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Practice Guidance

Renewable and Low Carbon Energy in Buildings

1 Introduction

July 2012

Wales Planning Policy Development Programme

This practice guidance was prepared for the Welsh Government by Mott MacDonald (herein referred to as MM).

Mott MacDonald
Prince House
43–51 Prince Street
Bristol
BS1 4PS

Tel: +44(0) 117 906 9500
Fax: +44(0) 117 906 9501

Web: www.mottmac.com

Planning Division
Department of Environment and Sustainable Development
Welsh Government
Cardiff
CF10 3NQ

Email: planning.division@wales.gsi.gov.uk
Web: www.wales.gov.uk/planning

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Background

This practice guidance has been prepared in response to Regulation 9 and 11 of *The Promotion of the Use of Energy from Renewable Sources Regulations 2011 (No.243)*. The regulations derive from Article 13 (5) and 14 (5) of the Renewable Energy Directive (2009/28/EC).

Disclaimer

This document is intended to serve as guidance only and should not be used as a design manual. Suitably qualified professional advice should always be sought in order to develop detailed design proposals. While all efforts will be made to ensure that this document is kept up–to–date, the reader must be aware of the fast pace of development in this area.

Each specific development opportunity will present a unique combination of opportunities and limitations, depending on geographic location, development size and the mix of building typologies and uses included; therefore it is not possible to create a one–size–fits–all solution for the optimal combination of renewables. Assessment of the available renewable energy resources for a given site should be undertaken as early as possible in the design process. This is required to ensure that the maximum potential is realised, but also because some technologies can require longer–term surveys and licensing negotiations (such as extraction licenses and local planning issues).

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List of Abbreviations

Organisations and Policy

BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BWEA	British Wind Energy Association
CCC	Committee on Climate Change (UK Government)
CCL	Climate Change Levy
CCW	Countryside Council for Wales
CDM	Clean Development Mechanism
CIBSE	Chartered Institute of Building Services Engineers
CRC	Carbon Reduction Commitment
CSH	Code for Sustainable Homes
DECC	Department of Energy and Climate Change (UK Government)
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ECA	Enhanced Capital Allowance
EP	Environmental Permitting
EST	Energy Saving Trust
ETS	Emissions Trading Scheme
FIT	Feed in Tariff
GIS	Geographical Information System
IPC	Infrastructure Planning Commission
IPCC	Intergovernmental Panel on Climate Change
LA	Local Authority
MCS	Microgeneration Certification Scheme
NREAP	National Renewable Energy Action Plan
PPC	Pollution Prevention and Control
PPW	Planning Policy Wales
REAL	Renewable Energy Assurance Limited
RHI	Renewable Heat Incentive
ROC	Renewables Obligation Certificate
SME	Small and Medium Enterprises
TAN	Technical Advice Note
UNCED	United Nations Conference on Environment and Development
UNFCC	United Nations Framework Convention on Climate Change (UNFCC)
WG	Welsh Government

Technical Terminology

AC	Alternating Current
AFC	Alkaline Fuel Cell
AQMA	Air Quality Management Area
ASHP	Air Source Heat Pump
ATES	Aquifer Thermal Energy Store
BGS	British Geological Survey
BIPV	Building Integrated Photovoltaics
BIR	Building Integrated Renewables
CCHP	Combined Cooling Heat and Power
CCS	Carbon Capture and Storage
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power
CHPQA	Combined Heat and Power Quality Assurance Programme
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoP	Coefficient of Performance
DC	Direct Current
DHW	Domestic Hot Water
DNO	Distribution Network Operator
EfW	Energy from Waste
EIA	Environmental Impact Assessment
EP	Environmental Permitting
ESCo	Energy Services Company
GHG	Greenhouse Gas
GSHP	Ground Source Heat Pump
ha	Hectare
km	Kilometre
kW	kilowatt (unit of power)
kWe	kilowatt electrical (unit of power)
kWh	kilowatt hour (unit of energy)
kW/m^2	kilowatt per metre squared (unit of heat density)
LZC	Low or Zero Carbon
m	Metre
m^2	Metres squared (area)
m^3	Metres cubed (volume)
m/s	Metres per second (unit of velocity)
MCFC	Molten Carbonate Fuel Cells
mm	Millimetres
MSW	Municipal Solid Waste
Mt	Mega tonne
MW	Megawatt (unit of power)

MWe	Megawatt electrical (unit of power)
NOx	Nitrogen Oxide (Emission associated with combustible fuels)
NPV	Net Present Value
p	Pence
PAFC	Phosphoric Acid Fuel Cell
PEM	Proton Exchange Membrane
pH	Measure of the acidity or basicity
PPC	Pollution Prevention and Control
PV	Photovoltaic
SAP	Standard Assessment Procedure
SBEM	Simplified Building Energy Model
SE	South East
SHW	Solar Hot Water
SOFC	Solid Oxide Fuel Cell
SW	South West
W	Watt (unit of power)

Chapter 1: Introduction

Purpose

The purpose of this guidance is to help all those involved in the built environment identify ways in which they can reduce the carbon footprint of a new building, extension or refurbishment by optimising the use of renewable and low carbon energy technologies in the design process. The decision to incorporate renewable and low carbon energy technologies into these projects should only be considered once the energy hierarchy has been applied. This guidance emphasises this but its purpose is to assist architects, planners, developers and other actors to plan for, design and incorporate the optimal combination of renewable and low carbon energy technologies in these projects.

The Welsh Government's approach to good design is set out in planning policy and guidance. This sets out an approach that can be applied to the three scenarios covered by this guidance – new buildings, extensions and refurbishment. Technical Advice Note (TAN) 12: Design states:

> **"Good practice in mitigating the causes of climate change is to apply the energy hierarchy which details a series of steps that should be taken to minimise the carbon emissions associated with a new development in the most efficient and cost effective way. In taking forward an energy hierarchy, an approach to 'carbon reduction' can be prepared for developments, where appropriate, and included or summarised in a design and access statement to illustrate how the design of the development has sought to reduce the carbon emissions associated with the development – including opportunities to move towards zero carbon."**

This practice guidance focuses on the final step of the energy hierarchy, through the promotion of renewable and low carbon energy sources.

What is Renewable and Low Carbon Energy?[1]

Renewable energy is the term used to cover those sources of energy, other than fossil fuels or nuclear fuel, which are continuously and sustainably available in our environment. This includes wind, water, solar, geothermal energy and plant material (biomass). These sources of energy can be utilised to generate power, heat, fuels (for transport) and cooling through a range of renewable energy technologies such as solar panels and wind turbines. Low carbon energy is the term used to cover technologies that are energy efficient (but does not include nuclear). Renewable and low carbon energy technologies will feature in many types of situations such as those that:

- are directly incorporated into the fabric of a building;
- are stand–alone directly connected to the grid;
- built within a new development (e.g. development scale combined heat and power);
- provide heat for a number of buildings (e.g., district heating);
- provide a fuel for use in transport; and
- provide cooling.

How to Use this Guidance

This guide is made up of 8 Chapters which address the key issues faced in optimising renewable and low carbon energy technologies in:

- new buildings;
- extensions; and
- refurbishment projects.

The chapters are presented in the order they are likely to occur to a project team tasked with one of these development scenarios. Within each chapter, specific stakeholder groups are addressed as appropriate, although as stated above, the intention is to establish a good level of general understanding and then sign–post existing guidance, rather than recreate it.

It should be noted that the terms 'Renewable and Low Carbon' and 'Low or Zero Carbon (LZC)' carry the same meaning in this practice guidance. The former is used throughout as this is the formal definition under Welsh Government Planning Policy, while the latter is in reference to the Building Research Establishments (BRE) definition used in the BREEAM and Code for Sustainable Homes (CSH) environmental assessment methods[2] for non–domestic and domestic buildings respectively.

In addition the following are used in this practice guidance:

- 'Actor' – This includes those associated with the procurement, design and construction of building development, for example the client, architect, engineer, or contractor.
- 'Stakeholder' – This refers to consultees who may have an involvement or vested interest in particular aspects of building developments, for example community groups, heritage groups, or environmental bodies.

2	Chapter 2 – Promoting Renewable and Low Carbon Energy in Buildings	This chapter explains the wider need to incorporate renewable and low carbon energy technologies. The chapter introduces climate change, as well as energy security and legislative drivers within Wales.
3	Chapter 3 – The Energy Hierarchy	Prior to discussing the promotion and actual implementation of renewable and low carbon energy in building development, it is important to understand why, how and when energy is used in a building. Only through understanding energy demand can significant steps be taken to reduce energy consumption and associated carbon emissions. This chapter provides an overview of the building 'energy hierarchy' and the process by which all developments should endeavour to reduce their carbon footprint through good design.
4	Chapter 4 – Integrating Renewable and Low Carbon Energy Technologies in Buildings	This chapter covers the practical aspects of designing and delivering renewable energy technologies within building development. It is intended to help create a common understanding of the process for all design–team actors through outlining a good practice approach.
5	Chapter 5 – Understanding Energy and Carbon in Buildings	This chapter provides an overview of the key factors that should be considered when determining the suitability of renewable or low carbon energy technologies. It is important that all stakeholders and actors are familiar with these factors, in order to better understand energy demand and consumption within a building. This will help lead to the most appropriate technologies being chosen for each development type, and in many cases define where more than one technology can be used in combination to provide an optimal approach.

6	Chapter 6 – Technology Selection	This chapter provides an overview of renewable or low carbon energy options. For each option, key considerations and design factors are presented, with a discussion on suitable applications and potential for combining with other technologies. Links to further resources and information are also provided.
7	Chapter 7 – Implementation and Delivery of Renewable and Low Carbon Energy	This chapter discusses the financial implications of renewable or low carbon energy systems, and the options for delivery of an energy system in order to encourage private or public sector leadership.
8	Chapter 8 – Renewable and Low Carbon Energy Feasibility Study Template	A template has been created in order to assist project teams in understanding the information that is needed and the steps required in order to carry out a renewable and low carbon feasibility assessment. This template should serve as guidance only; in reality each project will have different requirements, and the level of detail necessary in order to be confident the optimum technologies are chosen will differ substantially depending on the extent of the project.
App	**Appendices**	
	A: Case Studies of Low Carbon Buildings (Summary)	A list of 16 case studies of low carbon buildings have been published separately to complement the advice contained in this document. The appendix provides a summary of the case studies published.
	B: Glossary of Terms and List of Figures	A list of key terms used in this document followed by an explanation.
	C: Sources of Further Information	Details of other websites and documents that provide additional information to the issues covered in this guidance.

References

1 Planning Policy Wales (2011) www.wales.gov.uk/topics/planning/policy/ppw/

2 BREEAM: www.wales.gov.uk/topics/sustainabledevelopment/design/breeam
CSH: www.wales.gov.uk/topics/sustainabledevelopment/design/code/

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2 Promoting Renewable and Low Carbon Energy in Buildings

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Cover image: Senedd, Cardiff

Chapter 2: Promoting Renewable and Low Carbon Energy in Buildings

This chapter explains the key drivers for incorporating renewable energy technologies into new buildings, extensions and refurbishment development projects. This is important to drive all stakeholders in the project to understand the potential for optimising renewable energy and carbon technologies within these projects.

Climate Change and Energy Security

The fact that our climate is changing is supported by unequivocal scientific evidence. The evidence also shows that human factors contribute to the recent rapid changes, in particular:

- Increasing atmospheric concentrations of greenhouse gases, particularly carbon dioxide.
- Increasing overall global surface temperature.
- Changes to global land surface (i.e. deforestation and urbanization); and
- Increasing atmospheric concentrations of aerosols.

The Intergovernmental Panel on Climate Change (IPCC) consider that:

"Most of the observed increase in global average temperatures since the mid 20th century is >90%[3] due to the observed increase in anthropogenic greenhouse gas concentrations"

Carbon dioxide is the most important anthropogenic greenhouse gas, and global increases in carbon dioxide concentrations are primarily due to fossil fuel use and land–use change.

In the UK, nearly 50% of our national greenhouse gas emissions can be attributed to the burning of fossil fuels in order to supply our homes and businesses with heat and power. With an ever increasing global population and changing consumer behaviour our energy demands and consumption of fossil fuels have the potential to increase in the future. Consequently, there is now a significant focus on how the design of new developments can reduce this dependence on fossil fuels, supplies of which are not renewable.

Increased energy security can be achieved to some extent through the improvement of the built environment in terms of energy efficiency, which will reduce the total energy demand and thus the subsequent exposure to price fluctuations (refer to Chapter 2.0 for details of the energy hierarchy). Integration of alternative, renewable or low carbon energy generation is another means by which reduced dependency on fossil fuels can be achieved, however it is important to bear in mind that successful implementation of particular renewable or low carbon technologies requires careful planning. Poor selection could potentially have an adverse impact on energy security and fuel poverty issues.

The role of energy

Energy is increasingly considered as the most important sustainable development issue in meeting the climate change challenge. Progressively ambitious targets are being agreed to reduce our reliance on fossil fuels and to provide more secure and stable future energy generation. In responding to the causes of climate change, in 2009 the leaders of the G8 nations agreed to cut greenhouse gas emissions by 80% by 2050. The Welsh Government is committed to a reduction of 3% annually within areas of devolved competence from 2011, against a baseline of average emissions between 2006-10, and at least a 40% reduction in all greenhouse gas emissions in Wales by 2020 against a 1990 baseline.

Energy supply accounts for approximately 35% of net greenhouse gas emissions in Wales and to achieve this ambitious reduction agenda the UK Government recognises that by 2050 Wales will need to reduce by 80–90% its use of carbon based energy. The Committee on Climate Change has proposed that the UK's power sector needs to be largely decarbonised by 2030; and that around 30% of the UK's electricity in 2020 needs to come from renewable sources to meet our legally binding EU target for 15% renewable energy consumption by 2020.

Welsh renewable electricity production is equivalent to about 14% of consumption. Two thirds of this comes from wind and the remainder from other sources such as hydro. Welsh wind power output is equivalent to around 9% of Welsh demand.

Drivers for Renewable and Low Carbon Energy

Renewable and Low Carbon energy has been promoted via a number of legislative and policy drivers. The following sections provide a summary of the various European, UK and Wales specific drivers. It does not provide an exhaustive list of all the relevant legislative and policy drivers.

Table 1.1 Legislation, policy and guidance

International	
Kyoto Protocol	Under the Kyoto Protocol, 37 industrialised countries have committed to reduce their collective greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons (HFCs) and perfluorocarbons by 5.2% from the 1990 level.
European	
EU Renewable Energy Directive	In 2010 the EU adopted a wide–ranging package on climate change, building on the commitments made under the 1997 Kyoto Protocol and existing EU Directives[4] which are due to expire in 2012.

EU Renewable Energy Directive (cont'd)	The headline figure was for an EU–wide target of 20% reduction in greenhouse gas emissions over 1990 levels by 2020, with a clause to increase the target to 30% by 2020. This more stringent clause was subject to an international emissions reduction agreement that committed non–European developed nations to similar reductions. The strategy also sought to increase the contribution of renewable energy in meeting final energy demand to 20%, with energy efficiency also increased to 20%.
Europe 2020 Strategy	Building on the targets and legislation introduced under the "Europe 2020" strategy, and seeking to maintain its reputation as a global leader in climate change and sustainable development policy, the European Council has set an EU objective of reducing greenhouse gas emissions by 80–95% (over 1990 levels) by 2050[5]. This target is based on Intergovernmental Panel on Climate Change (IPCC) recommendations for the emissions reductions required in order to avoid a change in of more than 2°C.
United Kingdom	
Kyoto Protocol	Through the Kyoto Protocol, the UK is committed to reducing its greenhouse emissions by 12.5% over the period 2008–2012 against a 1990 baseline. The UK is also the only Kyoto signatory to go beyond its Kyoto Protocol target and commit to the UK goal to achieve a 20% reduction in carbon dioxide emissions by 2010 and 60% by 2050.
National Renewable Energy Action Plan	The UK Government has produced a National Renewable Energy Action Plan (NREAP)[6]. The UK NREAP is based on a template set by the European Commission, which asks for the trajectory and measures that will enable the UK to reach its target for 15% of energy consumption in 2020 to be from renewable sources.
Climate Change Act 2008	The UK's Climate Change Act is an act of parliament that places a legal duty to ensure that the net UK carbon account for all six Kyoto greenhouse gases[7] in the year 2050 are at least 80% lower than 1990 levels. The stated aims of the Act are as follows: • Improve carbon management and facilitate transition to a competitive low carbon economy; and • Demonstrate international leadership and highlight UK's commitment to reducing greenhouse gas emissions.

Climate Change Act 2008 (cont'd)	The following provisions were introduced under the Act in order to achieve the aims stated above: • Legally binding targets – Greenhouse gas emissions reductions of 80% by 2050, over 1990 levels. • Introduction of Carbon Budgets – Fixed emissions caps over five–year periods with three budgets being set at a time to give a 15–year projection.
Energy Act	The Energy Act provides for a step change in the provision of energy efficiency measures to homes and businesses, and makes improvement to the UK Government's framework to enable and secure low–carbon energy supplies and fair competition in the energy markets. It includes provisions on the green deal, the private rented sector and the energy company obligation.
Annual Energy Statement (AES)	The AES provides a statement on the progress made by the UK Government on energy.
Wales	
While energy is not devolved to Wales the Welsh Government have a number of policies on climate change, renewable energy and energy efficiency that relate to this guidance.	
One Wales: One Planet, a Sustainable Development Scheme for Wales	'One Wales: One Planet' set out the previous Welsh Government's (WG) vision of a sustainable Wales and was designed to serve as the over–arching strategic aim of all WG policies and programmes. It establishes sustainable development as the central organising principle of the Government and places a legal requirement on the Government to consider sustainability in all policy decisions. Headline targets include a commitment to reduce greenhouse gas emissions by 3% a year by 2011 in those areas of devolved competence, and ensure resilience to the impacts of climate change.
Climate Change Strategy for Wales (2010)	The Climate Change Strategy for Wales sets out the Welsh Government actions to deliver 3% annual reductions in carbon equivalent emissions in areas of devolved competence from 2011, against a baseline of average emissions between 2006-10, and at least a 40% reduction in all greenhouse gas emissions in Wales by 2020 against a 1990 baseline.
Energy Wales (2012)	Energy Wales sets out the Welsh Government's ambition to create a low carbon economy. It focuses on what the Government will do to drive the agenda.

Planning Policy Wales	National planning policy on renewable and low carbon energy is contained in Chapter 12 of PPW. This established a framework in which local planning authorities should plan positively for all forms of renewable energy. National planning policy on sustainable buildings is contained in Chapter 4 of PPW. This sets out an expectation for most new buildings in Wales to meet high sustainable building standards, including minimum energy/ CO_2 targets in order to deliver more sustainable buildings. Note: Town and Country planning is devolved to the Welsh Government. The national planning policy framework comprises Planning Policy Wales (PPW) and Technical Advice Notes (TANs). National planning policy may be material to decisions on planning applications, whether taken by local planning authorities, the Planning Inspectorate or Welsh Ministers.
Technical Advice Note 8 Planning for Renewable Energy (2004)	Published in 2005 to provide guidance on the land use planning implications of renewable energy generation. Key areas covered: • Onshore wind and strategic search areas. • Other renewable energy technologies such as CHP and EfW etc. • Renewable energy design implications. • Implications for Development Plans. • Development control; and • Monitoring.
Technical Advice Note 22 – Planning for Sustainable Buildings (2010)	Published in 2010, this document provides technical guidance to help local planning authorities and developers implement national planning policy. The document provides an overview of sustainable building standards and design solutions in addition to renewable and low carbon design solutions. A detailed Policy Implementation Map is also provided to assist local planning authorities and developers in order to ensure full implementation of the policy.
Welsh Building Regulations	The Welsh Government have indicated that they intend to consult on a 55% reduction in emissions from new–build housing in 2013, compared to 2006 standards.

Public Sector

Public buildings refer to those owned by a person or body with functions of a public nature[8]. Public buildings make up a large percentage of our built environment; and therefore, by requiring higher standards of public buildings the cost of new and innovative interventions can be reduced thanks to the economies of scale that can be achieved.

Public Buildings present Wales with a huge opportunity to enable effective integration of renewable or low carbon energy; helping to reduce carbon emissions and by extension environmental impact, but also to increase social and economic sustainability. For example, publicly funded housing schemes through the integration of district heating and low carbon infrastructure can help to reduce costs for residents and in some cases reduce social issues such as fuel poverty.

The benefits of integrating renewable energy generation into public sector buildings are generally no different to the private sector; offering the potential for energy security, lower energy costs and reduced greenhouse gas emissions. They can also generate a revenue stream (see Chapter 7) and help to improve the quality of the local environment. The public sector has an important role to play in the promotion of renewable and low carbon energy generation in building development as a:

- **Pioneer and leader** – Integrating renewable and low carbon energy generation into its own buildings and new development will help to provide assurance in the technologies and demonstrate political commitment to supporting the local low carbon economy as well as reducing greenhouse gas emissions. The public sector can set an example for the private sector to follow.
- **Facilitator** – Supportive policies are essential to catalyse the adoption of renewable and low carbon energy generation technologies. For example, policy requirements that apply to all developments can help to ensure a level playing field for all. Strategic planning to show the wider potential for renewable and low carbon energy in an area can guide development to the most sustainable location, minimise impact, reduce the risk for investors and help to ensure a joined up approach.
- **Partner** – For larger projects the public sector can be an influential partner, collaborating with the private sector. Whether the public sector is a financial partner or not, it can still help to facilitate successful delivery of the project through providing guidance and support, or giving confidence to potential stakeholders; and
- **Customer** – Offering public sector buildings as a heat customer in district heating schemes helps to de–risk the project for investment. The buildings can act as 'anchor loads' which provide some certainty of the heat demand and help to justify private sector investment to explore the opportunity to establish a wider network.

Welsh Government requirements

All new buildings promoted or supported by the Welsh Government or its Sponsored Bodies (SB's) are required to meet minimum sustainable building standards. This includes projects procured directly and indirectly. The standards used are the Code for Sustainable Homes (CSH) for new dwellings and the Building Research Establishment Environmental Assessment Method (BREEAM) for all other buildings. Each of these schemes uses the current Building Regulations in order to assess the carbon footprint of the development.

The current standards for these types of public sector schemes are:

- For residential development, a minimum Code for Sustainable Homes level 3; and
- For non–residential development BREEAM 'Excellent'.

Using schemes such as the Code and BREEAM simplifies the assessment process, reducing the burden on public authorities to develop technical standards which in turn makes it simpler for design teams who do not have to digest an entirely new set of standards. In other cases, authorities may implement additional requirements for specific credits under BREEAM and CSH (e.g. higher mandatory targets for the Energy categories) or simply impose a minimum renewable energy contribution as a percentage of total demand or carbon reduction.

Meeting these standards will require the energy hierarchy to be deployed in the design of new buildings. In some instances this may require the incorporation of renewable and low carbon energy technologies in the building, on–site or connected (heat).

For further information see www.wales.gov.uk/topics/sustainabledevelopment/design/standards.

Opportunities

The following outlines a number of reasons why the public sector should fulfil an exemplary role in the delivery of renewable and low carbon energy.

Table 1.2 Opportunities for the Public Sector

Opportunity	Description
Responsibility	Government's are responsible for setting national targets and, ultimately, for ensuring that they are met. Therefore public authorities undertaking construction projects should always seek to go beyond the legal minimum, both to increase its chances of meeting its own ambitious targets, and to "lead by example".

Opportunity	Description
Control	Where public authorities are providing all or part of the financing, or where they are the land–owners, they have the ability to directly influence a project beyond the standards contained in the relevant building regulations. In effect, they are the client, and they have the ability to act as a progressive client, or a regressive one. Therefore public authorities can insist on things for their own buildings that they could not require as a national legal minimum for all development.
Owner–occupied	Public authorities are more likely to occupy the buildings that they commission themselves, thus removing some of the complications that occur when the landlord is required to invest capital and the tenant reaps the rewards in terms of reduced operational expenditure (e.g. savings on fuel bills). This means that increases in build–costs can be recouped over time in reduced running costs.
Investment Cycle	Public institutions tend to be able to take a much longer–term investment view, even in the current economic climate. This means that larger–scale, holistic solutions (which typically suffer from longer return periods for a given capital investment) are more likely to be viable for a public sector client than a private sector investor.
District Heating	The ability to connect buildings of different types together is important because: • It enables "proof of concept" for district energy schemes which are largely unpopular in the UK due to negative experiences in the 1970's. • Once district infrastructure is established, private development can then connect to the district network, reducing the cost of LZC interventions for the private sector while opening up revenue potential for the Authority (e.g. Charges could be levied for connection, as well as potential on–going revenue from energy sales, though this depends on the legal model used to establish the network arrangements; and • Public buildings can also act as "anchor loads" to increase diversity of demand, and provide a higher "base" heating, or hot water load (refer to Chapter 5 for further details).

There are other important aspects of an exemplar role; namely, the need to generate feedback and disseminate lessons learned to all relevant stakeholders. For example, it is just as exemplary to demonstrate advanced metering and remote management techniques, as it is to demonstrate, for example, the application of small–scale urban wind generators.

Private Sector

The private sector may rely on the public sector for facilitation, supportive policies and strategic planning however the public sector cannot realise the full potential for renewable energy generation in Wales without the private sector's financing and delivery capability.

As discussed previously, benefits include energy security and lower energy costs. They can generate new revenue streams through financial support mechanisms such as the Feed–in Tariff, Renewable Heat Incentive and Renewables Obligation Certificates (see Chapter 7 for details on funding) and help meet requirements of the Carbon Reduction Commitment or, for larger energy consumers, the European Emissions Trading Scheme. The Department for Energy and Climate Change (DECC) has carried out work on the Social Cost of Carbon (SCC) and the associated benefits of renewable energy for the economy[9].

As energy costs increase, they are likely to become more of an issue for all consumers (domestic and commercial alike) and so the demand for buildings with lower energy bills may increase. The effect may be two–fold in terms of property value in that there may be a premium for high performing buildings and poorly performing buildings may depreciate considerably. Energy security is also widely reported as a future issue for the UK. There is serious concern as to whether there will be a consistently available electricity and gas supply in coming decades. Businesses may need to look at how they can guarantee the energy supply that is critical to operations. They may be looking for alternative, on–site measures for generating energy and buildings with the facilities to do so.

It is important to consider these factors when deciding whether to act now to ensure that our new and existing buildings are able to match the competition in perhaps the not so distant future. Taking a longer term view of the value of these technologies is a prudent approach for a sustainable business.

References

3 Refers to greater than 95% certainty - consideration of remaining uncertainty is based on current methodological limitations

4 Directives 2001/77/EC Directive on Electricity Production from Renewable Energy Sources and Directive 2003/30/EC on the Promotion of the use of biofuels and other renewable fuels for transport

5 A Roadmap for moving to a competitive low carbon economy in 2050 - Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: www.ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf

6 In accordance with Article 4 of the European Renewable Energy Directive (2009/28/EC)

7 Carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and pefluorocarbons

8 Promotion of the Use of Energy from Renewable Sources Regulations 2011 (No. 243). www.legislation.gov.uk/uksi/2011/243/made

9 The SCC measures the full cost of an incremental unit of carbon emitted now, calculating the full cost of the damage it will impose over the whole of its time in the atmosphere. For further information on the SCC, refer to the DECC website.

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3 The Energy Hierarchy

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Cover image: Greenhill Primary School, Caerphilly
Courtesy of Caerphilly County Borough Council

Chapter 3: The Energy Hierarchy

It is important to understand why, how and when energy is used in a building. Only through understanding how energy is supplied to a building and used (demand) can significant steps be taken to reduce energy consumption and associated carbon emissions. This chapter provides an overview of the building 'energy hierarchy' and the process by which all developments should endeavour to reduce their carbon footprint through good design.

Introduction

Best practice in building design states that interventions to mitigate carbon emissions (i.e. reduce the causes of climate change) from the use of energy in buildings should follow the 'energy hierarchy' described below:

This approach is supported in the wider discussion on how to achieve higher standards such as zero carbon.

1. Reduce Energy Demand - Use less energy
2. Be more energy efficient - Use energy efficiently
3. Use renewable and low carbon energy

The energy hierarchy provides a logical approach to design; to reduce the amount of energy required in the first place, then ensure that it is distributed and supplied in the most efficient way possible in order to reduce demand and wastage, and finally supply the remaining demand with energy from renewable and low carbon sources. All actors involved, notably architects must attempt to analyse whole–system approaches, and include environmental, economic and social concerns in their options appraisal.

Design Approach

This guidance focuses on the final step of the energy hierarchy - the promotion of renewable and low carbon energy. Projects in Wales should always seek to follow a design approach that follows the energy hierarchy approach as outlined by *Planning Policy Wales and TAN 12: Design*[10]. This sequential approach should be followed in order to maximise potential for reducing carbon whilst delivering cost effectiveness.

There are a number of legislative issues that require compliance with minimum standards in building design. The most important of these in relation to energy is Building Regulations Part L, Conservation of Fuel and Power. Compliance with Part L and other regulations should be achieved by following the energy hierarchy and in order of the following steps.

Step 1: Reduce Energy Demand

Energy demand reduction provides the greatest opportunity for minimising a building's potential carbon emissions. Orientation will have a significant effect on the buildings energy demand. For example, the direction the building faces will determine the amount of sun that enters each room or zone, affecting both the heating or cooling demand, in addition to the artificial lighting levels that will be required. Other passive design features that should be exploited where possible include natural daylight, which will help to reduce artificial lighting, and natural ventilation, which reduces the requirement for mechanical systems of ventilation and cooling in summer.

Focusing on form and fabric early in the building process is the most cost effective way of reducing energy consumption and by association, carbon emissions. Building functions and requirements will dictate which passive design features are most appropriate, therefore, project teams should always seek advice to ensure that they focus on the correct areas. TAN 12 gives further advice on passive design, a summary of the features of which are presented below:

Passive Solar Heating	Passive Cooling	Natural Lighting
Building orientation and internal layout	Minimise direct sun exposure and heat absorption (in summer months)	Maximise natural light
Window size and location Appropriate thermal mass to moderate temperature extremes	Natural ventilation to allow cool air to enter the building and hot air to escape	Special glazing and automated controls
	Adequate shading to guard against over–heating	

Whilst steps should always be taken to incorporate passive design features into building development, there is unlikely to be control of these issues in the case of refurbishment or building extension projects. In this case only steps 2 and 3 of the energy hierarchy are available.

Step 2: Energy Efficiency

The second stage, once steps have been followed to ensure demand has been reduced is to maximise energy efficiency. Energy efficiency is dictated by two primary components:

- Building fabric efficiency; and
- Building services efficiency.

The building fabric will dictate the amount of heat transfer a building will allow both in terms of thermal transmittance through the fabric, and by air leakage known as infiltration, which is uncontrolled air movement (i.e. not as ventilation for health or comfort purposes). High performance building elements, such as the walls, roof, floors and windows of a building will reduce a buildings energy demand significantly through measures such as insulation and air tightness.

Building services are responsible for the artificial environment created within a building. They ensure the creation and maintenance of comfortable living and/or working conditions, for example the temperature, lighting levels and ventilation levels provided. The design and use of high efficiency building services can facilitate minimisation of energy consumption through effective management and control strategies.

Step 3: Renewable and Low Carbon Technologies

By first focussing on reducing energy demand and secondly maximising efficient use of fabric and services, renewable or low carbon technologies can be used to supplement or meet the residual energy requirements for a building. Renewable and low carbon technologies can also be used to offset carbon emissions associated with the use of fossil fuels, with the final aim being to achieve 'zero carbon' buildings.

Summary

This practice guidance focuses on a framework to enable selection of appropriate renewable or low carbon technologies, through consideration of all the relevant influencing factors, and to ensure optimal combination of technologies for each building or development type. This practice guidance should be read with the assumption that the energy hierarchy is and should always be followed where practicable.

