Renewable Energies for the Norfolk Coast Area of Outstanding Natural Beauty (AONB)

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Summary

Norfolk Coast Partnership are aware of the numerous benefits of using renewable energy, and are keen that such technology is available for use within the Norfolk Coast Area of Outstanding Natural Beauty (AONB). This report was commissioned in order that their implications are understood more fully, and so that informed guidance can be given.

Carbon dioxide emissions are widely acknowledged as having a serious detrimental effect on the global climate; the current high levels of carbon dioxide production are a major contributor to global warming. Following encouragement from the European Union, the British government set a target in the 2003 Energy White Paper to produce 10% of all energy from renewable sources by 2010. The regional target, as established by the Sustainable Development Round Table for the East of England, is to produce 14% of all energy from renewable sources by 2010.

Renewable energy can be obtained using many different types of technology. However, not all of these technologies are suitable for use within the Norfolk Coast AONB, either because they are not physically applicable, or because the size of facility required is not appropriate, due to the sensitive, rural nature of the area. Those considered suitable for use are listed below, with a brief description:

- Small/Medium Scale Biomass – the burning of a wide range of organic materials to produce heating and hot water, and in some cases electricity.
- Biofuels – transport fuels that are manufactured from crops and other organic materials, and can be used as a supplement to, or replacement for, conventional transport fuels.
- Biogas – naturally produced gas that is created during the decomposition of animal and food waste. The gas can be retained and burnt off, providing a source of heating and hot water, and in some cases electricity.
- Solar Photovoltaics – panels or roof tiles that contain materials which produce electricity when exposed to sunlight.
- Solar Hot Water – panels that contain a capillary network of pipes. Water contained within them is heated by the sun and then pumped round the house to provide heating and hot water.
- Micro/Small Scale Wind – scaled-down wind turbine technology, small turbines can be used to provide electricity for individual buildings.
- Ground Source Heat Pumps – a closed pipe system, in which fluid gains heat as it is pumped through a pipe network buried in the ground. The heat is then extracted by heat exchanger and used to provide heating and hot water.

- Fuel Cells – chemical processes are utilised to convert various hydrogen-based fuels into electricity. The technology can be used at almost any scale, but is particularly used for emission-free transportation.
- Combined Heat and Power – the technologies applied to all forms of energy generation, whereby waste is reduced as far as possible, and used to generate additional energy.

In summary, the impacts of each of these on the AONB have been predicted and assessed. The issues associated with growing crops for biomass and biofuel are intricate and complex, and would therefore benefit from being assessed in greater detail.

Using the predicted impacts of each technology, a series of recommendations and principles are suggested, for adoption by the Norfolk Coast Partnership, to use when guiding development in the AONB. The principles are aimed at increasing the amount of renewable energy generated in the AONB, by minimising the impacts and suggesting mitigation measures where appropriate.

Details of relevant advisory bodies are listed at the end of the document, along with suggestions for funding sources applicable to renewable energy installations.

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1 Introduction

The Norfolk Coast was designated as an Area of Outstanding Natural Beauty (AONB) in 1968, and as such is recognised as being among the most important scenic areas in the UK.

The Norfolk Coast Partnership, based outside the AONB in Fakenham, was established in 1991. Its remit is to conserve and enhance the natural beauty of the area, facilitate and enhance the public enjoyment, understanding and appreciation of the area and to provide sustainable forms of social and economic development that in themselves conserve and enhance the area's natural beauty.

One aspect of the above that influences sustainability and conservation within the AONB is energy usage. This includes electricity generation and consumption, use of fuels for transport, and heating of buildings and water.

Society is moving towards sustainable energy generation as it is becoming increasingly aware of the detrimental effects of conventional methods, in particular the effect of releasing carbon dioxide into the atmosphere, which has a well-documented effect on global climate. As a means of reducing or eliminating these effects, renewable energy sources are becoming more popular and necessary.

Mott MacDonald has been asked to assist the Norfolk Coast Partnership to assess the viability of different renewable sources of energy, with a view to identifying which of these could be suitable for use within the Norfolk Coast AONB. The second aspect of the project is to understand the technology-specific impacts on landscape, ecology, community and economy of the AONB. With these impacts clearly identified, conclusions have been drawn to establish a set of guidelines and recommendations relating to renewable energy generation within the AONB.

This report has been produced in order that funding partners of the Norfolk Coast Partnership, and other relevant people and organisations, can fully understand the background to renewable energy generation, and the number of different sources of renewable energy available for use.

2 Plans and Policies

2.1 Introduction

This section sets out the background to renewable energy usage and availability, in terms of relevant policies and pieces of legislation, at European, national and regional levels.

2.2 European Level

1997 Renewables Directive

The Directive was produced to encourage EU member countries towards renewable energy generation. It initially states that exploitation of renewable energy sources within the European Community is underused, and recognises the need to promote renewable energy sources as a priority measure, given that their exploitation contributes to environmental protection and sustainable development. It stresses that changes are needed to comply with the Kyoto protocol and the UN Framework Convention on Climate Change.

The Directive intends to achieve this by promoting a substantial increase in the proportion of electricity generated from renewable energy sources across the European Union by 2010. It sets country-specific targets, which member states are required to meet. These relate to their current ability to use renewable sources, access to technology, and a number of other factors.

The target set by the EU for the UK is to source 10% of its energy from renewable sources by 2010. Targets for other countries vary greatly, for example Ireland must source 13.2%, Finland 31.5%, France 21% and Austria (subject to the highest target) 78.1%.

2.3 National Level

2003 Energy White Paper ‘Our energy future – creating a low carbon economy’

The policies and targets put forward in the White Paper aim to facilitate a quantified reduction in carbon dioxide emissions in the UK, at the same time maintaining reliable and competitive energy supplies. In doing this, it tackles three specific areas of growth for the energy production industry. These are energy efficiency, a low carbon economy and renewable energy. The white paper states that

> *‘renewable energy will also play an important part in reducing carbon dioxide emissions while also strengthening energy security and improving our industrial competitiveness as we develop cleaner technologies, products and processes.’*

The Energy White Paper will shortly be subject to a review to expand on government policy on nuclear power.

In considering renewable energy production, the White Paper committed the UK to producing 10% of all its energy from renewable sources by 2010, a target which includes provision for ongoing increases in energy consumption, as well as an overall increase in energy efficiency.

Beyond this, the White Paper highlighted the government's aspiration (rather than a fixed target) that this figured should be doubled to 20% by the year 2020. This target is as a direct result of the requirement placed on the UK by the EU Renewables Directive. Recently, an intermediate target to produce 15% of energy from renewable sources by 2015 was also established to ensure momentum for change continues between 2010 and 2020.

The above targets are intended to move the energy production industry towards to longer term target of reducing the UK's carbon dioxide production by 60% by the year 2050. This target was created as a result of recommendations by the Royal Environmental Commission for Pollution, which stressed that to achieve this, significant progress will need to be made by 2020, hence the earlier targets and aspirations.

Renewables Obligation

The mechanism by which the government is enforcing the move towards renewable energy production is the Renewables Obligation legislation. The Renewables Obligation, introduced in 2002, requires all energy producers to source a specific proportion of the energy they supply from renewable sources, with a system of fines/incentives in place as a means of backing up this requirement. The fines from under-performing producers are recycled to those that meet their targets as rewards. The Renewables Obligation target for 2005/06 is 5.5%, rising ultimately to 15.4% by 2014/15.

Renewable Transport Fuels Obligation

The Renewable Transport Fuels Obligation (RTFO) was proposed by the government in 2004, although was only put into action recently. It requires transport fuel suppliers to ensure that 5% of their sales in the UK are from a renewable source. It is predicted that this could reduce carbon emissions by 1 million tonnes per annum.

Non-Fossil Fuels Obligation

Both of these Obligations stem from the now-defunct Non-Fossil Fuels Obligation (NFFO), which was set up to push the electricity industry towards renewable sources of energy rather than the traditional fossil fuels. It did this by providing premium payments for renewables-generated electricity over a fixed period, with contracts being awarded to individual generators. No further contracts are being issued under the NFFO, although contracts are still being honoured by the government where they meet the Renewable Obligation.

Planning Policy Statement 22

Planning Policy Statements are produced by the Government to set out national policies relating to land use planning in England. Planning Policy Statement 22 (PPS 22) relates specifically to renewable energy, and is aimed at encouraging planning authorities to make decisions that will assist in meeting the national targets set out in the Energy White Paper.

PPS 22 provides specific principles and guidelines for regional planning bodies and local planning authorities when considering their approach to planning for renewable energy production. It is essentially a tool for providing advice on how to balance the local impact of development of renewable energy facilities against national policy, and establishes positive steps for planning authorities to use when considering development of the industry. It includes a set of key principles for all regional planning bodies and local planning authorities to adhere to in their approach to planning for renewable energy, and then expands on these by giving specific advice on how to establish appropriate regional targets for renewable energy production.

Finally, it outlines what actions should be taken when proposals are received for developments within both nationally and internationally protected areas, green belts, buffer zones and areas of local importance. Within Areas of Outstanding Natural Beauty, PPS 22 specifically states that

> *'…planning permission for renewable energy projects should only be granted where it can be demonstrated that the objectives of designation of the area will not be compromised by the development…'*

Produced in conjunction with the Statement is the Companion Guide, a document for use by planning authorities. It is designed as a tool for translating the requirements of PPS 22 into easily-understood principles for planners and regional and local decision-makers, and as such contains a series of illustrations, case studies and guidelines.

Building Regulations

Building Regulations are a comprehensive set of regulatory standards that apply to all new and improved buildings in the UK, and encompass many aspects of safety and suitability for materials and design. Within the regulations there is a section on the Conservation of Fuel and Power, which sets out requirements for all aspects of building design that must be met.

It includes requirements on minimum efficiency levels for heating systems and hot water storage, insulation of pipes and ducts, insulation of the building itself, and a multitude of other aspects, all aimed at creating a universal standard of energy efficiency for buildings.

This is linked to sustainable energy generation in that it aims to reduce the wastage of energy that buildings use, both residential and non-residential. In enforcing good practice, it ensures that energy is used efficiently and not wasted, thereby reducing the overall demand for energy that would otherwise be necessary.

2.4 Regional Level

East of England Draft Plan

The East of England Regional Assembly produced in 2005 the East of England Draft Plan, a regional spatial strategy aimed at guiding development in the region for the next 20 years. It is a revision to the Regional Spatial Plan produced previously. Chapter nine of the Plan discusses environmental resources, and within it Policy ENV 8: Renewable Energy and Energy Efficiency is established.

The plan requires that

> *"local development documents will contain policies for promoting and encouraging energy efficiency and renewable energy. These policies will presume in favour of, and emphasise the wider sustainable development benefits associated with, energy efficiency and renewable energy."*

The most significant point arising from this policy is that all new developments comprised of at least 50 developments, or developments that are over 1000 sq m, must have the facility to provide at least 10% of the predicted energy requirements from renewable sources.

