Wenhaston Energy Support Group

Carbon Reduction Plan – Stage 1

"Preliminary Carbon Reduction Options"

January 2011

Final Report

Prepared by Z. Wallage
The Low Carbon Innovation Centre
University of East Anglia
Norwich
NR4 7TJ

Executive Summary

The combustion of fossil fuels, such as coal, gas and oil, for power generation, heating and transportation releases carbon dioxide (CO_2) into the Earth's atmosphere, in addition to smaller quantities of other "greenhouse gases". During the past 250 years, since the start of the industrial revolution, there has been a steady increase in atmospheric CO_2 concentrations as a result of an increasing quantity of fossil fuels being combusted in response to global population growth. Greenhouse gases are so-called as they trap a proportion of incoming solar radiation and prevent its return to space by converting it to a form of thermal heat energy. The fact that atmospheric concentrations of key greenhouse gases are increasing results in average surface temperatures slowly rising, influencing localised weather systems and giving rise to the phenomenon known as climate change.

Fossil fuels are also a finite "non-renewable" natural resource – they take many hundreds of millions of years to form, and at the current rate of extraction reserves are being depleted far faster rates than any new stores may be formed. As fossil fuels become scarcer, energy prices increase and generally become more volatile in nature. Thus, any action that can be taken to reduce dependence on fossil fuels helps avoid emitting further quantities of CO_2 into the atmosphere, and can also protect users from the economic impacts of rapid fluctuations in price. Substituting energy production from fossil fuels with low carbon renewable energy sources is an important way to reduce carbon dioxide emissions. Technologies such as wind, hydroelectricity, solar and biomass are all carbon free, harnessing energy at locations where the resource is abundant and readily renewed, either by natural processes or well managed plantations.

In recent years there has been a rapid growth in the range and quality of renewable technologies available to generate heat and power and, when combined with the increasing threat of global climate change and dwindling natural resources, has resulted in an increasing focus by community groups to ascertain the benefits associated with installing wide-scale energy efficiency measures to reduce energy demand, supplemented by a programme to install renewable energy technologies to satisfy the remaining demand.

Wenhaston is one such community; here residents have become increasingly conscious of the impacts their actions impart on local carbon emissions. In their quest to become a more sustainable and energy efficient community, a group of villagers, via membership of the Wenhaston Energy Support Group (WESG), sought assistance from the University of East Anglia's Low Carbon Innovation Centre (LCIC)[1], who undertook two earlier carbon audits on behalf of the local community. Following consultation with WESG, LCIC was tasked with helping to develop a coherent and robust carbon reduction plan for the coming years, building upon the evidence incorporated in the preceding studies.

[1] 'Low Carbon Innovation Centre' (LCIC) and 'CRed' are trading names of Low Carbon Innovation Centre Limited, which is a wholly-owned subsidiary company of the University of East Anglia (UEA). LCIC employs 15 core staff and draws upon the knowledge and expertise of academics and researchers throughout the University, but most notably from within the School of Environmental Sciences and Norwich Business School.

To initiate this process of change, LCIC has undertaken this preliminary stage review in order to:

i) Help the community understand the source of their carbon emissions;

ii) Identify a preliminary set of carbon reduction options for the community, including renewable energy technologies, suitable for the context of the local parish; and,

iii) Highlight the likely cost and impact of such actions on the over-riding carbon emissions in order to help bolster community engagement in the challenge of reducing carbon emissions and dependency on finite fossil fuel resources.

The study is structured such that **Section 1** of the report provides a brief review of the two previous community carbon audits, highlighting the principal household emissions relating to the sources: Heating and hot water energy; non-heating energy; car usage; and, aviation. Emissions from heating and hot water dominated both carbon footprints, closely followed by car usage, which combined contributed almost 75% of household emissions. In total, community-scale emissions were found to be in the region of 4,200 tonnes of CO_2 per year, which equates to approximately 11 tonnes per household. This figure is useful for residents as it can be used as a baseline against which the success of future actions taken to reduce emissions can be gauged.

Section 2 compiles a preliminary set of carbon reduction actions for the Wenhaston community relating to the four emission sources, categorised using the three principal strategic actions of: Demand Reduction; energy efficiency; and renewable energy technologies. Due to the abundance of information available for each carbon reduction option, appendices were established for each strategy. Options relating to demand reduction and energy efficiency can be found in Appendix I and II (respectively) and information is presented in a format that highlights key details, including costs and associated carbon benefits. Meanwhile, options that relate to renewable energy technologies can be found in Appendix III, which provides a more detailed level of information for each option. Here additional data relating to issues concerning environmental, technical, planning and political, and social impacts is presented in addition to the likely cost and carbon savings. Data is presented using an objective rather than prescriptive approach in order that the community as a whole has an opportunity to explore the range of options available in a detailed systematic manner allowing them to carefully consider and compare options.

Section 3 presents a summary of the information presented in the appendices and uses a matrix format to highlight salient points, such as likely carbon savings, costs and financial implications, for each option. In doing so, it also considers what would be involved in developing a carbon reduction strategy and the importance of establishing targets in order to gauge the success of actions taken to reduce baseline emissions. Subsequently, it outlines the potential for establishing community-scale renewable energy generation, highlighting those technologies that have the greatest potential for scale up, and which (subject to public consultation) warrant further investigation. These include: Wind; hydroelectricity; solar photovoltaics (solar PV); biomass utilising combined heat and power (CHP) systems and district heating; and bio-fuels for heating. Consideration is also given to the infrastructure, management and commitment required for the development of community-owned power supply and establishment of units such as energy supply companies (ESCos).

The report concludes with **Section 4**, which provides an outline of possible next steps for the Wenhaston community, including an action list that may help guide residents in their selection of options to consider in greater detail during forthcoming community engagement events.

1. Review of Previous Community Carbon Audits

Wenhaston is a small rural village, situated to the south of the River Blyth in north-east Suffolk, and together with the neighbouring hamlet of Mells forms the civil parish of Wenhaston with Mells. Wenhaston is home to approximately 818 residents[2] living in an estimated 380 properties. In March 2007, the quest by residents to obtain the necessary information and support to become a more sustainable, energy efficient community resulted in the establishment of the "Wenhaston Energy Support Group" (WESG).

To date, WESG has commissioned the Low Carbon Innovation Centre (LCIC) (formerly known as CRed) to undertake two complimentary pieces of work to estimate the likely carbon footprint of the local community. This "footprinting" data provides a baseline upon which the impact of future mitigating actions can be measured to highlight the success of any carbon reduction schemes.

The purpose of this section is, therefore, to help the community understand the source of their carbon emissions[3].

"Wenhaston Community Carbon Audit – September 2007"

In the first carbon audit conducted in 2007, a survey was distributed to 360 households in the parish and a total of 166 responses were dutifully received. From the data collected it was possible to estimate that **residents, as a collective community, produced 4,202 tonnes of CO_2 per annum**.

The contribution to the overall community carbon footprint from the four key emission source categories was as follows:

- **Heating and hot water energy – 1,856 tonnes CO_2 (44%)**
- Non-heating energy – 759 tonnes CO_2 (18%)
- **Car usage – 1,245 tonnes CO_2 (30%)**
- Aviation – 342 tonnes CO_2 (8%)

Given the guided size of the local population (360 dwellings), **this suggests an average annual household emission of approximately 12 tonnes CO_2**, with the following breakdown per emission source:

- **Heating and hot water energy – 5.2 tonnes CO_2 (44%)**
- Non-heating energy – 2.1 tonnes CO_2 (18%)
- **Car usage – 3.5 tonnes CO_2 (30%)**
- Aviation – 0.95 tonnes CO_2 (8%)

---

[2] 2001 parish Census data.
[3] In presenting summary data from the two preceding carbon audits we must emphasise that the data are only as accurate as the respondents input to the surveys. The data collected in many cases are based on respondents' own estimates, or perhaps in some cases guesses. This must be taken into account if one is attempting to draw conclusions from these data on actual circumstances or behaviour of respondents.

As the survey design, the participants and some of the emissions factors have changed between the first and second audits any comparisons between the two reports should be made with care. At best comparisons are indicative of possible trends.

The households sampled in the 2007 carbon audit were predominantly large detached, dwellings, typically having very low levels of insulation and lacking most other energy efficiency measures. Most houses were heated by oil or electricity and, due to the remote setting of the village, many households had two or more vehicles of 2 litre capacity (or greater) driven with high annual mileage. There was also a relatively high incidence of flying recorded across several households. Combined, these factors all contributed towards the relatively high CO_2 emissions for the community, especially compared to the national average household at the time (9 tonnes CO_2).

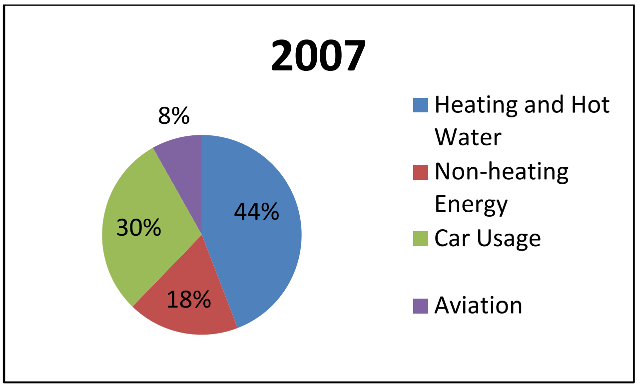

Figure 1: Proportional contributions of the estimated emissions for 2007

"Wenhaston Energy Support Group – Carbon Emissions Estimates and Survey Results 2009"

In the second audit, a survey was distributed to 380 households[4]. The survey consisted of questions concerning both domestic and transport-related themes, and received a total of 112 responses. Information was augmented with data taken from an additional 26 households using an identical domestic energy efficiency questionnaire, via the Energy Saving Trust's "home energy check" survey.

As evident in the preceding 2007 audit, the carbon footprint of a typical Wenhaston household in the 2009 study was dominated by emissions from space heating and hot water, and car transportation. This reflects the key challenges faced by residents of switching away from oil-based heating systems and reducing dependency on car use. The survey data generated an **average household emission of approximately 11 tonnes CO_2 per year**, which was slightly lower than 2007. The contribution to the footprint from the four key emission source categories was as follows:

- **Heating and hot water energy – 5.2 tonnes CO_2 (45%)**
- Non-heating energy – 1.6 tonnes CO_2 (14%)
- **Car usage – 3.8 tonnes CO_2 (36%)**
- Aviation – 0.5 tonne CO_2 (5%)

[4] Sixty of these dwellings are indicated as holiday homes. It is not certain from the data we received whether any of the holiday home owners responded to the survey.

Given the guided size of the local population in this survey (380 dwellings), this suggests **the overall community carbon footprint to be in the region of 4,180 tonnes CO_2 per annum**, which when distributed across the four emission sources generated the following community-level data:

- **Heating and hot water energy – 1,900 tonnes CO_2 (45%)**
- Non-heating energy – 570 tonnes CO_2 (14%)
- **Car usage – 1,520 tonnes CO_2 (36%)**
- Aviation – 190 tonnes CO_2 (5%)

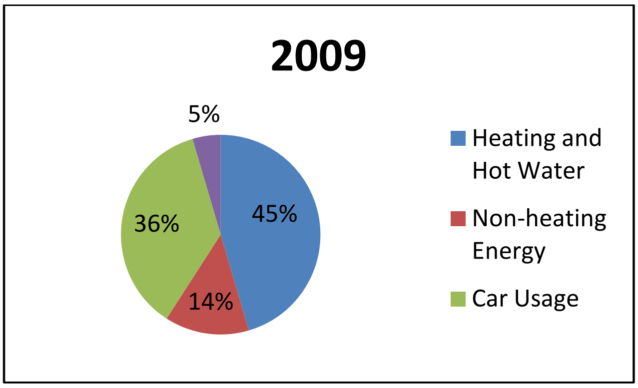

Figure 2: Proportional contributions of the estimated emissions for 2009

2. Preliminary Set of Carbon Reduction Options

At a time of growing global concern regarding the threat of global climate change and dwindling fossil fuel energy reserves (and with it volatile prices and increasingly intermittent supplies), residents of Wenhaston have become increasingly focused on the source of energy supplies and the associated impact this may have on the community carbon footprint. With the help of LCIC, Wenhaston's Energy Support Group is currently considering the actions required to develop a carbon reduction plan to help lower the village's carbon emissions.

The purpose of this section is, therefore, to identify a preliminary set of carbon reduction options for the community, including renewable energy technologies, suitable for the context of the local parish.

The carbon management process diagram (Figure 3, below) illustrates the fundamental steps required for the preparation and implementation of an effective carbon reduction action plan. It details that carbon reduction strategies can be classified into one of five categories: **I) Demand Reduction**; **II) Energy Efficiency**; **III) Renewables**; **IV) Carbon Capture and Storage (CCS)**; and **V) Offsetting**.

Carbon reduction plans generally follow a hierarchical structure. First and foremost, these actions begin by raising awareness of the need to reduce demand on carbon emitting resources and the need to avoid unnecessary energy usage. This is then followed by actions to increase the energy efficiency of products and services, and subsequently to decarbonise the power supply by enhancing the availability of low-carbon renewable energy technologies. The latter options of carbon capture and storage and carbon offsetting are not generally recommended as a starting point or as sole actions in any carbon reduction plan. However, they can be combined with other activities to help drive down carbon emissions particularly in the early years of a plan. At this stage in the development of carbon reduction plan, the availability of actions that fit within the categories of carbon capture and storage" and offsetting will not presented as these are generally regarded as secondary "displacement" actions, and their use will only provide benefit once all available measures to reduce energy demand, improve efficiency and source renewable heat and power have been exhausted.

Before any renewable energy technologies are installed it is essential that properties are optimised for efficient energy utilisation by ensuring that they are effectively insulated and are using appropriate technologies to help to reduce wastage and thus the demand for energy from conventional fossil fuels sources. A detailed assessment of the **Demand Reduction** options readily available to community can be found in **Appendix I**.

Energy Efficiency measures refers to methods and means for reducing the energy consumed in the provision of a given product or service, especially compared to standard approaches. For example, refrigeration systems with waste heat recovery are an example of such an energy efficient technology – they can provide the same level of cooling as conventional refrigeration technologies, but require significantly less energy. Energy efficiency measures can be applied to wide range of sectors and processes, and other leading examples include combined heat and power units, variable speed motors (e.g. compressors), improved insulation, high performance building envelopes and double or even triple glazed windows. **Appendix II** presents a detailed overview of the Energy Efficiency options available to Wenhaston.

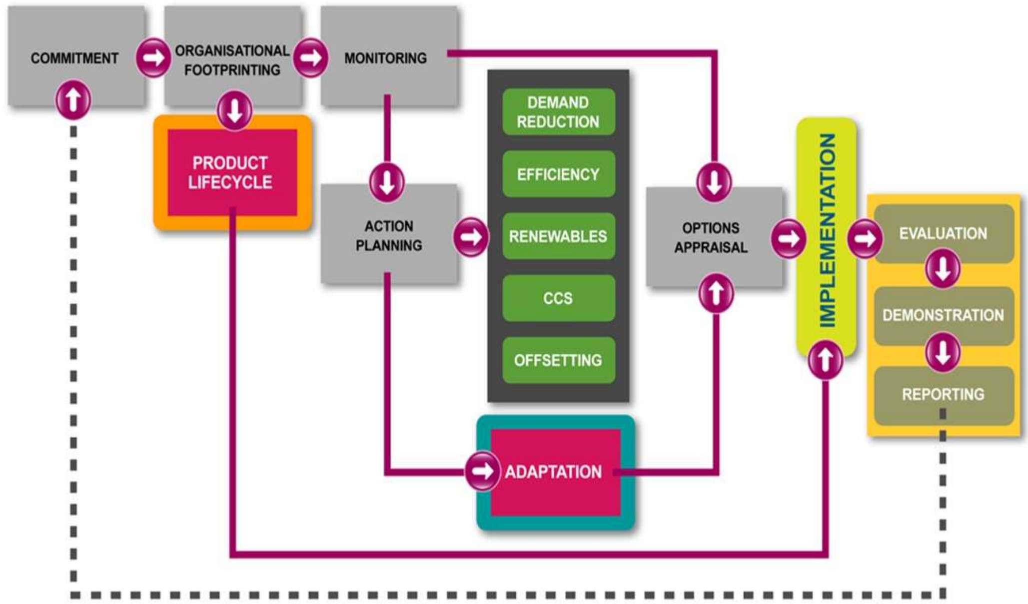

Figure 3: The Carbon Management Process

Meanwhile, **Renewable Energy Technologies** transform energy sourced from a renewable resource into useful heat and power, as well as cooling and mechanical energy. For example, the use of solar energy to heat a building does nothing to reduce the future use or supply of sunshine as it is abundant in presence and virtually infinitely available. Nonetheless, care must be taken with regards to other renewable resources that can quickly cease to be "infinite" if regeneration processes are prevented from taking their natural course. For example, trees can provide a renewable supply of biomass for bio-energy systems, but only if the rate of harvest occurs at a sustainable rate and is mirrored by a similar rate of re-forestation – otherwise the entire resource would be at risk from deforestation.

Individual householders can often be intimidated by uncertainty regarding the suitability and reliability of individual technologies and may be concerned about issues such as local planning conditions and environmental impacts. Thus, **Appendix III** provides a comprehensive overview of possible renewable energy technologies that the residents of Wenhaston could consider. Data relating to likely costs and carbon benefits is supplemented by further technical information within a structured template format that highlights the key principles of how the technology works in addition to information relating to environmental, planning & political, and social issues that will need to be carefully considered by the community when contemplating such measures. Further, those measures that may reduce the reliance on heating oil are duly highlighted.

Data is presented using an objective rather than prescriptive approach in order that the community as a whole has an opportunity to explore the range of options available in a detailed systematic manner allowing them to carefully consider and compare options, and to identify technologies most suitable for further investigation through further consultation and site investigation. Further information is provided that details whether a particular renewable energy technology is eligible to be considered for financial support from the two principle schemes the UK Government has developed to help promote installation at the domestic level – namely the "**Feed in Tariff**" and the "**Renewable Heat Incentive**".