References

[10] Technical Advice Note 12 – Design, Welsh Government, 2009

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Practice Guidance

Renewable and Low Carbon Energy in Buildings

4 Integrating Renewable and Low Carbon Energy in Buildings

July 2012

Cover image: Centre for Alternative Technology
Courtesy of Centre for Alternative Technology and
Wales Institute for Sustainable Energy

Chapter 4: Integrating Renewable and Low Carbon Energy in Buildings

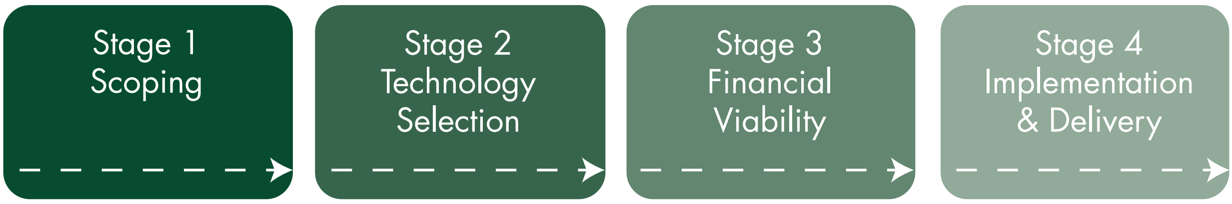
This chapter covers the practical aspects of designing and delivering renewable and low carbon energy technologies within new buildings, extensions and refurbishment projects. It is intended to help create a common understanding of the process for all design–team stakeholders and actors through outlining a good practice approach.

Overall Approach

The figure below shows the key steps in the process of integrating and optimising the use of renewable and low carbon energy technologies into new buildings, extensions or refurbishment development projects. This practice guidance provides an overarching framework but concentrates primarily on Stage 2 'Technology Selection' in order to promote appropriate and optimal combination of renewable or low carbon technologies. This should be read alongside the 'Route to Good Design' set out in TAN12 (2009).

A template is provided in Chapter 8 refelecting these key steps to assist project teams in understanding what information is needed and the steps required in order decide on which technologies and design approach are the most appropriate for a particular project.

Figure 4.1 Process for Integrating Renewable Energy Generation into Building Development



Actors and Stakeholders (Getting the Right Expertise)

A wide range of actors and stakeholders should be engaged and involved in the selection process for renewable and low carbon technologies. The following provides an overview of the key actors and stakeholders, although it should be noted that these will vary on a project by project basis:

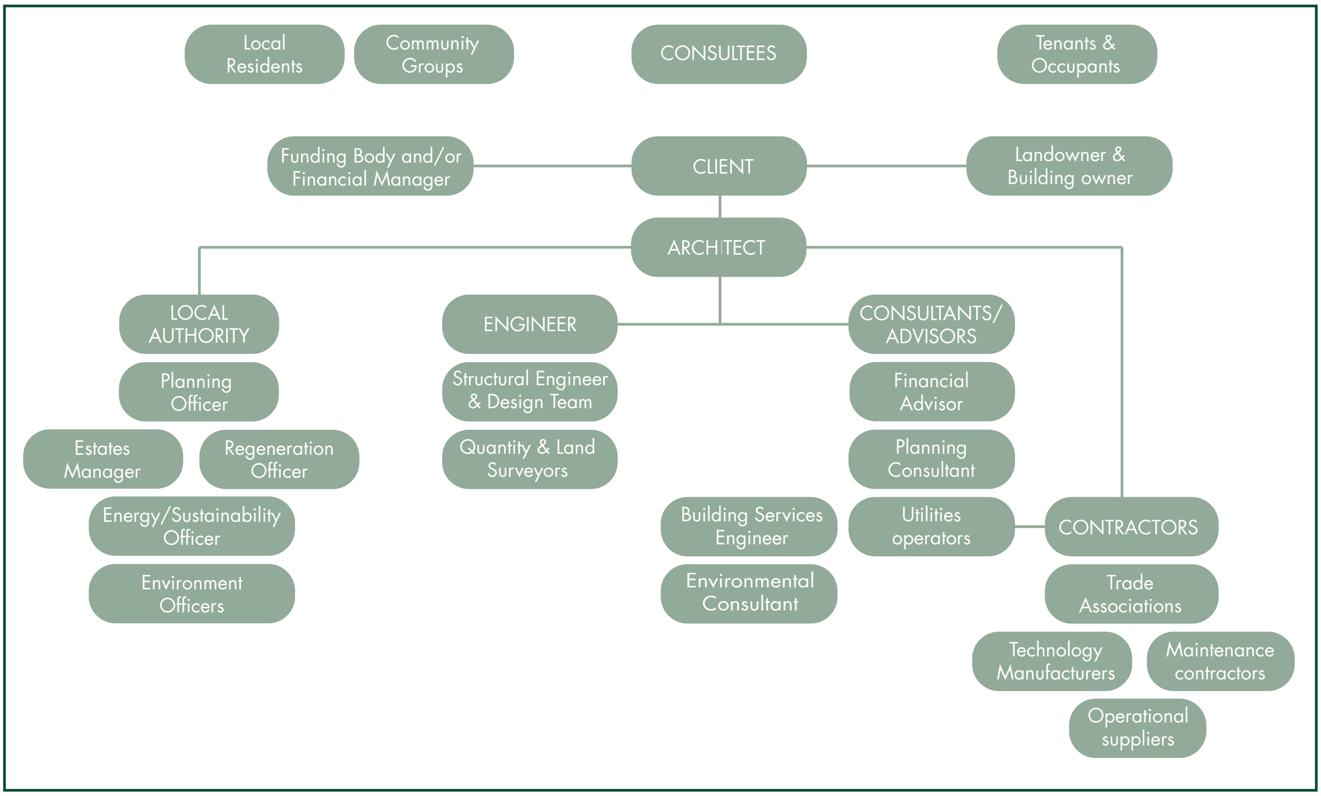
Table 4.1 Actors and Stakeholders	
Project Team	Relevant members of the project team will include the scheme architect, the engineering/design team and the funding body and client or developer for the development. In order to secure financial support, the specific requirements of renewable and low carbon design features must be understood by the funding bodies (who may include the building/land owner, the Local Authority or a private developer). Close and frequent liaison between the architect and engineer are also crucial from the project outset to maximise the potential for implementation of sustainable design features and to ensure successful design integration of renewable and low carbon technologies.
Local Authority	Consultation with the relevant departments of the Local Authority (LA) such as the Energy/Sustainability Officer and Planning Officer is recommended at an early project stage to ensure alignment with local authority sustainability targets and relevant planning policy. The LA should continue to be involved throughout the design development to facilitate timely planning permissions and consents.
Building Users and Local Community	The views and desires of the future or current occupants of a building should be considered when outlining the objectives and aims of a particular scheme. Additionally, the future building users may often be responsible for the ongoing maintenance and operation of any sustainable design strategies adopted and consequently should be consulted during the technology selection process.
Advisors and consultants	A wide number of external consultants and advisors may be necessary and may include: • Financial advisor; • Planning consultants; • Specialist technology contractors; and • Specific utilities providers. Involvement of a planning consultant from the initial technology appraisal stage will highlight any potential major issues and facilitate timely progression of the scheme through the planning process. Consultation with specialist contractors and utility providers will aid the technology appraisal stage to ensure development of the best solution.

	A financial advisor employed for the scheme may be able to identify suitable funding and grant mechanisms for particular technologies, in addition to assisting with financial assessment of the operational costs, maintenance requirement and anticipated payback period.
Contractors	These may include system installers, suppliers, maintenance contractors and trade associations who should be consulted and engaged throughout the design development and implementation stages to harness their specialist skills and knowledge.

Example Team Structure

The following diagram provides an example of a team approach to a building project and those that may need to be involved with determining and implementing renewable and low carbon energy technologies. The example below is for a new development; the actors and stakeholders involved in a retrofit or extension project will be different. Specialists may be required, for example, where technologies are being applied to historic buildings.

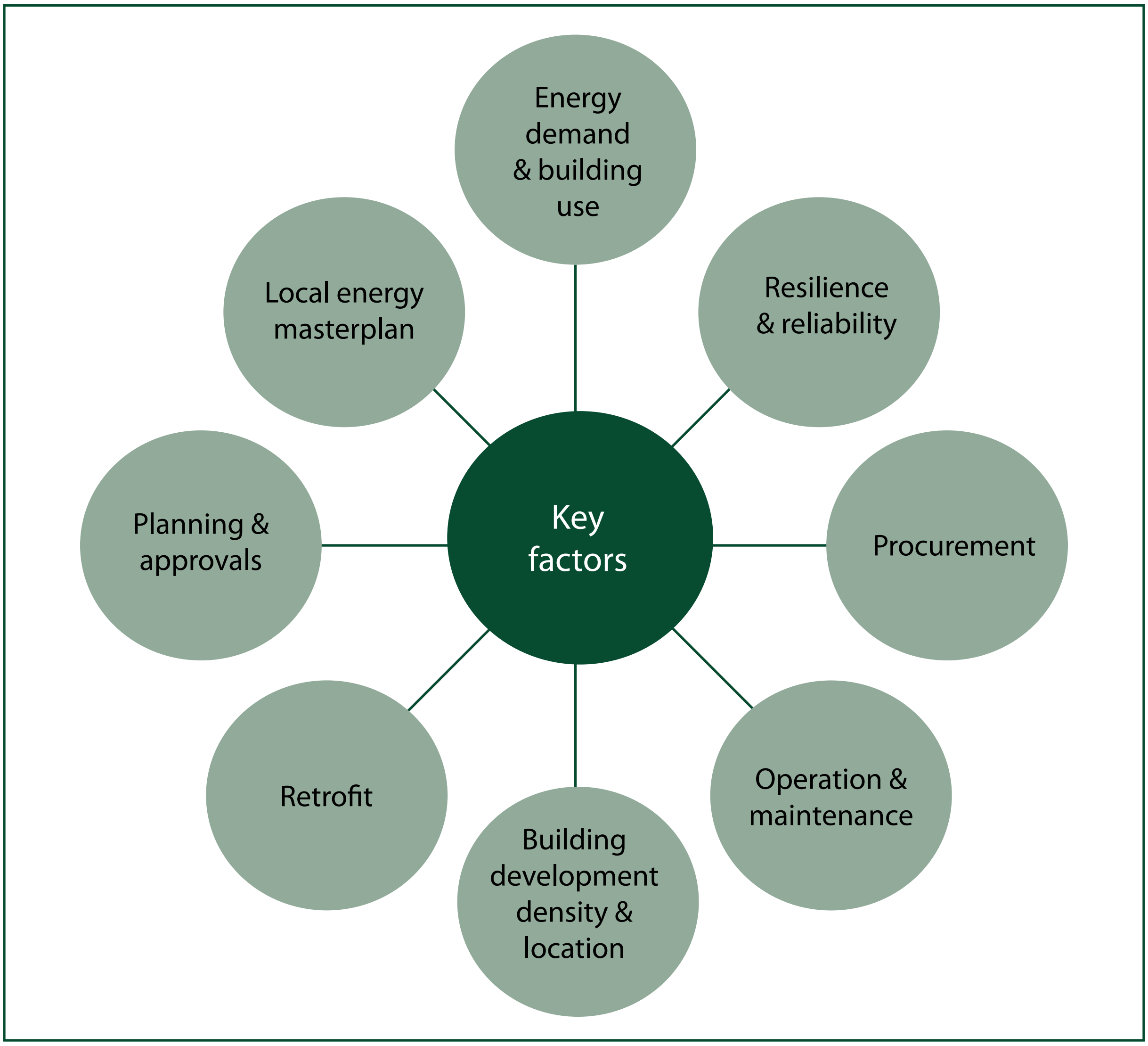
Figure 4.2 The team approach – (An example)



Stage 1 – Scoping[11]

The first step in integrating renewable and low carbon generation into building development is to carry out a scoping exercise.

Figure 4.3 Overview of key scoping factors



A scoping exercise should include the following:

Establishing the Vision and Key Objectives

Project actors and stakeholders at this stage include:

- Funding Body and/or Financial Manager.
- Building owner and/or landowner.
- Utilities operators.
- Local residents.
- Tenants and Occupants.
- Community groups.
- Local Authority Planning Officer.
- Local Authority Estates Manager.
- Local Authority Energy/Sustainability Officer; and
- Local Authority Regeneration Officer.

The objectives and aims for the project should be identified to guide the technology feasibility and financial viability stages. It will also help ensure that the project can be monitored and regularly assessed.

Example objectives are:

- Meeting Building Regulations requirements.
- Reducing energy costs.
- Reducing fuel poverty.
- Generating a new revenue stream.
- Reducing greenhouse gas emissions.
- Local job creation; and
- Meeting sustainable building standards (BREEAM/CSH) required by the client and/or planning policy.

At this stage key project stakeholders and decision makers should be involved in the discussions so that the objectives for the project are fully informed and agreement is reached on the project outcomes from the early stages.

There will need to be a commitment made at this stage to funding and resource to pursue the next stages of the project.

Assessment of Baseline Energy Profile

It is important in the scoping stage to understand the energy demand requirements of the new building, or existing building if it is being refurbished. This baseline assessment should include where possible:

- Identifying the fabric of the building, services and controls.
- Identifying the existing energy supply and distribution network (or proposed).
- The occupancy of the building and its use; and
- Current energy management policies and procedures (for existing buildings).

The level of complexity required in assessing baseline energy demand profiles will depend on the scale and type of building. In some instances, a simple benchmarking exercise may be sufficient, however in other cases detailed calculations are required, for example using energy software or 3D building modelling tools. Detailed calculations are typically carried out by engineering consultants. For further information on energy demand in buildings, refer to Chapter 5.

Stage 2 – Technology Selection (Technical Feasibility)[12]

Project actors and stakeholders at this stage include:

- Quantity surveyors.
- Land surveyors.
- Building services Engineer.
- Environmental Consultant.
- Trade Associations.
- Planning Consultant.
- Utilities operators.
- Technology Manufacturers.
- Community Groups.
- Local Authority Planning Officer.
- Local Authority Environmental Officers; and
- Local Authority Energy/Sustainability Officers.

The second step is to identify which renewable and low carbon energy generation technologies are technically feasible to be incorporated into the project. Chapter 5 of this practice guidance explains the key factors involved in this process, and Chapter 6 provides a more detailed overview of each renewable and low carbon energy technology.

Outline feasibility can often be assessed based on rules of thumb, benchmarks and the consideration of key factors outlined, however, due to the complexity of such systems, a full technical feasibility study will be required to establish:

- System capacity/size.
- System configuration.
- Energy generation potential.
- Environmental performance including greenhouse gas emissions generation and reduction.
- Risks associated with switching to a renewable energy supply; and
- Planning permission issues.

Any outline feasibility should recognise that the applicability of some technology options will be enhanced through changes to the design, layout and mix of the project. However, this should not be the driving factor and should recognise the impacts of changes to the design and layout of a building to the energy hierarchy – ie, by reducing any solar gain. When designing renewable and low carbon energy technologies, appropriate selection, and where applicable, optimal combination of options is integral to overall good building design.

There is no nationally prescribed approach for carrying out a technology feasibility assessment, many architects and designers will have developed their own approach which fits their internal practices, but as part of this practice guidance, an example template has been provided in Chapter 8. In addition reference should be made to the requirements and methodology described in BREEAM, under the issue Ene 04: Low and Zero Carbon Technologies[13].

The outputs of an energy feasibility study report may include[14]:

- Preferred LZC technology mix.
- Energy generated from energy source per year.
- Carbon emissions saved per £ spent.
- Expected carbon reductions (including from LZC sources).
- Land use.
- Planning.
- Noise.
- Whole life cost and lifecycle impact.
- Funding/grants.
- Energy demand of the development – application of the energy hierarchy.
- Reasons for excluding other technologies; and
- Drawings to indicate the location of LZC employed.

Depending on the client, feasibility studies are usually outsourced to energy consultants in order to obtain an independent assessment.

As detailed previously, the technology selection process is based on the assumption that the principles of the energy hierarchy are being followed, i.e., energy demand reduction and energy efficiency potential have been maximised. However, in the case of some projects, particularly for example retrofit schemes, it would be beneficial at the technology selection stage to consider whether there is the opportunity to carry out a comprehensive energy assessment for the project. This is very important as the capacity and hence capital cost of the technologies required for the project are dependent on the amount of energy that they are required to supply.

The objective of the assessment would be to identify opportunities for improving energy efficiency to reduce the energy requirement and therefore the capacity of renewable energy generation required.

Stage 3 – Financial Viability[15]

Project actors and stakeholders at this stage include:

- Financial Advisor.
- Building Services Engineer.
- Environmental Consultant.
- Planning Consultant.
- Technology Manufacturer.
- Maintenance contractors.
- Operational suppliers; and
- Community Groups.

The next step is to assess the financial viability of the development including the proposed LZC energy mix from Stage 2. This assessment should provide the project team with the following information:

- Capital investment required.
- Operation and maintenance costs.
- Revenue generation.
- Return on investment (Internal Rate of Return).
- Pay–back period; and
- Net present value.

The assessment should consider financial support mechanisms such as the Feed–in Tariff, Renewable Obligations Certificates, and Renewable Heat Incentive (see Chapter 7 for further information). The value of carbon through schemes such as Carbon Reduction Commitment or European Emissions Trading Scheme should also be factored in where applicable.

Possible degradation in energy generation over time is an issue that shouldn't be overlooked, and will differ depending on the technology chosen. It is important to obtain relevant and accurate manufacturers information particularly regarding any equipment and component replacement requirements which will have an affect on operational life expectancy and by association cost. Sources of data on performance in use are important to give confidence long term in a systems expected output and relationship to costs. For example the Energy Saving Trust has carried out a field trial to determine the key factors which impact the performance of domestic scale heat pumps.[16]

It may also be pertinent to provide a comparison to a 'business as usual' case too. A renewable energy supply may, for example, negate the need for a gas supply and hence the cost of the distribution network around the buildings.

There are numerous methods of cost assignment, the most common examples are outlined below:

Table 4.2 Methods of Cost Assignment

Cost assignment	Description
Payback	This presents an approximation of when the extra over cost of investment in a technology will break even. Payback periods are usually simplistic and don't take into account future cash flows.
Discount Cash Flow	This method discounts future costs and revenues at a rate to approximate them to present day values.
Net Present Value (NPV)	This uses discounted cash flow to provide an overall net present value which will either be positive or negative; if positive, the project is viable, if negative, it will need extra capital to make it positive.
Internal rate of return	An organisation can use a fixed rate which projects must meet to be worth investing in.
Whole life costing	This process includes discounted costs using NPV, in addition to factoring in future operational costs, and any additional capital expenditure.

Stage 4 – Implementation & Delivery

Project actors and stakeholders at this stage include:

- Financial Advisor;
- Maintenance contractors; and
- Operational suppliers.

Once the feasibility and viability assessment to determine the optimal combination of LZC technologies has been undertaken, a decision as to whether to proceed with the proposed technology (or mix) will need to be made.

Once the decision to proceed has been made, a key consideration of the successful implementation of a project is consultation of relevant stakeholders. Identification of consumers and their demand profiles in addition to the funding opportunities from local authorities and larger consumers are important outcomes of consultation.

Clear identification of project drivers ensures that procurement options remain focused. It is therefore important that, from the outset, the concerns and desires of the various parties involved are synthesised into a procurement strategy.

Successful implementation of renewable or low carbon technologies is dependant on being able to access finance, which should be considered from the earliest stages of project development. The specific requirements of funding options and grant mechanisms identified during Stage 3, such as the Renewable Heat Incentive or Feed–In Tariffs, should be considered and further developed at this stage to ensure eligibility of the project.

Another consideration at this stage is how the system will actually operate in practice; including the proposed structure of operation and system management. It may be preferable for larger scale systems to set up a dedicated company such as an Energy Service Company (ESCo) to generate, supply and distribute energy. A suitable business model should also be developed.

The detailed design phase will involve developing concepts into workable solutions, via detailed proposals in collaboration with consultants. Drawings and specifications will need to be prepared for most projects, demonstrating spatial requirements in addition to providing sufficient detail pertaining to how the system chosen should perform and operate.

At this stage all relevant planning consents and permits, in addition to other licensing and regulatory compliance need to be obtained and consequently continued consultation and liaison with the Environment Agency and local Authority will be necessary.

Installation of renewable and low carbon energy technologies will ultimately be by contractors. At this stage, fine tuning and commissioning may be required. In addition it is important to consider how end users could need to be educated to use the systems. In some instances a user guide alone may not be sufficient, and training may need to be provided. Finally post construction monitoring and targeting should be carried out where relevant, and particularly for larger systems, to ascertain whether the technologies are operating as designed. This will help to ensure that energy and carbon performance is maximised. Post Occupancy Evaluation provides one method of determining a buildings performance in use. Other valuable sources of data will include metered energy performance, and where installed, outputs from building management systems, that often provide logs of system performance.

Summary

Figure 4.4 overleaf presents the four stage process described and how it this to the Royal Institute of British Architects (RIBA) work stages, which are commonly used and referred to in building design and construction.

The next diagram, shown in figure 4.5, provides an example overview of the process for integrating renewable and low carbon energy into building development for an example project, and where each stakeholder or group might fit in relation to the four stage process described:

- **Stage 1:** Scoping.
- **Stage 2:** Technology Selection.
- **Stage 3:** Financial Viability; and
- **Stage 4:** Implementation and Delivery.

It should be noted that each project will be different and as such stakeholders and project stages that have been described in this practice guidance will differ depending on the type and scale of renewable energy project.

In addition there may be other stakeholders that should be involved that haven't been included. This practice guidance provides an example project only, to demonstrate that holistic thinking is necessary, with cross consultation across different groups and stakeholders.

Figure 44 Indicative RIBA Stages and Relation to Four Stage Process

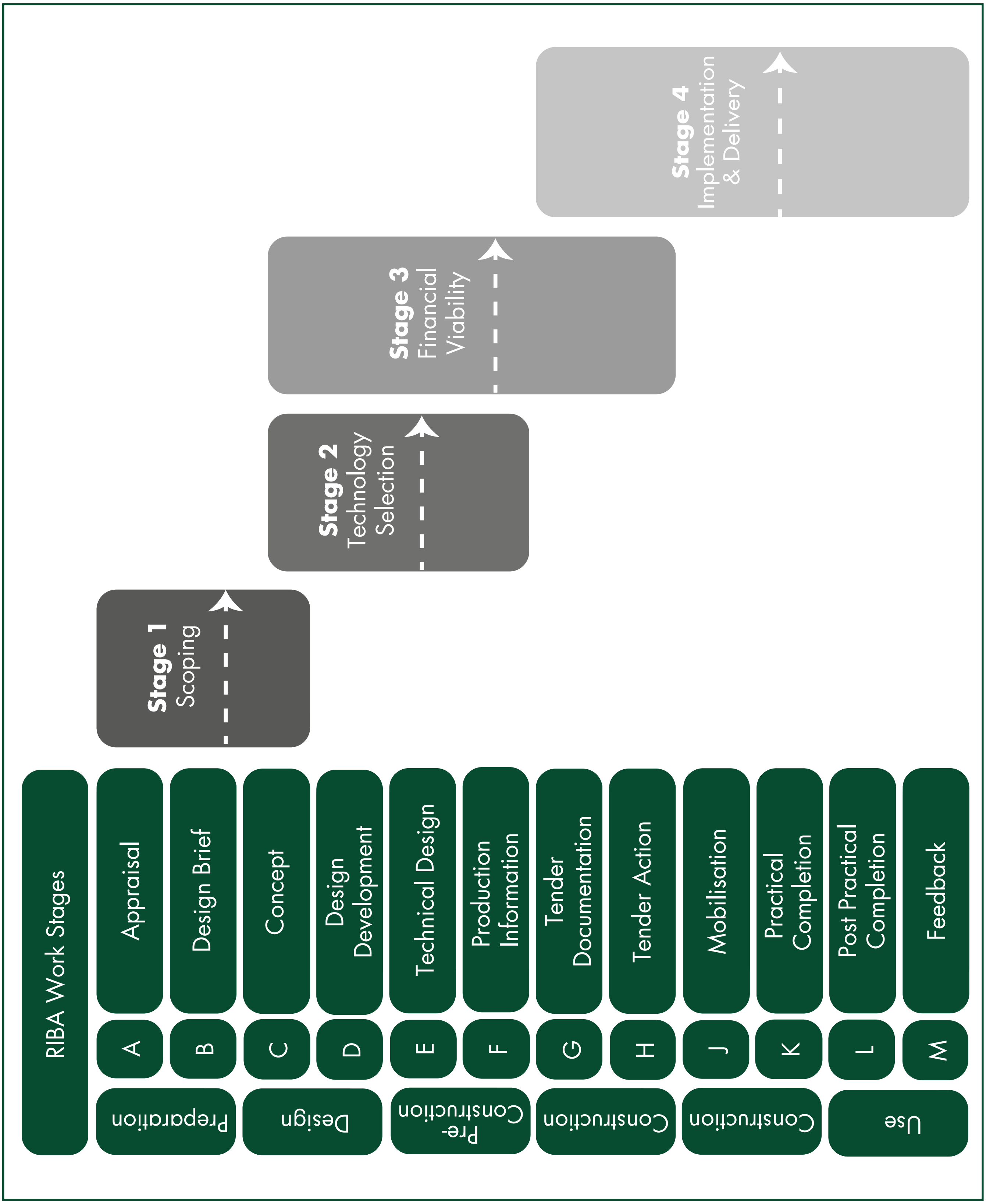
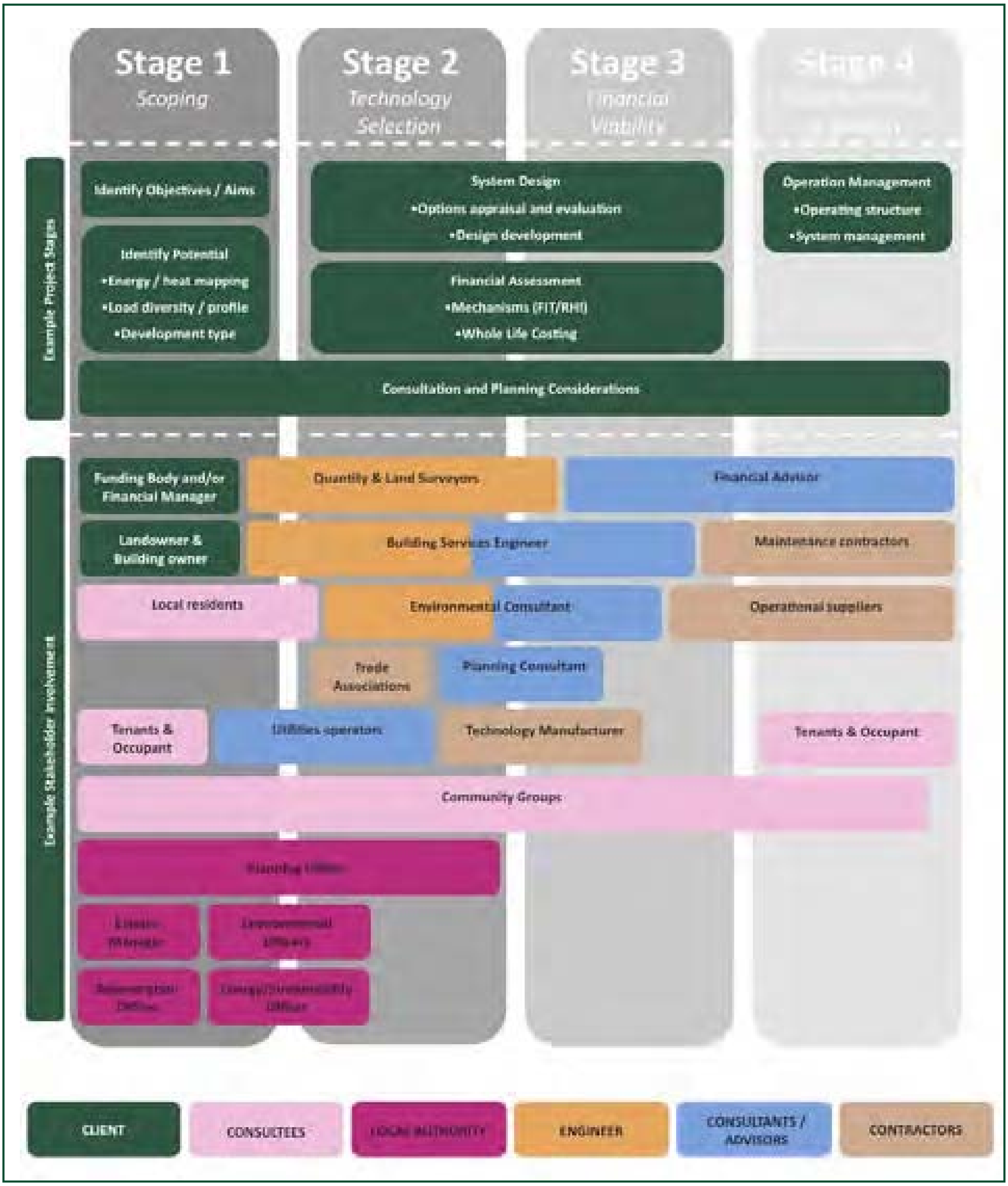


Figure 4.5 Example project timeline and actor/stakeholder involvement



References

11 See steps 1 and 2 of the example Renewable and Low Carbon Energy Feasibility Study Template in Chapter 7

12 See step 4 of the example Renewable and Low Carbon Energy Feasibility Study Template in Chapter 7

13 BREEAM 2011 New Construction Technical Manual www.bream.org

14 Adapted from Figure 4.3 in TAN22: Sustainable Buildings, Welsh Government, 2010

15 See step 4 of the example Renewable and Low Carbon Energy Feasibility Study Template in Chapter 7

16 Energy Saving Trust, Getting Warmer: a field trial of heat pumps, Energy Saving Trust, 2010 www.est.org.uk

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Practice Guidance

Renewable and Low Carbon Energy in Buildings

5 Understanding Energy in Buildings

July 2012

Cover image: Hazel Court, Swansea
Courtesy of Family Housing Association (Wales) Limited

Chapter 5: Understanding Energy in Buildings

This chapter provides an overview of the key factors that should be considered when determining energy demand in buildings which will help to inform selection of renewable and low carbon technologies. It is important that all stakeholders are familiar with these factors, in order to better understand energy demand and consumption within a building. This will help lead to appropriate technologies being chosen for each development type, and in many cases define where more than one technology can be used in combination to provide an optimised approach.

Energy Demand and Building Use

Renewable energy generation systems are sized according to the energy demand that they are required to satisfy. Understanding the behaviour of buildings and their occupants is fundamental to successful implementation of renewable and low carbon energy systems. Some key considerations that determine energy in buildings are provided in the following sections.

