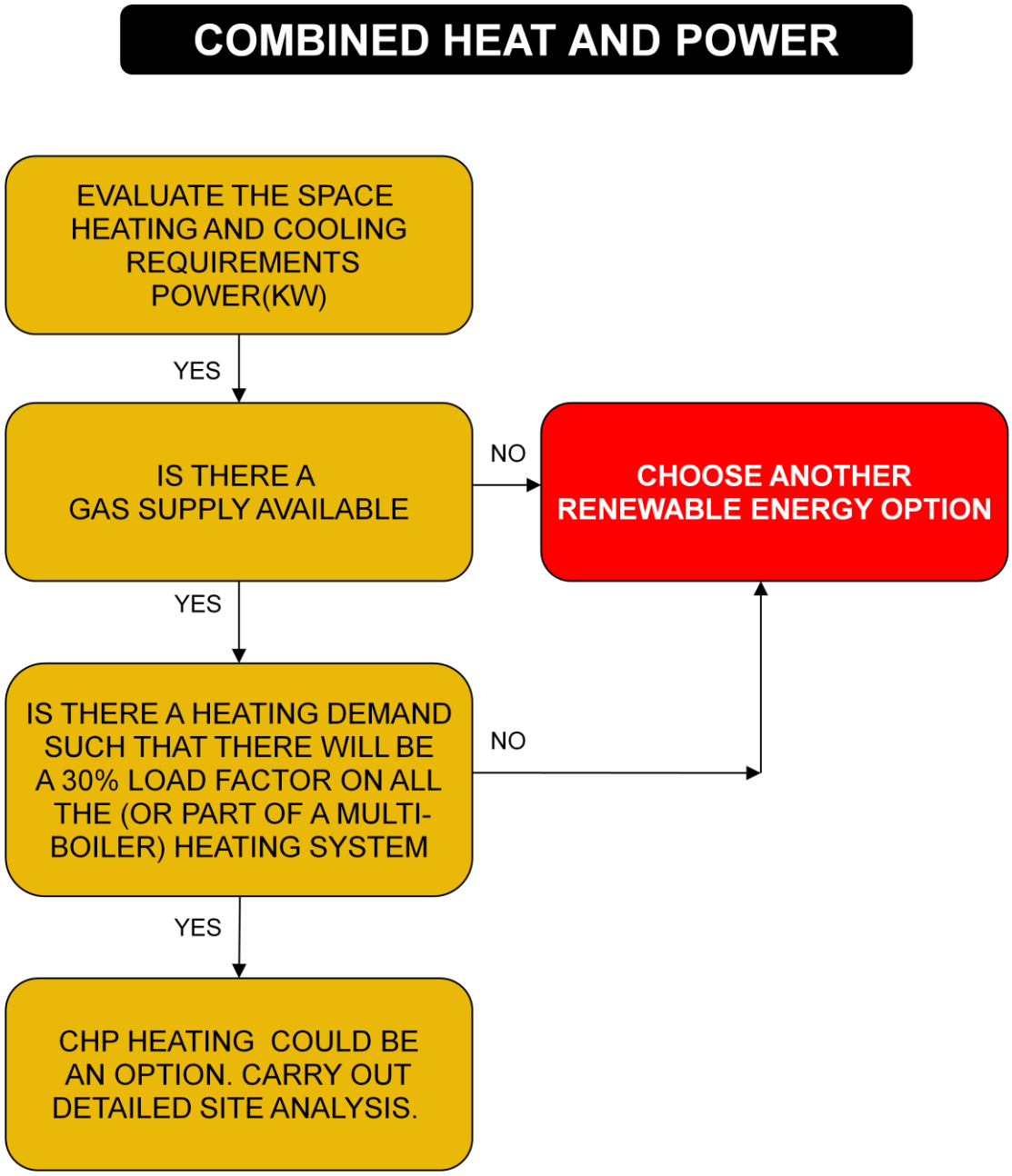
16.2 Electrical Connection – G83/1 and G59

When connecting any load, store or generator to the grid, this will have impacts on the surrounding electrical network, and hence the Distribution Network Operators.