Sustainable Development Round Table for the East of England Report: Making Renewable Energy a Reality – Setting a Challenging Target for the Eastern Region

This report summarises findings and feedback from consultation carried out in autumn 2000 by the Sustainable Development Round Table, on renewable energy generation.

It identifies renewable energy targets specifically for this region, stating that if appropriate measures were put in place, up to 14% of energy in the East of England cold be sourced from renewables by 2010.

It then breaks this figure down into individual sources, recommending that 1300GWh/year comes from offshore wind, 1700GWh/year comes from onshore wind, 700GWh/year comes from biomass, and 600GWh/year comes from other renewable sources. The specific target for Norfolk in that 17% of its energy comes from renewable sources by 2010.

3 Trends

3.1 Introduction

The following section describes the UK trends in energy consumption and electricity demand, as well as the proportion of electricity generated from renewable sources. It also outlines the recent history of different types of renewable energy technologies, and outlines future changes that are planned or predicted.

3.2 Energy Consumption

Energy consumption in the UK (including electricity, oil etc) has generally risen in recent decades. Figure 3.1 shows the total annual energy consumption in the equivalent number of tonnes of oil. Energy usage is very indicative of the health of the country's economy, with more prosperous times characterised by higher energy consumption, so the fluctuating economy of recent decades means that energy consumption has grown in an unpredictable manner.

The total energy consumed in the UK in 1970 was equivalent to 210 million tonnes of oil. By 1990 this figure had risen to 213 million equivalent tonnes of oil, and as recently as 2004 this figure had reached 239 million. The rise occurred partly because of society's ever-increasing demand for energy, despite a decline in large-scale industry in the UK and increases in technology, both of which have allowed us to use energy more efficiently.

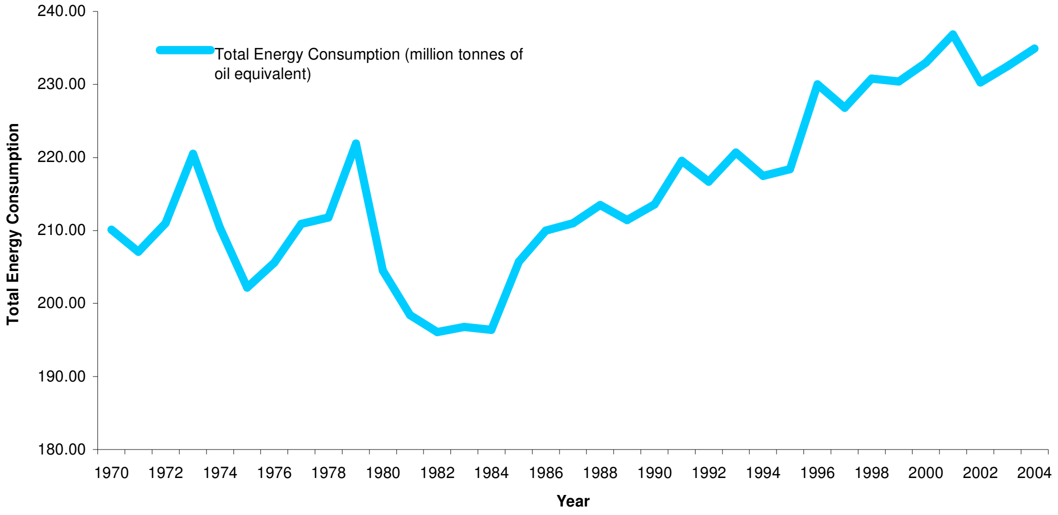

Figure 3.1: Total Energy Consumption in the UK since 1970, in equivalent million tonnes of oil. (Source: DTI - Digest of UK Energy Statistics 2005)

Cambridge Econometrics, who were commissioned to study energy usage by the DTI, forecast that the demand for energy usage will peak and then start to decline within the next five years. This prediction is based partly on their assumption that the further improvements in energy efficiencies will outweigh any increase in overall demand.

It is useful to remember that energy usage fluctuates in yearly cycles, with the highest demand being during the winter months when energy for heating is necessary. In addition to this, year on year energy usage fluctuates, in a more irregular manner.

3.3 Electricity Generation

The demand specifically for electricity (rather than energy as described above) also follows an upward trend, although it has risen steadily, with an annual growth of around 1.5 to 2% each year. As an illustration, the total demand for electricity in the UK in 1998 was 373,000 GWh, and by 2001 this had risen to nearly 402,000GWh.

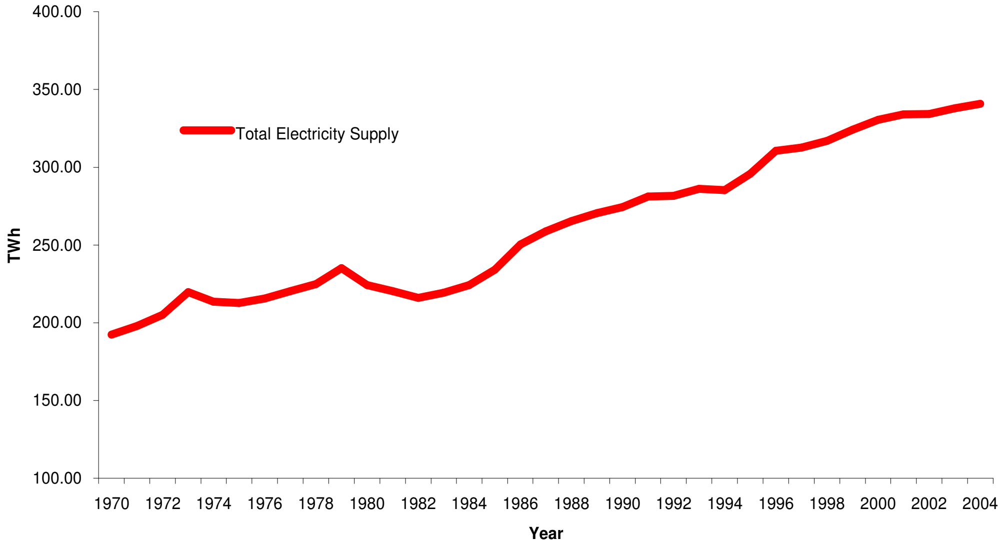

Figure 3.2: Total Electricity Supply in the UK since 1970, in TWh. (Source: DTI - Digest of UK Energy Statistics 2005).

3.4 Renewable Sources

Coal, oil, and gas have been the primary fuels for generating electricity historically. Recognition of the consequences of carbon dioxide production from these sources has meant that energy from renewable sources is much more desirable, and as a result the renewable energy sector is expanding, albeit from a low base level.

In 1991 5320 GWh of electricity was produced in the UK from renewable energy sources, representing 1.64% of all electricity generated. By 2001 this had risen to 9,549 GWh, equating to 2.47% of total electricity generated, and in 2004, 14,171 GWh was generated, equating to 3.58%.

Figure 3.3 shows how renewable energy has grown as a proportion of all energy generated in the UK

Figure 3.3: Proportion of the UK's electricity generated from renewable sources. (Source: DTI - Digest of UK Energy Statistics 2005).

In terms of meeting the target established in the Energy White Paper, of producing 10% of electricity from renewable sources, the government acknowledges that it is currently slightly behind target.

The sources of renewable energy, and their relative proportions, in 2004 are shown opposite. The overall proportions are shown on the left, and the biofuels category is broken down into its different types on the right. The overall total represents 3.58% of all electricity generated that year.

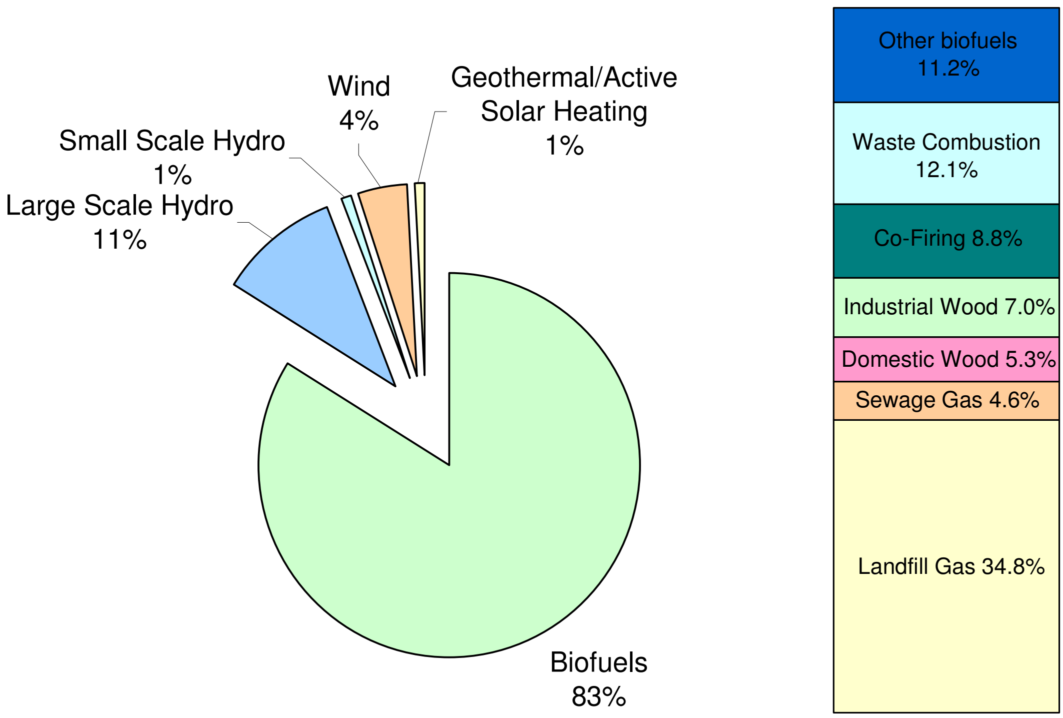

Figure 3.4: Relative proportions of renewable energy sources used in the UK in 2004. (Co-firing is the practice of supplementing conventional fuels for energy generation with biofuels.)

3.5 Renewable Energy in Norfolk

In 2005, the East of England was generating 4% of all energy from renewable sources, against a target of 14% by 2010.

Norfolk was generating 62 MW of energy from renewable sources, excluding offshore wind-farms. This figure was comprised of 7 MW from onshore wind-farms, 41.5 MW from biomass, 12.5 MW from landfill gas and 1MW from sewage gas. An additional 60MW was being generated from the sole offshore wind-farm at Scroby Sands.

