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Practice Guidance

Planning Implications of Renewable and Low Carbon Energy

February 2011

Cover image courtesy of Thermal Earth Ltd

Planning Divison
Welsh Assembly Government
Cardiff
CF10 3NQ

E-mail: planning.division@wales.gsi.gov.uk

Planning web site - **www.wales.gov.uk/planning**

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List of Abbreviations

AAP	Area Action Plan	LAPC	Local Air Pollution Control
AD	Anaerobic Digestion	LDP	Local Development Plan
AONB	Area of Outstanding Natural Beauty	LPA	Local Planning Authority
BREEAM	Building Research Establishment Environmental Assessment Method	LDF	Local Development Framework
CAA	Civil Aviation Authority	MoD	Ministry of Defence
CAD	Centralised Anaerobic Digester	NATS	National Air Traffic Services
CCHP	Combined cooling heat and power	NNR	National Nature Reserve
CCW	Countryside Council for Wales	NPA	National Park Authority
CHP	Combined heat and power	NPS	National Policy Statement
CIL	Community Infrastructure Levy	PLANED	Pembrokeshire Local Action Network for Enterprise and Development
CLA	Country Land and Business Association	PV	Photovoltaics
CLG	Communities and Local Government	RESTATS	Renewable Energy Statistics Database for the UK
CSE	Centre for Sustainable Energy	ROC	Renewable Obligation Certificate
CSH	Code for Sustainable Homes	SAC	Special Area of Conservation
DAP	Director of Aerospace Policy	SDF	Sustainable Development Fund
DECC	Department for Energy and Climate Change	SEA	Strategic Environmental Assessment
DNO	District Network Operator	SHW	Solar Hot Water
EA	Environment Agency	SNH	Scottish National Heritage
EIA	Environmental Impact Assessment	SPA	Special Protection Area
ESCOs	Energy Service Companies	SPG	Supplementary Planning Guidance
FIT	Feed In Tariff	SSA	Strategic Search Area
GSHP	Ground Source Heat Pump	SSSI	Site of Special Scientific Interest
HGV	Heavy goods vehicle	SuDS	Sustainable drainage system
IIPC	Integrated Pollution Prevention and Control	TAN	Technical Advice Note
IPC	Infrastructure Planning Commission	WAG	Welsh Assembly Government

1. Introduction

1.1 Background and purpose of this Practice Guidance

1.1.1 Climate change and energy security are key priorities of both the UK and Welsh Assembly Government. The use of fossil fuels is seen as a major contributor to greenhouse gas emissions, a major cause of global climate change and moving towards a low carbon energy based economy to tackle the causes of climate change and improve energy security are a Government priority.

1.1.2 The policy context for renewable and low carbon energy developments is strongly influenced by European and UK legislation. The UK has signed up to the EU Renewable Energy Directive 2009 and agreed to legally binding targets of 15% of energy from renewable sources by 2020. The UK Renewable Energy Strategy (2009)[1] sets out the path for the UK to meet this target.

1.1.3 In One Wales – the programme for government, the Welsh Assembly Government set out a commitment to reduce greenhouse gas emissions in Wales, with an aim to achieve annual carbon reduction-equivalent emission reductions of 3% per year by 2011 in areas of devolved competence, including actions on diversified renewable energy generation. The Assembly Government has reiterated the recognition that climate change is the greatest threat facing humanity and is committed to ensuring that Wales plays a full part in meeting the challenges which this presents. This is set out in the Climate Change Strategy for Wales (2010).

1.1.4 The Assembly Government has a legal obligation to promote Sustainable Development and has embarked on an ambitious and long-term programme of cross-cutting policy initiatives to address these issues. This is contained in One Wales: One Planet (2009)[2] which sets out a vision where within the lifetime of a generation we want to see Wales using only its fair share of the earth's resources. Renewable energy plays an integral part in achieving this vision.

1.1.5 In March 2010 the Welsh Assembly Government published *A Low Carbon revolution – The Welsh Assembly Government Energy Policy Statement*[3]. This set out a positive sustainable framework for renewable energy in Wales. It identifies the potential of a range of renewable energy technologies across Wales.

1.1.6 The planning system in Wales is a devolved responsibility of the Assembly Government. Local Planning Authorities have the responsibility for determining planning applications renewable energy projects under 50MW. Local Planning Authorities should take decisions in accordance with their development plan unless local material circumstances indicate otherwise. National Planning Policy is a key material consideration for Local Planning Authorities.

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[1] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx
[2] http://wales.gov.uk/topics/sustainabledevelopment/publications/onewalesoneplanet
[3] http://wales.gov.uk/topics/environmentcountryside/energy/renewable/policy

1.1.7 Local Authorities have several key roles to play to facilitate the use and generation of renewable and low carbon energy. These are:

- Preparing planning policies and allocating land in their **Local Development Plans.**
- **Development management** – taking decisions on planning applications submitted to the local authority for development; as well as preparing Local Impact Assessments for schemes which are determined by the Infrastructure Planning Commission.
- **Corporate** – taking action at a council wide level to achieve a low carbon economy.
- **Leadership** – taking forward wider community action and communicating the need to increase the uptake of renewable and low carbon energy.

1.1.8 For (a) above, a '***Practice Guidance – Planning for Renewable and Low Carbon Energy – A Toolkit for Planners***'[4] has been published by the Assembly Government to support local authority planning officers. It sets out how a Local Authority can prepare a robust evidence base to underpin a number of local development plan policies that can support and facilitate the deployment of renewable and low carbon energy systems. This is published alongside this practice guidance and can be found on the Assembly Government's website www.wales.gov.uk/planning. The toolkit may also be of use in the development management process in assisting the discussions with developers on local renewable energy schemes, as well as identifying potential opportunities.

1.1.9 For (b) this '***Practice Guidance – Planning Implications of Renewable and Low Carbon Energy Development'*** has been published. This sets out how local planning authority development management officers can identify the planning implications of applications for renewable and low carbon energy development.

1.2 What is this guidance for?

1.2.1 This *Practice Guidance* is a tool to support Local Planning Authorities (LPAs) in dealing with applications for renewable and low carbon energy development. It will do this by setting out a comprehensive evidence base of the land use planning impacts and benefits of different forms of renewable and low carbon energy, and provide guidance on how local planning officers can engage in a meaningful and proactive manner with developers when dealing with planning applications for renewable and low carbon energy developments.

1.3 Why should Local Authorities use the Practice Guidance?

1.3.1 Use of this *Practice Guidance* will assist local development management officers in considering applications for renewable and/or low carbon energy development. It will provide advice on the range of planning implications

[4] http://wales.gov.uk/topics/planning/policy/guidanceandleaflets

(environmental, social and economic) that may be considered in making a decision on an application for renewable and/or low carbon energy development. This will be framed by the national and local planning policies on renewable energy that exist at the time in which an application is considered. Developers and proposers of renewable and low carbon energy development (at all scales) may also consult with this document in order to identify these planning implications and seeks ways in which these impacts can be minimised.

1.4 How this guidance has been prepared?

1.4.1 In 2009 the Welsh Assembly Government commissioned Land Use Consultants (LUC) in association with the Centre for Sustainable Energy (CSE) to undertake a research study looking at the planning implications of renewable and low carbon energy developments in Wales. The report of this research was published in July 2010[5], alongside the first edition of this practice guidance which draws on the findings of this research. LUC were commissioned further in 2010 to consider the planning implications of solar PV array development, which is contained in this updated edition (February 2011).

1.5 Scope of this Practice Guidance

What does this Practice Guidance cover, and not cover?

1.5.1 This Practice Guidance covers a range of renewable and low carbon energy/technologies which may come forward as an application for planning permission. These are set out below:

Table 1.1 Renewable Energy Technologies covered by the Practice Guidance
1. Wind.
2. Biomass.
3. Anaerobic digestion.
4. Biofuels.
5. Small scale hydro.
6. Solar – building integrated (PV or solar thermal) and solar PV arrays.
7. Ground, water and air source heat pumps.
8. Geothermal.
9. Fuel cells.
10. Combined heat and power (CHP) and combined cooling heat and power (CCHP).
11. District heating.
12. Waste heat.

5 http://wales.gov.uk/topics/planning/planningresearch

1.5.2 The *Practice Guidance* does not consider 'Energy from waste' (i.e. incineration, gasification and pyrolosis) as this is being addressed through other Assembly Government workstreams such as the National Waste Strategy for Wales, regional waste plans, and will be contained as part of any future review of Technical Advice Note 21: Waste (2001)[6]

1.5.3 While the *Practice Guidance* focuses primarily on the implications from the types of renewable and low carbon energy technologies, it does recognise that this may vary depending on the size and scale of such proposals. This is to acknowledge that some types of technology may form part of an individual installation (i.e. individual biomass plant) or within a number of installations as part of a larger proposal (i.e. wind farm).

1.5.4 Those microgeneration technologies captured under permitted development rights as set out in The Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2009[7] which do not require planning permission fall outside the scope of this Practice Guidance. However this only relates to the scale of the technology (in terms of output).

1.5.5 Offshore renewable energy technologies also fall outside the scope of this *Practice Guidance* as they are not within control of Local Planning Authorities.

1.6 Policy context

National Planning Policy and Guidance

1.6.1 The Welsh Assembly Governments land use planning policies are contained in Planning Policy Wales (PPW)[8]. It is supplemented by a series of Technical Advice Notes (TANs), procedural advice is given in circulars and policy clarification letters. This provides the framework for Local Development Plans and the decision making responsibilities of LPAs.

1.6.2 Section 12.8 *Planning for Renewable Energy* of PPW sets out the Assembly Governments' planning policy on renewable energy, this is supplemented by TAN8 *Planning for Renewable Energy* (2005)[9]. This defines renewable energy as follows:

> *"Renewable energy is the term used to cover those sources of energy, other than fossil fuels or nuclear fuel, which are continuously and sustainable available in our environment. This includes wind, water, solar, geothermal energy and plant material often referred to as biomass".*

1.6.3 Low carbon energy cover a range of energy sources that are not renewable, but can still produce significantly lower carbon emissions than that of conventional

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[6] http://wales.gov.uk/topics/planning/policy/tans/tan21
[7] http://www.opsi.gov.uk/legislation/wales/wsi2009/wsi_20092193_en_1
[8] http://wales.gov.uk/topics/planning/policy
[9] http://wales.gov.uk/topics/planning/policy/tans/tan8

energy or heat generating stations. These are therefore considered an important part of decarbonising the energy supply.

1.6.4 The current national planning policy on planning for renewable energy states that Local Planning Authorities should facilitate the development of all forms of renewable energy and energy efficiency and conservation measures which fit within a sustainable development framework.

1.6.5 In addition, the national planning policy on sustainable buildings (Chapter 4, PPW) expects most new developments to meet a minimum sustainable building standard. Whilst the minimum standard does not necessarily require a renewable or low carbon energy technology to be incorporated into the design of the development, in moving towards higher standards through Building Regulations these technologies are likely to form part of the proposal.

1.6.6 Design and access statements (DAS) are required to accompany most applications for planning permission and listed building consent[10]. The statement must demonstrate the accessibility of the proposal, and illustrate how adopting good principles of inclusive design have informed and guided the application. Central to this is how the development has addressed *Environmental Sustainability*, which includes consideration on how the development has sought to reduce its carbon footprint.

1.7 How to use this practice guidance

1.7.1 This *Practice Guidance* is divided in the following chapters:

Chapter 1	sets out the role and purpose of this guidance.
Chapter 2	provides an introduction to the renewable and low carbon energy technologies.
Chapters 3 – 13	provides a review of the various sources of renewable energy and their environmental, social and economic impacts
Chapter 14	considers the cumulative effects of various sources of renewable energy.
Chapter 15	considers the effects of climate change
Chapter 16	considers the financial drivers and barriers that exist
Chapter 17	considers the role of community involvement and community benefits
Chapter 18	provides a review of renewable and low carbon energy development within designated areas
Chapter 19	reviews the opportunities for Local Planning Authorities to engage with developers, promote good design, secure planning obligations and attach planning conditions

[10] See Technical Advice Note 12 Design (2009) http://wales.gov.uk/topics/planning/policy/tans/tan12

2. Renewable and Low Carbon Energy Technologies

2.1 Introduction

2.1.1 This chapter provides a summary of information on the various types of renewable energy and low carbon technology. The technologies covered include:

- Wind	[electricity]
- Biomass	[heat/electricity]
- Anaerobic digestion	[heat/electricity]
- Biofuels	[transport fuel]
- Small scale hydro	[electricity]
- Building integrated solar photovoltaics (PV), solar thermal and solar PV arrays	[electricity/heat]
- Ground, water and air source heat pumps	[heat]
- Geothermal	[heat/electricity]
- Fuel cells	[electricity]
- Combined heat and power (CHP) and combined cooling heat and power (CCHP)	[heat/electricity]
- District heating	[heat]
- Waste heat	[heat]

2.1.2 As illustrated above, the above technologies have different energy outputs – i.e. they can be used to produce either electricity only, heat only, or power and heat simultaneously, for example when used in a Combined Heat & Power (CHP) plant.

2.1.3 For each technology the following information is provided:

A	A **non technical description** of the technology.
B	A review of the key **technological and financial constraints.**
C	**Key planning issues** – i.e. who the application will be determined by and the thresholds for Environmental Impact Assessment (EIA) screening.
D	A **summary** of the key land use planning impacts and benefits and associated design, mitigation and enhancement measures. This is broken down into the relevant topic areas that apply to the technology type.

2.1.4 Separate matrices providing more detailed information on the environmental, social and economic impacts of the different forms of renewable energy have been prepared and have been used to inform this section of the report – See Appendix 3.

Further details on the matrices are provided below. Please note that Section D does not include reference to **all** the potential impacts and benefits associated with the various forms of renewable energy, rather it provides a summary of the key impacts/benefits that may occur. As outlined above, more detailed information is provided in Appendix 3.

2.1.5 The chapter concludes with a discussion of the potential effects of climate change on the different forms of renewable and low carbon energy.

2.1.6 As outlined previously, offshore renewable energy developments fall outside the scope of this Practice Guidance as they lie beyond the control of the planning system. It is acknowledged however that the associated infrastructure – i.e. onshore sub-stations, control buildings, temporary construction accesses may require planning permission. With regard to any required onshore grid connections where the works required to connect the development to the local electricity distribution network are not permitted under the General Development Order, an application for consent would be submitted by the Distribution Network Operator to the Secretary of State for the Department of Energy and Climate Change (DECC) under Section 37 of the Electricity Act 1989 (in which event the Local Planning Authorities will be statutory consultees).

2.2 Impacts and mitigation matrices

2.2.1 Planning Policy Wales states that:

> "*Local Planning Authorities should consider the effects of any scheme and its associated infrastructure in relation to sustainable development criteria relating to economic, social and environmental impacts*."

2.2.2 In order for Local Authorities to undertake an assessment of the potential effects of a particular development, they need to be aware of the full range of potential impacts (positive and negative) that a renewable or low carbon development and its associated infrastructure can have and the extent to which these need to be considered in any planning decision.

2.2.3 Not all impacts associated with renewable and low carbon developments fall within the control of planning (e.g. the landscape and environmental impacts of biomass planting) and it is important that there is a **clear understanding of what planning can and cannot influence**. As set out in Planning Policy Wales, Local Planning Authorities have a key role to play in ensuring that potential impacts are minimised and that appropriate mechanisms (such as planning conditions) are used to secure any required mitigation/enhancement measures.

2.2.4 In order to inform the preparation of Section D for each technology on the land use planning impacts and mitigation measures associated with different types of renewable development, a series of detailed matrices have been compiled. These are provided as a separate Appendix (Appendix 3) in the form of an online spreadsheet. For each of the technologies the following information is set out:

- The **potential environmental, social and economic impacts and benefits** (which fall within and outside the control of the planning system).
- The **key mitigation/enhancement measures** which may be implemented to help avoid or minimise the potential impacts or enhance any benefits (this includes any design considerations).
- A summary of **further sources of information**.

2.2.5 The main potential benefit of renewable energy which is consistent across all the technology types is that it can result in a reduction in carbon emissions when replacing existing forms of fossil fuel energy generation. It therefore provides one of the primary forms of mitigation against climate change. However, some technologies such as biomass can generate wider benefits such as generating positive impacts for biodiversity resulting from the management of existing woodland. Where appropriate, these specific benefits have been highlighted in the text and tables in Appendix 3.

3. Wind Energy

Technology Summary

On-shore wind power is an established and proven technology with thousands of installations currently deployed across many countries. The UK has the largest wind energy resource in Europe, with Wales in particular holding significant opportunities due to its weather and geography.

Wind power uses energy from the wind to turn a rotor connected to an electrical generator. Although there are no rigid categories relating to the scale of wind turbines, individual on-shore turbines tend to fall within four size bands: micro, small, medium and large. These typically range from 5 watt battery charging models up to 2-3 megawatt commercial scale turbines. The number of turbines used per site ranges from the deployment of single turbines up to large groups of turbines (known as wind farms) capable of generating tens of megawatts.

The vast majority of turbines are currently designed using a horizontal axis three-blade rotor system mounted on a steel mast. Small or micro scale turbines can be installed with a free-standing mast or building-mounted, and are most commonly deployed as single machines supplying specific buildings or developments (e.g. farm buildings, schools, small businesses, etc).

Individual large scale turbines can also be deployed as single machines but are more often used in groups in the form of a wind farm development. Wind farms tend to be located in more remote areas and directly supply power to the national grid i.e. they are not associated with a particular development

3.1 A. Description of Wind Energy

Market Status

3.1.1 On-shore wind power is an established and proven technology with thousands of installations currently deployed across many countries. The UK has the largest wind energy resource in Europe, with Wales in particular having significant wind energy potential. The UK Renewable Energy Strategy (2009) sets out a lead scenario in which wind generation, both onshore and offshore, will provide over two-thirds of our renewable electricity supply by 2020. *A Low Carbon revolution – The Welsh Assembly Government Energy Policy Statement* (2010) sets Wales' onshore wind energy potential of 2GW by 2015/16. At time of writing the number of operational wind farms in Wales totalled 33, representing around 381MW installed capacity.

Figure 3.1: Carno Wind Farm, Powys

Source: © Npower Renewables

Equipment and infrastructure

3.1.2 The main visible components of a wind turbine consist of a tower, nacelle and rotor blade system (see Figure 3.1). There are two main types of turbine – horizontal axis and vertical axis. The vast majority of machines are currently designed using a horizontal axis three-blade rotor system mounted on a steel mast.

3.1.3 The rotor converts a portion of the power in wind into rotational motion, which is then converted into electricity by a generator located in the nacelle. Vertical axis turbines use a range of designs in which the rotor shaft spins on a vertical axis. Historically, vertical axis turbines have not performed well in the commercial market and globally the number of medium/large scale installations is extremely small. However, a key difference when compared to horizontal axis turbines is that they operate independently to wind direction i.e. they do not need to be aligned with the prevailing wind direction. This can be advantageous in locations which experience turbulent wind conditions such as urban areas and consequently a small number of small/micro-scale vertical axis turbines are now on the market.

3.1.4 Turbines are rated according to their maximum electrical output in kilowatts (kW) or megawatts (MW). Other components which may be present, depending on the scale and design of the turbine, are a nacelle gearbox and transformer, usually located at the base of the tower. The transformers can be located inside or outside the tower. The tower itself sits on a concrete foundation which is largely hidden from view. Small or micro scale turbines can be installed with a free-standing mast or building-mounted.

3.1.5 In addition to the turbines themselves, developments involving large scale wind turbines typically require additional infrastructure as follows:

- Road access to the site and on-site tracks able to accommodate Heavy Goods Vehicles (HGVs) carrying long, heavy and wide loads (for the turbine blades and construction cranes).
- A temporary construction compound and lay down area for major components.
- A concrete foundation pad for each turbine.
- An area of hardstanding next to each turbine to act as a base for cranes during turbine erection, which is generally removed after construction.
- Underground cables connecting the turbines (buried in trenches).
- One or more anemometer mast to monitor wind direction and speed.
- A control building (to ensure the turbines are operating correctly) and a substation (which are often located in the same building).

3.1.6 The District Network Operator (DNO) is responsible for establishing a connection between the substation and the national grid. This connection is routed via overhead cables on poles or by the considerably more expensive option of underground cabling. Some small-scale remote installations may be off-grid, in which case a battery storage system would be used.

Scale of application

3.1.7 There are no rigid categories to describe the scale of individual wind turbines (with the exception of microgeneration, see Para 1.5.4 below), installations tend to fall within four size bands. At the micro-scale, turbines range from 5W battery charging models up to around 2.5kW rooftop devices which provide a proportion of a building's electricity demand. Small scale turbines generally range up to around 50kW and medium scale turbines up to around 750kW. Most large onshore wind turbines are currently being produced in the 1-3MW range. Table 3.1 shows typical scales of turbine and potential outputs in terms of the number of homes supplied.

Table 3.1	Typical scales of individual wind turbine technologies		
Scale[11]	**Typical Turbine Rating**	**Typical Turbine Height (to blade tip)**	**Potential No. of Homes Supplied**[12]
Micro (less than 2.5kW)	2.5kW	11m	0.7

[11] The scales given are not definitive and are used for illustration purposes only.
[12] The potential number of homes supplied is assessed from the estimated annual energy outputs from the turbine ratings shown, using capacity factors of 0.3 (large scale), 0.2 (medium scale) and 0.15 (small scale and micro) and an annual average household electricity consumption in Wales of 4,278kWh (see http://www.assemblywales.org/sc_carbon_reduction_household_final_report_published_version.pdf) Energy output from micro-scale turbines is highly dependent on the local wind conditions but is significantly greater in rural or more exposed areas. The figure given of 0.7 assumes a suitably windy site (see: *Small-scale wind energy: Policy insights and practical guidance,* Carbon Trust CTC738, 2008).

Table 3.1	Typical scales of individual wind turbine technologies		
Scale[11]	**Typical Turbine Rating**	**Typical Turbine Height (to blade tip)**	**Potential No. of Homes Supplied[12]**
Small (1.5 - 50kW)	20kW	20m	6
Medium (50kW – 750kW)	500kW	65m	205
Large (above 750kW)	2.5MW	up to 135m	1,536

3.1.8 The number of turbines used per site ranges from the deployment of single turbines up to large groups of turbines (known as wind farms) capable of generating tens of megawatts. TAN 8 currently refers to wind developments of 25MW or more as being 'large scale onshore wind developments' i.e. in relation to wind development within the identified Strategic Search Areas. Such developments will also be referred to as 'large scale wind farm developments' in the sections below, to differentiate from 'individual large scale turbines' as set out in Table 2.1.

3.1.9 Small or micro scale turbines are most commonly deployed as single machines supplying specific buildings or developments (e.g. farm buildings, schools, small businesses, etc), providing power to an existing building or to meet emission reduction targets as part of a new development. Individual large and medium scale turbines can also be deployed as single machines but are more often used in groups to form part of a larger planning application in the form of a large scale wind farm. Wind farms tend to be located in more remote areas and directly supply power to the national grid i.e. they are not associated with a particular development.

3.1.10 These terms must not be confused with the legal term applied to microgeneration technologies as set out in Section 82(6) of the Energy Act 2004. This defines microgeneration technologies that generate electricity which do not exceed a capacity of 50 kilowatts.

Operation

3.1.11 Wind turbines operate between a range of wind speeds defined by the **'cut-in'**, **'rated'** and '**cut-out'** wind speeds, which are specific to the turbine model. Below a certain wind speed, (the cut-in speed) there is insufficient energy in the wind for the turbine to generate electricity. As wind speed increases, the turbine will then start generating, with its power output increasing up to its maximum 'nameplate' power rating at the rated wind speed. As wind speeds continue to increase, the turbine will remain at its maximum output up to the cut-out wind speed, at which point the turbine must stop and 'park' the rotor in order to avoid potential damage from the excessive forces in the wind. Therefore, the amount of energy that turbines generate will depend primarily on wind speed but will be limited by the maximum output (kW) of the individual turbine. As the turbine will not operate below the **cut-in** wind speed or above the cut-out wind speed, the blades will be periodically stationary. For a typical upland site in the UK, a turbine is likely to be operational for around 70-85% of the time[13].

[13] See http://www.bwea.com/energy/rely.html.

Costs and financial incentives

3.1.12 In the UK, the use of large-scale wind turbines, both individually and as larger groups, is currently a commercially viable proposition, as it is one of the cheapest forms of renewable energy technology. Renewable energy financial incentives such as Renewable Obligation Certificates (ROCs) and the Clean Energy Cashback Scheme (Feed-in Tariff) now guarantee a long-term fixed income for wind energy generated at all scales.

3.1.13 There are a number of financing options available for the development and operation of wind energy developments. These include 'Merchant Wind Power' companies that will install and operate turbines, with the site owners leasing land to the operator and purchasing the green electricity at reduced rates. The developer owns and operates the turbines, removing any financial or development risk from the landowner. Other options include community-ownership of turbines, where communities raise capital to purchase the equipment and earn revenue from the sale of electricity (see Chapter 17).

3.2 B. Technological and financial constraints of wind energy

3.2.1 The main technical constraints to the siting of wind power which also directly affect the economic viability of the scheme include:

- Wind speed.
- Grid connection.
- Vehicular access.

3.2.2 Other technical constraints include proximity to aviation routes, communication systems such as radar or microwave links and infrastructure such as roads, power lines and buildings. Wind turbines can also cause electromagnetic interference which can affect television and radio reception if near a transmitter. In assessing sites, discrete buffer zones are normally applied to each potential constraint in the area. The main constraints are discussed below:

Wind Speed

3.2.3 Wind speed is measured in metres per second (m/s). Identifying a site with a suitable wind speed profile is of critical importance as small variations in annual average wind speed will result in much larger variations in energy generation and hence revenue. This is because power produced is equal to the cube of the wind speed[14], so a turbine on a site with an annual average wind speed of 8 m/s would produce around twice the energy of an identical machine located on a site with an annual average wind speed of 6 m/s. For this reason, it is beneficial to accurately monitor sites as far as possible at the feasibility stage to establish wind speed

[14] Power is a function of the wind speed raised to the power of three, so if the wind speed doubles then the power will increase by a factor of eight.

profiles and to inform the modelling of turbine positioning to optimise energy yields. Costs may limit the extent of monitoring with small or micro scale turbines, but for medium and large scale turbines, this usually involves the erection of a meteorological mast at the site which is equal in height to the hub of the proposed turbines. This is used to measure wind speeds, wind direction, precipitation and other parameters.

3.2.4 As the strength of the wind varies considerably, so does the turbine power output. A measure of the performance of a turbine at a given site, usually stated as an average over the course of a year, is the Capacity Factor. A typical value for a good UK site is around 0.3, which means the turbines are producing 30% of their theoretical maximum[15]. Intermittency can have an impact on the national grid system in that a degree of short term reserve i.e. back-up generation is needed due to the unpredictability of wind output. The variability of wind output also creates an issue for the UK's overall generation capacity. Current analysis indicates that intermittency should be manageable in the period up to 2020, but could potentially become a problem after this date due to closures of old gas and coal power plants and any further increase in the deployment of intermittent renewable electricity supplies[16].

Grid connection

3.2.5 The costs involved in routing power transmission cables from a wind farm to a suitable grid connection point can be considerable and distance is therefore a critical factor. A 2009 study by BWEA Cymru[17] reports that the current availability of suitable grid connection points in certain parts of Wales can act as a barrier to the growth of wind power, but that a study has now been undertaken in conjunction with the National Grid to assess the high level constraints to grid infrastructure. It also states that further studies are planned to assess grid routing issues and environmental impacts.

Vehicular access

3.2.6 Vehicular access is needed to transport the turbines and associated equipment to the preferred sites. Turbine blades for individual medium and large scale turbines in particular require specialised transport arrangements as they are normally manufactured in one piece, with some models measuring upwards of 40m in length. Difficulties can therefore be experienced in planning transport routes to some wind power sites where the size of the roads may be a constraint.

Constraints to small or micro scale wind

3.2.7 Small or micro scale wind energy developments are subject to similar constraints relating to wind speed. In particular, loss of economy of scale together with lower wind speeds accessed by the shorter turbines generally result in small-

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[15] A capacity factor of 0.3 is generally used as the industry standard for large scale wind turbines in the UK (source: BWEA).
[16] *UK Renewable Energy Strategy.* (2009) HM Government. P179.
[17] *Wind Energy in Wales – State of the Industry*. (2009) BWEA Cymru.

scale wind being less financially viable. Rooftop micro-scale turbines in particular are prone to building-induced turbulence, resulting in low wind speeds. Sites therefore need to be chosen with care to ensure satisfactory performance. However, small or micro turbines are generally less geographically constrained in relation to issues such as noise and visual/landscape impact.

3.2.8 Small or micro scale turbines are also constrained by grid connection distance i.e. long routes are more expensive, although as typical installations of this scale supply specific buildings, availability of a connection is not often a constraint. Additionally, vehicular access would rarely be a constraint due to the size of equipment at this scale.

3.3 C. Planning and EIA Requirements

3.3.1 Wind farms of less than 50MW capacity will need to apply for planning permission to the local planning authority under the Town and Country Planning Act 1990.

3.3.2 Applications for wind farms greater than 50MW will need to apply for consent to the Infrastructure Planning Commission (IPC) as defined under the Planning Act 2008.

3.3.3 Individual wind turbines and windfarms are listed under Schedule 2.3(i) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. Local Planning Authorities are required to screen applications for the need for EIA where the development involves the installation of more than 2 turbines or the hub height of any turbine or height of any other structure exceeds 15 metres.

3.4 D. Summary of potential impacts and design, mitigation and enhancement measures of wind energy

Landscape and Visual

3.4.1 Individual large scale wind turbines (1-3MW) are tall structures – sometimes over 125 metres in height – and as a result they will have an impact on the landscape and on views. The key landscape and visual impacts that may occur include:

- Direct landscape impacts on the site - for example loss of landscape features or change in the character of the site resulting from ground disturbances, construction activity, lighting and presence of new features including access tracks, turbines, substation and cabling. These impacts will be less significant for an individual turbine as opposed to a wind farm, as construction activity and associated infrastructure will be more limited.

- Indirect impacts on the landscape character of the surrounding area – for example change in the character of adjacent landscapes as a result of the change in outlook from those landscapes.
- Direct impacts on views – for example change to views from settlements and viewpoints as a result of the introduction of tall moving structures and construction activities into views.
- Direct or indirect impacts on protected landscapes e.g. National Parks, AONBs, and other designations such as Registered Landscapes, Parks and Gardens of Special Historic Interest and World Heritage Sites.
- Cumulative impacts of one wind energy development in combination with other existing or proposed wind energy developments on landscape character and views (including combined visibility from a single viewpoint and sequential effects on routes).

3.4.2 It is important to note that landscape and visual impacts can be caused not only by the building of the wind turbines themselves but by the ancillary infrastructure particularly new or widened access roads, areas of concrete hardstanding, control buildings and substations and any required grid connections (if these are to be routed above ground).

3.4.3 Micro turbines can also have potential impacts on landscape and townscape character, as turbines can have a 'modernising' effect on landscape character, particularly if they are located on the principal elevation of a property.

3.4.4 Little can be done to mitigate the landscape and visual impacts of large-scale wind turbines (both individually and as larger groups), and micro turbines once they have been erected. It is therefore essential that appropriate care is taken in the siting and design of the layout of the turbines/wind farm – good design is the best form of mitigation. Wind turbines should be sited and designed so that adverse effects on landscape and visual amenity are minimised, and the special qualities of designated areas are protected. Equally important is the design of associated structures such as tracks, power lines and ancillary buildings which can also result in significant impacts on the landscape, particularly in open moorland settings. A Design and Access Statement can explain how landscape and visual considerations have been taken into account in the design of the scheme.

3.4.5 The colour of the tower, nacelle and turbine blades can also influence the visibility of the wind turbine and therefore careful consideration should be given to the colour and reflectivity of the turbine coating. To minimise on-site landscape impacts for large-scale wind turbines, efforts should also be taken to minimise ground disturbance and landscape restoration works should be undertaken at the end of the construction period.

Noise and vibration

3.4.6 Wind turbines, either individually, as larger groups or micro-turbines, generate noise from two distinct sources; mechanical noise from the generator and gearbox and aerodynamic noise from the turbine blades as they move through the air. Modern designs have reduced the mechanical noise so that it is now generally less than or at a similar level to the aerodynamic noise. The aerodynamic noise is generally unobtrusive in nature, having been described as similar to the noise of wind in trees. An increase in noise levels at nearby residences can occur during the construction and decommissioning of a wind farm – for example from construction activity such as the laying of access tracks, piling and construction or decommissioning of the turbines. Noise levels will be less significant during the construction and decommissioning of an individual wind turbine, as less infrastructure is generally required.

3.4.7 Careful consideration of the siting and layout design of individual turbines/wind farm is important to ensure that increases in ambient noise levels around noise-sensitive development (i.e. residential properties) are kept to acceptable levels in relation to existing background noise. Increases in noise levels can be minimised by ensuring that there is sufficient distance between the turbines and residential properties.

