Anderson Goddard Ltd
Independent Energy Consultants
Established 1985

Thurnscoe

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10% embedded LZC feasibility study and assessment provided by Anderson Goddard Ltd

For

The development at Thurnscoe, Barnsley, South Yorkshire.

By

Keepmoat Homes

Index

1. Introduction

Anderson Goddard Ltd have been commissioned to assess available LZC technologies which are capable of providing a reduction in CO_2 emissions of 10% for the development at the development at Thurnscoe, Barnsley, South Yorkshire

The following will also be considered.

- Energy generated from the LZC technology
- Payback
- Land use
- Local planning requirements
- Noise
- Whole life costs and lifecycle impact of the potential specification in terms of carbon emissions
- Any available grants
- All technologies appropriate to the site and energy demand of the development
- Reasons for excluding other technologies

The calculations and methodology used in this study have been taken from the October 2008 version of Code for Sustainable Homes CSH, ENE7 feasibility study and LZC technology assessments, both SAP and Table 1 assessments have been used to show the benefits provided by the proposed Low or Zero Carbon (LZC) technology and a comparison made against a standard case natural gas energy model following technical guidelines from the Code for Sustainable Homes (CSH) May 2009.

1.1 Embedded renewable technology

An embedded Low or Zero Carbon technology (LZC) is a technology recognised by the Department for Business Enterprise and Reform (BERR) under the Low Carbon Buildings Programme (LCBP) and which is capable of providing a total reduction in CO_2 emissions which included emissions from heating, lighting, cooking and household appliances.
A SAP calculation (The Governments Standard Assessment Procedure for calculating the energy performance of a dwelling) calculates the CO_2 produced from heating and lighting and takes no account of the CO_2 emissions from cooking and appliances therefore a Table 1 assessments from ENE7 are used to assess the total CO_2 emissions from cooking and appliances.
Table 1 is then used to compare the total benefit and CO2 reduction of the chosen LZC technology against a Standard case energy model.

1.2 Future proofing the "Building envelope"

Future retro improvements made to a buildings fabric are expensive, disruptive and most of the time impractical and therefore the thermal qualities of the building fabric must be one of the main considerations for the longevity of the dwelling and overall long term CO_2 reduction.

Reducing the CO_2 of the development by increasing the fabric specification provides the development with a high degree of longevity, by limiting the heat losses across the building envelope over the dwellings lifetime. In my opinion this approach will have the most significant long term effect on CO_2 reduction as the envelope is unlikely to be radically altered during its lifetime.

It would be easier and more cost effective in the long term to retrofit LZC technology to a well constructed well insulated dwelling that has been pre prepared for such technology than to try and increase the fabric U-Values of an existing dwelling.

LZC technology should not be used to compensate for a poor building specification although there would be a tendency for a developer to adopt this approach because of financial constraints and current financial market conditions and which such an approach could satisfy both 10% planning conditions and building regulations. Developers should be encouraged to build to high thermal standards and adopt modern building practices; the 10% planning policy does not address this fundamental issue.

1.3 Planning condition

The 10% planning condition original devised by Merton and Croydon generally referred to as the Merton rule, POL4 from eco homes, and Energy 7 (ENE7) from the Code for Sustainable Homes (CSH), were all introduced and intended to promote the use and development of Low or Zero Carbon (LZC) technologies. Ironically to satisfy these requirements the chosen technology must be included on the BERR list of approved LZC technologies, this requirement will undoubtedly have a major impact on the development of new innovative technologies which are not classified as LZC technologies yet produce deep cuts in carbon emissions.

The 10% planning policy by itself could be detrimental to the long term reduction in CO_2 emissions because of the reasons out lined in section 1.2 of this study, Croydon, Merton and some other planning authorities generally insist that developments are also assessed against the Code for Sustainable Homes (CSH) which provides a complete holistic sustainability assessment.