Below are two tables, showing existing and proposed wind-farms in Norfolk respectively, both onshore and offshore:

Existing Projects	Location	Capacity (MW)
Scroby Sands	Off Great Yarmouth	60
Blood Hill	West Somerton	3.75
Ecotech Centre	Swaffham	1.5
Sporle Road	Swaffham	1.8

Proposed Projects	Location	Capacity (MW)
Cromer	Off Cromer	100
Cromer	6.5km off Foulness	120
Sheringham Shoal	11 miles off Sheringham	315
Dudgeon East	Off Cromer	300
Docking Shoal	Off Wells	500
Race Bank	Off Wells	500
North Pickenham	Near Swaffham	16
Wood Farm	Shipdham	3.6
Guestwick	Reepham	12

The following other renewable energy generation schemes also exist in Norfolk:

Projects	Type	Capacity (MW)
Thetford Power Station	Biomass	41.5
Attlebridge Landfill Site	Landfill Gas	1.2
Beetley Landfill Site	Landfill Gas	1.0
Blackborough End Landfill Site	Landfill Gas	1.9
Costessey Landfill Site (1)	Landfill Gas	0.95
Costessey Landfill Site (2)	Landfill Gas	2.2
Feltwell (1)	Landfill Gas	1.0
Feltwell (2)	Landfill Gas	1.0
Edgefield Hall Farm	Landfill Gas	0.6
Mayton Wood Landfill Site	Landfill Gas	1.6
Snetterton Landfill Site	Landfill Gas	1.1

3.6 Sources of Renewable Energy

3.6.1 Wind

People globally have harnessed the power of wind for centuries, for powering windmills and pumps. Wind power to provide electricity started in 1888 in America, and the technology has been greatly refined ever since, particularly after the Second World War in Europe. As the efficiency of wind turbines has increased, and the technology has become cheaper and easier to manufacture, they have grown in number.

The first commercial wind farm in the UK was opened at Delabole in Cornwall in 1991, and provided 4 MW of power.

There are currently 117 wind-farms in the UK, producing 1,337 MW of electricity, and providing a reduction of over 3 million tonnes of CO^2 each year. In 2005, 19 wind-farms were constructed, one of which was offshore, compared to 2004, when 12 were constructed, also with one of these being offshore.

There are currently 24 wind-farms under construction in the UK, which will provide an additional 778 MW, 79 consented wind-farm projects which have been given the go-ahead, which will provide 2,133 MW, and another 165 in the planning stages, which if all are constructed would provide a further 9,649 MW.

Off the Norfolk Coast, two new wind farms have been given consent. Both will consist of 30 turbines, one off Cromer with a capacity of 108MW and the other, in The Wash, providing up to 120MW. A further 6 sites, in the Wash area and off the Norfolk and Lincolnshire coasts, are proposed but have not yet been given consent.

All the above information relates to medium and large scale wind power, which provides significant amounts of electricity to the national grid and can cater for significant demand. It does not include small or micro scale wind power generation, which caters for limited numbers of properties, with little or no viable contribution to national electricity generation.

3.6.2 Biomass

Before the industrial revolution biomass was a significant source of fuel globally. Wood was burned for heat, and vegetation was fed to horses, oxen etc as food, which were then used to carry out agricultural work and provide transport.

Biomass became sidelined as an energy source during and after the industrial revolution, as fossil fuels became more popular and the technology was developed to use it to greater effect. Globally, the current proportion of energy extracted from biomass is around 14%, and is sourced from wood fuel, animal waste and other forms of organic waste.

In the UK, biomass energy production has exhibited an upward trend. To illustrate, between 1991 and 2001, an average of 6 biomass projects providing either heat or electricity were commissioned each year. This figure rose considerably in 2003, when 17 were commissioned, and by 2004 this had risen to 58. The trend was therefore one of steady growth until 2001, when the number increased significantly.

Recent biomass installations in the East of England include Fibrothetford Ltd, a chicken litter-burning power station, which produces 38.5MW of electricity by burning 400,000 tonnes of chicken litter each year, and Ely Power Station, which at 38MW is the largest straw-burning power station in the world. A few landowners within the Norfolk Coast AONB provide fuel to this facility, in the form of miscanthus.

Biomass currently produces 41TWh/year in the UK, and the Carbon Trust suggests that this has to potential to rise to 80TWh/year in the future.

3.6.3 Biofuels

Currently two biofuels are in use; bioethanol, an additive for petrol, and biodiesel, a replacement for, or additive to diesel.

In Europe in 2000, over 700,600 million tonnes of biodiesel was produced by France, Germany, Italy, Austria and Belgium collectively, and this volume of production is likely to increase following the adoption of the European Biofuels Directive in 2003. The US Clean Air Act Amendments in 1990 had a similar effect on ethanol production in the USA.

Currently in the UK the production of biofuels is limited, as they are currently more expensive than regular fuels to produce. This is likely to remain the case unless the government offers more support to this sector of the fuel industry. Most biodiesel being produced is manufactured from waste vegetable oil.

A small number of companies exist currently in the UK, producing biofuels, including Global Commodities UK Ltd, based in Thetford. The company was established in 2001, and currently have the capacity to produce 30 million litres of biodiesel per year, but following their ongoing development will have the capacity to produce 180 million litres per year. British Sugar has recently commenced construction on a bioethanol plant in Wissington in Norfolk. The facility should begin operation in early 2007, and is designed to produce 70 million litres per year, which will utilise the entire sugar beet crop grown in the UK that can no longer be exported due to a recent World Trade Organisation ruling.

3.6.4 Tidal and Wave Power

Using the power of waves and tides is a segment of the electricity industry that is still in its infancy. There are only two wave energy facilities in the UK, both in Scotland. One of these is still being tested. There are currently no facilities to generate electricity using tidal movements, but testing and experimentation is ongoing.

3.6.5 Hydro Power

Hydro power provides around 13% of all renewable energy globally, and has been providing electricity reliably and competitively for nearly a century. In recent times this has mostly been generated by large scale facilities, by damming large rivers and incorporating turbine mechanisms into the release channels.

Small scale facilities, capable of providing power for individual dwellings or groups of dwellings, are rare in the UK. A report by the Energy Saving Trust in November 2005 into the potential for micro-generation stated that nationally there are only 12 small scale hydro-electric generator installations in the UK. Coincidentally, this is also the recorded number of installers for this fledgling technology.

3.6.6 Combined Heat and Power

In 2000 combined heat and power technology provided over 4730MW of energy. In the ten years up to this date, the increase in CHP energy production was on average 7% every year, meaning that over this period the energy production had doubled.

The government target for this sustainable energy source for 2010 is for the UK as a whole to generate 10GW, although the current prediction for actual generation capacity is only 8.1GW.

4 Technologies and Examples

4.1 Introduction

This section briefly outlines 11 different renewable energy technologies and their appropriateness to the Norfolk Coast AONB, where possible examples have been used. The technologies are:-

- Small/Medium Scale Biomass
- Biofuels
- Biogas
- Solar Photovoltaics
- Solar Hot Water
- Micro/Small Scale Wind
- Small/Medium Scale Wave and Tidal
- Small Scale Hydro Power
- Geothermal Energy
- Ground Source Heat Pumps
- Fuel Cells
- Combined Heat and Power

The remainder of the report will not consider large scale wind power. The issues and implications associated with this well-developed sector of the industry are wide-ranging and complicated, and are therefore beyond the scope of this report.

Similarly, large scale biomass, biofuel, wave and tidal power will not be considered. At large scales these technologies are likely to be unsuitable for use within the Norfolk Coast AONB, due to the size of the equipment required and associated visual impacts.

4.2 Small/Medium Scale Biomass

Biomass, unlike other renewable forms of energy such as wind and solar, has the potential for continuous generation of heat and electricity. There are two main ways of using biomass on a small or medium scale, in homes and businesses or community facilities.

The first is with stand-alone stoves, to provide space heating for a room. These can be fuelled by logs or pellets (only pellets are suitable for automatic feed). Generally, they are 6-12 kW in output, and some models can be fitted with a back boiler to provide water heating. They usually look like traditional log-burning stoves, in order that to make them suitable for use in houses.

The second is with larger biomass boilers, connected to central heating and hot water systems. These are suitable for wood in the form of pellets, logs or chips, or for other fuels like straw and are generally larger than 15 kW. The boilers are large, semi industrial-looking pieces of equipment, usually for external use. They have associated pipe work and a flue, and a hatch or opening for fuel to be put into the machine.

Small-scale biomass boilers are generally used to produce heat rather than the generation of electricity. Combined heat and power (CHP) facilities that could run on biomass would normally occur on a larger scale. CHP is considered fully in section 4.12.

A wood stove can comfortably heat a room in a home, providing 20-25% of a home's total heating needs. However, a wood boiler can provide all the space and hot water heating needs of a home, small business or community facility. A typical automated wood fuelled boiler currently costs around £4,500 and an automatic wood pellet stove around £2,500. Grants are available to assist in the purchase of these technologies.

Biomass for burning is derived from many types of organic matter. Below is a list (non-exhaustive) of fuel types that are currently used in the UK:

- Willow (grown in short rotation coppice)
- Other planted tree species (e.g. poplar)
- Woody materials gained from woodland management
- Straw, and other crop stalks (from corn, maize, rape etc)
- Miscanthus, and other non-native grass species
- Wood pallets and other untreated wood products
- Other construction waste
- Animal waste, particularly chicken litter

Some of these fuels can also be used in the production of biofuels and biogas, each of which are described in subsequent sections.

Woodland-sourced fuel would usually take the form of wood pellets, wood chips or wood logs. Some form of storage will be required for all fuels, which may take up a considerable amount of space, and the boilers themselves, particularly those used for heating larger buildings, will take up space too.

Despite providing a cheap source of heat and/or electricity, burning biomass also has its limitations. Unlike some other renewable energy sources, burning biomass does not eliminate the production of carbon dioxide emissions.

Despite the emissions, calculations show that the carbon dioxide created by burning the fuel in biomass boilers is roughly equal to the carbon dioxide absorbed by the vegetation as it grows. This approximate equilibrium means the system of energy generation is termed as being carbon neutral, one that does not create extra carbon dioxide, unlike conventional energy generation methods such as oil and gas.

Biomass will require transportation from source to point of use, which will create additional carbon dioxide emissions that will increase with distance. A local market is therefore desirable.

Energy crops as Biomass

Short rotation coppicing (SRC) is the most efficient way of growing willow. Willow is relatively easy and cheap to plant. Once the stems reach about 2m in length they are cut down and transported to their destination. Yields are known to vary due to soil and climatic conditions and quality of the plants. Short rotation forestry has also been trialled but on a much smaller scale, currently it is not considered as a major source as a biofuel. The willow would normally be chipped or pelleted for use in domestic heaters, while for larger scale power stations little further processing is required.

Miscanthus is a member of the grass family and is grown using conventional agricultural methods and harvested annually. One advantage of miscanthus is that it is fairly cold tolerant, to the extent that it can grow in temperatures that many arable crops would not be able to survive in.

Other grasses such as reed canary grass (which can be harvested between 2 and 4 times a year) are further examples of energy crops. One disadvantage of these additional energy crops is that some species are very invasive and known to take over wetland sites. Both miscanthus and canary grass would normally be used in large scale power stations rather than small scale operations. Ely Power station has successfully burnt miscanthus to generate electricity.