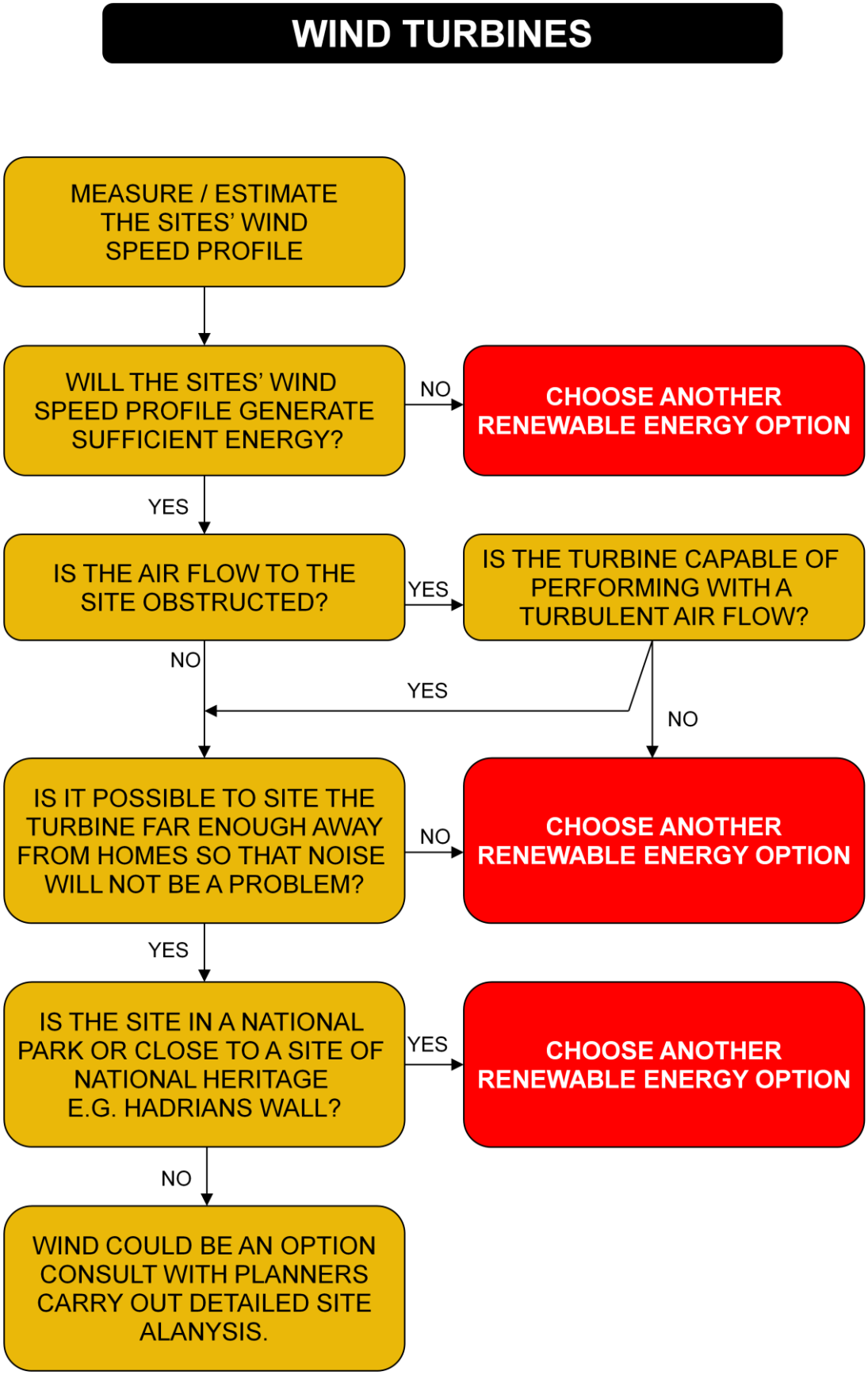
For systems to be connected to the grid, it is necessary to comply with the Energy Networks Association Engineering Recommendations. There are two relevant documents: G83/1 for installations up to 16A per phase and G59/1 for installations over 16A per phase. Where G83/1 applies (3 phase PV installations up to about 11kWp), there is no requirement to get prior permission from the Distribution Network Operator (DNO) so long as the technical requirements specified in G83/1 are followed. The DNO is merely notified after the installation has been completed. With larger installations, it is necessary to engage with the DNO at an earlier stage and have them approve the proposed connection design before installation. They also require the installation to be witness tested and the costs vary from one DNO to another. For the system suggested for Simonside it would be necessary to carry out a G59 installation. This is a service which Narec can offer commercially.