Planning and sustainability officers generally accept the previously mentioned concerns and may except alternative solutions with the objective of achieving long term CO_2 reduction, they may also accept the use of innovative technologies providing the proposed solution is not intended purely for economic reasons.
An assessment could be provided for an alternative approach to long term CO_2 reduction which would initially address the issues mentioned in section 1.2 of this report and then consider the effect of all technologies including LZC technologies should the Planning and Sustainability Officer accept these concerns.

2. The development

The residential development at Thurnscoe will comprises a total of 810 dwellings with an approximate Total Gross Internal Floor Area (TGIFA) of 64168.20m^2 of which 178 dwelling are to be rated against the Code for Sustainable Homes (CSH) level 3.

2.1 Housing mix

Information relating to the specific housing mix on the development was unavailable at the time of this report and this section will be revised once this information becomes available.

2.2 Preliminary Fabric specification

Element	Standard Specification	CSH Level 3
External Walls	0.30 W/m²K	0.23 W/m²K
Ground Floor	0.16 W/m²K	0.13 W/m²K
Roof Insulation	0.14 W/m²K	0.10 W/m²K
Windows	1.80 W/m²K	1.50 W/m²K
Doors	2.20 W/m²K	1.50 W/m²K
Y-Value	0.15	0.08
Air permeability	10m²	6m²
Low energy lighting	30%	75%

2.3 Assessment Methodology

There is currently no standard method or procedure for estimating the total carbon emissions for developments or comparing carbon savings provided by different LZC technologies although the most common accepted methods are as follows.

- The London tool kit 2004
- Carbon Mixer
- Code for Sustainable Homes, Energy 7 (CSH ENE7)

The London Tool kit 2004 provides an estimate of CO_2 emissions and is considered by most Planning Authorities to be out dated.

The Code for Sustainable Homes methodology is the most recent and accurate way of assessing the benefit provided by different LZC technologies and is approved and updated biannually by Government and therefore the calculations and methodology used in this study have been taken from the May 2009 version of Code for Sustainable Homes Energy 7 (CSH ENE7), both SAP and Table 1 assessments have been used to show the benefits provided by the proposed Low or Zero Carbon (LZC) technologies and a comparison made against a standard case natural gas energy model following technical guidelines from the Code for Sustainable Homes (CSH) revised May 2009.

An assessment of an average dwelling type in worse case detachment including worse case orientation has been used to estimate the total carbon emissions for the development and provide a comparison of each LZC technology assessed.

3. LZC Technology Overview

The following Low or Zero Carbon technologies are commercially available for use in the UK housing sector; the following overview will give a brief description of each technology which will provide a better understanding of how each technology works and its appropriation for use, either for use in this project or for future projects.

Low or zero carbon technologies available in the UK

Zero carbon technologies

- Solar Hot Water
- Solar Photovoltaic
- Small scale hydro power
- Wind turbines

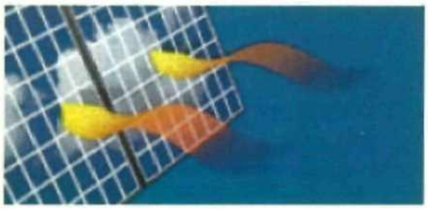
Low carbon technologies

- Biomass
- Combined Heat and Power (CHP) and micro CHP
- Community heating, including utilising waste heat from processes such as large scale power generation where the majority of heating comes from waste heat
- Heat pumps, Ground source heat pumps (GSHP) Geothermic heating systems, Air source.
- Other technologies, Fuel cells using hydrogen from any of the above renewable sources

Other innovative technologies

- Flue Gas Heat recovery systems (FGHRS)
- Shower saver waste water heat recovery

3.1 Solar water heating



Solar water heating systems use heat from the sun to work alongside conventional primary water heaters. The technology is well developed with a large choice of equipment to suit many applications.
For domestic hot water there are three main components
Solar panels or collectors - are fitted to your roof. They collect heat from the sun's radiation. There are 2 main types of collector:
Flat plate systems - which are comprised of an absorber plate with a transparent cover to collect the sun's heat, or
Evacuated tube systems - which are comprised of a row of glass tubes that each contains an absorber plate feeding into a manifold which transports the heated fluid.
A heat transfer system - uses the collected heat to heat water;
Hot water cylinder - stores the hot water that is heated during the day and supplies it for use later.