3.4.8 It is important to ensure that predicted operational noise levels fall within the established limits of ETSU-R-97 (*The Assessment and Rating of Noise from Wind farms* (1997) Energy Technology Support Unit). This guidance sets out indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farms. The levels are set relative to background noise limits, rather than as absolute limits, with separate limits for day-time and night-time. They are presented in a manner that makes them suitable for noise related planning conditions.

3.4.9 Noise impacts resulting from construction and decommissioning activity for large-scale turbines/wind farms can be mitigated by restricting working hours and adopting good practice measures for reducing noise in line with British Standards Guidance (i.e. BS 5228 Noise and Vibration Control on Construction and Open Sites and BS 8233 Sound Insulation and Noise Reductions for Buildings).

Ecology and Ornithology

3.4.10 The main ecological impacts resulting from wind turbines, either individually or as larger groups, are associated with the site infrastructure – i.e. the access roads, construction compounds and the turbines themselves. The key ecological and ornithological impacts that may occur include:

- Direct and indirect impacts of wind turbine construction on ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation.
- Direct and indirect impacts of wind turbine operation on ecological receptors – for example the disturbance of habitats and birds/bats colliding with the turbine blades during operation (aka 'bird strike'). These impacts will be less significant for micro turbines, as they are much smaller in scale and are therefore not as likely to result in bird strike.

3.4.11 Many potential impacts on local ecology can be mitigated through the careful design and layout of individual turbines/wind farm. Construction impacts can be minimised through the micro-siting of wind turbine features away from sensitive habitats and species using buffer protection zones, restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes at construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes. Impacts on birds and bats can be mitigated by ensuring any vegetation and ground clearance works are undertaken outside of the breeding season (March-August). The micrositing of turbines within the development site can also help to avoid areas of high flight activity, minimising the potential for ‘bird strike’.

3.4.12 Given that wind farms often require extensive development sites, mitigation and management measures for any ecological damage are easily feasible. This also presents an opportunity for habitat enhancement, which can be identified through the preparation of a habitat management plan and habitat re-creation elsewhere in the development site.

Peatland

3.4.13 Wind farm developments can have potential impact both on the ecology of peatland areas and the vital role they play in carbon storage. Given the inherent requirement for windy sites, wind farms (as opposed to individual wind turbines) are often proposed on, or in proximity to upland areas which may support habitats of national, European and international importance, including bogs, fens and heaths. ‘Active’ blanket bog and ‘active’ raised bog are listed as ‘Priority Habitats’ under Annex 1 of the Habitats Regulations 1994, as habitats in danger of disappearance for which the European Union has particular responsibility regarding conservation. Some fen habitats are also in Annex 1 of the Habitats Directive, and all fen habitats and bog habitats are priority habitats in the UK BAP.

3.4.14 Peatland habitats are complex hydrological systems that can be influenced by activities occurring beyond the boundaries of individual habitat patches. Indirect impacts can arise as a result of either temporary or permanent changes in the drainage pattern, quality or quantity of surface and ground water, and can result in down-slope droughting or up-slope flooding of peat-based habitats and/or cumulative or incremental impacts that collectively affect the ecological structure and/or functioning of bogs, mires and heaths.

3.4.15 Peatlands also hold large stocks of carbon (i.e. act as carbon ‘sinks’) and, during wind farm construction, carbon is lost from the excavated peat and from the area affected by drainage. Conversely, carbon savings can arise due to habitat improvement and site restoration. These considerations have to be factored into any calculation of the likely overall contribution of a wind farm to reducing greenhouse gas emissions. Whilst methodologies for calculating the likely ‘carbon balance’ associated with individual wind farms have been the subject of much debate, there have been efforts recently to reach consensus on a consistent and robust approach[18].

3.4.16 Where peat-related habitats have been identified, best practice suggests[19] that efforts should be made to locate wind farm components (turbines, tracks, compounds etc) outside of peatland habitats where possible.

Hydrology and hydrogeology

3.4.17 The construction and decommissioning of wind turbines, either individually or as larger groups, can have potential impacts on local watercourses, water bodies, groundwater and water supplies due to pollution, erosion, sedimentation and impediments to flow resulting from construction activity. The preparation of an Environmental Management Plan[20] prior to construction/decommissioning can mitigate any potential risk to ground and surface water by including measures such as the use of silt traps, buffer zones from watercourses and other best practice pollution prevention practices.

3.4.18 As with other types of development, wind turbines (particularly wind farms) create a development footprint that increases the potential of flood risk and surface water runoff. To minimise the potential of flood risk and surface water runoff, the following mitigation measures should be incorporated into the scheme design:

- Minimise the area of impermeable surface.
- Reinstate vegetation where possible.
- Provide storage and attenuation ponds in line with sustainable drainage techniques (SuDs).
- Use appropriate culverts and drains to match existing hydrological regimes.

Traffic and transport

3.4.19 Traffic movements during the construction and operation of a wind farm will depend on the number of wind turbines and the length of the construction period. Potential impacts on the local road network during the construction phase of a wind farm include:

- Driver delay on local road network, especially from abnormal loads.
- Increased vehicle movements on local roads.

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[18] See for example, *Calculating carbon savings from wind farms on Scottish peat lands - A New Approach.* (2008) The Scottish Government.
[19] See Rural Development Committee's - *Future of the Uplands* report (2010).
[20] Increasingly in the UK the EIA process is being supplemented by the integration of an environmental management plan (EMP) into the resulting environmental statement. The EMP specifically aims to manage the impacts during the construction phase of the development.

- Accidents and compromised safety on local roads.

3.4.20 These potential impacts will be less significant for individual wind turbines and micro turbines, as fewer vehicle movements will be required during the construction and decommissioning stages of the development. Furthermore, an individual turbine will generally require less maintenance during its lifetime than a multi-turbine wind farm. The preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic can help to minimise any impacts on the local road network during the construction period. Such a plan should also seek to include measures for vehicle sharing and the avoidance of HGV deliveries during local peak periods to minimise vehicle movements on minor roads. Accidents on local roads can be avoided through the use of temporary traffic management systems for the site access (i.e. temporary traffic signals) and reduced speed limits on all identified routes.

Aviation and telecommunications

3.4.21 Wind turbines, either individually or as larger groups, pose a potential threat to air traffic safety for two reasons. Firstly, they represent a collision risk for low flying aircraft. Secondly, they can interfere with ground-based air traffic control radar and aircraft landing instruments. With respect to ground-based aircraft tracking radar, rotating wind turbine blades present a moving target to the radar beam which can either be mistaken for an aircraft or create 'clutter' which interferes with the radar's ability to track aircraft in the same sector. For a ground-based radar to be affected, it must be in line of sight of the wind turbine blades.

3.4.22 In line with Civil Aviation Authority (CAA) policy (see CAP 764 below), the CAA's Directorate of Airspace Policy (DAP), the Ministry of Defence (MoD Defence Estates), and the National Air Traffic Services (NATS) should be consulted on wind turbine proposals at an early stage in the planning process. Consultation with these bodies should be conducted using a standard British Wind Energy Association (BWEA) proforma (see below). This is submitted to the MoD which consults with its various departments, as well as with the CAA and NATS.

3.4.23 In carrying out its assessment, DAP will refer to the requirements set out by the CAA in CAP 764[21]. If a site falls within 30 kilometres of a safeguarded aerodrome, the CAA generally devolves responsibility for safeguarding to the aerodrome in question. The MoD submits holding objections to all wind energy proposals within line of sight of air defence radars, unless the developer can provide evidence that it will have no impact on the radars. Proposals within tactical training areas may also raise objections. Where significant impacts on aircraft or radar are identified, these may potentially be mitigated by alterations to the planned turbine height and/or the exact location and spacing of turbines on a site. Developers must submit clear evidence that NIA, MoD and NATS have been involved in the Design Strategy.

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[21] *CAP 764 - CAA Policy and Guidelines on Wind Turbines*. (2009) CAA: http://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=2358.

3.4.24 Wind turbines, including micro turbines, can also interfere with telecommunications (i.e. TV, radio and phone signals) by blocking or deflecting those requiring line of sight or by the scattering of transmission signals. Links crossing the site of wind farms should be identified by consultation with Ofcom[22]. Ofcom will check whether any part of a wind turbine site, either individual turbines or part of a wind farm, falls within 0.5 – 1.0km (depending on the signal frequency) of the path of a fixed link, and if so, will instruct the developer to contact the appropriate fixed link operator. Developers may also wish to contact interested bodies directly, including local utility companies and emergency services.

3.4.25 Scattering of signals mainly affects domestic TV (both analogue and to a lesser extent digital TV) and radio broadcasts. Wind turbines can affect domestic television reception up to 5km from the turbines. Terrestrial television transmissions for domestic reception within the UK are the joint responsibility of the BBC and Ofcom.

3.4.26 Where fixed link signals are potentially blocked by proposed wind turbines, a detailed investigation of the likely impact should be sought from a competent supplier. It is often possible to mitigate impacts by careful siting of individual turbines within a site so that turbine blades avoid a buffer zone, typically 100m either side of the signal path. Failing this, it may be necessary for the developer to pay for a signal to be re-routed around the wind turbine(s). Where site investigations reveal a likely impact on domestic radio or TV reception, various solutions are possible including upgrading of domestic aerials or delivery of the signal by other means, for example by cable.

Shadow flicker

3.4.27 Shadow flicker can occur when the sun passes behind the rotors of a wind turbine, which casts a shadow over neighbouring properties that flicks on and off as the blades rotate. However, this only occurs under particular circumstances and lasts only for a few hours per day. Shadow flicker can cause a disturbance for affected residents of nearby properties and can have potentially harmful impacts on sufferers of photo-sensitive epilepsy. These potential impacts can be mitigated by micrositing turbines as far as practically possible from residential properties and through the use of technological fixes such as the shutting down of turbines during periods of predicted shadow flicker. The use of blinds at residential properties or tree/shrub planting to screen shadow flicker can also help minimise potential impacts.

Historic Environment

3.4.28 The key impacts of wind turbines, either individually or as larger groups, on features of cultural heritage (such as scheduled ancient monuments; listed buildings; conservation areas; world heritage sites; registered historic landscapes; and parks and gardens of special historic interest) include:

[22] windfarmenquiries@ofcom.org.uk.

- Loss or direct impact on identified features of historic interest, including undiscovered archaeology.
- Indirect impacts on the character or appearance and setting of features of historic interest – i.e. visual impacts.

3.4.29 Little can be done to mitigate for the direct loss of, or visual impacts of wind turbines on the character and appearance and setting of heritage features once they have been erected. It is therefore essential that appropriate care is taken in the siting and design of the layout of individual turbines/wind farm. Impacts relating to identified features of cultural heritage and archaeological features are more likely to result from wind farms as opposed to individual wind turbines due to the size of the development footprint required. Where necessary, trial trenching and an archaeological watching brief should be undertaken prior to and during the construction phase of a wind energy development to ensure no below ground archaeological features are damaged or destroyed and any undiscovered archaeology is appropriately recorded.

3.4.30 Planning Policy Wales[23] indicates that where nationally important archaeological remains (whether scheduled or not) and their settings are likely to be affected by a proposed development, there should be a presumption in favour of their physical preservation in situ. In cases involving lesser archaeological remains, Local Planning Authorities will need to weigh the relative importance of archaeology against other factors, including the need for the proposed development.

3.4.31 Building mounted micro-wind turbines can have potential structural impacts on buildings. Guidance from Cadw[24] states that in particular, they should not be fixed to chimneys or into soft materials, including colm, rendered infill panels, soft brick or stone or anywhere showing signs of pre-existing structural problem such as cracked or de-laminating stone walls, unless advice is sought first from a structural engineer. Generally, Cadw suggest that the siting of micro turbines on listed buildings or in conservation areas is likely to be difficult to achieve without having a significant impact on the character of listed buildings and their setting or the character or appearance of conservation areas. Therefore, where micro turbines are proposed, sensitive siting and a high level of design quality will be required. Where possible, good practice suggests that wall mounted micro turbines should be installed on unobtrusive areas of a roof or walls if possible.

Social and economic impacts

3.4.32 Wind farms and, to a lesser extent, individual wind turbines can potentially have negative impacts on existing farming activities through the loss of grazing/arable land. However, most wind farms will usually leave the land between the turbines unaffected and so the loss of arable/grazing land resulting from the development footprint is unlikely to be significant. Conversely, wind turbines can also

[23] *Planning Policy Wales,* Welsh Assembly Government.
[24] *Renewable Energy and your Historic Building: Installing Micro-generation Systems* (2010) Cadw.

have positive impacts on the local economy, notably through the use of local labour, services and supplies, creating knock-on effects on expenditure. They can also generate income for local communities. More information on the community benefits associated with wind turbines is set out in Chapter 4.

4. Biomass

Technology Summary

Biomass can be generally defined as material of recent biological origin, derived from plant or animal matter. This section mainly deals with the type of 'dry' biomass that is more commonly combusted either to generate heat or to produce electricity. However, other types of biomass can also be anaerobically digested to generate 'biogas' or used to produce a transport 'biofuel'.

Biomass is widely used in many countries as a 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.

The most common types of biomass include woodfuel from forestry sources, energy crops or wood waste, agricultural residues and the biodegradable fraction of municipal solid waste.

Experience with biomass plant in the UK to date shows that the key constraints to their development have been: high capital costs and the challenge of developing supply chains at the same time as stimulating demand.

4.1 A. Description of the technology - biomass

Definition of biomass

Market status

4.1.1 Biomass is widely used in many countries as a 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 (see Chapter 13). 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, although this application is currently limited to medium or larger scale installations as this offers advantages in terms of technical and economic viability. Although modern biomass energy generation is not yet well-established in the UK, the number of installations is rapidly increasing.

Biomass production

4.1.2 The principal sources of biomass fuel are as follows:

- *Forestry* – products from management of existing woodlands (small diameter roundwood from coppicing or branches, lop and top as forest residues). Alternately biomass may be derived from new woodlands specifically planted for the purpose (e.g. short rotation forestry).

- *Energy crops* - multi-annual short rotation coppice willow and poplar (SRC) which are coppiced every 2-4 years and miscanthus and other energy grasses (e.g. reed grass and switchgrass) which are cut annually.
- *Primary processing co-products* (sawdust, slabwood, points etc) and *clean wood waste from industry* (e.g. pallets, furniture manufacture). General wood waste can also be used as a renewable fuel but contains contaminants which severely constrain the type and size of plant in which it can be used.
- *Other by-products* e.g. straw and poultry litter.
- *Biodegradable fraction of Municipal Solid Waste* (MSW).

4.1.3 Biomass is considered to be a sustainable fuel, with low carbon emissions as the carbon dioxide (CO_2) released when energy is generated from biomass is balanced by that absorbed during its growth. The ultimate carbon balance can only be assessed once the fossil fuels used in the biomass growing process, processing and transport have been taken into account. However, overall CO_2 emissions per unit of energy generated are much lower for biomass when compared with fossil fuels.

4.1.4 Various processes are used to prepare the feedstock prior to it becoming suitable for use in a range of forms, which for woody biomass include logs, woodchips, pellets and briquettes. These processes largely dictate the final specification of the biomass in terms of moisture content, size and form. Quality control of these parameters is vital for use in specific types of energy plant.

Energy plant and equipment

4.1.5 Energy can be extracted from biomass through direct combustion or by using advanced thermal treatments such as gasification or pyrolysis. These latter two processes tend to be used for electricity generation plant or CHP units as they involve chemically transforming the feedstock into a different form such as gas or oil, which is more suitable for electricity generation plant.

4.1.6 Biomass plants generally consist of the following elements:

- Fuel delivery and storage facilities.
- Fuel extraction equipment to supply boiler plant.
- Specialised biomass combustion or advanced thermal process plant with or without electricity generation plant.

- Ancillary equipment such as flues, ash extraction mechanism, heat storage, connecting pipework, expansion tank, controls systems, electricity transmission systems and (in some cases) an integrated fossil fuel system.

4.1.7 Biomass plants require both fuel store and fuel reception facilities. Fuel stores can be located above or below ground level, usually adjacent to the boiler, and their design will influence the type of fuel reception arrangement, which commonly consists of straightforward tipping from a truck or trailer. In some cases woodchip or pellets can be blown into the fuel store using hose systems – this provides more flexibility for delivery vehicle access arrangements.

Scale of application

4.1.8 Biomass energy plants come in a variety of sizes to suit a range of applications. An indication of the scales commonly used is provided in **Table 4.1** below:

Table 4.1: Typical scales of biomass energy plants

Scale	Typical Capacity[25]	Description
Small	Less than $500kW_{th}$	Currently small scale applications below a few hundred kilowatts are virtually all designed as heat plant for domestic and small commercial use. These may comprise of standalone stoves or boilers.
Medium	$500kW_{th}$ – $10MW_{th}$	This range is used largely for the production of heat, covering a wide range of applications including individual buildings and larger developments serving multiple buildings. The use of biomass CHP for the production of both heat and electricity currently tends to fall in this category, although larger scale plant are also now being encouraged to find ways to utilise any heat that is generated.
Large	Over $10MW_e$	Plants at this scale are used primarily for the production of electricity. Some types of biomass are also used in very large conventional power plants alongside coal – this is known as ‘co-firing’.

[25] kW_{th} or MW_{th} refers to thermal (heat) output capacity; kW_e or MW_e refers to electrical output capacity.

Figure 4.1: 300kW woodchip boiler at Batsford House South Gloucestershire

4.1.9 The appearance and site footprint of biomass developments will depend on the scale of the plant. In the case of a **large scale** electricity generating plant, the following will typically be required: a medium sized industrial building of two-storey height; a slender chimney of between 25-90 metres in height; a barn scale building for on-site storage of fuel, and additional buildings for offices and workshops; and an extensive area for lorry manoeuvring. The external flue usually terminates above the ridge-line of the building and in certain weather conditions a plume may be evident from the chimney and/or drying equipment depending on the design of the equipment. Typically, a 1.5 MW_e plant producing electricity using gasification technology will require a site area of some 0.5 hectares and a 40 MW_e plant may require 5 hectares.

4.1.10 **Medium scale** biomass schemes such as those associated with community facilities, schools or industrial units tend to take the form of Combined Heat and Power (CHP) plants (i.e. used for generation of electricity and heat) or for the production of heat. In the case of a small heat plant for a school, the boilerhouse could typically be some 4m by 3m, with a fuel bunker of similar proportions. The bunker may be semi-underground with a lockable steel lid. The chimney will be 3 to 10m high, depending on plant design and surrounding buildings. Sufficient space to safely manoeuvre a large lorry or tractor and trailer will also be required.

4.1.11 **Small scale** stand alone biomass stoves used as room heaters tend to be a similar size to propane room heaters. These are normally used to provide background heating during the winter months. With an annual heating demand of perhaps 1800 kWh they would only require space to store approximately 360kg of pellets or 2-3 skip loads (2-3 tonnes) of logs. This could usually be accommodated within a typical garage. For boilers, a typical detached house would require roughly $3m^3$ of oil but $7m^3$ of pellets or $21\text{-}35m^3$ of wood chip weighing between 5-12 tonnes depending on moisture content. Hence, boilers require sufficient space to accommodate bulk deliveries of wood fuel. Space is also needed to accommodate the boiler and fuel hopper - which typically is about double the space required by an oil boiler. All small scale biomass systems require a flue which may be retrofitted inside most existing chimneys or can be provided as an architectural feature within a stainless steel sleeve in homes without a chimney.

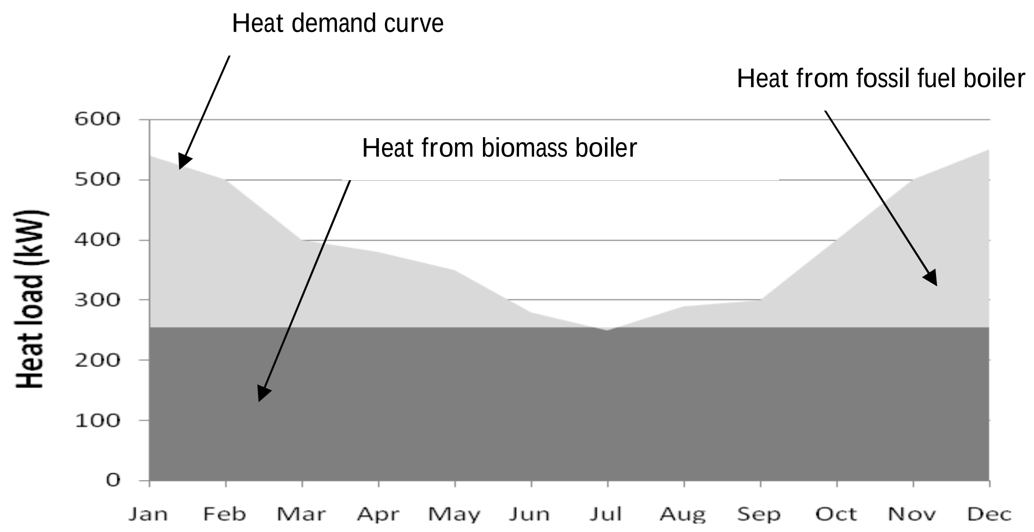
4.1.12 Please note: the use of biomass at the 'microgeneration' scale would comprise of virtually all heat generating equipment. Under the definition of microgeneration technologies as set out in Section 82(6) of the Energy Act 2004, this is defined as the generation of heat up to 45 kilowatts thermal.

Operation

4.1.13 Modern woodfuel heating plants operate automatically and deliver heat in the same way as a conventional fossil fuel plant. Most biomass boiler systems, especially those which comprise the only source of heating plant, are now specified with an accumulator hot water tank (heat store), which acts as a heat reservoir in meeting demand. This provides a certain degree of flexibility in sizing the boiler and can reduce the periods when it operates less efficiently at part load during warm periods when there is reduced or zero space heating demand.

4.1.14 Often a biomass plant will operate in tandem with fossil fuel plant such as a gas boiler, with the biomass boiler functioning as the lead boiler supplying the larger proportion of annual heat demand and the gas plant supplying additional heat during periods of high demand. **Figure 4.2** illustrates such an arrangement, where the biomass boiler supplies a constant base heat load throughout the year and the gas boiler provides top-up heat as required.

Figure 4.2: Example of base load sizing for biomass heating



4.1.15 Over the course of a year, biomass heating plant in a general occupancy building may typically provide output the equivalent of around 20% of their theoretical maximum[26] (i.e. a capacity factor of 0.2), although this will increase for applications such as the supply of industrial process heat. CHP or large scale electricity generating plant usually operates for much longer periods, as electricity can be continually fed into the grid. However, finding a continual use for the heat output from CHP is more difficult and the plant therefore needs to be optimally-sized and operated for the heat and electricity load profiles it is serving.

Cost

4.1.16 Compared to fossil fuel plant, and in common with most renewable technologies, biomass installations typically involve high capital costs but low running costs. The price of woodchip has proved competitive with mains gas and is significantly cheaper than heating oil. Medium and large scale plant will benefit from economy of scale and will typically cost less to build on a £/kW basis than small scale plant. Economic viability is sensitive to fuel price fluctuations and the availability of financial incentives such as capital grants and the forthcoming Renewable Heat Incentive[27]. Constraints around capital costs are discussed in more detail below.

4.2 B. Technological and financial constraints for biomass installations

4.2.1 A generic barrier to the wide scale implementation of biomass concerns the challenge of developing woodfuel supply chains at the same time as stimulating woodfuel heat demand. A number of localised initiatives and the introduction of the Renewable Heat Incentive in 2011 are expected to help address this and encourage a step-change in woodfuel use.

4.2.2 Experience with biomass plant in the UK to date shows that the other main constraints concern high capital costs and the availability of suitable fuel sources. These and other constraints are discussed below. Evidence from countries such as Austria, which has much greater experience with biomass compared with the UK suggest that heating plant technology is well-proven providing it is subject to best practice design and specification, including fuel supply processes.

Biomass supply

4.2.3 With regard to 'woody' biomass, woodchip quality is of paramount importance and needs to be compatible with the specification of the energy plant and fuel storage/handling system. For example, problems such as increased flue smoke can occur when the woodchip is too wet; and fuel handling systems can jam if the individual wood chips are too large. The presence of foreign matter e.g. stones, soil, refuse, etc. can also cause operational problems. Energy content of woodchip (and

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26 Source: *Biomass Heating: a Practical Guide for Potential Users (CTG012).* (2009) The Carbon Trust.

27 http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/renewable_heat/incentive/incentive.aspx.

combustion emissions) can vary according to a number of factors – key criteria include moisture content, chip size, leaf/bark content and dust content. Wood pellets are much more uniform in size and moisture content but can give rise to excessive dust (an explosive hazard) if not sufficiently mechanically robust. Quality standards exist for woodchip and pellets such as the Austrian ÖNORM specification and the more recent European CEN standards.

4.2.4 Woodfuel generally needs to be sourced locally to its end use to minimise transport costs and associated emissions. Woodchip will generally be sourced from round wood, slab wood or other off-cuts from local forestry or arboricultural activities, but can also be produced from clean recycled wood waste such as pallet wood. Wood pellets are generally manufactured from sawdust residues from wood-processing plant. The availability of locally-sourced woodfuel can be a constraining factor on size of plant – as evidenced by a number of developers of proposed large scale plant exploring options of importing biomass from overseas. Most end-users would not consider on-site wood processing, such as chipping, as part of their project and so the required specification of woodfuel needs to be delivered ready for use[28]. This means that end-users are limited to using local woodfuel suppliers producing the correct product for their chosen type of energy plant. Woodfuel supplies should therefore be considered at the earliest stage of project development.

4.2.5 Energy crops such as Short Rotation Coppice (SRC) and miscanthus have yet to become widely established in the UK. The quality and specification of woodchip from these sources may differ from forestry-derived chip and so may be more limited regarding end use. Logs and woodchip derived from forestry or arboriculture are more accessible. Often organisations that already produce clean wood residues, such as tree surgeons, waste management organisations, wood processing factories, etc can be considered as potential suppliers, but need to be made aware of the required quality standards. Wood pellets are manufactured to limited extent in the UK and include a production plant in Bridgend, South Wales.

4.2.6 The use of straw and poultry litter as a fuel is currently limited to large scale electricity generation plant which can draw in a sufficiently large resource from the local area, however it can also potentially be used on a smaller scale for heat or CHP.

Biomass delivery and storage

4.2.7 Biomass plants require both fuel store and fuel reception facilities. Limitations on space at a site may impact the potential for these and the subsequent arrangements for fuel deliveries. Fuel stores can be of various designs but need to be sized according the frequency of fuel deliveries. Smaller fuel stores are generally

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[28] Applications for pre-processing plant located on separate sites would be subject to a separate planning consideration, as for any other commercial or industrial facility. Ideally, pre-processing plant should be strategically located to serve several different biomass producers and consumers. Unfortunately there is no guidance available on planning for the strategic location of biomass processing facilities.

cheaper but will need more frequent deliveries to maintain plant operation – especially during cold periods when fuel is being used at a faster rate. Wood pellets are advantageous in this respect in that they are handled more easily and possess a higher energy density than woodchip, meaning that a smaller storage volume is required.

Plant constraints

4.2.8 The main technical constraints around plant design concern available space (including any supplementary back-up systems – see below) and provision for a suitable flue in accordance with Building Regulations on solid fuel combustion plant. The height and proximity of surrounding buildings can impact on flue design.

Cost

4.2.9 In general, logs and wood chip are a very cheap form of fuel and are competitive with mains gas. Pellets are more expensive but, on average, are comparable to oil. Minimising transport distance and buying in bulk can help to reduce costs to some extent.

4.2.10 The capital cost of biomass energy plant is significantly higher when compared with equivalent fossil fuel systems. This is partly due to the additional costs associated with the fuel store. Variations in woodfuel cost together with that of displaced fossil fuel, both now and in the future, are critical in establishing financial viability. An additional cost may also be incurred where a back-up system is used. The majority of UK installations to date incorporate a fossil fuel back-up plant to supplement the woodfuel boiler in times of high demand and to provide back-up in case of operational problems such as interruptions to fuel deliveries.

4.2.11 For larger scale plant, and those supplying district heating systems, the option of innovative financing arrangements using Energy Service Companies (ESCOs) has the potential to mitigate some of the financial risk constraints faced by developers over high upfront capital costs (see **Chapter 3** – Financial Drivers and Barriers).

Operation and maintenance

4.2.12 When compared to gas plant, woodfuel systems require additional operation and maintenance requirements in supervising regular fuel deliveries, performing regular maintenance checks and disposing of ash residues. These activities generally result in higher O&M costs than gas from the increased labour and servicing requirements. Costs can be minimised by increasing plant automation through the incorporation of automatic ash extraction, automatic cleaning and remote monitoring systems. However, these may increase capital costs. Maintenance checks and ash disposal can be undertaken by trained on-site personnel but servicing is normally carried out under contract with the equipment supplier. Electricity consumption is also greater from the use of additional motors, fans and pumps.

4.2.13 For small scale biomass heating, disposal of ash will normally be needed once or twice a fortnight during peak heating periods. The amount of ash produced by woodchip corresponds to less that 1% of the delivered biomass by weight meaning that on-site disposal is possible in some cases – currently, boiler 'bottom' ash from clean woodfuel can be used (sparingly) as a fertiliser in most applications. Otherwise it can be disposed to landfill in the normal waste stream. Bottom ash can also be used for the manufacture of lightweight aggregate blocks, however the quantities required for economic operation generally make this feasible only for large scale biomass plants.

4.3 C. Planning and EIA requirements for biomass installations

Biomass Plants

4.3.1 Heat only biomass plants and electricity plants of CHP with an electrical output of 50MW or less will require planning permission from the local planning authority under the Town and Country Planning Act 1990.

4.3.2 Applications for new electricity generating biomass plants with capacity of more than 50MW will need to obtain consent from the Infrastructure Planning Commission (IPC) as defined under the Planning Act 2008.

4.3.3 Biomass plants may fall under Schedule 2.3(a) or Schedule 2.3(b) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999, which relate to:

- Industrial installations for the production of electricity, steam and hot water, where the development exceeds 0.5 hectare.
- Industrial installations for carrying gas, steam and hot water, where the area of works exceeds 1 hectare.

4.3.4 It is also possible that where a development will process waste, it could also fall under Schedule 2.11(c) of the Regulations.

4.3.5 The installation, alteration or replacement of a flue, forming part of a biomass heating system, in a dwelling is classed as permitted development under The Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2009.

4.3.6 Development is not permitted if the height of the flue would exceed the highest part of the roof by one metre or more, or in the case of land within a conservation area or which is a World Heritage Site, the flue would be installed on a wall or roof slope forming the principal or side elevation of the dwelling house and would be visible from a highway. In such cases, planning permission would be required from the local planning authority under the Town and Country Planning Act 1990.

Biomass Crops

4.3.7 Applications for the planting of **short rotation coppice and short rotation forestry** are subject to the Environmental Impact Assessment (Forestry) Regulations 1999. These regulations require anyone carrying out a project involving afforestation above certain thresholds (see below) to obtain consent from the Forestry Commission before work can proceed.

- No threshold (i.e. EIA automatically required): National Nature Reserve, Site of Special Scientific Interest, The Broads, World Heritage Site, Scheduled Ancient Monuments, Special Areas of Conservation (designated or identified as a candidate), a site classified or proposed as a Special Protection Area.
- hectares: National Park, Area of Outstanding Natural Beauty (AONB), National Scenic Area.
- 5 hectares: Other land.

4.3.8 Applications for the planting of any crop on land which is currently **uncultivated or in a semi natural area** may be subject to the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) Regulations 2001 and the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) (Amendment) Regulations 2005. The regulations require any project bringing uncultivated and semi-natural habitat into intensive agricultural use to be assessed by Defra for the likelihood of significant environmental effects. Further information can be obtained from Defra[29].

4.4 D. Summary of potential impacts and design, mitigation and enhancement measures for biomass installations

4.4.1 Please note that this section provides a summary of the potential impacts of the biomass **processing plants**. The planting of biomass **crops** also has the potential to have environmental, social and economic impacts and benefits, however, this falls outside the direct control of planning[30]. Only biomass installations and their associated land use implications can be considered by Local Authorities in determining biomass proposals. Local Planning Authorities may however be requested to comment on EIAs for biomass crops where these are required under the Environmental Impact Assessment (Forestry) Regulations 1999 or Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) Regulations 2001 and the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) (Amendment) Regulations 2005 as set out in Section C above.

Landscape and Visual:

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[29] www.defra.gov.uk

[30] Section 55 of the Town and Country Planning Act states that "the use of any land for the purposes of agriculture or forestry (including afforestation)" is not included in the definition of development and therefore is not subject to planning control. The text of the Act can be found at: www.opsi.gov.uk/Acts/acts1990/ukpga_19900008_en_6. The definition of agriculture can be found in Section 336 of the Act, and includes horticulture and osier land (osier relates to growing of willow).

4.4.2 Large electricity generating and CHP biomass plants are industrial features, often with a tall chimney or stack which may result in landscape and visual impacts on the surrounding area. The key landscape and visual impacts that may occur include:

- Direct landscape impacts on the site - for example loss of landscape features or change in the character of the site resulting from construction activity or the presence of an industrial building.
- Indirect impacts on the landscape character of the surrounding area – for example change in the character of adjacent landscapes as a result of the change in outlook from those landscapes.
- Direct impacts on views – for example change to views from settlements and viewpoints as a result of the introduction of an industrial structure with chimney stack.