17 Flowcharts & Rules of Thumb

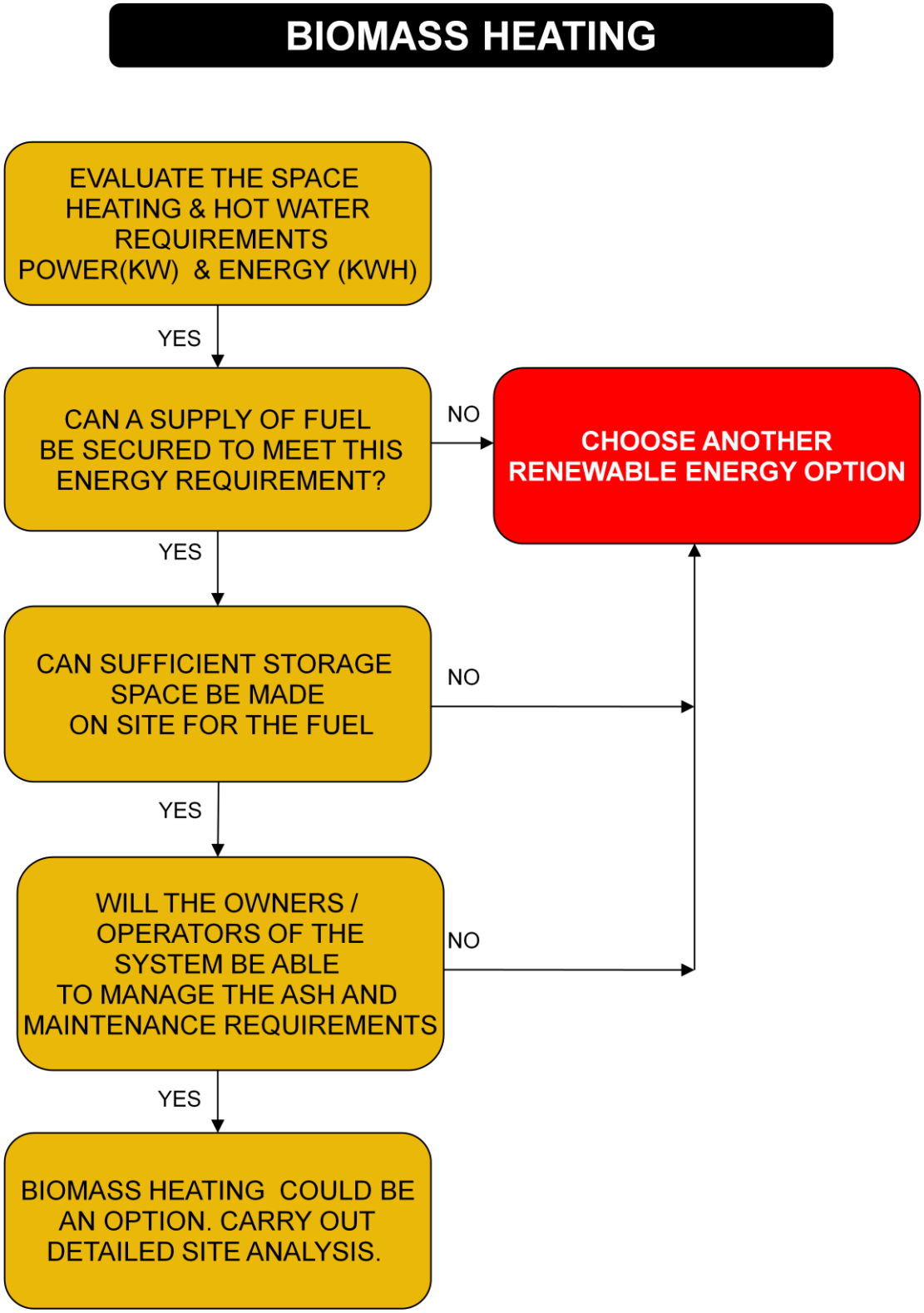
17.1 Combined Heat and Power



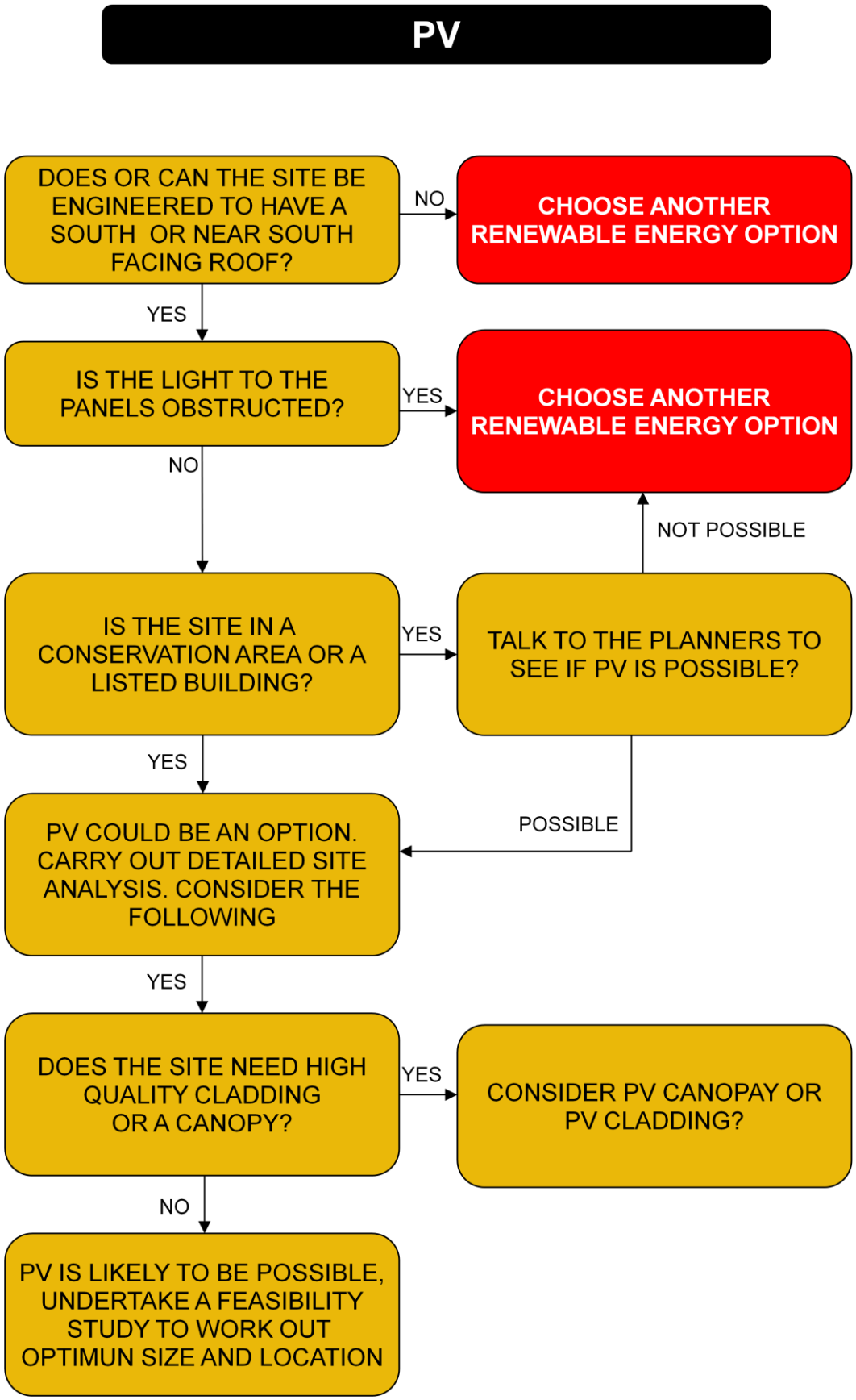
17.2 Wind


WIND TURBINES
MEASURE / ESTIMATE THE SITES' WIND SPEED PROFILE
WILL THE SITES' WIND SPEED PROFILE GENERATE SUFFICIENT ENERGY?
NO
CHOOSE ANOTHER RENEWABLE ENERGY OPTION
YES
IS THE AIR FLOW TO THE SITE OBSTRUCTED?
YES
IS THE TURBINE CAPABLE OF PERFORMING WITH A TURBULENT AIR FLOW?
NO
YES
NO
IS IT POSSIBLE TO SITE THE TURBINE FAR ENOUGH AWAY FROM HOMES SO THAT NOISE WILL NOT BE A PROBLEM?
NO
CHOOSE ANOTHER RENEWABLE ENERGY OPTION
YES
IS THE SITE IN A NATIONAL PARK OR CLOSE TO A SITE OF NATIONAL HERITAGE E.G. HADRIANS WALL?
YES
CHOOSE ANOTHER RENEWABLE ENERGY OPTION
NO
WIND COULD BE AN OPTION CONSULT WITH PLANNERS CARRY OUT DETAILED SITE ALANYSIS.