The benefits

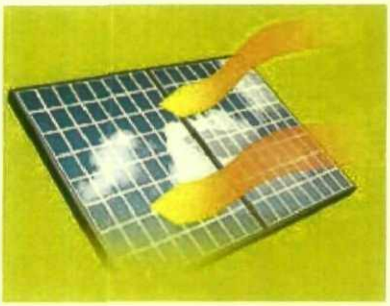
Solar water heating can provide about a third of the dwellings hot water needs. The average domestic system reduces C02 by around 325kg per year and about £50 a year of hot water bills, when installed in a gas heated home.

Fuel Displaced	£ Saving per year	CO2 saving per year
Gas	£50	325 kg
Electricity	£80	635 kg
Oil	£65	365 kg
Solid	£55	645 kg

All savings are approximate and are based on the hot water heating requirements of a 3 bed semi detached home.
Solar water heating can be used in the home or for larger applications, such as swimming pools. For a domestic system you will need 3-4 square metres of southeast to southwest facing roof receiving direct sunlight for the main part of the day, a space to locate an additional water cylinder if required.
In England, changes to permitted development rights for micro generation technologies introduced on 6th April 2008 have lifted the requirements for planning permission for most solar water heating installations. Roof mounted and stand-alone systems can now be installed in most dwellings, as long as they respect certain size criteria. Exceptions apply for Listed Buildings, and buildings in Conservation Areas and World Heritage Sites.
In Wales, Scotland and Northern Ireland, the devolved governments are currently all considering changes to their legislation on permitted developments, to facilitate installations of micro generation technologies, including solar water heating. Legislation is expected in all three countries later this year. Until then, householders in Wales, Scotland and Northern Ireland must consult with their local authority regarding planning permission.
Solar water heating systems tend to require little maintenance Installation and maintenance costs.

The typical installation cost for a domestic system is £3,000 - £5,000. Evacuated tube systems are more advanced in design than flat plate, and so tend to be more expensive.
Solar water heating systems generally come with a 5-10 year warranty and require little maintenance. A yearly check by the householder and a more detailed check by a professional installer every 3-5 years should be sufficient.

3.2 Solar Photovoltaic



Solar PV (photovoltaic) uses energy from the sun to create electricity to run appliances and lighting.
PV requires only daylight - not direct sunlight - to generate electricity.

How it works

Photovoltaic systems use cells to convert solar radiation into electricity. The PV cell consists of one or two layers of a semi conducting material, usually silicon. When light shines on the cell it creates an electric field across the layers, causing electricity to flow. The greater the intensity of the light, the greater the flow of electricity...PV systems generate no greenhouse gases, saving approximately 325kg of carbon dioxide emissions per year - adding up to about 8 tonnes over a system's lifetime - for each kilowatt peak (kWp - PV cells are referred to in terms of the amount of energy they generate in full sun light).
PV arrays now come in a variety of shapes and colours, ranging from grey '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. As well as enabling you to generate free electricity they can provide an interesting alternative to conventional roof tiles!
PV systems for a building with a roof or wall that faces within 90 degrees of south, as long as no other buildings or large trees overshadow it.
If the roof surface is in shadow for parts of the day, the output of the system decreases. Solar panels are not light and the roof must be strong enough to take their weight, especially if the panel is placed on top of existing tiles. Solar PV installations should always be carried out by a trained and experienced installer. The area of PV required to generate 1 kw hour peak varies but generally 6-8m² for Môn crystalline or 10^2 for polycrystalline modules of PV will produce 1 Kw peak of electricity.