4.4.3 Careful consideration over the siting and design of electricity generating and CHP plants is important in minimising visual impacts. The siting of a new plant should aim to ensure the building is in character with its locality and does not interfere with views of existing landmarks. Materials and colours should be used to facilitate the integration of the plant with the surrounding landscape. The incorporation of screen planting in key locations, on and off-site, in addition to landscape restoration works at the end of the construction period will also help minimise visual impacts on the wider landscape.

4.4.4 With regard to small scale domestic biomass heating systems, these require a vent which is specifically designed for wood fuel appliances, with sufficient air movement for proper operation of the stove. In most cases, an existing household chimney can be fitted with a lined flue. However, there may be instances where a separate flue is required, extending through the roof structure of a property. In such cases, the flue should be designed and sited to be unobtrusive in views of the building (particularly in the case of a listed building or a building in a conservation area), and should make use of suitable materials and colour treatment. Biomass systems also require a fuel storage facility, which can be either attached to the outside of a building, in an accessible location, or in an underground lined pit. Suitable materials should be used to facilitate the integration of such structures with their surroundings.

Noise

4.4.5 As with conventional power stations, both electricity generating and CHP biomass plants generate noise from plant operations, notably the combustion process, in addition to traffic-generated noise from HGV deliveries and the loading/unloading of fuel sources.

4.4.6 Appropriate site layout design and siting of particularly noisy pieces of plant, such as the air cooling condenser, away from sensitive site boundaries is important in minimising noise levels at noise-sensitive properties. Similarly, the incorporation of noise attenuation features within the roof and walls of industrial buildings will help reduce noise break-out. Noise impacts resulting from construction activity can be mitigated by restricting working hours and adopting good practice measures for reducing noise in line with British Standards Guidance (i.e. BS 4142 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas).

Air quality

4.4.7 Electricity generating and CHP biomass plants involve the combustion, gasification or pyrolysis of biomass fuel. Each of these processes generates emissions that can have an impact on air quality. The key impacts on air quality that may arise include:

- Stack emissions from operational procedures – for example nitrogen and sulphurous oxides and carbon dioxide emissions from biomass fuel combustion.
- Particulate emissions (i.e. 'fly ash') from operational procedures.
- Odour deriving from sources of biomass fuels (i.e. agricultural residues and waste streams).
- Emissions from construction and operation vehicles – for example dust generation during loading and unloading operations.

4.4.8 Air emissions are controlled by the Environment Agency under the Integrated Pollution Prevention and Control (IPPC) regime or by the Local Air Pollution Control (LAPC) regime under Part I of the Environmental Protection Act 1990. The incorporation of proprietary air pollution control systems into the scheme design will minimise any negative impacts on local air quality. Similarly, any particulate emissions ('fly ash') resulting from operational procedures can be kept within UK and European particulate emission limits through the incorporation of cyclone separation and electrostatic precipitation techniques in the design of the flue. External odours resulting from the on-site storage of certain biomass fuels can be minimised by avoiding the retention of large volumes of agricultural and municipal waste on-site, although this is likely to result in an increase in HGV deliveries loading/unloading fuel sources. Alternatively, the use of chemical deodorants in storage areas can reduce external odours.

4.4.9 Impacts on air quality resulting from construction activity (i.e. dust) can be mitigated by implementing best practice construction measures such as the enclosure of stockpiles, ensuring appropriate transport of materials, restricting vehicle speeds on site, wheel wash facilities and switching off engines when not in use.

4.4.10 Domestic biomass systems require the burning of wood pellets, wood chips or wood logs. This can give rise to emissions, notably the release of carbon dioxide emissions from the wood fuel source, which could have potential implications for air quality limits set within Air Quality Management Areas (AQMAs). However, an appropriately designed flue that incorporates the proprietary air pollution control systems will minimise the release of harmful emissions.

Ecology and ornithology

4.4.11 The main ecological impacts resulting from electricity generating and CHP biomass plants are associated with airborne and waterborne emissions from operational procedures.

4.4.12 The key ecological and ornithological impacts that may occur include:

- Direct and indirect impacts of plant construction on ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation arising from the construction of the plant itself.
- Direct and indirect impacts of plant operation on ecological receptors – for example disturbances to habitats and species from noise, airborne and waterborne emissions resulting from operational procedures.

4.4.13 Many potential impacts on local ecology can be mitigated through the careful design and layout of the biomass plant. Construction impacts can be minimised through the siting of plant and ancillary buildings away from sensitive habitats using buffer protection zones as necessary, restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes in construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes. Impacts on birds and bats can be mitigated by ensuring any vegetation and ground clearance works are undertaken outside the breeding season (March-August).

4.4.14 The use of biomass can also have significant positive benefits by creating a market demand for wood enabling existing woodlands to be brought back into use and the extension of semi-natural woodlands. The effective management of woodland is important for maintaining their biodiversity value.

Hydrology and hydrogeology

4.4.15 The operation of electricity generating and CHP biomass plants often requires a water supply for steam production and condensing, and so will have releases into the public sewer system that can have potential impacts on local watercourses and groundwater. Key impacts include:

- Risk to local watercourses/ groundwater from operational procedures (e.g. pollution from treated boiler drainings, condensate and effluent from water treatment processes).
- Risk to local watercourses/groundwater from storage of large wood chip piles (e.g. leach of liquids from piles).
- Potential flood risk posed by development.
- Increase in surface water runoff as a result of development footprint.

4.4.16 The Environment Agency (EA) has responsibility for the control of water quality and water abstraction and so the developer should consult with the EA at the earliest opportunity to discuss what permits may be required. The implementation of good pollution prevention practices through an Environmental Management Plan (submitted to and agreed with the determining authority prior to construction) will also help mitigate any potential risk to ground and surface water. This should include the use of collection dishes around storage areas to minimise runoff from large wood chip piles or other sources of biomass fuel.

4.4.17 A typical site area for an electricity generating or CHP plant ranges from 0.5 hectares for a 1.5MW plant to 5 hectares for a 40MW plant. Such a development footprint increases the potential of flood risk and surface water runoff. To minimise the potential of flood risk and surface water runoff, the following mitigation measures should be incorporated into the scheme design:

- Minimise area of impermeable surface.
- Reinstate vegetation where possible.
- Provide storage and attenuation ponds in line with sustainable drainage techniques (SuDs).
- Use appropriate culverts and drains to match existing hydrological regimes.

Traffic and transport

4.4.18 Traffic movements during the construction and operation of a biomass plant will be dependent upon the size of the facility. The transport of biomass fuel and subsequent by-products will result in traffic movements to and from the site during operation. Larger electricity generating and CHP biomass power plants often require a continual fuel supply, which could significantly increase traffic volumes in the local area.

4.4.19 The preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic will minimise any impacts on the local road network. Such a plan should also seek to include measures for vehicle sharing and the avoidance of HGV deliveries during local peak periods to minimise vehicle movements on minor roads.

Historic Environment

4.4.20 The main potential impacts on the historic environment that could occur as a result of the development of a large/medium scale biomass plant and associated ancillary infrastructure (e.g. drying sheds etc) include:

- Loss or direct impact on identified features of historic interest (e.g. scheduled ancient moments, listed buildings and features of archaeological interest - including undiscovered archaeology).

- Indirect impacts on the character/appearance and setting of features of historic interest (such as scheduled ancient monuments; listed buildings; conservation areas; world heritage sites; and registered landscapes, parks and gardens of special historic interest).

4.4.21 Little can be done to mitigate for the direct loss of, or indirect visual impacts of biomass developments on the character and appearance and setting of heritage features once the development has been completed. It is therefore essential that appropriate care is taken in the siting and design of biomass plants at the outset.

4.4.22 Planning Policy Wales[31] indicates that where nationally important archaeological remains (whether scheduled or not) and their settings are likely to be affected by a proposed development, there should be a presumption in favour of their physical preservation in situ. In cases involving lesser archaeological remains, Local Planning Authorities will need to weigh the relative importance of archaeology against other factors, including the need for the proposed development.

4.4.23 With regard to biomass crops – these are outside the scope of this report as they do not fall within the control of planning. It is important to note however that some biomass crops such as short rotation coppice and miscanthus can have potential impacts on archaeological sites and deposits via ploughing and sub-soiling of root growth, and the removal of rhizomes (e.g. miscanthus rhizomes for propagation). Care therefore needs to be taken to site crops away from sites of archaeological or cultural heritage importance. With regard to woodfuel, the use of harvesting machinery and the creation of woodland tracks also has the potential to impact on archaeological remains if appropriate mitigation is not put in place.

4.4.24 In relation to small scale biomass developments – typically involving the installation of individual boilers and stoves, there is the potential to do direct harm to the historic asset – e.g. listed building, although in many cases it will be possible to minimise this through good design. Potential design measures may include positioning new flues away from principal elevations, making use of existing chimneys where possible, or reducing the visual impact by painting flues with a heat-resistant dark coloured paint with a matt finish.

Economic impacts

4.4.25 The development of an electricity generating or CHP biomass plant can have a positive impact on the local economy, as the supply of biomass fuel can provide a long-term income for local farmers, forestry owners and transport operators. Approximately 80 to 90% of operational expenditure on biomass fuel supply can accrue to the local economy[32]. The use of local labour, services and supplies during the construction of a biomass plant can also have benefits to the local economy.

[31] *Planning Policy Wales,* Welsh Assembly Government. http://wales.gov.uk/topics/planning/policy/?skip=1&lang=en

[32] *Planning for Renewable Energy: A Companion Guide to PPS22.* (2004) ODPM.

5. Biomass – Anaerobic Digestion

Technology Summary

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.

The main types of organic material feedstock used in AD are sewage sludge, farm slurry, and some elements of Municipal Solid Waste. In addition to biogas which can be used for energy generation, AD also produces a nitrogen-rich liquor (digestate) and residual solid by-products which can be used respectively as a fertiliser or soil conditioner.

AD is most likely to be part of an integrated farm waste management system. However, larger-scale centralised anaerobic digesters (CADs) also exist which use feedstocks imported from a number of sources. An anaerobic digestion plant normally comprises of a digester tank, buildings to house ancillary equipment such as a generator, a biogas storage tank, a flare stack, and pipework.

5.1 A. Description of anaerobic digestion

Figure 5.1: Wanlip 1.4MWe anaerobic digestion plant (Bursom, Leicester)

5.1.1 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. As a greenhouse gas, methane is a significant contributor to climate change (around 21 times more potent than carbon dioxide over a period of 100 years).

5.1.2 The main types of organic material feedstock used in AD are:

- Sewage sludge: sewage sludge is the semi-solid residue remaining from the 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.
- 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.
- 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.

5.1.3 In addition to biogas which can be used for energy generation, AD also produces a nitrogen-rich liquor which can be used as a fertiliser, and solids which can potentially be composted to produce soil conditioner, provided that toxic materials are removed from MSW (if used) prior to digestion.

Scale of application

5.1.4 AD is most likely to be part of an integrated farm waste management system. However as outlined above, larger-scale centralised anaerobic digesters (CADs) also exist which use feedstocks imported from a number of sources. CADs are suited both to farms and to areas allocated for business use and traditional commercial/industrial urban areas, and are compatible with more intensive Class B1/B2 uses.

5.1.5 An anaerobic digestion plant typically comprises a digester tank, buildings to house ancillary equipment such as a generator, a biogas storage tank, a flare stack (3-10m in height) and associated pipework. Plants can vary in scale from:

- A small scheme treating the waste from an individual farm (e.g. 150kWe).
- A medium-sized centralised facility dealing with wastes from several farms (potentially supplemented by crops such as maize grown specifically to feed the digester).
- A sizeable industrial CAD plant handling large quantities of MSW (e.g. 2.1MWe).

5.1.6 An anaerobic digestion plant normally comprises a digester tank, buildings to house ancillary equipment such as a generator, a biogas storage tank, a flare stack, and pipework. Plants can vary in size depending on the amount of waste treated. A digester tank dealing with 50 tonnes of organic waste per day would typically have a height of up to 10m and cover an area of between 75 and 150 square metres, although for any given volume height can be traded for a greater diameter of tank. A digester tank processing 450 tonnes of waste would typically have a height of up to 15m and cover an area of around 1,000 square metres. Alternatively, high volumes of waste may be treated in a set of several small tanks. Flare stacks tend to be either between 6m and 10m with a narrow diameter, or shorter (around 3m) with a wide diameter.

5.2 B. Technological and financial constraints of AD

5.2.1 Anaerobic digestion technology is well-established and is widely used for the treatment of sewage. Although systems are not necessarily limited to sewage, the biological conversion processes in AD are very sensitive to the type and proportions of input materials so care needs to be taken in the choice of feedstock. Generally any biodegradable plant or animal matter can be used apart from ‘woody’ materials, as the micro-organisms involved find it difficult to break down lignin – a substance found in wood.

5.2.2 Solid residues and liquid digestate from the AD process will need to be disposed of appropriately. The residues can normally be used as a soil conditioner or fertiliser, but their use may be affected by the type of feedstock used. Solid residues may or may not contain useful levels of nitrate or phosphate and may be contaminated with heavy metals. There is also potential for the solid residue to be burned as a fuel.

5.2.3 The cost of an AD system can vary significantly depending on its size and sophistication. These costs must be weighed against the revenue streams created by the system’s by-products and, potentially, the feedstock. The value of feedstocks will vary significantly and may involve ‘free’ slurry from local farms or may even attract a gate fee. As with all biomass energy plant, maintaining a reliable source of AD feedstock is essential for the system to work economically. The Holsworthy Biogas Plant in West Devon (the UK’s first centralised anaerobic digestion power plant) has 2.7MW of installed generating capacity, but the amount of electricity being generated at any one time depends on the quantity and nature of the feedstocks being supplied to the plant. These come from various sources including industrial bakeries and food processors, abattoirs, fish processors, cheese producers, biodiesel manufacturers and Local Authorities. Large producers may supply 50-100 tonnes per week of waste, whilst small businesses may only generate 1 tonne per week.

5.3 C. Planning and EIA requirements of AD

5.3.1 Anaerobic digesters that generate electrical and heat output of 50MW or less will require planning permission from the local planning authority under the Town and Country Planning Act 1990.

5.3.2 Applications for new electricity and heat generating anaerobic generators with capacity of more than 50MW will need to obtain consent from the Infrastructure Planning Commission (IPC) as defined under the Planning Act 2008.

5.3.3 As with other types of biomass scheme, anaerobic generators are likely to fall under Schedule 2.3(a) or Schedule 2.3(b) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. It is also possible that where a development will process waste, it could also fall under Schedule 2.11(c) of the Regulations.

5.4 D. Summary of potential impacts and design, mitigation and enhancement measures for AD

Landscape and visual

5.4.1 Most anaerobic digestion (AD) plants will be located close to the waste source, and so smaller scale facilities treating locally produced waste are often sited on farms and other agricultural locations. On-farm digesters therefore have the potential to be accommodated within the existing complex of farm buildings. Conversely, centralised anaerobic digestion facilities (CAD plants) that handle large quantities of agricultural wastes, sewage sludge or municipal waste are likely to be located within or adjacent to existing commercial/industrial areas or wastewater treatment works. The scale and massing of the associated digestion tanks could be co-located amongst similar sized buildings. Digesters can also be partially buried to reduce the visual impacts and insulate the tank. Both types of AD plant therefore have opportunities to minimise impacts on the landscape character of the surrounding area and visual impacts from key viewpoints/settlements.

5.4.2 Careful consideration of the siting and design of the plant is important in ensuring visual impacts are minimised. Buildings that do not protrude above tree top level can be effectively screened by trees and use can be made of existing screening features such as trees/hedges, shelterbelts and woodlands. Suitable materials should also be used to facilitate the integration of structures with the surrounding landscape, such as the cladding of buildings and colour treatment.

Noise and vibration

5.4.3 The AD process is not inherently noisy and, as discussed above, on-farm digesters and CAD plants are often sited on farms and existing commercial/industrial areas where they are surrounded by other 'noisy' operations. However, an increase in noise levels can occur where an AD plant is located in close proximity to noise-sensitive developments due to construction noise, vehicle manoeuvring, loading and unloading as well as engines and pumps from plant operation.

5.4.4 Appropriate site layout design and siting of particularly noisy plant equipment away from sensitive site boundaries is important to mitigate noise levels at noise-sensitive developments. Similarly, the incorporation of noise attenuation features within the roof and walls of buildings will help reduce noise break-out. If necessary, the local authority can set noise limits at site boundaries or at sensitive receptors to ensure noise levels are not exceeded.

Air quality

5.4.5 The AD process is enclosed and so emissions to air should be well controlled. However, the production and use of biogas through the AD process does result in a number of emissions to air, primarily from gas vents, engine exhausts and flare stacks. As with other forms of renewable energy technology, air emissions are controlled by the Environment Agency and developers should consult with them at the earliest opportunity to discuss what environmental permits may be required. The incorporation of proprietary air pollution control systems into the scheme design will minimise any negative impacts on local air quality. Emissions resulting from construction and operation vehicles can be minimised through the implementation of best practice dust mitigation measures, such as the appropriate transport of materials, enclosure of stockpiles, restriction of vehicle speeds on site and use of wheel wash facilities.

5.4.6 The generation of odour from the AD process can have potential impacts on local air quality. Odour may arise from waste input storage bays, sorting and mixing plant, the digester and the digestate de-watering plant. Appropriate siting of odour-generating facilities away from sensitive developments alongside effective site and plant management will minimise the impact of odours. The scheme design can also incorporate negative ventilation systems fitted with biofilters to control and contain odours within buildings.

Ecology and ornithology

5.4.7 The main ecological impacts resulting from AD plants are associated with waterborne emissions from operational procedures, as discussed below. The key ecological and ornithological impacts that may occur include:

- Direct and indirect impacts of plant construction on ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation arising from the construction of the plant itself.
- Direct and indirect impacts of plant operation on ecological receptors – for example disturbances to habitats and species from noise, airborne and waterborne emissions resulting from operational procedures.

5.4.8 Many potential impacts on local ecology can be mitigated through the careful design and layout of the AD plant. Construction impacts can be minimised through the siting of plant and ancillary buildings away from sensitive habitats using buffer protection zones as necessary, restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes at construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes. Impacts on birds and bats can be mitigated by ensuring any vegetation and ground clearance works are undertaken outside the breeding season (March-August).

Hydrology and hydrogeology

5.4.9 Waste water can be produced as an output of the AD operational process, which can create a risk to local watercourses and groundwater if left untreated or an operational failure occurs. This risk can be minimised by ensuring Environment Agency measures are applied in the scheme design, which require all tanks and digesters to be surrounded by containment bundling of either concrete or clay.

Traffic and transport

5.4.10 Small-scale on-farm AD plants are unlikely to have any significant impacts on local traffic flows compared with other farming activities. However, CAD plants are likely to generate an increase in traffic movements from the delivery of feedstock and the distribution of subsequent outputs during operation.

5.4.11 The impact of deliveries to CAD plants on the local road network can be minimised through the preparation of a Traffic Management Plan, in conjunction with the local transport authority, to ensure delivery vehicles are routed away from inappropriate roads and sensitive areas and are scheduled to avoid peak traffic flows during construction and operation. Careful consideration of fuel supply logistics will also help minimise the distances travelled between the feedstocks, storage tanks, digester and distribution markets.

6. Biofuels

Technology Summary

Biofuels generally refer to biomass-derived liquids that are used as transport fuel. They are usually produced from plant materials and often blended with mineral fuels before use. The most common biofuels are **bioethanol**, which is made from fermenting crops such as sugar cane, wheat or maize, and **biodiesel**, which is made from oily crops such as soy and oilseed rape or by processing oily wastes such as used cooking oil and animal fats.

Biofuels are currently the most readily deployable renewable technology used in the transport sector and in 2008-09 around 2.6% of all UK road fuels used were biofuels, although the majority of these were imported.

Future advances in technology are expected to produce a range of second generation or advanced biofuels which will potentially broaden the scope of biomass feedstock to include the woody, waste parts of food crops, energy crops, waste and algae.

6.1 A. Description of biofuels

Figure 6.1: Ethanol plant in Midwest USA

Source: © Lynn Graesing | www.istock.com

6.1.1 Biofuels generally refer to biomass-derived liquids that are used as transport fuel. Some types of biomass-derived liquid fuels are also used for the generation of heat and/or power – these are considered in the above section on Biomass. As outlined in the summary above, biofuels are usually produced from plant materials and often blended with mineral fuels before use. The most common biofuels are bioethanol, which is made from fermenting crops such as sugar cane, wheat or maize, and biodiesel, which is made from oily crops such as soy and oilseed rape or by processing oily wastes such as used cooking oil and animal fats.

6.1.2 In Europe, biodiesel is currently the most popular form of biofuel and can be used in any diesel engine when mixed with mineral diesel (often using 5% biodiesel). Vegetable oil is also often used in diesel engines at higher concentrations. Ethanol-based biofuels come in a range of blends, one of the most popular being E10 (10% bioethanol, 90% petroleum).

6.1.3 Future advances in technology are expected to produce a range of second generation or advanced biofuels which will potentially broaden the scope of biomass feedstock to include the woody, waste parts of food crops, energy crops, waste and algae.

6.1.4 Biodiesel plant can range in scale from garage-sized do-it-yourself kits producing up to a few hundred litres (typically less than 0.25 tonnes) per day up to large scale commercial sites generating several hundred million litres or more per year. Bioethanol production is a more complex process and is normally deployed at larger scales, typically ranging from 1,000 to 200,000 tonnes per year. In terms of size, the actual land area required for manufacturing plant varies according to the processes employed but, on a tonnes output per year basis, is broadly similar to other chemical production plant manufacturing liquid products. A US study[33] suggests that an actual plant footprint for an (undefined) intermediate size bioethanol plant is approximately 4-6 hectares. However, the total site could typically reach 16 hectares once factors such as emission regulations, on-site transportation patterns and future plant expansion needs are taken into account. Large scale plants may often require sites of more than 65 hectares to accommodate key transportation links such as rail terminals.

6.1.5 Alongside road transport, biofuels also have the potential to be used in other transport sectors such as aviation and shipping. Research work is currently being carried out on behalf of the Committee on Climate Change to assess the potential for biofuels in UK aviation.

6.1.6 Bioethanol production involves processes such as milling, fermentation, distillation and drying which require infrastructure such as boiler plant and flue, cooling towers and waste water treatment, although water reuse has become a standard procedure in most plants today. Feedstock and product storage options can comprise warehouse/barn buildings and a series of tanks or vessels. Methods of moving the required feedstock and product volumes are also key elements of the site – this can involve large vehicle movements and pipe infrastructure both above and below ground.

[33] *A Guide for Evaluating the Requirements of Ethanol Plants*. (2006) US Department of Agriculture.

6.2 B. Technological and financial constraints of biofuels

6.2.1 Biofuels are currently the most readily deployable renewable technology used in the transport sector and in 2008-09 around 2.6% of all UK road fuels used were biofuels[34]. However, only around 10% of these were supplied by the UK biofuels industry, with the remainder being imported[35].

6.2.2 Biofuels are being commercially produced in a number of countries at large scales. Economic viability will clearly vary according to many factors including financial incentives, the type of biomass feedstock used and the way in which it is produced. Second generation or advanced biofuel production is currently at an early stage of development and is not yet fully technically proven.

6.2.3 There are certain technical constraints to the use of biofuels in Europe. Standard vehicles are currently warranted to run on a blend of 5% biofuel by volume due to concerns that higher levels would affect vehicle reliability and performance. Although the blending limit is due to be increased to 10% by volume for bioethanol in petrol and 7% for the biofuel content of diesel, the lower energy content of biofuels means that around a maximum of 6.5% biofuel by energy will be able to be used in standard vehicles[36]. The European Commission is conducting a review, for 2012, of automotive technology and the feasibility of increasing current blending limits.

6.3 C. Planning and EIA requirements of biofuels

6.3.1 Biofuel production plants fall under B2 (General Industrial) of the Use Class Order, as they are non-electricity generating, and so will require planning permission from the local planning authority under the Town and Country Planning Act 1990.

6.3.2 Large scale biofuel production plants are likely to fall under Schedule 2.3(b), Schedule 2.3(c) or Schedule 2.3(e) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. It is also possible that where a development will include storage facilities for petroleum, petrochemical or chemical products, it could also fall under Schedule 2.6(c) of the Regulations.

6.4 D. Summary of potential impacts and design, mitigation and enhancement measures of biofuels

Landscape and visual

6.4.1 Large biofuel plants are industrial features, often with a boiler plant and flue, cooling towers and a number of storage and process tanks which may result in

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[34] *HMRC Hydrocarbon Oil Bulletin.* (May 09); and Renewable Fuels Agency. Under the Renewable Transport Fuel Obligation (RTFO) as currently in place, 5% (by volume) of all transport fuels supplied in the UK will have to come from renewable sources by 2013-14.
[35] *UK Renewable Energy Strategy.* (2009) HM Government. P29.
[36] *UK Renewable Energy Strategy.* (2009) HM Government. P125.

landscape and visual impacts on the surrounding area. The key landscape and visual impacts that may occur include:

- Direct landscape impacts on the site - for example loss of landscape features or change in the character of the site resulting from construction activity or the presence of an industrial building.
- Indirect impacts on the landscape character of the surrounding area – for example change in the character of adjacent landscapes as a result of the change in outlook from those landscapes.
- Direct impacts on views – for example change to views from settlements and viewpoints as a result of the introduction of a large industrial structure.

6.4.2 Careful consideration over the siting and design of biofuel plants will be important in minimising visual impacts. The siting of a new plant should aim to ensure the buildings are in character with its locality and does not interfere with views of existing landmarks. Materials and colours should be used to facilitate the integration of the plant and its associated infrastructure with the surrounding landscape. The incorporation of screen planting in key locations, on and off-site, in addition to landscape restoration works at the end of the construction period may also help minimise visual impacts on the wider landscape.

Air quality

6.4.3 Biofuel plants, notably those producing bioethanol, involve processes such as milling, fermentation, distillation and drying. These processes can result in emissions that can have an impact on air quality. The key impacts on air quality that may arise include:

- Emissions from operational procedures – for example particulate matter (PM10) and volatile organic compounds (VOCs) resulting from boiler plant and site processes.
- Steam from cooling towers.
- Odour deriving from feedstock and product storage.
- Emissions from construction and operation vehicles – for example dust generation during loading and unloading operations.

6.4.4 Air emissions are controlled by the Environment Agency (EA) and developers should consult with the EA at the earliest opportunity to discuss what environmental permits may be required.

6.4.5 With regard to mitigation measures, the incorporation of proprietary air pollution control systems into the scheme design will minimise any negative impacts on local air quality. Appropriate siting of odour-generating facilities away from sensitive developments alongside effective site and plant management will minimise the impact of odours. The scheme design should also incorporate negative ventilation systems fitted with biofilters to control and contain odours within buildings.

6.4.6 Impacts on air quality resulting from construction activity (i.e. dust) can be mitigated by implementing best practice construction measures such as the enclosure of stockpiles, ensuring appropriate transport of materials, restricting vehicle speeds on site, wheel wash facilities and switching off engines when not in use.

Noise

6.4.7 As with electricity generating and CHP biomass plants, biofuel plants generate noise from plant operations in addition to traffic-generated noise from HGV deliveries and the loading/unloading of fuel sources and resultant by-products.

6.4.8 Appropriate site layout design and siting of particularly noisy pieces of plant away from sensitive site boundaries is important in minimising noise levels at noise-sensitive properties. Similarly, the incorporation of noise attenuation features within the roof and walls of industrial buildings will help reduce noise break-out. Noise impacts resulting from construction activity can be mitigated by restricting working hours and adopting good practice measures for reducing noise in line with British Standards Guidance (i.e. BS 4142 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas).

Ecology and ornithology

6.4.9 The main ecological impacts resulting from biofuel plants are associated with airborne and waterborne emissions from operational procedures.

6.4.10 The key ecological and ornithological impacts that may occur include:

- Direct and indirect impacts of plant construction on ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation arising from the construction of the plant itself.
- Direct and indirect impacts of plant operation on ecological receptors – for example disturbances to habitats and species from noise, airborne and waterborne emissions resulting from operational procedures.

6.4.11 Many potential impacts on local ecology can be mitigated through the careful design and layout of the biofuel plant. Construction impacts can be minimised through the siting of plant and ancillary buildings away from sensitive habitats using buffer protection zones as necessary, restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes in construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes. Impacts on birds and bats can be mitigated by ensuring any vegetation and ground clearance works are undertaken outside the breeding season (March-August).

Hydrology and hydrogeology

6.4.12 The operation of a biofuel plant requires a water supply for milling, fermentation, distillation and waste water treatment. Although the reuse of water has become a standard procedure in most plants today, plant operation will have releases into the public sewer systems that can have potential impacts on local watercourses and groundwater. Key impacts include:

- Risk to local watercourses/groundwater from operational procedures (e.g. effluent from water treatment processes).
- Risk to local watercourses/groundwater from storage and use of chemicals on-site.
- Potential flood risk posed by development.
- Increase in surface water runoff as a result of development footprint.

6.4.13 The Environment Agency (EA) has responsibility for the control of water quality and water abstraction and as outlined above should be consulted regarding what permits may be required. The implementation of good pollution prevention practices through an Environmental Management Plan (submitted to and agreed with the determining authority prior to construction) will also help mitigate any potential risk to ground and surface water. This should include the use of collection dishes around storage areas to minimise runoff from chemicals and feedstock.

6.4.14 As noted above, a typical site area for an intermediate size bioethanol plant ranges from 4-6 hectares up to 16 hectares. Such a development footprint increases the potential of flood risk and surface water runoff. To minimise the potential of flood risk and surface water runoff, the following mitigation measures should be incorporated into the scheme design:

- Minimise area of impermeable surface.
- Reinstate vegetation where possible.
- Provide storage and attenuation ponds in line with sustainable drainage techniques (SuDs).
- Use appropriate culverts and drains to match existing hydrological regimes.

Traffic and transport

6.4.15 Traffic movements during the construction and operation of a biofuel plant will be dependent upon the size of the facility. The transport of feedstock and export of subsequent by-products (i.e. liquid products) will result in traffic movements to and from the site during operation. Larger bioethanol plants often, however, require a large number of vehicle movements to/from the site, which could significantly increase traffic volumes in the local area.

6.4.16 The preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic can help to minimise any impacts on the local road network. Such a plan should also seek to include measures for vehicle sharing and the avoidance of HGV deliveries during local peak periods to minimise vehicle movements on minor roads.

Historic Environment

6.4.17 See Section 4 and 5 comments on large/medium biomass developments.

Economic impacts

6.4.18 As with electricity generating or CHP biomass plants, a biofuel plant can have a positive impact on the local economy, as the supply of feedstock (i.e. energy crops) can provide a long-term income for local farmers, forestry owners and transport operators. The use of local labour, services and supplies during the construction of a biomass plant can also have benefits to local economy.

7. Hydropower

Technology Summary
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. 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 hydro 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.

7.1 A. Description of small scale hydropower

Figure 7.1: Osbaston 150kW hydropower scheme and fish pass on the River Monnow in Monmouthshire, opened 2009

Source: www.aberdareonline.co.uk

7.1.1 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. It is a well developed form of renewable energy and most sites within Wales with potential greater than 1MW have already been developed. Potential exists for mainly small scale 'run of river' schemes (see below) although there is also limited potential to install small schemes at existing reservoirs in Wales[37]. A recent study by the Environment Agency identified around 4,100 sites in Wales with potential for hydropower, representing a theoretical total of 396MW. 23% of this potential exists in so-called 'win-win' sites which would be improved in ecological status by the addition of a hydropower installation incorporating a fish pass[38].

7.1.2 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. Plants at the smaller end of this scale (typically below 100kW) are often referred to as micro-hydro and may include schemes providing power to a single home.

Equipment and infrastructure

7.1.3 The key elements of a hydro scheme are as follows:

- A source of water that will provide a reasonably constant supply. Sufficient depth of water is required at the point at which water is taken from the watercourse, and this is achieved by building a weir across the watercourse (of sufficient height to fill the penstock). This is called the 'intake'.
- A pipeline, often known as a penstock, to connect the intake to the turbine. A short open 'headrace' channel may be required between the intake and the pipeline, but long headrace channels are rare due to environmental and economic constraints.
- A cover/small shed housing the turbine (converting hydro power into rotating mechanical power), generator (converting the mechanical power into electricity) and ancillary equipment – the 'turbine house'.
- A 'tailrace' returning the water to the watercourse.
- A link to the electricity network, or the user's premises.

7.1.4 The majority of suitable locations are likely to be for 'run of river' schemes, where a proportion of a river's flow is taken from behind a low weir and returned to the same watercourse downstream after passing through the turbine. There may also be potential, in isolated locations, for 'storage' schemes, where the whole river is dammed and flow released through turbines when power is required.

7.1.5 'Low head run of river' schemes are 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.