Feed-in Tariffs (FITs) became available in the UK on 1st April 2010 and were introduced as a means of providing financial support for electrical micro-generation, replacing Renewable Obligation Certificates (ROCs) that were previously available for initiatives under 5MW. Under the FIT scheme, energy suppliers have to make regular payments to householders and communities who generate their own electricity from renewable or low carbon sources. The scheme guarantees a minimum payment for all electricity generated by the system, as well as a separate payment for any electricity exported to grid. These payments are in addition to the utility bill savings made by properties using the electricity generated on-site.

The scheme covers the following electricity-generating technologies, up to an installation size of 5 MW:

- Solar electricity (PV) (roof mounted or stand alone)
- Wind turbine (building mounted or free standing)
- Hydroelectricity
- Anaerobic digestion
- Micro combined heat and power (micro CHP) (limited to a pilot at this stage)

The tariffs available and the process for receiving them vary, depending on when the technology was installed and whether the system and the installer were certificated under the Micro-generation Certification Scheme (an independent scheme that certificates micro-generation products under 50kW and installers in accordance with consistent standards).

If households are eligible to receive the FIT they will benefit in three ways:

1. **Generation tariff** – a set rate is paid by the energy supplier for each unit (or kWh) of electricity generated. This rate will change each year for new entrants to the scheme (except for the first 2 years), but once signed up, a household will continue on the same tariff for 20 years (or 25 years in the case of solar electricity). Rates vary by type and scale of technology.

2. **Export tariff** – households will receive a further 3p/kWh from their energy supplier for each unit of electricity exported back to the national grid for energy that isn't used on site. The rate is identical for all technologies.

3. **Energy bill savings** – households will make savings on electricity bills as they are generating their own source of electricity to power appliances.

Further information can be found on the Department for Energy and Climate Change (DECC)[5] and the Energy Saving Trust (EST) websites[6].

The **Renewable Heat Incentive** (RHI) has been designed to provide long term financial support that encourages individuals, communities and businesses to install renewable heat technologies, from household solar thermal panels to industrial wood pellet boilers. At this present time (January 2011) the full details of the scheme, including RHI tariffs and technologies supported, are still due to be confirmed by DECC, although the scheme is expected to be launched in June 2011.

The scheme is designed to pay households a set amount each year as an incentive to reduce CO_2 emissions by replacing an existing fossil fuel heating system with a renewable heating technology. The Government are not proposing to measure the heat generated from installations. Instead, payments will be derived by estimating the amount of heat energy needed to warm the home and/or hot water, which will vary by house age and size, as well as by technology. It has been proposed that payments would be made annually to householders.

Although full details are yet to be announced, the scheme is likely to cover the following technologies:

- Air, water and ground-source heat pumps
- Solar thermal
- Biomass boilers
- Renewable combined heat and power
- Use of bio-gas and bio-liquids
- Injection of bio-methane into the natural gas grid

Further information can be found on the DECC [7] and EST websites[8].

5 http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/feedin_tariff/feedin_tariff.aspx

6 http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Feed-in-Tariff-scheme

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

8 http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Renewable-Heat-Incentive

3. Matrix of Carbon Reduction Options

The preceding section (and associated appendices) provides a detailed overview of the measures available to the Wenhaston community to help lower carbon emissions and dependency on fossil fuels, such as heating oil. However, this information is presented in a fairly detailed, text-dense form.

The purpose of this section is, therefore, to highlight the likely cost and impact of such actions on the over-riding carbon emissions in order to help bolster community engagement in the challenge of reducing carbon emissions and dependency on finite fossil fuel resources.

Data is presented in a succinct form using a matrix system (Table 1, below) to highlight the most salient points relating to carbon savings and the key financial considerations, on a household basis, to allow useful comparisons to be made between options and to help guide residents towards technologies most suited to their individual needs.

Being a rural settlement, the housing density in Wenhaston is typically fairly dispersed in nature and relatively exposed to the elements, and factors, such as the potentially high proportion (~35%) of properties of un-insulated solid wall construction and the lack of connection to the national gas network, results in a relatively high thermal demand for heating and hot water. At present, this is met by the more carbon-intensive fossil fuels – oil and grid electricity. The rural location also results in there being a heavy reliance on car usage for personal transportation. Thus, the average household emission (11 tonnes CO_2 per annum) is typically higher than the present UK average (about 9 tonnes CO_2 per annum).

In its consideration of options to reduce carbon emissions, this report presents data relating to three key strategic action categories: Demand reduction; energy efficiency; and, renewable energy technologies. There is considerable potential to reduce carbon emissions through behavioural change and even though they are often seen as relatively rudimentary low-tech options those strategies aimed towards reducing energy demand and increasing efficiency are highly effective measures and typically far cheaper than commissioning new sources of heat and power generation.

The impact of demand reduction and energy efficiency measures can be greatly improved by factors such as behavioural change, building design and the installation of efficient technologies. It is important that residents consider both aspects as they typically go hand in hand. Once these actions have been explored and successfully implemented, it is then time to consider the use of domestic-scale renewable energy technologies as these will enable significant additional carbon savings due to the displacement of carbon-intensive fossil fuels. Further, due to schemes such as the UK Feed in Tariff and the forthcoming Renewable Heat Incentive, installation can be financial rewarding at the domestic scale as the income secured from the payment tariffs can significantly reduce payback periods.

Table 1: Matrix of Carbon Reduction Options[9]

Action	Emission Source	Carbon Saving Potential	Financial Considerations
Demand Reduction (For detailed accounts of each action, please refer to Appendix I)			
Install An Energy "Smart Meter"	• Heating and Hot Water Energy • Non-heating Energy	300 to 700 kg CO_2 per year	• Installation costs vary between £100 and £200. • Reduction in utility bills likely to be between £50 and £100 per year.
Install Cavity / Solid Wall Insulation	• Heating and Hot Water Energy	560 to 1,900 kg CO_2 per year	• Installation costs vary from £250 up to as much as £14,500. • Reduction in utility bills likely to be between £110 and £385 per year.
Install Loft Insulation	• Heating and Hot Water Energy	210 to 730 kg CO_2 per year	• Installation costs vary between £50 and £350. • Reduction in utility bills likely to be between £40 and £145 per year.
Install Under-floor Insulation	• Heating and Hot Water Energy	100 to 240 kg CO_2 per year	• Installation costs vary between £20 and £100. • Reduction in utility bills likely to be between £20 and £50 per year.
Insulate Hot Water Tanks and Pipes	• Heating and Hot Water Energy	60 to 170 kg CO_2 per year	• Installation costs vary between £10 and £15. • Reduction in utility bills likely to be between £10 and £35 per year.
Install Draught Proofing	• Heating and Hot Water Energy	200 kg CO_2 per year	• Installation costs vary between £100 and £200. • Reduction in utility bills likely to be about £25 per year.
Reduce Car Travel	• Car Usage	100 kg CO_2 per year	• Reduced petrol usage could generate savings of between £45 and £60 per year.
Effective Use of Heating Controls	• Heating and Hot Water Energy	473 kg CO_2 per year	• Reduction in utility bills likely to be in the region of £70 per year.
Switch off Unused Appliances	• Non-heating Energy	130 kg CO_2 per year	• Reduction in utility bills likely to be between £30 and £50 per year.
Wash Laundry at Lower Temperatures	• Heating and Hot Water Energy	44 kg CO_2 per year	• Reduction in utility bills likely to be about £10 per year.

[9] All data relating to Carbon Saving Potential and Financial Savings is presented on a per household basis, except the option considering "Reducing Air Travel", which is presented in on an individual user basis. It should be noted that although data is presented outlining the likely carbon savings and expected financial impacts associated with these measures that the precise figures will vary on an individual case-by-case basis, due to the specific assumptions that have been taken to generate the data and the fact that baseline emissions will vary with respect to age, type and size of property, existing fuel source, and measures already undertaken to reduce energy demand. Action specific information relating to the source and/or assumptions used to generate this data can be found in the relevant appendices of the report.

Efficient Kettle Usage	• Non-heating Energy	28 kg CO_2 per year	• Reduction in utility bills likely to be about £10 per year.
Switch off Un-necessary Lighting	• Non-heating Energy	24 kg CO_2 per year	• Reduction in utility bills likely to be about £10 per year.
Install Reflective Radiator Panels	• Heating and Hot Water Energy	35 kg CO_2 per year	• Installation costs vary between £30 and £50. • Reduction in utility bills likely to be between £5 and £25 per year.
Reduce Air Travel	• Aviation	600 kg CO_2 per year	• Dropping a long-haul flight should save at least £250.
Energy Efficiency (For detailed accounts of each action, please refer to Appendix II)			
Install Energy Efficient Glazing	• Heating and Hot Water Energy	420 to 680 kg CO_2 per year	• Installation costs likely to vary between £1,200 and £5,000. • Reduction in utility bills likely to be between £85 and £135 per year.
Install a Condensing Boiler	• Heating and Hot Water Energy	1,400 kg CO_2 per year	• Installation costs vary between £3,500 and £8,000. • Reduction in utility bills likely to be £260 per year.
Install Low Energy Lighting	• Non-heating Energy	135 kg CO_2 per year	• Installation costs vary between £54 and £360. • Reduction in utility bills likely to be about £45 per year.
Install A++ Rated Electrical Appliances	• Non-heating Energy	100 to 200 kg CO_2 per year	• Reduction in utility bills likely to be between £20 and £45per year.
Renewable Energy Technologies (For detailed accounts of each action, please refer to Appendix III)			
Install a Domestic Wind Turbine	• Non-heating Energy	2, 036 kg CO_2 per year	• Installation costs vary between £3,000 and £18,000. • Reduction in utility bills combined with income generation from Feed in Tariff likely to be about £1,500 per year.
Install a Domestic Hydroelectric System	• Non-heating Energy	2,036 kg CO_2 per year	• Installation costs vary between £12,000 and £20,000. • Reduction in utility bills combined with income generation from Feed in Tariff likely to be £2,654 per year.
Install Solar Photovoltaics	• Non-heating Energy	1,018 kg CO_2 per year	• Installation costs are likely to be in the region of £12,000. • Reduction in utility bills combined with income generation from Feed in Tariff likely to be about £911 per year.

Install a Biomass Heating System	• Heating and Hot Water Energy	4,840 to 5,358 kg CO_2 per year	• Installation costs vary between £5,800 and £11,500. • Reduction in utility bills likely to be between £432and £720 per year[10].
Install and Air Source Heat Pump	• Heating and Hot Water Energy	1,310 kg CO_2 per year	• Installation costs vary between £6,000 and £10,000. • Reduction in utility bills likely to be between £130 and £530 per year[10].
Install Solar Water Heating	• Heating and Hot Water Energy	250 to 570 kg CO_2 per year	• Installation costs are likely to be around £4,800. • Reduction in utility bills likely to be between £50 and £85 per year[10].
Incorporate Passive Solar Design	• Heating and Hot Water Energy	1,108 to 1,385 kg CO_2 per year	• Reduction in utility bills likely to be between £236 and £295 per year.
Install a Ground Source Heat Pump	• Heating and Hot Water Energy	1,310 kg CO_2 per year	• Installation costs vary between £8,000 and £12,000. • Reduction in utility bills likely to be between £40and £530 per year[10].
Utilise Bio-fuels for Heating	• Heating and Hot Water Energy	1,852 kg CO_2 per year	• Installation costs vary between £250 and £2,000.

Caveat:

Anaerobic digestion is another renewable energy technology. At the national level, its use has the potential to help the UK address several major environmental challenges, not least those focused on improving waste management and reducing greenhouse gas emissions from agriculture and food processing, by capturing the energy-rich biogas formed from the decomposition of organic materials, such as manures, crop residues and food wastes.

In principle, there are four options available to capitalise on the production of biogas from anaerobic digestion. These include:

Following minimal cleaning to remove acidic compounds and impurities:

1. The biogas can be burnt in an engine to produce electricity and heat;
2. The biogas can be burnt in a boiler to provide on-site heating or steam/hot water for a local heating system;

Additionally, if gaseous impurities such as carbon dioxide are removed, a pure bio-methane gas is formed that can be:

3. Injected into the national gas grid; or
4. Compressed and liquefied for use in an internal combustion engine as a replacement transportation fuel.

Thus, although anaerobic digestion is an effective and commercially viable technology that is currently being promoted for use at the farm-scale within the UK, its use for the direct benefit of the Wenhaston community will not be considered further in this report due to the fact that (at the time of publication) the local infrastructure does not support the transmission of heat and/or gas at the scale required for this type of technology, nor are there facilities available to residents to compress and liquefy the gas for fuel. Further, residents would need to carefully consider issues relating to availability, supply and security of feedstock materials.

[10] Financial savings are likely to be augmented by income generated from the forthcoming Renewable Heat Incentive

Developing a Carbon Reduction Strategy:

Due to the scale of carbon reduction options available, such as the wide-range of demand reduction techniques, energy efficiency measures and the numerous renewable energy technologies, it would be fairly easy for residents to be quickly overwhelmed by the level of choice presented to them. Being in a position to choose between different carbon reduction options involves careful consideration of, amongst other things: capital cost; investment returns and payback periods; risk management; potential positive and negative impacts on community cohesion; and scale of carbon reduction that each option might deliver against the baseline carbon footprint.

In terms of establishing a baseline upon which the residents of Wenhaston can gauge the success of future actions taken to reduce carbon emissions, the data presented in Section 1 outlined that community-scale emissions are in the region of 4,200 tonnes of CO_2 per year, which equates to approximately 11 tonnes CO_2 per household. Reducing carbon emissions from domestic properties at the community scale requires a near-universal rollout of a series of packaged measures tailored to different types of properties. Large-scale measures, such as the installation of renewable energy technologies, can be implemented but overall scale and effectiveness will be dependent upon the carbon reduction target set by the community beforehand.

As outlined in Section 2 and Figure 3, the most effective strategies to reduce carbon involve a sequential step-wise process that starts with the installation of energy demand measures, followed by energy efficient technologies and culminates by installing renewable energy technologies. It is imperative to follow such a process so that before any projects to install technologies are underway, the overriding demand and use of energy from "conventional" sources has been reduced in order that the scale and associated costs of any technological interventions can be minimised.

When developing a carbon reduction strategy, careful consideration needs to be given to the establishment of targets for carbon reduction in order to gauge the success of actions taken to reduce baseline emissions. Targets should be realistic, achievable and time-bound and residents should bear in mind the UK Government's goal to achieve an 80% reduction in carbon emissions by 2050. Wenhaston may want to set this as their overall target, or even try to achieve it earlier than 2050. Whatever the target, setting regular milestones will help to break the task down into manageable steps and allow progress to be monitored, helping motivate residents and satisfy funders that targets are being met.

When assessing how carbon reduction could be achieved, consideration should also be made of the "multiplier effect" – whereby even if every available action was undertaken, the savings would not necessarily be the sum of values presented in Table 1, as each action lessens the "baseline emissions" that another action can subsequently influence. Thus, it should be clear that the potential savings achievable if multiple actions are taken are not infinite, and the apparent effectiveness of each additional action taken will likely reduce as there is a limited mass of carbon to be saved.

That said, here follows an example set of carbon reduction scenarios for the community:

If all households were successful in undertaking just one demand reduction measure (e.g. external wall insulation, specifically solid wall insulation in pre-1920 properties) annual carbon emissions could be reduced by as much as 15%. If all demand reduction actions were implemented conservative estimates suggest that emission reductions could be in the region of 25%. Application of energy efficiency measures could contribute an additional 15%. Thus, even before renewable energy technologies are considered it may be possible to achieve a 40% reduction in emissions.

The carbon savings achievable from renewable energy technologies are fairly significant, although the precise figures will vary on a case-by-case basis, due to factors such as existing fuel source and the scale and efficiency of the chosen technology. As a rough guide however, data from Table 1 suggests that by installing a combination of the most effective renewable heat and power technologies (e.g. biomass and hydroelectricity) it may be possible to completely displace the use of fossil fuels and associated carbon emissions in some properties.

In a rural village such as Wenhaston, renewable energy technologies such as ground/air source heat pumps and biomass boilers are likely to be the most attractive heat-based options, whilst solar PV is likely to be the most reliable and readily available resource for electricity generation. However, that's not to say that where possible other technologies such as wind and hydroelectric power can't also be installed as these will prove effective energy providers where conditions allow. Whatever the case, there is great power and value in working as a collective in organising the installation of renewable energy technologies as a specialist installer can reduce travel and installation costs by undertaking multiple installations in the same street at the same time. WESG has already made good progress in this area, securing the installation of multiple solar thermal heating systems by using a tendering process.

Community-Scale Renewable Energy Generation:

Communities may wish to promote renewable energy generation by supporting individual households to install systems or developing community-owned renewable energy assets to generate revenue for the benefit of the local community. Most renewable energy technologies available at the domestic level can be readily and effectively expanded in scale to satisfy the demands of a community-wide initiative. Establishment of community-scale renewable energy technologies – be they heat or power based – are large complex projects that can take several years to complete, and which can face many additional technical, regulatory and financial challenges. A community working on such a venture generally requires the establishment of a group dedicated to the renewable energy project, which in this case could be undertaken by the Wenhaston Energy Support Group.

From the analysis undertaken in preceding sections it is evident that sources of renewable energy come in a variety of broad categories, many of which can be readily scaled up to meet the demands of a larger community building as many of the constraints and issues (as presented in Appendix III) will still apply. For example, ground source heat pumps are often considered ideal for use in public buildings requiring stable heating, such as swimming pools and church halls, whilst existing large boiler units such as those found at schools and hospitals can be readily upgraded to biomass boilers – a good case example being the biomass boiler recently installed in the Wenhaston Village Hall.