In recent years, forestry products have become more widely available for energy production, due to declining requirements for timber in construction and the production of paper. Forestry materials available for biomass fuel arise as a result of other forestry activities. Much of the timber in the UK is sent to sawmills. Saw dust, a by-product of the mills, can be pelleted to be used in domestic and small scale community/business heating systems.

Growing, cultivating and burning biomass as a renewable energy source are activities that are applicable in principle for use within the Norfolk Coast AONB.

4.3 Biofuels

Biofuels are a renewable source of energy for use in transportation. Using biofuels in vehicles can cut overall carbon dioxide emissions by replacing fossil fuels. The two biofuels are bioethanol and biodiesel. There are a number of sources that can be used for biofuel production, as listed below: (Please note this list is not exhaustive)

- Wheat
- Maize
- Sugar beet
- Rapeseed oil
- Waste vegetable oils from the catering industry
- Willow (grown in short rotation coppice)
- Other planted tree species (e.g. poplar)
- Miscanthus, and other non-native grass species

Bioethanol is mainly produced by the sugar fermentation process; other processes, such as pyrolysis of organic woody material, also exist but are less widespread. The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops can be grown specifically for energy use and include corn maize and wheat crops, waste straw, willow and poplar trees, sawdust, reed canary grass, cord grasses, sugar beet, miscanthus and sorghum plants. Research is ongoing into the use of municipal solid wastes to produce ethanol fuel.

Ethanol is a clear and colourless liquid, biodegradable, low in toxicity and causes little environmental pollution if spilt. Ethanol does however burn to produce carbon dioxide and water.

Biodiesel is an alternative fuel similar to conventional diesel and can be produced straight from vegetable oil, animal oil/fats, tallow and waste cooking oil. The largest possible source of suitable oil comes from oil crops such as rapeseed, palm or soybean, although in the UK rapeseed represents the greatest potential. An advantage of biodiesel is that modifications to cars are not required, although currently vehicle manufacturers do not allow more than 10% of biodiesel to be used without warranties becoming void.

At present most biodiesel is produced from waste vegetable oil sourced from restaurants, chip shops, industrial food producers. As the oil is considered to be waste material it is often sourced for free. It does however require sieving to remove impurities before it is converted to biodiesel. Another option is to manufacture oil straight from the agricultural crops. However, it is not currently commercially effective to do this.

Existing commercial-scale biofuel plants are very large units, and are very industrial in appearance. However, the process, and therefore the required facilities, can be scaled down to a more discreet size where appropriate.

Biodiesel can even be produced on a small scale in individual households, for use in private vehicles, also by using waste vegetable oil. The technique very simply uses a water butt or similar large scale container and a few additional pieces of equipment, at a very low cost.

The main environmental benefit of biodiesel is that it can be described as 'carbon neutral'. This means that the fuel produces no net output of carbon in the form of carbon dioxide.

The use and manufacture of biofuels are suitable for use within the AONB, provided the manufacturing facilities are not large scale.

4.4 Biogas

Biogas is a source of energy that can be harvested during the natural decomposition of organic matter. The process, called anaerobic digestion, is done without oxygen being present, and produces a usable gas, as well as an effluent that can be used as fertilizer. Biogas can use the following sources as fuel:

- Animal waste
- Sewage/slurry
- Domestic food waste
- Food waste from processing
- Municipal waste (from landfill sites)

Commercial scale biogas plants initially contain received waste in closed tanks, which are subject to bio-filtering, which reduces/eliminates unpleasant smells. The mixture is then moved to a heating tank, where its temperature is increased to 70°C, for one hour. This process kills any diseases present, as well as any seeds, to ensure that by-products are suitable for re-use by farmers.

Next, the mixture is kept at 37°C as anaerobic digestion occurs. The resultant methane is captured and cleaned, and used either as a source of heat, or to fire a generator to produce electricity. In the latter scenario, the water that is used to cool the generators can be fed through a heat exchanger to provide hot water for heating. The waste is then returned to farmers, to use as fertilizer on their land.

These plants have a number of large cylindrical silos/tanks, typically 10 metres in diameter and 10 – 15 metres in height, with associated buildings where the pipe work, burners etc are housed.

The UK's first biogas plant, Holsworthy Biogas, opened in Devon in 2004, and provides electricity to the national grid, and hot water to a local school, health centre, hospital and local homes.

The principle is also valid at smaller scales, suitable for individual farms, as illustrated by the recent installations of digester systems at seven dairy farms in southern Scotland. The collected animal waste is subject to anaerobic digestion in on-site facilities, and the resultant biogas is burnt off to provide heating and hot water. In some cases combined heat and power technology is also installed, to allow electricity to be generated. (See section 4.13 for more on CHP).

Pastoral farms usually have large silos for storage of animal waste. The additional equipment for harvesting biogas is made up of an extra, smaller silo for digestion to take place, with associated boiler and pipe work.

Biogas can also be harvested from the rotting of food waste. The same company that provided the farms with digester equipment, Greenfinch, is also working with South Shropshire District Council on a successful scheme that digests food waste from 1200 households to create a source of biogas.

This energy-from-waste philosophy also applies to capped landfill sites, which produce biogas as part of the natural decomposition process, which is tapped as part of the required venting system. In the past the gas has simply been burnt off in flares, but is increasingly being recognised as a valuable additional source of energy.

The availability of raw materials means that biogas technology is very suitable for use in the AONB.

4.5 Solar Photovoltaics

Solar Photovoltaic systems (solar electric power) produce electricity from special photovoltaic panels, normally placed at roof level. There are two types of systems; large, rectangular panels that bolt directly on to the building over the existing roof tiles, and fully integrated systems that replace normal roof tiles with photovoltaic tiles. Both are fairly discreet facilities, although they are very reflective, which makes them noticeable over standard roofing materials. The total area of panel required for an average house may be between 2 and 6m^2.

Photovoltaic panels contain one or two layers of semi conducting materials which, when light shines on the panels, create an electric field across the layers, causing electricity to flow.

The electricity produced is stored in special batteries for immediate or later use. Solar PV is suitable for urban and rural environments and over a year can provide a household with 30-50% of its electricity needs. Electricity is generated in the form of a direct current (DC) and can be used in that form or converted to an alternating current (AC) for household use. The electricity can also be exported to the national grid. A typical installed system can cost between £10,000-20,000.

An example of the successes of this technology is at Langdon Beck Youth Hostel, in Teeside. The hostel is in one of Britain’s largest Areas of Outstanding Natural Beauty.

A proportion of the electricity required for the Hostel is generated directly from the sun through photovoltaic panels on the roof (a solar hot water panel also provides domestic hot water). The system was installed in 2002 and produces about 20% of that required for the operation of the hostel.

Some of the advantages of solar photovoltaics include:

- silence during operation
- high level of reliability,
- low maintenance
- a lifetime of 30 years or more

As the energy source is universally available, and the installation of panels is applicable to all buildings, solar photovoltaic technology is suitable for use within the AONB.

4.6 Solar Hot Water

As stated in the previous section radiation from the sun can be harnessed directly in three different ways. This section of the report will consider 'active solar', i.e. the energy from the sun is used to heat water.

Most people understand solar hot water to mean rooftop solar water heaters. This is probably the most common form in Europe.

In northern European due to the colder climates particularly winter frosts, the most appropriate system is flat panels mounted on roof tops. This system is composed of three main parts, the panel on the roof, the storage tank and a pumped circulation system. Solar water systems depend on radiation rather than direct sunlight therefore it remains effective on duller days.

The panels are essentially very shallow, black glass-covered trays with a capillary pipe network within them. All the internal pipe work is obscured by the black glass, so all that is visible is the flat glass panel, typically between 2 and 6m^2. Slight adjustments or additions to the heating system will be required inside the building, but these are usually in the loft-space or cupboards, so no internal components will be visible.

A second similar solar heating system is where the water storage tanks are stored on roofs over the panels. This system is seen throughout the Mediterranean. However, in the UK this type of system is unsuitable due to freezing temperatures in winter.

Water is piped in a contained system to panels (or solar collectors) on the roof. Panels should face south or close to south and lie on a pitched roof that will provide the natural angle to face the sun. Once the sun has heated the water to the required temperature the circulating pump starts moving the hot water around the system. Through a heat exchanger, water contained in a normal domestic hot water cylinder is then heated. To prevent the water freezing, non-harmful antifreeze is added to the water. Research suggests that this type of system is believed to supply 40-50% of the hot water requirement for a typical house; most of this will be in the summer period.

Below is a table that gives typical indications to the area of the panels required for various household sizes:

Household size (no of rooms)	*Total panel area (m^2)*	*Typical volume of water that can be heated (litres)*
1-2	2.5	160
3-4	3.5	195
4-5	4.5	245
5-6	5.5	294

A well designed and installed solar heating system is likely to be reliable and safe and will typically last for 20-30 years.

A variation on the standard flat panel design is now available, called the evacuated tube system. This comprises of a series of 100 to 150mm diameter tubes laid adjacent to each other to form a panel. This design has an increased productivity over the flat panels, which only work at full efficiency when the sunlight falls on directly on them, perpendicular to their surface. This only happens when the sun is directly overhead at midday. However, the curved surface of the tubes means that the sunlight falls perpendicular its surface for most of the day, so they work at their optimum rate for a much longer period each day.

The typical cost for an installed solar water heating system is £2,000 - £3,000. However, this will vary depending on the size of the collector, type of system, the existing hot water system and the type of roof. Evacuated tube panels are slightly more expensive. A standard DIY system is likely to cost between £500 and £2000; this is substantially less than that required to convert a property. As with solar photovoltaic panels, solar hot water technology is applicable for use within the Norfolk Coast AONB.

4.7 Micro/Small Scale Wind

Micro and small scale wind turbines are considered to be turbines that are generally sufficient only to power a small number of buildings/commercial businesses, with an output of up to 10kW.

Wind as a resource is an almost ever-present feature of our weather. There are virtually no areas within the UK that these turbines could not physically be used because of a lack of wind, however some areas are more suitable than others. Turbines require a minimum wind speed of 7mph to be able to generate electricity, and are at their optimum output at speeds between 9 and 36mph.

Small scale wind turbines have been used to generate electricity countrywide for several decades now, and have been favoured where mains electricity is not available. This means they have usually been installed at remote houses/communities, or for charging batteries on boats, caravans etc. More recently they have been employed to power telephone masts, telephone boxes and remote traffic monitoring equipment.

Micro/small scale wind turbines typically have a set of blades between 1 and 3 metres in diameter. They can be free-standing, on a pole, between 5 and 12 metres in height, or mounted on a short pole on the top or side of a building, 2 to 4 metes above the roofline. A small unit or set of batteries would be required inside the building, although these are discreet, and can be easily installed in the loft-space or in a suitable-sized cupboard.

The technology for small and micro scale wind turbines is similar to that of large scale turbines; the wind turns the blades, which turns the turbine unit located behind the blades in the main head of the structure. As described above, the electricity produced can then be stored in batteries, as well as being used immediately by the consumer.