[37] See Technical Advice Note 8 *Renewable energy* , Welsh Assembly Government, 2005
[38] See *Opportunity and Environmental Sensitivity Mapping for Hydropower*, www.environment-agency.gov.uk/shell/hydropowerswf.html.

7.1.6 'High head run of river' schemes are 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.

7.2 B. Technological and financial constraints for small scale hydro

7.2.1 Hydropower is a well-established and proven technology and there are few technological constraints to its use other than ensuring that heads and flow rates are adequate throughout the year, that there is adequate site access, that the site can accommodate the necessary equipment and that the electricity generated can be transmitted to its end use.

7.2.2 For the same reasons, 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.

Figure 7.2: Padarn Hydro Scheme

Source: Dulas Ltd

7.3 C. Planning and EIA requirements for small scale hydro

7.3.1 Small-scale hydro power plants will require planning permission from the local planning authority under the Town and Country Planning Act 1990.

7.3.2 Installations for hydroelectric energy production are listed under Schedule 2.3(h) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. Local Planning Authorities are required to screen applications for the need for EIA where the development involves a generating capacity of over 500Kw (0.5MW). Development proposed within sensitive areas, as defined in Regulation 2(1), must all be screened as the thresholds do not apply.

7.3.3 Local Planning Authorities have a statutory duty to have regard to River Basin Management Plans in exercising their planning powers. For hydropower schemes, this means ensuring that the hydropower development will not compromise the ability to achieve:

- The environmental objectives of the River Basin Management Plan.
- Good ecological status/potential of the water body.
- The ‘no deterioration principle’.

7.4 D. Summary of potential impacts and design, mitigation and enhancement measures for small scale hydro

Landscape and visual

7.4.1 Small-scale hydro schemes including dams, weirs, leats and turbine houses are often common features in the rural landscape. However, some landscapes are able to accommodate hydro schemes more easily than others. In addition, the visual appearance of waterfalls can be affected by water abstraction, particularly where a waterfall is an important feature in immediate and longer distance views. Key landscape and visual impacts that may occur include:

- Landscape impacts – for example the impact of dams, weirs, leats, turbine houses and associated power lines on the character of the landscape.
- Visual impact – for example the visual appearance of dams, weirs, leats, turbine houses and associated power lines and changes in the visual appearance of waterfalls affected by water abstraction.

7.4.2 Careful consideration of the siting and design of hydro schemes is important to ensure integration with the surrounding landscape. Hydro schemes sited in rivers lined with trees may be concealed more easily. Consideration should also be given to the sensitive restoration of old water mill sites or other structures (i.e. weirs, mill ponds, millraces or leats, hammer ponds, sluice gates and tailrace outlets) relating to past water-powered industries, where possible. Appropriate siting can also help integrate new turbine housing into the landscape by making use of landform, existing vegetation or trees, local materials and architectural features. In areas of more open landscape, high standards of design will help to minimise visual impacts, including the use of local materials for weirs and built structures along with vegetation screening. Burying pipelines and minimising hard surfacing and 'formal' planting (of an appropriate species) can help to integrate the scheme into the rural landscape.

Hydrology and hydrogeology

7.4.3 During operation of a small-scale hydro scheme, water is abstracted over a short stretch of a river, which will alter the existing hydrological regimes. This can therefore have impacts on the aquatic ecosystems that are dependent on hydrological regimes (discussed below). In all cases the Environment Agency will need to be contacted to issue an abstraction licence. In addition hydropower schemes are also likely to require an Impoundment Licence and Flood Defence Consent from the Environment Agency.

7.4.4 However, hydro schemes do not pollute or consume water, as it is usually returned to the channel from which it was abstracted. Conversely, water that passes through a turbine is often improved by aeration and is free of debris, which can have positive impacts on fish populations.

7.4.5 The construction of a hydro scheme on or beside a river can have impacts on the watercourse due to pollution, erosion, sedimentation and impediments to flow. The production of an Environmental Management Plan, agreed with the local planning authority and the Environment Agency, can help ensure best practice pollution prevention practices are implemented during construction and help minimise pollution to watercourses.

Ecology

7.4.6 The most significant impacts resulting from small-scale hydro schemes relate to ecological issues, notably the effect of water abstraction on riverine ecology, as reductions in flows to watercourses can lead to an impact on the ecology of that reach. Key ecological impacts that may occur include:

- Direct impacts of hydro-power operation on ecological receptors – for example disturbance of habitats/species from the impact of altered hydrological regime, disturbance to migratory patterns and death/injury of fish.
- Direct impact of hydro-power construction on loss/displacement of ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation during the construction of the scheme.

7.4.7 Ecological impacts can be mitigated through good design. The incorporation of fish passes and screens into the weir will allow free passage of migratory fish and other freshwater animals and many turbines (i.e. low to medium head crossflow designs) can oxygenate river water, which will bring benefits to fish populations. Measures such as pulsed flow or seasonal operating of the hydro scheme to avoid seasonal fish migration will also minimise impacts on breeding fish populations.

7.4.8 The construction of hydro schemes should be avoided during seasonal fish migration to ensure the safe passage of fish upstream/downstream. Well designed schemes should also incorporate environmental improvements into the development through the restoration of natural riverside habitats that may be degraded or damaged during construction.

Historic Environment

7.4.9 Small scale hydro schemes can have direct impacts on historic landscapes and other designated areas, as well as the setting of individual assets such as listed buildings and scheduled ancient monuments. However, with care new installations can be well-integrated into their setting and their impacts can be minimal, even in historic landscapes. Guidance provided by Cadw[39] states that appropriate mitigation measures may include:

- Siting turbine houses where they will be least obtrusive and where they will be hidden by the contours of the land or blend into natural and existing man made features.
- Burying water pipes where possible or using black coloured piping.
- Designing turbine houses to have a low profile and incorporating local building material and traditions and using appropriate landscaping to further often the appearance.
- Considering potential for archaeological features to be present before undertaking any excavation work.

Social and economic impacts

7.4.10 The pipeline route of a hydro scheme is often designed to follow the route of an existing footpath alongside a river, which may cause diversions and/or closure to public footpaths. However, impacts are usually confined to the construction phase and developers can ensure the pipeline route is fully restored once the hydro scheme is operational. Small-scale hydro schemes also have the potential to impact local fisheries through the death or injury of migratory fish upstream/downstream of fisheries. This risk can be minimised through careful design, such as the incorporation of structures in the weir that allow free passage of migratory fish and afford fish and other freshwater animals protection from the turbines. Adjustment of the seasonal operating schedule of the plant to avoid seasonal fish migration will also minimise impacts on breeding fish populations.

[39] *Renewable Energy and your Historic Building: Installing Micro-generation Systems* (2010) Cadw.

8. Solar

Technology Summary

Solar energy generation involves the use of the sun's energy to provide hot water via solar thermal systems or electricity via solar photovoltaic (PV) systems. Both technologies are technically well-proven with numerous systems installed around the world over the last few decades.

Solar thermal systems use solar collectors, usually placed on the roof of a building, to preheat water for use in sinks, showers and other hot water applications. While the UK climate is not sufficiently hot and sunny to meet all domestic hot water requirements year round, a well designed solar thermal system should meet 50-60% of demand during May-September.

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. Other forms of solar PV technology are becoming more common in the UK, such as solar tiles, which can be integrated into new buildings or refurbishments alongside conventional roofing tiles or slates.

For both types of system, panels or collectors are becoming increasingly incorporated into a new or existing roof in much the same way as roof windows. For best performance in the UK, systems need to be inclined at an angle of 20 to 45 degrees, facing due south and clear of the shade of trees and buildings.

Commercial scale solar PV arrays are an emerging technology in the UK, although well established in other parts of the world. They consist of freestanding arrays of solar panels mounted on fixed frames or systems that track the sun and which feed their electricity into the national grid.

8.1 A. Description of solar energy

8.1.1 Solar energy generation involves the use of the sun's energy to provide hot water or electricity. **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. They do not provide enough energy for traditional high temperature space heating systems. The technology may also be referred to as Solar Hot Water (SHW) or Solar Water Heating (SWH). **Solar Photovoltaic (PV) systems** use solar cells to generate electricity directly from sunlight. The solar cells are normally packaged together into panels or other modular forms. Like solar thermal collectors, building integrated solar PV systems are normally roof-mounted. In contrast, commercial scale **solar PV arrays** normally comprise large numbers of individual panels grouped into 'arrays' and mounted on freestanding racks.

Solar thermal

8.1.2 While the UK climate is not sufficiently hot and sunny to meet all domestic hot water requirements year round, a well designed solar thermal system should meet 50-60% of demand during May-September. For best performance in the UK, the solar collectors (either flat plate or more efficient evacuated tube[40]) need to be inclined at an angle of 20 to 45 degrees from the horizontal, facing due south and clear of the shade of trees and buildings. Some flexibility may be necessary when installed on existing buildings but performance will be degraded when designed outside of these criteria. The collectors do not usually stand more than 12 cm proud of the existing roofline, are generally dark coloured, and on a domestic building, are typically 3 to 5m^2 in area. Increasingly, collectors are becoming available that can be incorporated into a new or existing roof in much the same way as roof windows. Although most commonly roof mounted, a free-standing ground structure is also possible and frequently used for swimming pools.

Figure 8.1: Solar thermal panel (evacuated tube system)

Source: www.cse.org.uk

8.1.3 Solar thermal energy represents the most easily installed and potentially cheapest renewable energy application for domestic buildings. For non-domestic buildings, it is only appropriate if they have a high hot water demand, such as swimming pools, hotels and some industrial buildings.

8.1.4 Solar thermal collectors work in conjunction with a hot water tank located within the building, which stores hot water and has an independent heating source such as a boiler or immersion heater to supplement the solar thermal system.

[40] Flat plate systems consist of an absorber plate with a transparent cover to collect the sun's heat; evacuated tube systems consist of a row of glass tubes, each containing an absorber plate feeding into a manifold.

Building integrated solar PV

8.1.5 Building integrated solar PV can either be roof mounted in modular form, or integrated into the roof or facades of buildings through the use of solar shingles, solar slates, solar glass laminates and other solar building design solutions. PV cells may also be attached directly to the appliances they power, such as lights or parking meters. The most common form of device comprises a number of semiconductor cells which are interconnected to form a solar panel or module. There is considerable variation in appearance, but all solar panels are dark in colour, and have low reflective properties. Other forms of solar PV technology are becoming more common in the UK, such as solar tiles, which can be integrated into new buildings or refurbishments alongside conventional roofing tiles or slates.

Figure 8.2: Retrofit solar PV panels

Source: www.cse.org.uk

Figure 8.3: Building-integrated solar PV tiles

Source: www.cse.org.uk

8.1.6 Similarly to solar thermal collectors, PV cells perform best in the UK when inclined at an angle of 20 to 45 degrees from the horizontal, facing due south and clear of the shade of trees and buildings. Some flexibility may be necessary when installed on existing buildings but performance will be degraded when designed outside of these criteria. Solar panels are typically 0.5 to 1.0m^2 in area, having a peak output of 70 to 160 watts. A number of modules are usually connected together in an array to produce the required output, the area of which can vary from a few square metres to several hundred square metres. A typical array on a domestic dwelling would have an area of 9 to 18m^2, and would produce 1 to 2 kW peak output. The electricity produced can either be stored in batteries or fed into the grid via the mains supply. PV is particularly suited to buildings that use electricity during the day such as offices, schools, and shops.

8.1.7 Grid-connected solar PV systems work in conjunction with an inverter to feed electricity into the mains. Off-grid systems, however, require battery storage the size of which will vary according to the load.

Solar PV arrays

8.1.8 Whilst a number of commercial scale solar PV arrays have been built in mainland Europe and the rest of the world, planning applications for them have only recently begun to come forward in the UK. This reflects the considerable financial support offered to arrays of up to 5MW capacity by the Feed-in Tariff (see **Chapter 17**). Since commercial scale solar PV arrays are an emerging renewable technology in the UK, there is limited information available on the specification, construction and impact of such schemes, relative to other renewable technologies. By virtue of the high levels of solar radiation received an increasing number of proposals have come forward in south Wales and the south west of England. Some of the information presented here builds upon the emerging practice and guidance on the development of solar PV arrays in Cornwall [41,42,43].

8.1.9 The main components of a solar PV array are likely to comprise:

- Free-standing **PV panels** – Solar PV panels are arranged in groups or 'arrays' of up to 50 panels mounted on a static metal stand, ideally facing due south and angled 20 to 45 degrees from the horizontal to maximize exposure to sunlight. The height of the rear edge of each stand will depend on the size of individual panels, their angle and the number of panels stacked above each other in the array. Typically, stands with a single row have a maximum height of less than 1.6m but those with two or three panels stacked above each other can be more than 2.5m high. The height of the solar panels from the ground (i.e. minimum height) can vary from schemes where the panels are placed

[41] An Assessment of the Landscape Sensitivity to On-Shore Wind & Large-Scale Photovoltaic Development in Cornwall: Methodological Report (November 2010) LUC for Cornwall Council
[42] The Development of Large Scale Solar Arrays in Cornwall: Draft 6 (November 2010) Cornwall Council, available from http://www.cornwall.gov.uk/default.aspx?page=25182
[43] Planning for Solar Parks in the South West of England (2010) Regen SW, available from http://www.regensw.co.uk/events/regen-sw-events-/planning-for-solar-pv-parks-

close to the ground to those which are above ground (such as in Figure 8.4). The latter can usually accommodate low density grazing by small livestock. A solar development may comprise a large number of arrays and these tend to be arranged in rows with gaps between them to avoid shading adjacent arrays and to allow access. Solar PV arrays may alternatively track the movement of the sun each day to maximise solar gain, however these are more expensive to install and maintain than static ones. An alternative arrangement is for the arrays to be fixed on a day-to-day basis but manually realigned every few months to take account of seasonal changes to the sun's path.

- **Ground anchors** – the arrays may be anchored to the ground by using pile-driven or ground screw anchors, pre-moulded concrete blocks ('shoes') or concrete-filled foundation trenches.
- **Inverter** – One or more inverters are required to convert the direct current (DC) generated by the panels into the alternating current (AC) required to feed into the grid. These are typically housed in small (typically of 'portakabin' size) new or existing buildings and are likely to be fed by a number of DC collectors (typically of 'telephone cabinet' size) that bring together the output of individual arrays.
- **Cabling** – Electrical output from the PV panels is directed along cables to the DC collectors and then to the inverter(s). This cabling is typically buried in shallow trenches but may be contained in above ground trunking.
- **Grid connection** – The electricity output from the inverter is connected via overhead or underground cable to an electricity sub-station where it is fed into the National Grid.
- **Security** – Security fencing (e.g. mesh or palisade) up to 3m high is likely to be required for insurance purposes. Proposals may also include pole-mounted CCTV cameras and associated security lighting.
- **Construction compound** – A temporary compound for the storage of plant, materials and machinery is required during construction.
- **Access track -** new access tracks may be required to bring the solar panels to a site, although they can often be avoided by the use of temporary mats if a site is not accessible by existing roads or tracks.

8.1.10 The generating capacity of solar PV array proposals is likely to be dictated by the eligibility threshold of the Feed-in Tariff of up to 5MW. A 5MW array can typically occupy 12.5-15.0 ha of land (2.5-3.0 ha per MW), but this may vary as technologies develops in the UK. The land take from such systems is dependent on the size of the individual panels that make up the solar array. The exact area required will depend on site factors such as orientation, slope and presence of existing features to be preserved.

Figure 8.4: Solar PV development under construction, Berlin - Germany

Source: www.landuse.co.uk

8.2 B. Technological and financial constraints of solar energy

Building integrated solar

8.2.1 Building integrated solar thermal and solar PV technologies are technically well-proven with numerous systems installed around the world over the last few decades. The main technical constraints concern the availability of suitably orientated and unshaded roof or external wall space, both in terms of area and structural integrity (to support the weight of panels, etc). Additional space for system components within a building may also be a constraint, i.e. a hot water tank in the case of solar thermal and a battery storage system with an off-grid PV system.

8.2.2 Energy yields from solar systems can be reasonably well-predicted and economic viability established relatively easily. Both types of systems have very low operation and maintenance costs and are relatively simple to install on buildings. Technically, they are highly accessible to both domestic and non-domestic users. The main financial constraint to their use is the high capital cost of systems, particularly in the case of PV. However, the introduction of Feed-in Tariffs and the Renewable Heat Incentive (see **Chapter 17**) is expected to significantly improve their financial viability.

Solar PV arrays

8.2.3 The main technical constraints for solar PV arrays are the availability of sufficient land on which to build them, the solar radiation received by the site and its proximity to a grid connection. Solar irradiation in the UK is greatest in the south and west of the country, creating more favourable conditions for solar PV arrays. As noted above, each MW of solar PV capacity currently requires 2.5 to 3.0 ha of land area and the greatest amount of electricity will be obtained from sites that allow arrays to face due south and avoid shading from surrounding features.

8.2.4 The distance from the proposed location of a solar PV array to a suitable grid connection with capacity to accommodate the additional supply [44] is an important consideration. Since April 2010, small scale solar PV and other renewable energy generators can obtain financial support from the Feed-in Tariff.

8.3 C. Planning and EIA requirements of solar installations

Building integrated solar

8.3.1 The installation, alteration or replacement of solar PV or solar thermal equipment on a dwelling house or a building situated within the curtilage of a dwelling house is classed as permitted development under The Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2009.

8.3.2 Development is not classed as permitted development if:

- The solar PV or solar thermal equipment would protrude more than 200mm beyond the plane of the wall or the roof slope when measured from the perpendicular with the external surface of the wall or roof slope.
- It would result in the highest part of the solar PV or solar thermal equipment being higher than the highest part of the roof (excluding any chimney).
- In the case of land within a conservation area or which is a World Heritage Site, the solar PV or solar thermal equipment would be installed –
  - On a wall forming the principal or side elevation of the dwelling house and would be visible from a highway, or
  - On a wall of a building within the curtilage of the dwelling house and would be visible from a highway, or
  - The solar PV or solar thermal equipment would be installed on a building within the curtilage of a dwelling house if the dwelling house is a listed building.

[44] The Development of Large Scale Solar Arrays in Cornwall: Draft 6 (November 2010) Cornwall Council, available from http://www.cornwall.gov.uk/default.aspx?page=25182

8.3.3 In such cases, planning permission would be required from the local planning authority under the Town and Country Planning Act 1990.

8.3.4 The development of solar PV or solar thermal equipment is permitted so long as it, as far as practicable, minimises its effect on the external appearance of the building and the amenity of the area. Commercial/ industrial PV building integrated development is currently not subject to permitted development rights and proposals therefore require a planning application.

Solar PV arrays

8.3.5 Solar PV arrays are not classed as permitted development.

8.3.6 Solar PV arrays are not explicitly listed within Schedule 2 of the EIA Regulations[45] which require EIA if the project is judged likely to give rise to significant environmental effects due to its size, nature and/or location. Although they are not specifically mentioned, they may fall within sub-category (a) of 'Energy industry', i.e. 'industrial installations for the production of electricity, steam and hot water', for which Schedule 2 indicates that developments more than 0.5 ha in area may require EIA. Given that proposals are likely to exceed this area threshold, that they are generally located in the open countryside, and that the European Court has ruled that the EIA Directive 'has a wide scope and broad purpose'[46], it is recommended that proposers of solar PV arrays submit a request for a Screening Opinion to the Local Planning Authority under the EIA Regulations at an early stage.

8.4 D. Summary of potential impacts and design, mitigation and enhancement measures of solar installations

Building integrated solar

Landscape and visual

8.4.1 Roof mounted solar units on buildings can have a 'modernising' effect on the character and appearance, particularly when they are located on the principal elevation of a property. The visual impact of a solar unit will be determined by its location which in turn will be determined by the orientation required to maximize solar energy gain. Maximum solar gain will be obtained by locating solar units on south facing roofs (solar units can still be productive if oriented eastwards or westwards, but will achieve maximum productivity if oriented due south). The scale of solar units in relation to the roof area will vary with the technology as PV roof shingles, for example, have a similar appearance to traditional roof coverings and so are more likely to cover a larger percentage of the roof compared to retrofit PV panels or solar thermal collectors.

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[45] The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations SI 293, HM Government, (1999)
[46] Kraaijveld (ECJ C-72/95, 1-5403)

8.4.2 Careful consideration of the design of solar units is therefore important, taking into account building materials - in particular colour, texture and reflectivity of roofing materials which may contrast with solar panels. Solar panels are available in different colours to suit varying architectural design, ranging from contemporary designs to those attempting to match more traditional tiles or slates. Consideration should therefore be given to matching solar panels with other roof materials. Where possible, solar panels should be flush with the roof and mounted at the same angle as the roof to minimise contrast.

Historic Environment

8.4.3 The siting of solar units on listed buildings or in conservation areas can potentially have impacts on the character of a listed building or the character or appearance of a conservation area. Therefore, sensitive siting and a high level of design quality will be required. If possible, solar panels should be installed on unobtrusive areas of a roof, such as the inner slopes of a roof valley, or where a flat roof is obscured by a parapet, although care should be taken to make sure that the panels are not shaded for long periods of the day, as their efficiency will be reduced. With regards to a listed building, it may be more appropriate to mount solar panels over existing slates, rather than replacing the historic fabric with PV roof shingles, to protect the integrity of the building.

8.4.4 The potential structural impact of solar panels also needs to be considered. The roofs of many historic buildings, particularly small vernacular buildings, are often constructed using scantling poles and lightweight timbers that do not confirm to modern building standards. Whilst they may be capable of taking the weight of the existing roof cladding, the advice of a structural engineer should always be sought before mounting solar units on the roof of a building, where there is any doubt regarding its structural integrity. As an alternative to roof-mounting on a historic building, solar units can be installed on ancillary buildings or ground-mounted on a frame in an unshaded area.

8.4.5 It should be noted that the installation of solar panels on a listed building or on another building or structure in its curtilage is likely to require an application for listed building consent.

Solar PV arrays

Landscape and visual

8.4.6 Along with ecological sensitivity, landscape sensitivity to the proposed development will be a key factor in determining whether an EIA is required and sensitive locations should be avoided where possible. A landscape and visual impact assessment, employing tools such as photomontages, may be useful in assessing potentials impacts[47].

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[47] For further information, see *Guidelines for Landscape and Visual Impact Assessment* (2002) Landscape Institute & IEMA

8.4.7 Solar PV panels appear dark in colour as a result of their non-reflective coating and the design requirement to maximise absorption of light. Their appearance has variously been likened to straw bales wrapped in black plastic or areas of standing water (e.g. reservoirs, lakes) or runways when viewed from certain angles and from a distance.

8.4.8 Solar PV arrays, although not prominent in terms of height, can result in a regular pattern of PV panels, ancillary buildings and security fencing occupying substantial areas of land. Considering the size of the potential developments, there is concern that they could lead to the creeping urbanisation of the countryside.

8.4.8 Construction of the solar PV array can result in impacts on, or the loss of landscape features such trees and hedges or contours through site levelling and the potential need to remove trees etc. to reduce shading. Key landscape and visual impacts which should be borne in mind during the siting decision include:

- Solar PV arrays may be particularly visible in long views when located on a hillside or adjacent to high ground.
- The presence of PV panels and associated infrastructure may mask underlying semi-natural habitats or archaeology.
- Solar PV developments may mask field patterns, particularly where the maximum height of supporting racks is higher than hedgerows or other field boundaries or where racks are arranged right up to the boundary.

8.4.9 Designated landscapes such as National Parks and AONBS are likely to be particularly sensitive in respect of one or more of these types of visual effect. Extreme care therefore needs to be taken to ensure the siting of solar arrays does not affect the special qualities of designated landscapes.

8.4.10 Potential mitigation may include using existing landscape features or new planting to screen the development although this will need to avoid the shading of the panels. Screen planting (including allowing hedges to grow out) around solar PV development can, however, change the sense of enclosure of a landscape and would need to be undertaken through careful design. Existing landscape features should be retained where possible.

Glint and glare

8.4.11 Despite their non-reflective design, it is possible that intense direct reflections of the sun (‘glint’/’specular reflection’) or more diffuse reflections of the bright sky around the sun (‘glare’) by solar PV panels (and their supporting frames) may cause viewer distraction. In addition to increasing the visual impact of a development in the landscape this can potentially impact on air traffic safety.

8.4.12 The potential impact of glint and glare should be discussed with the local planning authority at an early stage in the planning process. In some circumstances it may be necessary to undertake a glint and glare assessment as part of the planning application. Particular consideration should be given to properties that are higher up a slope than the proposed solar development as these are most likely to experience any glint/ glare effects created.

Ecology

8.4.13 Along with landscape sensitivity, the ecological sensitivity of the development site will be a key factor in determining whether an EIA is required and sensitive sites should be avoided where possible. Potential forms of ecological impact and relevant potential mitigation are as follows[48]:

- **Construction** - site clearance and construction of foundations, cabling trenches, access tracks and ancillary infrastructure may result in direct habitat or species loss, or damage or fragmentation of habitat. Other construction impacts (including from vehicle movements) may include disturbance of local species, and changes to site hydrology or pollution. Potential mitigation could include retaining existing habitat features such as trees and hedgerows, avoiding construction works taking place in sensitive periods such as the bird breeding season, or translocation to minimise impact on sensitive species, if present.
- **Operation** - little is known about the impact of operational solar PV arrays in the UK on ecology. Although panels may result in glint and glare (see above), the potential impact on ecological receptors such as birds or invertebrates is uncertain although CCW has commented that there is some evidence about arrays being confused for areas of water. The degree of impact on retained ground flora due to shading by the PV panels will depend on the dimensions of the panels and the separation between them. Security fencing may pose a barrier to movement through the site for larger species. Excessive security lighting should be avoided or designed so as to minimise potential impact on bats as well as the visual impact of light pollution. To minimise potential impact on bats, schemes should consider the following generic options: (i) use low pressure sodium bulbs, those with UV filters, or Passive Infra Red bulbs, (ii) install lighting at appropriate location and height and use cowling to minimise light spill (iii) use light sensors at appropriate location(s) to minimise hours of use.

8.4.14 Opportunities for ecological enhancement may include planting of suitable species such as wildflowers (of native provenance) beneath and between panels, or planting around field margins to increase habitat connectivity. Habitat management may include low density grazing by smaller livestock such as sheep that do not risk damage to the solar arrays.

Historic environment

8.4.15 The key potential impact on the historic environment from solar arrays is likely to be caused by the installation of the PV panels and any associated ground works

[48] See Technical Advice Note 5 Nature Conservation and Planning (2009) http://wales.gov.uk/topics/planning/policy/tans/tan5/?lang=en

such as piling for foundations or excavation of trenches for cables. The sensitivity of the development site will be a factor in determining whether it is EIA development and sensitive sites should be avoided where possible as construction could damage historic landscape features. A large scale PV array could also have an impact on the setting of other heritage assets such as scheduled monuments, listed buildings and historic landscapes. Care should therefore be taken in the siting of solar PV arrays to avoid impacts on potentially sensitive archaeological sites and features. The choice of ground anchors (see above), need for and layout of trenches for cabling, and design of any access tracks should have regard to the need to avoid damage to any buried archaeology. The use of surface ducting for cables and concrete shoes or ballast for ground anchoring may significantly reduce the potential for impacts on below ground archaeology. A desktop archaeological assessment and consultation with the local archaeology officer should therefore take place at an early stage in the project design.

Agriculture

8.4.16 In view of the national policy support for farm diversification[49] and the relatively large area of land required for solar PV arrays it is likely that a significant proportion of proposals for solar PV arrays will be on agricultural land. Both the use of natural resources (such as high quality agricultural land) and the reversibility of a development are factors in determining if EIA is required. National policy requires that the best and most versatile agricultural land (i.e. grades 1, 2 and 3a of the Defra Agricultural Land Classification System) '*should only be developed if there is an overriding need for the development, and either previously developed land or land in lower agricultural grades is unavailable, or available lower grade land has an environmental value recognised by a landscape, wildlife, historic or archaeological designation which outweighs the agricultural considerations.*'[50].

8.4.17 In addition to avoiding the best and most versatile agricultural land, other possible mitigation includes taking steps to enhance the reversibility of the development (e.g. by use of removable mats rather than permanent access tracks and use of ground screws rather than buried concrete foundations to anchor solar arrays) and avoiding soil compaction or contamination during construction and maintenance.

Hydrology and flood risk

8.4.18 The potential effects of a solar PV array on hydrology and flood risk should be considered. In general, these are unlikely to be significant because the presence of solar arrays will not greatly increase the time for rainwater to reach the ground where it can infiltrate in the usual way and because the panels will typically cover no more than one third of the site area. The effects of the panels, in combination with access tracks, earth works, buildings for inverters, cable trenches and site drainage works will nevertheless need to be assessed. An assessment of existing flood risk at the

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[49] See Section 7.3, Planning Policy Wales, Welsh Assembly Government
[50] See Section 4.9, Planning Policy Wales, Welsh Assembly Government

site should also be undertaken to consider the need for electrical equipment to be raised off the ground and to ensure that any on site works do not exacerbate flooding elsewhere. Further information can be found in Technical Advice Note 15 'Development and Flood Risk'[51]. It is also advisable to undertake early discussions with Environment Agency Wales.

Cumulative impacts

8.4.19 Proximity to the grid is a key factor affecting the economic viability of solar PV arrays. The need for sites to be located close to a suitable grid connection means that proposals are likely to cluster around these grid connection points. This makes it especially important that the sustainability effects of solar PV array proposals are considered not only in isolation but also in terms of the potential cumulative effects with similar proposals and other forms of development.

[51] See Technical Advice Note 15 Development and Flood Risk (2004) http://wales.gov.uk/topics/planning/policy/tans/tan15/?lang=en

9. Ground, Water and Air Source Heat Pumps

Technology Summary
Heat pumps systems capture the environmental solar heat energy stored in the ground (ground source heat pumps), bodies of water (water source heat pumps) or air (air source heat pumps). Applications include space heating, water heating, heat recovery, space cooling and dehumidification in both the residential and commercial building sectors. Although all the heat delivered by heat pumps comes from renewable energy (stored solar energy), a supply of electricity is required to pump the system, which may or may not come from renewable sources. However, a typical good quality installation will extract at least three times as much useful heat energy as it uses electrical energy to operate. A typical ground source heat pump (GSHP) system has three major components: a heat pump (located within the building and similar in size to a large refrigerator), a ground collector loop (either pipes laid in trenches in the ground or vertical pipes within boreholes) and an interior heating or cooling distribution system. Air source systems are commonly mounted directly on an external wall and are similar in appearance to conventional air-conditioning units.

9.1 A. Description of heat pumps

9.1.1 Heat pumps systems capture the environmental solar heat energy stored in the ground, bodies of water or air and use this for space and/or water heating within buildings. Although all the heat delivered by heat pumps comes from renewable energy (stored solar energy), a supply of electricity is required to pump the system, which may or may not come from renewable sources. However, a typical good quality installation using e.g. ground source heat will extract at least three times as much useful heat energy as it uses electrical energy to operate – it is then said to have a Coefficient of Performance (CoP) in excess of 3.0. Some heat pumps can also be used in 'reverse' to provide cooling. Heat pumps are modular and can be scaled up from a typical 5-10kW domestic system to provide heat to a range of commercial and industrial buildings.

9.1.2 **Ground source heat pump** technology makes use of the heat energy stored in the ground surrounding (or even underneath) buildings. Essentially, heat is taken out of the ground at a certain temperature and passed through a heat exchanger to release it into a building at a higher temperature. A typical ground source heat pump (GSHP) system has three major components: a heat pump, a ground collector loop (typically coils known as slinkies when laid in trenches in the ground or vertical pipes within boreholes) and an interior heating or cooling distribution system.

Figure 9.1: Ground source heat pump unit (left) and 'slinky' ground loop (right)

Source: www.gshp.org.uk

9.1.3 Diverse applications include space heating, water heating, heat recovery, space cooling and dehumidification in both the residential and commercial building sectors. As they operate most effectively when raising water to a temperature no more than about 40°C, GSHPs are best used with underfloor heating systems or low temperature radiators (with a larger surface areas), and are not usually considered suitable for retrofitting into existing high temperature radiator systems previously supplied by conventional boilers. Underfloor low temperature systems are particularly appropriate to large rooms, such as school classrooms and halls. The heat pump itself is a similar size to a large fridge and is situated inside the building.

9.1.4 **Water source heat pumps** extract heat from large bodies of water or rivers (with a reasonably high flow volume in order to minimise any resulting changes in water temperature). As with GSHPs, despite the relatively low temperatures of the water source, heat can be extracted from it in a heat exchanger to feed a low-temperature central heating system. An abstraction license from the Environment Agency is normally required.

9.1.5 **An air source heat pump** 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 (as they lack any need for external heat collector loops), but are also usually less efficient. They can either be mounted directly on an external wall (sometimes under a window) where they look like (and are in effect) air-conditioning units running in reverse, or they can feed a centralised ducted warm air central heating system. In certain cases, they can therefore be considered for retrofitting to previous gas systems.