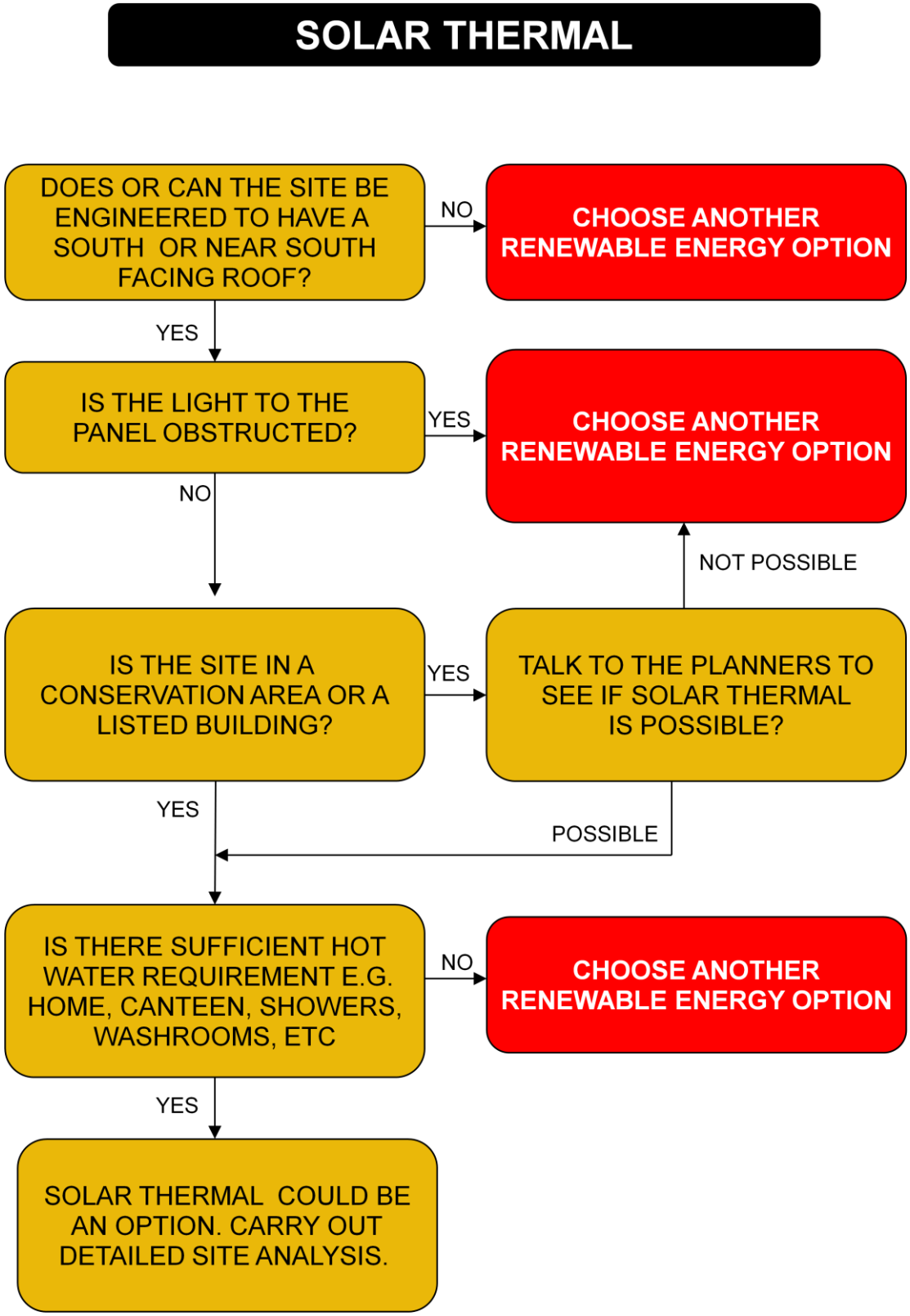
17.3 Biomass Heating



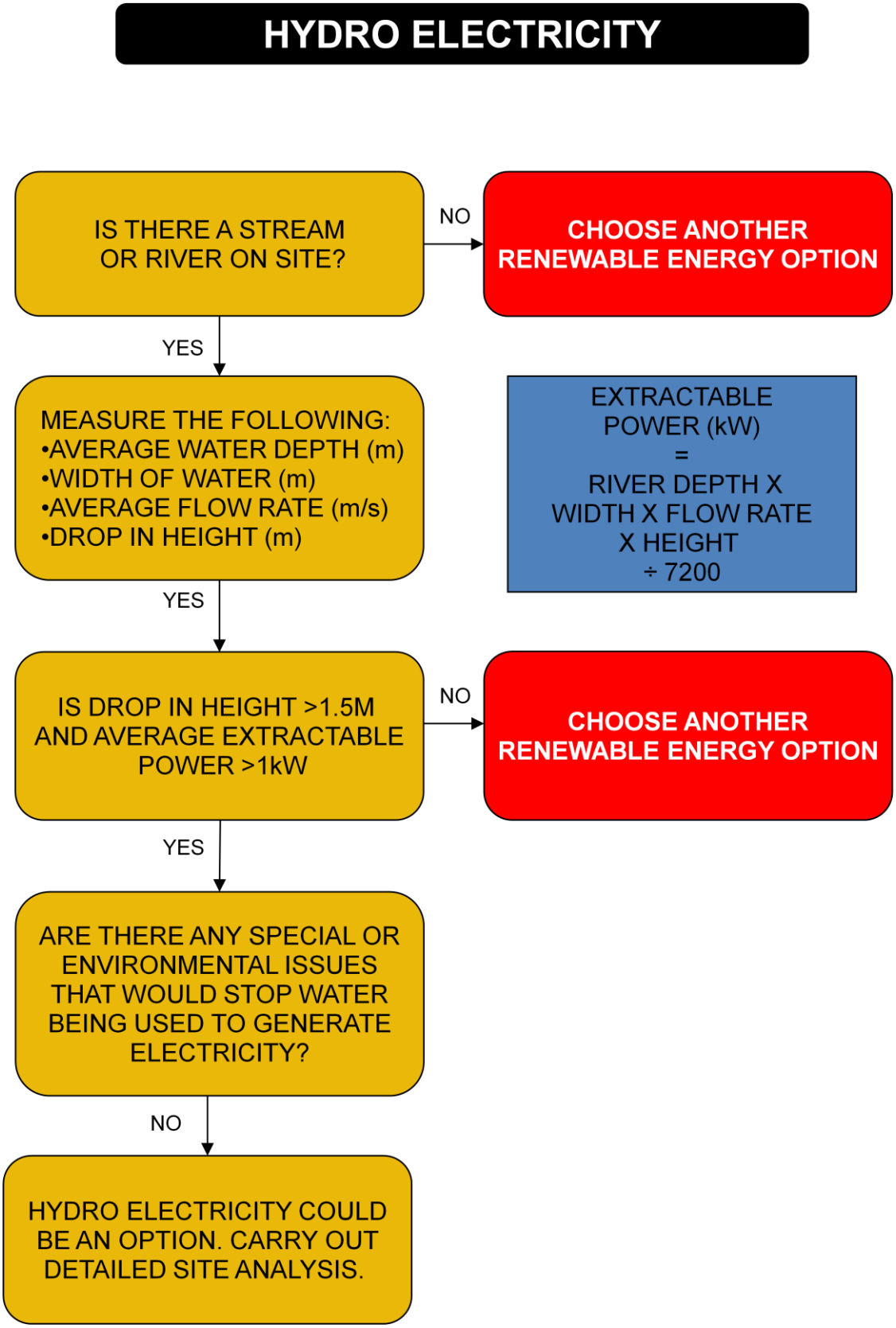
17.4 PV


PV
DOES OR CAN THE SITE BE ENGINEERED TO HAVE A SOUTH OR NEAR SOUTH FACING ROOF?
NO
CHOOSE ANOTHER RENEWABLE ENERGY OPTION
YES
IS THE LIGHT TO THE PANELS OBSTRUCTED?
YES
CHOOSE ANOTHER RENEWABLE ENERGY OPTION
NO
NOT POSSIBLE
IS THE SITE IN A CONSERVATION AREA OR A LISTED BUILDING?
YES
TALK TO THE PLANNERS TO SEE IF PV IS POSSIBLE?
YES
POSSIBLE
PV COULD BE AN OPTION. CARRY OUT DETAILED SITE ANALYSIS. CONSIDER THE FOLLOWING
YES
DOES THE SITE NEED HIGH QUALITY CLADDING OR A CANOPY?
YES
CONSIDER PV CANOPAY OR PV CLADDING?
NO
PV IS LIKELY TO BE POSSIBLE, UNDERTAKE A FEASIBILITY STUDY TO WORK OUT OPTIMUN SIZE AND LOCATION