The electricity generated can also be sold back to electricity companies. This feature of the system allows a useful degree of flexibility, because at some times the turbine will generate more electricity than can be used, creating an excess, which is supplied to the National Grid. In return, when more power is required than can be provided by the turbine, particularly in periods with little or no wind, the consumer can use electricity from the Grid instead. The system is set up to allow a seamless, uninterrupted switch between the two supply sources.

The installation and running costs of micro or small scale wind turbines, and the fact that they need rechargeable batteries to be included within the system if not connected to the Grid, means that they are currently not competitive with the cost of a freely available mains supply. However, the increasing awareness of their benefits in terms of carbon dioxide emissions and other environmental implications means that they are becoming much more widely used, in a variety of situations.

This sector of the industry is currently in its early stages, which means that the cost of wind turbines is still too high for major commercialisation to be achieved. The ongoing system of available grants will still be necessary for the short term, to support uptake. It is predicted that the increasing demand for the systems, and ever-improving technology will mean that the sector will become viable without grants and incentives in around ten years time, when uptake should increase further still.

Companies such as Windsave offer generation systems than can be installed, and plugged straight into the mains of a house, downstream of the electricity meter, to offer significant reductions in utility bills. When considering financial investment of around £1500 for purchase and installation of the system, the average payback period is around five years.

Micro and small scale wind turbines may be subject to planning permission, depending on location, size, proximity to others etc. This process will take into account, among other things, impacts on the community caused by noise and visual intrusion, therefore planning and approval are likely to be greater obstacles in sensitive areas such as the Norfolk Coast AONB than in other locations. New features such as wind turbines would, in some people's opinions represent significant damage to the appearance and character of the area, and this would potentially make achieving acceptance difficult. However, PPG22 states that planning authorities should look favourably on applications for creating renewable supplies of energy.

Well-planned applications for micro or small scale wind turbines, where all potential impacts are predicted and minimised, would benefit the users greatly, providing a virtually free source of electricity with zero carbon dioxide emissions. This renewable source of energy is very much an option for utilisation within the Norfolk Coast AONB.

4.8 Small/Medium Scale Wave and Tidal

Both tidal and wave energy represent predictable, continuous sources of energy that are increasingly being harnessed to generate electricity. Although being situated in similar environments, the way they generate electricity is very different.

Tidal electricity generation takes advantage of the difference in water levels between high and low tides, which represents an enormous amount of potential energy. By using the moving water in either direction to turn turbines, electricity can be generated with no emissions and no pollution.

Wave energy can be used in many ways, by many types of devices. Some use floats out at sea and use the constant oscillation caused by riding the waves to provide movement of mechanical part, which then turn turbines. Others are fixed installations on the coast, and use the energy of the waves breaking on them to force air through turbines. Others are fixed to the sea bed, usually in shallow areas, and use the energy of the waves to move a wing or blade, which in turn operates a turbine. There are a myriad of design variations on the basic types described above.

There are limited locations around the globe where either wave or tidal movements are great enough to gain useful amounts of energy from. Tidal fluctuations are greatest around temperate latitudes. Wave energy distribution is more variable, but the North Atlantic is acknowledged as having high enough wave energy for electricity generation. This means that both sources of energy are potentially suitable for use around the coast of the UK.

A well-known example of tidal energy for electricity generation is La Rance tidal scheme in Brittany, Northern France. Within the industry this is described as being medium scale, having a capacity of 240MW. To put this in context, the Scroby Sands wind farm off the Norfolk coast, comprised of 30 individual large scale turbines, has a capacity of 60MW. The La Rance scheme is essentially a barrage across the tidal Rance estuary, which allows the incoming tide through unrestricted, and then uses its outgoing movement to generate power.

Construction of the UK’s first commercial scale wave energy facility is to be started shortly, off Milford Haven in Wales. It is due to be completed in spring 2007 and will have a capacity of 7MW.

Although large scale tidal energy may be viable due to the presence of tidal streams off the North Norfolk coast, small and medium scale wave or tidal electricity generation, suitable for providing power for small communities, is not currently a feasible proposition for use on the coast of the AONB. The technology is in a fledgling state, and so it is felt that it would not be economically viable for any projects other than testing/research facilities .

Because of this, small and medium scale wave and tidal electricity generation will not be considered further, as at present it is not considered to be appropriate for use within the Norfolk Coast AONB.

4.9 Small Scale Hydro Power

Small scale hydropower, as with small scale wind, works on exactly the same principle as its full scale counterpart. The potential energy of water stored at height is converted to electricity as it falls or flows downhill, by turning turbines, either directly or indirectly.

With typical efficiency values of between 70 and 90%, hydropower is the most efficient of all renewable energy sources. Water flow is highly predictable as a resource, exhibiting regular cycles throughout the year, and short-term fluctuations in availability occur very slowly, typically over hours or days, which compares favourably with wind availability, which can fluctuate greatly in minutes.

Layouts and designs for hydropower scheme can take several forms. A barrage can be built, effectively damming the river and using constant the through-flow to turn a turbine. Or a separate channel called a mill leat can be dug, which diverts a portion of the flow to a turbine unit. Alternatively, a penstock can be constructed, which is similar to the leat in principle, but diverts a portion of the flow from the river by way of a pipe, which is then fed into a turbine unit.

The proportion of flow that remains within the river is called the compensation flow, and is usually at least 90% of the total flow, to ensure minimal environmental impacts on the river integrity downstream of the facility.

It is important when planning a hydropower facility that its viability is fully assessed, in order to determine whether or not the proposition is economically viable, and whether the location has the potential to generate a usable amount of electricity. The latter point relies on both sufficient water availability and a large enough head of water to take advantage of, ideally in the form of a weir or waterfall.

The above factors therefore dictate that the use of this technology within the Norfolk Coast AONB is an unrealistic proposition based on current technologies. The topography of the area is such that sufficient head of water is unavailable, so using turbines with any degree of efficiency would be virtually impossible. Further, East

Anglia is within the rain shadow of the more mountainous western parts of England, meaning this is one of the driest parts of the country.

Small scale hydropower is not believed to be a viable renewable source of energy for the AONB, therefore it will no longer be considered within this document.

4.10 Geothermal Energy

Geothermal energy is energy that comes from within the earth, and is therefore the only renewable energy source that is entirely independent from the sun. There are three different ways of harnessing this energy; directly, as a source of heat, or indirectly, as a means of generating electricity.

The three methods of gaining heat from the earth are based around the depth from which the heat is extracted. Deep drilling, to depths of around two miles, can provide water of at least 400°C, which is ideal for using, as steam, to turn turbines in electricity generators or in other industrial processes.

A second method, to access the heat in the uppermost layers of rock and soil, is by using ground source heat pumps. This is described fully in the following section.

The third method is to take advantage of the locations where the earth's heat is available at the surface. These locations occur at the edges of the tectonic plates that comprise the earth's surface, and are characterised by volcanic activity and earthquakes that result from the gradual movement of the plates, and the consequent build-up of pressure.

With the exception of ground source heat pumps, the scale of engineering required means that geothermal energy generation facilities is usually very large, and serve whole districts or even regions, as illustrated below.

A geothermal power station has been in use in Larderello in Tuscany, Italy since 1904. It takes advantage of steam produced where water meets the hot rock a short distance under the surface, and currently produces over 700MW, and following a refit that is in progress will be capable of producing more than 1200MW. The increasing generation capacity illustrates how forward-moving technology can take advantage of a continuous source of energy in a more and more efficient manner.

An example in use of geothermal energy in the UK is the Southampton district heating scheme. A 1.8km borehole was drilled in 1981 by the Department of Energy for research purposes, which was then handed over to the city council for development as a district heating scheme.

The borehole taps a 200 million year old geological formation that holds saltwater at 70°C, and uses a heat exchanger to pass heat to freshwater for heating and domestic hot water for various public buildings and private residences. The excess salt water is, in this case, pumped into Southampton estuary, although this is not the norm – more modern systems re-inject the pumped water back into the rock.

There is limited scope for taking advantage of geothermal energy in the UK, as there are only a small number of areas where the geology contains hot water close to the surface to be usable. These are in the North Pennines, Derbyshire, and parts of southern England.

Therefore, aside from the use of ground source heat pumps, which are described in the next section, geothermal energy is not considered to be a viable energy source for use within the Norfolk Coast AONB.

4.11 Ground Source Heat Pumps

Heat pumps work by transferring heat energy from one place to another, within a self-contained system. Fluid within the system is pumped to the heat source, where it changes from a liquid to a gas. The gas is then pumped round the system to where the heat is required, and is condensed back to a liquid, a process which releases energy in the form of heat. The heat source can be air, water or the ground, or even waste heat from industrial processes. Ground source heat pumps are those that extract heat specifically from underground.

Unlike most other renewable sources of energy, a small amount of electricity is required to drive the pumps that move the liquid/gas around the system, but the ratio of energy gained to energy required is at least 3:1. The user of the system is recommended to sign up to a supplier of electricity that uses renewable sources, so the whole system becomes one of zero emissions, and therefore totally sustainable.

The energy gained from ground source heat pumps is ideal for domestic heating, especially underfloor heating as it requires a slightly lower temperature water than conventional heating systems. It can also be used to heat domestic hot water for washing, bathing etc. Heat pumps can be installed internally in residential buildings, as they take up little more space than a conventional gas-fired boiler.

The International Energy Association's Heat Pump Centre provides example of residences and businesses using ground source heat pumps. One illustration is of a large single-family house in West Grinstead, Wiltshire, which installed a system in 1997. It provides space heating for nearly 300m^2 of living space, and domestic hot water. The annual performance factor for the property, comparing energy output to input is 3.16, and in the summer, when used mostly for providing domestic hot water this figure is still 2.5.

This heat pump has associated emissions of 3600 Kg CO_2/year. This can be compared to the calculated emissions of other systems that could be used to heat this property; a modern oil-fired boiler would create 6390 Kg CO_2/year, or a gas-fired boiler 4260 Kg CO_2/year. A 100% electric heating system would create 8590 Kg CO_2/year.

The systems are also suitable for larger, non domestic properties. A further example is of Charlestown Junior and Infant School in Cornwall, where a ground source heat pump is used to provide all heating and cooling requirements. Compared to its' previous direct electric system for heating and cooling, running costs are down by 50-

60%, and carbon dioxide emissions in providing energy are down by between 60 and 70%.

Ground source heat pumps are currently the cheapest option when considering small-scale renewable energy production. The benefits of ground source heat pump technology, and their universal application in terms of location, means that they could be suitable for use within the Norfolk Coast AONB.

4.12 Fuel Cells

Fuel cell technology is currently in its early stages of development, but is progressing rapidly. It is becoming increasingly associated with transport and vehicles, although these are not the exclusive uses of fuel cells.