Figure 9.2: Air source heat pump unit

Source: www.airsource-heatpump.co.ukhttp://www.gshp.org.uk/

9.2 B. Technological and financial constraints of heat pumps

9.2.1 The main technical constraints to using GSHPs concern the available space for ground loops and the nature of the building being supplied. Although bore hole ground loops require less space than trenched loops, they are considerably more expensive. The geology of the site will also influence the choice – rocky surface layers will be difficult to trench and certain geological conditions at depth can make bore hole drilling difficult. As mentioned above, the low temperature output from GSHPs (and water and air source heat pumps) requires a suitable low temperature heat distribution system within the building being heated. These systems also work best in highly insulated buildings.

9.2.2 In most cases, heat pumps are sized to provide only a proportion of space and water heating and need to work in conjunction with a supplementary heat source, often in the form of an electric immersion heater, to provide top-up heat. This is done to reduce the capital cost of the system, which would be significantly higher if sized to supply the total heat demand.

9.2.3 GSHPs exploit the fact that the temperature underground is relatively constant all year round and is above ambient air temperature for most of the winter. However, air source heat pumps rely on seasonally variable air input temperatures and so operate at reduced efficiencies during cold periods when the heat is needed most[52]. Overall efficiencies (CoP) for air source heat pumps will generally therefore be more unpredictable than for ground source heat pumps. Subsequent financial viability will depend on many factors, not least the cost of electricity to power the pump and the cost of the fuel that is being displaced. Air source heat pumps are generally quoted as having lower running costs and CO_2 emissions when compared to electric storage

[52] In other words the heat pump will use increasing amounts of electricity to output a set temperature as the external air temperature decreases.

heaters, but are likely to be more expensive to operate (with higher emissions) than a well designed gas condensing boiler system.

9.3 C. Planning and EIA requirements of heat pumps

9.3.1 The installation, alteration or replacement of a ground source or water source heat pump within the curtilage of a dwelling house is classed as permitted development under The Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2009.

9.3.2 Air source heat pumps are not currently classed as permitted development under The Town and Country Planning (General Permitted Development) (Amendment) (Wales) Order 2009 and therefore require planning permission from the local planning authority under the Town and Country Planning Act 1990.

9.4 D. Summary of potential impacts and design, mitigation and enhancement measures of heat pumps

Landscape and visual

9.4.1 Ground source heat pumps involve the laying of coils of pipe in either a horizontal trench or a vertical borehole. Once installed, the pipework can easily be covered with soft or hard surfaces and so the system will not be visible from outside the building. However, the laying of pipes linked to ground source heat pumps involves ground disturbance and sensitive installation can avoid disturbing ground which would be difficult to restore, such as unimproved grasslands and semi-natural habitats.

9.4.2 Air source heat pumps require an external heat pump that captures heat from the ambient outside air. These units resemble air conditioning units in terms of their size and appearance and can have visual impacts if not appropriately sited. Consideration should therefore be given to the sensitive design and siting of the pump equipment and its housing, including locating in least visible locations and using materials characteristic of the area.

Historic Environment

9.4.3 The installation of ground source heat pumps requires the excavation of trenches or deep boreholes. It is therefore important to consider whether any archaeological remains exist at the development site. An assessment of the archaeological potential of the site should be undertaken prior to excavation or groundworks and, if necessary, an archaeological watching brief should be undertaken during construction.

9.4.4 The siting of an external heat unit for an air source heat pump on a listed building or on several buildings within a conservation area could potentially have impacts on the character of a listed building or the character or appearance of a conservation area. Therefore, sensitive siting and a high level of design quality will be required. Where possible, external units should be installed where they will have the least visual impact such as to the rear of a property, in service areas or on flat roofs where they will be hidden from view. Appropriate materials and colour treatment should also be used if any housing for the unit is required.

Noise

9.4.5 The external heat unit of an air source heat pump that captures heat from the ambient outside air could potentially result in a modest increase in noise levels at nearby properties during operation. Although these units generally have noise emissions of only 48dBA at 1m distances, the use of anti vibration mountings and acoustic insulation in the scheme design will ensure any noise impacts are minimised.

Hydrology and hydrogeology

9.4.6 The construction and operation of ground source and water source heat pumps can have potential impacts on groundwater and watercourses (i.e. aquifers) through heat pollution and the leakage of additive chemicals used in the pipe system. It is therefore important to ensure that appropriate measures are in place during the construction phase, particularly when constructing boreholes, to prevent contamination of groundwater or watercourses such as rivers, canals and ponds in the case of water source heat pumps.

10. Geothermal

Technology Summary

Geothermal energy resources are found in the form of heat within the rocks below the earth's surface. The source of this heat comes from the radioactive decay of minerals deep within the earth rather than from solar energy, which only affects the top few meters of the earth's surface.

Various technologies exist to utilise geothermal energy as a direct source of renewable heat, or to use this heat to generate electricity. These generally involve the drilling of wells or boreholes several kilometres deep. Extracted geothermal energy is naturally replenished over time making the resource sustainable, although localised reduction in heat output can occur over long periods. Compared to conventional fossil fuel energy generation, carbon dioxide emissions from geothermal plant are very low as fossil fuels are not combusted.

Currently, geothermal energy installations are very scarce in the UK. Existing plants include a system in Southampton which supplies hot water to a number of customers in the city centre as part of a larger district heating scheme. In 2009 plans were announced to develop a heat and power 'hot rocks' plant in Cornwall, an area which has particular potential due to its geology, where granite outcrops occur relatively close to the surface.

10.1 A. Description of geothermal energy

Figure 10.1: Southampton Geothermal plant

Source: © Copyright Peter Facey: licensed for reuse under Creative Commons Licence

10.1.1 Geothermal energy resources are found in the form of heat within the rocks below the earth's surface. The source of this heat comes from the radioactive decay of minerals deep within the earth rather than from solar energy, which only affects the top few meters of the earth’s surface. Geothermal energy sources described in this section concern the high temperatures found at considerable depths. The lower, constant temperatures found close beneath the surface are commonly exploited through the use of ground source heat pumps – these are considered separately in Section 9 of this chapter.

10.1.2 Various technologies exist to utilise geothermal energy as a direct source of renewable heat, often for district heating applications, or to use this heat to generate electricity. These generally involve the drilling of wells or boreholes several kilometres deep – this compares to typical borehole depths of 50-150 metres for ground source heat pumps.

10.1.3 At sites where hot springs or deep aquifers exist, hot water or steam can be extracted directly from the ground. Alternatively, ‘dry’ sites (particularly where higher temperatures are found closer to the surface) can potentially be utilised by pumping water down one well to induce hydraulic fracturing. This creates a reservoir through which the water is then circulated under pressure, absorbing heat before returning to the surface via one or more production wells. This occurs in a continuous cycle and is commonly known as ‘hot dry rock’ technology.

10.1.4 The footprint of geothermal plant varies considerably according to scale and plant type. Small scale applications would typically include the supply of heat and power to a rural village, whereas a large scale plant may supply an entire city. Power (or CHP) generation plants tend to have a larger footprint than heat-only plants due to the power generation equipment needed. Visible elements of a plant would typically include cooling towers, pipework and one or more buildings to house generation equipment, pumps and compressors.

10.2 B. Technological and financial constraints of geothermal energy

10.2.1 Historically, geothermal plants have been limited to locations where hot springs or geysers are abundant, such as areas of California or Iceland – usually where the earth’s tectonic plates meet. However, recent technological advances, such as the use of ‘hot rocks,’ are now increasing the potential in other areas, including parts of the UK. A significant constraint to the development of geothermal energy has been the high cost of the drilling and testing phase of potential sites and the element of risk that the site ultimately proves not to be viable.

10.2.2 Currently, geothermal energy installations are very scarce in the UK. Existing plants include a system in Southampton which supplies hot water to a number of customers in the city centre as part of a larger district heating scheme[53]. In 2009

[53] Southampton’s system was the UK's first geothermal power scheme. Construction started in 1987 on a well to draw water from the Wessex Basin aquifer at a depth of 1,800 metres and a temperature

plans were announced to develop a heat and power 'hot rocks' plant in Cornwall, an area which has particular potential due to its geology, where granite outcrops containing higher temperatures occur relatively close to the surface.

10.2.3 The temperature of water or steam that can be successfully extracted is an important factor in the type of plant used. Electricity-generating geothermal plants have tended to be more geographically constrained than those solely generating heat, due to the higher temperatures that are needed in raising steam for electricity generation. The locations where these temperatures can be economically accessed are limited. Heat-only plants are able to use a wider range of sites with lower geothermal temperature gradient profiles. Geothermal plants have an inherent energy storage capability which makes them especially suitable for supplying base load power in an economical way.

10.2.4 Economic viability of geothermal plant is affected by many factors but has been demonstrated by numerous installations across several countries. This clearly depends on the selection of an appropriate site and economy of scale, but also on heat utilisation (as with any heat or CHP plant) and external factors such as the price of fossil fuels. Technological advances in using lower temperature heat sources for CHP plant are expected to improve the economics and efficiency, but it is not yet fully known how this may impact the geographical spread of potential sites in the UK.

10.3 C. Planning and EIA requirements of geothermal energy

10.3.1 Geothermal drilling falls under Schedule 2.2(d) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. Local Planning Authorities are required to screen applications for the need for EIA where the area of works exceeds 1 hectare or if the drilling is within 100 metres of any controlled waters.

10.4 D. Summary of potential impacts and design, mitigation and enhancement measures of geothermal energy

Landscape and visual

10.4.1 Compared to most other power plant, including renewables, geothermal has a small footprint relative to the amount of energy it produces[54]. This is because fuel combustion equipment is not needed and the energy source is constant, meaning the plant can operate at high capacity factors. The dominant visual aspect of geothermal plant is usually one or more cooling towers and the plumes of steam they produce.

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of 76DegC. The scheme now heats a number of buildings in the city centre, including the Southampton Civic Centre and the WestQuay shopping centre, by providing 8% of the heat distributed by a larger city centre district heating system that includes other combined heat and power sources.

[54] *Characteristics, Development and Utilization of Geothermal Resources*. (2007) GHC Bulletin.

10.4.2 Careful consideration over the siting and design of geothermal plants is important in minimising visual impacts. The siting of a new plant should aim to ensure the building is in character with its locality and does not interfere with views of existing landmarks. Materials and colours should be used to facilitate the integration of the plant with the surrounding landscape. The incorporation of screen planting in key locations, on and off-site, in addition to landscape restoration works at the end of the construction period will also help minimise visual impacts on the wider landscape.

Air quality

10.4.3 Compared to conventional fossil fuel energy generation, carbon dioxide emissions from geothermal plant are very low as fossil fuels are not combusted. For the same reason, no smoke is produced and the only visible emission is steam.

Historic Environment

10.4.4 Geothermal plant construction involves the drilling of deep boreholes so it is therefore important to consider whether any archaeological remains exist at the development site. An assessment of the archaeological potential of the site should therefore be undertaken prior to excavation or groundworks and, if necessary, an archaeological watching brief should be undertaken during construction.

Noise

10.4.5 Operational levels of noise will be similar to other heat or CHP plants, although plant construction can be noisy during the drilling phase. Appropriate site layout design and siting of particularly noisy plant equipment away from sensitive site boundaries is therefore important to mitigate noise levels at noise-sensitive developments. Similarly, the incorporation of noise attenuation features within the roof and walls of buildings will help reduce noise break-out. If necessary, the local authority can set noise limits at site boundaries or at sensitive receptors to ensure noise levels are not exceeded.

Hydrology and hydrogeology

10.4.6 Extracted geothermal energy is naturally regenerated over time making the resource sustainable, although localised reduction in heat output can occur over long periods. Subsidence and induced seismicity (earth movements) are two issues that need to be considered when withdrawing fluids from the ground. These impacts can often mitigated by injecting the spent fluid back into the same reservoir.

11. Fuel Cells

Technology Summary

Fuel cells are electrochemical energy conversion devices that produce electricity from the energy contained in a fuel. Like batteries, they produce direct current (DC) electricity; but, like engines, they are refuelled (by filling a fuel tank), rather than being recharged with electricity. They can provide an efficient storage and conversion technology, converting up to two-thirds of the energy contained in a fuel into electricity, with the rest being converted to heat.

Fuel cells can be powered by hydrogen, fossil fuels, such as petrol or natural gas, or renewables, such as biodiesel or biogas. The fundamental fuel cell reaction will use oxygen (usually obtained from the air) to react with hydrogen to produce electricity, heat and water, with no other emissions. Overall emissions will depend on the process used to produce hydrogen.

Fuel cells can be used in a very wide range of applications including power storage, transport and to drive CHP plants, but are not yet economically competitive for widespread commercial applications. The main obstacle to their uptake has been the high cost of fuel cell models with acceptable performance and durability.

11.1 A. Description of fuel cells

Figure 11.1: 1MW (4x250kW) fuel cell plant, Sierra Nevada, California

Source: Courtesy of SCS Energy

11.1.1 Fuel cells are electrochemical energy conversion devices that produce electricity from the energy contained in a fuel. Like batteries, they produce direct current (DC) electricity; but, like engines, they are refuelled (by filling a fuel tank), rather than being recharged with electricity. They can provide an efficient storage and conversion technology, converting up to two-thirds of the energy contained in a fuel into electricity, with the rest being converted to heat.

11.1.2 There are several different types of fuel cell which can be powered by a variety of feedstocks including hydrogen, fossil fuels, such as petrol or natural gas, or renewables, such as biodiesel or biogas. Hydrogen is the end-product derived from these fuels that is ultimately used in the fuel cell. Hydrogen is normally produced from hydrocarbons by a chemical process called reformation (which can occur within the fuel cell system or externally), or it can be produced from water by electrolysis. The reformation process strips hydrogen from the fuel producing carbon dioxide, heat and water as by-products.

11.1.3 The fundamental fuel cell reaction will use oxygen (usually obtained from the air) to react with hydrogen to produce electricity, heat and water, with no other emissions. Where renewables are used to produce hydrogen, e.g. using wind or solar electricity for electrolysis, the hydrogen provides a means of storing the energy and the fuel cell a means of using the energy when it is needed. This widens the scope of use of renewable electricity, as instead of only being used at the time it is produced, it can be converted to hydrogen, stored and used as a zero emission energy source when needed.

11.1.4 Fuel cells can be used in a very wide range of applications where they can convert fuel to energy more efficiently than many current technologies. Typical applications of fuel cells include:

- **Power storage** – fuel cells are particularly useful for remote off-grid applications as they are compact, have no moving parts and are very reliable. In these applications, they can be more cost-effective for energy storage in systems where renewables such as wind or solar are used to electrolyse water to produce hydrogen. Instead of a large, expensive battery, a smaller fuel cell can be used with a larger, cheaper hydrogen store. Markets are also developing for applications such as energy storage for laptop computers, cell phones, and military applications.
- **Transport** – a key area of research is the use of fuel cells in transport applications. It is likely that the number of electric vehicles will significantly increase in the future. Prototype vehicles have demonstrated that fuel cells can provide a convenient way of producing electricity on-board from a fuel – hydrogen or otherwise.
- **CHP** – stationary fuel cells can be used to produce heat and power, and are scaleable to potentially supply a wide range of domestic and industrial settings. A fuel cell system has been operating in Woking since 2003 supplying heat and power for a variety of uses[55].

[55] The Woking Park scheme was launched in June 2003 and comprises a 200 kWe fuel cell used as part of a wider CHP system. Hydrogen gas is chemically reformed from natural gas and oxygen is extracted direct from outside air to fuel the cell. The fuel cell is designed to support the Pool in the Park's heating and power systems and Woking Park's lighting. Excess heat produced is used to power the centre's air conditioning, cooling and dehumidification requirements via heat fired

11.1.5 Fuel cells typically come in a range of sizes up to several MW and their modularity enables fuel cell plants to be fully scaled-up according to demand. Residential fuel cell systems are similar in size to a large fridge, although space for fuel storage may also be required unless fuel, such as natural gas, is piped in from elsewhere. Larger scale applications tend to be made up of individual fuel cell modules each within a container-sized enclosure along with a fuel storage tank. As fuel cells are compact, clean and quiet in operation, they can be used in many applications, including sensitive urban locations.

11.2 B. Technological and financial constraints of fuel cells

11.2.1 Fuel cells are currently not economically competitive for widespread commercial applications. The main obstacle to their uptake has been the high cost of fuel cell models with acceptable performance and durability. Manufacturers predict that costs will reduce over time, making more applications (such as use of fuel cells for domestic CHP) economically viable.

11.2.2 Technological advances in the economic production of hydrogen will be key in the development of fuel cells. 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.

11.3 C. Planning and EIA requirements of fuel cells

11.3.1 Electricity generating plants with an electrical output of 50MW or less will require planning permission from the local planning authority under the Town and Country Planning Act 1990. Applications for new electricity generating plants with capacity of more than 50MW will need to obtain consent from the Infrastructure Planning Commission (IPC) as defined under the Planning Act 2008.

11.3.2 Fuel Cells may fall under Schedule 2.3(a) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 which relate to: industrial installations for the production of electricity, steam and hot water, where the development exceeds 0.5 hectare.

11.4 D. Summary of potential impacts and design, mitigation and enhancement measures of fuel cells

Landscape and Visual

11.4.1 Small-scale fuel cell installations are unlikely to have any landscape and visual impacts, as fuel cell units will often be contained within existing plant buildings. Larger installations are often contained within relatively small compact

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absorption cooling. Source: http://www.woking.gov.uk/environment/climate/Greeninitiatives/sustainablewoking/fuelcell.

enclosures/containers, which can be accommodated within existing commercial/industrial areas or sensitive urban locations. As such, the scale and massing of larger installations can be co-located amongst similar sized buildings, which presents an opportunity for minimising impacts on the landscape character of the surrounding area and minimising visual impacts from key viewpoints/settlements.

11.4.2 Careful consideration of the siting and design of larger fuel cell installations is important in ensuring visual impacts are minimised. Enclosures that do no protrude above tree top level can be effectively screened by trees and use should be made of existing screening features such as trees/hedges, shelterbelts and woodlands. Suitable materials should also be used to facilitate the integration of structures with the surrounding landscape.

Noise

11.4.3 Fuel cells are not inherently noisy, particularly if they are sited in existing plant buildings or on existing commercial/industrial areas where they are surrounded by other ‘noisy’ operations. However, an increase in noise levels can occur from ancillary equipment such as heat recovery units, particularly when located in close proximity to noise-sensitive developments.

11.4.4 Appropriate site layout design and siting of particularly noisy plant equipment away from sensitive site boundaries is important to mitigate noise levels at noise-sensitive developments. Similarly, the incorporation of noise attenuation features within the roof and walls of enclosures/containers will help reduce noise break-out. If necessary, the local authority can set noise limits at site boundaries or at sensitive receptors to ensure noise levels are not exceeded.

Hydrology and hydrogeology

11.4.5 Large fuel cell installations can increase the potential of flood risk and surface water runoff as a result of increased hardstanding. To minimise the potential of flood risk and surface water runoff, the following mitigation measure should be incorporated into the scheme design:

- Minimise area of impermeable surface.
- Reinstate vegetation where possible.
- Provide storage and attenuation ponds in line with sustainable drainage techniques (SuDs).
- Use appropriate culverts and drains to match existing hydrological regimes.

Traffic and transport

11.4.6 Traffic movements during the construction and operation of a fuel cell installation will be dependent upon the size of the facility. The transport of fuel will result in traffic movements to and from the site during operation, unless fuel is piped into the site from elsewhere. Larger fuel cell installations require a regular fuel supply, which could significantly increase traffic volumes in the local area. The preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic will minimise any impacts on the local road network during construction. Such a plan should also seek to include measures for vehicle sharing and the avoidance of HGV deliveries during local peak periods to minimise vehicle movements on minor roads.

Air quality

11.4.7 Emissions associated with fuel cells will depend on the type of feedstock fuel used and how this is produced. Where hydrogen is obtained through electrolysis using renewable energy, life-cycle emissions will be close to zero. Emissions will occur where fossil fuels are used to derive the hydrogen, but as the conversion process is highly efficient, the emissions will be significantly lower than if the fuel had been combusted to generate energy.

12. Combined Heat and Power/Combined Cooling Heat and Power

Technology Summary
Combined Heat and Power (CHP) plants produce both electricity and useful heat. This can be a much more efficient use of fuel than using thermal process to produce electricity only, provided that the balance of demand for power and heat is right, and that plant is located close to the source of heat demand. CHP is used extensively in industry and is also used in some district heating schemes. Generating plant which produces electricity, heat and chilling (through the use of absorption chillers) is known as Combined Cooling, Heat and Power (CCHP), or Trigeneration. CHP often uses natural gas, in which case it is an efficient but not renewable energy technology. When a renewable fuel source is used, typically woodfuel, CHP becomes a renewable energy technology. Gas-fired CHP is well-used in industry, but there are few biomass CHP schemes in the UK. CHP plant is available in a range of scales, from micro-CHP domestic applications and medium size plant serving an office block, to large industrial applications and CHP plant serving district heating schemes. The technology is better established for large scale biomass CHP plants in other parts of northern Europe, but small scale biomass CHP is currently less technically proven or economically viable. For CHP to be economically viable, it needs to be carefully sized in relation to the heat and power loads it is supplying. In particular, it is important to understand the heat load profile and how it changes on a daily, weekly and annual basis. This is especially important for CHP plant supplying district heating networks, where there may be a range of users with different requirements.

12.1 A. Description of CHP/CCHP

Figure 12.1: 3.3MWe biomass-fuelled CHP plant in Amel, Belgium

Source: © MW Power

12.1.1 Combined Heat and Power (CHP) plants produce both electricity and useful heat. This can be a much more efficient use of fuel than using thermal process to produce electricity only, provided that the balance of demand for power and heat is right, and that plant is located close to the source of heat demand. CHP is used extensively in industry and is also used in some district heating schemes (see Section 13 – District Heating). Generating plant which produces electricity, heat and chilling (through the use of absorption chillers) is known as Combined Cooling, Heat and Power (CCHP), or Trigeneration.

12.1.2 CHP often uses natural gas, in which case it is an efficient but not renewable energy technology. When a renewable fuel source is used, typically woodfuel, CHP becomes a renewable energy technology.

12.1.3 CHP plant is available in a range of scales, from micro-CHP domestic applications and medium size plant serving an office block, to large industrial applications and CHP plant serving district heating schemes. A CHP plant can either be designed to meet a specific heat load (known as heat-led operation), with the electricity produced being treated as a secondary benefit, or it can be designed specifically for power generation (known as electricity-led operation), with the waste heat being the secondary benefit.

12.1.4 A natural gas fired CHP plant consists of a reciprocating engine or in large installations, a gas turbine, coupled to an electrical generator. Waste heat is extracted from the exhaust gases (circa 450°C, known as high grade heat) via a heat exchanger or heat recovery steam generator. Heat is also available from the water jacket although at a significantly lower temperature (90°C, known as low grade heat). Gas fired CHP plants require no special pre-treatment of the fuel and little end of pipe emissions clean up. They are also relatively cheap in capital and operational terms.

12.1.5 Fuels other than natural gas (for example, wood or straw), are either combusted to raise steam for use in electricity-generating steam turbines, or undergo advanced thermal processes known as gasification or pyrolysis. Gasifiers use the same generating technology as gas fired CHP but add a gasifier in front of the engine/gas turbine which converts the solid fuel into a combustible gas, which is then suitable for use in electricity generation plant such as gas engines. Gasifiers have only been applied to biomass for energy generation relatively recently, and so have a limited track record.

12.1.6 Boilers and steam turbines are the most common and well established way of generating electricity from a solid fuel, be it wood, coal or waste. At small scale (<5MWe), they have relatively poor electrical efficiencies (circa 18-22%) and are therefore more suitable for projects which require much more heat than electricity, typically a ratio of 3:1 after internal losses.

12.1.7 Depending on the scale, CHP plant may be located in a boiler room within an existing building, or in its own building. Large scale plant generally requires a two-storey building. CHP using natural gas has a much smaller footprint (typically 500m^2 for a 2-4MW plant) than for biomass as it does not require any on-site fuel storage, fuel processing or a service area for fuel deliveries. These facilities may require anything up to ten times the area for similar rated biomass plant. For plants incorporating adsorption chilling, addition space may be required for cooling towers. All CHP requires an external flue, the height of which will vary according to the scale of the plant.

12.2 B. Technological and financial constraints of CHP/CCHP

12.2.1 Gas-fired CHP is well-used in industry, but there are few biomass CHP schemes in the UK. The technology is better established for large scale biomass CHP plants in other parts of northern Europe, but small scale biomass CHP is less technically proven or economically viable. Micro-CHP domestic units using gas are available but are not yet cost-effective compared to gas condensing boilers.

12.2.2 The type of biomass used will significantly impact both the technology and economics. Where there is potential for contaminants in the materials e.g. using waste wood or other types of waste, the plant needs to be compliant with the Waste Incineration Directive (WID), which in practice means a significantly more expensive plant due to the cost of fuel pre-processing and 'end of pipe' clean-up equipment. This technology is then classed as 'energy from waste', which is outside the scope of this report.

12.2.3 CHP technologies, particularly gasification, usually require a consistent quality of fuel in terms of particle size and moisture content. Most gasifiers require their feedstock to be dried to below 20% moisture content to maintain their efficiency levels. This can be an issue for virgin wood, i.e. forest residues or energy crops, which typically has a moisture content of around 40% - 50% when harvested. This means that, unless fuel can be delivered pre-dried, a significant proportion of the available waste heat is needed for drying, which reduces the amount available for end users.

12.2.4 For CHP to be economically viable, it needs to be carefully sized in relation to the heat and power loads it is supplying. In particular, it is important to understand the heat load profile and how it changes on a daily, weekly and annual basis. This is especially important for CHP plant supplying district heating networks, where there may be a range of users with different requirements (See Section 13 – District Heating).

12.3 C. Planning and EIA requirements of CHP/CCHP

12.4 D. Summary of potential impacts and design, mitigation and enhancement measures of CHP/CCHP

12.4.1 The potential land use impacts associated with CHP plants along with the design, mitigation and enhancement measures are summarised in the above section on biomass (see Section 5).

13. District Heating

Technology Summary
District heating 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. There is generally believed to be significant potential for district heating in the UK, although relatively few systems are currently in place. The technology typically comprises of an energy centre, a network of insulated pipes 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. In some cases, cooling can also be provided to end-users served by the network. The scale of district heating can range from small scale systems e.g. a biomass boiler supplying a group of ten dwellings, to large scale schemes supplying entire city centres or communities. District heating is adaptable and can utilise a wide range of energy sources such as traditional gas boilers, biomass boilers, gas or biomass CHP systems, and waste heat. As district heat networks are designed to last for many years, this flexibility can also future-proof the system to technological advances. Within the UK, the size and complexity of district heating schemes tend to act as a significant constraint along with the cost and associated risk. The technology itself is less of a constraint as demonstrated by the many successful installations outside of the UK.

13.1 A. Description of district heating

Figure 13.1: Heat main pipework at Heathrow Airport, Terminal 5

Source: © Vital Energi | www.vitalenergi.co.uk

13.1.1 District heating 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. There is generally believed to be significant potential for district heating in the UK, although relatively few systems are currently in place.

13.1.2 The technology typically comprises of an energy centre, a network of insulated pipes 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 (see Section 12) to generate both electricity and heat. In some cases, the heat output can also be used to drive an adsorption chilling process which can then provide cooling to end-users served by the network.

13.1.3 The pipe network can be installed at the same time as other services (water, drainage, etc.) to minimise costs in new developments. This type of system is also suitable for existing buildings, although a programme of works would be required for retrofitting. The scale of district heating can range from small scale systems e.g. a biomass boiler supplying a group of ten dwellings, to large scale schemes supplying entire city centres or communities.

13.1.4 District heating can be adaptable in terms of energy sources. While hot water is normally the energy carrier, the heat itself can be derived from a wide range of fuel, plant and conversion process types, including traditional gas boilers, biomass boilers, gas or biomass CHP systems, and importantly, waste heat from existing processes such as power generation and waste incineration. As district heat networks are designed to last for many years, this flexibility can also future-proof the system to technological advances.

13.1.5 District heating schemes can be operated under a range of business models, with most generally referred to as Energy Service Companies (ESCos). A common arrangement is for an ESCo to take responsibility for constructing, operating and maintaining a network, so that the end-user avoids the risk of maintaining their own plant and just needs to enter into a contract to purchase energy from the ESCo (see also Chapter 17: Financial Drivers and Barriers).

13.2 B. Technological and financial constraints of district heating

13.2.1 One of the main constraints to district heating is the need to identify a sufficient heat demand density. Heat demand density is a spatial characteristic that indicates the degree to which building heat loads are concentrated in a particular area. This characteristic can be used as a broad indication of areas with potential for district heating and can be mapped using GIS methods for both existing and proposed development[56]. Urban areas with high population density offer most potential for district heating schemes. For residential areas, a housing density of at least 40-50 dwellings per hectare is generally found to be a minimum threshold for viability. For a district heating scheme, civil works around the laying of heat mains and establishing connections to individual buildings is expensive; high heat densities therefore mean shorter pipe runs and lower costs.

13.2.2 A lack of overall size and diversity of heat loads can also act as constraints to district heating. Viability is very much site-specific but significant CO_2 savings generally occur at scales above 50 homes, and economies of scale mean that communities of over 500 homes are considered most appropriate for these kinds of schemes[57]. The co-location of existing and new development within district heating schemes can also help to diversify the heat load (i.e. promote a more constant demand for heat) and help to optimise plant design.

13.2.3 The phasing of large developments can present challenges to district heating schemes as the system needs to be able to adapt and accommodate future heat loads as they come on line. Existing buildings situated within or close to new developments which are considering district heating can offer significant benefits in that they can act as district heating 'anchor' points around which new systems could 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.

13.2.4 Within the UK, the size and complexity of district heating schemes tend to act as a significant constraint along with the cost and associated risk. The technology

[56] See Practice Guidance: Planning for *Renewable and Low Carbon Energy – a Toolkit for Planners, Welsh Assembly Government, 2010*
[57] *District Heating and Community Energy*. (2009) Energy Efficiency Partnership for Homes.

itself is less of a constraint as demonstrated by the many successful installations outside of the UK.

13.3 C. Planning and EIA requirements of district heating

13.4 D. Summary of potential impacts and design, mitigation and enhancement measures of district heating

13.4.1 The potential land use impacts associated with the energy centre element of a district heating scheme, along with the design, mitigation and enhancement measures, are summarised in the above section on biomass (see Section 4). The following potential impacts relate to the infrastructure required for distributing heat (i.e. the pipe network).

Landscape and visual

13.4.2 District heating schemes involve the laying of the pipe network in horizontal trenches. Once installed, the pipework is virtually all underground and can be covered with soft or hard surfaces, and so the system will not normally be visible from above ground once constructed. However, the laying of pipes involves ground disturbance and sensitive installation can avoid disturbing ground which would be difficult to restore, such as unimproved grasslands and semi-natural habitats.

Hydrology and hydrogeology

13.4.3 The construction and operation of district heating schemes can have potential impacts on groundwater and watercourses (i.e. aquifers) through heat pollution and the leakage of chemicals used in the pipe system. Pipe fractures are unlikely due to quality control measures and robust testing of equipment, however it is important to ensure that appropriate measures are in place during the construction phase of pipe laying to prevent contamination of groundwater.

Historic Environment

13.4.4 The installation of district heating schemes requires the excavation of trenches for the pipe network. It is therefore important to consider whether any archaeological remains exist at the development site. An assessment of the archaeological potential of the site should be undertaken prior to excavation or groundworks and, if necessary, an archaeological watching brief should be undertaken during construction.

Traffic and transport

13.4.5 Traffic movements during the construction of a district heating scheme will be dependent upon the scale of the scheme. However, the laying of the pipe network will inevitably result in an increase in traffic volumes on the local highway network, albeit this will be limited to the construction phase of the development. Combining construction work for the pipe network with other civil ground works on new developments will minimise disturbance. Furthermore, the preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic will minimise any impacts on the local road network.

Ecology and ornithology

13.4.6 The laying of the pipe network for a district heating scheme could potentially result in the loss of habitats and/or animal species as a result of disturbance and fragmentation resulting from the excavation of trenches. However, construction impacts can be minimised through the restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes in construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes.

Economic impacts

13.4.7 The use of local labour, services and supplies during construction can benefit the local economy, as can the availability of a secure, cheap source of energy which may act as an incentive to businesses interested in locating to or investing in the area.

14. Waste Heat

Technology Summary

Waste heat generally refers to heat produced by machines, electrical equipment and industrial processes for which no useful application is found, and is initially regarded as a waste by-product. When an end-use can then be found for this heat, it can be considered a low carbon technology as the source fuel is then being used more efficiently and will offset the need for additional heating fuel by the new end-user.

The largest sources of waste heat are from power stations and industrial plants such as oil refineries and steelmaking plant. Heat recovery systems can also be used in small scale applications such as computer centres, where cooling systems generate large amounts of waste heat. Larger sources of waste heat can also be used to supply district heating systems serving nearby homes and businesses.

Waste heat recovery technology is well-established but the economics will depend on the amount and quality of heat available and matching this to a suitable end-use.

Waste heat recovery systems will normally be located adjacent to the primary heat production process and it is the primary plant which will tend to dominate in terms of local environmental impact.