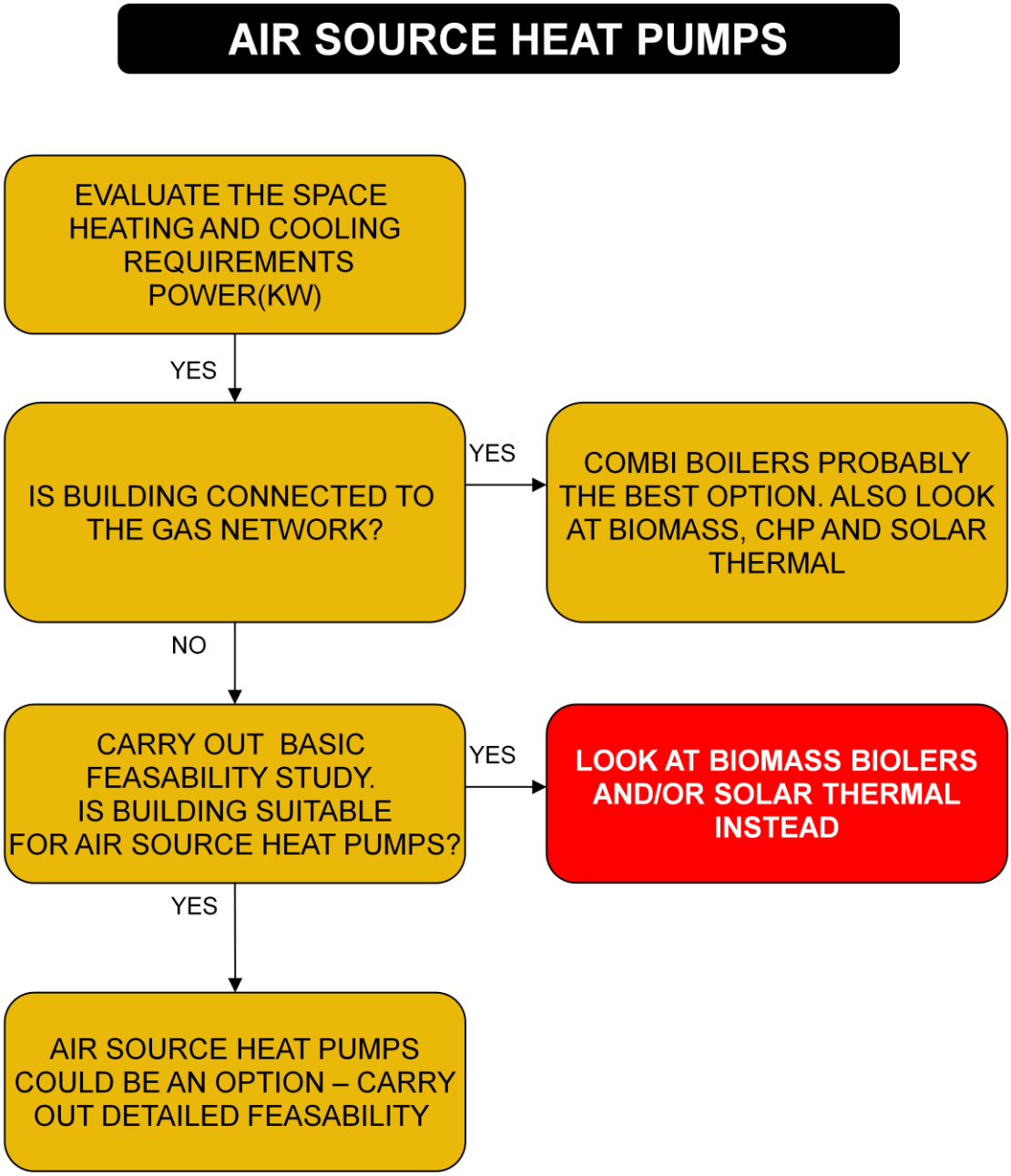
17.5 Solar Thermal



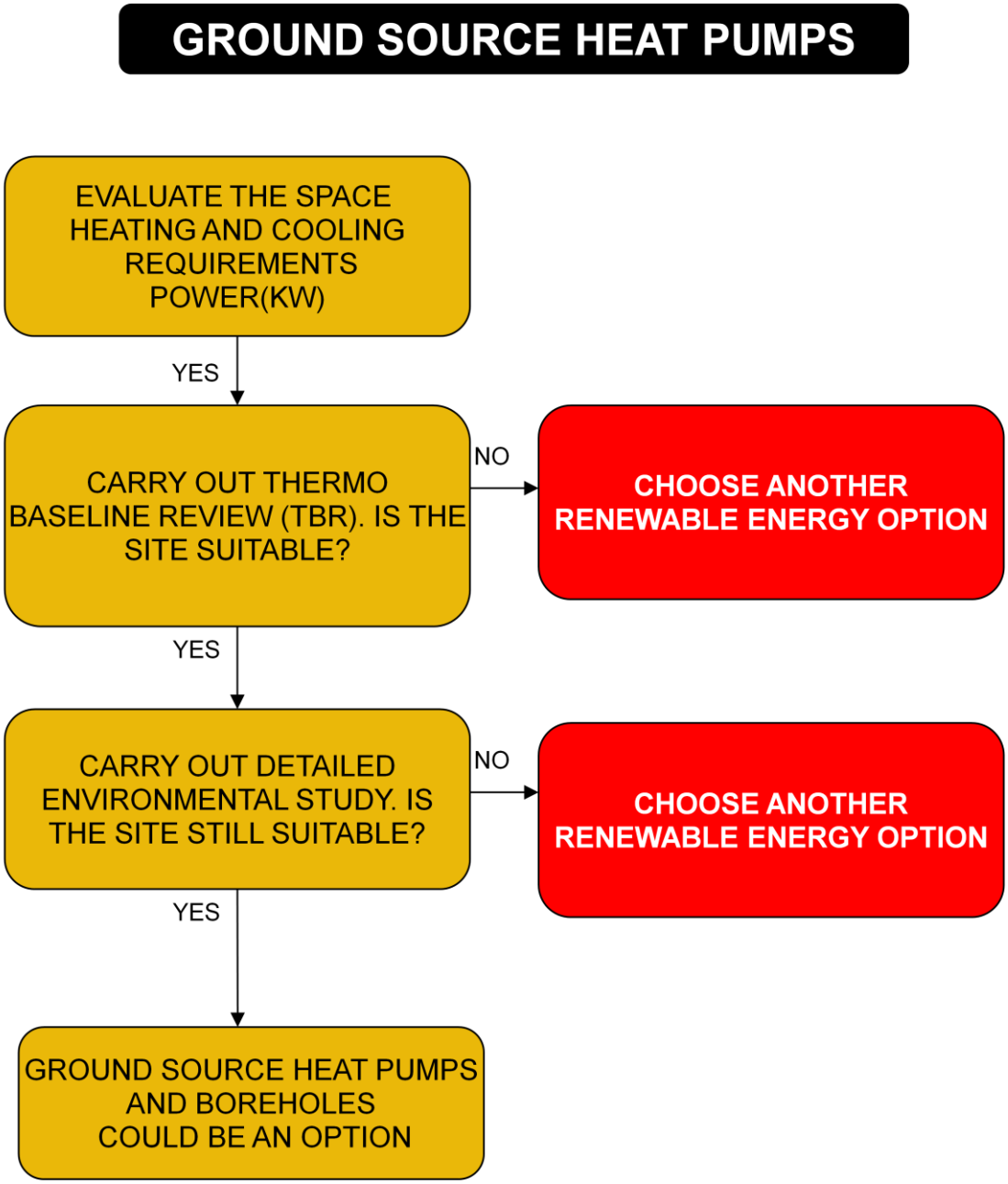
17.6 Hydro Electricity



17.7 Air Source Heat Pumps



17.8 Ground Source Heat Pumps



18 Energy Service Companies (ESCos)

Energy Service Companies (ESCos) are a different financial model for the development of energy sales. With the current model in the UK the energy companies sell a product, mainly electricity or gas, to the consumer, who then consumes. This model encourages the energy provider to sell as much product as possible, and hence is not interested in energy efficiency or savings. Any energy savings are relying on the initiative of the customer. The customer will most probably not be aware of the full range of products, grants or possibilities for their building, and may not have the capital to initially invest.