In addition, it would be possible for residents to develop a community-owned infrastructure to generate electricity and/or heat for local use and also generate a source of revenue for the local community. To do so however, requires careful consideration of issues relating to organisational structure and governance. Further, residents should bear in mind that any excess electricity produced that can be sold back to the national grid will always be at a lower price than any electricity that is purchased in the future, should it be required. Thus, it is always more efficient if the energy can be used at source and, if future demands dictate, that any excess is stored on site utilising appropriate infrastructure.

Those technologies that have greatest potential for this application, and which may benefit from further investigation include the following[11]:

Wind: Initial estimates suggest localised wind speeds in the region of 4.61 m per second, which suggests that small scale wind turbines in the village are on the borderline of suitability. Clearly further investigation would be required to determine an individual property's suitability, due to factors such as local topography and obstructions, and the same would be true should a larger-scale community turbine be considered. In general, wind power can provide potentially large-scale electricity generation at prices competitive with the national grid in community scale ventures. In terms of scaling up, a single large turbine or a group of turbines is typically used to generate electricity for local needs or sold into the grid with communities drawing a share in profits along with the developer. With regard to the establishment of a larger community-based wind system, it's is worth noting that whilst cheaper per kW to install, larger turbines are subject to more exacting connection requirements and will typically pay higher use of systems charges to use the distribution network as they will be connected at higher voltages. Thus, the planning process is likely to be more expensive and more objections are likely as larger turbines are often seen as more visually intrusive. In any case, a thorough assessment of proposed locations and available wind resources via an appropriately scaled monitoring programme will be required to establish robust estimates of annual production. This can then be used to calculate expected capacity and infrastructure, and allow annual income to be estimated, which will be required for securing project finance.

Hydroelectricity: Hydropower can be a valuable resource for communities close to a suitable water resource. River flow data sourced from the gauging station at Holton indicates mean flow rates of 0.429 m^3 per second. When combined with head data for a small 1m weir this indicates that there may be

[11] Note that this information provides only a brief overview of how these technologies may be applied to a community-scale venture. Information concerning installation at the domestic scale (including technical details and associated impacts) can be found in Appendix III

potential for a micro-hydro system of at least 3kW to be installed, which could potentially produce enough to power three domestic properties. Detailed resource monitoring and evaluation will be required on the river to assess the exact flow and head conditions to generate precise system capacity and annual production values, and also to assess the applicability to either scale up from the estimated 3kW or install multiple systems. This data will also help in the development of a strategy to balance resource availability and power demand and secure project finance. A local run of river hydropower scheme might incorporate a joint venture with a developer or major landowner. Although costly to install, hydroelectric power generation in the right location can prove financially rewarding and highly effective at reducing CO_2 emissions.

Solar PV: Community-scale application is favourable over domestic as the relative cost of installation can be greatly reduced by connecting a number of arrays to a single inverter to change from DC to AC. It can therefore be beneficial to combine cells across a number of localised properties and then connect to an electricity network. It is important to recall however, that any electricity sold back to the national grid will be at a lower price than any electricity that is purchased in the future, should it be required. Thus, it is essential to scale the technology appropriate and ensure that energy is utilised at source or stored on site if an excess occurs.

Bio-fuels for heating: The use of bio-fuels for heating could be an effective and socially rewarding venture if a community scheme was developed to promote the use and bulk purchase of bio-fuels in order to reduce costs and indirect emissions associated with its transportation to the village. Residents may benefit from a community-wide venture to distribute the findings of the recent OFTEC bio-fuels for heating trial[12] in order to bring potential users up to speed with its application to domestic heating and cooking. At present, bio-fuels are typically blended with conventional fossil fuels, with the most promising blend consisting of a mix of 30% cooking oil and 70% kerosene. Thus, until pure bio-oils can be utilised in the domestic setting without excessive cost and disruption, users should be aware that pricing and availability of bio-fuels will still be liable to some of the same fluctuations seen for conventional fossil fuels.

Biomass utilising Combined Heat and Power: For heat demands in excess of 100kW a combined heat and power (CHP) system can be used, which effectively captures and makes available the heat associated with electricity generation making the whole process extremely efficient (>80%). CHP plants are suitable for use with a variety of fuels (e.g. natural gas, bio-gas, biomass, and waste) but biomass is a typical application. Biomass CHP could supply a renewable source of heat and electricity to Wenhaston whereby heat is distributed via the installation of a district heating system (see below) and electricity supplied direct to individual households or sold back to the national grid (see below). In general, whilst retro-fitting is a possibility for Wenhaston this technology is most effective when applied to new-build developments where the disruption and costs associated with laying a bespoke pipe network and modifying individual heating systems are more readily absorbed.

[12] See Appendix III for further details

Community woodland: Following conversation with several members of the Wenhaston Energy Support Group it is evident that there is already a high demand for wood-fuel for domestic heating in the village. In this case, it is worth highlighting that there is potential for access to at least two woodland areas in the village that, if appropriately managed, could provide a sustainable, local source of affordably priced wood fuel for residents.

Thus, a future project may wish to investigate the feasibility of establishing a "community woodland" and associated wood-fuel supply chain, which could be partly or completely controlled by residents, through a focused group or association.

In essence, this may involve identifying areas of woodland that could be leased or purchased by the community, or managed in partnership with a suitable landowner. A large woodland may need to employ staff to help manage the site and could do so using the income generated from the sale of materials; whilst a smaller site might be managed entirely by volunteers with profits being fed back into the community to fund new ventures. The carbon/energy savings associated with the development of a community woodland are likely to vary according to factors such as the level of buy-in and the type and scale of resources available; however, it is worth noting that a well managed site could help contribute towards enhanced sustainability overall, with added benefit realised from:

- Enhanced biodiversity and conservation;
- Widened sporting and recreational pursuits;
- Stimulated local economy; and
- Enhanced social inclusion.

Important Considerations:

The development of community-wide energy supply from renewable technologies generally requires the integration and management of multiple energy sources. Thus, they are typically complex projects that require a high level of time and commitment from a community, both in the initial feasibility and design stages, and also in the operational phase. For systems of such scale a detailed feasibility assessment would be required for the preferred technologies. The design and installation of a community-scale venture will require residents to be in a position to raise the necessary finance, through a grant, loan or other funds. Subsequently, once a system has been installed and commissioned there will need to be expertise in the locality to maintain and repair the systems – which may provide at least a part-time job in the community.

A shared service system based on significant capital investment and a lifespan of several years needs particular attention to be given to the legal structure and ownership arrangements. A metering system for charging or cost sharing and a billing system will also be required for a community-owned energy project. Collecting payments can be a particularly difficult task, and it is essential that the system for billing is robust and efficient as even small delays in payment can cause considerable difficulties for the community operator, which will have wages and bills to pay. An Energy Supply Company

(ESCo) is sometimes formed to deal with billing and collection of payments for heat and power supply, and to maintain and manage systems, networks and associated infrastructure. ESCos can be community owned and run or can be a service provided by an outside company, such as the technology supplier.

In general, installation of community-scale electrical generation technologies is generally less complex than heat, as the transfer of heat outside a property requires the development and installation of bespoke distribution network (termed District Heating) to transmit the heat from a single heat source to a number of properties within a certain area. They are most effective where there is a cluster of houses or buildings in close proximity that can be supplied with heat through a communal system.

In a district heating system heat, in the form of hot water, is distributed to the participating households, offices and factories in a looping ring-main pipe network with cooler water returned to the boiler house for re-heating and re-pumping. The pipe transports heated water past each building, and each property is fitted with a heat exchanger which allows that individual building to take the heat it requires from the ring-main. For systems serving housing developments, the heat is used for the living space (radiators and under-floor heating pipes) and domestic hot water (hot water storage tanks). Each property drawing heat from the ring-main is metered for heat consumption and will pay for this heat accordingly.

The installation of district heating into an existing community is a large and complex project and community groups would need to work in association with local suppliers to assess feasibility of supply to determine the appropriate of scale project. For new-build developments an evaluation of the housing or building heat demand and the clustering of buildings at an early stage is advantageous so that a district heating scheme can be installed during site construction. For existing properties there would need to be retrofitting of the heat exchanger and ring-main network and so project economics will need to be evaluated closely. To date, the insulated pipe network for district heating has proved to be quite costly, and in most instances retrofit installation is unlikely to be economic.

4. Conclusions and Next Steps

This report presents the results of a preliminary stage assessment outlining the carbon reduction options available to the residents of Wenhaston to reduce their carbon emissions and tackle issues relating to increasing fuel costs and volatile supplies. It is evident that there are many options available to consider, and where possible data has been presented in an objective rather than prescriptive fashion in order to provide residents with an open platform to allow the community as a whole to explore the suite of options available to it in a detailed systematic manner.

A great deal of support and momentum for renewable energy installation can be gained from acting collectively as a community group to address these concerns, and the most successful schemes benefit from the active engagement of all residents. Thus, when considering next steps it would be beneficial for a further screening process to be undertaken in consultation with the wider community to identify those technologies most suitable for further investigation and subsequent incorporation into a community-wide carbon reduction plan.

A process that may help guide residents in their selection is presented below, which outlines the key conditions favouring successful implementation of renewable energy technologies:

- **A need for energy**: This is a prerequisite for energy-related projects, especially those considering installing clean low carbon technologies. For community renewable systems it is important to ascertain exactly how much heat and electricity is being consumed and when, as the pattern of consumption can help to ensure that the most appropriately scaled technology is chosen for the scheme.

- **A new construction project or planned renovation**: The installation of renewable energy technologies is generally more cost-effective when done as part of an existing construction/renovation project. The initial costs of the clean energy technology may be offset by the costs of the equipment or materials it supplants, and early planning can facilitate integration of the technology into the rest of the facility.

- **High conventional energy costs**: When conventional energy supplies are expensive, the initial capital costs of installing renewable energy technologies are often soon overcome by the realisation of lower fuel costs through time.

- **Interest by key stakeholders**: Seeing a project through to completion can be a lengthy affair involving a number of key stakeholders. It is critical to acquire buy-in from all parties, as even if just one principal stakeholder opposes a project, even the most financially and environmentally attractive schemes could be prevented from moving to successful implementation.

- **Access to funding and finance**: With careful consideration of the availability of financing, subsidies, and grants for the installation of renewable energy technologies, the higher initial costs need not present such a major hurdle to community-scale ventures.

- **Adequate local resources**: Most renewable energy technologies rely heavily on the abundant availability of local renewable resources, such as wind, water, biomass and solar radiation. The availability of an appropriate and reliable natural resource will have to be considered in detail for preferred technologies.

Residents will also need to consider points such as, the scale of intervention, the desired target and associated timescales for carbon reduction, and careful thought needs to be given to the appropriate legal structure and ownership arrangements required for large-scale community renewable energy projects and the establishment of initiatives such as ESCos and district heating systems. This will help save a significant amount of time and money for residents, and help identify the most relevant opportunities for the community.

Appendix I: Demand Reduction Options

Action: Install An Energy "Smart Meter"

Emission Source:

- Heating and Hot Water Energy
- Non-heating Energy

Description:

Smart meters are essentially the next generation of gas and electricity meters, and installation and use will eventually remove the need for manual meter readings. Fully automated, smart meters work by monitoring energy use in a property and collecting and storing electronic information at regular intervals. The in-home display unit helps communicate something that is relatively "invisible" to most householders – that is, the extent to which they use energy, either instantaneously or over a period of time.

Smart meters are also helpful for those households looking to generate their own energy to sell back to the national grid, if electricity is being produced that is surplus to requirements at the household level. Energy suppliers may also offer other services to enable households to track energy usage, for example web-based accounts or accounts accessible through mobile phone applications.

The installation of an energy smart meter needs to be carried out by a professional, and the UK Government has set a target that every home in England, Wales and Scotland should receive a smart meter by 2020. Thus, over the coming years every household in Britain will receive smart meters, one for gas and one for electricity, in one of the largest infrastructure projects to have taken place since the Second World War.

Although the plan is for energy supply companies to roll-out the installation of smart meters in every home before 2020, more pro-active households can contact their energy provider to indicate willingness to trial these units. Alternatively they could invest in their own "DIY" clip-on display units – the Wenhaston Energy Support Group already has access to a few of these.

Carbon Saving Potential:

Preliminary trials conducted on behalf of the Energy Saving Trust[13] suggest that the installation of smart meters could reduce domestic energy use by between 5-10%, which could result in savings of between anywhere between 300 and 700 kg CO_2 per year.

Financial Considerations:

Based on a UK-wide rollout, initial estimates put the installation cost of a smart meter at between £100 and £200 per household, and preliminary trials conducted in the US and Sweden have shown that smart meters could reduce household energy bills by approximately 5-10 % (about £50 to £100 per year) as a consequence of demand reduction.

[13] Energy Saving Trust "Green Barometer" Report

Action: Install Cavity / Solid Wall Insulation

Emission Source:

- Heating and Hot Water Energy

Description:

About a third (33%) of the heat lost in un-insulated properties occurs through the walls. Cavity wall insulation is generally most suited to properties built between 1920's and 1980's as they were typically constructed with external walls made up of two layers separated by a small void or "cavity" to provide an insulating barrier. For properties built before or around 1920, external walls are likely to be of a solid wall construction and thus devoid of any air cavity meaning that nearly twice as much heat may be lost. For solid wall properties, there are two types of insulation that can be applied - internal or external.

Carbon Saving Potential:

It has been estimated that carbon savings are likely to be between 560 kg CO_2 and 1,900 kg CO_2 per year[14]:

- 560 kg CO_2/year for cavity wall insulation;
- 1,800 kg CO_2/year for solid wall insulation (internal);
- 1,900 kg CO_2/year for solid wall insulation (external)

Financial Considerations:

Cavity wall insulation is generally a lot cheaper to install than solid wall insulation. On average, cavity wall insulation will cost about £250, whilst solid wall insulation will be higher at between £5,500 and £14,500 depending on the type of house covered and the method chosen (Internal vs. External).

The Energy Saving Trust estimate the likely financial savings to be realised from a reduction in utility bills are:

- £110/year for cavity wall insulation;
- £365/year for solid wall insulation (internal);
- £385/year for solid wall insulation (external)

[14] As sourced from the Energy Savings Trust

Action: Install Loft Insulation
Emission Source: • Heating and Hot Water Energy
Description: Without proper insulation in loft areas about a quarter (25%) of the valuable energy used to heat homes is lost through the roof. The recommended depth for mineral wool insulation is currently 270mm; however there are other insulating materials that can be used that require a different depth.
Carbon Saving Potential: On average, carbon savings are likely to be in the region of[15]: • 730 kgCO_2/year for installing loft insulation to a depth of 270mm • 210 kg CO_2/year for topping up insulation to 270mm
Financial Considerations: Insulating a loft is a simple and effective way to reduce heating bills and can be easily undertaken by DIY enthusiasts. Installation costs vary depending on the size of the loft, the type of insulation used and whether or not a professional is contracted, but on average installation costs are likely to be between £50 and £350. The financial savings that are likely to be realised from a reduction in utility bills are: • £145/year for installing loft insulation to a depth of 270mm • £40/year for topping up insulation to 270mm Loft insulation is effective for at least 40 years, and will pay for itself many times over during this time.

[15] 15 As sourced from the Energy Savings Trust

Action: Install Under-floor Insulation

Emission Source:

- Heating and Hot Water Energy

Description:

The timber flooring present in many homes can be insulated by lifting up floorboards and laying mineral wool insulation supported by netting between the floor joists. In addition, shop-bought silicon sealants can be used to fill gaps between floorboards and skirting boards to stop draughts.

Carbon Saving Potential:

On average, estimated carbon savings are likely to be in the region of[16]:

- 240 kgCO_2/year for insulating under floorboards;
- 100 kg CO_2/year for sealing gaps between floorboards and skirting boards

Financial Considerations:

Insulating flooring will likely cost £100 to purchase materials, whilst purchasing silicone sealant to seal cracks and gaps around the property will likely cost about £20.

The financial savings that are likely to be realised from a reduction in utility bills are:

- £50/year for insulating under floorboards;
- £20/year for sealing gaps between floorboards and skirting boards

[16] 16 As sourced from the Energy Savings Trust

Action: Insulate Hot Water Tanks and Pipes

Emission Source:

- Heating and Hot Water Energy

Description:

Insulating hot water cylinders is one of the simplest and easiest ways to save energy and money. Fitting a British Standard insulation "jacket" around a cylinder will cut heat loss by over 75%, and if the cylinder has an existing jacket it is worth checking that it's insulated to a thickness of at least 75mm. Hot water pipes also benefit from insulation to avoid un-necessary heat loss via transmission of heat through the home.

Carbon Saving Potential:

On average, carbon savings are likely to be[17]:

- 170 kg CO_2/year for fitting a 75mm thick hot water tank jacket;
- 60 kg CO_2/year for insulating primary hot water pipe-work

Financial Considerations:

A new, 75mm thick hot water cylinder jacket will likely cost about £15 to purchase, whilst piping insulation will be about £10 and both can be fitted by DIY enthusiasts.

The financial savings that are likely to be realised from a reduction in utility bills are:

- £35/year from installing a new 75mm thick hot water cylinder jacket;
- £10/year from insulating hot water pipes

[17] As sourced from the Energy Savings Trust

Action: Install Draught Proofing

Emission Source:

- Heating and Hot Water Energy

Description:

Draught proofing is another cheap and efficient way to save energy in most types of property, and literally involves using materials to seal unwanted cracks and gaps to prevent the entry of cold external air in to the building, thus helping to reduce heating demands. Draughts can be found at any accidental opening that leads outside. Key areas to focus attention include:

- Windows;
- Doors;
- Chimneys and fireplaces;
- Suspended floorboards;
- Loft hatches;
- Pipe-work leading outside;
- Extractor fans;
- Cracks in walls;
- Ceiling to wall joists;
- Electrical fittings on walls and ceilings

Carbon Saving Potential:

On average, the carbon savings achievable by draught proofing an entire property are likely to be in the region of 200 kg CO_2/year[18].

Financial Considerations:

DIY draught proofing costs around £100 to purchase materials, whilst professional services are likely to cost nearer £200.

Full draught proofing is likely to save about £25/year, and because draught-free homes are more comfortable at lower temperatures, the thermostat can also be turned down so additional savings are likely to be realised.