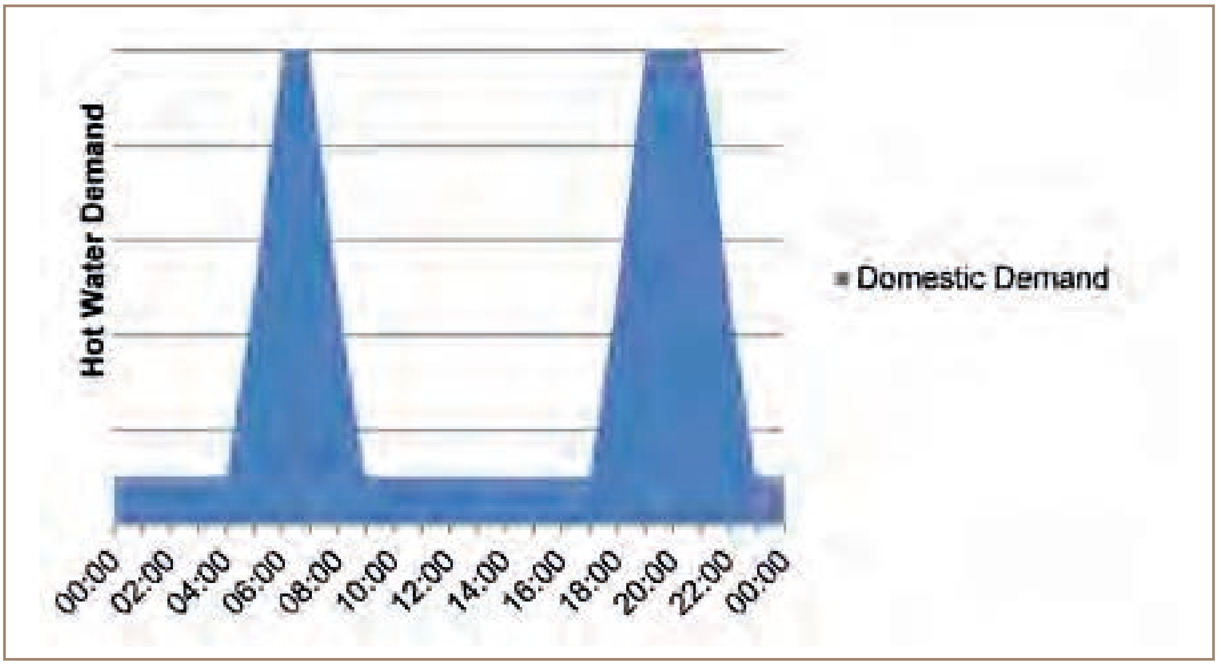
Energy Demand Profile

The pattern of energy use in a building, which varies during the day and over the year, is known as a demand or load profile. It is important to know the demand profile for a project as this will be a major consideration when determining which technologies are appropriate to satisfy that demand and the system configuration required. The demand profile is dictated by how the building is used and similar building types will have similar profiles.

A simplified hot water demand profile for a typical residential building is shown in the diagram on the following page. As can be seen in the diagram, there is a hot water demand in the morning and evening when the building is occupied, while the demand drops to a baseline level when unoccupied or during the night. This is an important consideration when determining which renewable or low carbon system would be appropriate.

Renewable energy generation is sometimes reliant on an intermittent energy source (the sun in this case) which may or may not be available when there is a demand for that energy. For example if a solar thermal hot water system was installed in the building, hot water would be generated during daylight hours, which contrasts in this case with the demand profile. The excess energy generated that is not used in the building during will need to be distributed so that it can be used elsewhere, or stored in a buffer vessel, otherwise the energy generated would be wasted.[18] Unlike heat or hot water, renewable or low carbon electricity can be diverted back to the national grid when not utilised.

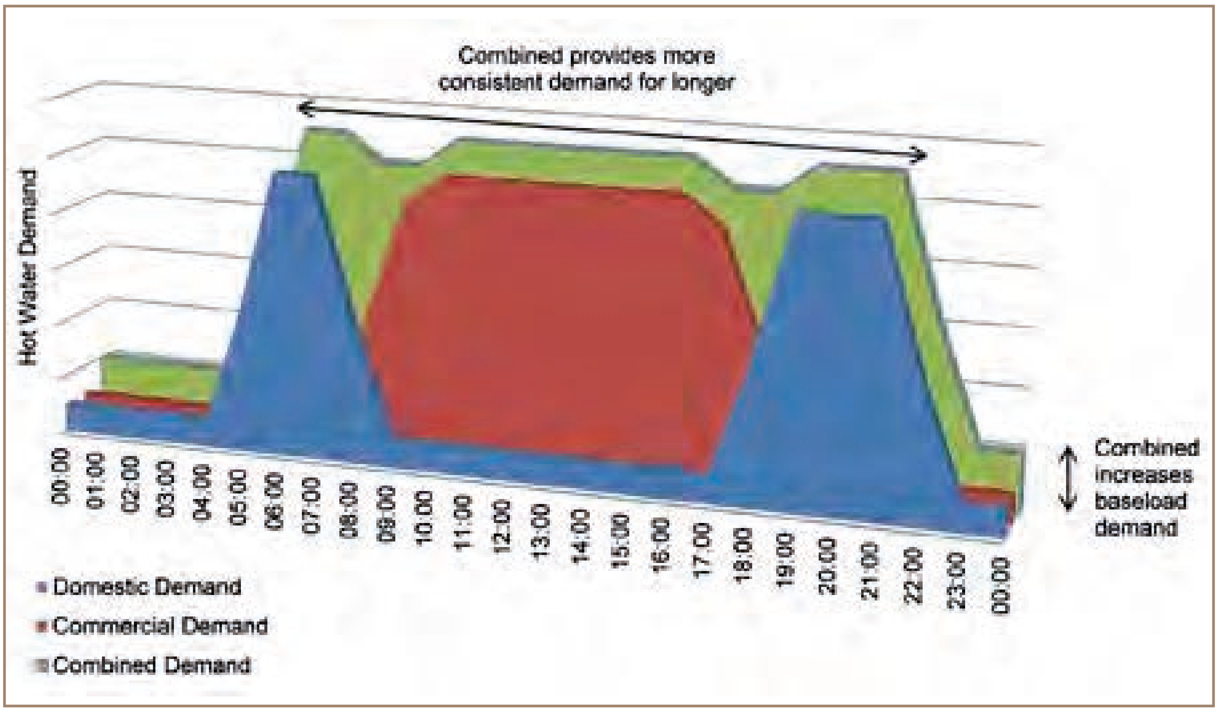
Figure 5.1 Simplified Hot Water Demand Profile for a Domestic Building



Due to the nature of load profiles, the use of community energy systems allow for heating or cooling capacities to be reduced when compared to individual buildings. This is essentially due to the peak demands being spread out.

Contrasting the example given above with that of a commercial building, the demand for hot water in a commercial building will primarily be during working hours on week days (whereas for domestic buildings, the demand will be outside of these hours; in the morning and evenings as already stated, and during the weekend). By combining building loads through a district or community energy system, the peaks and troughs are spread out, as shown in the following diagram. This design philosophy can also help to reduce the overall design peak load of the hot water system when compared to the cumulative total of separately sized individual boilers (as for a traditional system. Other benefits can include less backup capacity requirement.

Figure 5.2 Load Diversification



Retrofit and Extensions

When retrofitting renewable and low carbon energy generation technologies into existing buildings it is important to consider whether the technology is compatible with the existing building services systems.

This is of particular importance when considering the application of renewable heat generation technologies. Key questions to ask are:

Q. How is the space heating currently provided?
Renewable heat generation technologies are typically only suitable for wet systems although some can be used for air conditioning systems. It is likely to be very costly to retrofit a wet central heating system into a building that currently uses electric heating hence it may be more cost effective to consider renewable electricity generation to provide the heating for these buildings.

Q. What is the operational temperature of the current heating system?
For example, solar thermal, ground source heat pump (GSHP) and air source heat pump (ASHP) systems are usually best suited to low temperature hot water distribution systems such as under–floor heating. For higher temperature systems biomass boilers or combined heat and power (CHP) are generally more suitable (see Chapter 5 for further information on technologies).

The installation of some technologies will involve fixing to the building fabric and it is important to ensure that the integrity of the building fabric isn't compromised. For example, when installing wind turbines and solar panels to roofs this can require direct fixing to the roof. This should be designed to ensure that no leaks occur as a result of this fixing.

In addition to the risk of leaks, when installing technologies at a high level on buildings, consideration should be given to providing safe access for installation and maintenance. Construction Design and Maintenance (CDM) regulations must always be followed across all projects[19]. The roof structural integrity should be checked to ensure that it can accommodate the additional loading from the technology, associated equipment (such as lifting equipment) and the people that will be installing and maintaining the equipment.

The retrofit of renewable energy generation technologies into a building is likely to be more costly than if integrated into the original design, however the refurbishment of a building can offer a good opportunity minimising this additional cost as enabling works may already be included.

Finally, it can be difficult to retrofit renewable energy generation technologies due to lack of space for the equipment and fuel storage. An assessment of the required space against the available plant room space should be carried out. Additional structures may be required in order to accommodate the new systems.

Building Development Density and Location

The types of renewable or low carbon technologies which are likely to be suited to particular buildings are dependant on the density and type of development surrounding the project site, in addition to the site location. Development density and type can be considered on a scale of reducing population density; ranging from urban city centres, through suburban residential areas, to out–of–town industrial areas and rural settlements.

Successful implementation of particular renewable or low carbon technologies may also require consideration of a development on a number of planning levels, from the masterplanning scale, down to assessment of the form and type of the individual building. Additionally, the physical location of a particular development will have an influence on the type of renewable or low carbon technology best suited for the site.

The energy hierarchy plays an important role in these considerations. The centre of a town or city also often contains the most historic architecture, which is frequently associated with poor insulation and energy efficiency, therefore demand reduction should first be prioritised where possible, through increased fabric and energy efficiency prior to considering renewable technologies.

Table 5.1 Building Development Density and Location

Density	Example of Location	Descriptions
High	City Centre	City centres are characterised by a high density urban mix of building types and uses. The majority of important public buildings such as central libraries, civic centres and museums are typically located in the urban centre in addition to key transit nodes such as central railway and bus stations. A city centre will also contain a high number of mixed use buildings housing offices, apartments, hotels and retail facilities. Due to the mix of uses and high development density, city centres tend to have a high heating baseload throughout the day during winter months, in addition to a cooling requirement during summer months. Commercial and public buildings also tend to have a high electricity demand during the day. Due to the integration of offices and other commercial premises in mixed use residential buildings; these consumers have a flatter, more consistent electricity load profile than single use residential buildings, which tend to have defined morning and evening energy load peaks.
High/Medium	Outer Centre	This may include large hospital and university sites, in addition to newer residential and mixed use developments which are typically located in high development density 'clusters'. The localised high density development of outer city areas results in areas such as university campuses, hospital buildings and residential/ mixed use developments, each with a differing energy load profile. It should be noted that thermally efficient building envelopes of newer residential and mixed use developments will have a significantly lower heat load than older developments of a similar type.

Density	Example of Location	Descriptions
Medium	Inner City Districts	Inner city districts tend to comprise a range of housing types, including sheltered housing and local authority owned apartment blocks or housing estates. Associated community buildings are also present in these areas, such as schools, leisure centres, and libraries. Given the prevalence of council owned property, strategic heat plans can be developed which identify the spatial location and heat requirements for key public buildings, in addition to the heat and electricity loads of the council owned residential estates.
Low	Suburban Districts	Suburban districts are characterised by residential dwellings, typically detached and semi–detached houses. Neighbourhood centres containing retail facilities, and commercial business parks are also common within the suburban areas of a town or city. The large majority of residential development exists within suburban districts, much of which comprises older property with poor thermal efficiency and consequently a high heat demand. Suburban energy load profiles are dominated by morning and evening demand peaks from residential properties. With a lower proportion of rental and council owned property compared to the city centre and inner city districts, suburban householders tend to have a greater interest in investing and making improvements to their properties. There is consequently a high potential for adoption of microgeneration technologies. Due to the high potential for integration of microgeneration technologies, consideration of the individual building should be made as a priority when selecting suitable technologies, and fabric and energy efficiency should always be prioritised in the first instance.

Density	Example of Location	Descriptions
	Industrial	Industrial areas are generally located at the edge of a town or city and comprise a range of industrial premises, storage and distribution warehouses, and offices. Power generation facilities may also be present in some industrial areas. Energy generation projects in industrial areas can be used to supply industrial and commercial sites within the industrial area, or alternatively power and heat can be distributed to the rest of the town or city via district heating networks and the electricity grid.
	Rural	The rural areas surrounding a town or city should be primarily considered for their potential to provide and contribute towards renewable energy generation. Opportunities for the development of medium to large scale wind power generation, and space and fuel provision for biomass supply chains may be presented by the rural landscape.
Mixed	Urban Extensions	New settlements and urban developments can comprise entire communities, inclusive of retail, leisure and healthcare facilities, educational and community buildings, commercial developments and residential housing and apartments. As these urban extensions tend to be developed at the masterplanning level, with the entire urban extension developed as a cohesive design, there is a great potential to integrate renewable energy generation from the outset, whilst minimising energy demand through efficient building envelopes and services.

Energy Mapping

Energy maps are a useful tool in enabling the identification of suitable technologies for understanding how best to generate, distribute and supply energy.

Energy maps can also be used to determine opportunities for linking to existing projects, and where appropriate to share energy. By developing an energy map, projects can be prioritised at a masterplanning level, to ensure resources and technologies are applied in the most effective manner to maximise cost and carbon savings.

Energy mapping is just one potential option as part of the options appraisal stage, but it can quickly filter out where schemes are not viable, such as for district heating.

The Welsh Government has undertaken a Pilot Study on energy mapping as part of a Renewable Energy Assessment. The study provides the results of a robust exercise to establish potential for renewable energy, which could be used by public sector departments, and also relevant private sector organisations. These kind of exercises are essential in order to encourage cooperation between public and private sector and promote larger scale heat networks or renewable electricity[20].

References

18 Unlike heat or hot water, renewable or low carbon electricity can be diverted back to the national grid when not utilised

19 Construction Design and Maintenance (CDM) regulations must always be followed across all projects. For further information refer to the Health and Safety Executive (HSE)

20 Pilot Study – Pembrokeshire County Council Renewable Energy Assessment, Welsh Government, 2010

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Practice Guidance

Renewable and Low Carbon Energy in Buildings

6 Technology Selection

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Cover image: Canolfan Hydggen, Machynlleth
Courtesy of Powys County Council

Chapter 6: Technology Selection

This chapter provides an overview of renewable or low carbon energy options. For each option, key considerations and design factors are presented, with a discussion on suitable applications. Technologies can be used in combination in many instances as part of a developments building services strategy in order to meet project targets; these are referred to as 'complimentary' technologies. Finally links to further resources and information are provided.

Introduction

In line with current planning policy, this practice guidance considers principally, renewable and low carbon energy scales from Micro (below 50 kW) to Sub Local Authority (between 50 kW and 5 MW), i.e. those that are applicable at a building development scale.

Table 6.1 Renewable and Low Carbon Energy Scale for Planning Purposes

Scale of Development	Threshold (Electricity and Heat)
Strategic	Over 25 MW for onshore wind and over 50 MW for all technologies
Local Authority–wide	Between 5 MW and 25 MW for onshore wind and between 5 MW and 50 MW for all other technologies
Sub Local Authority	Between 50 kW and 5 MW
Micro	Below 50 kW

Source: Planning Policy Wales

The technologies in this guidance have been aligned to correspond with those outlined in the Welsh Government Practice Guidance – Planning Implications of Renewable and Low Carbon Energy Development (February 2011)[21].

Resilience and Reliability

Some renewable energy generation technologies are unable to dispatch energy on demand due to the intermittency of the energy source (such as solar and wind). As a result energy generation from these may not be possible when the energy is needed.

This is an important consideration for applications where there are critical systems in buildings, for example in hospitals. The main solutions for this are to have a back–up alternative energy supply (such as the national grid or gas boilers) or to have on–site energy storage (such as batteries, pumped storage or thermal storage).

Planning and Other Approvals

Planning permission is required for various types of development. In most cases the installation, alteration or replacement of a renewable energy technology is considered as development for the purposes of planning, and therefore require permission from the local planning authority (council). There are, however, some types of micro–generation technologies that do not require planning permission as they are given the status of permitted development.

Depending on the renewable energy system selected, there may also be other permissions and consents needed in addition to planning, such as:

- Listed Building consent if a building is listed.
- Conservation area consent if the development is in a conservation area.
- Many trees are protected by tree preservation orders which mean you need the council's consent to prune or fell them.
- New building work will often need to comply with Building Regulations.
- Some buildings may hold roosts of bats or provide a refuge for other protected species – these are given special protection; and
- Environment Agency licences.

Renewable and low carbon energy projects will generally be supported provided sustainability impacts (environmental, economic and social) are avoided or minimised, and nationally and internationally designated areas are not compromised. This includes:

- designated landscapes (e.g. National Parks, Areas of Outstanding Natural Beauty, Heritage Coasts);
- nature conservation areas (Special protection Areas (SPAs), Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSI), National Nature Reserves); and
- sites/areas of historic importance (e.g. World Heritage Sites, historic landscapes, Registered Parks and gardens, Ancient Monuments, Conservation Areas and listed buildings).

A suite of leaflets has been published by the Welsh Government on these technologies including detailed practice guidance on the planning implications of renewable and low carbon energy technologies at all scales. The Welsh Government has also published practice guidance on the planning implications of renewable and low carbon energy developments, this should be referred to in the first instance[22]. The local planning authority will be able to provide guidance as to whether any of these apply to a project.

Wind

Description

Wind power uses energy from the wind to turn a rotor connected to an electrical generator. Wind power can be used to generate electricity, either in parallel with a mains supply, or for stand–alone applications with battery backup.

Key Feasibility Questions:

☑ Absence of ground obstacles and landforms (to avoid turbulence)?

☑ Local average windspeed?

☑ Absence of landscape designations in site vicinity (e.g. conservation areas, historic sites)?

Types

Wind turbines can be free standing or building mounted. Larger free standing turbines are best suited to larger developments, with building mounted used to provide supplementary power particularly in urban locations. Turbines traditionally have a horizontal axis, i.e. the blades revolve vertically around a horizontally mounted hub, much like a traditional windmill, but some modern turbines can have a vertical axis.

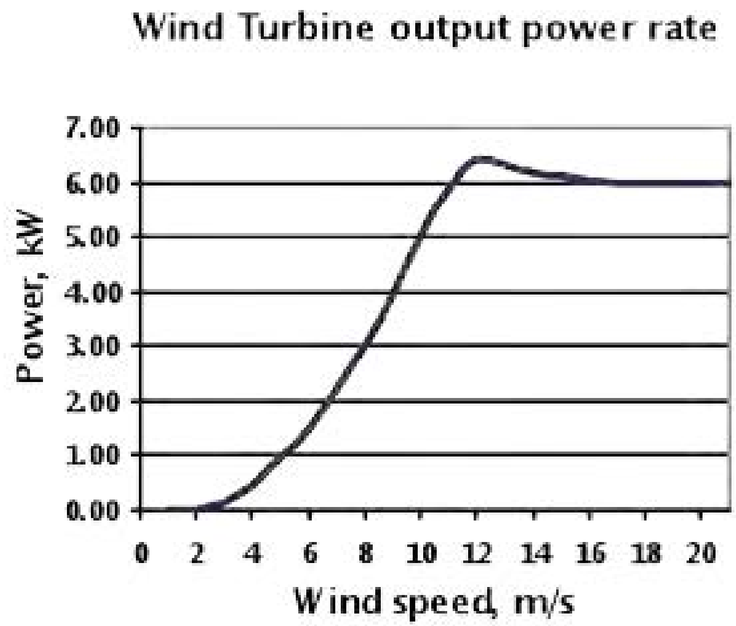
Location, Demand and Optimal Combination

Location is a key factor in getting the most energy out of a wind turbine to meet a buildings electrical demand. Wind speed is the overarching determinant of the potential to generate power. Wind speed increases with height and elevation above sea level, and as such the rotor hub height of a wind turbine should be maximised.

The relationship between wind speed and power is cubic, therefore a doubling in wind speed with have an eightfold effect on power output potential. It is thus extremely important to determine wind speeds at a site in order to assess the feasibility of wind power for a particular development. As an outline rule of thumb indicator to feasibility, the yearly average wind speeds on site should be 5 m/s or greater for wind turbines to be a suitable renewable low carbon technology selection.

It should be noted that most wind turbines rated outputs are at a wind speed significantly higher than 5 m/s, therefore they will typically operate at a power output significantly lower than their theoretical maximum (see the below description of 'capacity factor'). In addition, most wind turbines will not 'cut–in' until a minimum wind speed is reached, typically 3–4 m/s (cut–out is around 25 m/s). At speeds below the cut–in speed, no power will be produced.

Figure 6.1 Example power curve for example standalone wind turbine[22]



Source: Carbon Trust Guide[23]

The 'capacity factor' determines how well a wind turbine will perform for a given site. It is the ratio of the amount of electricity actually produced in a given period, to the amount of electricity that would have been produced if the turbine was operating at its rated power. Utility scale turbines may operate at around 25–35% while small turbines (covered in this practice guidance) may operate at 15–20% or less. The example wind turbine shown in figure 6.1 has a rated output of 6 kW at speeds of 12 m/s or above, while at 5 m/s only 1 kW is produced; approximately 17%.

Wind speed measurement options are as follows:

- Direct measurement using anemometers and wind vanes (ideally over one full year).
- Existing datasets; or
- Calculator tools[24].

Accuracy can only be guaranteed from direct measurement on site to determine potential power generation, and detailed feasibility assessment will help to prevent unsuitable application of wind technology. The level of detail involved in assessing wind speed on site will depend on the certainty required by the project team and client.

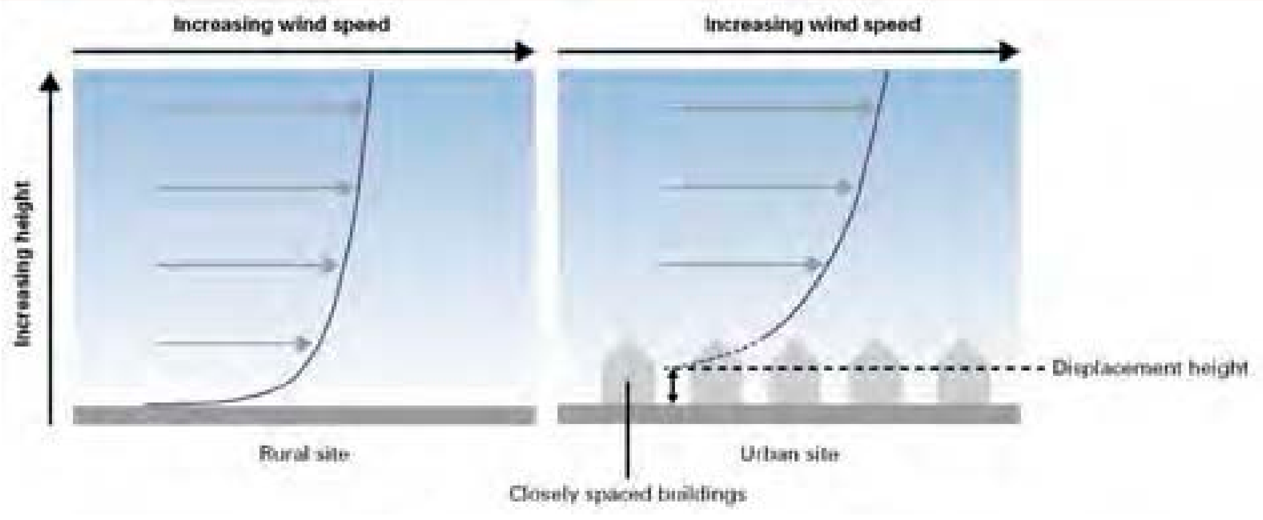
Ground obstacles such as buildings have a large impact on wind speed and turbulence, and as such a large 'fetch' is required for turbines to work efficiently. The fetch (or distance of the turbine from any ground obstacles) should be a minimum of 10 times the obstacle height, with a recommendation of 30 times for optimum performance. In addition to a large fetch, wind turbine hubs also need to be exposed. The exposure should be at least 1 to 1½ times any obstacle height upstream of the turbine[23].

Other factors that need careful consideration include the following:

- Gradient – A sharper topographical gradient will affect the wind speed and consistency of flow at the turbine.
- Shear effect – Terrain type has a large impact on velocity profile for a given location. Rural sites will experience higher wind speeds as there is less shielding effect from buildings. Wind turbines are therefore more suited to rural locations.
- Boundary effects – In addition to reducing wind velocity, urban areas (and closely spaced buildings) can cause sheltering and turbulence. These need careful consideration when siting a building in proximity to buildings or other turbines, and for larger developments complex modelling may be required (e.g. computational fluid dynamics, CFD); and
- Wind profile – Exposure to predominant winds needs to be considered.

The figure overleaf demonstrates shear effect and its result on wind speed according to location. For the rural site, the velocity profile is unobstructed, however, for the urban site the effect of buildings and obstructions displaces the velocity profile. In addition the effect of the buildings and obstructions reduces wind speed at lower heights.

Figure 6.2 Simplified Shear Effect and Wind Speed



Source: Image reproduced with permission from the Carbon Trust

As stated previously, wind turbines are more suited to rural developments than urban. Applications may include community power for a housing development, or for high power consuming activities such as industrial processes. Building mounted turbines will rarely produce a significant power supply, however, they can be used to supplement or achieve zero carbon for well designed low 'residual' energy demand schemes (refer to Chapter 3 on the energy hierarchy).

Wind turbines can be used with most other renewable technologies, particularly renewable heating, where the power generated can be used to drive pumps and other equipment. Wind can also work well with other power generating technologies, including PV.

Operation and Maintenance

If correctly installed and commissioned, maintenance of a wind turbine will be limited to technical maintenance inspections and servicing once every one to two years. Inspection of the turbine components is also recommended after particularly stormy weather.

Maintenance inspections should be undertaken by the installer or other suitably qualified technician and comprise an assessment of the rotor, hub, blades, tower, fixings and all connections. Any minor damage to blade edges can be repaired, although blade replacement will be required where there is evidence of damage or cracking near the blade root. Bearings and seals are also likely to require relatively regular replacement.

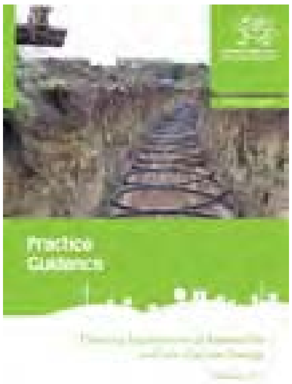
When properly maintained, wind turbines can operate for up to between 20 and 25 years.

Financial Viability

Wind is one of the most financially viable renewable technologies, particularly for the case of large freestanding turbines, which can have payback periods of only a few years. The Carbon Trust estimates that some rural installations can have costs of energy below 12 p/kWh, which is comparable to grid supplied electricity, however, urban sites are unlikely to have costs of energy below 25 p/kWh[23]. The value of offset electricity, in addition to the value of exported electricity should both be considered when determining feasibility.

Wind is also supported under the Government Feed–in Tariff (FIT) for all scales. For further information, see Chapter 7.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for wind energy and should be referred to in the first instance if the decisions is made to install or incorporate biomass into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[25]

Planning permission is currently required for all scales of wind turbines, and consultation should always be made with the relevant Local Authority Planning Department. In addition, the following factors should be considered:

- Environmental Impact Assessment (EIA) – This will be required if there are three or more turbines proposed, and/or if the hub height or structure exceeds 15 m.
- Conservation areas – Where applicable, the Countryside Council for Wales (CCW) should be consulted.
- Archaeology – Where applicable, Cadw should be consulted[26].

Wind turbines can have a significant environmental impact, and the following outline issues should be considered when assessing site suitability:

- Landscape and visual – Turbines are visually intrusive, and consultation with the relevant Local Authority Planning Department should always be made.
- Noise and vibration – rotor hubs and blades will generate some noise, particularly at higher wind speeds.
- Ecology and ornithology – planning constraints may require a bat and/or bird survey.
- Radiological survey – Larger turbines may cause interference to TV, radar or telecommunication signals; and
- Shadow flicker – Effect caused when an operating turbine is located between the sun and a building, which will cause light intensity to brighten and darken for building occupants.

Large scale wind turbines are not considered in detail in this practice guidance, however, for further information, Strategic Search Areas for large scale wind deployment are detailed in Welsh Government Technical Advice Note (TAN) 8, *Planning for Renewable Energy*[27].

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Ground obstacles (long fetch required; 10 times obstacle height minimum, 30 times recommended) (exposure of rotor hub; 1 to 1½ obstacle height). • Avoid sharp gradients. • Shear effect (rural vs. urban). • Boundary effects of buildings (cause sheltering and turbulence). • Exposure to predominant wind direction. • Maximise hub height and elevation above sea level. • Wind speed (5 m/s or greater for outline feasibility. Cut–in wind speed typically 3–4 m/s. Cut–out around 25 m/s).

Consideration	Details
Location, Demand and Optimal Combination (cont'd)	**Demand:** • Capacity factor (small turbines operate at 15–20% of rated power, utility scale operate at 25–35%). • Better suited to rural developments. • High power consuming activities and community power (due to relatively constant baseload). **Complimentary technologies:** • Heat pumps, solar thermal, solar photovoltaics, biomass.
Operation and Maintenance	• Maintenance inspections by a suitably qualified technician (every 1 to 2 years). • Replacement of bearings, seals and blades as necessary. **Components:** • Tower, rotor and hub, nacelle, gearbox, generator, bearings, brake, yaw mechanism, anemometer.
Financial Viability	• Supported under Government Feed–In Tariff scheme. • Short payback period (2 to 5 years).
Planning and Environment	• Planning permission is required. • Environmental Impact Assessment (EIA) (if three or more turbines and/or hub height or structure exceeds 15 m). • Conservation areas (Inform Countryside Council Wales (CCW)). • Archaeology (Consult Cadw Wales). • Environmental impacts: noise, visual impacts, shadow flicker, ecology.

Further Information

Organisation	Details	Website
Cadw	Welsh heritage sites	www.cadw.wales.gov.uk
CCW	Protected sites map	www.ccw.gov.uk/interactive–maps/protected–sites–map.aspx
Carbon Trust	Wind estimator tool – Allows users to input site and turbine details to determine mean wind speed, energy generation potential and CO_2 saving	www.carbontrust.co.uk/emerging–technologies/current–focus–areas/offshore–wind/_layouts/ctassets/aspx/windpowerestimator/windpowerestimatorterms.aspx
Energy Saving Trust	General information on wind power	www.est.org.uk
Microgeneration Certification Scheme (MCS)	Accredited installers	www.microgenerationcertification.org
Renewables UK	Trade and professional body for the UK wind and marine renewables industry	www.bwea.com
Micropower Council	Representative organisation for companies and organisations in the microgeneration sector	www.micropower.co.uk/
Energy networks association	Industry body representing the 'wires and pipes' transmission and distribution network operators for gas and electricity in the UK. Standards for wind power: • Engineering Recommendation G83 • Engineering Recommendation G59	www.energynetworks.org

Case Study: Greenhill Primary School, Caerphilly

Greenhill Primary School in Gelligaer, Caerphilly, is a state of the art building which replaces a former 1960's school. The school has been designed as an exemplar of sustainability and incorporates a number of renewable technologies, including photovoltaics and four micro 1.5 kW wind turbines, which are integrated into the building structure. The wind turbines were selected following a feasibility study which identified a high wind harnessing potential at the build site, in addition to the benefit of a visual learning resource for the students. For full details of case study, refer to Appendix A.

Source: Greenhill Primary School, image reproduced with permission of Caerphilly County Borough Council

Biomass

Description

Biomass can be generally defined as material of recent biological origin, derived from plant or animal matter. Biomass is widely used in many countries as feedstock for modern heating systems. Modern biomass heating technology is well developed and can be used to provide heat to buildings of all sizes, either through individual boilers or via district heating networks. Biomass is also increasingly being used to fuel electricity plant or combined heat and power (CHP) plant due to the low carbon emissions associated with its use.

Biomass can be described as a low carbon fuel as the amount of carbon released during combustion is equivalent to the amount that is absorbed during growth, with a small amount of additional carbon emitted due to the transport and treatment processes of biomass fuel.

Key Feasibility Questions:

☑ Location of potential fuel supplies and fuel delivery potential?

☑ Space for boiler plant and fuel storage?