It is important not to confuse fuel cell use in vehicles with hybrid/dual-fuel technology, which is simply a way of increasing fuel economy of conventionally-fuelled vehicles. Hybrid vehicles do this by combining the use of conventional fuel with electricity, which is either generated by the forward momentum and/or braking energy of the vehicle, or is supplied by regular recharging. Batteries are used as storage devices for the electrochemical energy. Fuel cell technology requires no recharging and no batteries, just a fuel, a variety of which can be used.

No matter what type of fuel is used, the basic chemical principle utilised in fuel cells is the same. The reaction that occurs on a molecular scale is as follows: hydrogen and oxygen are combined, and react with each other to produce electricity, heat and water. No other products result from this reaction, and this represents on of the main attractions of fuel cell technology - the total absence of any unwanted emissions or pollutants.

The basic construction of fuels cells consists of two electrodes, one anode (positive) and one cathode (negative), with an electrolyte in between that carries the electric charge between the electrodes. The type of electrolyte varies, and fuel cells are categorised by the type of electrolyte that is used.

The different types illustrate the origins of the technology, for example alkaline fuel cells use an alkaline such as potassium hydroxide, and were originally developed by NASA for use in space shuttles. This type is now used almost exclusively in spacecraft and submarines. Other types of fuel cell are ideal for use in large scale operations such as power stations.

On a smaller scale, direct methanol fuel cells use pure methanol as fuel, and are ideal for use as small, portable sources of energy. Proton Exchange Membrane fuel cells are flexible in power output so can meet a varying demand easily, and operate at comparatively low temperatures. This type of fuel cell is therefore ideal for use in vehicles, buildings and other small scale situations. In vehicles, this type of fuel cell is at least twice as efficient as an internal combustion engine, and most major vehicle manufactures regard this technology as its natural successor.

There are numerous materials that fuels can be produced from. Whereas the technology surrounding the cells themselves is well-developed and usable, creating the fuel is still difficult. Further, it is important that the fuel comes from a sustainable material via non-polluting procedure, if the benefits of fuel cell usage are not to be contradicted. It is this aspect of the technology that is currently under-developed and requires the most pushing. Once the two complimentary aspects are easily accessible and at a reasonable cost, fuel cell usage will become much more everyday in energy production.

The use of fuel cell technology is being tested around the world. A project called Clean Urban Transport for Europe (CUTE), whereby the EU has allocated €18.5 million to nine cities across Europe; the money financed integrated tests of fuel cell buses to be carried out, within the existing public transport systems. In London, three buses were running on locally-produced fuel, with the aim of proving that this technology is applicable, reliable and emission-free.

The results were promising, especially in terms of reliability, as after initial tentative trials were carried out, the three buses were all put into full time duty, replicating the work done by the conventional buses. The trials came to an end in December 2005, with no further announcements on their success, or whether they were likely to be repeated.

To facilitate the above scheme a BP filling station, which would have allowed the fuel cell buses to refuel close to their working routes, was denied planning permission by the local government in Romford on the grounds of national security, suggesting that the hydrogen fuel station could represent a significant target for terrorist attacks. BP appealed to get the decision overturned, stating that they have thousands of LPG stations that represented just a big a risk, and these were installed all over the country.

Aside from any logistical problems, or limited access to fuels, fuel cells represent a technology that is ideal for use within the Norfolk Coast AONB. Fuel cell usage would undoubtedly benefit the AONB and its communities, and, assuming that the fuel came from a sustainable, non-polluting source, the entire system would be free of emissions. As commercialisation develops, and the availability of the fuel cells increases and the fuels becomes cheaper, fuel cell usage will become more widespread and common.

4.13 Combined Heat and Power

Combined heat and power (CHP) technology is not a renewable energy source like all of the other technologies described so far. Instead it is a set of techniques to make energy generation methods as efficient as possible, by ensuring that as much of the unused waste energy as possible is utilised.

Conventional electricity generation, for example by means of a coal-fired power station, is generally only 30 - 50% efficient. This means that of all the energy created by burning the coal, less than half is actually used to generate electricity, with the remaining energy being lost as waste. By capturing the waste energy and making it available for use, the efficiency of the power station can rise to between 70 - 90%.

The above example cites a large scale power station, but combined heat and power technology can be employed in many instances where power alone is generated currently, at any scale. It is usually done by the installation of a heat exchanger, which absorbs the exhaust heat that is created during power generation, and transfers it to a water supply, which can then be used for heating, hot water supply or even to generate more electricity, if the temperature is high enough.

Existing CHP facilities in the UK produce 30% less CO_2 by weight than an equivalent coal-fired power station, and the constantly improving technology means that modern installations could increase this figure to 50%.

CHP technology can be in one of four forms; a steam turbine, a gas turbine, a combined cycle system or a reciprocating engine. Most of these systems do not use renewable energy, around 65% use gas for fuel, for example. This suggests that perhaps CHP technology should not be regarded as a renewable energy technology; it is primarily a more efficient way of using existing fuels, whether conventional or renewable. Only 2% of the fuel used in CHP generation in 2004 was from renewable sources, although there is no reason why this should not be increased in the future.

When considering CHP in relation to renewable energy in the Norfolk Coast AONB, for inclusion in biomass boilers, biogas plants etc, the required equipment would be internally located, rather than as a separate unit. Therefore CHP facilities will mean slightly larger versions of the non-CHP equipment.

As a means of becoming more energy efficient and less wasteful, CHP technology is very much an applicable technology for use within the Norfolk Coast AONB.

4.14 Summary of Technologies suitable for the Norfolk Coast AONB

The following renewable energy sources and technologies may be suitable for use within the AONB:

- Small/Medium Scale biomass
- Biofuels
- Biogas
- Solar Photovoltaics
- Solar Hot Water
- Micro/Small Scale Wind
- Ground Source Heat Pumps
- Fuel Cells
- Combined Heat and Power

5 Impacts

In this section, the impacts of each of the suitable technologies are identified and assessed. The effects on the landscape of the AONB are considered, as well as other factors such as biodiversity and wildlife, the built environment, cultural heritage, employment, the community and cost.

5.1 Small/Medium Scale Biomass and Biofuels

Biomass and biofuel technologies are both complex issues, which have two distinct aspects that may cause impacts within the Norfolk Coast AONB.

The first aspect, which is perhaps the most significant, is that their use requires an ongoing need for fuels to be grown. Growing these fuels, either biomass for burning or crops for conversion to biofuels, is an issue that is likely to have implications for large swathes of the countryside, affecting it's appearance, character and use. As growing biomass and biofuel crops are so similar, their impacts are considered together.

The second aspect is the actual use of biomass and biofuels within the AONB. Unlike above, biomass and biofuels are used in very different circumstances, and are therefore likely to have differing sets of impacts and effects. They are therefore considered separately.

5.1.1 Growing Fuel Sources

The numerous types of fuels that can be used for burning in biomass boilers and for converting to biofuel means that this is a very broad subject, and the specific impacts will depend on the circumstances, location and fuel type that is grown. Fuels may be harvested from sources that already exist, or new sources may be planted. Again, both of these scenarios will have different impacts, so are considered separately.

(i) Existing Biomass and Biofuel Sources

Ongoing rural practices, such as woodland management and harvesting existing crops, produce materials and by-products than can be used as biomass and biofuels. These products are often either underused or regarded as waste, and so discarded. Instead, they could be utilised, as a free renewable energy source, reducing or eliminating the need to pay for conventional fuels.

Biomass from Habitat Management

Existing woodland management activities provide a plentiful supply of wood that is available to be chipped, dried and then burnt as biomass. Where an existing fuel source such as this can be utilised, there need be no negative impact on the biodiversity, landscape and appearance of the countryside, as no change to the practice is required. For example, an active woodland management programme is carried out by the National Trust at Sheringham Park. The biomass material gained by thinning etc. is used in their biomass boiler to provide heating. Such practices are in fact likely to offer some benefits, as outlined below.

Operations such as this often produce more biomass than can be used solely by the landowner, and this situation means that two options for further improvement may be open:

Firstly, the excess biomass could be made available to the community for burning on their own properties, creating positive impacts in terms of increased revenue for the landowner, and in encouraging the use of sustainable fuels within the local community. Secondly, the landowner could install more biomass boilers, elsewhere on their property, to take advantage of the freely-available fuel source. One or both of these options could realistically be put into action.

As evidence of the above point, several farms in the AONB, including Copys Green Farm and the Bayfield Estate, currently use biomass boilers. In some cases additional boilers are being planned because they have been so successful, to take advantage of the renewable energy source as it is cheaper than conventional energy and uses a freely-available fuel.

Woodland management is beneficial for woodland ecosystems, encouraging greater biodiversity, benefiting wildlife and improving overall woodland integrity. Where this ongoing process is already in place, no real positive impact can be attributed to its arrival. However, if the practice was encouraged among landowners who do not currently manage their woodlands, it could have a positive impact on comparatively large areas of important, and currently undervalued, habitat. Using these areas as a source of biomass will support the economic viability of their management.

Areas of ancient woodland, of which there are several within the Norfolk Coast AONB, are a valuable part of its rural cultural heritage, so any improvements to these designated areas created by improved management could have a positive impact.

Although woodland management uses existing material as fuel, the necessary purchase of additional equipment for chipping or pelleting the wood may require a significant cost to be borne. The opportunity exists for farmers and landowners to group together in co-operatives, to spread the cost of purchasing such equipment, as its use by each farmer would be intermittent. This would mean that the cost could be shared, increasing the financial viability of the prospect, and perhaps even promoting further community spirit among landowners within the initiative. Larger areas of planting would increase the financial viability of purchasing such equipment.

Biomass from Agriculture

A further example of a source of biomass being available as the by-product of an ongoing process, is that of straw that is left after harvesting. In East Anglia up to 80% of straw is surplus to existing requirements, and so could be seen as a valuable cost-free source of energy. It may be the case that the cost saving gained by burning the straw instead of paying for conventional fuel is greater than the value of the straw as livestock bedding, or as nutrient enrichment if ploughed back into the fields.

The use of surplus straw would mean there would be no negative impact on the landscape, biodiversity or cultural heritage of the AONB assuming no expansion of straw cropping, as the process is already being employed and no changes would be required. Conversely, the costs of running the farm could be reduced, and it may add weight to the financial viability of farming, where currently there is very little incentive due to the very low prices that crops achieve at market. This could have associated positive impacts of employment within the community.

Sugar beet, like many other arable crops, currently achieves low prices at market. However, the expanding biofuel market may mean that an alternative market becomes available, stimulating competition and therefore increasing prices. A specific trigger for this may be when the Wissington bioethanol plant becomes operational in 2007.

Like the earlier examples, sugar beet is already grown in the AONB, so no regime change need take place. Because of this, no adverse impact would be imposed on the landscape, assuming no significant expansion of planting occurred. Also in common with the previous examples, it may result in increased financial viability of farming, benefiting the landowners and their staff.

(ii) New Biomass and Biofuel Sources

If no suitable existing areas of crops are available, or the existing fuel sources are not sufficient to support energy production in a sustainable manner, landowners may choose to create new areas of planting.