14.1 A. Description of waste heat

14.1.1 Waste heat generally refers to heat produced by machines, electrical equipment and industrial processes for which no useful application is found, and is initially regarded as a waste by-product. When an end-use can then be found for this heat, it can be considered a low carbon technology as the source fuel is then being used more efficiently and will offset the need for additional heating fuel by the new end-user.

14.1.2 The largest sources of waste heat are from power stations and industrial plants such as oil refineries and steelmaking plant. Heat recovery processes are often employed to re-use the heat on-site in further industrial processes or for space or water heating. Heat recovery systems can also be used in small scale applications such as computer centres, where cooling systems generate large amounts of waste heat.

14.1.3 Heat recovery technology usually consists of some form of heat exchanger or heat pump. End-uses for the recovered heat will be partly determined by its ‘quality’ i.e. its temperature. Industrial uses for high grade heat (high temperature) include pre-heating of combustion air and steam generation; low grade heat (low temperature) is more likely to be used for space/water heating or drying processes.

14.1.4 Larger sources of waste heat can also be used to supply district heating systems serving nearby homes and businesses. Such a scheme is underway in Barking, London where waste heat from the existing gas-fired power station will be used as part of a phased roll-out of district heating in Barking town centre and beyond.

14.1.5 The scale of systems and infrastructure required to utilise waste heat varies greatly as there are many different types of waste heat sources from numerous processes comprising solids, liquids and gases. Most small scale heat exchangers/pumps will have an appearance similar to air-conditioning units and may be internal or external to a building. A common application involves using heat recovery units mounted on a wall or roof to reduce a building's ventilation energy load. When it is cold outside, the unit recovers heat from outgoing air by using a heat exchanger to preheat fresh incoming air, which the unit then distributes throughout the building. Heat recovery from larger scale industrial processes or power stations will involve substantial infrastructure such as complex pipework (above and below ground), boiler and cooling vessels, flues and water treatment equipment – although much of this is likely to be integrated with existing equipment producing the source heat.

14.2 B. Technological and financial constraints of waste heat

14.2.1 Waste heat recovery technology is well-established but the economics will depend on the amount and quality of heat available and matching this to a suitable end-use. Generally, the higher the temperature of the waste heat, the greater the potential value for heat recovery.

14.2.2 The viability of waste heat recovery from power stations for district heating will be largely dependent on the following factors:

- There should be a sufficient heat load density i.e. a significant nearly population.
- The power station should operate with a high enough load factor to provide a consistent heat resource.
- The power station should have a sufficient remaining lifespan.

14.3 C. Planning and EIA requirements of waste heat

14.3.1 Electricity generating plants with an electrical output of 50MW or less will require planning permission from the local planning authority under the Town and Country Planning Act 1990.

14.3.2 Applications for new electricity generating plants with capacity of more than 50MW will need to obtain consent from the Infrastructure Planning Commission (IPC) as defined under the Planning Act 2008.

14.3.3 Waste heat plants may fall under Schedule 2.3(a) of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 which relate to: industrial installations for the production of electricity, steam and hot water, where the development exceeds 0.5 hectare.

14.4 D. Summary of potential impacts and design, mitigation and enhancement measures of waste heat

Landscape and visual

14.4.1 Small scale waste heat systems require heat exchangers/pumps that capture heat from outgoing air from a building. These units resemble air conditioning units in terms of their size and appearance and can cause visual impacts if not appropriately sited. Consideration should therefore be given to the sensitive design and siting of the pump equipment and its housing, including locating in least visible locations and using materials characteristic of the area.

14.4.2 Larger systems that recover heat from large-scale industrial processes or power stations require more substantial infrastructure (i.e. pipework, boiler and cooling vessels, flues and water treatment equipment) that can have direct visual impacts. However, much of this infrastructure is likely to be integrated within the industrial plant producing the source heat, which is often located on existing commercial/industrial areas, and so the existing plant will normally be the predominant feature within the landscape.

14.4.3 Careful consideration of the siting and design of waste heat systems is important in ensuring visual impacts are minimised. Structures that do no protrude above tree top level can be effectively screened by trees and use should be made of existing screening features such as trees/hedges, shelterbelts and woodlands. Suitable materials should also be used to facilitate the integration of structures with the surrounding landscape, such as the cladding of buildings and colour treatment.

Noise

14.4.4 The external heat exchanger/unit of a small-scale waste heat system that captures heat from outgoing air could potentially result in a modest increase in noise levels at nearby properties during operation. Although these units generally have low noise emissions, the use of anti vibration mountings and acoustic insulation in the scheme design will ensure any noise impacts are minimised.

14.4.5 Larger systems that recover heat from large-scale industrial processes or power stations are likely to generate noise from operational processes (i.e. from pumps, fans and valve steam emissions). However, these systems are likely to be integrated within the industrial plant producing the source heat, which are often located on existing commercial/industrial areas, and so are likely to be surrounded by other ‘noisy’ operations.

14.4.6 Appropriate site layout design and siting of particularly noisy pieces of infrastructure, such as the pumps and cooling vessels, away from sensitive site boundaries is important in minimising noise levels at noise-sensitive properties. Similarly, the incorporation of noise attenuation features within the roof and walls of structures will help reduce noise break-out. Noise impacts resulting from construction activity can be mitigated by restricting working hours and adopting good practice measures for reducing noise in line with British Standards Guidance (i.e. BS 4142 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas).

Ecology and ornithology

14.4.7 The main ecological impacts resulting from large waste heat systems are associated with airborne and waterborne emissions from operational procedures.

14.4.8 The key ecological and ornithological impacts that may occur include:

- Direct and indirect impacts of construction on ecological receptors – for example habitat loss and/or loss of plant or animal species, disturbance and fragmentation arising from the construction of the infrastructure itself.
- Direct and indirect impacts of operation on ecological receptors – for example disturbances to habitats and species from noise, airborne and waterborne emissions resulting from operational procedures.

14.4.9 Many potential impacts on local ecology can be mitigated through the careful design and layout of the associated infrastructure. Construction impacts can be minimised through the siting of plant and infrastructure away from sensitive habitats using buffer protection zones as necessary, restoration of habitat edges adjacent to infrastructure, exclusion fencing and translocation programmes in construction areas. Species specific measures can also be applied to mitigate impacts, such as covering excavation works, provision of escape ramps for mammals, implementing speed limits onsite, protecting watercourses and maintaining hydrological regimes. Impacts on birds and bats can be mitigated by ensuring any vegetation and ground clearance works are undertaken outside the breeding season (March-August).

Hydrology and hydrogeology

14.4.10 The construction and operation of large-scale waste heat systems can have potential impacts on groundwater and local watercourses (i.e. aquifers) through heat pollution and the leakage of chemicals used in the underground pipe system. Pipe fractures are unlikely due to quality control measures and robust testing of equipment, however it is important to ensure that appropriate measures are in place during the construction phase of pipe laying to prevent contamination of groundwater.

14.4.11 Thermal power stations need large amount of water for cooling and steam to run the turbines, therefore there may be impacts on local aquifers used to source this water and appropriate licences from the Environmental Agency will be required.

Historic Environment

14.4.12 The installation of large-scale waste heat systems requires the excavation of trenches for the underground pipe network and foundation pilings for any necessary plant. It is therefore important to consider whether any archaeological remains exist at the development site. An assessment of the archaeological potential of the site should be undertaken prior to excavation or groundworks and, if necessary, an archaeological watching brief should be undertaken during construction.

Traffic and transport

14.4.13 Traffic movements during the construction of a waste heat system will be dependent upon the scale of the scheme. However, the laying of the pipe network and construction of any necessary plant will inevitably result in an increase in traffic volumes on the local highway network, albeit this will be limited to the construction phase of the development. The preparation of a Traffic Management Plan in conjunction with the local transport authority to determine the most appropriate times and routes for HGV traffic will minimise any impacts on the local road network.

15. Cumulative effects

15.1 Where more than one renewable energy scheme is proposed by one or more developers or where a single scheme is proposed in an area with existing schemes, the combined effect of all schemes taken together is known as the 'cumulative effect'. Although it is a fundamental principle of the planning system that each planning application is determined on its individual merits, cumulative effects must also be taken into account.

15.2 If a proposed development requires an Environmental Impact Assessment, Schedule 4, Part 1 of the EIA Regulations[58] states that "*A description of the likely significant effects of the Development on the environment, which should cover the direct effects and any cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the development."* The accompanying guidance on EIA as set out in Circular 02/99 gives further advice in relation to cumulative impacts stating in paragraph 46 that *"in judging ... the effects of a development ... Local Planning Authorities should always have regard to the possible cumulative effects with any existing or approved development."*

15.3 Under the Habitats Regulations (1994), the likely significant effects of any plan or project on a European site of nature conservation importance (e.g. SPAs, SACs, Ramsar sites) alone *or in combination* must also be considered.

15.4 The potential cumulative effects of renewable energy developments may include for example:

- Potential impacts on landscape and visual amenity, viability of bird populations, features of ecological interest, noise levels, road traffic congestion (during construction) as a result of several wind turbine developments within an area.
- Potential impacts on the historic environment – e.g. the cumulative impact associated with the installation of microgeneration technologies (e.g. solar panels, micro-wind etc) within conservation areas which in isolation may not be significant but in combination may result in a change to the character of appearance of the area.

15.5 The cumulative effect of two developments may not simply be the sum of their separate effects, as illustrated by the following generic examples drawn from Scottish Natural Heritage (SNH) guidance[59]:

- The construction of a new building in a rural setting may have a significant visual impact on an otherwise natural scene but the addition of a second building in close proximity to the first may only have a small incremental impact, the two buildings forming a single cluster.

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[58] *Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations* (1999).
[59] *Cumulative Effect of Wind farms: Version 2 revised 13.04.05*. (2005) SNH.

- A single wind farm may give rise to a small increase in bird mortality that is deemed acceptable because it is within the bird population's natural ability to regenerate through reproduction. Addition of a second wind farm may be unacceptable, however, since it increases total bird mortality rates to a level that exceeds the population's ability to regenerate, causing it to go into permanent decline.

15.6 The issue of cumulative impacts can be complex. However, there may be circumstances when a planning authority is willing to accept cumulative impacts where, for example, this means that other, more sensitive areas can be protected from development.

16. Climate Change Effects

16.1 A key issue which needs to be taken into account in assessing the future technical and economic viability of different forms of renewable energy technology is the current and future effects of climate change. Planning Policy Wales (Section 12.1.4) states that in determining applications for renewable and low carbon energy development local planning authorities should take into account:

> *"…the impacts of climate change on the location, design, build and operation of renewable and low carbon energy development. In doing so consider whether measures to adapt to climate change give rise to additional impacts."*

16.2 Emerging guidance on considering the impact of climate change on new energy infrastructure is contained in the draft National Policy Statement (NPS) for energy EN-1[60]. This states that new energy infrastructure should take into account the projected impacts of climate change, using the latest UK climate projections to ensure that they have identified appropriate measures to mitigate risks to the infrastructure from climate change. While the NPS' concern projects above 50MW the advice regarding the projected impacts of climate change can be usefully applied to all planning applications for renewable and low carbon energy infrastructure. It states that whichever emissions scenario that the Independent Committee on Climate Change believes the climate is currently most closely following should be used, along with the 10%, 50% and 90% estimate ranges.

16.3 In 2010 the Assembly Government published the *Climate Change Strategy for Wales*[61] to set out how the Assembly Government intend to limit greenhouse gas emissions and adjust to changes in our climate The following section summarises the predicted climate change impacts within Wales and the implications for the various forms of renewable and low carbon energy.

Summary of Climate Change Impacts in Wales

Temperature, rainfall and sea levels

16.4 Table 16.1 summarises the predicted increases in temperatures in Wales by 2020, 2040 and 2080. The information has been obtained from the document, *Climate Change: its impacts for Wales*, published by the Welsh Assembly Government in November 2009. All changes described are relative to a 1961-1990 baseline.

60 https://www.energynpsconsultation.decc.gov.uk/home

61 http://wales.gov.uk/topics/environmentcountryside/climatechange/tacklingchange/strategy/walesstrategy

Table 16.1 Summary of predicted temperature rises in Wales			
	By 2020s	**By 2040s**	**By 2080s**
Increase in average annual temperatures (°C)	+1.3	+2.0	+3.3
Increase in summer maximum temperatures (°C)[62]	+1.9	+2.8	+4.8
Increase in winter minimum temperatures (°C)[63]	+1.5	+2.1	+3.5
Summer average rainfall	-7%	-12%	-20%
Winter average rainfall	+7%	+11%	+19%

16.5 Average annual rainfall is predicted to stay broadly the same, as the decreases in summer rainfall will be balanced out by the increases in winter rainfall, although there will be some increases in the west and decreases in the east. The greatest summer decreases and winter increases in rainfall will be in South West Wales.

16.6 Sea levels are predicted to rise by 36cm by the 2080s.

Other climate impacts[64]

16.7 **Wind speeds**: It was not possible for UK CIP to make probabilistic predictions (predications with probability levels attached) for wind speeds. A Met Office model predicts little change in onshore average wind speeds across the UK[65].

16.8 **Storms:** As for wind speed, it was not possible for UK CIP to make probabilistic predictions about the frequency and intensity of storms, and so it has not been possible to draw robust conclusions about whether storms will become more or less frequent or intense.

16.9 **Cloud cover[66]:** It is predicted that winter average cloud cover will remain broadly the same, increasing or decreasing by a few percent by the 2080s. Summer

62 Averaged over the whole of Wales over the summer months (June, July and August).
63 Averaged over the whole of Wales over the winter months (November, December and January).
64 *UK Climate Predictions Briefing Report* (2009); http://ukclimateprojections.defra.gov.uk/content/view/826/519/. Again a 1961-1990 baseline is used.
65 http://ukclimateprojections.defra.gov.uk/content/view/1999/519/.
66 *UK Climate Predictions* (2009) User Interface, using medium emissions scenario and 50% probability level, covering the whole of Wales.

average cloud cover may decrease slightly by the 2020s, and is predicted to reduce by around 8% by the 2080s.

Impacts of climate change on different technologies

16.10 Table 16.2 summarises the potential impacts of climate change on the various renewable energy low carbon energy technologies.

Table 16.2: Potential impacts of climate change on renewable energy low carbon energy technologies

Technology	Potential impact
Onshore wind (under 25MW)	There is uncertainty around the potential changes to the onshore wind regime caused by climate change. At present, the best prediction shows little change on onshore wind speeds over the period to the 2080s. Different turbine types cut-in and cut-out at different wind speeds. Correct sizing of the turbine to match the wind regime is important for project economics because power produced is equal to the cube of the wind speed, small changes in the wind speed lead to much larger changes in power production. Likewise, there is uncertainty about changes to the frequency and intensity of storms. Wind turbines cut out in high winds to avoid damage, and so stormier weather could lead to lower wind power production. However, there is too much uncertainty in current climate change impact predictions to recommend what adaptation measures should be used.
Biomass	Changes in temperature, rainfall, and summer water availability could affect growing patterns, leading to reduced or increased yield, depending on the type of tree or crop. Where electricity is produced from biomass, water is needed for steam production and cooling. Reduced water availability in the summer months could lead to restricted plant operation; the same is true for fossil fuel and nuclear power stations.

Table 16.2: Potential impacts of climate change on renewable energy low carbon energy technologies	
Technology	**Potential impact**
Anaerobic digestion	Increased precipitation in winter will increase the risk of flooding. If flood waters were to damage plant, there could be serious pollution impacts allowing slurry to run off into water courses. However, the same applies where slurry is stored in other ways, particularly in pits. Increases in temperatures, particularly during the summer, could lead to increased odours, but again this also applies to slurry stored in other ways, particularly pits. Where electricity is produced and water is needed for steam production and cooling, reduced water availability could lead to restricted plant operation in the summer months. This also applies to fossil fuel and nuclear power plants.
Biofuels	Changes in temperature, rainfall, and summer water availability could affect growing patterns, leading to reduced or increased yield, depending on the type of crop. The same conditions will have an impact on food production, which could lead to future restrictions on the quantity of biofuels that can be produced from food (although it is to be hoped that in future it will be possible to produce biofuels from the non-edible, woodier parts of food crops and from wood itself).
Hydroelectric	Changes in rainfall patterns will lead to reduced electricity production in periods of drought and increased production in periods of higher rainfall, although increased production is only possible up to the capacity of the turbine. It will be necessary to consider the predicted impacts of climate change on river flows as part of the project design and the environmental permit process. In cases of flooding, equipment may be damaged. This is more likely in small schemes where the turbine and generator are situated in a turbine house on the river bank. The impact will be greater on run-of-the-river schemes which do not have water storage. Schemes which do have storage can help to regulate flooding in periods of heavy rainfall.
Solar Power (solar thermal)	Summer cloud cover may decrease slightly, which would lead to higher solar thermal production in the summer months.
Solar Photovoltaic	Summer cloud cover may decrease slightly, which would lead to higher production from solar panels in the summer months.
Geothermal energy	Predicted changes in the climate will have little impact on geothermal energy.

Table 16.2: Potential impacts of climate change on renewable energy low carbon energy technologies	
Technology	**Potential impact**
Heat Pumps	Higher average annual temperatures will lead to more heat being captured by the ground and in bodies of water over the summer, which could improve winter performance of ground and water source heat pumps.
Combined Heat and Power/Combined Cooling Heat and Power	Changes to growing patterns due to higher temperatures could affect the availability of biomass for biomass-fuelled CHP systems. Increases in minimum winter temperatures could reduce the amount of heat required from CHP systems used for district heating, meaning that the heat load is insufficient to make the system efficient. Increases in maximum summer temperatures could increase the need to adapt systems to include cooling.
Waste heat	Thermal power stations need large amount of water for cooling and steam to run turbines. Limited water availability may force power stations to operate at reduced capacities. However, drought periods will be more likely in the summer, when there is limited need for home heating, and so there the knock-on impact on district heating systems is likely to be negligible.

17. Financial Opportunities and Barriers

Introduction

17.1 This section briefly summarises the main financial opportunities and barriers to the uptake of renewable and low carbon energy developments in Wales.

Direct Financial Assistance (Income)

Clean Energy Cashback Scheme (Feed-in Tariff)

17.2 From April 2010 **householders and communities** who generate their own ***electricity*** from renewable or low carbon sources can obtain regular payments from their energy supplier. The Clean Energy Cashback Scheme (Feed-In Tariff (FIT) will be open to new projects until at least 2020. The scheme aims to incentivise small-scale (maximum 5MW) low carbon electricity generation, in particular by individuals, households, and organisations (including community groups) who have not traditionally been involved in the electricity market except as end users. The technologies supported are anaerobic digestion, hydro, solar PV and wind. As a pilot, the scheme will also support the first 30,000 installations of micro-CHP with an electrical capacity of 2kW or less. The maximum installation size will be 5MW.

17.3 The FIT has two elements.

Generation tariff	Paid to generators for all the electricity they generate, regardless of whether it is used on-site or exported to the grid. The amount of this tariff varies according to the type and scale of technology.
Export tariff	Paid to generators for the electricity they export to the grid.

17.4 For domestic properties generating electricity mostly for their own use, income from the FIT will not be subject to income tax. Generators can opt out of the export tariff and instead sell their electricity on the open market.

17.5 The tariff level varies according to type and scale of technology, and type of installation. For example, the FIT for a PV retrofit up to 4kW is higher than the same size PV system for new build. The tariff lifetime also varies between technologies; from 10 to 25 years, or 27 years in the case of microgeneration (50kW or less) which has transferred from the Renewables Obligation (see below). For more information visit the Energy Saving Trust website on http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Feed-in-Tariff-Clean-Energy-Cashback-scheme.

Renewables Obligation Certificates

17.6 The Renewables Obligation (RO) has been the main support scheme for renewable electricity projects in the UK since 2002. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a tradable certificate issued to an accredited energy generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier[67].

Interaction of the FIT with ROCs

17.7 With the introduction of the FIT, generators with a capacity of 50kW or less (known as 'microgenerators') will no longer be eligible for support under the RO. Those that were previously being supported under the RO will need to find a supplier who can pay them the FIT. Generators with a capacity of more than 50kW and up to 5MW (known as 'small generators') can choose whether to receive support under the RO or the FIT (unless they applied for the RO before 15th July 2010, in which case they must stay with the RO). Once they have chosen, they cannot switch schemes. Renewable electricity installations of more than 5MW will continue to be supported under the RO.

17.8 The range of installation size that the FIT covers means that it will apply to both smaller, building-integrated renewables (up to 50kW) and larger, stand-alone renewables (up to 5MW). The latter, which have a choice between the FIT and the RO, will need to make a decision on a case-by-case basis about which scheme is best for them.

Renewable Heat Incentive

17.9 At time of writing the UK Government consulted on proposals for a Renewable Heat Incentive (RHI), which would offer direct financial support to renewable heat installations and which is planned to start in April 2011. It will be similar to the FIT in that tariff levels and the length of time over which the tariff is paid will vary by technology, and in that it will be open to new projects until at least 2020. Two major differences are that: there will be no upper limit on installation size for the RHI; and because heat is not normally metered, for most installations payments will be made according to an estimated level of generation (known as 'deeming')[68].

Indirect Financial Assistance (Grants)

17.10 The following section provides a summary of the main grants available for energy efficiency and renewable energy.

[67] see http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx.
[68] See http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/renewable_heat/incentive/incentive.aspx.

The Carbon Emissions Reduction Target

17.11 The Carbon Emissions Reduction Target (CERT) requires energy suppliers across Great Britain to install carbon saving measures in households; the majority of these involve insulation but there is scope to install microgeneration technologies as well. It is up to the energy suppliers to decide which measures to use, and the amount of microgeneration to be installed as part of the scheme is therefore not fixed[69].

Community Energy Saving Programme

17.12 The Community Energy Saving Programme (CESP) is similar to CERT, but requires energy suppliers and generators to focus on specific low-income areas of Great Britain[70].

Arbed Strategic Energy Performance Investment Programme

17.13 The Arbed Strategic Energy Performance Investment Programme[71] aims to help fund energy efficiency and renewable energy retrofit installations for households in Wales' Strategic Regeneration Areas. The first phase was launched in November 2009 with over £30m allocated to the programme through the Welsh Assembly Government's Strategic Capital Investment Fund (SCIF)[72].

Ynni'r Fro (Community Scale Renewable Energy Generation)

17.14 This Assembly Government project intends to support community-scale renewable energy projects across Wales. It will enable the establishment or further development of some 22 sustainable social enterprises based on new community scale renewable energy installations. The project will be delivered through the Energy Saving Trust (EST) providing project management, technical advice and grant administration services procured in accordance with EC requirements. This consists of three elements, the provision of development support, preparatory grants and capital grants. For further information contact the Energy Saving Trust Wales[73].

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[69] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx.
[70] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx.
[71] http://wales.gov.uk/topics/environmentcountryside/energy/efficiency/arbed/?skip=1&lang=en.
[72] http://wales.gov.uk/topics/environmentcountryside/energy/efficiency/arbed/?skip=1&lang=en
[73] http://www.energysavingtrust.org.uk/Energy-Saving-Trust-Wales.

18. Community Involvement and Benefits

Introduction

18.1 This chapter outlines the scope for community involvement in renewable energy developments, including both small scale, community-owned developments and large scale commercial schemes. The range of potential benefits and the mechanisms necessary for securing these are also discussed. The chapter includes a number of case studies which provide examples of where communities have benefited from involvement with renewable energy developments in the UK. Much of the existing literature on community benefits focuses on wind energy developments, hence the greater emphasis on this type of technology in this chapter.

What is 'community benefit' and 'community involvement'?

18.2 A 'community benefit' in the context of renewable energy developments can be described as:

> *"… a "goodwill" contribution voluntarily donated by a developer for the benefit of communities affected by development where this will have a long-term impact on the environment"[74].*

18.3 The increasingly common approach taken by developers in delivering such community benefits, particularly for wind energy developments in Wales, is through a financial contribution to a community fund[75]. The level of financial contribution is usually related to the capacity (in MW) of the development and payments are made annually throughout the lifetime of the installation.

18.4 Communities may also benefit from establishing their own renewable energy developments (which may also benefit from the Feed in Tariff – see Chapter 17). As such, benefits move beyond the peripheral status referred to in the above definition, where reliance is on the 'goodwill' of the developer, to direct 'involvement' by the community itself. The distribution of any 'outputs' from the development therefore remain within the control of the community. These different approaches to community involvement in, and benefits from, renewable energy developments are discussed in more detail later in the chapter.

The UK Context and Lessons from Europe

18.5 As noted above, any contribution from a renewable energy developer for the benefit of the community is not mandatory in the UK. It cannot be a condition of planning, unless it is justified to mitigate a negative impact of the development (e.g. restoring a natural habitat). Examples of community benefits secured through the planning system include Planning Obligations and certain types of developer

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[74] Highland Council website: www.highland.gov.uk/livinghere/communityplanning/communitybenefit/.
[75] *Wind Farm Development in Wales: Assessing the Community Benefits. A research project for the Welsh Assembly Government.* (2007) Cowell, R., Bristow, G., Munday, M., and Strachan, P.

offers (see Annex B of TAN 8). Beyond impact mitigation, the local planning authority has little power to enforce any community benefit. Any proposed benefits that are offered are not a material consideration unless they are directly relevant to planning and the proposed development[76]. In referring to community benefits offered through major wind farm development, TAN 8 makes it clear that Local Planning Authorities, where reasonably practical, should facilitate and encourage such proposals and make clear in their development plans the scope of possible "planning contributions", whilst ensuring that such contributions do not enable permission to be given to a proposal that otherwise would be unacceptable in planning terms.

18.6 Community benefits, particularly from wind farms, are increasingly becoming a matter of routine in European countries which have seen high levels of renewable energy developments. Rather than relying on the goodwill of developers, benefits are integral to the development process, through, for example, local tax payments, jobs and manufacturing opportunities, and local ownership.

18.7 By ensuring local or regional manufacturing and construction jobs, imposing taxes that accrue locally, and support mechanisms that enable local ownership, community benefits from wind energy developments in Germany, Denmark and Spain have effectively become 'built into the fabric' of the development process. Whilst it is appealing to attempt to mirror such approaches in the UK, some aspects would be very difficult to replicate, requiring fundamental changes to planning and taxation systems. For example, the use of permitting systems in Spain to support local manufacturing does not sit with the UK's strict interpretation of EU procurement rules[77] that stipulate a fair and competitive tendering system. However, there are number of case studies from the UK which demonstrate some of these community benefits evident on the continent, although benefits are mainly limited to indirect financial benefits through local contracting and employment; in-kind contributions; direct financial contributions to a community fund; and income through local ownership or shares.. These are outlined in more detail below under the heading of 'Securing Community Benefits'.

The Role of Local Authorities in Securing Benefits

18.8 Community benefits, beyond those considered necessary mitigating actions, are not considered material to the planning decision in the UK. A local authority can play a role in helping communities to benefit from renewable energy developments, but to avoid conflicting interests, the local authority must either process the application before becoming involved in negotiations, or ensure any discussions about community benefits that run in parallel to the planning decision are kept completely separate (i.e. with different officers and/or councillors involved in each

[76] *Community benefits from wind power. A study of UK practice and comparison with leading European Countries. Report to the Renewables Advisory Board and the DTI.* (2005) Centre for Sustainable Energy and Garrad Hassan. www.cse.org.uk/pdf/pub1049.pdf.
[77] *Community benefits from wind power. Policy Maker's summary*. (2005) Centre for Sustainable Energy and Garrad Hassan. www.cse.org.uk/pdf/pub1051.pdf.

aspect)[78]. The advantage of the latter approach is that it ensures discussions and community involvement are initiated early in the process- an approach promoted by the Protocols for Public Engagement with Proposed Wind Energy Developments[79]. Some developers favour the former however, with fears that any community benefits offered will be seen as an attempt to 'buy' planning permission.

18.9 The following case studies provide examples of renewable energy developments that have delivered community benefits through practical intervention by the local authority. Some of these examples are sourced from the Community Benefits Toolkit, as referenced.

Case Study 1 : Argyll and Bute Council (see also Annex B of TAN8)

The potential for harnessing renewable energy resources is significant in the area of Argyll and Bute. The council has also recognised the potential for such developments to help alleviate some of the social and economic problems of the area. It has therefore taken a proactive approach and developed its own policy on delivering community benefits from renewable energy developments. In doing so, concerns over potential conflicts of interest, inherent in the common approach of creating community wind farm trust funds (via Section 75 agreements), are avoided. It also ensures that benefits are not limited to communities in the immediate vicinity of the development. The council's aim is to forge strong long-term relationships with renewable energy companies in their area and achieve maximum benefits for local and wider communities.

The process developed by Argyll and Bute maintains the necessary separation from the planning decision-making process. It is delivered under the mechanism of the Local Government (Scotland) Act 2003 'powers of wellbeing', making the process more transparent. Renewable energy companies proposing developments in the area voluntarily enter into an agreement under a Strategic Concordat with the council. In doing so, they agree to provide funding at preset levels and proportions to the immediate community and to the Argyll, Lomond and Island Energy Agency (ALI Energy). A number of parties will be involved in the negotiation and agreement of individual Trust Fund details, including the developer, the community, ALI Energy and the Council[80].

[78] *Delivering community benefits from wind energy development: a toolkit. Report to the Renewables Advisory Board.* (2009) Centre for Sustainable Energy, with Garrad Hassan & Partners Ltd, Peter Capener & Bond Pearce LLP. www.decc.gov.uk/Media/viewfile.ashx?FilePath=What%20we%20do%5CUK%20energy%20supply%5CEnergy%20mix%5CRenewable%20energy%5CORED%5C1_20090721102927_e_@@_DeliveringcommunitybenefitsfromwindenergyATookit.pdf&filetype=4.

[79] *The Protocol for Public Engagement with Proposed Wind Energy Developments in Wales. A report for the Renewables Advisory Board and DTI.* (2007) Centre for Sustainable Energy with BDOR Ltd and Peter Capener. www.berr.gov.uk/files/file38706.pdf.

[80] For more information about the Argyll and Bute's community benefits policy see: www.argyll-bute.gov.uk/content/planning/environment/renewablenergy/.

Case Study 2: Nottinghamshire County Council

In Nottinghamshire the Council adopted a quite different approach to ensuring community benefits from renewable energy development (although also utilising the power of well-being), establishing 'Renewable Nottinghamshire Utilities Ltd' - a private company limited by guarantee and set up as a social enterprise. This stemmed from the County Council's Wood Heat Project and aims to 'develop the physical and commercial infrastructure necessary to encourage the wood heat industry into the East Midlands'[81]. It provides support and opportunities for local wood fuel supply contracts, thereby offering environmental, social and economic benefits to the local community. The well-being power enables Nottinghamshire County Council to own a stake in the company (limited to 19%) whilst also maintaining its role in determining renewable energy developments.

Case Study 3: The Highland Council

The Highland Council has also taken a proactive approach in ensuring community benefits from renewable energy developments, by producing guidance notes and clearly setting out their policy on the issue. The guidance shows preference for communities to take the lead in negotiations, with support available from the Area Manager. The Council clearly states that any members taking part in negotiations will forgo any involvement in determining the planning application. Guidance is also provided on the level of community benefit contribution in monetary terms. A charity, dedicated to supporting communities in Scotland in sustainable energy projects, has also been established[82], although this is targeted more at communities wanting to develop their own projects, rather than negotiating benefits from a proposed development.

18.10 The Community Infrastructure Levy (CIL) as enabled under the Planning Act 2008 was introduced on 1 April 2010. The CIL enables Local Authorities in Wales to fund infrastructure required to implement development plan proposals. It cannot be used to rectify existing infrastructure deficiencies. The CIL is discretionary for Local Planning Authorities to decide whether, or not, to introduce it, and is linked to the Local Development Plan. The CIL charge is liable on development defined as 'buildings' into which people access on a regular basis. More information on the CIL can be found in Chapter 17.

Securing community benefits

18.11 As discussed above, examples throughout the UK and Europe demonstrate broad scope for communities to benefit from renewable energy developments. Benefits to the community may result from actions by the developer. These benefits may be incidental, such as the generation of local employment in the manufacture, construction and operation; integral to the development process, such as habitat

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[81] *Local authority legal powers to promote sustainable energy: case studies. A report funded by the Pilkington Energy Efficiency Trust*. (2006) Impetus Consulting Limited. www.impetusconsult.co.uk/PEET_R.pdf.

[82] Community Energy Scotland: www.communityenergyscotland.org.uk/.

enhancement and impact mitigation; or directed, through financial payments by the developer to a community fund. Alternatively, a renewable energy development may be entirely community-driven with direct local ownership and control.

18.12 Community benefits from wind farms can be categorised into four areas:

- Local contracting and employment – during construction and operation.
- Benefits in kind – the developer provides or funds: a new (or improvements to an existing) community facility, environmental features, visitor and/or educational facilities, etc.
- Community funds – direct financial contributions from an external developer.
- Local ownership – local people wholly own or have shares in the project.

18.13 Each of these is described below, with signposting to the relevant case study examples[83]. Note – further case studies of interest are included in Annex B of TAN8.