[18] As sourced from the Energy Savings Trust

Action: Reduce Car Travel
Emission Source: • Car Usage
Description: Data presented in Wenhaston's 2009 carbon audit showed that the modal distance travelled and the replication in end destination amongst respondents suggested that shorter journeys (~ 2miles) may be catered for by improving public transport services and ridership, or by improving car sharing, by setting up a parish car sharing scheme. Walking and cycling are also alternatives to the car for short distance journeys, and are relatively simple means of reducing carbon emissions associated with annual travel. They often prove faster, less stressful and cheaper methods as well, as they don't rely on expensive fossil fuels, parking and can they often take more direct routes avoiding potential congestion. They are also an effective means of increasing exercise levels.
Carbon Saving Potential: Nearly 25% of all car journeys are 2 miles or less, and using alternative methods of travel could save about 100 kg CO_2/year on average[19].
Financial Considerations: If walking or cycling is used as an alternative, the financial savings likely to be realised from a reduction in car usage could easily equate to a tank of petrol, so savings could be in the region of £45 to £60 per year.

[19] As sourced from LCIC's CRed System

Action: Effective Use of Heating Controls
Emission Source: • Heating and Hot Water Energy
Description: Although modern homes tend to warm up quite quickly compared to older homes, particularly those with solid walls, all heating thermostats should be set to the lowest comfortable temperature (typically between 18°C and 21°C) to reduce energy consumption. Heating controls, such as a programmer or timer, are also useful as they set the heating to only turn on when it is required. For example, during the early morning, evenings and weekends when the house is occupied. If the house is empty during the day then it shouldn't be left switched on all the time, and for most heating is not required at night whilst asleep.
Carbon Saving Potential: On average, it is estimated that turning the thermostat down by just 1°C could save as much as 473 kg CO_2/year[20].
Financial Considerations: The financial savings to be realised from a reduction in utility bills as a result of turning down the thermostat are likely to be about £70/year.

[20] As sourced from the Energy Savings Trust

Action: Switch off Unused Appliances
Emission Source: • Non-heating Energy
Description: Estimate suggest that the "standby" function on many conventional appliances means that an average household wastes at least 5% of its annual electricity bill on appliances left on standby, compared to those who switch off from the main power socket when not in use.
Carbon Saving Potential: On average, the carbon savings likely to be realised by turning appliances off at the mains and avoiding the use of standby are in the region of 130 kg CO_2/year[21].
Financial Considerations: Keeping an eye on which appliances can be turned off at the mains when not in use could save households between £30 and £50/year.

[21] As sourced from LCIC's CRed System

Action: Wash Laundry at Lower Temperatures
Emission Source: • Heating and Hot Water Energy
Description: Due to advances in technology, most modern washing powders and detergents work just as effectively at lower temperatures. For day-to-day laundry needs, washing clothes at 30 C instead of 60 C can reduce the electricity demands of the machine by around 40%.
Carbon Saving Potential: On average, approximately 44kg CO_2/year could be saved by washing laundry at 30°C[22].
Financial Considerations: The financial savings achievable from washing laundry at lower temperatures are likely to be about £10/year.

[22] As sourced from LCIC's CRed System

Action: Efficient Kettle Usage
Emission Source: • Non-heating Energy
Description: It has been estimated that, on average, people boil between two and three times as much water as they actually require. Therefore, instead of automatically filling the kettle to maximum capacity, only boil the quantity of water you need as this saves time, energy, money and CO_2.
Carbon Saving Potential: Using the kettle more efficiently and boiling only as much water as you need could save approximately 28 kg CO_2/year[23].
Financial Considerations: Although a relatively simple measure, by using the kettle more efficiently households could save as much as £10/year.

[23] As sourced from LCIC's CRed System

Action: Switch off Un-necessary Lighting
Emission Source: • Non-heating Energy
Description: In any house, no matter how efficient the lighting system, vital energy can be saved by remembering to turn off the lights in unused rooms.
Carbon Saving Potential: On average, it is estimated that turning off un-necessary lighting could save about 24 kg CO_2/year[24].
Financial Considerations: The financial savings to be realised from reduced utility bills as a result of turning off lights in unused rooms could easily be £10/year.

[24] As sourced from LCIC's CRed System

Action: Install Reflective Radiator Panels
Emission Source: • Heating and Hot Water Energy
Description: As much as 70% of the heat expelled from the back of a radiator can end up being used to heat the wall behind it, rather than the room itself. On external walls that means the heat is inadvertently being transferred outside the property. A thermal radiator panel is a thin insulated heat-reflective panel that reflects heat away from the wall and cuts down on this waste. Rolls of foam ~3mm thick with a metallic film are available in most DIY outlets, whilst more rigid profiled units can be bought from radiator manufacturers. It is also wise to ensure that radiators are not blocked by any bulky furniture or heavy curtains, as obstructions stop air flowing freely around the radiators - and thus reduce their overall efficiency.
Carbon Saving Potential: On average, it is estimated that installing reflective radiator panels on to externally facing walls could save in excess up to 35 kg CO_2/year[25].
Financial Considerations: Reflective radiator panels cost approximately £4 each, and therefore for a typical-sized property installation costs are likely to be in the region of £30 to £50. The financial savings that are likely to be realised from a reduction in utility bills are between £5 and £25/year.

[25] As sourced from the Energy Savings Trust

Action: Reduce Air Travel

Emission Source:

- Aviation

Description:

Taking a journey by airplane is, unfortunately, one of the fastest ways to increase a carbon footprint. Air travel is also responsible for some non-CO_2 emissions, although there is still considerable scientific uncertainty about the scale of these impacts.

No matter how green you are on the ground your good work can be quickly undone when you fly. Reducing the amount of air travel can help reduce carbon emissions and could also save time and money, as there are often ways to achieve what you want without travelling as far or as often. For example,

- Consider video or teleconferencing, instead of flying to business meetings;
- Think about taking a holiday within the UK;
- Change your vacation habits - taking one longer holiday will have a lower impact than going on several short trips if you are flying each time

Carbon Saving Potential:

As people travel to different destinations it is hard to put an exact figure on the likely carbon reduction achievable, as it varies on a case-by-case basis. However, using an estimate the associated carbon saving (per person) for dropping a single long-haul flight could be around 600 kg CO_2[26]

Financial Considerations:

The financial implications obviously vary for each journey, but if a long-haul return flight was dropped and no alternative travel occurred, savings would easily be upwards of £250.

[26] As sourced from LCIC's CRed System - This particular estimate assumes that at one long haul economy class return flight from London Heathrow to New York has been dropped.

Appendix II: Energy Efficiency Options

Action: Install Energy Efficient Glazing

Emission Source:

- Heating and Hot Water Energy

Description:

Properties lose ~10% of heat through glazed openings, such as windows and doors. By installing double and triple-glazed units, in which layers of glass are insulated by gas-filled spaces, high efficiency levels can be achieved and energy demand reduced.

Energy efficient windows and doors are available in a variety of frame materials and styles. Their non-standard construction also means their ability to enhance energy efficiency also varies, as different materials influence how well the glass prevents heat from passing through the unit, how much sunlight is able to infiltrate through the glass and how much air can leak in or out around the window and its frame.

The addition of a second pane of glass to an existing window is known as secondary glazing, and has the advantage that no alterations are made to a property's external appearance. Whilst secondary glazing reduces heat loss, it is not as effective as double glazing. Secondary glazing options range from temporary plastic films to custom built systems comprising opening panes.

Carbon Saving Potential:

On average, 680 kg CO_2/year could be saved if all single glazed windows and doors are replaced with energy efficient glazing[27].

If secondary glazing is installed, carbon savings of approximately 420 kg CO_2/year could be achieved.

Financial Considerations:

Windows are fairly expensive to replace, so the payback on the investment is quite long. Double glazing is generally more expensive to install than secondary glazing, and on average will cost in the region of £3,000 to £5,000 compared to between £1,200 and £2,000.

The financial savings that are likely to be realised from a reduction in utility bills are: Replacing all single glazed windows with new energy efficient glazing could save around £135/year on energy bills. Installing secondary glazing is likely to realise savings of about £85/year.

[27] As sourced from the Energy Savings Trust

Action: Install a Condensing Boiler

Emission Source:

- Heating and Hot Water Energy

Description:

Boilers account for up to 60% of the CO_2 emissions in domestic properties. Modern condensing oil-fired boilers can be highly efficient and manufacturers claim net seasonal operating efficiencies of up to 97%. As with gas boilers, the highest rated boilers will offer the greatest efficiency, and there are now over 90 "A" rated models on the market. It has been mandatory since April 2007 to install condensing oil boilers to comply with Building Regulations, and it is possible to check the rating of a boiler by visiting the Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK) website[28].

A high efficiency condensing boiler works on the principle of recovering as much of the waste heat as possible (via a heat exchanger), which is normally exhausted by the flue of a conventional boiler. High efficiency condensing boilers convert 86% or more of their fuel into heat, compared to 65% for old G rated boilers.

Carbon Saving Potential:

If a boiler is 15 years old or more then it is likely to be a G rated boiler. Replacing a G rated boiler with a new A rated condensing boiler and a full set of heating controls can save up to 1,400kg CO_2/year.[29]

Financial Considerations:

Oil-fired condensing boilers are expensive, but they are very efficient. For example, the Grant 36kW Vortex Condensing Boiler is 97% efficient compared to the best natural gas boiler which runs at 91.3% efficiency. Installation costs for a new oil-fired boiler are likely to range between £3,500 and £8,000.

Fitting an A-rated high efficiency condensing boiler with the correct heating and hot water controls could generate savings in the region of £260/year.

[28] SEDBUK Website: http://www.sedbuk.com/

[29] As sourced from the Energy Savings Trust. If your boiler is less than 15 years old then it is likely to be more efficient so will save less if replaced

Action: Install Low Energy Lighting

Emission Source:

- Non-heating energy

Description:

Lighting is a major consumer of electricity, and old-style lighting systems generate heat when switched on. In the case of old-style incandescent light bulbs, about 95% of the electricity is wasted as heat[30] with only 5% being used to provide light.

In recent years, lighting has been made more efficient by the introduction of new technologies, such as low energy light bulbs, high intensity discharge lamps, and fluorescent tubing. An energy saving light bulb for example uses up to 80% less electricity than a standard bulb, but produce the same amount of light. Advances in technology mean that energy saving bulbs are now available in a wide variety of fittings, shapes and sizes. They are also recyclable, unlike traditional incandescent bulbs.

Energy consumption can also be reduced by:

- Directing light where needed (task–directional lighting);
- Using lighting only when required;
- Making the most of daylight

Carbon Saving Potential:

It is estimated that fitting low energy light bulbs throughout a property could save in the region of 135kg CO_2/year[31].

Financial Considerations:

Energy saving bulbs generally cost more to manufacture, so are a bit more expensive to buy. Bulbs typically cost between £3 and £20, depending on the wattage and manufacturer. This suggests a household installation cost of between £54 and £360.

They quickly pay for themselves however, and thereafter save money through lower energy bills and much longer life spans. Depending on how long the lights are in use, just one energy-saving light bulb could save on average around £2.50/year, and around £6 for brighter bulbs or those used for more hours a day. Because it will last around 10 times longer than a standard bulb, it could save around £45 in its lifetime.

If all the lights in a house were replaced with energy saving bulbs around £45/year could be saved, or approximately £390 over the lifetime of all of the bulbs.

30 Because of this, though, they help to keep a building warm during the heating season. Changing to energy efficient lighting may therefore mean more energy is needed for heating (this is known as the heat replacement effect). The additional energy requirement will partially offset the cost and CO_2 savings of energy efficient lighting.

31 As sourced from LCIC's CRed System

Action: Install A ++ Rated Electrical Appliances

Emission Source:

- Non-heating Energy

Description:

The EU Energy Label is a compulsory notice applied to all new "white goods" and electrical appliances sold within the EU – for example, light bulbs, cars and most electrical appliances (e.g. refrigerators, stoves, and washing machines) carry the EU Energy Label. The labels allows consumers to clearly see the efficiency and energy consumption of a product, and uses a scale that runs from A to G, with "A" being the most energy efficient and "G" the least. Recently, the qualification A+ and A++ were introduced for refrigerated appliances.

The Energy Rating label enables consumers to compare the energy efficiency of appliances, and also provides an incentive for manufacturers to improve the energy performance of their products. When replacing old household electrical appliances, consideration should be made of those appliances that are rated at least "A" grade as these are the most energy efficient appliances and will, in the long term, cost less.

Carbon Saving Potential:

On average, each electrical appliance that is replaced by a modern high efficiency unit should save between100 and 200 kg CO_2/year[32].

Financial Considerations:

If replacing a defunct electrical unit the financial outlay is not an additional cost as a replacement unit would have to be purchased in any case, and energy efficient appliances aren't necessarily more expensive.

Energy use could be cut by one-third by using an A-rated high efficiency appliance, and could generate savings of between £20 and £45/year.

[32] As sourced from LCIC's CRed System

Appendix III: Renewable Energy Technology Options

Action: Install a Domestic Wind Turbine

Emission Source:

- Non-heating Energy

Description:

Wind turbines are energy systems that convert the kinetic energy of moving air into electricity or mechanical power. The UK is a prime location for wind energy systems as it is estimated that 40% of all wind energy in Europe blows over the United Kingdom. Small wind energy systems, also known as "micro" wind turbines, can be installed on domestic properties to generate electricity to power lighting and electrical appliances. Suitability is, however, highly dependent on local average wind speeds so it is vital to accurately predict the wind speed before installing a domestic turbine.

Carbon Saving Potential:

The Energy Saving Trust estimate that a well sited 2.5kW turbine can generate around 4,000kWh per year, which could save in the region of 2,036 kg CO_2/year[33].

Financial Considerations:

Systems up to 1kW are likely to cost around £3,000, whereas larger systems (1.5kW to 6kW) would cost between £4,000 and £18,000. These costs are generally inclusive of the turbine, mast, inverters, battery storage (if required) and installation; however, costs vary depending on location, manufacturer and the size and type of system

A good wind resource and appropriate turbine placement are critical to the success of a financially viable wind energy project. Recent monitoring by the Energy Saving Trust of a range of small domestic wind systems has shown that a well sited 2.5kW turbine can generate around 4,000kWh per year, which could provide savings and income generation of around £1,500[34] a year via the Feed In Tariff.

Environmental Considerations:

Wind energy is a green, renewable energy and its generation does not consume scarce resources, or release carbon dioxide or any other atmospheric pollutants. However, the nature of certain geographical features often considered of significant environmental resource (e.g. crests of long, gradual slopes, passes hills, and valleys, grassy plains, and the edge of water bodies) tend to channel air movement and accelerate winds.

Thus, wind turbines – in particular those of the medium to large scale - are often deemed to be visually intrusive for nearby residents. Wind developers are required to consider all environmental aspects of wind energy project, and most wind farms (and all large wind farms) are required to produce an Environmental Impact Assessment, which covers all the issues as part of the application for planning permission. At the domestic scale however, visual impact is likely to be minimised, and in most cases these and other potential environmental issues can be mitigated through careful planning, research and consultation with neighbouring properties.

---

[33] Assuming an annual household electrical consumption of 3,300 kWh is displaced.

[34] Assuming annual household electrical consumption of 3,300 kWh, an annual electricity bill of £461, and a combined FIT income (generation and export) of £1,089

The energy available from the wind increases in proportion to the cube of the wind speed, which typically increases with height above the ground. At minimum, the annual average wind speed for any feasible wind energy project should be 5 m per second (m/s) at a height of 10 m above the ground. However, wind speeds are fairly difficult to predict and highly variable. The Energy Saving Trust offers a tool[35] to help predict wind speed for domestic properties. The tool requires user specific household data, including postcode and general location (e.g. rural) to estimate average wind speeds. For a postcode relating to the centre of Wenhaston (IP19 9EF) and using a rural setting the tool predicts a wind speed of: 4.61 m/s. This suggests that small scale wind turbines in the village are on the border of suitability, and further investigation would be required to determine an individual property's suitability, due to factors such as local topography and obstructions (e.g. large trees, peripheral buildings) that surround the property of interest.

If wind turbines are to be considered as a possible carbon reduction option for the Wenhaston community, the Carbon Trust[36] offers a slightly more technical tool to help estimate wind yields. Following this, it is recommended that a trial be conducted using an aenometer to monitor the local wind speed and determine the wind speed distribution in order to help identify the most preferential sites.

Technical Considerations:

Wind turbines consist of a series of aerodynamic blades designed to interrupt the flow of wind, which forces them to rotate in a cyclical motion driving a turbine capable of generating electrical power. Wind speed increases with height so it is best to have the turbine high on a mast or tower. The stronger the wind, the faster the blades rotate resulting in more electricity being produced. Modern wind energy systems operate automatically, and the turbine control system includes an anemometer that continuously measures wind speed.

When the anemometer records that the wind speed is high enough to overcome friction in the wind turbine drive train, the control system allows the rotor blades to rotate, thus producing a very small amount of power. The cut-in wind speed is usually a gentle breeze of about 4 m/s. Power output increases rapidly as the wind speed rises. When output reaches the maximum power that the machinery was designed for, the wind turbine controls govern the output to the rated power. The wind speed at which rated power is reached is called the "rated wind speed" of the turbine, and is usually a strong wind of about 15 m/s. If the wind speed increases further, the control system shuts down the wind turbine to prevent damage to the mechanical components. This cut-out wind speed is usually around 25 m/s.

Households are advised to consider domestic small-scale wind products and to use installers that are certified under the Micro-generation Certification Scheme (MCS)[37]. Wind turbines are commercially available in a vast range of sizes. However, there are two main types of domestic-sized wind turbine:

- Mast mounted: Free standing and erected in a suitably exposed position, often with electrical capacities of around 2.5kW to 6kW;
- Roof mounted: Smaller systems that tend to be installed on the roof of a property with suitable wind resource. Electrical capacities are between 1kW and 2kW.