New areas of planting for biomass or biofuel crops have the potential to greatly affect the landscape of the Norfolk Coast AONB. These impacts will depend on a number of interlinked factors, each of which will either reinforce or counteract the others. Each instance of proposed planting within the AONB is likely to have a different set of circumstances associated with it, so no fixed rules can be applied. Each case should therefore have its impacts quantified individually.

Location and Visibility

A primary factor relating to the impact on the landscape will be the chosen location of the new planting area. For example, an exposed, elevated area will be much more readily observed than a sheltered, screened valley bottom, and may therefore be subject to much greater impact. However, as described above, a number of other factors will also influence the overall impact, so it is not simply that case that one type of location would be suitable for new areas of planting, whilst others would not.

Landscape Value and Character

It is also vital to consider the landscape value of the area that new planting will replace. Generally, a positive impact would be felt if the new planting is of higher landscape value and character than that it is replacing, and a negative effect would be felt if the opposite is true. So although planting in a valley bottom may not be easily seen, new planting in it could replace an area of high landscape value, and so have an overall negative impact.

Size of Planting Area

The amount of land given over to biomass planting is likely to correlate with the magnitude of impact caused. Generally speaking, the larger the area, the greater the impact on the landscape will be, either positive or negative. Again, this factor will be interlinked with all others, as a large area of poplar coppice may have more of a positive impact on the landscape than a smaller one. Conversely, a large area devoted to rapeseed may arguably have more of a detrimental effect on the landscape than a smaller one.

As biomass and biofuels take off and become more popular, it is reasonable to expect landowners to increase their output of these crops to cater for the expanding market. The impacts of larger-scale operations will be similar to those of small-scale schemes, only larger in magnitude.

Type of Vegetation Planted

The type of vegetation planted will markedly influence the impacts at each type of location. As illustration, areas of additional conventional crop like sugar beet or wheat are already present and are likely to be readily accepted as part of the natural landscape, so are perhaps suitable for more open, easily viewed areas. On the flip side, less common, less traditional crops like miscanthus or canary grass are more likely to be considered as out of character. Their location is therefore something to be considered carefully.

Biodiversity

Also in reference to vegetation type, some areas may be more sensitive to detrimental impacts than others. Willow grows well in damp conditions, and is therefore a prime candidate for planting in river valleys and on floodplains.

River valleys and floodplains areas are particularly sensitive within the AONB as they contain a high number of County Wildlife Sites, which are afforded a good level of protection. Also located in river valleys are large areas of floodplain grazing marsh. These marsh areas, although marginal in terms of agricultural value, are important habitats, and are recognised as a priority habitat in the Norfolk Biodiversity Action Plan. Their value for wildlife and biodiversity is high, so any loss of such areas would have a negative impact.

Habitats that are not afforded protection like County Wildlife Sites are still likely to have some value for biodiversity, so the existing habitat value should be compared to the habitat value of the proposed planting. New areas of biomass would have a positive impact on biodiversity if it replaces habitat of lesser value, for example by planting areas of coppice in arable fields. Conversely, planting would have a detrimental effect if it were to replace a habitat of a greater value, perhaps by growing wheat as a source of straw to burn, in a species-rich, unimproved grassland meadow.

Costs

New areas of planting would need to be replanted or managed at regular intervals, which could incur an extra cost, in terms of time and man-power. This need not be a negative impact of growing biomass – any farm activities that prevent the ongoing trend of redundancy of existing farm workers should be a positive effect of the system.

Each time replanting takes place it is also likely to have an associated cost impact, although this should be offset against the cost saving gained by eliminating requirement for conventional fuel. The overall effect should be one of financial saving, especially if the biomass burnt in the boiler is a by-product that would otherwise be wasted or used in a less financially-sound manner.

Logistics/Vehicle Movements

An extra, detrimental impact that may be caused by the likely increase in transportation as the biomass industry expands. As commercial biomass operations become more widespread, more vehicles movements will be required to distribute the product between source and point of use.

The type and size of vehicle, and the frequency of journeys, will all depend on the distance to be travelled. Transporting biomass long distances is likely to involve occasional journeys for large HGVs, whereas transporting biomass to local markets can be done more frequently, meaning that smaller lorries/trailers could be used.

A local supply chain of growers and users should mean that large HGV journeys are minimised, and should therefore have much less of an impact than transporting biomass great distances.

Summary

In summary, new areas of crops for biomass of biofuel have the potential to greatly impact on the landscape and appearance of the Norfolk Coast AONB. There are a great many factors that will influence the associated impacts, each of which are likely to be different for each individual area of planting. No fixed rules can therefore be applied, and each case should be individually assessed. The following factors should be considered in each instance:

- Availability of existing fuels
- Location/visibility of area of planting
- Landscape value/character
- Size of area
- Type of crop
- Biodiversity value of habitat to be replaced

- Protection status
- Suitability of physical conditions e.g. soil, hydrology
- Cost of equipment required
- Cost of replanting, if necessary
- Proximity of market, and level of demand.

The complexity of the issues surrounding biomass and biofuel cultivation means that specific, accurate predictions should be carried out on a case-by-case basis. The depth of work required to assess the subject sufficiently is beyond the scope of this report. Further work in a separate follow-up report would therefore be beneficial, in order to provide a more comprehensive set of predictions into all probable impacts.

5.1.2 Using Biomass

Biomass boilers themselves need have no major impact on the landscape or the built environment in which they are located. Their very nature means they are not likely to be used within urban/semi-urban residential buildings unless at a very small scale, such as log burners etc. Instead, biomass boilers are more suited to larger scale building complexes such as farms, factories and schools. The layouts of such locations lend themselves to the installation of external equipment, and tend to generate less sentiment about their appearance than private residences. Externally-located boilers in these types of locations should not detract from their appearance in any significant way.

Biomass boilers can also be installed inside buildings, and where this is the case, very little visual impact would be felt. A chimney or flue will be required, but can be incorporated into the fabric of the building, or its size kept to a minimum.

If done sensitively, the installation of biomass boilers need have no detrimental impact on listed buildings or conservation areas, especially if installed internally, however, consent for the alterations is likely to be required.

There may be a localised negative impact on air quality, as the burning will produce carbon dioxide and other emissions. However, assuming that the fuel has been dried to sufficiently low moisture content, and the burner is operating at a suitably high temperature, the amount of emissions should be low.

5.1.3 Using Biofuels

The biofuel industry is currently in the early stages of development. This means that in the near future both bioethanol and biodiesel could be employed as supplements to conventional fuels, rather than as complete substitutes. Initial proportions of biofuels use are likely to be only 5-10%, resulting in only a marginal reduction in emissions produced. As the technology evolves and becomes more readily accessible, the proportion of biofuels to conventional fuels will increase, and emissions per vehicle km will consequently decrease.

The initial use of biofuels will have very few impacts within the Norfolk Coast AONB, as their use will not require significant alterations to, or replacement of, existing vehicles engines. As the technology evolves, more and more vehicles will be built that are capable of using higher proportions of biofuel. As this trend progresses the resultant carbon dioxide emissions should decrease.

The conversion of crops to biofuels is easily achieved on a small scale, so it is likely that biofuel facilities would be constructed within the AONB, most likely within rural or light industrial settings. Small scale operations could be undertaken by landowners to covert their own crops to biofuel for private use, or slightly larger, more commercial enterprises may be established, producing enough biofuel for sale locally.

If a biofuel conversion plant were installed in existing buildings, no adverse impacts would be imposed on the landscape. However, if new buildings are required, their design, location and size would need to be considered carefully in order that they did not have negative impacts. New buildings would be subject to the regular planning permission process, which should go some way towards ensuring their suitability to the proposed location.

If of a sufficient size, biofuel manufacturing facilities may have the potential to offer new employment opportunities within the Norfolk Coast AONB, both directly at the conversion plants, and indirectly, by promoting the viability of the farming industry, as described in section 5.1.1 (ii).

Further positive effects from manufacturing biofuels locally would include the reduced requirement for transporting biofuels from outside the AONB. This would lessen the frequency of large fuel tanker journeys within the area, as the fuel source and final market would be located close to each other. As with biomass use, a local market for a product greatly enhances its sustainability.

5.2 Biogas

The utilisation of waste organic products to produce biogas would have a number of positive impacts within the Norfolk Coast AONB, most notably the financial savings for farmers that would be created by the reduced need for conventional heating fuels.

At a farm by farm scale, using animal waste or crop waste such as beet tops, the required apparatus is likely to be smaller and more discreet than the existing silos and waste storage facilities, so it is likely there would be no significant impact on the rural landscape. The fuel source would reduce or eliminate the need for conventional fuel to be paid for, and the main by-product of the process, the burnt waste, can be used as a fertilizer, further reducing the running costs of the farm.

The establishment of larger, commercial operations, perhaps to process domestic food waste, would require significant new construction to take place, including the large storage silos and digesters. Such a development would have to be located away from built up areas, and may be considered to have a considerable negative impact on the landscape.

However, in its favour, the set-up could appear very similar to a conventional farm complex, so need not appear totally alien within the landscape. Sensible positioning and appropriate screening with vegetation to hide the low level apparatus could result in a discreet facility capable of providing gas and electricity to a fair-sized local community.

Such an arrangement would provide farmers with a local use for their animal or crop waste, or residential areas a use for food waste, and the by-product of the process would represent a local source of fertilizer.

5.3 Solar Photovoltaics and Solar Hot Water

Solar photovoltaics and solar hot water systems are very similar in usage and appearance, and so can be considered together when assessing their impacts.

In relative terms, solar panels are small scale features when considered in the wider scale of the overall landscape of the AONB. The scale of the impact of such features is likely to vary depending on the where the solar panel is located on a property or garden and how it is viewed by others. If the new style solar panels system are installed the impact is likely to be negligible as the panels replicate roof tiles.

Perhaps the only potential for visual impact caused by the panels is the reflection created by the sunlight bouncing off their highly reflective surface. The glare would be localised, and would move during the day due to the transit of the sun across the sky.

The use of solar panels on listed buildings is likely to be highly restricted, as they are likely to detract greatly from the integrity and appearance of the building on which they were mounted. Instead, their use within the grounds of the building could be investigated.

While solar photovoltaic panels are expensive because of the silicone content, solar hot water panels are one of the cheaper renewable energy technologies to install, and in the future should get cheaper still. Following installation, both are virtually free of running cost, and provide a free energy source. This means that owners need spend less money on conventional energy supplies.

Solar panels produce no carbon dioxide emissions, and so are very beneficial in this respect. They can go some way to reducing the carbon dioxide emissions created by households or businesses, which would otherwise be created by conventional energy generation methods.

5.4 Micro/Small Scale Wind

In common with solar panels, wind turbines can provide a virtually cost-free source of energy, so allow their users to significantly reduce their spending on electricity, whilst being totally free of carbon dioxide emissions.

Wind turbines require a clean, uninterrupted air-flow, and therefore must be erected in an open area or at a significant height, which makes them prominent within the landscape, both in rural and built environments. This is likely to mean a significant visual impact, one that is likely to generate mixed views and opinions as to their acceptance within the AONB.