Local contracting

18.14 Indirect financial benefits may be accrued to the local economy through fabrication and construction work and ongoing maintenance. As discussed in the previous section, other European countries have made this a condition of planning, but the current UK procurement framework prevents such an approach. Furthermore, some aspects of the project are likely to require specialised materials or labour that are not available locally anyway. However, for those aspects that could be sourced within the vicinity of the site, the developer and Local Authorities or development agencies can all play a role in maximising this opportunity as described below.

18.15 By providing details locally of the specification of works early in the development process, and holding briefings for contractors in the locality, developers can give local businesses and industry a 'head start'. The developer can make clear to all their contractors and suppliers a clear preference to source labour and materials locally, on sustainability grounds, where this is possible.

18.16 Local Authorities and/or economic development agencies can assist by identifying contractors potentially qualified to deliver contracts and providing, through economic development officers, active encouragement and support to local contractors to engage with the developers and the tendering process. They can also engage with the developer early to secure a commitment to encourage local sourcing of labour and materials.

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[83] These case study examples have been taken from the Renewable Benefits Toolkit: *Delivering community benefits from wind energy development: a toolkit. Report to the Renewables Advisory Board.* (2009) Centre for Sustainable Energy, with Garrad Hassan & Partners Ltd, Peter Capener & Bond Pearce LLP.
www.decc.gov.uk/Media/viewfile.ashx?FilePath=What%20we%20do%5CUK%20energy%20supply%5CEnergy%20mix%5CRenewable%20energy%5CORED%5C1_20090721102927_e_@@_DeliveringcommunitybenefitsfromwindenergyATookit.pdf&filetype=4.

18.17 Case study examples:

- Nottinghamshire County Council (see Case Study 2 above).
- Awel Aman Tawe (see Case Study 4 below).

Benefits in kind

18.18 These comprise local activities delivered directly by the developer, such as improvements to local facilities and infrastructure, environmental enhancements, providing tourism, recreational or education facilities, etc. These actions need to remain separate from those mitigating actions that are a necessity of planning approval.

18.19 Offers of and opportunities for benefits in kind should consider: the authenticity of the 'benefit' being offered to the community; who benefits and how; the best approach for delivering this benefit (e.g. directly by the contractor or with a financial contribution to the community); specification and timetable for delivery; and any ongoing maintenance requirements (cost and responsibility).

18.20 The provision of benefits in kind could be enforced through planning obligations (Section 106), or will require an agreement between the developer and local community body.

18.21 Case study examples:

- Altahullion Wind Farm (see Case Study 5 below).
- Beinn an Tuirc Wind Farm (see Case Study 6 below).
- Cefn Croes Wind Farm (see Case Study 7 below).

Direct financial benefits

18.22 The first type of community benefit as listed above, involves a direct financial contribution paid by the developer. This is may be:

- An annual payment per megawatt, for an agreed number of years of the project. This has the advantages of being simple, low risk for both parties and provides ongoing, long term support.
- A lump sum payment, at the start of operation or some other time. This has the advantage of providing large and immediately accessible funds, which could meet an existing need for capital. However, if no such need is immediately apparent, an investment strategy should be developed to help manage the fund long term.
- A payment related to project revenue. This provides an even lower risk strategy for the developer, but introduces heightened risk for the community, as payment

would be affected by poor performance or low prices. Agreeing a minimum payment level could help to reduce this risk.

18.23 The above approaches may be offered in combination, for example a lump sum payment followed by (lower) annual payments to provide ongoing revenue to the community.

18.24 Identifying communities that should benefit from direct financial benefits will depend on the type, scale and location of the development. However, consideration could be given to:

- Proximity to the development.
- Visual impact.
- Level of disruption and nuisance during construction.
- Previous uses of the development site.
- Number of residents.

18.25 In some cases, limitations on the application of the funds have been enforced, for example that the money should be used to support further sustainable energy initiatives. In others the fund is simply for the benefit of the community and left to the community's discretion. Determining the purpose of the funds when the fund is initially set up can avoid difficult discussions at a later stage.

18.26 Case study examples:

- Cefn Croes Wind Farm (see Case Study 7 below).
- Novar Wind Farm (see Case Study 8 below).
- Deeping St Nicholas Wind Farm (see Case Study 9 Below).

Local ownership

18.27 Individuals and communities can gain direct financial benefit from a wind energy development through ownership. Performance and profitability of the development will govern the level of financial gain. In addition to direct financial benefits, some research suggests local ownership can have wider benefits stemming from local involvement in the development process. Such benefits include: increasing levels of social acceptance of wind energy; social benefits through interaction and cooperation; raising awareness of environmental and sustainability issues; and technical innovation and developing local knowledge and skills.

18.28 Local, community ownership may be achieved by individuals or groups directly investing in a development for a share of the profits. However, this raises a number of issues. As with any shareholding, there is an element of risk: return is not guaranteed and even if the project is successful, may take several years to pay through. Investing in a project also requires a level of personal finance that will exclude certain members of the community and administrative requirements can present further barriers.

18.29 However, schemes do exist to facilitate direct investment in wind energy projects by individuals and communities. Such schemes may offer low investment opportunities, making them accessible to the wider community (though still not all encompassing, requiring some level of personal finance). Shareholders involved in the scheme will often be concentrated within the vicinity of the development, thereby providing a form of local community benefit, although all returns on investment are paid to the individual.

18.30 There are approaches that enable local communities to have a share in a local wind farm without actually investing themselves. For example, the developer may offer shares in the company or ownership of a turbine(s) as a 'gift' to a local community organisation. The financial benefits would be paid to the organisation for investment in local initiatives. However limitations on how the community group can use its 'ownership' would have to be applied, which essentially means the gifted share of profits is being offered at a percentage of its total value. The advantage of this approach is that revenue is directly related to performance of the development. However, this also presents risks of low rates of return.

18.31 Case study examples:

- Deeping St Nicholas Wind Farm (see Case Study 9 below).
- Talybont-on-Usk Energy (see Case Study 10 below).
- Bro Dyfi Community Renewables (see Case Study 11 below).
- Earlsburn Wind Farm (see Case Study 12 below).

Case Study Examples

Case Study 4: Awel Aman Tawe[84] (local contracting)
Awel Aman Tawe (AAT) is a community energy project that grew out of a local Agenda 21 meeting in 1998. A community owned wind farm was identified as an 'innovative and effective' method of generating revenue that could be used for local regeneration projects. Despite significant development work, a planning application for four turbines was rejected, as was a later application for two turbines, due to the visual impact of the scheme. However, with grant funding, the project has grown significantly in other directions, to encompass a range of renewable energy and energy efficiency measures. These include: the installation of hot water solar panels on local community centres, private dwelling and a cinema (funded by the Energy Saving Trust and the Local Regeneration Fund through the National Assembly of Wales); PV on the roof of a local school (funded by the Energy Saving Trust's PV Demonstration fund and the National Assembly's Local Regeneration Fund); a thermafleece insulation project; and a biomass district heating scheme for a new Family Housing Association

[84] For more information: www.awelamantawe.org.uk/shared_pages/body.php?lang=english&cat=1.

development in a deprived village. For the latter, the fuel is likely to be accessed from a new local wood granules supply company based five miles from the village (Brynaman), thereby reducing transport costs and environmental impact and providing up to 8 new local jobs.

Case Study 5: Altahullion wind farm (in-kind contribution)

Altahullion is a 20 turbine site, with an installed capacity of 26MW, situated near Dungiven, County Londonderry, Northern Ireland. During the pre-application stage of the Altahullion wind farm, a local community group requested that tourist work be included in the development. Although not material to the planning decision, the developers of the wind farm implemented a number of measures in response to this request.

The turbine closest to the main road was identified as a tourist turbine. A car park was created on site and visitors are able to follow a footpath leading right up to the turbine. Information boards provided by the wind farm owner, the RSPB and the local council provide information about the wind farm and associated environmental issues. The Road Service Department installed a road sign identifying the wind farm as a place of interest and a Sustrans cycle route also passes by the site.

The local council, Limavady Borough Council, now markets the site as a tourist attraction on its website (www.limavady.gov.uk/visiting/attractions/14/) and it features in their 2008 visitor guide (www.limavady.gov.uk/filestore/documents/publications/Final_Visitor_Guide_2008.pdf).

For more information:
www.res-ltd.com.

Case Study 6: Beinn an Tuirc wind farm (in-kind contribution)

The Beinn an Tuirc wind farm, developed and owned by Scottish Power and located in Kintyre (Argyll and Bute), was commissioned in December 2001 and consists of 46 turbines with a generating capacity of 30.4MW. The environmental assessment undertaken as part of the proposal identified a pair of golden eagles at the site, resulting in some adjustments to turbine siting.

Planning conditions required the developer to submit a bird monitoring scheme, maintenance programme including details of measures to minimise the impact of maintenance works on the eagles, and to avoid carrying out construction works during the eagle breeding season.

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Scottish Power decided to go above and beyond these obligations by developing a

£2 million habitat enhancement scheme, led by their consultant ornithologist that would benefit the eagles by increasing the availability of important prey species such as red grouse, and making the eagle territory sustainable in the longer term. The Habitat Management Plan includes actions to: manage an area of some 700 ha of existing heather moorland, through burning; clear an area of 450 ha of commercial forestry to enable the natural heather moorland to regenerate; and control predator populations (foxes and crows). Scottish Power has employed a full-time ranger to oversee the management of the site. At the time, this was the first such site to have a full-time ranger and is a good example of best practice, in having someone 'on the ground' who knows the site and can oversee its management. The ranger reports to the Habitat Management Committee, which includes representatives from Scottish Natural Heritage, RSPB and Argyll & Bute Council.

For more information:
www.scottishpowerrenewables.com/pages/golden_eagle_habitat_beinn_an_tuirc_argyll_bute.asp.

Case Study 7: Cefn Croes wind farm (in-kind contribution; and direct financial benefit)

Responsibility for mitigation of landscape and environmental impacts of the Cefn Croes wind farm (Ceredigion, Wales) was assumed by the developer (Falck Renewables) as an inherent aspect of the planning proposals. Therefore, this was not included as a planning condition for the development. However, a Section 106 agreement was drawn up for funds to further enhance the land, through the implementation of a Land Management Plan, overseen by the Environmental Management Committee.

The 39-turbine, 58.5MW wind farm was officially opened in June 2005. Subsequent to the planning decision, the committee was established and a detailed management plan was submitted based on the framework agreed under the Section 106 condition. The committee is a partnership of bodies including with the Forestry Commission, the Welsh Assembly, ADAS (an environmental and rural solutions and policy advisor), the Countryside Council for Wales, the RSPB, and Ceredigion Councils.

Cambrian Wind Energy (wind farm operator and subsidiary of Falck Renewables) contributes £10,000 per year for the lifetime of the wind farm (totalling £250,000) for the restoration of the site's ecological value, lost through commercial forestry and intensive agriculture at the site prior to the wind farm's construction.

For more information:
www.falckrenewables.com/projects/project_details/index/34.

Cefn Croes – Community Trust Structure

In addition to the site restoration works, a trust fund committee has also been established to manage a community fund, index-linked to the generating capacity of the wind farm for community projects.

This Trust has five trustees, one from Cambrian Wind Energy and two from each of the community councils of Pont-ar-Fynach and Blaenrheidol. The Trust is now a registered charity. The funds are managed by the Trustees, who consider applications twice a year for project funding from the local communities and other charitable organisations. The purpose of the Trust is to support any type of activity that involves local people, through small community organizations, that benefits their community. The Trust Deed states that the funds will be spent in Ceredigion with priority given to projects in the two community council areas most affected by the development.

For more information about Cefn Croes Wind Farm Community Trust: http://ponterwyd.pumlumon.org.uk/index.php?page=104&lang=eng..

Case Study 8: Novar wind farm (direct financial benefit)

Before the 17MW wind farm at Novar received planning permission in 1996, the developer, National Wind Power Ltd (now npower renewables), notified the Highland Council of its intention to donate to a community fund. Negotiations took place during and after the determination of the planning application, involving representatives from the three nearest community councils (Ardross, Alness and Kiltearn), local council members and the local area manager. The agreed sum was index-linked, beginning at £1,000 per MW per year.

Separate negotiations took place between the three community councils to agree the distribution of funding according to the proximity of the wind farm to each community council area and the size of its population. The council's local area manager facilitated these negotiations. They resulted in a three-way split of 36.6%, 33.3% and 30% in the allocation of funds. Payment is made to the Highland Council, which then disseminates funding to the respective community councils as previously agreed. Whilst this limits the level of direct contact between the site operator (npower renewables) and the community councils, this has the advantage of reducing administrative demands on the former.

Projects that have benefited to date include, Ross-shire Care Scheme for Handicapped Children, the West End Community Hall, the Millennium Garden Project for Alness Environmental Group and Alness & District Times Community Newspaper.

As well as groups benefiting, two individual members of the community also received funding: one to participate in a national cricket competition, and another to attend a drama week in Glasgow during the school holidays.

For more information:
http://www.npower-renewables.com/novar/index.asp.

Case Study 9: Deeping St Nicholas (direct financial benefit; and local ownership)

As part of the consultation process for the Deeping St Nicholas wind farm, Wind Prospect (project developer) set up a community liaison group of 7 people; this did not include the council project planning officer in order for them to remain an objective body. Six meetings were held pre-application and three post-application.

The development, which comprises eight 2 MW REpower wind turbines on land at Vine House Farm and Worths Farm, near Spalding, Lincolnshire, became fully operational in the Summer of 2006. The site is open to visitors, and offers regular open days and organised tours. Groups, such as school parties, can also contact the site owner directly to arrange a private visit.

In addition to having access to the site for educational purposes, local people also had the opportunity to invest directly in the development. The Fenland Green Power Co-operative (www.fens.coop), an initiative set up in association with Wind Prospect Ltd, gives local people the opportunity to invest in wind farm developments in their area. The share offer for the Deeping St. Nicholas development raised £2.66 million- enough to purchase 2 operational 2MW wind turbines at the site. Each shareholder, who invested an average of £2400, now owns a stake in the wind farm.

The wind farm at Deeping St. Nicholas also contributes to the Deeping Fen Wind Farm Trust. The trust fund was given £30,000 initially and receives £10k annually from the wind farm. The Trust Committee administer the fund and award grants to local projects, primarily to promote energy efficiency and conservation. However, recognising that small communities may be not be able to comply with these narrow guidelines, all of the time, and that long-neglected community projects could be realised with an injection of funding, the grants are not restricted solely to projects related to environmental enhancement.

For more information:
www.windprospect.com/wf_project?wf=23&c=engineering_completed&p=services&pa=e.

Case Study 10: Talybont-on-Usk Energy (local ownership)

Talybont on Usk Energy (TOU Energy) is a not-for-profit community enterprise formed following a series of public meetings by Brecon Beacons National Park Authority, in 2001, on the potential for community renewables, which prompted interested individuals to take the ideas forward. Initially all efforts were voluntary, until funding from Powys Association for Voluntary Organisations enabled a Project Development Officer to be employed part-time. TOU Energy focuses on all aspects of sustainable energy, from energy efficiency to renewables. In 2005 the group saw its first community renewable installation - a micro-hydro plant at the site of an old turbine - completed. The scheme was funded by grants from Beacons National Park Authority Sustainable Development Fund, Welsh Development Agency and Mid-Wales Energy Agency. Electricity generated by the hydro plant is sold to the grid and the revenue generated is used to fund further renewable energy and energy efficiency projects in the community, all led by the community-initiated Talybont on Usk Energy[85].

For more information:
www.talybontenergy.co.uk/index.php.

Case Study 11: Bro Dyfi Community Renewables (local ownership)

Bro Dyfi Community Renewables (BDCR) is community energy cooperative. It was established in 2001 with the aim of developing community-owned renewable energy projects in the Dyfi Valley area of Wales. The first community-owned project – a 75kW turbine - was installed in 2003. The project was funded from a share offer, from 55 individuals and a sum from an Energy Saving Trust grant, and some grant funding from Scottish Power Green Energy Trust and the European Commission. The turbine originally supplied nearby CAT (Centre for Alternative Technology) with power, with the surplus being sold to the National Grid. Latterly however, CAT has installed its own CHP plant so all power generated from the turbine goes to the Grid. A power purchase agreement (PPA_ was signed with Good Energy, providing over £100 per MWh generated. Revenue generated is split between shareholders, who receive an annual dividend, and a community energy fund, which receives 30% of the profits. The community energy fund is to be used support other sustainable energy projects in the area, included providing energy efficiency measures to local households. More recently, BDCR has replaced a non-operational wind turbine with a 500kW turbine, again using finance raised through a share offer and European funding.

For more information:
www.bdcr.org.uk/content/index.php.

Case Study 12: Earlsburn wind farm (local ownership)

The original proposal for the Earlsburn wind farm, put forward by the Renewable Development Company (RDC) and Falck Renewables, was for a 14-turbine development, with a capacity in the region of 30MW, on a site on the Campsie Hills, Stirling. As part of the proposal, the developers offered a typical community benefit package of an annual payment, proportional to the capacity of the wind farm, to communities local to the site. However, one local village, Fintry, saw opportunity to extend the scope of the benefits of the development, to include all members of the community, with potential to have a wider influence on energy use behaviour and attitudes, within the village and beyond.

Fintry therefore put forward its own proposal for an additional ‘community’ turbine at the site, bringing the total to 15. The turbine would be uniquely ‘owned’ by the

[85] CSE, 2009. Best practice review of community action on climate change. Report to the Energy Saving Trust.
www.cse.org.uk/downloads/file/Best%20Practice%20Review%20with%20Case%20Studies_140509.pdf.

village, with the revenue it generated going in to a community fund. With RDC's support, the proposal was successful and planning permission secured for an additional turbine. A finance deal was agreed with Falck Renewables, whereby Falck agreed to pay the full initial cost of the 'Fintry Turbine' and the village pay this back over the first 15 years of operation.

Fintry Development Trust was set up to manage the revenue received from the operation of the turbine, with the aim of reducing the carbon footprint of the village as a whole. Its activities include working with a local PhD student to gather baseline data; an energy survey of all buildings in the village identifying opportunities for loft and cavity wall insulation to be installed for free.

The Fintry community believe their approach demonstrates a truly holistic approach to a community wind energy development. The benefits go beyond financial – the turbine is symbolic of the commitment and enthusiasm of the local community to changing their energy use and events such as a community open day at the site and a visit by the village primary school can help to sustain and encourage this commitment.

The experience in Fintry is being shared with other communities, through a consultancy service, with the aim of providing reassurance to communities concerned about wind energy developments.

For more information:
www.free-energy.org.uk.

In addition to the benefits to the Fintry community, Falck renewables pay £35,000 annually to the Earlsburn Wind Farm Community Benefit Fund. This fund is managed by the Scottish Community Foundation and will provide grants to charitable activities that: 'enhance quality of life for local residents'; 'contribute to vibrant, healthy, successful and sustainable communities'; or 'promote community spirit and encourage community activity'. For more information about the Earlsburn Wind Farm Community Benefit Fund:
www.scottishcf.org/resources/funds/view/60/earlsburn-community-benefit-fund/?from=E/1.

19. Renewable and Low Carbon Developments in Designated Areas and Sites

Introduction

19.1 This chapter considers the role of renewable and low carbon energy generation within nationally designated areas and sites – including designated landscapes (e.g. National Parks, Areas of Outstanding Natural Beauty (AONBs), Heritage Coasts), nature conservation areas (Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Sites of Special Scientific Interest, National Nature Reserves etc) and sites/areas of historic importance (e.g. World Heritage Sites, historic landscapes, Registered Parks and Gardens, Ancient Monuments, Conservation Areas and listed buildings). This includes an overview of the key issues associated with the development of renewables and low carbon energy technologies within designated areas and sites.

Overview of Designated Areas and sites

Landscapes of National Importance

19.2 There are three nationally defined landscapes in Wales – National Parks and, AONBs and Heritage Coasts. There are three **National Parks** (Brecon Beacons National Park, Snowdonia National Park, Pembrokeshire Coast National Park) covering 4,122 sq km, equivalent to 20% of the total area of Wales. These National Parks are home to only 2.9% of the Welsh population – roughly 83,300 people, although they attract 22.2 million visitors per year. By area they contain 10% of the Sites of Special Scientific Interest (SSSIs) in Wales and 32% of the National Nature Reserves. They also contain 26% of the Welsh Scheduled Ancient Monuments[86].

19.3 There are five **Areas of Outstanding Natural Beauty** (AONBs) within Wales: Anglesey, the Clwydians, Gower, Llŷn and Wye Valley (the latter is shared with England)[87]. Whilst covering only 5% of Wales, these AONBs are also landscapes of national importance having the same level of statutory protection as National Parks.

19.4 Nearly half of the Welsh coastline is also recognised as **Heritage Coast** including 14 different stretches of coastline, 11 of which are within National Parks or Areas of Outstanding Natural Beauty.

National Nature Conservation Designations

19.5 There are five international/national nature conservation designations within Wales: (the international designations include Special Protection Areas (SPAs), Special Conservation Areas (SACs), Candidate Special Conservation Areas (cSACs)

[86] All the statistics in this paragraph provided by CCW.
[87] *An introduction to Areas of Outstanding Natural Beauty in Wales.* (2003) CCW.

and Ramsar sites. The national designations include Sites of Special Scientific Interest (SSSI)s and National Nature Reserves).

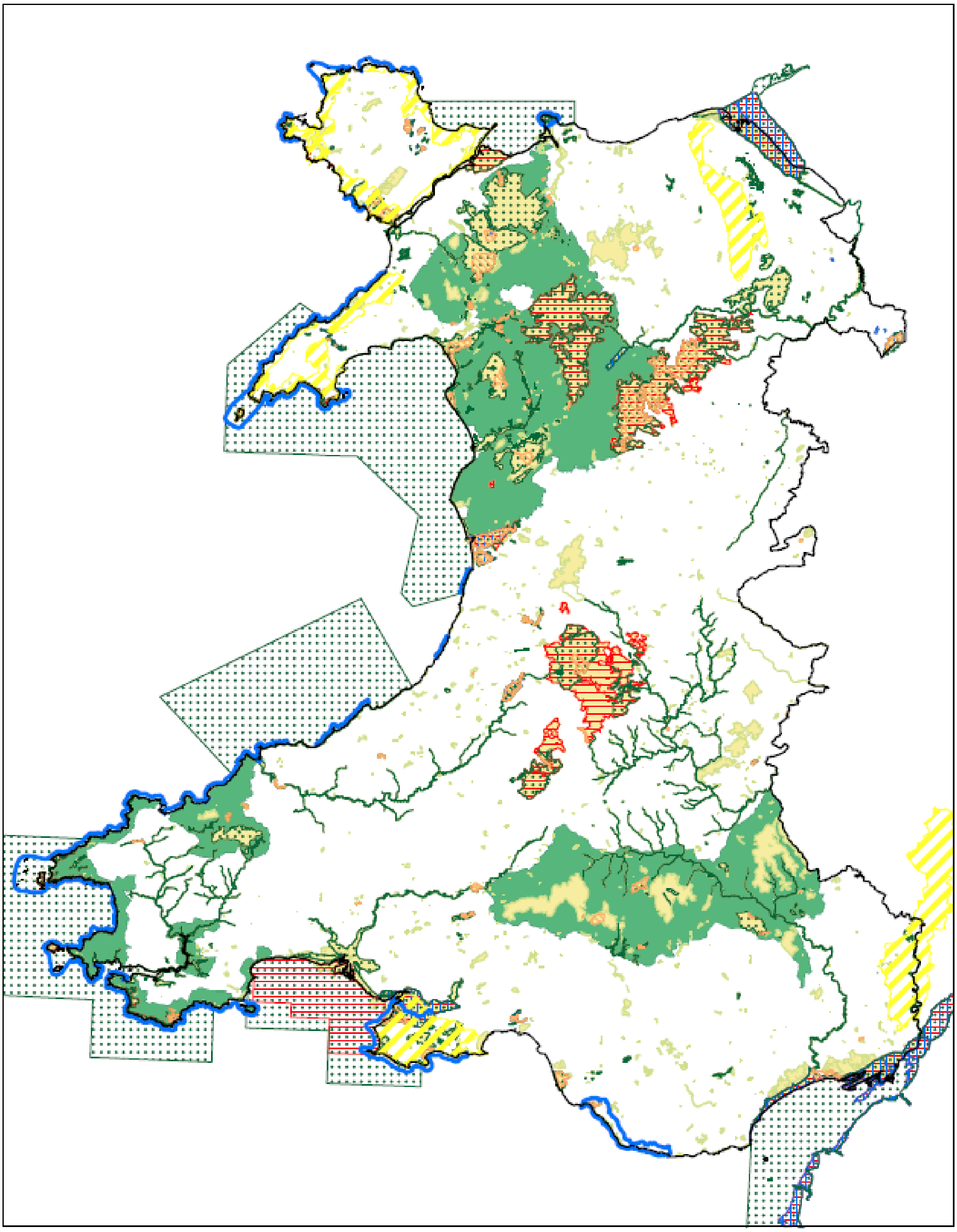
19.6 There are 19 **SPAs** and 90 **SACs** or **candidate SACs** in Wales. SACs and SPAs are protected under the European Community Habitats and Birds Directives respectively

19.7 **Ramsar sites** are wetlands of international importance designated under the Ramsar Convention and there are 10 sites within Wales. They are especially important for waterfowl which gather in Wales during winter from nearly every part of the northern hemisphere. All Ramsar sites in Wales are also Sites of Special Scientific Interest, which means that they have legal protection and guidelines for management.

19.8 There are more than 1,000 **SSSIs** in Wales, covering about 12% of the country. SSSIs are a national suite of sites providing statutory protection for the best examples of the UK's flora, fauna, or geological or physiographical features.

19.9 Wales also has 72 **National Nature Reserves (NNRs)** covering a diverse array of landscapes and habitats. NNRs were set up to conserve – and to allow people to study - their fauna, flora, or geological features of special interest. All of Wales's NNRs are also Sites of Special Scientific Interest.

19.10 A summary of the statutory purposes of these landscape and nature conservation designations and policies relating to their protection are outlined in *Planning Policy Wales* (2011) & TAN 5: *Nature Conservation and Planning* (2009) Sections 5.1 – 5.4, Annex 3. Approximately 635,100 hectares or nearly 30% of the total land area of Wales is covered by the national landscape or nature conservation designations outlined above. A map showing the location of these designated areas and sites is provided in Figure 19.1.



WAG Renewable Energy Study

Figure 19.1: National landscape and nature conservation areas in Wales

Key

Ramsar sites
Special Areas of Conservation (SACs)
Special Protection Areas (SPAs)
Sites of Special Scientific Interest (SSSIs)
National Nature Reserves (NNRs)
National Parks
Area of Outstanding Natural Beauty (AONB)
Heritage Coasts

0 8,500 17,000 34,000 Km

N W E S

File: S:\4700\4788 WAG Renewable Energy Study\GIS\Themes\ArcGIS9\4788-01_001_Designations.mxd

Historic Environment

19.11 The main sites, buildings and areas of historic interest within Wales include - World Heritage Sites, landscapes of historic interest, Registered Parks and Gardens, Ancient Monuments, Conservation Areas and listed buildings.

19.12 Wales has two **World Heritage Sites**[88] - the Castles and Town Walls of King Edward in Gwynedd, and the Blaenavon Industrial Landscape. It also hosts approximately 600 **Conservation Area**s, 370 **Historic Parks and Gardens,** 4121 **Scheduled Ancient Monuments** and nearly 30,000 **Listed Buildings**.

19.13 In 1998 and 2001, as a first step towards raising the profile of historic landscapes in Wales, Cadw, CCW and ICOMOS (UK)(International Council on Monuments and Sites) published the two-volume Register of **Landscapes of Historic Interest** in Wales. This advisory and non-statutory document highlights what are considered to be the best examples of different types of historic landscape in Wales.

19.14 A summary of the importance of these historic sites and policies relating to their protection are outlined in Planning Policy Wales and Circulars 60/96, 61/96, 1/98.

Existing policy context for renewables and designated sites/areas

19.15 Planning Policy Wales (Section 12.8-10) makes it clear that renewable energy projects should generally be supported by Local Planning Authorities provided environmental impacts are avoided or minimised, and nationally and internationally designated areas are not compromised. It goes on to state that the development of wind farms or other large-scale renewable energy schemes will not generally be appropriate in internationally or nationally designated areas.

19.16 Planning Policy Wales (Section 12.8-10) also maintains that where a development is likely to cause demonstrable harm to a designated area by virtue of having a significant adverse impact on the qualities for which the site was designated, consideration should be given to refusing the development if such effects cannot be overcome by mitigation measures, planning conditions or obligations.

19.17 Paragraph 8.4 of Annex D to TAN 8: Renewable Energy states that there is *"an implicit objective in the TAN to maintain the integrity and quality of the landscape within the National Parks/AONBs of Wales i.e. no change in landscape character from wind turbine development."* TAN 8 also states that large wind power proposals within a National Park or designated AONB would be contrary to well established planning policy and therefore were not considered for the SSAs. The Natura 2000 network, historic landscape designations, the core area of the Dyfi Biosphere

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[88] Please note that World Heritage Sites are not a statutory designation but rather are identified by 'inscription' on the UNESCO listing maintained by the international World Heritage Programme.

Reserve, and the World Heritage Site at Blaenafon were similarly all excluded from consideration as SSAs (TAN 8: Renewable Energy, 2005, para. 2.7).

19.18 In its policy statement for the National Parks in Wales[89], the Welsh Assembly Government welcomes the progress being made by the NPAs in stimulating and supporting sustainable resource use in their areas. It encourages the NPAs, working in conjunction with partner organisations, to build on this in the future - especially in the key sectors of tourism, transport, construction and energy – so the Parks can provide models of sustainable resource use in the Welsh countryside.

19.19 It also reiterates TAN 8 – stating there should be no significant change in landscape character as a result of wind turbine development within National Parks (or the AONBs). In conjunction with this, it is an aim of the Welsh Assembly Government that, where feasible, transmission cables should be under-grounded. It is also noted that while wind turbines raise specific issues in the National Park context, other types of renewable energy generation may have more potential for development – especially perhaps at the community level – and subject to planning considerations. This may include hydro-electric and biomass/biofuels projects which may be encouraged as sustainable exemplar systems.

19.20 In addition to formal policy guidance on renewables outlined in national and local policy documents, the three National Parks have developed *Guidance for Sustainable Design in the National Parks of Wales*[90]. This includes advice on the design of renewable energy schemes for standalone and integrated renewables (i.e. within buildings) within the National Parks. The National Parks are proposing to adopt the guidance as Supplementary Planning Guidance.

19.21 With regard to the historic environment, Cadw are in the process of finalising guidance on *Renewable Energy and Your Historic Building: Installing Micro-generation Systems.* This is due to be published in June 2010. This provides guidance for building owners, equipment installers and Local Planning Authorities when considering the installation of micro-generation equipment on the key design issues that need to be considered in relation to historic buildings.

Existing renewables activity

19.22 There is little comprehensive information available on the numbers and types of renewable projects which have been granted planning permission within or in close proximity to designated areas and sites within Wales. However, existing evidence suggests that much is being done to promote renewable energy and a low carbon economy within designated areas – most notably in the National Parks. Within Snowdonia for example, three times more energy is generated within the Park than is consumed[91].

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[89] *Policy Statement for the National Parks and National Park Authorities in Wales: Working Together for Wales* (2007) WAG.

[90] *Guidance for Sustainable Design in the National Parks of Wales.* (2009) Brecon Beacons, Snowdonia and Pembrokeshire Coast National Park Authorities.

[91] Excluding pump storage facilities.

19.23 There are a wide range of initiatives which have been or are in the process of being progressed within the National Parks. Three notable areas of activity include:

- **The use of Sustainable Development Funds (SDF)[92] to support initiatives and projects linked to energy awareness, energy efficiency and renewable energy.** For example, within Snowdonia National Park, over 25 projects relating to renewable energy activity have received SDF funding – these cover a range of different initiatives from biomass demonstration events to the refurbishment of community buildings incorporating renewable technologies. In the Brecon Beacons, the Renewable Energy Assistance Programme (REAP) launched in September 2006 which is partly SDF funded currently offers advice and grants for members of the public and community groups for most forms of micro renewable energy sources including solar thermal, PV, hydro-electric, wood-fuelled heat systems, heat pumps, and wind.
- **Use of renewables within the NPAs own estate.** For example Snowdonia NPA is proposing to construct a small-scale hydro power scheme at the environmental studies centre in Plas Tan y Bwlch. In Pembrokeshire the NPA's head office, several schools and leisure facilities use biomass fuels for space and water heating.
- **Work of local community groups.** For example PLANED[93] and the West Wales ECO Centre have worked hard with local communities, individuals and businesses within Pembrokeshire Coast National Park, encouraging a wide range of local initiatives such as Area Energy Groups, renewable energy trips/workshops, reports and studies aimed at carbon emissions reduction. The ECO Centre also provides energy efficiency and renewable energy advice services to householders and community groups within the National Park, and further afield.