[35] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Can-I-generate-electricity-from-the-wind-at-my-home

[36] Details of the Carbon Trust wind yield estimation tool can be found here: http://www.carbontrust.co.uk/emerging-technologies/current-focus-areas/offshore-wind/_layouts/ctassets/aspx/windpowerestimator/windpowerestimatorterms.aspx

[37] MCS certificates micro-generation technologies used to produce electricity and heat from renewable sources. Further details can be found here: http://www.microgenerationcertification.org/

Turbines are rated to a certain capacity; however this output is only achieved for the time that wind speed is at its optimum level. As a rough guide, a good wind site will produce an average output of 30% of the rated capacity of the turbine. The size of the wind turbine determines the total amount of energy generated each year. For example, if a 5kW wind turbine generates the equivalent rated power for 30% of the year, it will generate 13,140kWh per year. To make the most efficient use of the energy produced, any excess electricity can be stored in batteries for future use.

Most small wind turbines generate direct current (DC) electricity. Off-grid systems require battery storage and an inverter to convert DC electricity to AC (alternating current). A controller is also required to ensure the batteries are not over or under-charged and, depending on the capacity of the system, to divert power to another useful source (e.g. space and/or water heaters) when the battery is fully charged. It is common to combine the system with a generator or another renewable energy technology for use during periods of low wind speeds. Wind systems can also be installed where there is a connection to the national grid. A special inverter and controller converts DC electricity to AC at a quality and standard that is acceptable to the national grid. No battery storage is required. Any unused or excess electricity can be exported to the national grid and sold to the local energy supply companies via the Feed in Tariff.

Planning & Political Considerations:

Mast-mounted turbines require an area of exposed open ground with a flow of wind unobstructed by buildings, trees or hills in order to avoid turbulence. Alternatively for individual roof mounted turbines an unobstructed flow of wind to a high point on the property is required. Turbines vary in size. Household systems are typically sized up to 6kW but there are larger turbines of up to 50kW available for larger community scale projects.

Knowledge of the local wind resource is critical to designing a suitable wind energy system and predicting output. For domestic installations a useful source of information on local wind speeds is the Carbon Trust's technical tool (see above) or the UK Department of Energy and Climate Change's wind-speed database[38]. Alternatively, residents can look to collect their own primary data by setting up a monitoring mast to record wind speed using an anemometer.

The planning regime for installing wind turbines is evolving. However, wind energy systems are not currently covered in "Permitted Development" rights. Therefore, consultation with the local authority is required as installing a wind turbine will usually require planning permission regardless of the size of the turbine. Small battery charging systems are least likely to incur any problems as they are generally treated in a similar fashion to TV aerial installations - as long as they are not in a conservation area or next to a listed building. The UK's Planning Portal "Interactive House"[39] tool provides a useful overview of planning permission and building regulations for individual householders, and more information can be found on the British Wind Energy Association website[40]

If a wind turbine is to be attached to a home, building regulations will normally apply, and would make consideration of size, weight and force exerted on fixed points. Building regulations also apply to other aspects of the work such as electrical installation. It is advisable to contact an engineer who can provide the necessary advice. If the wind turbine is not attached to a property, then only the electrical installation and connection will be captured by the requirements of the building

[38] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/wind/windsp_databas/windsp_databas.aspx
[39] http://www.planningportal.gov.uk/permission/house
[40] http://www.bwea.com/index.html

regulations.

Social Considerations:

The scale and location of wind turbine installation is very important with regards its potential impact on the surrounding environment. The planning system should make full consideration of any potential social issues, such as visual impact, noise and shadow flicker effects, as well as any possible technical issues, such as television/radio interference.

Visual impacts and noise are the two most common social issues that should be considered in any location. Noise is a concern often raised in relation to wind turbines, although it has frequently been exaggerated. All machines emit noise, and in the case of a wind turbine there are two sources: the noise of the blades cutting through the air and the sounds emitted from the gearbox and generator. The working parts of the turbine are generally enclosed to dampen down noise; however, the blades can sometimes act like a loudspeaker and amplify any sound generated. Noise levels are generally low and, under most operating conditions it's likely the turbine noise would be completely masked by wind-generated background noise. Further, smaller domestic turbines do not tend to have a gear box, which reduces the noise compared to larger turbines. Nonetheless, it is important to ensure that there is a reasonable distance between a turbine and the nearest neighbours.

In terms of visual impact, the common factors that tend to affect the perception of wind turbines are: number of turbines; distance to turbines; their size; their height; paint and structure; fit with local materials. On the rare occasion, wind turbines can also interfere with electromagnetic transmissions, either by emitting electromagnetic signals, or by interfering with other electromagnetic signals. The nature of the interference depends on the size of the structure relative to the wave-length of the radiation, but provided diligent planning is undertaken, turbines should not cause any significant problems of electromagnetic interference.

Most large-scale turbines are based on the horizontal axis turbine. Current turbine sizes that could be used in a community project generally range from 850kW to 3MW, with rotor diameters that span from 44m - 100m. When considering the installation of large-scale wind turbines, the community should bear in mind that any excess electricity produced that can be sold back to the national grid will be at a lower price than any electricity purchased in the future. Thus, it is always more efficient if the energy can be used at source with any excess then going to the grid. In areas with a good wind resource, a wind-battery or wind-storage heater system can capture and store energy for when it is required.

With regard to the establishment of a larger community-based wind system, it should also be noted that whilst cheaper per kW for installation, larger turbines are subject to more exacting connection requirements and will typically pay higher use of systems charges to use the distribution network as they will be connected at higher voltages. The planning process is likely to be longer and more expensive and more objections may occur as larger turbines are often seen as more visually intrusive. In any case, there will need to be a thorough assessment of the available resource and monitoring regime to determine a robust estimated annual production figure can be determined. This will help to predict annual income and will be required for securing project finance.

Timescales:

Domestic installation is likely to take between 3 and 6 months due to the planning and approval process. Maintenance checks are required every few years, but a well-maintained turbine should last over 20 years. On some turbines, blades may need replacing during the lifetime of the appliance.

Action: Install a Domestic Hydroelectric System

Emission Source:

- Non-heating Energy

Description:

As water travels down slope from an area of high elevation, it generates useful potential and kinetic energy. Small scale hydroelectric systems are able to harness this energy by directing moving water bodies (e.g. streams and rivers) across a network of turbine-powered generators to create useful electrical power. In the right locations, small-scale hydroelectric systems are more than capable of producing enough power to meet the lighting and electrical appliance demand of an average sized property.

Carbon Saving Potential:

The installation of a domestic hydroelectric system could reduce CO_2 emissions by up to 2,036 kg CO_2/year[41].

Financial Considerations:

Costs for installing a small-scale hydroelectric system vary considerably, depending on the location and the amount of electricity that is intended to be generated. The majority of the cost stems from the upfront expenses accrued during construction and equipment purchase, which if not carefully considered can easily render a project uneconomic.

In general, the costs per unit of electricity of high-head schemes are lower than those of low-head schemes. Assuming a property is close to water body, a low head system of up to 10kW would cost around £3,000 - £4,000 per kW installed. Medium head systems are generally more expensive, and would come with a fixed cost of around £10,000 plus £2,500 per kW installed. A typical 3kW scheme suitable for an average property might cost between £12,000 and £20,000 for equipment and installation. Systems with outputs higher than 10kW typically cost less per kW to install. Therefore, if the costs appear too high for an individual household, one option is for neighbours or the wider community to club together to install a larger, more cost-effective system that serves a greater population.

The financial savings that could be realised critically depend on the amount of hydroelectricity used to displace electricity bought from another source. Efficiencies for micro size systems are generally high at between 50 – 75% depending on size, type and location. A 3kW unit could generate approximately 10,522 kWh per year[42], which for a single property could provide savings and income generation of £2,654 [43] a year via the Feed In Tariff.

If, for example, the hydro system replaces electricity bought from the national grid then typical savings could be fairly substantial as the property may not need to ever use conventional electricity again so there will be 100% savings on electricity bills. Thus, in theory proprietors could realise savings of at least £400/year. Further savings could be seen if suitable technologies exist to allow excess electricity to be used for household heating and hot water systems, and/or sold to the national grid via the

[41] Assuming annual household electrical consumption of 3,300 kWh is displaced.

[42] Assuming an efficiency capacity of 40%

[43] Assuming annual household electrical consumption of 3,300 kWh, annual electricity bill of £461, and a combined FIT income (from generation and export) of £2,193

feed in tariff.

Hydroelectric projects typically have low operating costs and although maintenance costs can vary, they are usually low as hydro systems are generally very reliable

Environmental Considerations:

Hydroelectricity is a green, renewable energy and its production does not consume scarce resources, or release carbon dioxide or any other atmospheric pollutants. Small scale operations typically refer to a mode of system called "run of river" in which the hydro plant uses only water that is available in the natural flow of the river, and implies there is no water storage, meaning power generation could fluctuate in response to stream flow and the hydrological cycle.

Small-scale hydro electricity schemes can impact the landscape and visual amenity, nature conservation and the water regime. One of the most important environmental considerations is protection of the water source and its surrounding habitat, as even a small hydropower plant can cause water pollution, disrupt fish migration and cause ecological damage if badly designed and/or constructed.

Controls are in place to protect the environment and to preserve the water course's natural ecological state. For example, restrictions are made on the proportion of water that can be diverted through a turbine, with the Environment Agency guiding legislation, licensing and planning issues in this area[44].

Technical Considerations:

An appreciable, constant flow of water is critical to the success of a small hydro project, and the amount of energy available from a hydro turbine is proportional to the quantity of water passing through the turbine per unit of time (i.e. the flow), and the vertical difference between the water source and the point at which it flows through the turbine (i.e. the head). Thus, with regards to location, hydroelectric power schemes require a suitable rainfall catchment area, a water intake placed above a weir or behind a dam and a sufficient drop (head) between inlet and outlet.

Hydropower systems use flowing water to turn turbines, which generate electricity. The amount of energy that can be generated depends on the volume of water available and the variability of flow throughout the year – the faster the water flows and the greater the volume of water captured, the more electricity can be generated. Projects in the range of 100 kW to 1 MW are generally referred to as "mini" hydro and projects less than 100 kW "micro" hydro. Most micro hydro systems are efficient enough to convert around half of the potential energy into electricity.

Micro hydro systems are categorised as low head, medium head and high head, depending on the height that the water falls at the site. Low head systems have a drop of 5-20 metres, medium head systems are 20-100 metres, and high head systems are over 100 metres. Even a small stream can produce enough kinetic energy to turn a turbine. For example, a small turbine on a hill stream that flows at a rate of 15 litres per second – and from a head of 15 metres – will generate around 1kW of electricity at any given time: more than enough to meet the basic needs of an average home. For homes with no mains electricity connection, a well designed micro hydro system can generate a steady, more reliable electricity supply than most other renewable technologies, and at a lower cost. Depending on the capacity of the system, in some instances additional power can be used to generate heating and hot water.

The River Blyth offers potential for hydropower generation in Wenhaston. River flow data sourced from the gauging station at Holton by the UK Centre for Ecology and

[44] NetRegs is a partnership between the various UK environmental regulators and its website provides useful guidance concerning the environmental aspects of hydropower: http://www.netregs.gov.uk/netregs/118773.aspx

Hydrology indicates mean flow rates of 0.429 m^3 per second which, when combined with head data for a small 1m weir, indicates that there may be potential for a micro-hydro system of at least 3kW to be installed. A single unit of this scale could generate approximately 10,522 kWh per year, which could potentially be enough electricity to power three domestic properties.

In terms of construction, a small hydro power station can be described under two main headings: civil works, and electrical and mechanical equipment. The primary electrical and mechanical components of are the turbines and generators whilst the principal civil works are the construction of a diversion dam or weir, the water passages and powerhouse. The diversion dam/weir directs water into an artificial channel and the flowing water passes through a turbine with enough force to create electricity in a generator. The water then flows back into the natural river system via a tailrace.

Generally, small hydro projects are termed "run-of-river" developments, meaning that water is not stored in a reservoir and is used only as it is available. Thus, although there is less ecological impact careful foresight is required as during drier summer months the hydro system may not be able to supply all the electricity required due water shortages/restrictions. Thus, depending on the capacity of the hydro plant a backup power system may need to be in place.

Planning & Political Considerations:

Due to its reliance on a nearby source of water, not every property will be able to tap into hydroelectricity. Properties wishing to use hydro power require access to a fairly fast flowing river or stream, and must hold the right to build around it. Even if there is suitable access to flowing water, it is worth assessing whether there any big seasonal variations in water flow.

In order to preserve a river or stream's natural ecological state, there are restrictions on the proportion of water that can be diverted through a hydroelectric system in any particular location. The proposed European Water Framework Directive[45] specifies a number of aspects relating to the ecological environment that have to be considered in the planning of a hydropower scheme. Included is the protection of fish species, and the maintenance of water quality. There is an expectation that the local environment is maintained or even improved while developing hydropower schemes in Europe.

The UK Planning Policy Statement 22 (PPS22)[46] on renewable energy recommends that anyone intending to install a small-scale hydro system should make early contact with the developer, planning authorities, the Environment Agency and any other relevant statutory agencies, such as Natural England, to ensure that all statutory remits are met and that proposals do not detract from the existing value and interest of the watercourse and its surroundings. The Environment Agency should typically be the first port of call for guidance on planning issues, and subsequently contact should be made with the relevant planning authority to ensure that the site and design are acceptable as it is likely that an Environmental Impact assessment would be required. Further guidance on planning and legislation can be sourced from the British Hydropower Association (BHA)[47].

[45] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

[46] The Planning Policy Statement 22 (PPS22) sets out the Government's policies for renewable energy, which planning authorities should refer to when preparing local development documents and when taking planning decisions. Further details can be found here:
http://webarchive.nationalarchives.gov.uk/+/http:/www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps22/

[47] BHA Website: http://www.british-hydro.org/index.html

Social Considerations:

Water turbines could potentially stand out in a landscape and generate a certain amount of noise. However, such issues can be resolved fairly easily with careful foresight, appropriate consultation and planning during the development stages. Consideration should be given to integrating a new scheme into the landscape as far as possible. For example, where rivers are lined with trees it will be relatively simple to conceal hydropower facilities, particularly if the existing woodland is supplemented by new planting.

In some cases, the visual appearance of water courses may be affected by water abstraction. In these cases, consideration should be given to potential users/viewers, and certain measures could be adopted to overcome visual objections, such as requiring abstraction to be reduced during the day in summer months when visitors are most likely to be present. Measures to minimise the visual impact of any pipes and power lines should also be considered carefully at the design and planning stages.

The noise emitted from a water turbine will generally be well contained by the turbine house and not be heard more than a few metres away. If necessary, limits can be set on noise emissions if the site is close to residential properties, by way of a planning condition.

Hydropower can be a valuable resource for those communities close to a good water resource. For larger scale projects, integrated hydro power resource monitoring will be required to assess the availability of resources and estimate capacity and annual production, which will help in the development of a strategy to balance resources and power demand in order to secure project finance.

Timescales:

The development of small hydro projects typically takes anywhere from 2 to 5 years to complete, from conception to final commissioning. This time is required to undertake detailed investigative studies and design work, to acquire relevant approvals and to construct the system. Once constructed, small-scale hydroelectric plants require little maintenance over their useful operating lifespan, which can be well over 50 years. A part-time operator can normally handle operation and routine maintenance.

Action: Install Solar Photovoltaics (Solar Electricity)

Emission Source:

- Non-heating Energy

Description:

Solar photovoltaic (PV) systems capture solar radiation energy emitted from the sun, and convert it into a source of direct current electricity that can be transformed for use in domestic properties. PV systems are composed of an array of photovoltaic cells that usually comprise of thin crystalline silicon wafers or strips of advanced semiconductor film, and which generate a small electric current when sunlight strikes the surface layer. The greater the intensity of light, the greater the flow of electricity.

Carbon Saving Potential:

A typical household could save approximately 1,018 kg CO_2 per year by installing a photovoltaic system[48]

Financial Considerations:

Solar PV systems are particularly cost-effective in small off-grid applications providing power, for example, to rural homes, off-grid cottages and motor homes. They are also used for remote telecommunications, monitoring and control systems where their installation typically costs less than the cost of connecting to the national grid.

The costs for installing a solar electricity system vary considerably, and solar tiles are generally more costly than conventional panels, and panels built into a roof are more expensive than those that sit on top of existing tiles. Per kWp[49], solar electricity systems cost in the region of £4,500 to £9,000, but generally costs per kW reduce as the size of the system increases. For an average size system (2.2kWp) costs are likely to be around £12,000.

A typical home PV system can produce at least half the electricity a household requires in a year, and thus electricity costs are likely to be reduced by approximately £230 per year. Under the FIT, this would generate an income of approximately £681 per year. If the system is able to produce more electricity than is required the excess can be stored in batteries for future use or used to help power other renewable heating and/or hot water systems. Alternatively, excess electricity can be sold back to the national grid, generating an income of 44.3p per kWh sold

Several companies are now offering free solar PV installation in return for the income generated through the feed-in tariffs, with the customer still benefiting from some reduction in electricity bills.[50]

Environmental Considerations:

Solar electricity is a green, renewable energy source and its generation does not consume scarce resources nor does it release carbon dioxide or other atmospheric pollutants during use. Typically, the greatest risk to the environment associated with photovoltaic devices relates to their manufacture, rather than their installation and use.

Although PV cells don't require direct sunlight to work, they do require a surface such

[48] Assuming half (1,650 kWh) the annual household electrical consumption of 3,300 kWh is displaced.
[49] The strength of a PV cell is measured in kilowatt peak (kWp)
[50] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-electricity/Consumer-guidance-on-free-solar-PV-offers

as a roof or wall that faces within 90 degrees of south, and need to be positioned so that they aren't overshadowed by any trees or neighbouring buildings.