The ESCo model incentivises energy savings; Instead of selling a product, the company will sell comfort. Therefore, all the customer is paying for is to ensure their building is heated adequately and they have a supply of domestic hot water. In this case, it is to the advantage of the company to ensure that the minimal amount of product is used, as it is expensive. It is in their interests to insulate buildings as much as possible, and ensure that all energy saving measures are implemented. Additionally, to take advantage of the Renewable Heat Incentive and Feed-In tariff the company can install microrenewables for the consumers. This methodology means a company with existing capital can take advantage of the microrenewables.

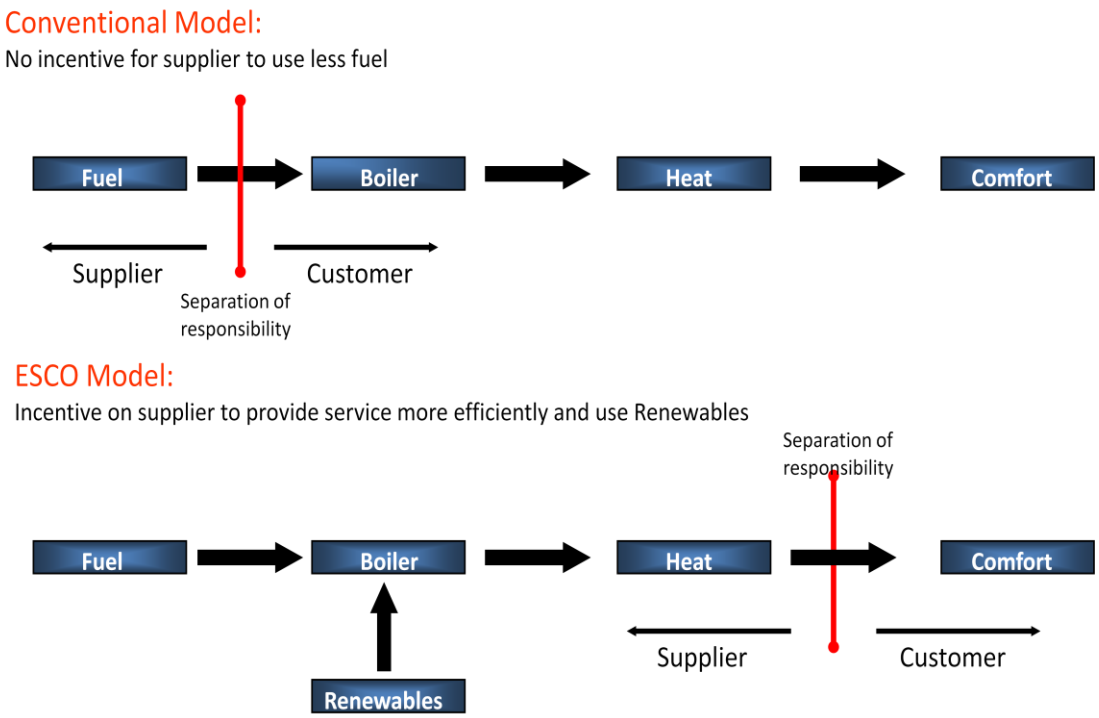


Figure 22: ESCo model

19 Case Studies

19.1 Planning & Renewables Case Study

PRIMARY SCHOOL – NEW BUILD

Hetton Lyons Primary School located in the Houghton le Spring undertook a re-build programme. The new school building was designed to produce an environment where a positive contribution to learning and attainment is achieved.