Table 6.2 Typical Biomass components

Components
Boiler unit(s)
Fuel storage and extraction
Ancillaries (flue, ash extraction, heat store, pipework, controls)

The key benefits of biomass are:

- Significant carbon savings – compared against gas, oil or coal.
- Reduced fuel price volatility – if sustainably sourced, a high long term security of supply of biomass fuel can be achieved.
- Wider sustainable development benefits – through sustainable management and enhancement of forest and woodland.
- Reduced exposure to climate–change related legislation.
- Improved energy performance ratings for buildings – due to the BRE classification of biomass as a 'low carbon' energy source.
- Owners of sites with biomass installations can 'grow' their own fuel in certain circumstances; and boost rural economies – through generation of employment in biomass fuel supply chain.

Types

There are a variety of biomass systems available, from stand–alone stoves or small boilers that will usually be manually fed (typically by hand every day), to larger automatic fuel feed options that use a conveyor system connected from a silo or store to the boiler.

A range of biomass fuels are available, including virgin wood, energy crops, and residues (e.g. agricultural, food, or industrial) but the two most common for use in building development are wood chips and pellets.

Wood pellets have a higher energy density than wood chips and therefore require a smaller storage volume for an equivalent energy supply. In addition, wood pellets are made to a strict standard in terms of size, moisture content and energy density. The greater variability of these factors in wood chips means that greater care must be taken in the procurement arrangements to ensure the required specifications for size, moisture and energy density are met. Disadvantages of pellets include their greater expense compared to wood chip, their highly processed nature, and their lower availability compared to wood chips.

Location, Demand and Optimal Combination

To reduce the carbon emissions associated with transporting biomass the fuel source should be as close to the operation as possible. This will allow the transport emissions are considered to be offset by the CO_2 'sequestered' during the growth of the biomass.

Other factors that need consideration include:

- Fuel storage – A large volume fuel store is required to store the biomass fuel, which needs to be located close to the boiler and be easily accessible to enable fuel deliveries.
- Deliveries – Regular deliveries of fuel will be required to the site, requiring consideration of delivery routes, times and neighbours; and
- Fuel bills – Unlike solar thermal, photovoltaics and wind turbines, biomass systems do not use a free source of energy.

Table 6.3 Typical Biomass Fuel Costs

Fuel	Price			
	Min (£/tonne)	Max (£/tonne)	Min (p/kWh)	Max (p/kWh)
Wood chip	30	100	1.8	2.7
Wood pellet	130	200	2.8	4.3

Source: Carbon Trust[28]

Biomass suits developments that have a constant and reliable heat demand. Biomass boilers can be modulated down to approximately 30% of their peak output, however, they are most efficient when running at peak load. In some cases it may be beneficial to size plant to meet a percentage of the yearly demand, and use a supplementary technology to provide the remainder of the load for peak demand. This will help to reduce costs of plant and maximise the hours at which the biomass boiler is running at optimum output. Boiler 'cycling' will also be reduced, for instance, by not using the boiler over the summer months where the overall heat demand is lower, instead using a different technology to provide domestic hot water, eg, solar thermal hot water. Another example would be to use a supplementary technology to cater for peak winter loads on very cold days.

The technology can suit a range of developments, but its application relies on meeting set site characteristics as previously described. Of particular importance are a local fuel source and a designated on–site location for fuel storage and plant space. In general wood chip or pellet biomass boilers are most suited to larger developments with a relatively constant baseload heating and/or hot water demand. Examples include schools, hospitals or district heating schemes. This practice guidance mainly deals with non–domestic schemes, however, wood fuelled boilers or wood stoves can also be used on a micro scale to provide heating to homes.

Complementary technologies with biomass include all forms of renewable power. In addition the following renewable heating options are suitable to combine with biomass:

- CHP – Biomass can be used as a fuel source for some CHP units. By using a renewable fuel, the power and hot water produced from the CHP unit will then be 'zero carbon', as opposed to 'low carbon' where gas is used; and
- Solar hot water – SHW systems work in combination with biomass, particularly where biomass is used for space heating only, and SHW for domestic hot water.

Operation and Maintenance

Quality control and storage of biomass fuel can be technically challenging issues and can significantly influence the effectiveness of a biomass installation. A local and secure biomass fuel supply chain needs to be in place in order to ensure successful and reliable operation. This creates an ongoing management issue and consequently building operators need to consider this within biomass boiler maintenance arrangements.

As previously stated, regular deliveries will be required, and access will need to be provided to the site. In addition, maintenance in the form of cleaning or de–clogging components will be required. Depending on the level of usage, ash (a by–product of biomass combustion) will periodically need to be removed from the boiler. Ash is typically disposed of, but it can in some instances be used as fertilizer. Bottom ash consists of large particles that collect during combustion and can be used as fertilizer if distributed thinly. Fly ash should not be used as fertilizer as it can contain heavy metals. For further information, refer to the Biomass Energy Centre[29]. As a rule of thumb, between 0.5 and 1.5 maintenance days will be required per month for larger biomass systems[28], in addition to annual servicing.

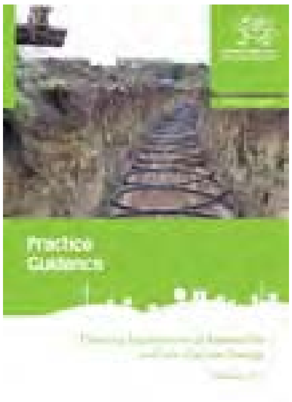
Financial Viability

There are a number of considerations to take into account when determining the financial viability of biomass. Firstly, the capital cost of plant, and other associated ancillary equipment needs to be factored. Biomass will be particularly cost effective for retrofit schemes where there is existing infrastructure in place to house the plant equipment and fuel store.

Operational costs will include system operation and maintenance, and the cost of fuel transport and delivery. The implications of fuel price fluctuations need to be accounted for when assessing the running costs of a biomass system.

Biomass is supported under the Renewable Heat Incentive (RHI) for systems of all scales and consequently, a payback may be achievable against traditional boilers. Refer to Chapter 7 for further information.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for biomass and should be referred to in the first instance if the decisions is made to install or incorporate biomass into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[30]

Key planning impacts:

- Landscape and visual.
- Noise.
- Air quality.
- Ecology and ornithology.
- Hydrology and hydrogeology.
- Traffic and transport.
- Historic environment.[31]
- Economic impacts.

The relevant Local Authority should also always be consulted to determine if a proposed site is located in an Air Quality Management Area (AQMA) or Smoke Control Area. For further information refer to the Welsh Government Smoke Control Areas Regulations 2009[32], this covers four partial areas; Wrexham, Flintshire, Newport, and Swansea. Certain plant and fuels are exempt from the ban which typically includes biomass.

Biomass systems can produce a significant level of nitrous oxides (NOx) emissions. NOx are pollutant gases that can produce ozone, and react with water to produce acid rain. The level of NOx emissions for particular biomass fuels and systems should be checked with manufacturers. Other emissions include some carbon monoxide (CO) and particulates.

Biomass boilers require a flue 'stack' to exhaust the by–products produced when burning fuel. Stacks should ideally be placed approximately 2–3 metres above the height of a building, and therefore will have a visual impact. The location and design of stacks should take into account other buildings or receptors downstream of the stack. Flue stacks will need planning permission, and the relevant Local Authority Planning Department should always be consulted.

There are further sustainability standards associated with larger biomass systems. Biomass electricity generators that are over 50 kW in size are required to report against the following sustainability standard[33]:

- Minimum 60% Greenhouse Gas (GHG) emission saving for electricity generation using biomass/biofuel; and
- Restrictions on using materials from land with high biodiversity value or high carbon stock.

In addition liquid biomass fuels used for heat and electricity generation must comply with the sustainability criteria set out under the EU Renewable Energy Directive[34]:

- Minimum GHG saving of 35% compared to fossil fuel.
- Not to be produced on land of high biodiversity or high carbon stock; and
- Minimum GHG saving to rise to 50% in 2017 and 60% 2018 for new installations.

Summary of Key Considerations

Consideration	Details
Location, Demand and Combination	**Location:** • Local, sustainable and reliable supply of fuel (ideally within 20 miles of site). • Typically wood pellets or chips (other options forms: virgin wood, Energy crops, Agricultural residues, food residues, Industrial residues). • Fuel to equipment matching (reduce risk). **Demand:** • Reliable and constant heating demand. • Sizing (consider reducing plant size and costs by not sizing to meet peak loads. Heat store/ other fuel to meet peaks). **Complimentary technologies:** • Renewable electricity, solar thermal, CHP and district heating schemes.
Operation and Maintenance	• Transport, delivery and storage of fuel. • Fuel specification (consider heat density, moisture content). • Labour (regular maintenance, 0.5–1.5 days per month). • Servicing (annual). • Automation (consider auto–feed, and cleaning options).
Financial Viability	• Supported through the Renewable Heat Incentive (RHI). • Cost of fuel transport and delivery. • Payback period may be achievable under RHI.
Planning and Environment	• Smoke Control Areas (exempt appliances on DEFRA website). • Stacks will need planning permission (ideally 2–3m above height of building). • Emissions (NOx, CO and other pollutants). • Air Quality Management Areas (AQMA) (monitor pollutants, check with LA).

Further Information

Organisation	Details	Website
Energy Saving Trust	General information on biomass	www.est.org.uk
Biomass Energy Centre	General information on biomass	www.biomassenergycentre.org.uk
Coed Cymru	Promotion of locally sourced biomass fuel in Wales	www.coedcymru.org.uk
Carbon Trust	Technical guidance for biomass heating users	Biomass Heating: A practical guide for potential users, Carbon Trust Guide CTG012, 2009
Wood Fuel Wales	General information on fuel suppliers, installers and technical support	www.woodfuelwales.org.uk
Wood Energy Business Scheme (WEBS 2)	Grant support to businesses for woodfuel heating systems	www.forestry.gov.uk/forestry/INFD–8JNQQR
Environment Agency	Regulation of combustion installations. Regulatory advisory consultee for biomass installations	www.environment–agency.gov.uk
Forestry Commission	General information on UK forest and woodland	www.forestry.gov.uk
DECC	Renewable Heat Incentive	www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/incentive/incentive.aspx
DEFRA	Exempt appliances for Smoke Control Areas	www.smokecontrol.defra.gov.uk/appliances.php
DECC	Sustainability Standard for >50 kW biomass	www.decc.gov.uk/en/content/cms/meeting_energy/bio_energy/sustainability/sustainability.aspx
European Commission	Renewable Energy Directive – Bioenergy Sustainability Criteria	www.ec.europa.eu/energy/renewables/bioenergy/sustainability_criteria_en.htm

Organisation	Details	Website
Micropower Council	Representative organisation for companies and organisations in the microgeneration sector	www.micropower.co.uk
Renewable Energy Association	Trade and professional body for the UK wind and marine renewables industry	www.r–e–a.net

Case Study: Treglown Court, Cardiff

The new offices of Stride Treglown Architects in Cardiff was designed as an exemplar of sustainable design which achieved a BREEAM 'Outstanding' rating at the design and procurement stage.

The development incorporates a number of renewable and low carbon technologies, including a 50 kW biomass boiler which provides 80% of the space heating and hot water demand for the building. Wood pellet fuel is sourced locally and stored in an onsite hopper.

The biomass boiler is performing well and operates in conjunction with the natural ventilation system to maintain a comfortable internal temperature throughout the new building.

For full details of case study, refer to Appendix A.

Source: New office building and wood pellet hoper, image reproduced with permission of Stride Treglown

Biomass – Anaerobic Digestion

Description

Anaerobic Digestion (AD) is the process of breaking down plant or animal matter by microbial action in the absence of air, to produce a gas with a high methane content. This methane can be captured and burned to produce heat, electricity or a combination of the two.

Key Feasibility Questions:

☑ Large area for plant and fuel storage (in an area away from sensitive receptors)?

☑ Useable waste stream?

Types

AD is a natural process in the absence of oxygen where micro–organisms break down organic matter, such as sewage sludge, animal manure, or food waste, to produce biogas (comprising approximately 60% methane and 40% carbon dioxide), and nitrogen rich fertiliser. Biogas can be burned using a gas boiler to produce heat, or alternatively burnt in a combined heat and power (CHP) unit to produce heat and electricity. Biogas can also be cleaned or scrubbed to remove the carbon dioxide and other substances to produce biomethane. This can then be injected into the national gas grid and used in the same way as natural gas, or used as a vehicle fuel.

AD Organic Material Feedstock	Description
Sewage Sludge	Semi–solid residue remaining from treatment of sewage and waste water. AD of sewage sludge currently takes place at many sewage treatment works in the UK, although only some of these schemes recover the energy from the sewage gas. Since sewage treatment is generally centralised in the UK, the digesters tend to be large scale.
Farm Slurry	Intensive livestock rearing produces large quantities of slurry (liquid manure) and AD is used widely in UK agriculture, generally in the form of small on–farm digesters from which biogas is captured and burned to heat farm buildings, although larger centralised schemes also exist.

AD Organic Material Feedstock	Description
Municipal Solid Waste (MSW)	Municipal solid waste (MSW): municipal solid waste is waste collected by or on behalf of a local authority and predominantly consists of household waste, but may also contain commercial or industrial waste. MSW contains a significant proportion of organic materials, including food, garden cuttings and paper, and the EU Landfill Directive requires that organic materials are progressively diverted from landfill. Some elements of MSW can undergo energy extraction via AD therefore having the potential to contribute to both waste management and renewable energy targets.
Conservation Arisings	Experiments have also been ongoing in Wales to assess the use of conservation arisings, such as reeds, in small–scale anaerobic digestion and the mixing of such sources with more conventional organic materials.

Source: Welsh Government[35]

Location Demand and Optimal Combination

It is important to ascertain a reliable long term supply of suitable waste material in order for an anaerobic digestion scheme to be viable. As for biomass, transport and delivery are significant factors. The specification of fuel should determine the energy density requirement and energy generating potential for the waste. AD systems are traditionally integrated farm waste management systems, however, larger–scale centralised anaerobic digesters (CADs) use feedstocks imported from a number of sources. These may be suited to farms and also other areas including commercial or other industrial.

Connecting to a larger and more diverse profile of buildings in a new or existing development ensures that there will be a constant demand for energy or power with a reliable baseload. When assessing outline feasibility, potential heat or power users need to be identified, taking into account potential local markets such as industry.

Operation and Maintenance

Energy from waste schemes are likely to be at a large scale, and as such, require a detailed and specialist operation and maintenance regime. Specialist advice should therefore, be sought when considering the technology. Waste deliveries are likely to be a key concern when determining feasibility, and traffic movements will need to be planned at an early stage. Plant size is dependent on the amount of waste to be treated. Digesters can be sized as one large unit or several smaller tanks where there are high volumes of waste to be treated (indicative sizes are provided below).

Table 64 Digester Plant

Waste Digested/tonnes	Approximate Digester Plant Size (tonnes)
50	Height = 10 m Area = 75 – 150 m^2
450	Height = 15 m Area = 1,000 m^2

Source: Welsh Government[35]

AD as a technology is well–established, and widely used in treatment of sewage, however, care needs to be taken in choice of feedstock; biodegradable plant or animal matter are suitable, but woody materials should be avoided, as the micro–organisms struggle to break down lignin.

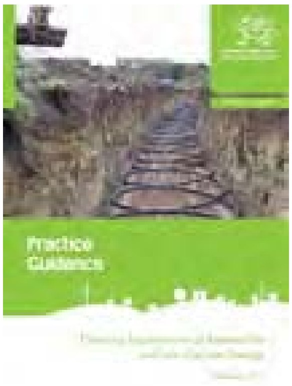
Solid residues and liquid digestates need to be disposed of. As already discussed, these can be used as soil fertilisers, and potentially solid residue can be burnt as fuel.

Financial Viability

The economic feasibility of AD will be site dependent and based on the source of waste. A detailed assessment will need to be made to account for factors such as the capital and operational costs associated with the design, and the installation and operation of such as system. The value of feedstocks vary significantly and can involve free slurry from local farms. The electrical output of an AD plant will vary depending on the quality and type of feedstock being used, and this should be taken into account when carrying out financial assessments.

There are grant and funding mechanisms in place for energy from waste; biomethane injection, biomass combustion, and MSW is supported under the proposed Government Renewable Heat Incentive (RHI) gas. All other forms of energy from waste are not currently supported under the RHI. Anaerobic digestion is separately under the Government Feed–in–Tariff (FIT) for systems of all scales.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for biomass – anaerobic digestion and should be referred to in the first instance if the decisions is made to install or incorporate biomass – anaerobic digestion into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[35]

There are numerous environmental regulations that must be considered when assessing feasibility for an energy from waste scheme. There are regulations concerning waste handling in addition to animal by–products where relevant. It should be noted that the Environment Agency (EA) and Resource Action Programme have created a quality protocol specifically for anaerobic digestate, where it can be sold without requiring waste handling controls.

The deliveries of waste to the plant will result in significant increases in traffic movements on or near site for large schemes, therefore discussions and consultation with the local community will be key to successful project implementation.
Finally odour, noise and visual impact of the plant should all be taken into account. For further information refer to the Environment Agency.

Summary of Key Considerations

Consideration	Details
Location, Demand and Combination	**Location:** • Reliable supply of waste materials. • Transport and delivery of fuel. **Demand:** • Fuel specification. • Reliable and constant heating and/or power demand. • Determine heat users, or local markets. **Complimentary technologies:** • CHP and district heating.
Operation and Maintenance	• Management of fuel supply chain. • Changing calorific value of waste materials (refer to Lerwick case study for further information). **Components:** • Digester tank, buildings to house ancillary equipment (e.g. generator), biogas storage, flare stack, and associated pipework.
Financial Viability	• May be supported under Government Renewable Heat Incentive. • Currently supported under Feed–in Tariff. • Viability dependant on reliable source of waste.
Planning and Environment	• Discussions with local community are key. • EIA might be required for larger schemes. • Numerous regulations concerning environmental protection (animal by–products, waste handling, increased traffic movements, odour and noise, visual impact).

Further information

Organisation	Details	Website
European Commission	The Waste Incineration (England and Wales) Regulations 2002	www.legislation.gov.uk/uksi/2002/2980/contents/made
UK National Centre for Biorenewable Energy, Fuels and Materials (NNFCC)	General information on energy from waste	www.nnfcc.co.uk/
DEFRA	Government Anaerobic Digestion Portal	www.biogas–info.co.uk
Wales Centre of Excellence for Anaerobic Digestion	Technical and non–technical support for rapid deployment of anaerobic digestion in Wales	www.walesadcentre.org.uk
EA and Resource Action Programme	Quality protocol for anaerobic digestate	www.environment–agency.gov.uk
DECC	RHI Grant mechanisms (biomethane injection and biogas combustion)	www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx
DECC	FIT for anaerobic digestion	www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/feedin_tariff.aspx

Case Study: Lerwick Energy from Waste plant

Lerwick, the capital of the Shetland Islands, is home to around 8,000 people. A district heating scheme utilising an energy–from–waste plant has been successfully installed, providing heating and hot water and diverting waste generated on the island from landfill. In order to successfully implement an Energy–from–Waste scheme, waste was obtained from a number of sources, including offshore waste from the oil industry, and waste from the islands of Orkney and Shetland. The plant operates at around 80% thermal efficiency and serves approximately a third of the buildings in Lerwick. For full details of the case study, refer to Appendix A.

Source: Image reproduced with permission from Shetland Heat Energy and Power Ltd

Hydropower

Description

Hydropower is the use of water flowing from a higher to a lower level to drive a turbine connected to an electrical generator, with the energy generated proportional to the volume of water and vertical drop or head. In principle, the faster the water is flowing and the bigger the drop, the more electricity that will be generated.

It is a well developed form of renewable energy and potential exists in Wales for mainly small scale 'run of river' schemes (where no water storage is required) although there is also limited potential to install small schemes at existing reservoirs.

Small scale hydropower plants in the UK generally refer to sites ranging up to a few hundred kilowatts where electricity is fed directly to the National Grid. The key elements of a hydropower scheme are a water source with sufficient flow and head, an inlet pipeline (penstock) to direct water, turbine generating equipment and housing, a tailrace to return water to the watercourse, and electricity transmission equipment.

Key benefits of hydropower include it's high capacity factor, which can be greater than 50% compared to 10% for solar and 30% for wind. Additionally, hydropower is a very predictable and reliable source of energy, and finally, the correlation with demand for electricity is usually high, as flowrates will tend to be greater during winter and storm events, when electricity consumption is greater.

Key Feasibility Questions:

- ☑ Presence of waterfall or river in an accessible location?
- ☑ Absence of designated sites (e.g. conservation area)?
- ☑ Presence of constant electricity demand in local area?

Table 6.5 Hydro Components (typical)

Component	Description
Intake	Water flow is diverted from a normal watercourse (often incorporated into a weir).
Penstock	A sluice or gate that controls water flow to the turbine.
Powerhouse	Contains the turbine and generator.
Tailrace	Where water is released via an outflow back into the watercourse.
Transformer	Used to convert electrical current from DC to AC.

Types

Hydropower schemes can range from community scale to large scale utility providers. This practice guidance focuses on the smaller community level scale.

Hydropower is a well developed technology, and there is potential for large uptake of small scale 'run of river' schemes in Wales. 'Run of river' refers to schemes where a proportion of a rivers flow is taken from behind a low weir and returned to the same watercourse downstream after passing through the turbine. The Welsh Government practice guidance document, *Planning Implications of Renewable and Low Carbon Energy, February 2011*[35] also highlights that there may also be potential, in isolated locations, for 'storage' schemes, where the whole river is damned and flow released through turbines when power is required. There may be limited potential to install small schemes at existing reservoirs in Wales[36].

Table 6.6 Run of River Scheme Type

Run of River Schemes	Description
Low Head	Typically sites in lowland areas, often installed on historic mill sites using the existing channel system and weir or dam. They divert water from behind a weir along a 'leat' (channel) to a turbine intake which is screened to exclude debris and fish. After passing through the turbine, water is discharged along the 'tailrace' (channel) back into the river. The 'depleted reach' of river between leat entrance and tailrace exit will have reduced water flow whilst the turbine is running.
High Head	Typically found on steeper ground in upland areas and the diverted water is typically carried to the turbine via an enclosed penstock (pipeline). The length of depleted reach tends to be shorter as the water needs to travel a shorter horizontal distance to build up the same head. The volume of water diverted from the river to generate a given amount of power is also lower.

Location, Demand and Optimal Combination

The feasibility of hydropower for a development primarily relies on the proximity and existence of a waterfall or weir, in addition to a suitable location to site a turbine. To be viable a hydropower scheme will need a consistent flow of water, to allow a predictable security of supply, in addition to a useable 'head' (see glossary). Knowing this information, an initial indication of power and annual energy output can be calculated. As a rule of thumb, capacity can be calculated roughly by head (m) x flow (m^3/s).

Site access for the delivery and transport of construction equipment is also an important issue, as many optimal waterfalls may be highly inaccessible and therefore not viable as potential sites. The Environment Agency (EA) have identified approximately 4,100 sites in Wales with potential for hydropower. 23% of these sites are also potentially in 'win–win' sites, which would be improved in ecological status by the addition of a hydropower installation incorporating a fish pass.[37]

The impact of water diversion to a turbine on the local hydrology must be established, in addition to the acceptability of the scheme to relevant stakeholders. Consultation with local landowners and other stakeholders must be undertaken; in some cases the land may need to be secured or leased, which will have a cost implication.

Hydropower schemes require a nearby and constant demand for electricity. They are, therefore, well suited to larger mixed use developments with a high diversity. Like wind power, hydropower schemes produce power continuously, therefore a grid connection will be required in order to cater for surplus electricity. Complimentary technologies to hydropower include all forms of renewable heating.

Operation and Maintenance

Hydropower schemes will require a maintenance regime to be set up. Specialist advice should be sought in all instances. The powerhouse will need to be monitored and maintained and checks will need to be made to the various intake, penstock and tailrace on a regular basis depending on the system installed.

Financial Viability

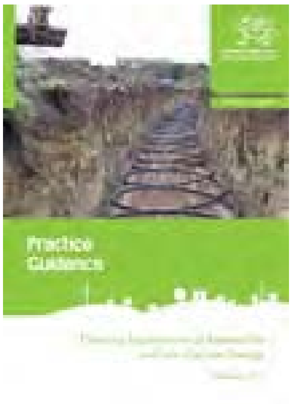
Hydropower is a well–established and proven technology. Energy yields can be accurately predicted and economic viability established relatively easily. Cost will vary depending on the site – for example, machinery costs for high head schemes are generally lower than for low head schemes of similar power. Generally, the cost per kW of new schemes increases as size reduces, due to economy of scale and the fact that any scheme has a certain fixed cost element which does not greatly change with the size of scheme.

Capital costs for a hydropower scheme will include the plant machinery, such as the turbine and generator, in addition to civils works to install the intake and pipeline. There will be some electrical works associated with controls and connections, and external fees may be required to obtain licenses and permissions.

Operational and maintenance costs predominantly relate to the ownership arrangement for the scheme, for example leasing, maintenance, and servicing of equipment carried out by a third party. In this instance, rates for electricity will need to be agreed, and the process by which the electricity is metered.

Financial feasibility is very much on a site by site basis, however, hydropower schemes are supported under the Government Feed–in Tariff (FIT) for all scales. For further information refer to Chapter 7.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for biomass – anaerobic digestion and should be referred to in the first instance if the decisions is made to install or incorporate biomass – anaerobic digestion into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

The social and environmental impact on the surrounding area should be assessed and mitigation measures implemented. For instance, screens may be required to prevent fish and other water based ecology from entering the 'penstock' (see glossary). There will be a visual and noise impact from any hydropower scheme.

With regards to consultation, the following bodies and organisations should generally be consulted:

- Environment Agency (EA).
- Planning Authority.
- Fisheries bodies.
- Statutory Environmental bodies.
- Landowners; and
- Regional Electricity Company.

Consultation with the Environment Agency (EA) is essential in order to obtain the relevant environmental authorisations, and dialogue will need to be maintained throughout the process.

In conservation areas or where there is any archaeology on site, the Countryside Council for Wales (CCW) or Cadw respectively should be consulted[39]. In addition, where the proposed scheme is greater than 500 kW, or if in a protected area, an Environmental Impact Assessment must be carried out. The following licenses will also be required in order to operate a hydropower scheme:

- Abstraction license.
- Impoundment license; and
- Land drainage consent.

Summary of Key Considerations

Consideration	Details
Location, Demand and Combination	**Location:** • Determine suitable waterfall or weir, and a turbine site (consistent flow of water at a usable head). • Acceptability of diverting water to a turbine. • Suitable site access for construction equipment. • Land ownership (and/or the prospect of securing or leasing land for the scheme at a reasonable cost). **Demand:** • A nearby reliable demand for electricity (or the prospect of a grid connection at reasonable cost). **Complimentary technologies:** • Renewable heating schemes.
Operation and Maintenance	• Maintenance regime to be set up (specialist advice to be sought). • Components: plant machinery (turbine and generator), pipework, electrical controls and connections.
Financial Viability	• High capital costs associated with civils works, operational management/ownership costs. • Supported by Government Feed–In Tariff Scheme.

Consideration	Details
Planning and Environment	• Contact EA for environmental authorisations (abstraction license, impoundment license, land drainage consent). • EIA must be carried out (where >500 kW or if in protected area). • Ecological impact (screens may be required). • Consultation bodies (EA, local planning authority, fisheries bodies, statutory environmental bodies, landowners, regional electricity company). • Conservation areas (contact Countryside Council for Wales (CCW)). • Archaeology (contact Cadw Wales).

Further Information

Organisation	Details	Website
British Hydropower Association	General information on hydropower in the UK	www.british–hydro.org/index.html
Cadw	Welsh heritage sites	www.cadw.wales.gov.uk/
Centre for Ecology and Hydrology	Flowrates of UK rivers	www.ceh.ac.uk/data/nrfa/index.html
Countryside Council for Wales (CCW)	Protected sites map	www.ccw.gov.uk/interactive–maps/protected–sites–map.aspx
Energy Networks Association	Distribution Network Operators and grid connection information	www.2010.energynetworks.org/electricity–distribution–map
Environment Agency Wales	Environmental impacts and licenses, fisheries Issues associated with developing a hydropower scheme in England and Wales Environmental assessment of low head hydropower schemes	www.environment–agency.gov.uk Hydropower: A guide for you and your community, 2010 www.publications.environment–agency.gov.uk/PDF/GEHO1010BTDN–E–E.pdf Good practice guidelines to the environment agency hydropower handbook, 2009 www.publications.environment–agency.gov.uk/PDF/GEHO0310BSCT–E–E.pdf

Organisation	Details	Website
Legislation	Salmon and Freshwater Fisheries Act 1975	www.legislation.gov.uk
Renewable Energy Association	General information on hydropower	www.r–e–a.net

Case Study: River Bain Hydro Project

Bainbridge is a small village in the Yorkshire Dales National Park, which crosses the River Bain, reputedly the country's shortest river. A partnership between Water Power Enterprises (H2oPE) and River Bain Hydro Limited (an Industrial and Provident Society) was established to facilitate the delivery of a micro low–head hydroelectric installation on the Bain.

The hydro scheme at Bainbridge utilises a reverse Archimedean screw turbine and generates around 175 MWh per year, sufficient to power around 40 homes. Ecological considerations were particularly important for the scheme due to the impact on the river of diverting flow to the turbine. For full details of the case study, refer to Appendix A.

Source: Image reproduced with permission of Water Power Enterprise

Solar Thermal

Description

Solar thermal systems use solar collectors, usually placed on the roof of a building, to preheat water for use in sinks, showers, underfloor heating and other hot water applications.

Key Feasibility Questions:

- ☑ Available roof area (orientated within 45 degrees of south)?
- ☑ Year round demand for hot water?
- ☑ Space for hot water storage?

Types

There are numerous configurations of SHW systems available, but the two main types are flat plate collectors, and the more efficient evacuated tube collectors that use a vacuum to act as an insulator. Due to their greater efficiency, evacuated tube collectors are able to produce more hot water during winter operation than glazed flat plates.

Table 6.7 Technology Components

Component	Description
Collector	Usually roof mounted to absorb radiation from the sun.
Heat transfer fluid	Water, antifreeze or air, which is typically driven around the system by pumps.
Storage vessel	Thermal store to for water that has been heated by the system for use late.

Location, Demand, and Combination

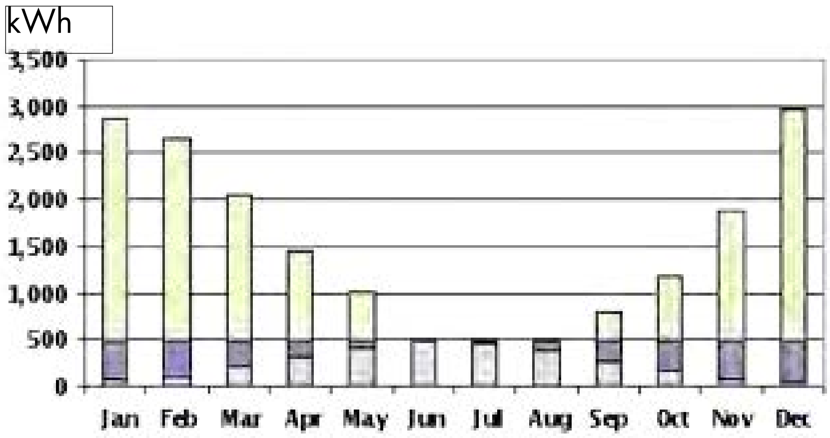
Solar thermal hot water systems should ideally be orientated to the south, but can operate between an east and west orientation. The optimum pitch is between 20 and 45 degrees. Systems are typically roof mounted, but can also be placed on a building façade or at ground level. Key factors are as follows:

- Space for access and maintenance; and
- Avoid overshadowing (e.g., from building obstacles or trees).