Maps[51] highlighting the total average solar irradiation falling on a one square metre surface on the horizontal, measured in kilo-watt hours (kwh) identify that the sun's rays falling on the ground surface in East Anglia are approximately 1,100 kwh m^2. By tilting a surface to an angle the amount of solar radiation falling on it will be greater than that falling on a flat surface, in this country. Fortunately, the average tilt of a UK house roof is about the optimum for receiving solar energy. To help identify the most suitable sites for installation it would be beneficial for proprietors to use a pyranometer to monitor the average solar irradiance at proposed sites.

Technical Considerations:

PV systems are relatively simple technologies as they are modular and highly reliable due to the lack of moving parts, they are also easy to maintain. Each PV cell is made from one or two layers of semiconducting material, usually silicon. When light shines on the cell it creates an electric field across the layers. The stronger the sunshine, the more electricity is produced.

The strength of a PV cell is measured in kilowatt peak (kWp), which dictates the amount of energy a cell can generate in full sunlight. Multiple photovoltaic cells can be assembled into modules that can be wired in an array of any size, with the largest arrays having capacities in excess of 5 MW. The system size for residential units is typically in the 2 to 4 kW range, whilst for commercial buildings, the system size can range up to 100 kW.

There are three principal types of solar cells:

- **Mono-crystalline** – PV cells are made from thin slices cut from a single crystal of pure silicon. They are very efficient; however the cost of production is high as it is energy and labour intensive. This would be useful for small installations or areas with very limited mounting space.
- **Poly-crystalline –** PV cells made from small grains of mono-crystalline silicon. They are cheaper and easier to manufacture, but are also found to be less efficient than mono-crystalline cells.
- **Amorphous Silicon –** PV cells made from very thin films of silicon that are in less order than the crystal lattice structure of mono-crystalline and poly-crystalline cells, causing low efficiencies. This technology is most often used in smaller applications, such as calculators or garden lights.

The electricity produced by solar PV panels is Direct Current (DC). It can be stored in batteries and it can also be converted to Alternating Current (AC) using an inverter to power domestic electrical appliances or for connection to the national grid. PV systems can be combined with other power producing systems for applications that have higher energy demands or in climates characterised by extended periods of low sunshine to form hybrid systems. Depending on the capacity of the system, in some instances surplus electrical power can be used to help generate heating and hot water when combined with other renewable technologies.

Solar PV is unique among renewable energy technologies in that in addition to generating electricity from daylight it can also be used as a building material in its own right. PV can either be roof mounted or free-standing, in modular form or integrated into the roof or facades of buildings through the use of solar shingles, solar slates, solar glass laminates and other solar building design solutions. However, solar panels are not light and the roof (or wall) must be strong enough to take its weight, especially if the panel is placed on top of existing roofing tiles. Prior consultation with an experienced installer or roofing engineer is advised before purchase.

[51] For example: http://www.solar-trade.org.uk/solarHeating.cfm

General maintenance of PV systems is low, and only requires that the cells are kept relatively clean of dust and dirt, and are not overshadowed by growing vegetation. The wiring and electrical components of the system require checking on occasion by a qualified technician. For stand-alone systems, i.e. those not connected to the national grid, further maintenance is required on other components (e.g. batteries).

Planning & Political Considerations:

Solar PV panels require a significant amount of space to produce a relatively small amount of electricity. They also require a roof or wall that faces within 90 degrees of south, and which isn't overshadowed by trees, vegetation or buildings. If the surface is in shadow for parts of the day, the system will generate significantly less energy.

The size of PV array required for a typical domestic property varies, depending on factors such as: demand for power; the type of cell used; available roof space; and budget. Typical domestic systems are around 1.5-2kWp, which should provide at least half the average family's annual supply[52]. This size of array would typically cover 10-15m^2 of roof area.

In many cases fixing solar PV panels to the roof of a single dwelling house is likely to be considered "permitted development" under planning law, with no need to apply for planning permission. There are, however, important exceptions and provisos that must be observed and full details can be found on the appropriate Planning Portal webpage[53]. These permitted development rights only apply to houses. It is always worth checking with the local planning authority if the property is of another type, a listed building or located within a conservation area.

The UK's Planning Portal's "Interactive House"[54] tool provides a useful overview of planning permission and building regulations for householders considering installing renewable energy technologies. Meanwhile, the UK's Planning Policy Statement 22[55] sets out the Government's policies for renewable energy, which planning authorities should refer to when preparing local development documents and when taking planning decisions. Households are advised to use installers[56] certified under the UK Micro-generation Certification Scheme[57] in order to authenticate that electricity is produced from truly renewable sources, and fits the criteria required from initiatives such as Feed in Tariffs.

Social Considerations:

Photovoltaic systems are particularly well suited to the urban environment as they make no noise and cause no pollution in operation, and solar energy is freely and virtually infinitely available. Solar PV has a relatively low visual impact compared to other technologies, and PV cells are available in a variety of different shapes and colours, ranging from "solar tiles" that look like roof tiles, to panels and transparent cells that you can use on conservatories and glass to provide shading as well as generating electricity. It can also be roof mounted or free-standing, in modular form or integrated into the roof or facades of buildings.

---

[52] This Energy Saving Trust estimation assumes gas is used for heating requirements and no energy efficiency savings have been introduced.
[53] Planning portal details on planning permission for Solar Panels: http://www.planningportal.gov.uk/permission/commonprojects/solarpanels
[54] http://www.planningportal.gov.uk/permission/house
[55] The Planning Policy Statement 22 (PPS 22) sets out the Government's policies for renewable energy, which planning authorities should refer to when preparing local development documents and when taking planning decisions. Further details can be found here: http://webarchive.nationalarchives.gov.uk/+/http:/www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/planningpolicystatements/planningpolicystatements/pps22/
[56] The solar trade provides details of UK solar PV installers: http://www.solar-trade.org.uk/
[57] MCS certificates micro-generation technologies used to produce electricity and heat from renewable sources. Further details can be found here: http://www.microgenerationcertification.org/

The relative cost of installation can be reduced by connecting a number of arrays using a single inverter to change current from DC to AC. In a community setting, it can therefore be beneficial to combine cells across a number of properties and then connect to an appropriate electrical network. When considering the establishment of large-scale community solar PV systems, it is important to recall that any electricity sold back to the national grid will be at a lower price than any electricity that is purchased in the future.
Timescales: PV has a proven working life of up to 45 years, and modules typically come with a 25 year manufacturer's warranty[58]. The longer the panels are in residence, the more electricity they can generate and the greater benefit they can provide financially and environmentally. Over time, efficiency of the panels is likely to reduce, and thus will likely produce less electricity near the end of their operational life.

[58] http://www.solar-trade.org.uk/solarHeating/pvSystemCost.cfm

Action: Install a Biomass Heating System

Emission Source:

- Heating and Hot Water Energy

Description:

Biomass is essentially a form of "ancient" solar energy, and is available in a number of different forms. Biomass fuelled heating systems utilise organic materials, typically wood (logs, chips, pellets and briquettes) to generate heat and hot water. In the domestic setting, this is typically via a biomass boilers or wood stoves. Other suitable biomass sources include purpose grown energy crops (e.g. short rotation coppice, and grasses such as miscanthus) and agricultural residues (e.g. husks and straw).

Biomass systems differ from most other renewable energy technologies as the fuel source is grown rather than harnessed, and biomass systems release carbon dioxide. Nonetheless, technologies utilising biomass are typically considered "carbon neutral" as the CO_2 released when energy is generated is offset by the CO_2 absorbed in the original growth of the biomass, or captured in the growth of new biomass to replace the materials used – i.e. carbon dioxide is circulated in a closed loop system. Thus, using biomass for heating results in very low net "lifecycle" carbon emissions relative to conventional fossil fuels, as long as the material is derived from sustainable sources.

Carbon Saving Potential:

The CO_2 resulting from the combustion of biomass is recaptured by the new growth of sustainable biomass, thus direct emissions are zero. However, small net emissions still occur as a result of indirect activities, such as cultivation, harvesting, processing and transportation of the fuel, which typically consume fossil fuels.

The average indirect CO_2 emissions per unit of power achievable for biomass when used for heating, are as follows[59]:

- Biomass (wood logs) 0.01895 kg CO_2/kWh
- Biomass (wood chips) 0.01579 kg CO_2/kWh
- Biomass (wood pellets) 0.03895 kg CO_2/kWh
- Biomass (grasses/straw) 0.01020 kg CO_2/kWh

This can be compared to heating oil, which is a non-renewable resource so every litre burnt adds CO_2 to the atmosphere (direct emissions), and activities associated with its production and transportation to the end user also emit CO_2 (indirect emissions). Thus, the carbon savings are fairly significant – between 4,840 and 5,358 kg CO_2 per year – if a wood-fuelled boiler replaces an oil-fired heating system[60].

Financial Considerations:

Biomass heating systems tend to incur higher capital costs than conventional boilers. Costs for a standalone wood stove are around £5,800 (including installation), whilst an automatically fed wood-fuelled domestic boiler would cost around £11,500 (including installation). Manually fed log-based boiler systems tend to be slightly cheaper.

Biomass heating systems are most attractive where conventional energy costs are high and biomass feedstock costs are low. This occurs when: electricity or some other costly form of energy (e.g. oil) is used for space and/or water heating, and biomass residues are available on-site or nearby at little or no cost. For example, if solid fuel, oil

[59] Sourced from DECC's 2010 GHG Guidelines
[60] Assuming an annual non-electric energy consumption of 18,000 kWh (DECC).

or electric heating is replaced households could save between £170 and £390 per year. However, if a gas heating system is replaced the user may end up paying more for their fuel. As long as biomass is sourced from a local sustainable resource the purchaser will be insulated from any major price increases due to shortages of supply or conflict, which tend to cause a more volatile market for fossil fuels.

A reliable, low-cost, long-term supply of biomass fuel is essential to the successful operation of a biomass heating system, and fuel costs often depend on the distance of the supplier to the property and whether it's possible to purchase and store wood in large quantities. Ideally, biomass fuel should be sourced locally to reduce costs and environmental burden as a result of transport emissions. Typically, logs and wood chips are cheaper products, whilst wood pellets are a more compact form of energy and thus require less storage and transportation.

Prices per kWh vary with regard to moisture content, but as of December 2010 the UK Biomass Energy Centre suggested typical prices for bulk purchase of fuels at the domestic scale for wood chips and pellets was £80 per tonne and £185 per tonne (respectively), which equates to 2.3p/kWh and 3.9p/kWh[61]. Thus, households are likely to see a fairly significant reduction in annual fuel costs, with annual fuel bills being reduced by between 40% and 65%, which could equate to approximately £432 to £720 per year if switching from oil[62]. The National Energy Foundation[63], HETAS[64] and the Biomass Energy Centre[65] provide details of wood fuel suppliers and technology providers, and Anglia Wood Fuels is a localised service[66].

Generation of domestic heat by biomass technologies is expected to be covered in the forthcoming UK Government Renewable Heat Incentive, and this mechanism should provide households with additional financial support upon its proposed launch in June 2011.

Environmental Considerations:

Whatever the source of the biomass, it can only be considered a renewable resource if it's harvested sustainably. The goal of forestry operations should be to maximise the utilisation of harvested trees and to provide a means of establishing a productive replacement crop. The growth of biomass crops may help create new environments, and some biomass may create suitable habitats for rare or endangered species. Some schemes may result in more intensive forest or woodland management, which may promote biodiversity, creating more attractive breeding or feeding habitats for certain species.

The use of biomass for heating systems generally emits lower levels of pollution and greenhouse gas emissions, relative to fossil fuel systems, and also their use for energy can often displace emissions from alternative methods of disposal. For example, using waste wood can be a means of disposing of materials that might otherwise be sent to a landfill site and left to decompose, emitting carbon dioxide and methane.

Biomass combustion may generate airborne emissions that can affect local air quality and which may be subject to local regulation. These emissions include particulates (e.g. soot) and gaseous pollutants such as carbon monoxide, sulphur oxides, nitrogen oxides, hydrocarbons, and in some instances Poly-Aromatic Hydrocarbons (PAHs).

[61] N.B. Prices are for guidance only, and represent the typical cost per unit of fuel energy for comparison. It is not the same as cost per unit of delivered heat, which will depend on the efficiency of the specific boiler or stove, and may include other charges such as service and maintenance for heat supply contracts.
[62] Assuming an average cost for heating oil of 6.3p/kWh.
[63] National Energy Foundation: http://www.nef.org.uk/logpile/fuelsuppliers/index.htm
[64] HETAS: http://www.hetas.co.uk/
[65] Biomass Energy Centre: http://www.biomassenergycentre.org.uk/portal/page?_pageid=77,225275&_dad=portal&_schema=PORTAL
[66] http://www.angliawoodfuels.co.uk/Content/Default.asp

The exact emissions generated will depend on the fuel type as well as the size and nature of the combustion system, and local emission regulations vary in their approach accordingly (e.g. smoke control zones).

The main solid bi-product of the conversion of biomass into energy is ash, usually termed "bottom ash". Bottom ash is produced at a rate of around 1% of the total weight of the biomass burned, and will need to be disposed of appropriately. Ash cans need to be emptied every 2-6 weeks depending on the fuel and the size of the boiler, and the ash residue can be added as a soil amendment to gardens and/or placed in compost bins.

Technical Considerations:

There are two main ways of using biomass to heat domestic properties:

1) Stand-alone stoves providing space heating for a single room. These can be fuelled by logs or pellets, but only pellet-based systems are suitable for automated feed. They are typically 6-12 kW in output, and some models can be fitted with a back boiler to provide water heating.
2) A biomass boiler connected to a central heating and hot water system. These are suitable for pellets logs or chips, and are generally larger than 15kW. More sophisticated than conventional open fires and most stoves, wood-fuelled boilers are highly efficient heating systems capable of achieving near complete combustion through careful control of the fuel and air supply.

Biomass can be sourced from a wide range of sources, and thus the product tends to vary more in terms of its quality and consistency than fossil fuels. Feedstock delivery, storage, and handling are also more complex, and often more physical space is required. All these factors require a higher level of operator involvement and diligence and the installation must be preceded by a thorough assessment of the quality and quantity of the biomass resources available, the reliability of the suppliers, the fuel handling requirements imposed by the characteristics of the biomass, and possible changes in the future demand for the targeted biomass resource.

Although only stoves and boilers are considered in this particular example as a means of generating heat via combustion, biomass can be harnessed using other methods. Direct combustion is the most commonly used technology for "heat-only" systems. However, both combustion and a process termed "gasification" can be adopted to produce "electricity only" systems, or alternatively both technologies can be used in the most efficient form of "combined heat and power" (CHP) systems.

Planning & Political Considerations:

The typical dimensions of a household wood-fuelled boiler are approximately 90cm x 110 cm x 165cm, although this varies according by model and the type of fuel used. The measurements for a typical wood-burning stove are generally smaller at around 65cm x 50 cm x 45 cm – but again vary according to the model and fuel type used.

Wood chips take up more space than logs, and pellets need the least amount of space due to their higher bulk density. During initial planning, careful consideration should be given to fact that these systems benefit from direct access for truck deliveries of fuel, space for fuel storage, and an ash removal system. For domestic properties, a dry store area of at least $2m^3$ is required to store wood pellets, assuming two fuel deliveries per year. Ideally, this space should be close to where the wood is delivered in order to minimise the distance it has to be transported by hand. In theory, a smaller store area could be used if more frequent deliveries of fuel can be accommodated.

A vent is required that is specifically designed for wood fuel appliances, with sufficient air movement for proper operation of the stove or boiler. Existing chimneys can be fitted with a lined flue, which is relatively inexpensive. Proprietors would need to talk to the Local Authorities if flue systems need to be extended more than 1m above the height of the roofline, if a home is in a Conservation Area, of if it is intended for a flue to be installed on the principle elevation from a road.

Planning permission is not normally needed when installing a biomass system in a house if the work is all internal, and even if the installation requires a flue outside, it will normally be within permitted development as long as specific conditions are met. It is always worth checking what is required to comply however, especially for residents living in older or more unusual homes. Further information can be sourced from the UK planning portal[67].

For certain areas, wood can only be burnt using certain exempted appliances due to the UK "smokeless" zone requirements. It appears there are no smoke control areas in the Suffolk Coastal DC Local authority, but it is always worth checking the most recently published data[68].

Social Considerations:

Biomass is often harvested, collected, and delivered by local operators; in contrast, most fossil fuels are imported from outside the UK. The preparation and delivery of biomass is typically more labour intensive than is the case for fossil fuels. As a result, expenditures on biomass have a stronger "multiplier effect" for the local economy by creating fuel supply chains and making use of resources that would otherwise be treated as waste and sent to landfill. Thus, money tends to stay within the community rather than leave, creating local jobs and improving the local tax base.Log fuel is more labour intensive for a community but a lot less costly than wood chip or pellets, and can help stimulate community forest enterprises. Logs supplied by a community will require cutting of harvested or delivered logs to required length, air drying to decrease moisture content, and the boilers normally require manual loading of logs.

Although relatively unobtrusive at the domestic scale, those wishing to install biomass heating systems should take into account factors such as ventilation, noise and general safety. When looking to scale up this technology, biomass is generally well suited for small power plants, although in many circumstances it may be better to use the biomass to provide heat rather than power as this is often a more efficient use of the resource. For heat demands in excess of 100kW a combined heat and power (CHP) system can be used, which effectively captures and makes available the heat associated with electricity generation making the whole process extremely efficient (>80%). CHP plants are suitable for use with a variety of fuels (e.g. natural gas, bio-gas, biomass, and waste) but biomass is a typical application. Heat can be distributed via the installation of a district heating system and electricity supplied direct to individual households or sold back to the national grid. In general, whilst retro-fitting is a possibility this technology is most effective when applied to new-build developments where the disruption and costs associated with laying a bespoke pipe network and modifying individual heating systems are more readily absorbed.

Timescales:

Installation is likely to be complete in a matter of days, subject to obtaining necessary planning approval. Typically, woodchip and pellet boilers have a life expectancy of about 20 years.