Figure 23: Hetton Lyons Primary School

The enhanced facilities at Hetton Lyons aimed to provide resources to raise standards and provide new and extended opportunities for pupils, their parents and the community. The primary school set aims and objectives for this programme to encourage the development of a school suitable for 21st century learning, with conservation and environmental issues being an integral part of the design. The new school also developed models of good practice to promote economic and environmental sustainability. The school community benefited from their new building for both its technological and personalised environment to maximise pupil attainment and good health.

The project brief for the re-build programme stated that attention will be paid to sustainable design taking particular attention to the local environment and whole life cycle costs. The client therefore requested the new school design to be assessed under the BREEAM schools scheme with a goal of achieving a Very Good rating. This will ensured that environmental targets have been set for the new school building. This process also provided a useful tool to help designers demonstrate the environmental performance of the design.

To meet these aims and objectives, steps were taken to encourage features that help reduce the CO_2 emissions from the school and reduce atmospheric pollution by encouraging locally generated renewable energy to supply a significant proportion of the building's energy demand.

Figure 24: Hetton Lyons Primary School elevation

After carrying out a feasibility study, the design team identified that a 50kW biomass fuel boiler used as the lead boiler to cater for the base load in conjunction with gas fired condensing boilers would achieve 10% of the heating load. The feasibility study also identified that a 6kW Proven wind turbine, connected to the grid, and at its maximum estimated rated output could also achieve 10% of electricity requirements. It was estimated that these 2 technologies will reduce emissions by 15 tonnes of CO_2 per annum.

The design outcome therefore delivered 10% of heating and electrical load from renewable sources.

A number of other sustainable features incorporated and are summarised in the following table:

Feature	Advantages
Sedum Roof covering to Children's Centre	Improved thermal performance, reduced rainwater run off, biodiversity, better appearance.
Enhanced insulation above Building Regs minimum values. (Walls U 0.26 instead of 0.35; roof U 0.23 instead of 0.25)	Energy conservation
Composite aluminium / timber windows	Energy conservation
Use of mineral wool insulation instead of foamed plastic	Less oil feedstock/pollution in manufacture
Carpets with higher natural fibre content	Less oil feedstock/pollution in manufacture
FSC Certified timber and timber products.	Confidence that timber has been legally and sustainably logged.
Use of recycled local slate over cheap Chinese or Spanish slate	Lower environmental impact of transport. Confidence the slates have not been quarried by children.
Passive ventilation system	Improved air quality without need for powered fans. Lower long term running costs.
Rainwater harvesting to supply WC's and urinals.	Lower water consumption and charges.
Biomass boiler	Energy conservation
Wind turbine	Energy conservation
External light fittings to avoid light pollution.	Dark skies.
Waste recycling facilities on site. (extra bins, compost heaps etc)	Reduced waste.
Interior luminaries daylight regulating type	Energy Conservation
Interior lighting controls, presence / daylight sensing.	Energy Conservation
Pulse meters to both gas and water supplies.	The intention is to allow the building occupier / owner to monitor benchmark and manage efficiently the schools usage. Thereby avoiding unnecessary or wasteful use of water and gas supplies.
Automatic sanitary water supply shut off.	The intention is to provide proximity detection water shut off systems to prevent water wastage.
Low energy mechanical ventilation to WC areas.	The intention is to utilize EC/DC motors in the extract system to reduce energy usage.

Table 26: Hetton Lyons Primary School energy efficiency measures

The successfully completed building included:

- 50 kW Wood pellet boiler
- 6kW wind turbine
- Green sedum roof

- Rainwater collection to flush toilets
- Insulation level higher than building regulations
- Natural, sustainable building materials, including FSC timber, and local

19.2 The Green House – New Build

The Green House at Annfield Plain, County Durham has been developed by Groundwork West Durham and is built on brown field land at Greencroft Industrial Park. The two storey building provides an open plan office area for a main tenant occupying 40% of the floor area and a series of small business starter units, catering facilities and conferencing facilities. Total floor area of the building is approximately 1,800m^2.

The project brief had a strong focus on sustainable development and therefore includes a number of sustainable features.

Heating and summer cooling are provided by ground source heat pumps whilst an adjacent 225kW wind turbine provides the electrical supply with surplus power exported to the National Grid.

Figure 25: The Green House

The geo-thermal heating and cooling system (Kensa Heat Pump) was designed and installed by Geo-Warmth of Hexham. The system operates by using a buried slinky system with over 1,500m of pipe laid under the pond and car parks. This system provides 80kW of heating and 20kW of cooling. The Primary Care Trust (main tenant) offices use this heating with a condensing gas boiler as back up.

High efficiency flat plate solar collectors are installed on the south facing flat roof area at an angle to maximise the annual thermal yield (~35°). Heat is transferred from the solar collectors to the mains pressure hot water calorifier within the plant room. This incorporates a high efficiency coil, low in its base, through which the solar heated fluid circulates thus transferring heat into the cooler water at the base of the calorifier.

An immersion heating element is installed in the calorifier in order to raise the water temperature to above 60°C once per day to control Legionella risk.

Within the building there is a natural ventilation system utilising side, cross and stack effect ventilation principals assisted by wind flow to maintain comfort levels and a combination of openable windows and roof mounted chimney terminals are also integrated into the building.

Figure 26: The Green House wind turbine

The wind turbine is a Vestas 225kW mounted on a tubular tower and has been refurbished following its prior use at a Cumbrian wind farm. Tower height is 30m with blades of 15m length giving a total height to blade tip of 45m. Surplus electricity is exported to the national grid.

Rainwater is collected from the roof area and passes through a leaf filter system before being collected into an underground storage tank. The filtered water is pumped into the building for use in flushing toilets and urinals. A mains water feed allows the tank to be topped up during periods of drought.