Cost and maintenance

Prices for PV systems vary, depending on the size of the system to be installed, type of PV cell used and the nature of the actual building on which the PV is mounted. The size of the system is dictated by the amount of electricity required. For the average domestic system, costs can be around £4,000- £9,000 per kWp installed, with most domestic systems usually between 1.5 and 2 kWp. Solar tiles cost more than conventional panels, and panels that are integrated into a roof are more expensive than those that sit on top. Grid connected systems require very little maintenance, generally limited to ensuring that the panels are kept relatively clean and that shade from trees has not become a problem.
The wiring and components of the system should however be checked regularly by a qualified technician.
Stand-alone systems, i.e. those not connected to the grid, need maintenance on other system components, such as batteries

3.3 Hydroelectricity

Hydro power systems use running water turning a turbine to produce electricity. A micro hydro plant is one that generates less than 100kW. Improvements in small turbine and generator technology mean that micro hydro schemes are an attractive means of producing electricity. Useful power may be produced from even a small stream.

Benefits

For houses with no mains connection but with access to a micro hydro site, a good hydro system can generate a steady, more reliable electricity supply than other renewable technologies at a lower cost. Total system costs can be high but often less than the cost of a grid connection and with no electricity bills to follow.
It should be noted that in off grid applications the power is used for lighting and electrical appliances. However, space and water heating can be supplied when available power exceeds demand.
Hydro power systems convert potential energy stored in water held at height to kinetic energy

How it works

Hydro power systems convert potential energy stored in water held at height to kinetic energy (or the energy used in movement) to turn a turbine to produce electricity.
Energy available in a body of water depends on the water's flow rate and the height (or head) that the water falls. These are divided into low head, medium head and high head, where the height drop is greater. The scheme's actual output will depend on how efficiently it converts the power of the water into electrical power (maximum efficiencies of over 90% are possible but for small systems 60 - 80% is more realistic).
Hydro power requires the source to be relatively close to where the power will be used or to a suitable grid connection.
Hydro systems can be connected to the main electricity grid or as a part of a standalone (off grid) power system. In a grid connected system, any electricity generated but not used can be sold to electricity companies.
In an off grid hydro system, electricity can be supplied directly to the devices powered or through a battery bank and inverter set up. A back up power system may be needed to compensate for seasonal variations in water flow.

Costs and savings

Hydro costs are very site specific and are related to energy output. For low head systems (assuming there is an existing pond or weir), costs may be in the region of £4,000 per kW installed up to about 10kW and would drop per kW for larger schemes.
For medium heads, there is a fixed cost of about £10,000 and then about £2,500 per kW up to around 10kW - so a typical 5kW domestic scheme might cost £20-£25,000. Unit costs drop for larger schemes. Maintenance costs vary but small scale hydro systems are very reliable.

3.4 Micro wind

Wind turbines use the wind's lift forces to rotate aerodynamic blades that turn a rotor which creates electricity. In the UK we have 40% of Europe's total wind energy. But it's still largely untapped and only 0.5% of our electricity requirements are currently generated by wind power.
How does it work? Most small wind turbines generate direct current (DC) electricity. Systems that are not connected to the national grid require battery storage and an inverter to convert DC electricity to AC (alternating current - mains electricity). Wind systems can also be connected to the national electricity grid. A special inverter and controller converts DC electricity to AC at a quality and standard acceptable to the grid. No battery storage is required. Any unused or excess electricity may be able to be exported to the grid and sold to the local electricity supply company.
There are two types of wind turbines:
Mast mounted - which are free standing and located near the building(s) that will be using the electricity.
Roof mounted - which can be installed on house roofs and other buildings.