[67] http://www.planningportal.gov.uk/permission/commonprojects/biomass/

[68] Further information on regulation and the location of smokeless zones can be found here:
http://www.biomassenergycentre.org.uk/portal/page?_pageid=77,20950&_dad=portal&_schema=PORTAL
http://smokecontrol.defra.gov.uk/locations.php

Action: Install an Air Source Heat Pump

Emission Source:

- Heating and Hot Water Energy

Description:

Air source heat pumps incorporate a system that absorbs heat energy from ambient external air, in the same way that a fridge extracts heat from inside its compartments. Air source heat pumps can be used to extract heat even when the temperature of external air is as low as -15 °C, and can be used to heat radiators, under-floor heating systems, warm air convectors and hot water systems.

Carbon Saving Potential:

A recent Energy Saving Trust report[69] identified a heat pump of mid-range efficiency can be expected to use only one-third the energy that an average existing gas or oil boiler requires to produce the same amount of heat. Heat pumps do require a small amount of electricity for power, which if taken from the national grid will be more carbon-intensive per kWh than gas. Taking these factors into account, and based on Government projections for grid electricity carbon factors, a heat pump installed in 2010 would produce 9% less CO_2 than an average gas boiler and 28% less than an average oil boiler, per unit of heat. Figures suggest savings may be in the region of 1,310 kg CO_2/year for an oil-based system[70] but, as ever, exact savings will vary depending on the fuel displaced and the performance of the pump.

Financial Considerations:

As the energy extracted from air typically exceeds the energy used to run a heat pump, system efficiencies often exceed 100%, and generally average 200 to 300% over a season. The system will pay for itself quickly if it's replacing an electrical or coal-fired heating system, but will be less financially rewarding for gas-fired systems. The costs for installing a typical system suitable for a detached home range from about £6,000 to £10,000 including installation. Running costs will vary depending on a number of factors - including the size of the property and how well insulated it is. Combining installation with other building work can reduce the cost.

The Energy Saving Trust recently undertook a series of field trials with air source heat pumps to evaluate their performance and gauge the savings they could achieve in real life environments.[71] In summary, the report found that using typical system efficiencies annual savings are expected to be between -£130 and £530 (depending on the fuel displaced, the performance of the pump, the heat distribution system, and hot water dependency) when replacing an existing heating system in a three bedroom semi detached home.

Generation of domestic heat by air source heat pumps is expected to be covered in the forthcoming UK Government Renewable Heat Incentive, and this mechanism should provide households with additional financial support upon its proposed launch in June 2011.

---

[69] Energy Saving Trust report: "Getting warmer: A field trial of heat pumps". Available from: http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF

[70] Assuming an annual energy consumption of 18,000 kWh (DECC) for heating and hot water, and that the pump is powered using electricity sourced from the national grid.

[71] Energy Saving Trust report: "Getting warmer: A field trial of heat pumps". Available from: http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF

Environmental Considerations:

Air source heat pumps do not directly create any combustion products, so do not emit any emissions to air, soil or water, but they do require an electricity source to run the pumping mechanism which if sourced from the national grid has associated carbon emissions. This impact could be easily reduced by ensuring energy is sourced from renewable sources (e.g. solar PV) or by subscribing to a green tariff.

The heat that the pumps extract from the air is constantly renewed, so this is not a concern. If considering the full life cycle of the system, the refrigerants present in could pose a threat to the environment through being toxic, flammable and having high global warming potentials. However, new types and blends of refrigerant with minimal negative impacts are being developed, and there are suitable means of sustainably disposing of the equipment, similar to household refrigerators.

Technical Considerations:

Air source heat pumps absorb low temperature energy from ambient air and, using a pump-based circulation system, raise it to a higher, more useful temperature using a refrigerant cycle. Heat from the air is absorbed into a fluid which is pumped through a heat exchanger in the heat pump. Low grade heat is then extracted by the refrigeration system and, after passing through the heat pump compressor, is concentrated into a higher temperature useful heat capable of heating water for the heating and hot water circuits of the house, such as radiators and under-floor heating systems. Air-based transfer can be used for warm air convector systems.

The general process is the same as in that used for fridges or air-conditioning units. In the cases of both fridges and heat pumps, additional energy is required to power the pump, and this typically requires an electricity source. However, these systems have high efficiencies and for every 1 unit of electricity used, 3-4 units of heat are produced.

There are two main types of air source heat pump system:

- Air-to-water systems distribute heat via wet central heating systems. Heat pumps work much more efficiently at a lower temperature compared to standard boilers. So they're more suitable for use with under-floor heating systems or larger radiators, which expel heat at lower temperatures over longer periods of time.
- Air-to-air systems, which produce warm air that is circulated by fans to heat homes. Such systems are unlikely to provide hot water, and internal units may be necessary in every room, which can be expensive. These installations are not common in the UK.

Most heat pump installations will be designed to produce domestic hot water at temperatures between 50 and 55°C, and higher temperatures can be achieved with the assistance of an electric immersion heater. Good practice assumes heat pumps to be correctly sized to meet the total space and water heating needs of a property.

Most air-source heat pumps are sited just outside the property. An electrically-driven fan draws air across an evaporator, cooling the air stream and supplying heat to the heat pump. Below about 7°C, ice may form on the evaporator as the air is cooled, restricting the air-flow and impairing performance. For this reason, systems always include a defrost cycle. A common defrosting method is to extract heat from the heat sink (the house or hot water tank) and re-supply it to the evaporator to melt the ice – in effect, operating the heat pump in reverse. While this is happening, not only is heat being taken from the house, but no heat is being sent to the house, which may temporarily lower the heat pump's performance.

Controls regulate the temperature of the air in the building by adjusting the mix of re-circulated and fresh air or by modulating the output of a conventional heater. When heat is not required, as in summer months, a damper can be used to provide cooling. The system also provides a measure of insulation, recuperating heat lost through walls.

Unlike gas or oil boilers, heat pumps deliver heat at lower temperatures over much longer periods. This means that during the winter they may need to be left on 24/7 to heat homes efficiently. It also means that radiators should never feel as hot to the touch as they would do when using a gas or oil boiler.

Planning & Political Considerations:

Air source heat pumps work best when producing heat at a lower temperature than traditional boilers. Therefore, it is essential that properties are well insulated and effectively draught proofed for the heating system to be effective, and that the size of the heat pump is appropriately considered to ensure the correct heating load is provided. Air source heat pumps generally perform better when combined with under-floor heating systems or warm air heating, rather than radiator-based systems, because of the lower water temperatures required.

Domestic installations require a place outside the property where an air extractor fan unit can be fitted to a wall or placed on the ground. The unit requires plenty of space around it in order to get a good flow of air. Ideally, a sunny position is chosen. A typical external heat pump unit measures approximately 80cm high x 130cm wide x 35cm deep. They also need an unobstructed area around the unit for air flow and access, measuring around 200cm wide and 195cm deep. The main considerations in choosing an air source heat pump are the amount of space available and proximity to neighbouring properties For flats or apartments, units could be installed on an external wall or balcony providing the relevant permission is obtained.

Air-source heat pumps have to comply with building regulations, and their installation currently requires planning permission, so proprietors will need to contact the Local Authority[72]. Households are advised to use installers that are certified under the Micro-generation Certification Scheme (MCS)[73] to authenticate systems, and ensure they fit the criteria required from initiatives such as the forthcoming Renewable Heat Incentive.

Air source heat pumps are generally easier to install than ground source heat pumps, but efficiencies tend to be lower as the soil offers a greater thermal resistivity and conductivity than air.

Social Considerations:

Minimal visual and transport related disturbance should be expected as external fuel deliveries are not required, and apart from the initial installation, there is likely to be little impact from the technology on a day-to-day basis. However, there may be possible background noise from the use of the outdoor fan at night.

Timescales:

Air source heat pumps are relatively robust systems that require little maintenance over their projected 20-25 year lifespan, and are generally regarded as "fit and forget" technologies.

---

[72] In 2010 the Government issued a consultation on proposals for removing this requirement and extending permitted development rights to air-source heat pumps.

[73] MCS certificates micro-generation technologies used to produce electricity and heat from renewable sources. Further details can be found here: http://www.microgenerationcertification.org/

Action: Install Solar Water Heating (Solar Thermal)

Emission Source:

- Heating and Hot Water Energy

Description:

Solar water heating systems utilise solar radiation and convert it to useful heat energy in the form of hot water. Solar thermal is a mature and recognised technology, with systems available in the UK for the past 40 years. There is a large choice of equipment to suit a wide range of applications, and depending on the type of solar collector used, the weather conditions, and the hot water demand, the temperature of the water heated can vary from tepid to nearly boiling.

Carbon Saving Potential:

Carbon savings from solar thermal are estimated to be between 250 and 570 kg CO_2 per year, depending on the type of fuel being replaced[74].

Financial Considerations:

A domestic solar water heating system, with installation, costs in the region of £4,800. The financial savings to be made are fairly moderate, with water heating costs likely to be reduced by between £50 and £85 a year.

Generation of domestic heat by solar thermal is expected to be covered in the forthcoming Renewable Heat Incentive, and this mechanism should provide households with additional financial support upon its proposed launch in June 2011.

A large demand for hot water helps reduce the relative importance of fixed costs, as do factors such as: high costs and unreliable supplies for conventional energy. Maintenance costs are typically low due to the robustness of the technology, and most solar water heating systems come with a 5-10 year warranty.

Environmental Considerations:

Solar electricity is a green, renewable energy source and its generation does not consume scarce resources nor does it release carbon dioxide or other atmospheric pollutants during use. Typically, the greatest risk to the environment associated with photovoltaic devices relates to their manufacture, rather than their installation and use.

Solar panels don't require direct sunlight to work, but they do require a surface such as a roof or wall that faces within 90 degrees of south, and they need to be positioned so that they aren't overshadowed by any trees or neighbouring buildings.

Maps[75] highlighting the total average solar irradiation falling on a one square metre surface on the horizontal, measured in kilo-watt hours (kWh) identify that the sun's rays falling on the ground surface in East Anglia are approximately 1,100 kWh m^2. By tilting a surface to an angle the amount of solar radiation falling on it will be greater than that falling on a flat surface, in this country. Fortunately, the average tilt of a UK house roof is about the optimum for receiving solar energy. To help identify the most suitable sites for installation it would be beneficial for proprietors to use a pyranometer to monitor the average solar irradiance at proposed sites.

[74] As sourced from the Energy Savings Trust and assuming a property utilises a 3.4m^2 panel.
[75] For example: http://www.solar-trade.org.uk/solarHeating.cfm

Technical Considerations:

A domestic solar water heating system comprises three main components: solar panels; hot water cylinder; and a liquid handling system. The liquid handling unit typically includes a pump to circulate fluid from the collector panels to the storage tank and control and safety equipment. When properly designed, solar water heaters can work when the outside temperature is well below freezing and they are also protected from overheating on hot, sunny days.

There are two main types of solar water heating panels; these are evacuated tubes and flat plate collectors. Flat plate collectors can be fixed on the roof tiles or integrated into the roof have an efficiency of around 30% and are cheaper to install. Evacuated tube systems occupy a smaller area, have an efficiency of approximately 40%, but are generally more expensive. In both types, radiation from the sun is collected by an absorber, and transferred as heat to a fluid, which may be either water, or a special fluid employed to convey energy to the domestic system using a heat exchanger.

Solar thermal can provide almost all domestic hot water during the summer months, and a well-designed system should provide 50–60% of annual domestic hot water requirements, with most of this energy capture being between May and September. The remaining demand being met by conventional heating sources (e.g. an electric immersion heater), which either raises the temperature of the water further or provides hot water when the solar system cannot meet demand (e.g. at night).

Solar systems can be used wherever moderately hot water is required, and off-the-shelf packages are typically available for domestic usage. The solar collector area depends upon the loads, the type of system installed, and the collector. An accredited installer[76] is recommended to assess individual properties and discuss the best configuration to meet household needs. This includes ensuring that the solar system is efficiently integrated with any auxiliary water heating sources to gain the greatest benefit.

Planning & Political Considerations:

Solar panels are not light in weight, and so roofs must be strong enough to take their weight, especially if the panel is placed on top of existing tiles. However, panels don't always have to be mounted on a roof; they can be fixed to a freestanding frame or mounted to the side of buildings. All installation work will need to comply with the relevant building regulations.

For best performance, at least 5m^2 of roof space is required and solar water heating collectors need to be inclined at an angle of 30-40 degrees (depending on the latitude) and orientated to face due south. In practical terms, this is not always possible on existing buildings, and some degree of flexibility in inclination and orientation is acceptable, although this will be at the expense of best performance. To function satisfactorily, collectors can be inclined at between 10 and 60 degrees, and orientated to within 90 degrees of due south (i.e. facing from east to west). For example, (if enough space prevails) two solar panels could be installed – one facing east and the other facing west, although this would make installation more costly. However orientated, it is important to ensure that the solar panels will not be shaded by other buildings or trees for the main part of the day.

Most conventional boilers and hot water cylinder systems are compatible with solar water heating; however, if a dedicated solar cylinder is not already installed then the existing cylinder will need to be replaced with a dual coil one or a dedicated cylinder with a solar heating coil added. Combination boilers don't utilise hot water tanks, and

[76] The solar trade provides details of UK solar thermal installers: http://www.solar-trade.org.uk/

thus are not generally compatible with solar hot water system. A typical hot water cylinder for solar water heating system measures 1m high with a diameter of 40 - 70cm. The water cylinder can be located anywhere within a property where there is adequate space (e.g. an underutilised airing cupboard).

In England most solar water heating installations don't require planning permission, as fixing solar panels to the roof of a single dwelling house is generally considered "permitted development". Nonetheless, there are important exceptions, provisos and conditions that must be observed, and permitted development rights only apply to houses. Thus, other property types are advised to contact the local planning authority for guidance. As in most cases, a planning application will likely be required if a property is a listed building, or located in a conservation area. The UK Planning Portal provides a detailed overview of the conditions associated with the installation of solar thermal.[77]

Social Considerations:

Solar hot water systems are particularly well suited in residential areas as they are silent in operation and release no emissions or atmospheric pollutants, and solar energy is freely and virtually infinitely available. They are also associated with minimal visual impact – domestic solar collectors rarely project more than 120mm above the existing roofline and connecting pipework normally runs from the back of the collector directly through to the roof void, so is not normally visible from the exterior of the building. Solar thermal has already proved to be a successful option for local residents who participated in the recent WESG bulk-purchase initiative.

Timescales:

Domestic installation is likely to be complete within a couple of months, and solar systems have a life expectancy of more than 20 years and are usually supplied with a 10 year manufacturer's warranty. Panels should be checked by the user every year and inspected more thoroughly by an accredited installer every 3-5 years.

[77] http://www.planningportal.gov.uk/permission/commonprojects/solarpanels/

Action: Incorporate Passive Solar Design

Emission Source:

- Heating and Hot Water Energy

Description:

Passive solar design is the selective and efficient use of solar radiation energy to provide space heating and lighting in buildings by using properly oriented, high-performance windows, and selected building materials to optimise the collection and storage of heat from solar radiation during the winter and to reject solar heat in the summer. It is termed passive as, unlike active solar technologies (solar PV or solar thermal), it doesn't involve the use of mechanical and electrical devices.

Carbon Saving Potential:

A building employing passive solar design is able to maintain a comfortable interior temperature year round, and in modern housing up to 20–25% of heating and lighting energy can be saved by the application of passive solar design principles[78]. This suggests that for an oil-fired heating system, carbon savings could be between 1,108 and 1,385 kg CO_2 per year[79].

Financial Considerations:

Passive solar heating is most cost effective for new-build construction or during major renovation since at this stage many good design practices can be implemented at little or no additional cost compared to conventional design.

It is estimated that in modern housing heating and lighting energy demands could be reduced by between 20 and 25% by applying of passive solar design principles[80], which suggests annual savings in the region of £236 to £295[81].

Environmental Considerations:

Virtually all buildings enjoy free energy and light from the sun; the objective in passive solar systems is to maximise this benefit by using simple design approaches which intentionally enable buildings to function more effectively and provide a comfortable environment for living and/or working. Passive solar systems tend to be environmental benign as they do not result in any direct impacts, but rather help to reduce those which would inevitably arise as a consequence of the occupation and use of a property (e.g. energy demands).

Technical Considerations:

The key to designing passive solar buildings is to accommodate prevalent conditions of the local climate and adapt elements, such as window placement and glazing type, thermal insulation, thermal mass and shading, to maximise solar gain. Passive solar design is most easily applied to new buildings or major refurbishments, where the orientation of the building, the size and position of the glazed areas, the density of

[78] http://www.communities.gov.uk/documents/planningandbuilding/pdf/147447.pdf

[79] Assuming an oil-fired heating system is replaced, and the initial annual consumption was reduced from 18,000 kWh (UK average annual consumption for heating and hot water, (DECC)).

[80] http://www.communities.gov.uk/documents/planningandbuilding/pdf/147447.pdf

[81] Assuming reductions are against domestic UK standards of 18,000 kWh for heating and hot water and 3,300 kWh for electricity (DECC), and calculated using average UK energy prices for 2009 – see link: http://www.decc.gov.uk/assets/decc/statistics/publications/trends/articles_issue/1_20100324125048_e_@@_variationtarifftypes.pdf

buildings within an area, and materials used for the remainder of the structure and shading can be readily incorporated into the design brief. Careful arrangement of room layouts completes passive solar design, with a common recommendation for residential dwellings being to place living areas facing solar noon and sleeping quarters on the opposite side.

The primary element in passive solar heating systems are glass windows, which have the beneficial property of transmitting solar radiation - allowing light energy from the sun to enter a building and warm the interior spaces, but restricting the transmission of thermal radiation back outdoors. Recent improvements to commercial window technologies have facilitated passive solar heating by reducing the rate of heat escape, while still admitting much of the incident solar radiation. This design is particularly useful for supplying heating energy during colder winter months.

Annual heating demand can be significantly reduced by selecting high-performance windows (low heat loss and high solar transmission) and by orienting the window area to face towards the equator (south-facing in the Northern Hemisphere). Studies have shown that houses designed using passive solar principles can require less than half the heating energy of the same house using conventional windows with random window orientation. Passive solar designs can also provide a better use of natural daylight for lighting purposes, not to mention a more pleasant living environment. In addition, the proper selection of shading devices (e.g. awnings, trees) can result in reduced cooling loads during hot summer months.