Motional activated sensors are installed in the male toilets to minimise urinal flushing.

All office areas use high efficiency T5 fluorescent lamps with high frequency control gear. Lighting is controlled by presence detection.

Other features have been incorporated to minimise energy consumption. Solar gain is minimised by the provision of coatings on all external windows whilst the double glazed units are argon filled and have low-e coatings for heat retention. High levels of insulation to walls and roof have been achieved.

19.3 Reed Street, South Shields

The Reed Street Project involves the construction of 21 carbon negative homes in South Tyneside. The project is headed by the housing association, Four Housing Group, and the environmental charity Groundworks. Funds for part of the development were provided by the Regional Development Agency for the North East of England, One North East.

The design of the homes is being carried out by Fitz Architects, CK21 and RNJ Partnership Construction Consultants. The contractors are Galliford Try, whilst the Code for Sustainable Homes Assessment is being carried out by Ian Lanarch Associates Ltd. Narec was employed by Groundworks to produce an energy strategy for this development, the objective of which was to meet the ambitious target of delivering a Carbon Negative development.

Thermal modelling of Reed Street, was undertaken using the industry standard software, Virtual Environment from Integrated Environmental Solutions, (IES<VE>) and the Passive House Planning Package (PHPP), as produced by the highly respected PassivHaus Institute in Germany.

Electricity demands from appliances and cooking were based on a mixture of recommendations from Code Level 6 and real world data from both peer reviewed literature, actual developments and UK government statistics.

Based upon the above energy demands, feasibility studies for all relevant technologies were undertaken. The aim being to find how this specific site would lend itself to a range of renewable and low carbon electrical and thermal generators.

The technologies investigated were solar thermal, air source heat pumps, ground source heat pumps, photovoltaic, microwind, large scale wind, biomass boilers and CHP. These were sized according to the plans for Reed Street available at the time, and outputs calculated from demands and local weather conditions.

Finally, Narec considered the smart metering technologies to be implemented in Reed Street. These will allow for future monitoring the development, to ensure that the claims of Carbon Negativity can be verified, and so that any mistakes can be traced, allowing for future developments to be improvements of this project.

This project will allow the Reed Street Development to produce negative carbon emissions net over the period of a year. When coupled with the sustainable building techniques and materials used in the construction, this will allow Reed Street to successfully back up the claim that it is truly a Carbon Negative Development.

20 Carbon Mixer® North East 2.0

The Carbon Mixer® has been developed by Bobby Gilbert and Associates. This software allows the user to create a benchmark scenario with a number of different buildings and energy sources. They can then create new scenarios with different generating technologies, to compare the CO_2 emissions, capital cost and operating costs over a period of years. This way multiple energy strategies can be quickly compared for their cost effectiveness in combating fuel poverty and climate change.

In 2007 BG&A in association with Narec, BRE and CP Energy provided a cut down version of the Carbon Mixer® for the North East. This had reduced functionality compared with the full commercial version, but free copies were provided to all North East Planners. Since then, many things have changed, both technologically and politically; meaning a large amount of work had to be carried out on the software to bring it up to date. A reduced consortium of BG&A and Narec have been working on this. Changes include a completely new user interface, added financial incentives such as Feed In Tariffs, new buildings and new technologies.

It has been noted that one major issues in the North East is that the restructuring of the councils, this led to a large loss in skill and capability locally in the operating of the Carbon Mixer® North East. As a result Narec has worked with BG&A, ANEC and ONE to provide additional training on the original version.

A full guide on how to use the software is provided with the online help, and also training sessions will be offered by Narec and BG&A throughout the North East region to ensure planners have full confidence in operating the software

The main purpose of the software is to provide a common language for developers, planners and architects, allowing a quick comparison of the sustainability of various developments. The software is provided free to all planners in the North East.

An educational version of the Carbon Mixer® has been created by BG&A in association with Narec and the Centre for Design Research at Northumbria University. This has a cut down number of buildings and generators, to teach students about renewable energy and climate change.

The software is available to all planners, free of charge. To gain a copy, please contact ONE or ANEC.

21 Summary

This document has covered the legislation which effects local authorities and planners with regard to carbon and energy. Additionally, the various technologies have been detailed, and the planning issues considered.

Using this document, and the Carbon Mixer 2.0, it is hoped that the Microrenewables Toolkit will become a valuable part of ensuring the North East becomes a world leader in developing a low carbon society.

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23 Appendix A - Nottingham Declaration

The Nottingham Declaration on Climate Change

We acknowledge that

- Evidence shows that climate change is occurring.
- Climate change will continue to have far reaching effects on the UK's people and places, economy, society and environment.

We welcome the

- Social, economic and environmental benefits which come from combating climate change.
- Emissions targets agreed by central government and the programme for delivering change, as set out in the UK Climate Change Programme.
- Opportunity for local government to lead the response at a local level, encouraging and helping local residents, local businesses and other organisations - to reduce their energy costs, to reduce congestion, to adapt to the impacts of climate change, to improve the local environment and to deal with fuel poverty in our communities.
- Endorsement of this declaration by central government.

We commit our Council from this date_____to

- Work with central government to contribute, at a local level, to the delivery of the UK Climate Change Programme, the Kyoto Protocol and the target for carbon dioxide reduction by 2010.
- Participate in local and regional networks for support.
- Within the next two years develop plans with our partners and local communities to progressively address the causes and the impacts of climate change, according to our local priorities, securing maximum benefit for our communities.
- Publicly declare, within appropriate plans and strategies, the commitment to achieve a significant reduction of greenhouse gas emissions from our own authority's operations, especially energy sourcing and use, travel and transport, waste production and disposal and the purchasing of goods and services.
- Assess the risk associated with climate change and the implications for our services and our communities of climate change impacts and adapt accordingly.
- Encourage all sectors in our local community to take the opportunity to adapt to the impacts of climate change, to reduce their own greenhouse gas emissions and to make public their commitment to action.
- Monitor the progress of our plans against the actions needed and publish the result

_____ Council

acknowledges the increasing impact that climate change will have on our community during the 21st century and commits to tackling the causes and effects of a changing climate on our city/county/borough/district.

Leader of the Council	Chief Executive	Phil Woolas MP Minister of State Environment DEFRA	Parmjit Dhanda MP Parliamentary Under Secretary of State CLG

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