The location of panels and plant should be considered carefully in order to limit the length of distribution pipework required. This will help to keep circulation and control system sizes to a minimum i.e. by minimising pump sizes which use electricity.

For optimal performance, there should be a year round demand for domestic hot water. Systems are typically sized to meet a baseload, with top up provided by supplementary technologies such as gas boilers. SHW systems are typically sized to meet between 30 to 50% of the buildings year round domestic hot water (DHW) demand, depending on the function of the building. During summer operation when the daily solar radiation levels are highest, SHW systems can provide up to 100% of the DHW demand.

Figure 6.6 Example yearly space heating and hot water demands and solar hot water heat production



The graph above shows a typical yearly heating demand profile for a small office (yellow representing space heating demand and dark blue representing domestic hot water demand). The pale blue portion represents the amount met through the SHW system, through sizing to meet peak summer hot water demand.

Potential heat sinks should be considered when choosing to use SHW systems, for example a swimming pool will have a year round high demand for hot water. For a typical building profile, sizing the system according to the summer DHW demand will help to avoid the need to 'dump' excess heat. In addition thermal storage should be considered to help even out availability of daily demand and intermittency of solar radiation; this is usually achieved via a thermal hot water cylinder.

Solar thermal hot water systems are typically used to provide DHW for a building. They are therefore best suited to developments or buildings with high hot water demands, e.g., leisure centre, hotels, and multi–residential properties.

Complimentary renewable technologies with SHW systems include:

- Photovoltaics (PV) – Electricity generated can be used to power the SHW pumps and controls;
- Wind – Similarly to PV, electricity generated can be used to power the SHW pumps and controls; and
- Biomass – Biomass is well suited to provide a buildings space heating demand, but can also top up a building hot water supply, that isn't met by a solar thermal system.

Operation and Maintenance

Once commissioned, SHW systems can operate effectively for up to 25 years. Care should be taken to ensure dust or dirt is removed from the panels, which will reduce the efficiency and hot water generating potential. Panels that are tilted to the optimum angle will in a number of cases be self cleaning.

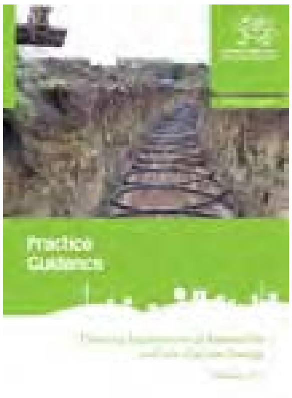
For retrofit installations, there will be a number of considerations depending on the existing buildings space heating and hot water system. Specialist advice should be sought in this instance[40].

Financial Viability

SHW systems are one of the least expensive renewable technologies on the market. They are abundant in use, and are a tried and tested technology. As such, a specifier of SHW systems can be reasonably confident in their long term performance, and systems usually perform economically with a low payback period (in the region of 10 years).

SHW systems are supported through the Renewable Heat Incentive (RHI) for systems up to 200 kWth in size. For tariff levels and duration, refer to Chapter 7.4.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for hydropower and should be referred to in the first instance if the decisions is made to install or incorporate hydropower into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

There are a number of ways to minimise the environmental impact of SHW, through careful design, location and installation. Potential impacts include:

- Landscape and visual – Consider integration into existing building features, and placing in unobtrusive areas; and
- Historic environment – Seek advice from the relevant body, such as Cadw[39].

Further approvals may also be required including:

- Listed Building consent.
- Conservation area consent.
- Trees – Consents may be required where tree preservation orders in place.
- Building Regulations.
- Wildlife – A number of species including bats are protected; and
- Environment Agency licenses.

Key Considerations

Consideration	Details
Location, Demand and Combination	**Location:** • Orientation (ideally south facing, but between east and west). • Pitch (ideally between 30 and 45 degrees). • Avoid overshadowing (to maintain high efficiency); and • Roof space (allow 2 times the size of panels for maintenance, access and frames). **Demand:** • Domestic hot water (year round, and particularly suited to high summer demand). • Intermittency (backup or supplementary plant usually required. Storage can even out availability of daily variations in demand); and • Size to avoid needing to dump excess heat in summer (ie, size to meet baseload hot water demand). **Complimentary technologies:** • Photovoltaics, wind, biomass.

Consideration	Details
Operation and Maintenance	• Remove dust/dirt from panels (to maintain hot water generating potential). • Components: Rooftop collectors, pumps, heat transfer fluid (water, antifreeze or air), and storage.
Financial Viability	• Supported under Renewable Heat Incentive. • Payback period typically in the region of 10 years.
Planning and Environment	• Permitted Development (check with LA).

Further Information

Organisation	Details	Website
Micropower Council	General information on micro generation	www.micropower.co.uk
Renewable Energy Association (REA)	General information on solar thermal systems	www.r–e–a.net
Solar Trade Association	General information on solar thermal systems	www.solartrade.org.uk
Microgeneration Certification Scheme	Accredited installers of SHW	www.microgeneration certification.org
CIBSE	Technical guidance on solar thermal hot water systems	Capturing solar energy, Knowledge Series KS15, 2009 Solar Heating Design and Installation Guide, 2007

Case Study: Centre for alternative Technology, Wales Institute of Sustainable Energy

The Wales Institute of Sustainable Energy (WISE) is a new, highly sustainable building, completed in 2010 at the Centre for Alternative Technology (CAT) in Machynlleth. The WISE building houses the post graduate department of CAT and includes a lecture theatre, seminar rooms and workshops, study bedrooms and a restaurant and bar.

The building maximises the use of natural building materials throughout. For instance, the wall of the 180 seat lecture theatre is constructed of rammed earth and the use of PVC and cement have been minimised and avoided wherever possible.

The WISE building also incorporates a number of sustainable technologies, including a large array of evacuated tube solar thermal collectors, orientated on a south facing roof, which provides around two thirds of the buildings hot water demand. Top up of hot water during times of peak load is then achieved using a biomass fuelled district heating system which supplies the wider CAT site. For full details of the case study, refer to Appendix A.

Source: WISE image reproduced with permission of the Centre of Alternative Technology

Solar Photovoltaics (PV)

Description

Building integrated solar PV systems use solar cells to generate electricity for a building directly from sunlight. The solar cells are normally packaged together into panels or other modular forms which, like solar thermal collectors, are normally roof mounted. PV panels don't need direct sunlight to work, and electricity can still be generated on a cloudy day.

Key Feasibility Questions:

- ☑ Available roof area (orientated within 45 degrees of south)?
- ☑ Potential for objects that could cause overshadowing?

Types

There are numerous types of PV technologies available. The main variations are listed in the table below, showing each approximate module efficiency. There are also hybrid systems that can have a module efficiency in excess of 18%.

Table 6.8 PV Types and module efficiency

	Efficiency
Polycrystalline	12%
Monocrystalline	15%
Amorphous	6%
Other thin films	8%

Source: NCM

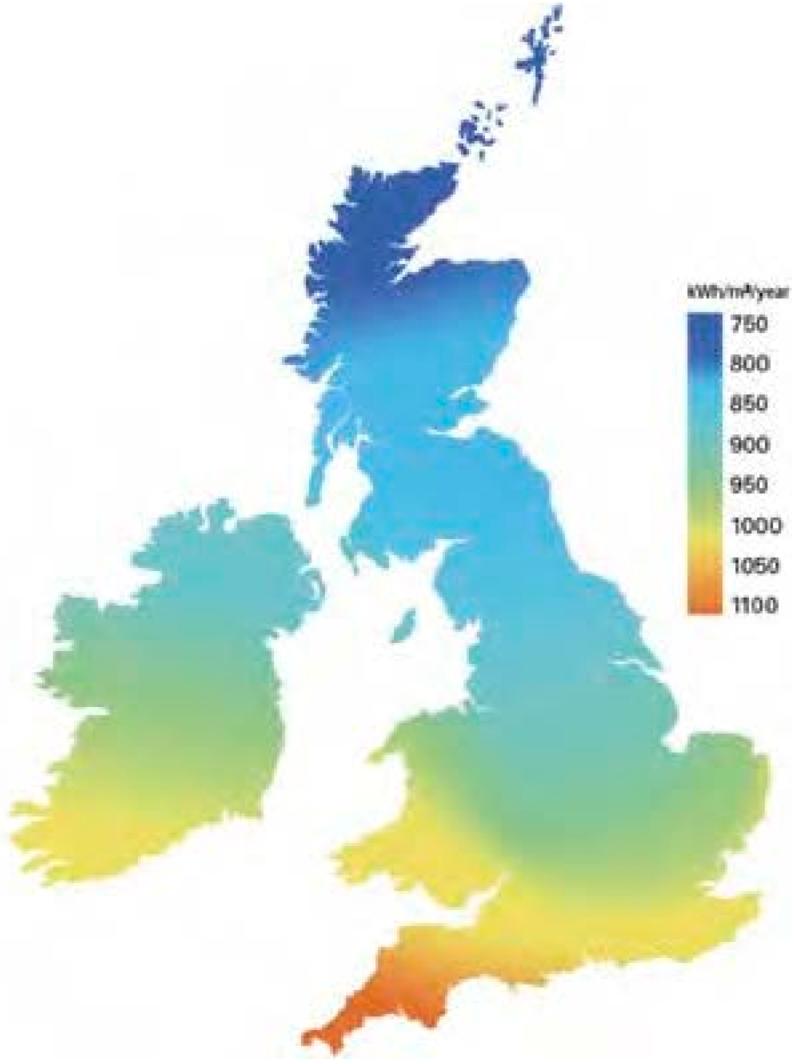
While most PV technologies are building or roof mounted, building integrated PV (BIPV) modules are available that can form a dual function, such as roof tiles or brise soleil. Used in this way, the cost of the technology and embodied energy can be offset.

Location, Demand and Optimal Combination

PV panels should face between SE and SW, at an elevation ideally between 20 and 45 degrees, but even flat roofs will receive 90% of the energy of an optimum system. Solar radiation levels in Wales are between approximately 950 and 1025 kWh/m^2 per year[42], with the electrical output based on orientation and tilt.

As for SHW systems, there should be no overshadowing of PV panels, as this reduces overall efficiency. Unlike SHW, however, even shading a small part of a PV panel could significantly reduce its efficiency and the collective efficiency of other panels connected in the same 'string' (or array).

Figure 6.8 UK Solar Radiation



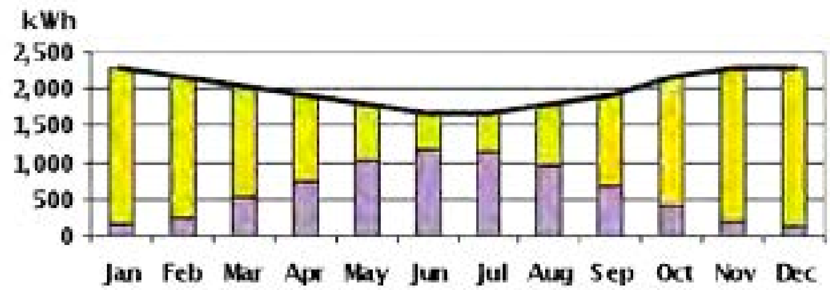
Source: Carbon Trust[43]

PV power generation is dependent on the sun, therefore, intermittency of power generation should be accounted for through a grid connection. When determining the suitability of PV for a development, consideration needs to be made for when there will be an electrical demand at the site. For example, an office is likely to be well suited, as there will be an electrical demand throughout the day, which will coincide with electrical power generation of the PV panels. Domestic properties on the other hand, that are likely to be vacant during normal working hours, may not be able to utilise a substantial portion of the electricity generated on site. In this instance, homeowners can still benefit as income can be generated during unoccupied hours as a result of the Feed–in Tariff (FIT). Refer to Chapter 7 for further information.

PV systems can be applied to almost any building or development type, but are best suited to those that have a significant daily power consumption, such as commercial or industrial premises. To maximise the onsite utilisation of electricity generated by PV for a particular building type and function, the orientation and pitch of panels should be considered:

- East facing – Energy will be captured at the start of the day.
- West facing – Energy will be generated in afternoon or early evening.
- Vertical – Suits buildings with high winter power demand; and
- Horizontal – Suits buildings with summer power demand.

Figure 6.9 Example annual electricity demand for a small office showing amount met by PV array



The graph above shows a typical yearly electrical demand profile for a small office (yellow representing electrical demand). The purple portion represents the amount met through a PV system. The system will need to be supplemented by grid electricity or other type of renewable power system for this particular case.

PVs can be used with most other renewable technologies, particularly renewable heating, where the power generated can be used to drive pumps and other equipment. PVs can also work well with other power generating technologies, wind for example:

- Summer operation – Higher performance from PV array and lower from wind turbine; and
- Winter operation – Higher performance from wind turbine and lower from PV.

Utilisation of roof space for large scale uptake of photovoltaic (PV) panels could minimise electricity peak loads for city centre developments, particularly in summer when building cooling requirements and daytime electricity consumption can be high. High level adoption of PV arrays can additionally take advantage of economies of scale when installing, purchasing and maintaining photovoltaics. The deployment of PV at this scale may require a strategic approach by the funding body.

Operation and Maintenance

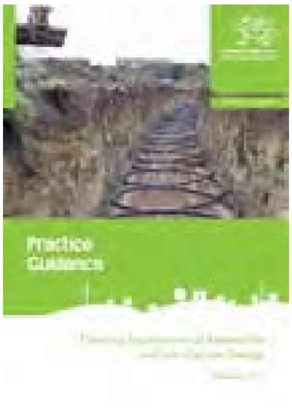
Similarly to SHW systems, care should be taken to ensure dust or dirt is removed from the panels, which will reduce the efficiency and power generating potential. PV panels that are tilted to the optimum angle will in a number of cases be self cleaning. Once installed, PV systems have low maintenance requirements and running costs. PV can have a useful lifetime of up to 40 years, however, the output will drop over the duration of this period.

Financial Viability

The production of electricity through photovoltaic cells has become increasingly common in the UK. Costs have reduced substantially over the last decade, however capital costs are still relatively high.

PV is supported under the Government Feed-in Tariff (FIT) for systems of all scales, but principally up to 50 kW. There are additional requirements for solar PV installation to ensure the building to which the solar is attached has a high level of energy performance. For further information see Chapter 7.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for solar and should be referred to in the first instance if the decisions is made to install or incorporate solar into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

Key planning considerations described by the guidance include landscape and visual impacts such as the removal of trees to minimise shading, and the potential for glint or glare from the PV array. The guidance also describes the key technological and financial constraints associated with PV systems, including the potential for financial support through Feed–In Tariffs and the importance of positioning the array correctly.

As for solar thermal systems, there are a number of ways to minimise the environmental impact of PV, through careful design, location and installation. Potential impacts include:

- Landscape and visual – Consider integration into existing building features, and placing in unobtrusive areas; and
- Historic environment – Seek advice from the relevant body, such as Cadw[39].

Further approvals may also be required including:

- Listed Building consent.
- Conservation area consent.
- Trees – Consents may be required where tree preservation orders in place.
- Building Regulations.
- Wildlife – A number of species including bats are protected; and
- Environment Agency licenses.

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Solar radiation (Wales levels are between 950 and 1,025 kWh/m²/yr, depending on latitude and prevailing weather). • Orientation (ideally south facing, but between east and west). • Pitch (ideally between 20 and 45 degrees). • Avoid overshadowing. **Demand:** • Match generation with demand periods (e.g., suited to offices which have a high daytime demand). • Orientation can be altered to match demand peaks (East facing; energy generated in morning, West facing; energy generated in afternoon). **Complimentary technologies:** • All forms of renewable heating and power (particularly wind power).

Consideration	Details
Operation and Maintenance	• Remove dust/dirt from panels (to maintain electricity generating potential). • Components: Solar modules, inverter (to covert from DC to AC) and isolator.
Financial Viability	• Supported through the Feed–In Tariff Scheme. • Consider substituting PV for where high quality cladding materials are proposed.
Planning and Environment	• Domestic BIPV classed as Permitted Development (check with LA). • Planning permission needed for most other domestic PV arrays and commercial installations.

Further information

Organisation	Details	Website
Micropower Council	General information on micro generation	www.micropower.co.uk
Renewable Energy Association (REA)	General information on solar photovoltaics	www.r–e–a.net
Solar Trade Association	General information on solar photovoltaics	www.solartrade.org.uk
Microgeneration Certification Scheme	Accredited installers of PV	www.microgeneration certification.org
CIBSE	Technical guidance on solar photovoltaics	Capturing solar energy, Knowledge Series KS15, 2009 Understanding Building Photovoltaics, 2000

Case Study: Case Study Example: Welsh Future Homes

The Welsh Future Homes project is located in a former steel works site in Ebbw Vale and comprises one zero regulated carbon home and two low carbon, affordable homes in addition to a visitor centre. Amongst other sustainable design features, the development includes roof mounted PV arrays (2.5 kW on Lime House, pictured left, and 4.6 kW on Larch House, pictured right).

The development aspired to very high levels of insulation and airtightness in accordance with Passivhaus. Viable technologies for the development were those associated with hot water and electricity provision, as space heating demand was very low. The complimentary technologies of solar thermal and solar PV were selected as suitable technologies for the development.

The PV arrays were sized to theoretically fully meet the electricity demands of the dwellings. 12 No. 210W polycrystalline PV panels were installed on the roof of Lime House, while 16 No. 235W panels and 3 No. 210W panels were installed on the roof of Larch House.

For full case study information, refer to Appendix A.

Source: Lime House and Larch House, Ebbw Vale, images reproduced with permission of Bere Architects

Ground and Water Source Heat Pump

Description

A heat pump is a device that moves heat energy from one place to another and from a lower to a higher temperature, or visa versa. Heat pumps are available as both heating only or reverse cycle heating/cooling systems and are classified according to the type of heat source, and the heat distribution medium used.

A ground source heat pump (GSHP) utilises the principles of a heat pump (see next page). There are many different variations of GSHP available, but the main types involve utilising the natural thermal conditions of the ground. The CoP of a GHSP system typically lies between 3 and 5, although this is dependant on the source ground temperature and the temperature to which it is being raised.

A water source heat pump extracts heat from large bodies of water or rivers. As with GSHPs, despite the relatively low temperatures of the water source, heat can be extracted from it through a heat exchanger to feed a low-temperature central heating system.

The earth absorbs a large proportion of incident solar radiation (approximately 50%), maintaining the ground and groundwater in the UK at a stable temperature of around 11-12°C throughout the year. This is warmer than the mean winter air temperature and cooler than the mean summer air temperature, and therefore can be used to provide warmth or cooling to a building via a heat exchanger.

Key Feasibility Questions:

- ☑ Space for heat pump plant and pipework (large area of land may be necessary)?
- ☑ Absence of ground obstacles (e.g. buried services, archaeological resources)?
- ☑ Specification of low temperature hot water circuit for development?
- ☑ Favourable ground conditions?

Types

There are several configurations of GSHP systems; open or closed loop vertical borehole, or closed loop horizontal trench[44]. While land requirements for laying pipework are considerable for both types of system, the area is less for vertical systems, and the output for vertical systems tends to be more predictable[45]. There are a number of other factors which should be accounted for:

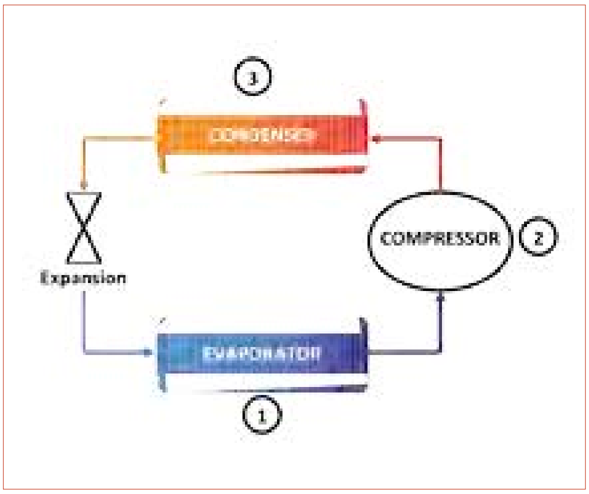
- Spacing – Clearance is required between pipe runs for horizontal systems, typically > 0.7 m, to avoid ice forming around clustered coils in winter. Vertical borehole systems also require separation of, between 5–6 m in order to prevent interference and allow for adequate regeneration of warmth in the summer; and

- Orientation – Consideration should be made as to where the ground collector pipework is laid in relation to the building development.
- Systems will have more potential for abstracting heat when orientated south of the development.

Open loop water based systems extract heat from bodies of water. The flow rate of water and the rate at which it can be extracted will determine if an open loop system is suitable. These systems require a reasonably high flow volume in order to minimise any resulting changes in source water temperature.

Typical systems are based on a refrigeration cycle and use electrical energy to drive the process. Heat pumps are generally more efficient when used in combination with heating applications which use lower temperatures (such as underfloor heating). The efficiency of heat pumps is measured in terms of the coefficient of performance, or CoP. The lower the temperature difference (seasonally) between the average source and sink temperature, the higher the operational CoP. Higher CoPs mean lower CO_2 emissions.

Figure 6.11 Heat Pump Vapour Compression Cycle



1. Refrigerant in evaporator is colder than heat source (water, ground, air). Heat moves from heat source to refrigerant which then evaporates.
2. Vapour moves to compressor and reaches higher temperature and pressure.
3. Hot vapour enters condenser and gives off heat.
4. Refrigerant moves to expansion value and drops in temperature and pressure.

Location, Demand and Optimal Combination

The 'abstraction capacity' for a given site will determine the amount of useful warmth or coolth that can be utilised for heating and cooling in a building.
In order to prove that ground conditions for a site are suitable for GSHP installation, extensive hydrogeology and geology studies may be required, particularly for larger schemes.

Table 6.9 GSHP Configuration Rule of Thumb	
Configuration	**Rule of Thumb**
Vertical borehole (closed loop)	Borehole depth required = 13 m/kW to 50 m/kW (depending on ground conditions and operating period).
Horizontal trench (closed loop)	Area required for ground coils = 25 m^2/kW to 125 m^2/kW (depending on ground conditions and operating period).

Source: BSRIA[46]

GSHPs can be used for heating only, or heating and cooling, with cooling met by operating the pumps in reverse in summer. GSHPs are ideally suited to low temperature applications, such as underfloor heating, rather than traditional wet radiator systems which require a higher water temperature. Due to the lower temperatures of water being circulated, GSHPs are best suited to buildings that have reduced space heating demand through high performance building fabric i.e., high levels of airtightness and insulation (see Chapter 2). One disadvantage of GSHPs, and underfloor systems in general, is that they are less responsive than traditional radiators. Thus, they may not be suitable in all instances, particularly where buildings have adopted a 'lightweight' fabric approach. These buildings are likely to be used intermittently and require a faster response.

As for all heat pumps, complimentary technologies include all forms of renewable power (e.g., PV and wind), as the renewable electricity generated can be used to power the pumps and other equipment, thus making the system zero carbon. Like other renewable and low carbon heating technologies, heat pumps are often sized to provide only a baseload or proportion of space and hot water heating demand, with the remainder being provided via a supplementary heating source for pre–heating, top–up (or 'peak trimming'), which may help to reduce plant size and capital cost (see glossary). This is typically from either an electric immersion heater or gas boiler.

Operation and Maintenance

GSHPs require little or no additional maintenance than that required for a traditional heating system. Heat distribution systems in the building should aim to utilise the lowest temperatures feasible (e.g., underfloor systems) in order to maximise efficiency. GSHPs are not usually suitable for retrofit applications where there are existing high temperature radiators installed supplied by conventional boilers.

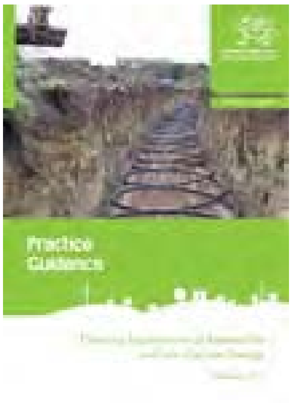
Internal plant space will be required to house the heat pump equipment, which includes a heat pump unit, manifolds and pumps. Space should also be allowed for thermal stores, particularly for larger schemes.

Financial Viability

The largest component of a GSHPs or ASHPs capital costs relates to the civil works required for the ground collector pipework. Although initially disruptive, horizontal loops are typically cheaper overall than vertical boreholes. Projects should aim to combine drilling or laying of ground pipework with other civil woks, such as building foundations and landscaping, in order to offset the cost. The economic incentive for GSHPs is highest where alternative fossil fuels are expensive or not readily available.

GSHPs and ASHPs are supported through the Renewable Heat Incentive (RHI). For further information refer to Chapter 7.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for heat pumps and should be referred to in the first instance if the decisions is made to install or incorporate heat pumps into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

The visual impact of GSHPs once installed is minimal and they generate very little noise. However, the Environment Agency (EA) will need to be consulted where any of the following instances are applicable:

- Drilling causes groundwater from different strata to mix.
- Pump causes change in groundwater temperature; or
- Pump causes groundwater pollution;

where there is any archaeology on site Cadw should be consulted[39].

Where installing an open loop system, the EA will also need to be contacted in order to obtain permissions to abstract ground water. Firstly a consent to investigate groundwater will be required, and where the abstraction rate for the system is 20 m^3 per day or above, an abstraction licence will be necessary. Finally an environmental permit is needed to discharge groundwater. The EA have produced a good practice guide for ground source heating and cooling, which should be referred to in the first instance.

It should be noted that geothermal drilling requires screening for EIA where the area of works exceeds 1 hectare, or where the drilling is undertaken within 100 m of any controlled waters.

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Heat abstraction capacity of ground (determined by local ground conditions). • All types require a significant area of land to be available to lay pipework. • Open loop systems depend on flow rate of water and rate of extraction required. **Demand:** • Reliable heating demand (and if applicable cooling). • Suited to low temperature applications (underfloor heating). **Complimentary technologies:** • Renewable electricity (PV, wind).
Operation and Maintenance	• Minimal operational requirements (management/maintenance of pump). • Components: heat pump unit, manifolds and pumps.
Financial Viability	• Significant and costly civil works but typically low running costs. • Supported through the Renewable Heat Incentive.
Planning and Environment	• Permitted development rights for small systems (check with LA). • No noise or visual impact once installed. • Contact EA (where applicable; consent to investigate groundwater, abstraction license where greater than 20 m^3 per day, environmental permit to discharge groundwater).

Further Information

Organisation	Details	Website
Environment Agency Wales	Groundwater abstractions Good practice guide	www.environment–agency.gov.uk Environmental good practice for ground source heating and cooling, GEHO0311BTPA–E–E
British Geological Survey	UK geology	www.bgs.ac.uk
Heating and Ventilating Contractors Association	Technical guidance on heat pump design and installation	Guide to Good Practice – Heat Pumps, Technical Report TR/30, HVCA, 2007
Cadw	Welsh heritage sites	www.cadw.wales.gov.uk
Energy Saving Trust	General information on heat pumps	www.est.org.uk
DECC	RHI	www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx
Heat Pump Association	General information on heat pump technologies	www.heatpumps.org.uk
Carbon Trust	General information on ground source heat pumps	www.carbontrust.co.uk
Micropower Council	General information on micro generation	www.micropower.co.uk
Renewable Energy Association	General information on ground source heat pumps	www.r–e–a.net
BRE	General guidance on ground source heat pumps	Assessment of the cost–effectiveness and potential of heat pumps for domestic hot water heating, Information Paper 8/85, BRE, 1995 Ground Source Heat Pumps, Information Paper 2/10, BRE, 2010

Case Study: Greenwatt Way

Greenwatt Way is a development of 10 dwellings in Essex, England. The development is a pilot study being undertaken by Scottish and Southern Energy (SSE) in order to assess the performance of various Renewable and Low Carbon technologies. A GSHP has been installed in the development and was sized to provide sufficient thermal energy to meet the entire heating demand of the site. Initial trials undertaken indicate that the GSHP was able to adequately provide the dwellings with heat during a particularly cold winter in 2010. For full details of the case study, refer to Appendix A.

Source: Energy Centre image reproduced with permission of SSE

Air Source Heat Pump

Description

An air source heat pump (ASHP) uses the ambient air as a heat source for heating a building. These heat pumps tend to be much easier and cheaper to install than ground source heat pumps, but are also usually less efficient.

ASHPs operate by extracting heat from the external air. Heat from the air is absorbed into a fluid which is then pumped through a heat exchanger in the heat pump. The heat is extracted by the refrigeration system and, after passing through the heat pump compressor, is concentrated into a higher temperature providing useful heat.

Key Feasibility Questions:

☑ External space for heat pump unit (with good airflow and clear of obstacles)?

☑ Specification of low temperature hot water heating circuit for development?

Types

There are two general categories of ASHP available, 'air to air' which use a ventilation system circulated by fans, and 'air to water' which is best suited for low temperature heating systems, such as underfloor heating.

Location, Demand and Combination

ASHPs have a lower CoP than for GSHPs. The reason for this is that the air temperature, and therefore, efficiency of the heat pump is lower in cold weather at the point when heat demand is highest. The scale of the effect depends on the operating conditions, but a reduction in outside air temperature from say 10 degrees to 0 degrees could reduce the CoP by 20%, which means more electricity has to be used to meet the set internal temperature requirement. In cold weather it is usually preferable to operate a supplementary technology to cater for peak loads.

Heat pumps are typically sited externally, and can be mounted at ground level, or on the wall or roof of a building. Indoor and outdoor units are usually linked by refrigerant pipework, however, packaged air systems can be installed where the outdoor air is ducted to an indoor unit.

ASHPs principle advantage is that they require no ground works and are consequently significantly cheaper to install than GSHPs. ASHPs can be used for all building scales and development types. As for GSHPs, complimentary technologies include all forms of renewable power (e.g. PV and wind), as the renewable electricity generated can be used to power the pumps and other equipment, thus making the system zero carbon.

Operation and Maintenance

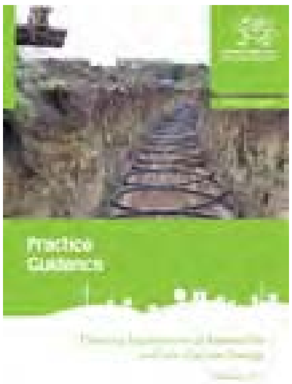
ASHPs require little or no additional maintenance than that required for a traditional gas heating system. The heat pump unit needs to be housed externally, unless a ducted supply and extract is provided to an internal plant space, therefore a suitable space needs to be identified on the proposed project site.

Ice formation can be a problem in very cold weather. This will not only reduce the heat transfer, but also mean that the external coil has to be defrosted which will further interrupt supply.

Financial Viability

ASHPs are one of the most financially viable renewable technologies. They are relatively inexpensive, and unlike GSHPs, do not require ground works. ASHPs are not currently expected to be supported under the proposed Government Renewable Heat Incentive (RHI).

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for heat pumps and should be referred to in the first instance if the decisions is made to install or incorporate heat pumps into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

Key planning issues are as follows:

- Visual impact – The heat pump cannot be covered as this may cause short circuiting of the air intake. Consequently, there is potential for a visual impact if the unit is sited externally.
- Noise – The outdoor fan can produce a relatively high noise level when not controlled effectively. Units should be sited in order to avoid this where possible[47].

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Heat pump unit to be housed externally unless ducted supply/extract provided to internal plant space. • All types require a significant area of land to be available to lay pipework. **Demand:** • Reliable heating demand (and if applicable cooling). • Suited to low temperature applications (underfloor heating). **Complimentary technologies:** • Renewable electricity (PV, wind).
Operation and Maintenance	• Minimal operational requirements (management/maintenance of pump). • Components: heat pump unit, manifolds and pumps.
Financial Viability	• Relatively inexpensive. • Not supported under Government RHI.
Planning and Environment	• Planning permission may be required (check with LA). • Environmental impacts include visual impact.