Key issues for the development of renewables and designated landscape and nature conservation areas

19.24 The following section provides a discussion of the key issues associated with the development of renewables within designated landscape and nature conservation areas. A summary of the key issues associated with historic sites is provided in the following section. It is generally acknowledged that designated areas and in particular protected landscapes have a vital role to play in contributing towards reducing carbon emissions. This is recognised in many of the management plans for designated landscapes. It is also evident that renewables could have a key role to play in boosting economic and social regeneration within these areas. However, this needs to be achieved within the context of accommodating

[92] The Sustainable Development Fund is provided to National Parks and AONBs in Wales to aid the achievement of National Park and AONB purposes by encouraging individuals, communities groups and businesses to cooperate together to develop practical sustainable solutions to the management of their activities.
[93] Pembrokeshire Local Action Network for Enterprise and Development.

development without unacceptably compromising the purposes/integrity of the designations.

19.25 Key issues of particular relevance to the development of renewables within designated areas include:

- Recognition that the generation and use of renewable energy is an essential part of making these protected areas more sustainable and therefore is an essential part of their role as test beds of sustainable development[94] - with a particular emphasis on community and household generation that meets local needs.
- The need to maximise the contribution of renewable energy developments to support the rural economy – i.e. through the creation of local jobs and skills development.
- The potential for tapping into the strong sense of community which can be prevalent in designated areas such as National Parks. Within the Pembrokeshire Coast National Park, for example, there is a very high level of commitment to energy saving and the development of renewable energy resources, as indicated by the work of PLANED and the West Wales Eco Centre, as well as many local groups and individuals, that are very well informed on the renewable opportunities available.
- The potential for renewable energy developments to contribute towards environmental objectives within designated areas – for example through the use of biomass linked to the management of existing woodland and the extension of semi-natural woodland.
- The need to consider renewable energy within the context of the wider energy hierarchy and not overlooking the importance of energy reduction and energy efficiency. For example, the main factor influencing Snowdonia National Park's energy use is the nature of its built heritage – mostly solid walled traditional buildings which are intrinsic to the area's special qualities. To this end, the development of technology to improve traditional buildings' energy efficiency whilst retaining their character is considered to be a priority.
- Concerns regarding the potential direct and indirect environmental impacts of certain types of renewable energy developments within or in close proximity to designated landscape or nature conservation areas – i.e. landscape and visual impacts of large-scale wind energy developments and traffic impacts of medium-large scale biomass projects.
- Concerns regard the cumulative impact of renewable energy developments and their ancillary infrastructure on protected areas i.e. the landscape and visual impacts of wind farm developments adjacent to designated landscapes.

[94] *Review of the National Parks of Wales.* (2004) Land Use Consultants.

19.26 To date, limited work has been undertaken to assess the capacity of designated areas within Wales to accommodate renewable and low carbon energy; aside from the Pembrokeshire Coast National Park Renewable Study which is outlined in more detail at the end of this chapter. With 30% of Wales covered by national landscape and nature conservation designations, it is important that the potential of these areas to accommodate renewable and low carbon energy is realised. However, when undertaking assessments of the capacity of these areas to accommodate renewables, due consideration must be given to ensuring that the type and level of development proposed can be accommodated without compromising the purposes/integrity of the designations.

19.27 In considering the different types of renewable energy technology that could be developed within designated areas, it is possible to identify a hierarchy of three distinct categories:

- **Those technologies that operate in symbiosis with the objectives of designated areas (for example, as expressed in their management plans) and help support the existing rural economy** - as in anaerobic digestion of farm and tourism wastes and aspects of biomass linked to the management of existing woodland and the extension of semi-natural woodland within National Parks and AONBs and the use of existing mills sites to generate hydro power.
- **Those technologies that have no or limited impact on the environment and have the potential to make significant renewable energy contributions to individual households and communities** - such as ground and air source heat pumps; solar technologies associated with individual premises; and micro-hydro.
- **Those technologies that can have an impact on the environment but nonetheless can make a significant contribution to energy generation** - such as larger scale biomass plants and large scale wind energy developments. It is acknowledged that developments of this nature within designated areas could have a potential impact on the integrity/purposes of statutory designated sites and therefore may not be appropriate.

19.28 In order to maximise the potential benefits of renewable energy within designated areas, the development of community or local renewable energy schemes has a key role to play. Aside from environmental implications, all local renewable energy sources meeting local energy needs will help support the local economy in terms of broader skills, new jobs and services. In addition, revenue from energy production can be recycled locally rather than exported out of the area.

19.29 The development of renewables within designated areas has the potential to deliver significant benefits, as long as the location, scale and design of the schemes are appropriate and do not compromise the purposes of the designation. However, designated areas such as National Parks are ‘living landscapes’. Change will be inevitable. It is the extent of change that is deemed acceptable, balanced against the national and international imperative to reduce carbon emissions that needs to be weighed up.

Case Study 12: Renewable Energy Assessment for Pembrokeshire National Park Authority

In 2008, the Pembrokeshire Coast National Park Authority with partners commissioned a study to assess the potential for renewable and low carbon energy development within the National Park. The study sought to take a more pro-active role in identifying potential opportunities for renewable energy developments within the National Park, and to embed the findings of the study in the National Park Local Development Plan with policies to enable those types of renewable and low carbon generation deemed appropriate within the study. More specifically, the study aimed to provide clear information on the contribution that the National Park area could make to potential renewable energy provision to help meet the Welsh Assembly Government's targets, without compromising the National Park purposes.

The study involved six main activities:

- Collection of national, regional and local datasets identifying renewable resources available (e.g. water power) and the constraints to energy generation such as, nature conservation designations, protection of water resources, and grid connection issues.
- Consultation with key organisations and individuals on the potential for renewable energy developments within the National Park including officers of the National Park Authority (NPA); Pembrokeshire County Council; PLANED; the West Wales Eco Centre; Forestry Commission; Countryside Council for Wales; Coed Cymru; Pembrokeshire Bioenergy; Welsh Water; and Western Power Distribution.
- A landscape sensitivity assessment covering those aspects of renewable energy generation that are likely to have a landscape-wide effect, namely the planting of biomass crops and wind turbine developments.
- Review of the economic potential/feasibility of the various renewable energy technologies – including identification of relevant funding sources.
- Review of the potential for renewables within the study area, taking into account the key environmental, economic and social constraints and opportunities and the need to ensure that the purposes of the National Park are not compromised.
- Assessment of the opportunities for the potential renewable resources to be delivered via community based schemes.

The information provided by the study was used to develop targets for renewable energy developments and planning policies for inclusion in the Local Development Plan (end date 2021).

Key issues for the development of renewables and the historic environment

19.30 The following section provides a brief discussion of the issues associated with the development of renewables in the context of the historic environment. A more detailed summary of the potential impacts of different renewable energy technologies on the historic environment is provided in the relevant sections of chapter.

19.31 The key issues associated with the development of renewables in the context of the historic environment include:

- Potential loss or direct impact on identified features of historic interest (e.g. scheduled ancient moments, listed buildings and features of archaeological interest - including undiscovered archaeology.) as a result of the construction/installation of a renewable energy technology itself.
- Potential loss or direct impact on identified features of historic interest as a result of the ancillary features of renewable energy developments – e.g. access tracks, control buildings, grid connections.
- Indirect impacts on the character/appearance and setting of features of historic interest. For example, historically sensitive settings and views are particularly vulnerable to damage from large-scale renewable energy developments e.g. wind turbines, large-scale biomass plants.

19.32 Microgeneration technologies such as solar PV or thermal and heat pumps can also have potential impacts on the historic environment as detailed in previous chapters**.** As previously outlined, guidance on the appropriate installation of microgeneration technologies within the historic environment is provided in Cadw's draft publication *Renewable Energy and Your Historic Building: Installing Micro-generation Systems.*

20. Influencing Planning Decisions

Introduction

20.1 This chapter focuses on the role of development management officers in the decision making process for renewable and low carbon energy applications. Following an overview of the consenting mechanisms, the chapter provides specific advice on:

- The role and nature of pre-application advice.
- The role of good design.
- The use of planning conditions.
- The use of planning obligations.

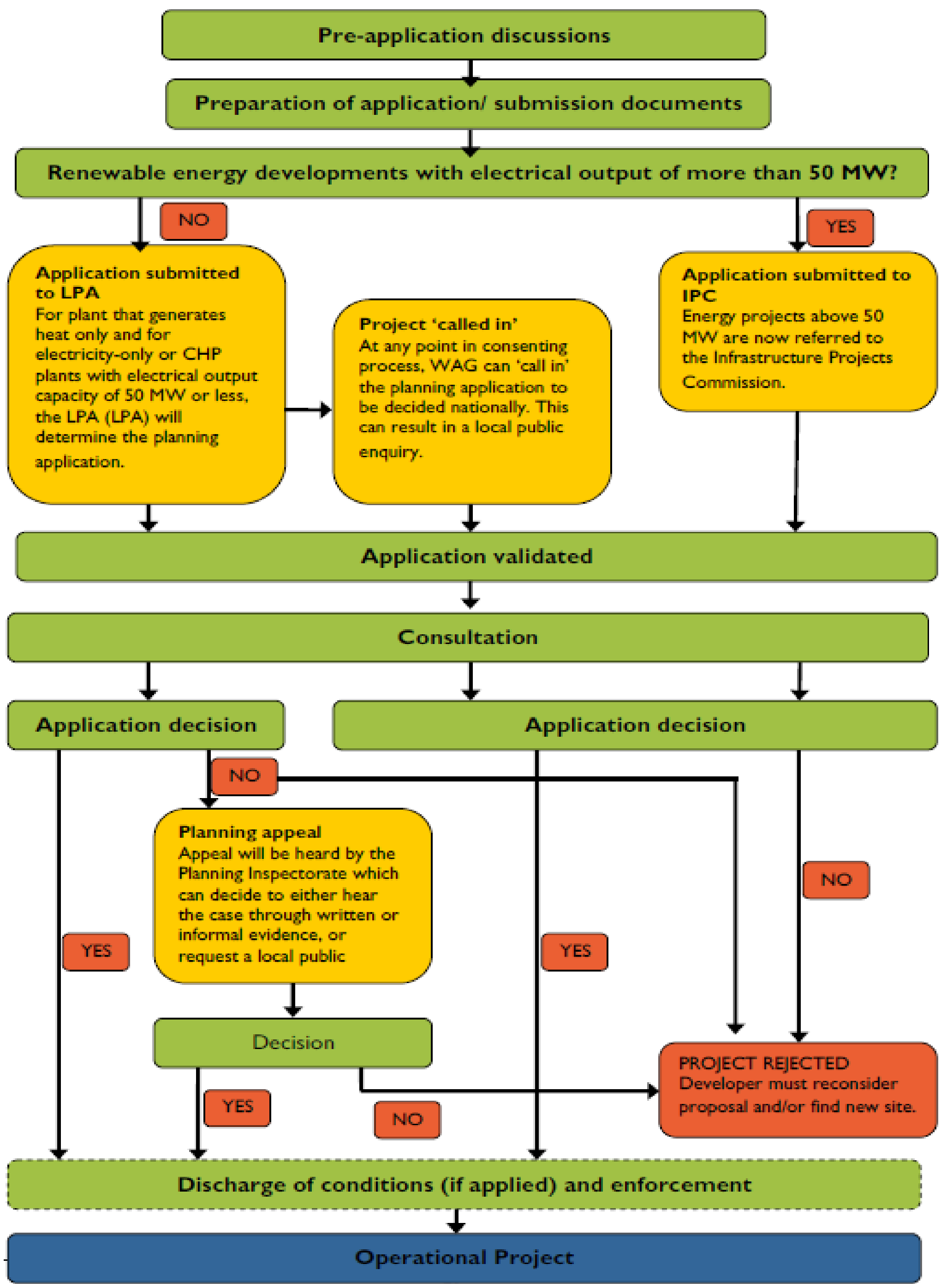
20.2 This chapter provides a summary of the potential role that these mechanisms could play in facilitating the delivery of renewable energy developments.

Consenting Mechanisms

20.3 Energy is largely a reserved matter for the UK Government. Local Planning Authorities are responsible for determining planning applications for renewable energy developments an electrical output capacity of 50MW or less. Renewable energy developments with an electrical output capacity of more than 50MW (or 1MW offshore) are currently determined by the Department for Energy and Climate Change. The Welsh Assembly Government is formally consulted on all such applications, as is the host LPA. The Planning Act 2008 introduced a new planning regime for nationally significant infrastructure projects, including energy generation over 50MW. The Act empowers the newly established Infrastructure Planning Commission (IPC) to examine applications and make recommendations on nationally significant developments. As part of this process, Local Authorities are required by the IPC to produce a 'local impact report'. The IPC must have regard to this report in making its decision-making. More detailed information on the IPC and the role of Local Authorities is available from the IPC website http://infrastructure.independent.gov.uk/.

20.4 Renewable energy developments can be connected to the electricity network by means of an underground cable or overhead line. The connection to the electricity network is the responsibility of the local Distribution Network Operator. Where the works required to connect the development to the local electricity distribution network are not permitted under the General Development Order it will be necessary to submit either a separate planning application or, in the case of an overhead line, an application for consent of the Secretary of State (for DECC) under Section 37 of the Electricity Act 1989 (in which event the Local Planning Authorities are statutory consultees). Either the developer or the local electricity distribution company may make such an application. However, notwithstanding that a separate application to a separate decision-maker may be necessary, electricity companies are encouraged to cooperate with the local planning authority during consultations about the application to construct the wind farm, in order that any preference or need for overhead or underground connection may be demonstrated. Developers should provide information on the most likely route and method for the grid connection to the farm with their planning application and as part of any EIA.

Figure 20.1 Guide to the current planning consenting process for renewable energy applications.



Role and Nature of Pre-Application Discussions

20.6 Dialogue between developers and planning authorities early on in the application process can help both parties to save time, money and effort and may result in an improved application being submitted with an increased chance of success. Planning authorities may be able to provide advice on a range of issues that can assist potential developers, including the history of a site and any previous planning applications and any planning policies or constraints that may affect the likely success of an application. In 2007 the Welsh Assembly Government consulted on a draft Technical Advice Note 17 *Planning and Managing Development*.[95].

20.7 The quality of an application may also be improved significantly by taking advice from the planning authority and may help developers to realise more fully the potential of a particular site and to achieve the maximum local benefits. In addition, early consultation with planning officers may help to identify more quickly where there is a need for expert advice and input, which may save time and money overall. In some cases, it may be possible to establish that an application has very little or no chance of success, therefore preventing developers wasting time and money in producing and submitting an application for which there is no reasonable chance of success. On the other hand, Local Planning Authorities may be able to point developers to sites or areas which are likely to be more acceptable for renewable or low carbon energy development.

20.8 TAN 22: *Planning for Sustainable Buildings* (2010) provides guidance on the range of pre-application issues that should be discussed in relation to development/building integrated renewables. In relation to standalone renewable energy developments, key issues for discussion at the pre-application stage may include:

- Signposting developers to the relevant policy context and guidance (e.g. any relevant SPGs).
- Providing an early indication of if an EIA is likely to be required.
- Setting out the potential scope of key issues/surveys etc that will be required.
- Identifying any key design issues to be taken on board.
- Discussing potential public consultation arrangements for large schemes.
- Providing contacts for key consultees e.g. CCW, Environment Agency, Cadw.

20.9 Some general advice on realising the potential of pre-application discussions has been provided by the Planning Advisory Service[96]. A checklist can be helpful for developers as it provides a structured way to address the key issues that a local planning authority would wish to be considered in an application. A checklist approach can also be helpful when development management assess the

[95] See http://wales.gov.uk/consultations/planning/tan17consultation.
[96] http://www.pas.gov.uk/pas/core/page.do?pageId=111329

application and set any planning conditions. The matrices, which have been prepared to accompany this report, provide a potential source of information on the key issues that Local Authorities may wish to include in technology specific checklists. The matrices are set out in Appendix 3**.**

20.10 In addition to planning requirements, other permits may also be required for certain renewable energy developments such as Environmental Permits from the Environment Agency. Developers should therefore be encouraged to contact the necessary bodies and consultees early on in the planning process to discuss what permits may be required.

Role of Good Design

20.11 Good design is fundamental in promoting sustainable development and responding to the impacts of climate change. Planning Policy Wales (Section 4.10), for example stresses the importance of good design in protecting and enhancing environmental quality, tackling climate change and improving quality of life. An integrated and holistic approach to design, including consideration of location, density, layout and built form can ensure that development responds and adapts to climate change impacts. Good design is also required to protect and help minimise any negative impacts on the historic environment.

20.12 Planning Policy Wales (Section 4.10) is supplemented by TAN 12: *Design*, which provides guidance on the design solutions and issues arising from environmental sustainability that will assist in meeting or exceeding sustainable building standards. The guidance is based upon five key aspects that are essential in delivering good design: access, character, community safety, environmental sustainability and movement. Fundamental to the delivery of good design is the importance of understanding the proposal site and its immediate and wider context. An appraisal of site context can therefore provide the basis for ensuring sustainable design in new development. The design process for new development, including standalone and integrated renewable energy schemes, should therefore seek to meet the objectives of good design.

Design and Access Statements

20.13 A design and access statement is a communication tool explaining how the objectives of good design have been considered from the outset of the development process. It is a statutory requirement that applications for planning permission and listed building consent (with exceptions) are accompanied by a design and access statement[97]. A design and access statement must explain the design concepts and principles applied to the development, in relation to access, character, community

[97] Article 4D of the Town and Country Planning (General Development Procedure) Order 1995 (SI1995/419) and regulation 3B of the Planning (Listed Buildings and Conservation Areas) Regulations 1990 (SI1990/1519) as inserted by The Town and Country Planning (General Development Procedure) (Amendment) (Wales) Order 2009 (SI 2009/[7024] W.[87]), and The Planning (Listed Buildings and Conservation Areas) (Amendment) (Wales) Regulations 2009 (SI 2009/[1026] W.[88]).

safety, environmental sustainability and movement. Further guidance can be found in Technical Advice Note 12: *Design* (2009) The Design Commission for Wales have also produced a guidance document on *Design and Access Statements in Wales: Why, What and How* (2008)[98].

Use of planning conditions

20.14 The purpose of planning conditions is to control development and to enable development which would otherwise be refused permission to go ahead. Certain conditions are also required by legislation (e.g. conditions putting a time limit on planning permission[99]).

20.15 Guidance is set out in Welsh Office Circular 35/95 (The Use of Conditions in Planning Permissions), and Chapter 3 of *Planning Policy Wales*.

Key tests for planning conditions

20.16 The tests for planning conditions are set out at paragraph 14 of Circular 33/95: conditions must be: i. necessary; ii. relevant to planning; iii. relevant to the development to be permitted; iv. enforceable; v. precise; and vi. reasonable in all other respects.

20.17 Planning permission cannot be granted subject to conditions which specifically require works on land outside the application site and outside the control of the applicant. However it is possible for Local Planning Authorities to grant permission subject to a condition that development should not be commenced or occupied until some obstacle to the development has been overcome (Chapter 3, *Planning Policy Wales*

Examples of conditions

20.18 Examples of model conditions can be found in Appendix A of Circular 33/95 and on the Planning Inspectorate's website. For example, Circular 33/95 includes guidance on attaching conditions limiting noise levels at particular properties. More detailed guidance on planning conditions for onshore wind energy development is available from the Department for Business, Enterprise and Regulatory Reform (BERR)'s Onshore Wind Energy Planning Conditions Guidance Note (2007).

20.19 Key matters to be addressed by condition include:

- Conditions relating to transport movements e.g. routeing, times of delivery/construction work, hours of operation etc.
- Highway works, e.g. creation or improvement of access to the site, temporary works to enable delivery of large components etc.

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[98] http://dcfw.org/publications/view/design_and_access_statements_in_wales.
[99] Sections 91 and 92 of the Town and Country Planning Act 1990 require the imposition of time-limiting conditions on grants of planning permission.

- Design of development, including provision for submission and agreement by the local planning of detailed design of particular parts of the development.
- Mechanism to agree a detailed ‘Method Statement’ for construction, operation or management, e.g. detailed construction details, pollution control measures, procedures for phasing development of a district heating main.
- Set limits for noise levels at the nearest properties (e.g. for wind energy development) or for particular plant/buildings on site (e.g. energy from waste processing plant).
- Monitoring requirements, e.g. for noise levels, odour, percentage of renewable energy used by a development, protected species monitoring etc.
- Management requirements, e.g. preparation, agreement and implementation of an Environmental Management Plan.

20.20 Specific examples of conditions for particular development types (e.g. wind energy development, decentralised heat supply, environmental performance) are provided below:

Wind Energy Development

20.21 Typical conditions that may be used for wind energy developments include:

- Control of the decommissioning and removal of turbines.
- The restoration and afteruse of the site.
- Noise limits at nearest properties.
- Size of turbines permitted (with reference to height and rotor diameter).
- Colour and finish of turbines.
- Design and materials of ancillary buildings, housing sub-stations and electricity distribution network connections (to be approved by local authority).
- Limit construction activity to certain (specified) times of year to avoid any identified impacts on breeding, passage or wintering birds.
- An archaeologist and/or ecologist to be present during construction.

Solar PV arrays

20.22 At the time of writing, only a small number of solar PV arrays have been consented in the UK to allow generalisation about typical planning conditions. Instead, conditions applied in the consenting of a solar PV array at Wheal Jane by Cornwall Council are provided as a case study.

Case Study 13: Wheal Jane Solar PV array, Cornwall (planning conditions)

Description of development

The development of a Solar Photovoltaic Farm on the site of the former mill at Wheal Jane Mine, Near Truro, Cornwall, and associated infrastructure. (PA10/03993)

Conditions applied to permission

Commencement

- Development to start within three years of permission and construction to last no longer than four months.

Control of development

- Development to be in accordance with named plan documents.

Schemes to be submitted prior to commencement

- Assessment of impacts from glint/glare/reflectivity and measures for mitigation to be implemented during operation.
- Security fencing, gating and infra-red security cameras scheme.
- Scheme for management and removal of injurious weeds on site including Japanese Knotweed.
- An Environmental Management Plan and a Construction Method Statement.
- Topographical survey and geological site investigation report, including orientation of the solar arrays, the method for ground anchoring and any ground reprofiling works.
- Landscaping scheme, including existing vegetation to be retained, the method of protection during construction, new vegetation to be planted and arrangements for its protection and maintenance. New planting to be replaced if it fails to become established during first five years.
- Scheme for management of surface water from the site.

Schemes to be submitted following commencement

- Habitat creation scheme within 12 months of commencement of development, including ongoing management, monitoring and reporting.
- Formal reviews of operations conducted to manage the areas of landscaping and habitat creation at least annually for the first five years and then once every two years.

Lighting

- No external artificial lighting to be installed during operation.

Timing of construction and decommissioning

- Works limited to 08.00-18.00 Monday to Friday and 08.00-13.00 Saturday.

Noise from construction and decommissioning

- Not to exceed an LAeq,T noise level of 65 dB 1 metre from the façade of any occupied residential dwelling.

Expiration of planning permission

- Within the sooner of 25 years and six months following completion of construction or six months of cessation of electricity generation, all development to be dismantled and removed from site.

Permitted development rights

- Not withstanding the provisions of the Town and Country Planning (General Permitted Development) Order, 1995 or other Orders amending or replacing it, no fixed plant or machinery, buildings, structures and erections, or private ways shall be erected, extended, installed or rearranged.

For more information:
http://planning.cornwall.gov.uk/online-applications/applicationDetails.do?activeTab=externalDocuments&keyVal=L5JSZXFG0K600

Decentralised Heat Supply

20.23 To ensure that an agreed percentage of energy needs are sourced from a renewable or low carbon supply, the following model condition can be used. It is taken from the Planning Inspectorate's website[100]:

> *"Decentralised Energy Supply*
>
> *Before the development hereby permitted is begun a scheme for generating X% of the predicted energy requirement of the development from decentralised renewable and/or low carbon sources (as defined in the glossary of Planning Policy Statement: Planning and Climate Change (December 2007) or any subsequent version) shall be submitted to and approved in writing by the Local Planning Authority. The approved scheme shall be implemented before the development is first occupied and shall remain operational for the lifetime of the development."*

Environmental Performance

20.24 Conditions may be applied to ensure delivery against design information or specifications submitted with a planning application, e.g. commitment to install a particular technology.

Use of planning obligations

20.25 Planning obligations, in the same way as conditions, enable development to go ahead which would otherwise be refused planning permission. Where possible, conditions should be used in preference to planning obligations. Planning obligations (also known as S106 Agreements) are required where off-site works or financial contributions (e.g. towards infrastructure required for the development) are required in order for a development to be acceptable in planning terms.

[100] http://planninginspectorate.gov.uk/cymru/wal/appeals/model_conditions.html#energy.

20.26 The power to enter into a planning obligation is contained in Section 106 of the Town and Country Planning Act 1990 as amended by Section 12 of the Planning and Compensation Act 1991. *Planning Policy Wales* (PPW)[101], Welsh Office Circular 13/97[102] (paragraph 7) provide five tests which need to be satisfied when entering into Section 106 planning obligations. Section 122 of the Community Infrastructure (CIL) Regulations 2010[103] now sets out three tests which should be applied when entering into a planning obligation. The revised three tests reflect those previously stated in PPW and Circular 13/97, giving them legal effect. Local Planning Authorities can seek, or a developer can, unilaterally volunteer, financial contributions to mitigate matters raised from proposed development. The scope and scale of such obligations is set out in Supplementary Planning Guidance, produced by Local Authorities.

20.27 Planning Policy Wales (2010) notes that planning obligations may be used to:

- Restrict development or use of the land.
- Require operations or activities to be carried out in, on, under or over the land.
- Require the land to be used in a specified way.
- Require payments to be made to the authority either in a single sum or periodically (Para 4.7.1[104]).

20.28 With reference to financial contributions, these *"may be used to offset negative consequences of development, to help meet local needs, or to secure benefits which will make development more sustainable"* (Chapter 3, Planning Policy Wales, Edition 2, June 2010). Further advice on the use of planning obligations are set out in Annex B to TAN 8 *Planning for Renewable Energy*[105].

Tests for Planning Obligations

20.29 Section 122 of The Community Infrastructure Levy Regulations 2010[106] , state that a planning obligation (Section 106 of TCPA 1990) may only constitute a reason for granting planning permission for the development if the obligation is:

(a) Necessary to make the development acceptable in planning terms.

[101] *Planning Policy Wales*, Welsh Assembly Government. http://wales.gov.uk/topics/planning/policy/?skip=1&lang=en
[102] Welsh Office Circular 13/97 Planning Obligations (this is identical to the English Circular 1/97) now superseded in England only by Circular 05/2005).
[103] The Community Infrastructure Levy Regulations 2010, http://www.opsi.gov.uk/si/si2010/draft/ukdsi_9780111492390_en_1.
[104] *Planning Policy Wales,* Welsh Assembly Government. http://wales.gov.uk/topics/planning/policy/?skip=1&lang=en
[105] *Planning Policy Wales*. Technical Advice Note (TAN) 8: Planning for Renewable Energy. (2005), Welsh Assembly Government.
[106] The Community Infrastructure Levy Regulations 2010, http://www.opsi.gov.uk/si/si2010/draft/ukdsi_9780111492390_en_1.

(b) Directly related to the development.

(c) Fairly and reasonably related in scale and kind to the development.

20.30 As advised by WO Circular 13/97 a planning obligation must be:

(i) Relevant to planning.

(ii) Necessary to make the proposed development acceptable in planning terms.

(iii) Directly related to the proposed development.

(iv) Fairly and reasonably related in scale and kind to the proposed development.

(v) Reasonable in all other respects.

Examples of Planning Obligations

20.31 TAN 8: *Planning for Renewable Energy* provides some examples of where planning obligations may be required in order for a wind energy development to go ahead. These examples relate to where there is a need for highway infrastructure improvements, wildlife management or creation, payments to overcome problems with telecommunications networks (Annex B, Para 1.1), and financial provision and arrangements for the restoration of a site (Para 6.4). TAN 8 also provides guidance on how agreements may cover community benefits from renewable energy schemes (see below).

20.32 In addition to the example set out in TAN 8, for other types of renewable energy/low carbon development, planning obligations could cover:

- Provision of a financial bond against specific future requirements for replacement or upgrading of a renewable/local carbon energy installation, or failure against particular standards (e.g. for specified odour or noise levels).
- Off site improvements to energy efficiency of homes or other buildings in a specified area (e.g. a housing estate managed by a registered social landlord; a neighbouring school, industrial or retail park).
- Contributions towards a district heating main (which could be the subject of a Local Development Order).

20.33 In addition to dealing with essential matters, developers may also make an offer to set up a community trust, for example, by which a community would benefit from the generation of energy from a wind farm. This type of offer may be secured through a planning obligation agreement, but must not be taken into account in the planning decision making process (Para 1.3, Annex B, TAN 8). This type of community benefit may be addressed separately from the planning process through an agreement between the developer and a suitable community organisation (Section 2, Annex B, TAN 8).

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Appendix 2: Glossary of Terms

Term	Explanation
Anaerobic digestion	Organic matter broken down by bacteria in the absence of air, producing methane gas and solid digestate. The by-products such as biogas can be used in a furnace, gas engine, turbine or gas-powered vehicles, and digestates can be used as an agricultural fertiliser.
Arboriculture	The cultivation and management of trees.
Biofuels	Renewable fuels produced from biomass.
Biogas	A type of biofuel produced from the biological breakdown of organic matter in the absence of oxygen.
Biomass	Living or recently dead biological material that can be used as fuel, e.g. plant matter grown to generate electricity or produce heat.
BREEAM (BRE Environmental Assessment Method)	A voluntary scheme from the Building Research Establishment (BRE) that aims to reduce the environmental impacts of buildings by rewarding designs that take steps to reduce their environmental impacts.
CERT (Carbon Emissions Reduction Target)	A funding scheme which domestic energy suppliers are obliged to make available for energy saving measures and the installation of energy saving products.
Climate Change Levy (CCL)	This adds around 15% to typical energy bills of UK businesses. The CCL is applied to electricity, gas, coal and Liquid Petroleum Gas (LPG), but is not applied to any domestic supplies.
Combined Heat and Power/Combined Cooling Heat and Power (CHP/CCHP)	The simultaneous generation of usable heat and power in a single process, thereby reducing wasted heat.
Communities and Local Government (CLG)	This department has the remit to promote community cohesion and equality and has responsibility for housing, urban regeneration, planning and local government.
Community Infrastructure Levy (CIL)	A proposed levy, which Local Authorities can impose on most types of new development. Charges will be determined by the size and character of the development and will be used as a top-up source of funding for local community facilities such as roads, public transport, open space or health centres, though it won't replace the need for mainstream public funding.
DECC (Department of Energy and Climate Change)	DECC was created in October 2008, to bring together responsibility for energy policy and climate change mitigation policy.
Decentralised energy supply	An energy supply from local renewable and low-carbon sources usually on a relatively small scale. Decentralised energy is a broad term used to denote a diverse range of technologies, including micro-renewables, which can locally

Term	Explanation
	serve an individual building, development or wider community and includes heating and cooling energy.
District heating network	A system where a centralised heat generating plant provides heat to surrounding buildings in the area through pipes.
Energy from Waste (EfW)	The conversion of waste into a useable form of energy, often heat or electricity.
ESCo (Energy Service Company)	A commercial interest which usually operates and maintains the plant associated with a district heating network.
Feed in Tariffs (FITs)	A scheme to incentivise renewable electricity installations up to a maximum capacity of 5 MW. FITs will significantly increase revenue for small-scale generators of renewable electricity and provides a guaranteed price for the electricity generated.
Gasification and pyrolysis (advanced thermal treatment)	A way of recovering energy from waste, known as advanced thermal treatment. Waste is heated at high temperatures and a useable gas is produced.
Geothermal energy	Heat under the ground is used to heat water and make steam to turn generator turbines and make electricity.
Installed capacity	The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions. It is commonly expressed in megawatts (MW).
Microgeneration	This refers to the use of on-site technologies to generate heat and/or electricity from low or zero carbon sources.
Municipal Solid Waste (MSW)	Household waste and any other waste collected by a waste collection authority.
Nacelle	A cover housing the workings of the wind turbine.
Photovoltaics (PV)	A renewable system converting sunlight into electricity, which can be used to power electrical equipment and appliances.
Planning Policy Statement (PPS)	These are issued by central government to replace the existing Planning Policy Guidance notes.
Renewables Obligation (RO)	The main financial support scheme for renewable electricity in the UK, which is administered by Ofgem. It obliges electricity suppliers in the UK to source a proportion of their electricity from renewable supplies. This is proven by obtaining the required quantity of Renewable Obligation Certificates (ROCs), which renewable electricity generators are given to demonstrate their output.
Retrofit installations	Installations put into an existing development, e.g. not built as part of the original design at the time of construction.
Sustainable Drainage System	A sequence of management practices and structures designed to drain surface water in a more sustainable fashion than some conventional techniques. They are designed to improve the rate of water absorption in order to reduce the total amount, flow and rate of surface water that runs directly to rivers through stormwater systems.

Term	Explanation
Waste heat	Waste heat from industrial processes and power stations rated at more than 10MWe and with a power efficiency of less than 35%.