More specifically, the use of wind turbines may not be entirely compatible with areas of notable cultural heritage, such as conservation areas and listed buildings. Their erection could have significant detrimental impact on the character of buildings that are currently very traditional in appearance, and so their use within these areas is likely to be met with some resistance. The traditional, rural nature of the AONB is one of its main assets, and should therefore be protected as far as possible.

Wind turbines may be more suited to areas that are less traditional in appearance, where resistance to their erection is likely to be much less. Locations such as semi-industrial estates, newer buildings on the edges of residential areas, farms etc are all far more appropriate, as the turbines would affect the setting to a much lesser extent.

5.5 Ground Source Heat Pumps

Heat pump technology is intended for installation within buildings, and an individual unit consisting of pump and heat exchanger need take up little more room than a conventional gas-fired boiler. Therefore no visual impacts would be felt within the rural landscape or the built environment. In addition, there need be no negative impacts on listed buildings if the installation is planned and carried out carefully.

The installation of the pipes in the ground will mean some temporary disturbance, but on completion this aspect too should have no visual impact. Digging the trenches for the pipes could impact upon any below-ground archaeology present, and it is also important to remember that areas can be designated as Sites of Special Scientific Interest specifically for their geology as well as for their biodiversity value, so could be damaged if trenches were dug.

Burying pipes straight down into the ground, rather than horizontally underneath the surface, in a borehole, is an option to reduce potential impacts, but this has a much higher associated cost.

The systems permit the use of a free heat source, which can easily replace existing conventional heating systems. This means that running costs are low, although they are not totally eliminated as a supply of electricity will still be required to operate the pump that drives the system. As a consequence, heat pumps provide heating whilst producing a lot less carbon dioxide emissions than conventional systems.

Heat pump systems are the least expensive renewable energy technologies to install at a building scale, and should therefore have the shortest payback time.

5.6 Fuel Cells

The introduction of fuel cell technology would have few detrimental impacts within the AONB. A number of positive impacts would be felt; vehicular carbon dioxide emissions would be reduced, and vehicular noise would be reduced. However, the requirement for new fuel stations may have negative impacts on the appearance and character of the built environment.

However, the use of fuel cells within the AONB is not currently a feasible proposition, due to the sector being at such an early stage of development. Although fuel cells have recently been proved as a usable, useful technology in pilot schemes and studies, they are enormously expensive to buy, and fuel availability is strictly limited. Fuel cell technology is not likely to be cost-effective in the short to medium term within the AONB.

5.7 Combined Heat and Power

Combined heat and power (CHP) technology is designed to compliment all energy generation technologies, both conventional and renewable. When CHP is applied, it can be incorporated into the main body of the equipment, and therefore need have very few additional impacts than the technology that it is based on.

CHP will allow greater efficiency to be achieved, or a second type of energy to be generated, so will increase the financial benefits for its employers where utilised by reducing dependence on conventional energy supplies.

5.8 General Comments

As a general rule, small-scale renewable energy technologies impact upon individual buildings, and often on the built environment as a whole. Conversely, the rural landscape is affected by larger scale operations, as well as by growing fuels for biomass and biofuels. Wind turbines are perhaps the exception to this rule, as they need open areas for effective operation, whether in rural or built environments, and are therefore installed at height in readily observed positions.

All the described technologies have associated set-up and installation costs, some higher than others, which must be borne in mind. The varying costs, combined with the variations in the amount of energy produced, mean that payback periods will differ. This will undoubtedly influence the rates at which the public chooses to invest in them.

In addition, the equipment will require significant amounts of energy to be invested in obtaining the required raw materials and subsequently in their manufacture, which some may argue detracts from their sustainable credentials. The cost in energy terms often corresponds with the necessary financial outlay, for example solar photovoltaic panels are particularly expensive, because of the requirement for silicon, which is difficult to obtain and therefore high in cost.

Aside from the growing of biomass and biofuels, potential employment opportunities associated with renewable energy technologies within the AONB are limited. New employment sectors would only become a possibility if any of the technologies experience sufficient demand to warrant local installers/maintenance companies being set up. However, this is unlikely in the near future as the use of renewable energy is such a limited characteristic of the AONB currently. Any increase in employment would happen slowly, and total numbers even as their use becomes widespread may not be abundant.

Similarly, only the growing of biomass and biofuels are likely to have an observable impact on biodiversity within the AONB. The use of other renewable fuels will undoubtedly reduce net carbon dioxide emissions from the area, and therefore play a very small but valuable role in reducing the effects of global climate change, with consequent indirect positive impacts on biodiversity.

The incorporation of renewable energy technologies into new buildings is a much more efficient process, and is therefore cheaper and more economically viable than as retro-fit installations.

6 Principles and Recommendations

By identifying and predicting the potential impacts of the individual technologies, the formulation of a series of principles and recommendations has been possible. By adopting these, the Norfolk Coast Partnership would be able to evaluate proposals for renewable energy technologies in a consistent and informed manner, to the benefit of the AONB and its contained communities.

6.1 Small/Medium Scale Biomass and Biofuels

Future Work

The multitude of factors that affect the impacts of growing crops for biomass and biofuels, and their inherent complexity and interaction, equate to a level of required detail that is beyond the scope of this report. Therefore, in order to predict the impacts more accurately and in finer detail, the production of a detailed follow-up report specifically into biomass and biofuel production within the AONB would be very beneficial.

This in-depth study should allow a greater level of detail to be achieved, which could then be used to accurately predict the specific impacts of these renewable energy sources being grown within the Norfolk Coast AONB. The starting point for such a piece of work could be a detailed matrix that compared all the different fuel types, and assessed each related issue in detail, which could then be complimented by further, explanatory text.

Local Supply Chain

Where biomass is grown for commercial purposes rather than just for use by the landowner, local users should be sought. This will maintain the sustainability credentials of the system and keep transport impacts to a minimum.

Co-operatives

Encourage the establishment of co-operatives between landowners, whereby required peripheral equipment such as wood-chippers and pelleting machines are shared. The sharing of costs for the purchase of equipment would be beneficial for all members of the co-operative.

6.2 Biogas

Farm-scale systems for the extraction of biogas from animal waste should be recommended for application within the AONB. This source of biogas will allow the waste to be used productively, and will reduce heating fuel costs for farmers. The by-products are also usable as fertilizer.

Commercial-scale biogas plants, whatever the fuel source, should be permitted, providing the visual intrusion into the rural landscape of the AONB can be mitigated against to an acceptable level.

6.3 Solar Photovoltaics and Solar Hot Water

Solar panels, both photovoltaic and hot water, should be allowed and encouraged on buildings within the AONB, except listed buildings, assuming that they will integrate with local design and landscape impacts have been considered. Planning permission must be obtained.

Planning authorities could be briefed to provide advice on alternative, more appropriate renewable energy technologies for use in association with listed buildings.

Where solar photovoltaic systems are proposed, the use of tiles that can be incorporated into the construction of the roof should be encouraged over the large, single-piece panels, in order that visual intrusion is kept to a minimum.

6.4 Micro/Small Scale Wind

Wind turbines should be permitted and encouraged, but must be sensitively sited within the Norfolk Coast AONB, in order that their visual impact is kept to an absolute minimum. Planning permission must be obtained.

Stand alone turbines should be encouraged for use away from more urban areas, to ensure that impacts on the built environment are minimised.

Where new non-residential developments are proposed, wind turbines should be encouraged as a means of generating electricity.

6.5 Ground Source Heat Pumps

The installation of ground source heat pumps should be permitted and encouraged in all instances. Assuming no archaeology or valuable habitats will be damaged, there are virtually no negative impacts associated with this technology, partly due to the fact that they can be installed internally, and take up no more room than a conventional boiler.

6.6 Fuel Cells

No feasible principles can be established relating to fuel cell technology due to its prohibitive cost and its early stage of development and accessibility.

6.7 Combined Heat and Power

Where renewable energy technologies are installed within the AONB, combined heat and power capabilities should be promoted and encouraged.

CHP should also be heavily promoted where other, conventional energy sources are used, in order that efficiency and productivity are as high as possible, and that the minimum of wastage occurs.

7 Support

these were correct at time of report presentation March 2006

7.1 Advisory Bodies and Agencies

Defra

Department for Trade and Industry

Carbon Trust

Energy Saving Trust

Renewables East:

7.2 Funding Opportunities

(i) Department for Trade and Industry grants:

Clear Skies

Low Carbon Building Programme - Details to be announced.

(ii) DEFRA grants:

Rural Enterprise Scheme

Objective 2 of the Structural Fund initiative

Energy Crops scheme

Environmental Stewardship scheme

(iii) Energy Saving Trust grants:

Community Energy grants

Energy Saving Trust Innovation Programme

Energy Saving Trust Solar Photovoltaic grants programme

8 References

The following sources of information have been used in the production of this report. They are listed approximately in order that they were used:

* website links provided in original report have since been removed as out of date

Department for Trade and Industry Renewable Energy - It's Only Natural:

Defra

Renewables East

Carbon Trust

Energy Saving Trust

EU Renewables Directive

2003 Energy White Paper

Renewable Obligation (DTI)

Office of the Deputy Prime Minister - Planning Policy Statement 22

Office of the Deputy Prime Minister - Building Regulations

East of England Regional Assembly - East of England Draft Plan

Sustainable Development Round Table for the East of England – Making Renewable Energy a Reality – Setting a Challenging Target for the Eastern Region

Digest for the UK Energy Statistics

Renewables Statistics

Department for Trade and Industry/Energy Saving Trust renewable energy micro-generation report

(i) Specific Technology Links

The Micropower Council

Greenenergy (Part of the National Energy Foundation)

The Logpile (NEF project to promote wood fuel)

Dragonheat (Biomass boiler manufacturers

FCB Group (Biomass boiler manufacturers and biomass suppliers)

British Association for Bio Fuels and Oils (BABFO)

British Bioethanol (British Sugar subsidiary)

Global Commodities UK Ltd (Biodiesel producers)

Holsworthy Biogas (UK's first biogas plant)

Greenfinch (Anaerobic Digestion & Biogas Specialists)

Solar Trade Association

EcoWarm (solar hot water panel manufacturers)

Energise Engineering (solar hot water panel manufacturers)

British Photovoltaic Association

PV Systems (solar photovoltaic panel manufacturers)

Segen Ltd (solar photovoltaic panel manufacturers)

British Wind Energy Association

Windsave (Wind Turbine manufacturer)

Proven Energy (Wind Turbine manufacturer)

Wavegen (manufacturers of trial wave energy equipment)

British Hydropower Association

Ground Source Heat Pump Club

UK Heat Pump Network

International Energy Association Heat Pump Centre

Heat Pump Association (part of the Federation of Environmental Trade Associations)

Fuel Cell Today

London Hydrogen Partnership

Transport for London

Combined Heat and Power Association

Combined Heat and Power Club