Further Information

Organisation	Details	Website
Renewable Energy Association	General information on heat pumps	www.r–e–a.net
DECC	General information on heat pumps	www.decc.gov.uk
Carbon Trust	General information on air source heat pumps	www.carbontrust.co.uk
Heating and Ventilating Contractors Association	Technical guidance on heat pump design and installation	Guide to Good Practice – Heat Pumps, Technical Report TR/30, HVCA, 2007
Heat Pump Association	General information on heat pump technologies	www.heatpumps.org.uk
Micropower Council	General information on microgeneration	www.micropower.co.uk
Microgeneration Certification Scheme	Accredited installers	www.microgeneration certification.org

Case Study: St Athan

Developed by the Wales & West Housing Association (WWHA) the St Athan development comprises 16 homes. ASHPs were installed in combination with underfloor heating to provide heating for the dwellings, at a total cost of £9100. ASHPs work well in conjunction with underfloor heating, due to the lower output heating temperatures compared to those associated with a traditional radiator system. Installation of underfloor heating at the St Athan development improved the ASHP coefficient of performance (CoP). For full details on this case study, refer to Appendix A.

Source: ASHP image reproduced with permission of WWHA

Fuel Cells

Description

A fuel cell is an electrochemical energy conversion device, in which as result of the chemical reaction, electricity is produced. The reactants are fuel and oxygen and the reaction product is water. Heat is a by–product of the process that can be used to warm other systems.

Fuel cells do not operate with a thermal cycle and consequently they have very high efficiencies in converting chemical energy into electrical energy, from 40% to 60%, double that of an internal combustion engine. At present, many of the hydrocarbons used to produce hydrogen originate from finite fossil fuels such as natural gas and therefore cannot be technically classed as a renewable source of energy.

Key Feasibility Questions:

- ☑ Requirement for large amount of heat and electricity?
- ☑ Power storage requirement?
- ☑ Large plant space available?

Types

All fuel cells work on the same principle of generating electricity by combining gaseous hydrogen with air via the use of two electrodes (see glossary) separated by an electrolyte (see glossary). There are five main categories of cell, primarily distinguished by the kind of membrane they use.

Table 6.10 Types of fuel cell

Type	Operating temperature (°C)	Capacity (kW)	Application
Proton Exchange Membrane (PEM)	80	1–250	Automotive, portable, backup power for small commercial
Phosphoric Acid Fuel Cell (PAFC)	150–200	~200	Distributed generation
Molten Carbonate Fuel Cells (MCFC)	600–700	1–2000	Distributed generation, electrical utility
Solid Oxide Fuel Cell (SOFC)	800–1000	25–100	Auxiliary power, distributed generation, electrical utility
Alkaline Fuel Cell (AFC)	300–400		Military, Space

Source: Fuel Cells 2000[48]

Location, Demand and Combination

A key issue regarding siting a fuel cell is the availability of space for plant. The operation of fuel cells is very quiet therefore the units can potentially be sited in sensitive areas.

Fuel cells are suitable where there is a relatively constant baseload energy demand, such as offices and mixed use developments. Typical applications include those that require large amounts of heat and electricity such as:

- Large stationary systems.
- Transport applications.
- Military.
- Portable applications.

Fuel cells can work in developments where power storage is required, such as remote off–grid sites. Here, other renewables such as PV or wind can be used to electrolyse water to produce hydrogen which can then be used to run the fuel cell. Fuel cells also work well as CHP systems due to their high operating temperatures and generation of high temperature water as a by–product.

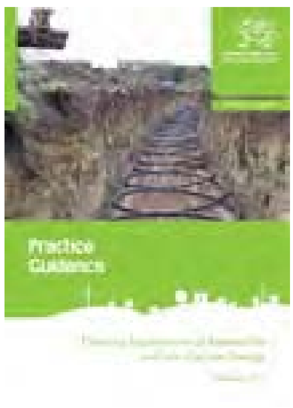
Operation and Maintenance

The operation and maintenance requirements of fuel cells once installed are minimal and predominantly relate to the provision of a reliable supply of hydrogen. This can be reformed (see glossary) from a variety of feed stocks (see glossary) including fossil fuels (e.g. natural gas), or renewables, (e.g. biogas). Replacement of membrane components will also be required every 5 to 10 years.

Financial Viability

Fuel cells currently have a limited commercial application due to their very high capital cost and nature as an emerging technology (performance and durability issues). In order to reduce the cost of fuel cells, technological advances are required in the economic production of hydrogen, in addition to further development in fuel cell applications[49].

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for fuel cells and should be referred to in the first instance if the decisions is made to install or incorporate fuel cell technology into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

Visual, landscape and noise issues are likely to be minimal for fuel cells due to their compact nature, ability to be located within internal space and their quiet operation. Air quality issues are dependant on the hydrogen feedstock, where the hydrogen is generated using renewable technologies, the related emissions will be negligible.

Planning permission is required under the Town and Country Planning Act for any fuel cell plant generating less than 50 MW. EIA screening will also be required where the fuel cell installation exceeds an area of 0.5 ha.

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Availability of plant space. • Can be used in sensitive locations due to quiet operation. **Demand:** • Constant energy baseload. • Remote off–grid connections (for power storage applications). **Complimentary technologies:** • CHP, all renewable power technologies.
Operation and Maintenance	• Supply of hydrogen (from feedstock via reformation or electrolysis). • Components: Fuel cell, hydrogen reforming plant, distribution pipework.
Financial Viability	• High capital cost, operational fuel (feedstock) cost. • Not currently supported by Government RHI or FIT.
Planning and Environment	• Contact EA (EIA may be required). • Planning permission is required (contact LA).

Further Information

Organisation	Content	Website
The Carbon Trust	General information on fuel cells	www.carbontrust.co.uk
DECC	General information on fuel cells	www.decc.gov.uk
CIBSE	Technical information on fuel cell operation	Fuel cells for buildings, datasheet 04, 2005
Fuel Cells 2000	Detailed information on fuel cells	www.fuelcells.org

Case Study: Palestra Building

In 2006, Transport for London (TfL) relocated from a number of small, disjointed offices into the Palestra building in Southwark.

An on–site 1 MWe Combined Cooling, Heat and Power plant (CCHP) was installed and integrated into the existing heating, chilled water and electrical systems. The new CCHP system includes a hydrogen fuel cell CHP unit.

A 74,000 litre thermal storage tank is located at the front of the building and stores surplus heat generated on site for usage in the heating system.

For full details of the case study, refer to Appendix A.

Source: Image used with permission from Transport for London

Combined Heat and Power (CHP)

Description

Combined Heat and Power Units are essentially small electricity power stations. They generate electricity and are more efficient than power stations because the heat generated as a by–product of electricity generation is used to provide hot water to buildings. CHP typically operates in three stages:

1. Power generation.
2. Heat Recovery.
3. Heat Use.

It can also provide:

4. Cooling.

Key Feasibility Questions:

☑ Presence of year round heat and electricity demand?

☑ Available space for plant and distribution pipework?

☑ No or minimal requirement for high grade waste heat (>90 degrees)?

Table 6.11 CHP Components

Component	Description
Prime mover	Engine to drive the generator.
Fuel system	Typically gas, but biomass or other fuels can be used.
Generator	To produce electricity.
Heat recovery device	To recover usable heat from the engine for hot water generation.
Cooling system	To dissipate heat rejected from the engine which cannot be used.
Ventilation system	To supply fresh air to and carry air away from the engine.
Control system	To manage boiler sequencing.
Enclosure	To provide physical and environmental protection.

Types

A CHP unit in theory can be fuelled by any fuel, however, in practice the main fuel used is gas, and in some instances biomass. Gas CHP can be referred to as low carbon, whereas a biomass CHP system would be zero carbon.

An extension of the application of CHP is to convert the waste heat output from CHP into cooling using an absorption chiller. This is known as Trigeneration (or CCHP for Combined Cooling, Heat and Power).

Location, Demand and Optimal Combination

Generally, for CHP to be viable at a development there needs to be a high and constant heating demand typically for more than 4,500 hours per year. This equates to approximately 17 hours per day, 5 days a week, throughout the year[50]. For this reason CHP units are generally sized to match a baseload year round heating demand.

For the vast majority of buildings, this means matching the hot water demand, as this is the only heating requirement that is year–round. The additional peak loads will then be supplemented by other technologies. Where there is not a sufficient baseload heating demand, units may have to be oversized to cater for peak loads and are likely to be less efficient as they will not be running at full capacity for as many hours per year. The optimum size of CHP unit, therefore, usually depends on how large the baseload hot water demand is. Buildings such as hotels or leisure centres are more likely to be appropriate applications for CHP.

Note that unlike surplus electricity, which can be sold back to the grid, surplus hot water must be either stored, or 'dumped'. With this in mind, by linking buildings through a district heating scheme (see chapter 6.12), the hot water or heating baseload can be increased through diversity which will make CHP more viable. The use of CHP to supply district heating networks is well suited to high density developments, where the distances between consumers for a heat distribution network are small and where there is a high daytime winter heating or ideally year round hot water load.

Table 6.12 CHP Operation

Priority	Description	Example Applications
Heat–led	• Preferred option, as avoid need to 'dump' waste heat that isn't used. • Plant is sized to meet a specific heat load, with electricity produced treated as secondary benefit. In cases of multiple heat sources, CHP should be the lead boiler.	• Leisure centre. • Multi–residential. • District heating applications.
Electricity–led	• Plant is sized for power generation, with waste heat being secondary benefit.	• Sites where there is no electricity supply, or where supply must be guaranteed. • Waste heat in this instance that cannot be used may need to be 'dumped' via a radiator.

As already stated, heat from CHP systems can also be used to drive absorption chillers to provide cooling (CCHP) for commercial buildings in the summer. For developments where a significant cooling demand is present year round, combined cooling heat and power (CCHP) offers a low carbon solution to energy demands, but only where economic and environmental evaluation shows a suitable match between the technology and the building. CCHP usually incorporates an absorption chiller. A single effect chiller is the most basic type, with a COP of typically 0.6, while double effect chillers have internal heat recycling to improve their COP to 1.2 and above. It should be noted that compared with a conventional chiller (typical COP of 3.5) an absorption chiller will require a significantly larger area of heat rejection plant (condenser).

Complementary technologies to CHP include all renewable heat generating technologies, as these can be used as fuel for the CHP unit. Wood biomass fired CHP is considered to be a proven technology at over 300–400 kWe. The CO_2 emissions from woody biomass fired CHP are likely to be around 85% less than from gas CHP.

Implementation of multi–consumer renewable or low carbon technologies such as CHP requires high level co–ordination and a "masterplanning" strategic approach by the funding body. A major issue for biomass CHP is securing a suitable, stable, local fuel source.

Operation and Maintenance

CHP systems require an appropriate control regime to ensure that they are operating efficiently i.e. acting as a 'lead' boiler, and this should be monitored throughout the lifetime of the system. For large schemes a specialist will be employed to provide ongoing support.

Large district heating schemes will include significant infrastructure to be installed; underground network of supply and return heating pipes, with heat exchangers installed at each building off the network. CHP district heating schemes typically have a centralised plant known as an 'energy centre'.

Financial Viability

CHP systems are likely to be financially viable in instances where there is a high density development with a relatively stable baseload. The cost of CHP systems can be significantly reduced where an existing distribution pipe network is in place (e.g., in a large building with existing heating system).

The key to maximising the economic benefits of a CHP scheme is to utilise all of the heat and electricity generated on site. Systems, therefore, must be carefully sized in relation to the heat and power loads they supply. It is important to understand the heat load profile and how it may change on a daily, weekly and annual basis (see Chapter 5). This is very important when considering district heating networks, where there are a range of users with different requirements (see Chapter 6.12).

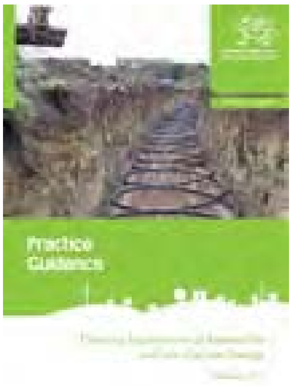
The capital costs of CHP systems primarily relate to installation of the CHP plant, and laying of the distribution pipe network. The Carbon Trust has published typical capital costs for varying sizes of CHP system which are summarised below[50]:

- £2000 / kWe for 5 kWe micro CHP.
- £1250 / kWe for 50 kWe; and
- £800 / kWe for 1 MWe.

Operational costs relate to the cost of fuel and ongoing maintenance and management arrangements. The fuel for CHP units is typically gas and electricity, although biomass can be a viable option where the fuel cost is low. Maintenance of the CHP system will result in ongoing costs. Typical running costs of CHP systems are around 0.6 p/kWh for systems larger than 40 MWe) and 1–1.2 p/kWh for small systems less than 1 MWe[50].

CHP installations are currently supported by the Renewables Obligation (RO) for both renewable electricity and heat. Micro CHP (under <2 kW) can be registered under the Feed-in-Tariff (FIT) scheme (refer to chapter 7.4 for further information.

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for CHP and should be referred to in the first instance if the decisions is made to install or incorporate CHP into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

There are a number of environmental issues that relate to CHP, these are summarised below:

- Noise – the plant itself is inherently noisy, and can affect people not only in the same building or on the same site as the CHP, but also people on neighbouring sites or properties. Noise levels are generally brought down to acceptable levels by suitably attenuated enclosures.
- Vibration – sufficient measures must be included within the design of the installation to control vibration to acceptable levels.
- Emissions – CHP is not a zero carbon technology where gas is used as fuel, instead it is classed as ‘low carbon’. In this case, CO_2 and other greenhouse gas emissions produced by the CHP unit must be dealt with.

The following permits and consents are also likely to be required:

- Planning.
- Pollution Prevention and Control (PPC); and
- Environmental permitting (EP).

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Well suited to city centre developments (when used in combination with district heating). • Can be integrated to existing distribution pipe network (e.g., large building with existing heating system). **Demand:** • Typically aim to match CHP unit to baseload consumption. • Utilise all of the heat and power produced (note: can export excess electricity to grid). • 4,500 hrs per year of high and constant heat demand required (approx 17 hours a day, 5 days a week throughout year). • Thermal storage (to counter low heat demand). **Complimentary technologies:** • Biomass, waste from energy, district heating and cooling schemes.
Operation and Maintenance	• Control regime required (management of 'lead' boiler etc). • Components: CHP unit, boilers, district heating network, heat exchangers.
Financial Viability	• Requires high density development with reliable baseload to be viable. • Capital cost of CHP plant, operational fuel costs. • Micro CHP (<20 kW) supported by Government Feed–In Tariff Scheme.
Planning and Environment	• Contact EA (Environmental Permit may be required). • Planning permission is required (contact LA). • Pollution Prevention and Control (PPC) permit may be required. • Environmental impacts include noise, vibration and emissions.

Further Information

Organisation	Content	Website
Carbon Trust	General information on CHP	www.carbontrust.co.uk
CIBSE	Guidance on CHP installations	Applications Manual AM12: 1999 'Small–Scale Combined Heat and Power for Buildings'
Combined Heat and Power Association	General information on combined heat and power	www.chpa.co.uk
Combined Heat and Power Association	Technical specification for CHP	Guidelines for the Technical Specifications for Small Scale (<1 MWe) Combined Heat and Power Installations, 1997
DECC	CHP site assessment tool	www.chp.decc.gov.uk/ CHPAssessment/ (S(hunphhhy 0oonbr4za5pd3a0z)) /Default.aspx
DECC	UK Heat map	www.chp.decc.gov.uk/ heatmap
DECC	Enhanced Capital Allowances	www.eca.gov.uk
DECC	CHP Quality Assurance	www.chpqa.decc.gov.uk/
Energy networks association	Engineering Recommendation G59	www.2010.energynetworks. org/distributed–generation
Energy Saving Trust		www.est.org.uk
Microgeneration Certification Scheme	Accredited installers	www.microgeneration certification.org
The Carbon Trust	General information on CHP	www.carbontrust.co.uk

Case Study: Hazel Court, Swansea

The Hazel Court development is a partnership scheme between Family Housing Association and The City and County of Swansea, providing 120 retirement apartments in a village for the over 55s. The development is supplied by a gas fired micro–CHP system, supplemented by a biomass boiler to provide hot water.

Electricity generated by the CHP system is used onsite in communal areas, while the space heating provided by the CHP system is distributed around the development via a district heating system in combination with underfloor heating.

For full details, refer to the case study in Appendix A.

Source: Hazel Court development image provided by Family Housing Association

District Heating

Description

District heating is the most common form of decentralised energy systems and is an infrastructure for delivering heat to multiple buildings from a central heat source through a network of pipes to deliver heating and hot water. In this way heat can usually be generated and delivered more efficiently than with multiple individual systems.

Decentralised Energy Systems

Traditionally, each building utility, such as electricity, gas, water and waste removal are provided separately to individual consumers. There are potentially large environmental, social and economic savings that can be achieved when using a different and more holistic approach. Decentralised community energy systems can supply a combination of hot water, space heating, space cooling and power via a community energy network. Although centralised in relation to a particular community, such systems are considered decentralised in relation to grid energy generation and distribution, as is typical for the UK.

While community based systems have not been used extensively in the UK, they are prevalent in Europe, with the Scandinavian and Eastern European regions in particular having a large percentage of their total space heating load supplied by district heating schemes. The UK has one of the lowest shares of district heating schemes, currently producing only 2% of the UK heating demand, however, the DECC have estimated that district heating could supply up to 14% of the UK heat demand.[51]

Key Feasibility Questions:

- ☑ Heat density of 3,000 kW/km^2 or greater?
- ☑ Available space for plant (or energy centre) and distribution pipework?
- ☑ Mixture of different heat users?

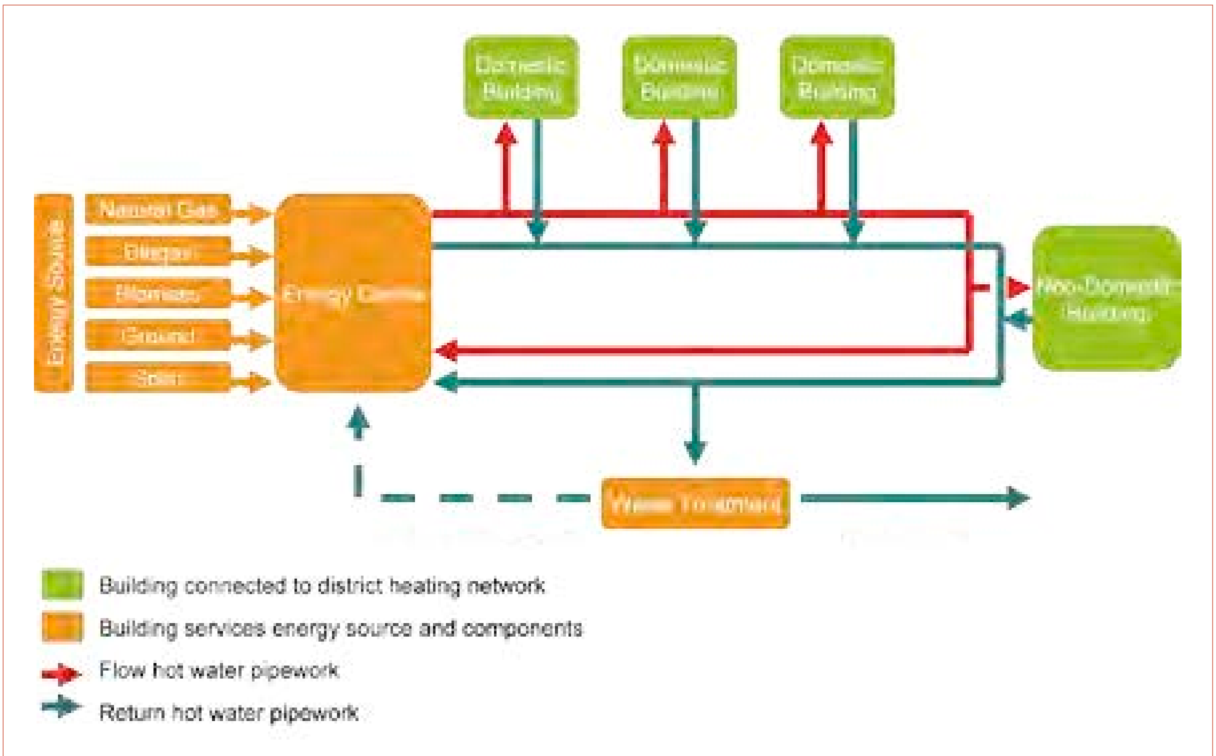
Location, Demand and Combination

In general, district heating schemes are likely to be viable where there is a high heat density. As a rule of thumb, a heat density of 3,000 kW/km^2 or greater is required[52]. Heat density is a spatial characteristic that indicate the degree to which building heat loads are concentrated in a particular area. Opportunities can be mapped using GIS methods for existing and proposed developments[53] (see Chapter 5.4). District heating is, therefore, well suited to high density housing developments such as flats rather than individual dwellings. In terms of scale, district heating could potentially be applicable to small schemes, involving only a group of dwellings, up to large scale community wide systems or city centre applications. District heating is best suited where there is a mix of different building types.

The figure below presents the principles behind a district heating scheme. The technology comprises of an energy centre, a network of insulated pipes (shown below as flow and return) and a series of heat exchangers with heat meters in buildings being supplied with heat. The energy centre can generate heat alone, or can be designed as a CHP plant to generate both electricity and heat. As a further variation and in cases where relevant, such as for large commercial systems, cooling can be provided to end–users served by the network (refer to Chapter 6.11 for further information on CHP and CCHP). The diagram shows how different renewable or low carbon heating source could be used as the heat source, these might include:

- Natural gas.
- Biomass.
- Combined heat and power (CHP).
- Waste heat from power plants.
- Waste heat from industrial processes.
- Energy from waste; or
- Anaerobic digestion.

Figure 6.16 Principles of district Heating



There are a number of potential advantages that arise through the introduction of a district heating network when used in the correct application:

- Diversity increased – Loads can be shared (see Chapter 5).
- Plant sizing – This can often be optimised more effectively than for a single building.
- Renewable and low carbon technologies – These can often be integrated more effectively at a larger scale, and at lower cost through economies of scale.
- Operation and maintenance – Costs can be lowered per household or other building consumer and shared through the implementation of a managed energy centre.
- Future proofing – Once the infrastructure (district heating/cooling/hot water) pipework has been laid, it is easier to retrofit other technologies at a later date. For example, a system could be designed to use biomass or CHP but changed in the future to allow for other more efficient technologies once cost/efficiency has improved.

Existing buildings that are situated within or close to new developments that are considering district heating can offer significant benefits in that they can act as district heating 'anchor' loads around which a new system might be established. As these heat loads already exist, incorporating them into the network would provide a stimulus for early implementation of the scheme. The inclusion of large public sector sites such as social housing schemes, universities and local authority buildings can be particularly beneficial.

Operation and Maintenance

Typically decentralised generation plant will be housed within a community 'energy centre' or large plant room, so usually are best suited to new developments. District heating is viable for retrofitting to existing buildings, but there will be added complexities in connecting to existing distribution systems in buildings. In addition a heat mapping or energy benchmarking (see Chapter 5) exercise may be required in order to confirm heat density and viability of such systems.

District heating pipework infrastructure will last for decades, and alterations or replacements to heating sources can be relatively straightforward (future–proofing the system to technological advances). Due to the size of district heating systems they will need to be maintained by a dedicated specialist, and in most cases by Energy Services Companies (ESCo), who will construct, operate and maintain a network (refer to Chapter 7 for further information).

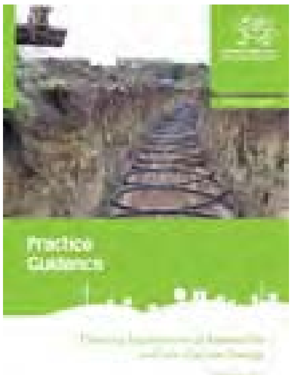
Financial Viability

Within the UK, the size and complexity of district heating schemes has tended to act as a significant constraint along with the cost and associated risk. However, the technology itself is less of a constraint as demonstrated by the many successful installations outside of the UK. The economic case for district heating systems increases as heat density increases, as the costs for laying heat mains and establishing connections to individual buildings will reduce[51]. Ideally pipework would be installed at the same time as other infrastructure (for example, surface or foul water drainage and water supplies), both to minimise costs and environmental impact associated with the civil works.

While the single largest costs will relate to capital cost of installation, these costs when compared to comparative traditional individual systems for each building are likely to be lower, as plant and the associated costs with maintenance and insurances can be shared.

The ability to potentially generate heat at low costs also means that district heating can contribute to the goal of reducing fuel poverty[54].

Planning and Environment



Practice guidance on the planning implications of renewable and low carbon energy technologies has been published separately.

The guidance summarises the key planning requirements for district heating schemes and should be referred to in the first instance if the decisions is made to install or incorporate district heating into a proposed development.

Source: Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011, Welsh Assembly Government[38]

Key Considerations

Consideration	Details
Location, Demand and Optimal Combination	**Location:** • Well suited to city centre developments. **Demand:** • Heat density of 3,000 kW/km² or greater. • Aim to achieve high diversity to increase operational time and reduce size of boilers. • Public buildings can serve as anchor loads. **Complimentary technologies:** • Potentially all forms of renewable heating and power.
Operation and Maintenance	• Dedicated energy centre (usually maintained by an ESCo). • Components: Energy centre, network of insulated pipes, and heat exchangers with heat meters in buildings.
Financial Viability	• Requires high density development with reliable baseload to be viable. • Pipework costs reduce as density increases. • Potentially retrofit to high density applications, but usually more cost effective where installing other infrastructure (particularly below ground utilities). • Potentially supported by Government Renewable Heat Incentive depending on renewable heating technology chosen.
Planning and Environment	• Contact EA (Environmental Permit may be required). • Planning permission is required (contact LA). • Pollution Prevention and Control (PPC) permit may be required. • Environmental impacts include noise, vibration and emissions.

Further Information

Organisation	Content	Website
Biomass Energy Centre	Information on the use of biomass in district heating schemes	www.biomassenergycentre.org.uk/portal/page?_pageid=77,97356&_dad=portal&_schema=PORTAL
BRE	Performance of district heating when supplying heat to new developments for a range of dwelling densities in the UK	Performance of district heating in new developments application guide, BRE Information Paper 3/11, 2011
Combined Heat and Power Association	General information on combined heat and power	www.chpa.co.uk
	Technical documents on design	www.chpa.co.uk/technical–documents_202.html
DECC	UK Heat map	www.chp.decc.gov.uk/heatmap
	Information on district heating	www.decc.gov.uk/en/content/cms/meeting_energy/district_heat/district_heat.aspx
	Publication on costs of district heating	The Potential and Costs of District Heating in the UK, 2009
	CHP site assessment tool	www.chp.decc.gov.uk/CHPAssessment/(S(hunphhhy0oonbr4za5pd3a0z))/Default.aspx

Case Study: Aberdeen District Heating

In 1999 Aberdeen City Council (ACC), which has some 26,500 properties, adopted a comprehensive Affordable Warmth Strategy. As part of improvements, district heating networks (with heat supplied by CHP) have now been introduced in three social housing developments.

The high development density of multi–storey council owned apartment blocks lends itself to district heating as distribution network costs and losses can be minimised. Additionally, the maintenance and operational requirements of district heating systems are suited to local authority schemes, where a designated company or organisation can be set up to centrally control the system. In the winter months when electricity prices are high, the district heating system provides sufficient heat and hot water to supply all residences.

The long term vision for ACC is to develop a city centre district heating network to link with other co uncil owned apartment blocks and public buildings.

For full details, refer to the case study in Appendix A.

Source: Distribution pipe installation, image reproduced with permission of Aberdeen City Council

References

21 See www.wales.gov.uk/topics/planning

22 Power curve calculated based on a theoretical horizontal axis 6 kW wind turbine. Note that power curve will alter depending on scale and type of system. A vertical axis wind turbine, for example, will have a very different profile

23 Carbon Trust Guide (CTG) 738: Small–scale wind energy: Policy insights and practical guidance, Carbon Trust www.carbontrust.com

24 Calculator tools include the DECC Windspeed Database, (note: no longer being updated, but useful for outline feasibility) and the Carbon Trust Wind Estimator tool

25 Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, Welsh Government, 2011 www.wales.gov.uk/planning

26 Renewable energy and your historic buildings, Cadw, 2010 www.cadw.wales.gov.uk

27 Technical Advice Note 8 – Planning for Renewable Energy, Welsh Government, 2005 www.wales.gov.uk/topics/planning/planningstats/windfarminterest/?lang=en

28 Information sourced from the Carbon Trust Guide CTG012: Biomass Heating: A practical guide for potential users. www.carbontrust.com

29 See www.biomassenergycentre.org.uk/portal/page?_pageid=77,109209&_dad=portal&_schema=PORTAL

30 Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, Welsh Government, 2011 www.wales.gov.uk/planning

31 Renewable energy and your historic building, Cadw, 2010 www.cadw.wales.gov.uk

32 Air Quality advice, Welsh Government. www.wales.gov.uk/topics/environmentcountryside/epq/airqualitypollution/airquality/legislation/smokecontrol/;jsessionid=v8CJNnxXKdvdQZ5JwCMV2pHdtlQRY6ftMV0nPvFBWTKk7Vvnlpbc!2129002960?lang=en

33 See DECC: www.decc.gov.uk/en/content/cms/meeting_energy/bioenergy/sustainability/sustainability.aspx

34 See OFGEM: www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=RO%20sustainability%20criteria%20for%20bioliquids%20guidance.pdf&refer=Sustainability/Environment/RenewablObl/FuelledStations

35 Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, Welsh Government, 2011. www.wales.gov.uk/planning

36 Technical Advice Note 8 – Planning for Renewable Energy, Welsh Government

37 Opportunity and Environmental Sensitivity Mapping for Hydropower webpage, Environment Agency

38 Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, Welsh Government, 2011 www.wales.gov.uk/planning

39 Renewable energy and your historic building, Cadw, 2010 www.cadw.wales.gov.uk

40 Solar Heating, Design & Installation Guide, CIBSE, 2007

41 NCM SBEM Technical Manual v4.1.C March 2011

42 Figures sourced from the Solar Trade Association www.solartrade.org.uk

43 Map used with permission from the Carbon Trust. Image sourced from Carbon Trust Guide CTG038, A Place in the sun, Lessons Learned from low carbon buildings with photovoltaic electricity generation. Document can be found at the following website: www.carbontrust.co.uk/publications/pages/home.aspx

44 'Closed loop'. i.e. a heat exchange fluid is circulated through pipes laid either vertically in boreholes, or horizontally in trenches in the ground. Note 'Open loop' aquifer systems are dealt with separately as 'Aquifer Thermal Energy Storage' (ATES) systems.

45 A recent study by the Carbon Trust has found that 'open loop' aquifer systems can be up to 40 times more efficient than for 'closed loop' ground source heat pump systems. For further information refer to the Carbon Trust Guide (CTG) 036: Down to earth: Lessons learned from putting ground source heat pumps into action in low carbon buildings. www.carbontrust.com

46 Information sourced from BSRIA Guide (BG) 7/2009: Heat Pumps: A guidance document for designers

47 BSRIA Guide (BG) 7/2009: Heat Pumps: A guidance document for designers provides detailed guidance on how to reduce noise from external units

48 Fuel Cells 2000 www.fuelcells.org/

49 The Renewable Hydrogen Research and Development Centre in Baglan Energy Park, South Wales, has recently been set up to enable further research and development of hydrogen vehicles, fuel cell applications and overall hydrogen energy systems

50 Carbon Trust Guide (CTG) 044: Introducing combined heat and power: a new generation of energy and carbon savings www.carbontrust.com

51 See www.decc.gov.uk/en/content/cms/meeting_energy/district_heat/district_heat.aspx

[52] Sourced from SQW Energy and Land Use Consultants: DECC Methodology for assessing the opportunities and constraints for deploying renewable and low–carbon energy development in the English Regions (2010)

[53] Pilot Study – Pembrokeshire County Council Renewable Energy Assessment, Welsh Government, 2010

[54] A household is said to be in fuel poverty if it needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime. For further information see the Welsh Government website

Llywodraeth Cymru
Welsh Government

www.cymru.gov.uk

Practice Guidance

Renewable and Low Carbon Energy in Buildings

7

Implementation and Delivery

July 2012

Cover image: Llandundo Junction,
Welsh Government Offices

Chapter 7: Implementation and Delivery of Renewable and Low Carbon Energy

This chapter discusses the financial implications of renewable or low carbon energy systems, and the options for delivery of an energy system in order to encourage private or public sector leadership, for example through the potential formation and procurement of an Energy Services Company (ESCo).