Benefits

Wind power is a clean, renewable source of energy which produces no carbon dioxide emissions or waste products.
In the UK we have 40% of Europe's total wind energy
Individual turbines vary in size and power output from a few hundred watts to two or three megawatts (as a guide, a typical domestic system would be 1 - 6 kilowatts). Uses range from very small turbines supplying energy for battery charging systems (e.g. on boats or in homes), to turbines on wind farms supplying electricity to the grid.
You should consider the following issues if you're thinking about small scale wind. An accredited installer will be able to provide more detailed advice. Wind speed increases with height so it's best to have the turbine high on a mast or tower. Generally speaking the ideal site is a smooth top hill with a flat, clear exposure, free from excessive turbulence and obstructions such as large trees, houses or other buildings.
Small scale wind power is particularly suitable for remote off grid locations where conventional methods of supply are expensive or impractical. Please note that the electricity generated at any one time by a wind turbine is highly dependent on the speed and direction of the wind. The wind speed itself is dependent on a number of factors, such as location within the UK, height of the turbine above ground level and nearby obstructions. Ideally, you should undertake a professional assessment of the local wind speed for a full year at the exact location where you plan to install a turbine before proceeding. In practice, this may be difficult, expensive and time consuming to undertake. Therefore I recommend that, if you are considering a domestic building mounted installation and electricity generation is your main motivation, then you only consider a wind turbine under the following circumstances:
The local annual average wind speed is 6 m/s or more. There are no significant nearby obstacles such as buildings, trees or hills that are likely to reduce the wind speed or increase turbulence

Planning issues such as visual impact, noise and conservation issues also have to be considered. System installation normally requires permission from the local authority.

Costs and savings

Roof mounted

These cost from £3000.The amount of energy and carbon that roof top micro wind turbines save depends on several things including size, location, wind speed, nearby buildings and the local landscape. At the moment there is not enough data from existing wind turbine installations to provide a figure of how much energy and carbon could typically be saved. The Energy Saving Trust is monitoring up to 100 wind turbine installations; the results of this activity will help to provide further information for householders considering this technology.

Mast mounted

Larger systems in the region of 2.5kW to 6kW would cost between £11,000 - £19,000 installed. These costs are inclusive of the turbine, mast, inverters, battery storage (if required) and installation; however it's important to remember that costs always vary depending on location and the size and type of system. Turbines can have a life of up to 22.5 years but require service checks every few years to ensure they work efficiently. For battery storage systems, typical battery life is around 6-10 years, depending on the type, so batteries may have to be replaced at some point in the system's life.

3.5 Biomass

Biomass is produced from organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural products. It is often called 'bio energy' or 'bio fuels'. It doesn't include fossil fuels, which have taken millions of years to be created.
Biomass fall into two main categories:
Woody biomass includes forest products, untreated wood products, energy crops and short rotation coppice (SRC), which are quick-growing trees like willow.
Non-woody biomass includes animal waste, industrial and biodegradable municipal products from food processing and high energy crops. Examples are rape, sugar cane, maize.
For small-scale domestic applications of biomass the fuel usually takes the form of wood pellets, wood chips or wood logs

The benefits

Producing energy from biomass has both environmental and economic advantages.
Although biomass produces CO2 it only releases the same amount that it absorbed whilst growing, which is why it is considered to be carbon neutral. Furthermore, biomass can contribute to waste management by harnessing energy from products that are often disposed of at landfill sites.
It is most cost effective and sustainable when a local fuel source is used, which results in local investment and employment and also minimises transport miles to your home.

Fuel

It's important to have storage space for the fuel, appropriate access to the boiler for loading and a local fuel supplier.

Flue

The vent material must be specifically designed for wood fuel appliances and there must be sufficient air movement for proper operation of the stove. Chimneys can be fitted with a lined flue.
Regulations
The installation must comply with all safety and building regulations.
See Part L of the Building Regulations, Northern Ireland
See Section 3 of the Technical Handbooks, Scotland

Smokeless zones

Wood can only be burnt in exempted appliances, under the Clean Air Act.

Planning

If the building is listed or in an area of outstanding natural beauty (AONB), then you will need to check with your Local Authority Planning Department before a flue is fitted.

Costs and savings

Stand alone room heaters generally cost £2,000 to £4,000 installed. Savings will depend on how much they are used and which fuel you are replacing. A biomass stove which provides a detached home with 10% of annual space heating requirements could save around 840kg of carbon dioxide when installed in an electrically heated home. Due to the higher cost of biomass pellets compared with other traditional heating fuels, and the relatively low efficiency of the stove compared to a central heating system it will cost more to run.