As sunshine is not a constant and is variable with regards to strength and duration, heating energy is variable. Therefore, the design would benefit from including some sort of heat storage method and consideration of the thermal mass of the building. For example, heavy materials such as stone or concrete can be used to store heat inside the building during the day, releasing it slowly overnight.

Planning & Political Considerations:

Passive solar design must form part of an overall approach towards reducing the need for conventional energy sources in providing heating, light and ventilation. Thus, it should always be used in conjunction with other low energy and efficiency measures. Passive solar design does not require any other consent beyond planning control. It is, however, relevant to the application of the Building Regulations

Passive solar technology can only really be considered at the design stage – as the larger the window, the greater the amount of sunlight that can enter the building. However, as windows are not as thermally insulating as walls, careful consideration is required during the planning stage to ensure that the passive solar design optimises window surface area, orientation and thermal properties to increase the energy input from the sun and minimise heat losses to the outside, whilst optimising occupant comfort.

Application of passive solar design will always be constrained to an extent by building and location specific factors. At present the most significant barriers to its widespread application are lack of familiarity and a perception that its use will inevitably produce buildings that are unconventional in appearance and difficult to market. This should all but disappear once this approach is adopted into use in mainstream housing development.

There are currently no regulations dictating passive solar design within normal development control policy governing the layout, positioning and appearance of buildings. Typically, such guidelines seek to ensure residential buildings, in particular, enjoy adequate natural light and privacy. Going beyond this to require consideration of solar heat and light capture has not been regarded as a normal planning matter. Where planning authorities have sought to apply passive solar design principles this has been done in the past by using Supplementary Planning Guidance, possibly with a reference in the local plan or Unitary Development Plan.

The UK Planning Policy Statement 22 (PPS22)[82] now specifically includes passive solar design in its list of renewable energy technologies to consider in the preparation of development plan policies, and helps deal with any past uncertainty about its status by making it a normal planning matter. It also recommends a checklist of actions to consider when preparing a planning application and include issues relating to: location and layout; land form and landscaping; and design and fenestration.

Social Considerations:

The deliberate use of sunlight transmitted through windows to provide warmth in winter is a mature concept, and many properties can achieve reductions in heating expense without obvious changes to their appearance or usability. In the planning stages, especially for retrofit buildings, consideration is required on the placement and orientation of elements, such as windows, in order to strike a balance between enhancing solar gain and maintaining adequate privacy. However, in general well designed passive solar buildings capitalise on the availability of natural light and warmth, which helps improve user thermal comfort and well being.

Passive solar design is most effective and more economic when utilised in new-build construction, and would be of most benefit to the community in the development of any new properties or community buildings in the village.

Timescales:

The usual timescales for planning applications will apply for household modifications, and/or for the establishment of new developments. Once installed however, passive solar design is essentially permanent and benefits will accrue for the remainder of the time that the particular building is in use/occupied.

[82] A companion guide to PPS22 can be found at: http://www.communities.gov.uk/documents/planningandbuilding/pdf/147447.pdf

Action: Install a Ground Source Heat Pump

Emission Source:

- Heating and Hot Water Energy

Description:

Ground-source heat pumps provide low temperature heating by extracting heat from the ground via a network of buried pipes and pumping it through a refrigeration cycle that allows heat to a be delivered within a property. The two most common types are known as horizontal (or trenched) ground loops and vertical borehole loops. Its principal application is space heating via radiators or under-floor heating systems, though many also supply domestic hot water.

Carbon Saving Potential:

A recent Energy Saving Trust report[83] identified a heat pump of mid-range efficiency can be expected to use only one-third the energy that an average existing gas or oil boiler requires to produce the same amount of heat. Heat pumps do require a small amount of electricity for power, which if taken from the national grid will be more carbon-intensive per kWh than gas. Taking these factors into account, and based on Government projections for grid electricity carbon factors, a heat pump installed in 2010 would produce 9% less CO_2 than an average gas boiler and 28% less than an average oil boiler, per unit of heat. Figures suggest savings may be in the region of 1,310 kg CO_2/year for an oil-based system[84] but, as ever, figures will vary depending on the fuel displaced and the performance of the pump.

Financial Considerations:

As the energy extracted from the ground typically exceeds the energy used to run a heat pump, system efficiencies often exceed 100%, and generally average 200 to 500% over a season. Due to the more stable temperature of the ground, these systems are generally more efficient than air-source heat pumps.

The installation cost is generally double that of conventional central heating systems in residential applications. However, ground source heat pumps attract lower life-cycle costs due to their very high efficiencies and low maintenance requirements. Costs for professional installation range from about £800 to £1,400 per kW of peak heat output, excluding the cost of the distribution system. Trench systems are cheaper so tend to be at the lower end of this range, and the price per kW gets lower as the systems get larger. The installed cost of a typical 8kW system is likely to vary between £8,000 and£12,000 plus the cost of the distribution system[85].

Heat pumps typically incur lower maintenance costs than conventional heating systems, and running costs will depend on a number of factors - including the size of the property and how well insulated it is, and annual savings will vary with respect to: fuel displaced, the performance of the pump, the heat distribution system, and hot water dependency. The Energy Saving Trust recently undertook a series of field trials with ground source heat pumps to evaluate their performance and gauge the likely savings achievable in real life environments.[86] In summary, the report found that using

[83] Energy Saving Trust report: "Getting warmer: A field trial of heat pumps". Available from: http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF

[84]Assuming an annual energy consumption of 18,000 kWh (DECC) for heating and hot water, and that the pump is powered using electricity sourced from the national grid.

[85] Costs are dependent on property and location so will vary between properties.

[86] Energy Saving Trust report: "Getting warmer: A field trial of heat pumps". Available from:

typical system efficiencies annual savings are expected to be between £40 and £530[87].

Generation of domestic heat by ground source heat pumps is expected to be covered in the forthcoming UK Government Renewable Heat Incentive, and this mechanism should provide households with additional financial support upon its proposed launch in June 2011.

Environmental Considerations:

Ground source heat pumps do not create any direct combustion products so do not emit any emissions to air or water, but they do require an electricity source to run the pumping mechanism, which if sourced from the national grid has associated carbon emissions. This impact could be easily reduced by ensuring energy is sourced from renewable sources (e.g. solar PV) or by subscribing to a green tariff.

Efficiencies routinely average 200 to 500% over a season, and these systems tend to be more efficient than air-source heat pumps as well as conventional heating and air-conditioning technologies. Peak electricity consumption during cooling season is lower than with conventional air-conditioning, so utility demand charges may be also reduced. The heat that the pumps extract from the ground is constantly renewed, so this is not a concern. If considering the full life cycle of the system, the refrigerants present in could pose a threat to the environment through being toxic, flammable and having high global warming potentials. However, new types and blends of refrigerant with minimal impacts are being developed, and there are suitable means of sustainably disposing of the equipment, similar to household refrigerators.

Technical Considerations:

Due to its high thermal mass, the ground in the UK keeps a constant temperature of about 11-12°C throughout the year. Ground source heat pumps work by transferring this residual solar heat from the ground into a building to provide space heating and, in some cases, domestic hot water.

Ground source heat pumps operate in a similar way to a refrigerator or conventional air conditioning system in that they rely on an external source of energy- typically electricity - to concentrate the heat and pump it to where it's required. Lengths of pipe are buried in the ground, and the heat pump uses compression and expansion of a refrigerant (a mixture of water and antifreeze) to drive heat flows between the inside of the building and the earth connection. The heat pump (via an evaporator, a compressor and a condenser) transfers the heat to a hot water tank, which feeds the heating distribution system. At certain times of the year, the ground temperature will be such that heat would flow in the desired direction anyway. The heat pump may still need to operate, however, in order to ensure that the rate of heat flow is sufficient.

A ground source heat pump system comprises three major components: the earth connection, a heat pump, and the heating distribution system. The earth connection is where heat transfer occurs and typically comprises tubing buried in horizontal trenches or vertical boreholes. An antifreeze mixture is circulated from the heat pump, through the tubing, and back to the heat pump in a "closed circuit." The heat distribution system consists of under-floor heating or radiators for space heating and in some cases water storage for hot water supply. A heat pump can be designed to meet 100% of space heating requirements but it will usually only pre-heat domestic hot water so top up heating (e.g. an electric immersion heater) will be required.

Typically, each kilowatt (kW) of electricity used to operate a heat pump results in

http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF

[87] Assuming replacement of an existing heating system in a three bedroom semi detached home.

more than 3 kW of renewable heat generated from the ground. Heat pumps typically range from 3.5 to 35 kW in capacity and a single unit is generally sufficient for a house or a small commercial building. Good practice assumes heat pumps sized will be correctly sized to meet the total space and water heating needs of a property.Unlike gas or oil boilers, heat pumps deliver heat at lower temperatures over much longer periods. This means that during the winter they may need to be left on 24/7 to heat homes efficiently. It also means that radiators should never feel as hot to the touch as they would do when using a gas or oil based heating system. The lower the distribution temperature in the heating system, the higher the efficiency of the heat pump. Heat pumps are therefore best suited for use with low temperature heating systems, such as under-floor heating.

Planning & Political Considerations:

Ground source heat pumps work best when producing heat at a lower temperature than traditional boilers. Therefore, it is essential that properties are well insulated and effectively draught proofed for the heating system to be effective. Also, it should be noted that ground source heat pumps generally perform better when combined with under-floor heating systems than radiator-based systems because of the lower water temperatures required. A typical domestic pump unit measures approximately 170cm high x 60cm wide x 60cm deep. Smaller systems can incorporate a hot water tank within the unit. Larger homes (5 or more bedrooms) will likely require a separate hot water tank in addition to the heat pump unit.

Although the land area required doesn't have to be particularly large, the ground needs to be suitable for digging a trench or a borehole and accessible to digging machinery. The length of ground loop required depends on the size of property and the household heat demand - longer loops can draw more heat from the ground, but ultimately require more space to be buried in. Approximately 200m^2 of trench would be needed for a horizontal ground loop, or 100m^2 of trench for a coiled slinky for a typical domestic installation. Vertical ground loops can be inserted in U-tubes into boreholes that are anything from 15 to 120m deep. Approximately 80 to 120m of borehole would be needed for a typical domestic system. Assuming boreholes of 30m depth, a typical house would need a land area of around 10m x 12m to dig the boreholes.

Ground source heat pumps will have to comply with building regulations, but their installation does not usually require planning permission as it should fall within "permitted development". However, if the property is a listed building or located a conservation area, the local authority will need to be contacted to check policy. Households are advised to use installers that are certified under the Microgeneration Certification Scheme (MCS)[88] in order to authenticate systems, and ensure they fit the criteria required from initiatives, such as the forthcoming Renewable Heat Incentive.

Social Considerations:

Minimal visual and transport related disturbance should be expected as external fuel deliveries are not required, and apart from the initial installation, there is little impact from the technology on a day-to-day basis.

Timescales:

Heat pumps are relatively robust, require little maintenance and are generally regarded as "fit and forget" technologies. The ground collector should have a life span of at least 50 years.

[88] MCS certificates micro-generation technologies used to produce electricity and heat from renewable sources. Further details can be found here: http://www.microgenerationcertification.org/

Action: Utilise Bio-fuels for Heating

Emission Source:

- Heating and Hot Water Energy

Description:

Despite extensive use in transport, bio-fuels have not, until recently, been considered for heating application. This is despite the fact that more than 1.7 million households in the UK and Ireland currently use oil (e.g. kerosene) for home heating, hot water and/or cooking.

Bio-fuels are renewable liquid fuels that have potential for application in domestic properties as an alternative to fossil fuels. Manufactured using a simple chemical process from a wide variety of natural growing materials, such rape seed oil, palm oil, and used cooking (vegetable) oil, they combust in the same way as traditional fossil fuel oils. The Oil Firing Technical Association (OFTEC)[89] recently tested heating bio-fuels that were blend of either 30% or 50% of cooking oil with kerosene.

Carbon Saving Potential:

Bio-fuels derived using best practice are generally considered carbon neutral as the carbon absorbed by the plant during its growth is offset by the carbon emitted during the combustion of the bio-fuel. However, some net emissions still as a result of indirect activities, such as cultivation, harvesting, processing and transportation of the fuel, which typically consume fossil fuels and have associated CO_2 emissions. Bio-fuels produced from used cooking oil typically generate the greatest carbon savings as they effectively utilise a waste product and thus minimise emissions from its disposal.

At present, bio-fuels are typically blended with conventional fossil fuels, with the most promising blend consisting of a mix of 30% cooking oil and 70% kerosene. Thus, until pure bio-oils can be utilised in the domestic setting without excessive cost and disruption, CO_2 will still be emitted. OFTEC has reported that the bio-fuel blend consisting of 30% cooking oil and 70% kerosene (B30K) has a carbon emission factor of 0.205 kg CO_2/kWh[90], which is about two-thirds of that reported for 100% kerosene. Thus, use of B30K is likely to reduce annual emissions by approximately 1,852 kg CO_2 [91]

Financial Considerations:

OFTEC estimate the cost of converting an existing oil-fired appliance to use the new bio-fuel blend to be as low as £250.00, but that in most domestic installations a new oil tank will be required increasing the total conversion cost to around £2,000[92]. The cost of bio-fuel blends is dependent upon the price of the principal fossil fuel component. Thus, until pure bio-oils can be utilised in the domestic setting, users should note that pricing and availability of bio-fuels will still be liable to some of the same fluctuations seen for conventional fossil fuels, and they may even find the price per litre increases slightly to account for localised blending and distribution.

Generation of domestic heat by bio-liquids (and bio-gas) is expected to be covered in the forthcoming UK Government Renewable Heat Incentive, and this mechanism should provide households with additional financial support upon its proposed launch in June 2011.

---

[89] http://www.oftec.org/index.htm
[90] Sourced from: http://www.ecofriendnews.com/environmental_article9820.html
[91] Assuming an annual energy consumption of 18,000 kWh (DECC) for heating and hot water.
[92] 92 Sourced from: http://www.ecofriendnews.com/environmental_article9820.html

Environmental Considerations:

Although waste oils can be used, if crops are purpose-grown for their oils or alcohol products, the agricultural practices leading to their production must be sustainable in order to be considered truly renewable.

Technical Considerations:

At present, the market for bio-fuel is geared towards transport and road diesel, with the target for all UK forecourts in 2009/10 being to provide at least 3.25% (by volume) of all transport fuels from renewable sources, as directed under the "Renewable Transport Fuel Obligation". The properties and characteristics of bio-fuels and bio-fuels blends are very different compared to kerosene used for domestic heating; thus different materials or devices are typically required. Further, domestic heating fuel is typically stored for longer periods than transport fuels resulting in additional handling and storage issues.

In general, bio-fuels are thicker and heavier and have different energy contents relative to liquid fossil fuels. They also interact differently with standard fuel tank materials – for example, the rubber in fuel pumps and filter seals is not compatible with bio-fuels, and vaporising burners traditionally used for heating and cooking ranges are not currently able to run on pure bio-fuels. These are important factors to consider as it means that to change from anything other than a 100% fossil fuel typically requires conversion and re-commissioning of installations and equipment. Heating conversion would commonly require at least the replacement of: Atomising nozzles; fuel pumps; flexible oil lines; filters and/or filter seals. However, it may be necessary to obtain a bio-liquid compatible burner.

Bio-fuels are hydroscopic (they absorb water) and should never be introduced to oil storage and supply systems that are contaminated. Contaminated systems should be cleaned before application of bio-fuels otherwise the system will inevitably encounter blocked filters and inoperable systems due to the greater viscosity of the liquids. Bio-fuels should never be introduced to existing oil storage installations that do not have secondary containment as the "cleaning effect" of the fuel may well find weaknesses in existing tanks, which could lead to leaks. It is recommended that wherever possible new integrally bunded oil storage tanks suitable for bio-fuels are installed. To help prevent long-term storage stagnation it is recommended that smaller tanks are utilised based upon half yearly usage. For bespoke installations where 100% bio-fuel is being used, consideration will need to be made to the use of heated and insulated (and possibly agitated) fuel storage tanks, as well as trace heated and insulated supply lines.

OFTEC recently initiated a project in which it drafted industry blend standards (30% and 50% blends of cooking oil with kerosene) and subjected them to intensive trials, in which over 30 oil-fired appliances were tested over a 12 month period to determine reliability. The project aimed to demonstrate that renewable fuel options could be available to customers without the expense of upgrading or replacing equipment as is currently necessary. The study has been hailed as a success and it has been reported that the bio-fuel consisting of a blend of 30% cooking oil with 70% kerosene (B30K) has been accepted as eligible for the forthcoming renewable heat incentive.

Planning & Political Considerations:

In theory, the use of bio-fuel blends for heating would require limited disruption to existing oil-fired heating systems. However, further investigation is required reagrding storage issues. There may be potential for Wenhaston residents to take part in future trials, and this could be followed up if enough support is gained from residents.

Once data is available, additional support will be required from Government and politicians to introduce the use of bio-fuels for heating across the UK, as the extent of its application depends heavily on Government policy.

Social Considerations:

For existing oil-fired heating systems there is expected to be minimal social impacts of switching to a bio-fuel blend as the majority of technology is already in place – it will likely just require a few modifications. The use of bio-fuels could be socially rewarding if the community were able to participate in any trials and/or if a community scheme was developed that promoted the bulk purchase of modified tanks (or components thereof) and bio-fuels to reduce transport related emissions and associated costs.

Depending on the results of the trial data, residents may benefit from a community-wide venture to promote the findings and to bring users up to speed on any different properties associated with its use and storage.

Timescales:

Trials are still ongoing and UK policy will need to be developed, therefore it is likely that full UK adoption to bio-fuels for heating is still several years away. In terms of time taken for installation, it is envisaged that it would take a matter of days to have the correct system and fuels in place to utilise renewable heating fuels.