Stakeholders

The question of which bodies are involved in the delivery of any sustainable energy system depends heavily on the type of system, the demands required and the appetite of each body for raising capital, which is financed by future operational profit or future gain in other areas.

Most examples of district heat networks in the UK have had substantial involvement from public authorities, particularly at their initiation. Public authorities' ability to ensure co–ordination across a range of planned projects, combined with the potential to bring large anchor loads is often crucial to bring forward systems of a viable scale with appropriately managed risk.

Involvement from local authorities in creating an opportunity for sustainable energy can range from reducing risk for private sector investment, to direct procurement or even to establishing an ongoing interest in the ownership of the system itself. The ability for the public sector to borrow at lower cost and take a longer term view can be useful in helping to fund a system that would be operating for many decades.

Drivers

A key requirement of early discussions at the beginning of the process will be to identify the various drivers involved. Having a clear view helps to ensure that discussions regarding the procurement options remain focused and do not go down a blind alleys or become protracted. Thus it is important that, from the outset, the concerns and desires of the various parties involved are synthesised into a procurement strategy.

Ultimately, it is likely that assignment of any energy contracts would be passed to the parties responsible for the long term management of the areas supplied, such as management companies, the housing associations, the local authority or the energy supply company. Therefore it is important that these are among the procuring parties or at least their interests are taken into account. Furthermore, it is also important to bear in mind the interests of other stakeholders such as the future potential consumers and developers with interests in the area.

Outline Costs

Accessing finance at the earliest stages of project development can be one of the major barriers facing implementation of renewable or low carbon energy. Each renewable or low carbon energy technology considered can be affected by various uncertainties surrounding the supply chain, coupled with local differences due to the character of the local renewable resource. It is important therefore, to assess each sites suitability in respect to the effects that supply chain and location may have on cost for each technology.

Rule of thumb guides, such as those produced by the Carbon Trust or Energy Saving Trust, provide a good early stage indication of the outline costs for technologies. When determining outline feasibility, consultants or manufacturers should be liaised with, and further developed schemes will require more detailed assessments will need to be carried out.

The Energy Saving Trust has produced an Energy Model which explores how different energy efficiency measures and renewable energy technologies affect the energy performance of homes in the UK.

The following outlines the full costs that must be considered when determining suitability of renewable technologies. Importantly all energy efficiency measures should be compared in cost benefit terms.

- Marginal technology costs – These include costs of materials and scaleable installation costs.
- Fixed technology cost – These include fixed material, installation and set up costs.
- Ongoing variable costs – These include fuel and maintenance costs; and
- Costs/benefits not included – These include not only hidden costs, but also the effect of grants and funding mechanisms.

Funding Options

There are various funding and support options for renewable and low carbon energy technologies. Many of these are listed in the table below.

Table 7.1 Funding for renewable and low carbon energy technologies

Fund	Provider	Description
Feed–in tariff	Energy suppliers	Householders, communities and businesses who generate their own electricity from renewable or low carbon sources can obtain regular payments from their energy suppliers. The scheme guarantees a minimum payment for all electriocity generated by the system, as well as a separate payment for the electricity exported to the grid. Those who take up the scheme can expect a monthly reduction in their electricity bill and an income from their clean energy cashback provider. Technologies currently eligible include: • Wind; • Solar photovoltaics; • Hydro; • Anaerobic Digestion; and • Domestic scale micro CHP. In order to benefit from the scheme technologies have to be certified with the Microgeneration Certification Scheme (MCS)[55] and must be installed by an MCS accredited installer. Tarrif rates and duration can be found on the DECC Website[56].

Fund	Provider	Description
Renewable Heat Incentive (RHI)	Heat provider	The Renewable Heat Incentive provides payments over a set period of time to generators of renewable heat. The RHI covers low carbon heating energy generating technologies, with the following low carbon technologies proposed to be eligible to receive RHI's: • Solar heating. • Ground and water source heat pumps. • Biomass. • Biogas; and • Energy from waste. Details on the current tariff rates can be found on the DECC website[57].
Renewable Heat Premium Payment		The Renewable Heat Premium Payment is a scheme to support people who want to install renewable heat technologies. It provides a grant to qualifying technologies. Individuals who own their own property and reside within Wales can apply for installations at their primary residence. If you rent your property privately, you will need to approach your landlord as you may need to work with them to apply for the scheme. You can apply online by going to the Energy Saving Trust website www.est.org.uk
Electricity and gas Supply Companies	Depends on supplier	All energy suppliers have a statutory obligation to reduce carbon emissions by investing in measures in customers' homes. The Energy saving Trust hold information on these schemes and provide free and impartial advice on the offers available from energy suppliers. See www.est.org.uk

Fund	Provider	Description
Wood Energy Business Scheme 2 (WEBS 2)	European Regional Development Fund	Multi–million capital grant scheme for Wales and runs till 2013. Provides capital grant support to micro businesses, SMEs and social enterprises for renewable wood heating across Wales. The scheme is for wood biomass heating and CHP technologies.
Ynni'r Fro/Arbed	Welsh Government (Energy Saving Trust)	This fund encourages development of community scale energy schemes. It is open to social enterprises, registered charities, Companies Limited by Guarantee, Community Interest Companies, Companies limited by guarantee or shares and Limited liability partnerships. See www.est.org.uk
Nest	Welsh Government	This scheme offers advice and support to help improve the energy efficiency of homes across Wales. Nest is targeted at those households on the lowest incomes and in the most inefficient homes. See www.nest.org.uk.
Carbon Trust Business Loan	Carbon Trust	The Carbon Trust provides interest–free loans to companies investing in energy saving equipment. For more information see www.carbontrust.co.uk/wales
Carbon Trust Surveys	Carbon Trust	A Carbon Trust free on–site survey guarantees to identify quick and effective ways to reduce energy. The Carbon Trust The Carbon Trust offer free on–site surveys up to £3,000,00 group energy spend per annum for applicants in Wales. See www.carbontrust.co.uk/wales

Energy Services Company (ESCo)

Where a community energy system is being installed, an approach that is favoured is to set up or procure a body to generate, supply and distribute energy via an Energy Services Company (ESCo). The ESCo for a project would operate the energy system and provide energy services on a long term contract.

ESCos can be a special purpose vehicle company set up specifically for a development, or an existing company. These can be subsidiaries of commercial ESCo companies and partially/wholly owned by community organisations, public authorities or developers. In essence, they are not substantially different from the current large utilities companies in the way that they operate. In short, the ESCO can be responsible for the following aspects:

- Development of the system over the phases according to the energy strategy.
- Operation, management and ongoing maintenance of the community energy system.
- Direct management of energy billing and development of mechanisms for managing this service and billing occupants.
- Purchase of all primary energy required by the scheme.
- Provision of capital funding to the scheme and details of mechanisms for providing such funding.
- Achievement of carbon targets for the project and hence potential plant arrangements in terms of renewable and low carbon technologies.

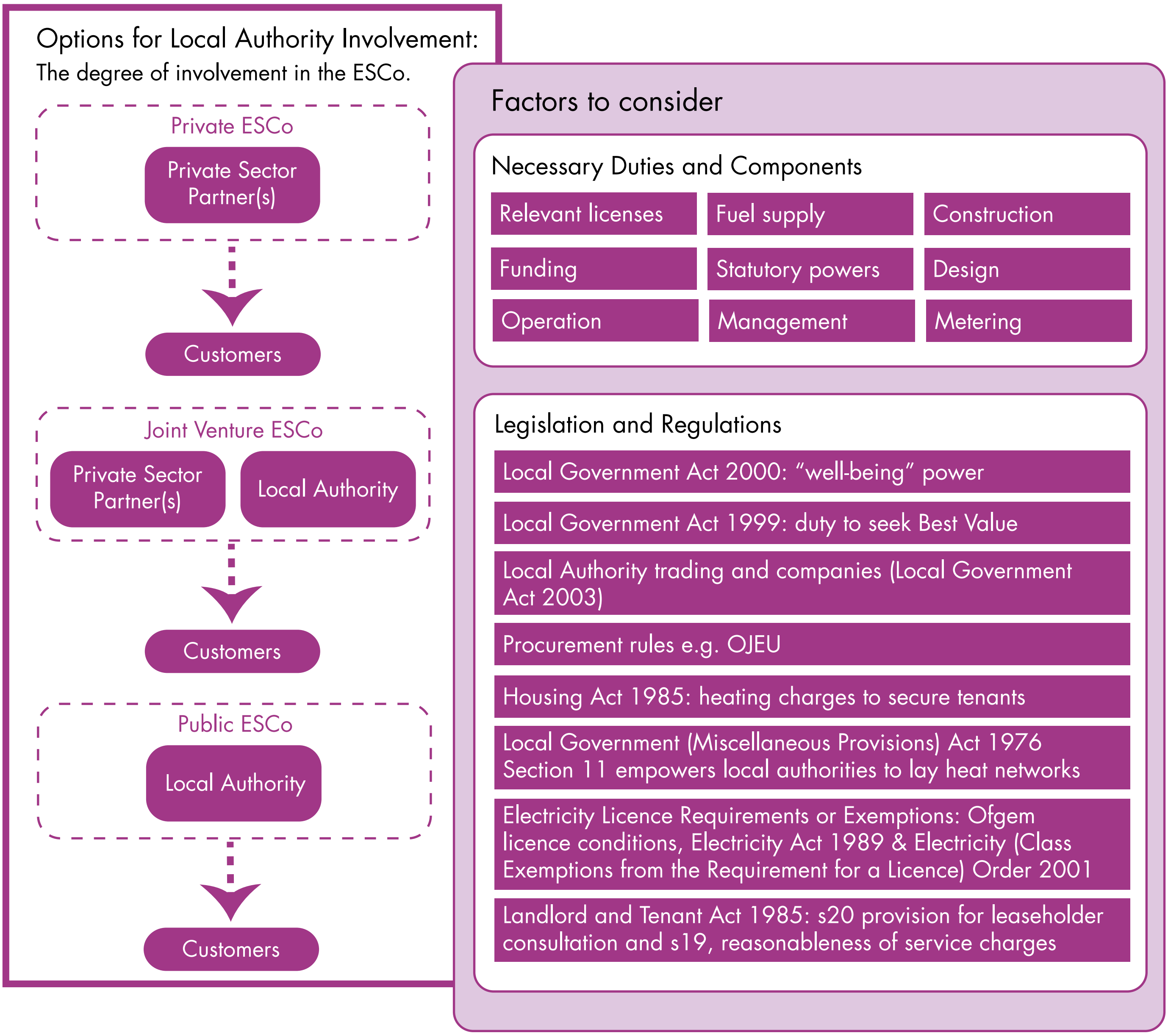
Business Models

After establishing the drivers and stakeholders, the next major item would be to identify suitable business models. This would involve looking at the various options of ownership, investment, distribution of risks and profits, and legal structures. When considering both private and public sectors it is critical to establish how they are to combine; at the most basic level it can take the following forms:

- Wholly private sector.
- Joint venture; and
- Wholly public Sector.

There is a complex array of legislative and regulatory frameworks involved, particularly when considering Local Authorities, all these will influence the decision of which form to use. Figure 7.1 displays some possible arrangements and the factors influencing them.

Figure 7.1 Involvement level and responsibilities



The document *Making ESCos Work: Guidance and Advice on Setting Up & Delivering an ESCo*[58] by Brodies LLP on behalf of the London Energy Partnership provides a good background. It highlights the role that Local Authorities can play in helping to establish ESCos, their powers to facilitate new infrastructure and the legal scope of their ability to participate in new ventures. The following highlight some of key areas:

- Well–being Power.
- Local Authority Trading.
- Procurement.
- Heat Charges.
- The Electricity Market.
- Landlord and Tenant Act.
- Potential Involvement Level.
- Private Sector.
- Joint Venture.
- Public Sector.
- Community Benefit; and
- Components.

Delivery

The delivery of a project depends on many factors such as the type of building or technology, or the groups involved. In basic terms the delivery process would typically begin with outlining the objectives of the project and subsequently assessing options involved to meet them.

Alongside this, consideration of the stakeholders involved by building partnerships should be made, with consultation undertaken with relevant groups. As more certainty is gained around the project, a business model can be developed and methods of procurement can be investigated. Then services or equipment can be procured as necessary and procedures set up. Finally the system can be launched.

Although the technology and financial aspects of a project often gain most attention, the other practicalities such as setting up a suitable arrangement to deliver the system and manage it are equally important. Where services or equipment are required a tender process may be necessary to identify the best provider depending on the criteria used. The formality of this process would depend on the costs involved and the nature of the procurer, for example public bodies may need to obey Government or Official Journal of the European Union (OJEU) rules.

A basic process would be to use the project objectives to identify criteria which would facilitate the identification of potentially suitable companies. These companies would then be invited to tender to an agreed brief. From the tender returns and subsequent interviews a preferred bidder would be selected for detailed negotiations.

Depending on complexity of project there is an increasing array of legislation and regulation involved, particularly when considering government authorities, and external advice, whether legal, financial or commercial, may be necessary to assist in the process.

Barriers to Implementation

Funding

As discussed in Chapter 6.4 there are sources of funding available that could assist with the deployment of low carbon and renewable energy technologies. However, there has to be a distinction between those that provide operational income, like FITs or RHI, as opposed to initial capital because most projects will require upfront investment. In an optimum scenario, upfront investment would be provided by the parties involved, thus eliminating the requirement to borrow capital. Obtaining upfront costs through borrowing can be difficult even if the return on investment is good, particularly in the current credit environment. Innovative financing schemes have been used to address this, such as co–operatives where members can contribute to the scheme. For example Energy4All[59] is one the UK's leading pioneers in Community–owned wind farm schemes, and H_2OPE[60] is a social enterprise using a Community Interest Company model for small–scale hydropower projects financed by individual shareholders.

Finding a Suitable Model

Deciding upon a model on which to base the project delivery may present a sticking point, however it can be addressed by examining aforementioned points such as consideration of the objectives, the stakeholders and the various functions constituting the project. It is important to note that selecting a model before it is required may not be beneficial to the project and may reduce flexibility, for instance in the case of starting the procurement process or raising finance.

Regulatory/Licensing

The various regulations and licences involved in a project may create a perceived barrier, especially at the first attempt of a project. Depending on the nature of the issue, free regulatory advice can often be sourced from one or more of the following organisations:

- The Energy Saving Trust (EST).
- The Carbon Trust.
- Environment Agency (EA).
- Local Authorities.
- District Network Operator (DNO);
- Energy Suppliers; and
- Ofgem.

Additionally, accredited Microgeneration Certification Scheme (MCS) installers should be able to assist with many of the issues, particularly related to FITs or RHI registration.

Opportunities for Local Income Generation

Opportunities for the generation of local income can be created through the use of existing public or mixed private–public buildings by third parties for installation of energy systems.

For instance a large south facing roof of a village hall can be an ideal location for a PV array owned by a community co–operative. In general, the key challenges are not technical but more legal and commercial in setting up arrangements that satisfy stakeholders, meet funding eligibility, guidelines or regulations and are financially viable. In the example above, the body responsible for ownership for the village hall would need to be satisfied that the PV array would not affect the building and they would need to agree that the Feed–in Tariff generation payments are paid to the community Co–op which in turn would benefit its members.

There is a slight difference in how the two main incentive mechanisms work, FITs can be assigned to third parties (as in the example used) but the RHI is payable only to the owner of the heat installation.

The FIT payments would normally be received from the tenant's energy supplier. To get these payments assigned to a third party, they would need to make a contract with the tenant to this effect. The tenant would still benefit from reduced electricity bills if they're responsible for paying them.

With the RHI, the owner of the installation applies for and receives the payments – the only exception is in the circumstance of a hire purchase agreement, a conditional sale agreement or any agreement of a similar nature. A separate contractual mechanism would be required to pass the benefits to a third party. For example if the village hall wanted to install solar thermal to supply hot water to the next door rugby club, the village hall could own the installation, receive the RHI payment and pass this on through a reduced heat price in a heat supply arrangement.

Summary

Understandably there are large interdependencies between the delivery of a system and the system as one influences the other. An energy system would need to have an acceptable method of delivery and operational management, and the body responsible would need to be competent in this for the particular system and prepared to do it.

References

[55] www.microgenerationcertification.org/

[56] Feed-in tariff, Department of Energy and Climate Change www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/feedin_tariff.aspx

[57] The Renewable Heat Incentive www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

[58] Document can be found at the following location: www.lep.org.uk/uploads/lep_making_escos_work.pdf

[59] Energy4all www.energy4all.co.uk

[60] H_2OPE www.h2ope.co.uk

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Practice Guidance

Renewable and Low Carbon Energy in Buildings

8 Renewable and Low Carbon Feasibility Template

July 2012

Chapter 8: Renewable and Low Carbon Feasibility Template

This template is has been created in order to assist project teams in understanding the information that is needed and the steps required in order to carry out a renewable and low carbon feasibility assessment[61]. This template should serve as guidance only; in reality each project will have different requirements, and the level of detail necessary in order to be confident the optimum technologies are chosen will differ substantially depending on the extent of the project.

Step 1: Determine Project Objectives[62]

This could involve:

- Determining Client or stakeholder objectives and aspirations – for instance, the Client may have a sustainability policy.
- Meeting policy objectives and requirements – for example Code for Sustainable Homes, BREEAM, or Welsh National Planning Policy.
- Setting minimum CO_2 reduction targets – set as a percentage reduction against the CO_2 levels associated with the building without renewable and low carbon technologies.

Best practice in building design states that interventions to reduce carbon emissions from new (and existing buildings) should follow the 'energy hierarchy' as described below:

- Reduce energy demand;
- Energy efficiency; and
- Renewable and Low Carbon technologies.

For further information refer to Chapter 3 of this Practice Guidance.

Step 2: Determine Baseline Energy Demand and CO_2 Emissions[62]

The first stage here is to design the building and layout to reduce the demand for energy through solar gain/shading (Energy hierarchy stage 1). Next the energy demand of the building should be reduced further by designing it to achieve high energy efficiency standards (Energy hierarchy Stage 2). After this stage you should know how much energy you will need to be provided by renewable and low carbon energy sources in order to meet the projects carbon objective[63].

This may involve:

- Utilising energy demand and consumption benchmarks. Percentage reductions may need to be applied in order to meet site specific policy or regulatory objectives (for example Building Regulations).
- Approaching an appropriate consultant to carry out calculations to determine expected energy consumption.
- Collecting metered readings, or carrying out energy monitoring where planning to retrofit renewable and low carbon technologies in a building or development.

Step 3: Assess Renewable and Low Carbon Energy Options (Technical Feasibility)[64]

This should cover where practicable, all of the technologies described in this report. The following summarises outline technical feasibility questions that should be considered (See Chapter 6 for more information):

Fuel Cell:

☑ Requirement for large amount of heat and electricity?
☑ Power storage requirement?
☑ Large plant space available?

Combined Heat and Power:

☑ Presence of year round heat and electricity demand?
☑ Available space for plant and distribution pipework?
☑ No or minimal requirement for high grade waste heat (>90 degrees)?

Solar Thermal:

☑ Available roof area (orientated within 45 degrees of south)?
☑ Year round demand for hot water?
☑ Space for hot water storage?

Step 3: Assess Renewable and Low Carbon Energy Options (Technical Feasibility)[64]

Wind:

- ☑ Absence of ground obstacles and landforms (to avoid turbulence)?
- ☑ Local average windspeed (in excess of 5 m/s)?
- ☑ Absence of landscape designations in site vicinity (e.g. conservation areas, historic sites)?

Ground and Water Source Heat Pump:

- ☑ Space for heat pump plant and pipework (large area of land may be necessary)?
- ☑ Absence of ground obstacles (e.g. buried services, archaeological resources)?
- ☑ Specification of low temperature hot water circuit for development?
- ☑ Favourable ground conditions?

Air source heat pump:

- ☑ External space for heat pump (with good airflow and clear of obstacles)?
- ☑ Specification fo low temperature hot water heating circuit for development?

Biomass:

- ☑ Location of potential fuel supplies and fuel delivery potential?
- ☑ Space for boiler plant and fuel storage?

Biomass – anaerobic digestion

- ☑ Large area for plant and fuel storage (in an area away from sensitive receptors)?
- ☑ Useable waste stream?

Photovoltaics:

- ☑ Available roof area (orientated within 45 degrees of south)?
- ☑ Potential for objects that could cause overshadowing?

Hydro:

- ☑ Presence of waterfall or river in an accessible location?
- ☑ Absence of designated sites (e.g. conservation area)?
- ☑ Presence of constant electricity demand in local area?

District Heating:

- ☑ Heat density of 3,000 kW/km^2 or greater?
- ☑ Available space for plant (or energy centre) and distribution pipework?
- ☑ Mixture of different heat users?

Step 3: Assess Renewable and Low Carbon Energy Options (Technical Feasibility)[64]

The technologies will then need to be sized depending on their function, and/or proposed building/development CO_2 emissions reducing potential. The energy generating potential for each technology will need to be calculated. Depending on the stage of the project this could be carried out in a number of ways:

- During outline feasibility – Benchmarks can be used (rule of thumb measures).
- At detailed design – Energy generating potential can be modelled using design tools[65] or based on manufacturers information.

At this stage, the assessment should also cover:

- Local planning criteria – This may include EIA requirements.
- Environmental impacts – Landscape and visual, noise and vibration, ecology and ornithology, peatland, hydrology and hydrogeology, traffic and transport, aviation and telecommunications, shadow flicker, historic environment, and social and economic impacts.
- Site constraints – As outlined on the previous page, but principally climatic conditions (e.g. solar radiation levels, wind speeds, ground conditions, area of land available).
- Operational issues – For example vehicular access for deliveries, potential for grid connection.

Finally the potential for community or district schemes should be assessed. This could involve:

- Assessing potential to existing district heating or community energy infrastructure.
- Utilising existing heat (or energy) mapping studies to determine heat priority areas, and potential to connect or provide anchor loads (e.g. public buildings).
- Carrying out a heat mapping study; or
- Stakeholder engagement and/or workshops.

Step 4: Financial Assessment

This will involve:

- Determining capital costs of each technology.
- Lifecycle costs – Including any maintenance, equipment replacement requirements, and where applicable the cost of fuel (e.g. for biomass, heat pumps, or CHP).
- Grants and funding – for example FIT or RHI.
- Determining payback periods for technologies or assess against alternative forms of cost assignment (refer to Chapter 4.4 for further information); and
- Operation and maintenance costs.

Step 5: Appraisal of Renewable and Low Carbon Technologies

This will involve:

- Ranking technologies against pre–agreed targets/aspirations with the Client.

Targets or scoring categories may include:

- CO_2 saving potential.
- Cost effectiveness.
- Technology risk.
- Environmental impact.
- Potential to meet BREEAM/Code for Sustainable Homes credit scores.
- Educational potential.

The following table provides an example of how technologies could be presented for a project. It should be noted that the rankings are purely indicative, appropriate weightings should be determined according to the project objectives.

Table 8.1 Example Building Ranked Technologies[66]

Technology	Technical Feasibility	Technical Feasibility CO_2 Saving Potential	Financial Viability Capital Cost	Environmental Impact	Rank
Solar Thermal	√	Low	Low	Low	1
Photovoltaics	√	Medium	High	Low	3
Wind	√	Medium	Medium	High	6
Biomass	√	High	Low–Medium	Medium	2
Energy from Waste	×	–	–	–	–
ATES	×	–	–	–	–
GSHP	√	Medium	High	Low–Medium	5
ASHP	√	Low	Medium	Medium	6
Hydro	×	–	–	–	–
CHP	√	Medium	Medium	Medium	3
Fuel Cells	×	–	–	–	–

Step 6: Choose Preferred Renewable and Low Carbon Technology/Technologies
At this stage the appropriate technology or technologies should be chosen. Liaison with consultants and manufacturers will be required in order to size and specify the technologies.

Step 7: Incorporate Chosen Technology into the Design of Proposed Building/Development
Taking into account the specifics of the technology the early designs of the proposed development should incorporate the chosen technology or technologies.

References

61 Note that if a BREEAM/Code standard is being sought feasibility studies should always be carried out by a suitably qualified energy specialist or consultant. BREEAM defines an energy specialist as "an individual who has acquired substantial expertise or a recognised qualification for undertaking assessments, designs and installations of low or zero carbon solutions in the commercial buildings sector, and is not professionally connected to a single low or zero carbon technology or manufacturer".

62 See Chapter 3 for further information.

63 In this case of Building Regulations Part L, this would be the Target Emission Rate (TER) in kg $CO_2/m^2/yr$. In order to comply with Part L, a buildings actual CO_2 emissions, known as the Building Emission Rate (BER) must be equal or less than the TER.

64 See Chapter 5 for further information.

65 Other emerging technologies that have not been included in this report may also be appropriate. For example, kinetic energy recovery systems have recently been used where there is large amounts of pedestrian movement.

66 Not an actual assessment. Scores are shown for illustration purposes only.

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Appendices

July 2012

Cover image: Welsh Future Homes
Courtesy of Building Research Establishment

Appendix A: Case Studies

A selection of case studies for buildings and developments that have incorporated renewable or low carbon energy technologies have been published to support this practice guidance. Each case study provides a background to the project, including key drivers and targets, followed by an overview of the project scope, costs and procurement process.

The technology selection process is then outlined, followed by a summary of the developments performance in use and lessons learnt from the project.

Each case studies presented will be unique and important lessons are shared in these case studies which can help to reduce scepticism and dispel myths that are associated with some technologies. Successful examples of implementation can be used to help increase confidence that renewable energy technologies can be successfully delivered in new buildings, extensions and refurbishment projects.

A list of the case studies is set out below. All case studies can be found on the Welsh Government's website at www.wales.gov.uk/planning.

Appendix B: Glossary of Terms

Term	Abbreviation	Definition
1997 Kyoto Protocol		The Kyoto Protocol is protocol to the United Nations Framework Convention on Climate Change; an international environmental treaty aimed at tackling climate change. The Protocol places legally binding targets on Annex I (developed) nations to reduce their carbon dioxide emissions relative to 1990 baseline concentrations. The current emissions reductions commitments are due to expire in 2012.
Acid rain		Acid rain is rain or any other form of precipitation that is unusually acidic. It is caused by emissions of carbon dioxide, sulphur dioxide and nitrous oxides which react with atmospheric water molecules to produce acids. Acid rain can damage infrastructure and harm plants and aquatic wildlife.
Air Quality Management Area	AQMA	Local Authorities are responsible for managing local air quality under Part IV of the Environment Act 1995. Assessments are undertaken of local air quality against standard objectives in order to identify areas which are at risks of not achieving quality objectives. These are then declared as 'Air Quality Management Areas', where action plans are put in place in order to improve local air quality. In Wales, AQMAs are controlled under the Air Quality (Amendment) (Wales) Regulations 2002.

Term	Abbreviation	Definition
Anchor loads		In the context of district heating and combined heat and power systems, anchor loads are large consistent consumers of heat, such as hospitals universities, prisons or industrial processes. The location and size of anchor loads need to be considered when designing a district heating network, as they will have an influence on the sizing of the system, the route of the distribution network, and the siting of the heat station or energy centre.
Anthropogenic		Caused or produced by humans. Anthropogenic climate change refers to the effect on the global climate as a result of human activity.
Baseload		This is the non–weather dependent energy consumption (either heat or electricity) and typically refers to energy uses that are not involved with directly heating or cooling the building, for example, lighting, equipment, or domestic hot water use. It is usually expressed as an average figure in kWh (daily, weekly, or monthly).
BREEAM		Building Research Establishment Environmental Assessment Method. This is an environmental assessment method for buildings. Credits are awarded in ten categories (such as energy, health & wellbeing, management, materials, land use & ecology etc) according to performance. The credits are then added to produce an overall score of 'Pass', 'Good', 'Very Good', 'Excellent' and 'Outstanding'.
Brise soleil		A permanent sun shading technique or system on a building. An innovative use of brise soleil is to integrate sun shading systems with PV arrays, thus serving a dual purpose of shading and electricity generation.
Building envelope		This is the physical separator between the interior and exterior environments of a building, and is typically referred to when assessing the thermal performance of a building. The building envelope helps to control the indoor environment and facilitate its climatic control.
Building fabric		The building fabric comprises the physical materials from which the basic structure of a building shell is constructed, including the walls, floor and roof.

Term	Abbreviation	Definition
Building façade		The building façade comprises the external architectural face of a building and forms part of the building envelope. The façade provides opportunities to integrate passive design features such as solar shading systems.
Building services		Building services are the elements required to facilitate operation of a building and meet the needs of occupants. They include (but are not limited to) heating/cooling, water services, electricity, lighting, ventilation and renewable energy systems.
Capacity factor		This is the ratio of the actual energy produced by a power or heat generating system in a given period, to the hypothetical maximum possible, i.e. if running full time at rated power. Capacity factors of wind turbines typically range between 20% and 40%, due to the intermittent nature of wind, whilst hydropower schemes can achieve capacity factors of more than 50%.
Carbon dioxide	CO_2	Carbon dioxide (CO_2) is a chemical substance released and absorbed through natural processes such as respiration and photosynthesis. Since the 1700s, atmospheric carbon dioxide concentrations have significantly increased as a result of human activities such as the combustion of oil, coal and gas, and deforestation. CO_2 is a potent greenhouse gas (see glossary) and is internationally recognised as an indicator and measurement of climate change mitigation commitments.
Carbon monoxide	CO	Carbon monoxide (CO) is a gas produced in the partial oxidation of carbon containing compounds. It is highly toxic to humans and while not a significant direct greenhouse gas, it indirectly contributes to the abundance of other greenhouse gases such as CO_2 through reactions in the atmosphere.
Carbon negative		In the context of buildings, this is where the net emissions of carbon dioxide from a building resulting from its operation are less than zero i.e. energy savings made through demand reduction, efficiency measures, and renewable/low carbon energy generation negate the emissions that would be emitted from an equivalent building compliant with Building Regulations.

Term	Abbreviation	Definition
Carbon neutral		This is where the net carbon dioxide emissions resulting from energy consumed by a building (in the operation of space heating/cooling, ventilation, hot water systems and lighting) are zero or better. Unregulated emissions (see glossary) are not included in this assessment.
Carbon Reduction Commitment	CRC	Recently renamed the CRC Energy Efficiency Scheme, this is a mandatory carbon trading scheme implemented by UK Government as part of a commitment to reduce CO_2 emissions by 80% by 2050. The CRC is compulsory for organisations with an annual energy consumption of over 6,000 MWh.
Climate change		Climate change is defined as the significant and lasting change in statistical distribution of global and local weather patterns over periods ranging from decades to millions of years. This practice guidance document is concerned with anthropogenic climate change, that is, climate change associated with human activities.
Closed loop		When referring to energy systems, a closed loop system comprises two closed pipe circuits, respectively through which typically refrigerant and water/anti–freeze are pumped. A heat exchanger transfers heat between the two loops.
Code for Sustainable Homes	CSH	This is the UK National Standard for the sustainable design and construction of new domestic properties and is applicable to England, Wales and Northern Ireland. The Code aims to reduce carbon emissions from the domestic sector. The Code comprises six 'Levels' with Level 6 representing a 'zero carbon' dwelling.
Coefficient of performance	CoP	The CoP of a heat pump is defined as the ratio of heat supplied to the energy consumed by the heat pump (i.e. number of heat units produced for each unit of electrical input).
District heating		District heating systems comprise a central heating system (such as a CHP system or boiler house) which serves several consumers of heat via a network of distribution pipes which pump hot water.
District Network Operator	DNO	These are the companies licensed to distribute electricity in the UK. There are 14 licensed geographically defined areas where DNOs distribute electricity. Supply of electricity to the distribution system is undertaken by separate electricity supply companies.

Term	Abbreviation	Definition
Diversity		For the purposes of this guidance, diversity is a measure of the variety of energy sources of demands and can refer to: • Load diversity – the range of energy demands and profiles from particular consumers; or • Supply diversity – The various energy supplies provided by different renewable and low carbon technologies. The greater the number of supply types (e.g., wind power, solar PV, hydroelectricity), the greater the diversity.
Domestic hot water	DHW	This refers to the hot water supplied to taps i.e. used for washing and cleaning, as opposed to hot water supplied to radiators (which is used for space heating).
Economies of scale		These are the financial advantages that can be gained as the unit cost of an item decreases as the size of a facility and other inputs increase. An example of economies of scale is bulk–buying through long term contracts.
Electro–chemical		An electrochemical reaction is one where electricity is generated from chemical reactions.
Electrolysis		Electrolysis of water is the decomposition of water into oxygen and hydrogen. Direct current is used to drive the reaction by promoting the interchange of electrons.
Electrolyte		This is an electrical conductor used to make contact with a non–metallic part of a circuit.
Electrode		This is any substance which contains free ions, or charged particles, which allows the solution to become an electrical conductor.
Embodied energy / carbon		This refers to the energy or carbon that is associated with the production and manufacture of a particular product i.e. capital energy.
Energy centre		This refers to a dedicated building that serves as a plantroom for a number of heating, cooling and/or electricity consumers for district heating or community energy schemes.
Energy consumption		For the purpose of this guidance, this refers to energy used by a building and its occupants to meet heating and electrical requirements.
Energy demand		This is the amount of electricity and/or heat required by a building and its occupants in order to operate.

Term	Abbreviation	Definition
Energy density		The energy density of a fuel is an important consideration when designing/sizing a biomass system. Energy density is measured in Joules per m^3.
Energy Performance Certificate		A certificate that describes the theoretical energy performance of a building against a scale of ratings from A to G, where A is the most efficient and G is the least efficient. The energy performance of a building is shown as a Carbon Dioxide (CO_2) based index. EPCs must be generated by accredited energy assessors using approved software.
Energy security		This is a term to describe the availability of natural resources for energy consumption in order to meet demand. Access to affordable and reliable energy is essential for modern economies and a country can become vulnerable where an energy supply is not secure.
Energy Services Company	ESCo	This is a commercial business responsible for the design, implementation and management of an energy supply. The ESCo purchases all primary energy required, provides and arranges capital funding for the scheme and manages energy billing. The ESCo is also responsible for ensuring carbon targets are met and that the system achieves its payback period.
Environmental Impact Assessment	EIA	Environmental Impact Assessment is an assessment of the potential impacts (beneficial and adverse) of a development or project on the surrounding environment (including natural, social and economic aspects). EIA forms part of the UK planning process and is often required under the Town and Country Planning Act 1990.
EU Directive		This refers to a legislative act of the European Union and requires member states to achieving a particular result, without stipulating the means of achieving it.
Europe 2020 Strategy		This is the growth strategy for Europe and one of its key objectives is that, by 2020, the EU will achieve a 20% reduction of CO_2 emissions relative to 1990s baselines; generate 20% of its energy through renewable sources, and make a 20% improvement on energy efficiency.

Term	Abbreviation	Definition
Feedstock		This is any bulk raw material used as the main input to an industrial or chemical process. In the context of fuel cells, feedstocks such as biogas or natural gas are used to produce hydrogen.
Fetch		This is the clear area or exposure in–front of a wind turbine. i.e. distance over which the wind flows uninterrupted (most notably in the prevailing wind direction).
Finite		For the purposes of this guidance, this refers to any natural resource which has a limited supply. Fossil fuels (oil, coal and natural gas) are finite as they take millions of years to form and are now being consumed at a rate vastly greater than the rate at which they are being replenished.
Green Deal		This is the planned UK Government's initiative to improve the energy efficiency of UK homes and businesses.
Greenhouse gas		These are atmospheric gases which contribute to the 'greenhouse' effect, whereby thermal radiation emitted from Earth's surface is absorbed (or 'trapped) by atmospheric gases such as CO_2 and re–emitted in all directions, including to Earths surface and lower atmosphere. Consequently, a smaller proportion of radiation is reflected into space and so the temperature of the atmosphere increases. Examples of greenhouse gases include carbon dioxide and methane.
Head		This is a measurement of water pressure above a datum. It is typically expressed as a water surface elevation (or 'head' of water) in metres.
Heat 'dumping'		This is where the heat generated by a heating system exceeds the instantaneous heat demand by consumers and is therefore 'dumped' as waste heat to atmosphere or to another thermal sink.
Heat abstraction capacity		In relation to heat pump systems, the abstraction capacity refers to the amount of heat which can be transferred from the ground to the heat pump system. The abstraction capacity is dependant on local ground conditions, the most important of which are the thermal conductivity and heat capacity. Heat abstraction capacity is measured in W per m^2.

Term	Abbreviation	Definition
Heat exchanger		This is a piece of equipment which is designed for the efficient transfer of heat from one medium/fluid to another. Heat exchangers are used in a wide range of applications, including space heating systems, refrigeration units and ventilation systems.
Heat to power ratio		This term is used for combined heat and power systems to express the proportions of heat and power required by the development or building served by the CHP unit.
Hydrocarbon		An organic compound comprising entirely of carbon and hydrogen.
Hydrogeology		Associated with the distribution and movement of water within soil and rocks of the Earths crust, commonly in groundwater aquifers.
Hydrology		The study of distribution, movement and quality of water on Earth.
Infiltration		In the context of air movement, this is the unintentional introduction of external air into a building, typically through cracks in the walls and through doors (also known as air leakage).
Intergovern–mental Panel on Climate Change (IPCC)		The IPCC was established by the World Meteorological Organisation and United National Environment Programme as an international body for the assessment of climate change. It reviews and assesses scientific, socio–economic and technical information pertinent to the issue of climate change.
Lifecycle assessment		A technique used to assess the environmental impacts associated with a product or system over the course of its lifetime (including it manufacturer, operation and decommissioning.) LCA compiles an inventory of all relevant energy and material inputs and emissions and subsequently assesses the impacts of the inventory against a number of impact categories, such as global warming potential, acidification potential and ecotoxicity.
Load profile		The daily and seasonal variation of energy consumption for a building.
Low carbon		Defined as energy from a non–renewable source where, due to greater efficiency, significant carbon emission savings are made relative to a traditional energy system.
Manifold		An arrangement of pipes and/or valves designed to control, distribute and/or monitor fluid flow.

Term	Abbreviation	Definition
Masterplanning		High level strategic planning of a development. This will consider the location, scale and or relative size of development, and the functional relationship between constituent parts of a development.
Microgeneration		This is the small scale generation of heat and power by an individual building to meet its own requirements. Examples of renewable and low carbon technologies which can be implemented at the micro generation scale include solar PV, solar thermal and biomass boilers. Microgeneration typically covers energy technologies up to 50 kW in size.
Microgeneration Certification scheme	MCS	This is a scheme developed by the Department of Energy and Climate Change which certifies microgeneration technologies used to produce electricity and power. A microgeneration installation must be certified under MCS in order to be eligible for FIT.
Near–site		In the context of renewable energy, this refers to energy generated near to the site of the building using the energy generated. Typically the source is providing energy to a community of buildings, for example through a decentralised energy generation network such as district heating.
OJEU		Official Journal of the European Union. This is the publication in which all tenders from the public sector above a certain financial value must be published.
On–site		With regards to renewable energy, this means renewable energy generated on the site of the particular building.
Open loop		This refers to a heat pump system where natural water is pumped through a secondary loop into a heat exchanger in the heat pump, with the water then injected back into the body of water.
Particulates		Also known as particulate matter (PM), these are tiny particles of solid matter suspended in a gas or liquid. Particulates are an air pollutant and contribute to the greenhouse effect.
Passive design		In the context of buildings, this is design that utilises renewable energy sources such as the sun and wind to provide heating, ventilation, cooling and lighting. Passive design does not require active (mechanical) means of heating or cooling. The key features of passive design are building layout and orientation, window design, thermal mass, insulation, shading and ventilation.

Term	Abbreviation	Definition
Payback period		This is the period of time required for a financial return on an investment to equal the sum of the original capital investment.
Peak load		This describes the maximum demand for electricity and/or heat required by consumers i.e. the maximum amount of energy that is required of a supply.
Peak trimming		This refers to heating systems that use two heating sources or systems (known as 'bivalent' operation). The advantage of this is that the baseload system size (in kW) can be reduced, with peak loads being met by a supplementary source. This is a useful design method to reduce capital costs of renewables.
Penstock		In the context of hydropower systems, a penstock is a sluice or gate that controls water flow.
Permitted Development		This is development which does not require planning permission under the Town and Country Planning Act 1990. Examples of Permitted development include the installation of building integrated PV systems and solar thermal water collectors.
Pitch		This is the angle to the horizontal at which solar PV arrays and solar thermal collectors are positioned to maximise their efficiency.
PV module efficiency		This refers to the conversion efficiency of a PV cell, i.e. the proportion of sunlight energy that the cell coverts to electrical energy.
Refrigeration		Process whereby a heat pump removes heat from a low temperature source to a higher temperature heat sink.
Reformation		The chemical process whereby steam is reacted with organic fuels to produce hydrogen.
Regulated energy		This refers to Building energy consumption resulting from the specification of controlled, fixed building services, e.g. heating systems, ventilation and lighting. Regulated energy is defined by Building Regulations.
Regulation		This is administrative legislation that allocates responsibilities and defines rights.
Renewable Energy Route Map		This was a report consulted on by Welsh Government in 2008 to identify the potential for utilisation of renewable energy resources in Wales.

Term	Abbreviation	Definition
Renewable Heat Premium Payment Scheme		A government scheme which provides financial support to householders who buy renewable heat systems. In March 2012, the Renewable heat Incentive will be introduced for domestic homes and will replace the Renewable Heat Premium Payment Scheme.
Renewables Obligation	RO	The main Government led scheme supporting renewable energy projects in the UK. Under the RO, an obligation is placed on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources.
RHI		Renewable Heat Incentive. The RHI Scheme is a UK Government funding mechanism for renewable and low carbon heating systems in the UK. The scheme will provide support for both the non–domestic and domestic sectors.
SAP		Standard Assessment Procedure. This is the procedure recommended by Government for measuring the energy rating of a residential development.
SBEM		Simplified Building Energy Model. This is a tool used to determine the energy and carbon dioxide emissions for non–domestic buildings in compliance with Part L of the Building Regulations (England and Wales).
Sequestration		For the purposes of this guidance, sequestration refers to the capture of carbon dioxide, whether by natural processes (e.g. photosynthesis of plants and trees), or via carbon capture and storage, where carbon dioxide is removed from flue gases and stored in underground reservoirs.
Shadow flicker		This is an effect occasionally experienced in the vicinity of wind turbines, where at particular times of day, the angle of the sun behind a wind turbine creates a flickering shadow as the turbine blades rotate. If shadow flicker occurs it can have a detrimental effect on local residents, although it can be mitigated through careful siting of turbines and the use of blinds in affected dwellings.
Shear effect		This is where wind speed and direction change over a relatively short distance. The local terrain can have a strong influence on the wind velocity profile, which can be affected by the presence of obstacles such as buildings.

Term	Abbreviation	Definition
Smoke Control Area		As defined under the Clean Air Act 2008, these are areas (often associated with Air Quality Management Areas) where it is an offence to emit smoke from a chimney of a building, furnace or any fixed boiler.
Solar irradiation		This is the electromagnetic radiation given off by the Sun.
Strategic Search Area	SSA	These are seven areas across Wales targeted by Welsh Government as potential development sites for large onshore wind power.
Sun path		This is the apparent seasonal and hourly changes in position of the sun in the sky as the Earth rotates and orbits the sun.
Sustainable Development		The most widely used definition of sustainability or sustainable development is the Brundtland Commission definition which states that "sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs."
Thermal efficiency		In the context of building envelope, this refers to the degree to which a building can retain or reject heat transfer e.g., through insulation and specification of materials with low U values. In the context of energy generation, this refers to the ratio of the heat output to the energy within the fuel used in the system (i.e. the 'calorific value' of the fuel).
UK National Renewable Energy Action Plan		In line with the requirements of the European Renewable Energy Directive, the UK NREAP outlines the proposed trajectory via which the UK plans to achieve a contribution of 15% from renewables to its 2020 energy consumption.
Unregulated energy		This is building energy consumption resulting from uncontrolled processes in a building, such operational equipment including computers, or cooking appliances. Unregulated energy does not have performance criteria required by Building Regulations.
Ventilation		This is the process of changing or replacing air to maintain a high quality indoor environment. It includes both the exchange of internal and external air, and the circulation of air around a building.
Wet heating system		This is a heating system where water is heated and pumped around a network of radiators or underfloor heating pipes.

Appendix C: List of Figures

List of Tables

Appendix D: Sources of Further Information

Organisation	Abbreviation/ Acronym	Website	Details
8.1 Organisations and Websites			
Biomass Energy Centre	BEC	www.biomassenergycentre.org.uk	BEC is owned and managed by the UK Forestry Commission. BEC provides advice, guidance and information on a wide range of biomass fuels and conversion technologies. The website contains details of types of biomass fuel, system and supply chain and includes links to other relevant websites specific to Wales.
British Geological Survey	BGS	www.bgs.ac.uk	BGS is a part of the Natural Environment Research Council (NERC) and is the leading UK provider of geoscientific data. BGS can provide information such as geological rock descriptions, mean annual ground temperature at depth and thermal conductivities of geological strata for the purposes of designing ground source heat pump systems.
British Hydropower Association	BHA	www.british–hydro.org/index.html	BHA is dedicated to the promotion of the hydropower industry in the UK. The website includes a 2010 publication on hydropower resources in England and Wales, in addition to details of relevant legislation and policy and general information on hydropower systems.
Cadw	–	www.cadw.wales.gov.uk	Cadw (meaning 'to keep') is the historic environment service of the Welsh Government. Cadw is responsible for the preservation of Welsh heritage and archaeological sites. Cadw should be consulted during the planning process wherever the historic environment may be impacted by the installation of a renewable or low carbon technology.
Coed Cymru	–	www.coedcymru.org.uk	This is an initiative to promote use of locally grown hardwood timber in Wales. The website includes information and advice on wood pellets and woodfuel heating for sites in Wales.

Organisation	Abbreviation/ Acronym	Website	Details
Combined Heat and Power Association	CHPA	www.chpa.co.uk	CHPA promotes the use of integrated energy solutions across the UK. The website provides information on types of CHP system, funding models, in addition to a number of CHP case studies.
Countryside Council for Wales	CCW	www.ccw.gov.uk	CCW is the Welsh Government statutory advisor for the protection of wildlife and landscape in Wales. Consultation with CCW is particularly important for renewable and low carbon schemes where the installation is likely to have a significant impact (visual or physical) on the surrounding local environment (for instance wind turbines and hydro schemes).
Department of Energy and Climate Change	DECC	www.decc.gov.uk	DECC is the UK Government Department responsible for the management of UK energy in line with Governmental commitments on climate change. DECC implements a number of funding mechanisms for renewable and low carbon energy solutions, such as the Renewable Heat Incentive and Feed–In Tariffs. The DECC website contains extensive guidance and information on a wide range of energy sources and specific renewable and low carbon energy technologies, including available funding mechanisms.
Energy4all	–	www.energy4all.co.uk	Energy4all is a renewable energy co–operative which was set up to aid the transition to a low carbon UK economy. Energy4all has developed a number of business models to assist the development of wind farms and other renewable energy developments.

Organisation	Abbreviation/ Acronym	Website	Details
Energy Saving Trust	EST	www.est.org.uk	EST is an independent UK organisation whose primary aims are to save energy and reduce UK carbon emissions. The EST in Wales works with Welsh Government to advise on policies and programmes required to reduce personal energy consumption in Wales. The EST website provides information on grant mechanisms available for domestic, business and community energy reduction schemes, in addition to technical information on a range of renewable and low carbon technologies.
Environment Agency Wales	EA	www.environment-agency.gov.uk	The EA is a central and Welsh Government sponsored body responsible for the protection and improvement of the environment in England and Wales, in addition to the management of water resources and protection of communities at risk of flooding. The EA regulates a wide range of processes and installations which may have an impact on the environment, such as groundwater abstractions for ATES, emissions to atmosphere associated with biomass installations and any environmental impacts associated with development. The EA must therefore be consulted with regards to any renewable, low carbon technology proposals for a development during the planning process.
Forestry Commission Wales	–	www.forestry.gov.uk	The Forestry Commission Wales is the Welsh Government department for Forestry and is responsible for the management of the proportion of Welsh Woodland owned by Welsh Government (currently 38%). The Forestry Commission Wales is a source of general information on woodland management and biomass availability in WG owned Welsh woodland.

Organisation	Abbreviation/ Acronym	Website	Details
Fuel Cells 2000		www.fuelcells.org	This is a non–profit independent organisation which aims to promote the commercialisation of fuel cells. Detailed information on fuel cell types, operation and research is available on their website.
Heat Pump Association	HPA	www.heatpumps.org.uk	HPA provides guidance and technical information on available heat pump technologies in the UK.
Micro generation Certification Scheme	MCS	www.microgenerationcertification.org	The MCS scheme is an internationally recognised EN45011 quality assurance scheme to ensure the quality of renewable energy technology installations and products. The MCS website contains a comprehensive list of all MCS accredited suppliers and installers of renewable and low carbon technologies across the UK. MCS is also used by UK Government as an indicator of the eligibility of microgeneration installations for funding under the Clean Energy Cashback scheme (comprising the Renewable Heat Incentive and Feed–In Tariffs).
Micropower Council	–	www.micropower.co.uk	The Micropower Council represents organisations and companies working in the microgeneration sector in the UK. The website provides general information on specific renewable and low carbon microgeneration technologies such as solar PV; solar thermal hot water systems; heat pumps; and micro wind, CHP and biomass.

Organisation	Abbreviation/ Acronym	Website	Details
Renewable Energy Association	REA	www.r–e–a.net	REA represents producers of renewable energy in the UK and aims to secure a robust legislative and regulatory framework for the renewable energy production in the UK. The website provides an overview of Government policy relating to renewable energy in addition to technical information on biofuels, renewable heat and renewable power.
Renewable Energy Assurance Limited	REAL	www.realassurance.org.uk	The REAL Assurance Scheme was set up by REA to ensure quality of small–scale renewable energy installations and products. The website provides information on the scheme and the Consumer Code to which REAL or MCS registered installers and suppliers must adhere to.
Renewable UK	–	www.bwea.com	Renewable UK is a trade and professional body representing the wind and marine renewable industries in the UK. Formerly known as the British Wind Energy Association, Renewable UK provides technical information on all scales of wind power in the UK, in addition to wave and tidal power. The website includes the UK Wind Energy Database, which rovides statistical data, tables and map relating to wind energy across the UK.
Solar Trade Association	STA	www.solartrade.org.uk	STA represents the solar electricity and heating industries in the UK. The website provides general information about solar PV and solar thermal hot water systems.

Organisation	Abbreviation/ Acronym	Website	Details
The Carbon Trust	–	www.carbontrust.co.uk	The Carbon Trust is a non profit organisation which aims to accelerate the move to a low carbon UK economy. It provides technical guidance, advice and information for businesses and the public sector on emerging low carbon supply and demand energy technologies, and has a large number of publications and calculator tools relating to specific renewable and low carbon technologies.
UK National Centre for Biorenewable Energy, Fuels and Materials	NNFCC	www.nnfcc.co.uk	The NNFCC advises UK Government and industry on biorenewable energy. NNFCC produces technical guidance and worktools for the design of biorenewable energy systems. The website provides detailed information and publications on anaerobic digestion, biofuel/crops, and energy from waste.
Wales Centre of Excellence for Anaerobic Digestion	–	www.walesadcentre.org.uk	The Wales Centre of Excellence for Anaerobic Digestion forms part of the Sustainable Environment Research Department at the University of Glamorgan and offers technical and non–technical support for the rapid deployment of anaerobic digestion in Wales. The website provides detailed information on particular forms of anaerobic digestion systems.
Water Power Enterprises	H_2OPE	www.h2ope.org.uk	H_2OPE is a limited Community Interest Company which aims to develop 'low head' hydro sites across the UK using the Archimedean screw.
Welsh Government	WG	www.wales.gov.uk	Provides information on energy and planning issues.

Organisation	Abbreviation/ Acronym	Website	Details
Wood Energy Business Scheme	WEBS 2	www.forestry.gov.uk/forestry/INFD–8JNQQR	This is a £20 million project (part–funded with £7.8 million from the European Regional Development Fund through the Welsh Government Grant). The scheme provides capital grant support to businesses in Wales for woodfuel heating systems and processing equipment.
Wood Fuel Wales	–	www.woodfuelwales.org.uk	This website provides general information on fuel suppliers, installers and technical support for wood fuel in Wales.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
7.2 Publications and Guidance Documents			
Brodies LLP	–	Making ESCos Work: Guidance and Advice on Setting Up & Delivering an ESCo, Brodies LLP, London Energy Partnership, February 2007	This document discusses the role played by Local Authorities to help establish ESCos, their powers to facilitate new infrastructure and the legal scope of their ability to participate in new ventures.
Building Research Establishment	BRE	www.bre.co.uk/sap2009	SAP (Standard Assessment Procedure) – This is the procedure recommended by Government for measuring the energy rating of a residential development.
		www.ncm.bre.co.uk	SBEM (Simplified Building Energy Model) – This is a tool used to determine the energy and carbon dioxide emissions for non residential buildings in compliance withPart L of the Building Regulations (England and Wales).
		Ground Source Heat Pumps, Information Paper 2/10, BRE, 2010	Provides an overview on the operation of ground source heat pumps and their applications.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Centre for Ecology and Hydrology, National Environment Research Council	CEH	www.ceh.ac.uk/data/nrfa/index.html	National River Flow Archive providing historic flowrate data obtained for UK rivers.
Chartered Institute of Building Services Engineers	CIBSE	'Capturing solar energy', Knowledge Series KS15, 2009	Provides an overview of the available domestic and non–domestic solar system technologies such as solar PV and solar thermal collectors.
		'Small–Scale Combined Heat and Power for Buildings', Applications Manual AM12 2009	Provides guidance on the considerations and processes required to design, install and operate small–scale CHP systems.
		'Fuel cells for buildings', datasheet 04, 2005	Provides a summary overview of the operation of fuel cells, including a description of specific types of fuel cell.
		Solar Heating Design and Installation Guide, 2007	Provides technical guidance for the design and installation of domestic solar thermal hot water systems.
Combined Heat and Power Association	CHPA	Guidelines for the Technical Specifications for Small Scale (<1MWe) Combined Heat and Power Installations, 1997	Technical specification for CHP.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Countryside Council for Wales	CCW	www.ccw.gov.uk/interactive–maps/protected–sites–map.aspx	Interactive map of environmentally protected sites and landscapes across Wales.
Department of Energy and Climate Change	DECC	Renewable Heat Incentive Scheme (RHI) www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/incentive/incentive.aspx	The RHI Scheme is a UK Government funding mechanism for renewable and low carbon heating systems in the UK. The scheme provides support for the non–domestic and domestic sectors. The following technologies are supported under the RHI scheme: • Biomass boilers (including CHP biomass boilers). • Solar Thermal. • Ground Source Heat Pumps. • Water Source Heat Pumps. • On–Site Biogas combustion. • Deep Geothermal. • Energy from Municipal Solid Waste; and • Injection of biomethane into the grid.
		Sustainability Standard for >50 kW biomass www.decc.gov.uk/en/content/cms/meeting_energy/bio_energy/sustainability/sustainability.aspx	Since April 2011, biomass electricity generators over >50 kW are required to report under the Renewables Obligation against the following sustainability criteria: • Minimum 60% Greenhouse Gas ("GHG") emission saving for electricity generation using solid biomass or biogas relative to fossil fuel; and • General restrictions on using materials sourced from land with high biodiversity value or high carbon stock – including primary forest, peatland, and wetlands.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Department of Energy and Climate Change (Cont'd)	DECC	Feed–In Tariffs www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/feedin_tariff.aspx	The Feed–In Tariff (FIT) scheme was introduced through the Energy Act 2008 by DECC in April 2010. FITs are available for small scale (<5 MW) low carbon electricity generation to encourage small–scale deployment of the following technologies: • Wind • Solar PV • Hydro • Anaerobic digestion; and • Domestic scale microCHP (< 2 kW or less).
		CHP Site Assessment Tool www.chp.decc.gov.uk/CHPAssessment/(S(hunphhhy0oonbr4za5pd3a0z))/Default.aspx	This application is a free tool provided by DECC which provides non technical users with an indicative assessment for CHP installation with a review of potential CHP options.
		UK CHP Development Map www.chp.decc.gov.uk/heatmap	Provides an interactive map of the UK indicating the heat load of particular areas in kW/km^2.
		Enhanced Capital Allowances (ECA) www.eca.gov.uk	ECAs allow businesses to reclaim 100% of capital spending on plant and machinery associated with a wide range of specific energy–saving measures, including: • CHP • Boilers • Heat exchangers; and • Solar thermal systems.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Department of Energy and Climate Change (Cont'd)	DECC	CHP Quality Assurance (CHPQA) www.chpqa.decc.gov.uk/	The CHPQA Scheme aims to ensure the quality of CHP systems supported by ECAs.
Department for Environment, Food and Rural Affairs	DEFRA	Smoke Control Areas (exempt appliances) www.smokecontrol.defra.gov.uk/appliances.php	Under the Clean Air Act, smoke control areas are defined as areas where it is an offence to emit smoke from a chimney of a building, furnace or any fixed boiler within a smoke control area. A list of exempt appliances for Smoke Control Areas in Wales is provided by DEFRA and includes specific types of biomass boilers, used with specific fuel types. Where a development falls within a smoke control area, selection of any biomass system should be made with reference to the DEFRA guidance.
		Government Anaerobic Digestion Portal www.biogas–info.co.uk	This portal provides detailed information on anaerobic digestion, biogas and digestate for the UK. The weblink also provides a biogas map of the UK highlighting available biogas resources and the operators.
EA and Resource Action Programme		Waste Protocols Project, Quality protocol: Anaerobic digestate www.environment–agency.gov.uk	This is a joint EA and Waste & Resources Action Programme (WRAP) initiative which sets out criteria for the production of quality products from anaerobic digestion of material.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Energy networks association	–	Standards for Wind Power, Engineering Recommendations G38 and G59 www.2010.energynetworks.org/distributed–generation	Both Engineering Recommendations provide guidance on the required connections to the National Grid electricity network for distributed generation systems such as wind turbines.
Energy Networks Association	–	Electricity Distribution Map of UK www.2010.energynetworks.org/electricity–distribution–map	The map provides information on the Distribution Network Operators (DNOs) and grid connections, useful for developers of grid connected wind turbines.
Energy Saving Trust	EST	Housing Energy Model www.energysavingtrust.org.uk	This is a model developed by EST in order to examine the sources of CO_2 emissions in the UK domestic sector and consider methods of emission mitigation.
European Commission	–	The Waste Incineration (England and Wales) Regulations 2002 www.legislation.gov.uk/uksi/2002/2980/contents/made	The Waste Incineration Regulations implement the EU Waste Incineration Directive and place strict environmental standards on energy from waste installations with regards to their emissions and operation.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
European Commission (Cont'd)	–	Renewable Energy Directive:Bioenergy Sustainability Criteria www.ec.europa.eu/energy/renewables/bioenergy/sustainability_criteria_en.htm	The criteria provide information on the sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling.
Heating and Ventilating Contractors Association	HVCA	Guide to Good Practice – Heat Pumps, Technical Report TR/30, HVCA, 2007.	This document provides technical guidance on heat pump specification and design for heating and cooling in buildings.
Renewable UK (formerly British Wind Energy Association)	–	Small wind performance and safety standard www.bwea.com/small/standard.html	This standard supports the MCS and is a technical standard relevant to manufacturers of small wind turbines who wish to supply into the British marketplace.
The Carbon Trust	–	Biomass Heating: A practical guide for potential users, Guide CTG012, 2009	This guide provides a detailed introduction to the policy background of biomass heating which covers issues such as sustainability and fuel supply, in addition to providing a detailed introduction to the technicalities of fuel and plant operation. The guide also discusses implementation of biomass heating systems, including requirements for feasibility studies and commissioning.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
The Carbon Trust (Cont'd)		Wind Yield Estimation Tool www.carbontrust.co.uk/emerging–technologies/current–focus–areas/offshore–wind/_layouts/ctassets/aspx/windpower estimator/windpower estimator terms.aspx	This online tool allows users to input site and wind turbine details to determine the mean wind speed, the energy generation potential and the carbon dioxide emissions savings. Information required in order to operate the tool include: • The full grid reference and location of the proposed wind turbine, • The model/manufacturer of the turbine; • The mid rotor height from ground level; and • If available, data from the power curve (power output vs. wind speed) for the specific turbine.
		Climate Change Act 2008	This Act sets a target and methodology for 2050 for the reduction of targeted greenhouse gas emissions and to facilitate the development of a low carbon economy in the UK.
UK Government Legislation and Regulations		Planning Act 2008	This Act aims to accelerate the planning approval process for major new infrastructure projects such as airports, roads, harbours, and energy facilities such as nuclear power and waste facilities.
		The Promotion of the Use of Energy from Renewable Sources Regulations 2011, SI 243.	These regulations transpose articles of the EU Renewable Energy Directive 2009/28/EC and set out the action plan for the promotion of renewable energy sources in the UK.
		Town and Country Planning Act 1990	This Act (and all subsidiary orders and regulations) forms the overarching framework for the development of land in England and Wales.
		Salmon and Freshwater Fisheries Act 1975	This Act encompasses illegal obstruction of migratory pathways of fish in the UK and is therefore an important consideration when developing a hydro scheme.

Organisation	Abbreviation/ Acronym	Website/ Publication Title	Details
Welsh Government	–	Practice Guidance: Planning Implications of Renewable and Low Carbon Energy, February 2011	This guidance document aims to aid local authorities in their decisions regarding applications for renewable and low carbon developments.
		Planning Policy Wales	This document outlines the current land use planning policy for Wales and sets out the overarching framework against which Welsh Local Planning Authorities base their development plans.
		One Wales: One Planet	The sustainable development scheme for Wales which aims to secure a long term sustainable future for future generations.
		Technical Advice Note 8: Planning for Renewable Energy	Provides technical planning advice on renewable energy.
		Technical Advice Note 12: Design	Provides technical planning advice on good design.
		Technical Advice Note 22: Planning for Sustainable Buildings	Aims to assist local planning authorities and developers to implement the national planning policy on sustainable buildings.
		The Smoke Control Areas (Authorised fuels) (Wales) Regulations 2009 The Smoke Control Areas (Exempted fireplaces) (Wales) Order 2011	These documents transpose requirements of the Clean Air Act 1993 into Welsh Government. Wales contains four (partial) Smoke Control Areas. These are: • Wrexham • Flintshire • Newport; and • Swansea.