The cost for boilers varies depending on the system choice; a typical 15kW (average size required for a three-bedroom semi detached house) pellet boiler would cost around £5,000 - £14,000 installed, including the cost of the flue and commissioning. A manual log feed system of the same size would be slightly cheaper. A wood pellet boiler could save you around £750 a year in energy bills and around 6 tonnes of C02 per year when installed in an electrically heated home. Unlike other forms of renewable energy, biomass systems require you to pay for the fuel. Fuel costs generally depend on the distance from your supplier and whether you can buy in large quantities.

3.6 Heat Pumps

There are two types of heat pumps, ground source and air source.
Heat pumps work in a very similar way to fridges and air conditioners and absorb heat from the ground or from the air.
Ground or air source heat pumps are mainly designed to work with under floor heating systems because of the lower design temperatures of under floor systems.
Efficiencies of ground source heat pumps are between 350%-400% and air source between 200%-250%.

Heat pumps are a viable alternative to electric, LPG and oil fuel boilers, but are not considered as an alternative to natural gas.

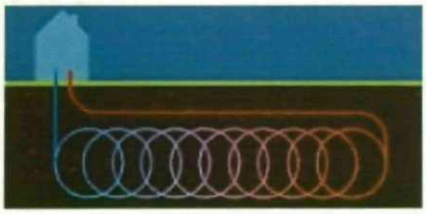
Ground source heat pumps

Ground source heat pumps use a buried ground loop which transfers heat from the ground into a building to provide space heating and, in some cases, to pre-heat domestic hot water. As well as ground source heat pumps, air source and water source heat pumps are also available.

The benefits

The efficiency of a ground source heat pump system is measured by the coefficient of performance (CoP). This is the ratio of units of heat output for each unit of electricity used to drive the compressor and pump for the ground loop. Average CoP over the year, known as seasonal efficiency, is around 3-4 although some systems may produce a greater rate of efficiency. This means that for every unit of electricity used to pump the heat, 3-4 units of heat are produced, making it an efficient way of heating a building. If grid electricity is used for the compressor and pump, then you should consult a range of energy suppliers to benefit from the lowest running costs, for example by choosing an economy 10 or economy 7 tariff.

Ground source heat pumps



How it works

There are three important elements to a ground source heat pump:

1. **The ground loop**
   This is comprised of lengths of pipe buried in the ground, either in a borehole or a horizontal trench. The pipe is usually a closed circuit and is filled with a mixture of water and antifreeze, which is pumped around the pipe absorbing heat from the ground. The ground loop can be:
   - Vertical, for use in boreholes
   - Horizontal, for use in trenches
   - Spiral, coil or 'slinky', also for use in trenches
2. **A heat pump**
   In the same way that your fridge uses refrigerant to extract heat from the inside, keeping your food cool, a ground source heat pump extracts heat from the ground, and uses it to heat your home. A ground source heat pump has three main parts:
   - The evaporator, (e.g. the squiggly thing in the cold part of your fridge) absorbs the heat using the liquid in the ground loop;
   - The compressor, (this is what makes the noise in a fridge) moves the refrigerant round the heat pump and compresses the gaseous refrigerant to the temperature needed for the heat distribution circuit;
   - The condenser, (the hot part at the back of your fridge) gives up heat to a hot water tank which feeds the distribution system.
3. **Heat distribution system**
   This consists of under floor heating or radiators for space heating and in some cases water storage for hot water supply.

You should consider the following issues if you're thinking about installing a ground source heat pump. An accredited installer will be able to provide more detailed advice.

- You will need space outside your house for the ground loop.
- The ground will need to be suitable for digging a trench or borehole.
- What fuel is being replaced? If it's electricity, oil, LPG or coal the savings will be more favourable than gas. Heat pumps are a good option where gas is unavailable.
- The type of heat distribution system. Ground source heat pumps can be combined with radiators but these will normally be larger than with standard boiler systems. Under floor heating is better as it works at a lower temperature.
- Want to further reduce your home's carbon dioxide emissions? Install solar PV or some other form of renewable electricity generating system to power the compressor and pump.
- Is the system for a new building development? Combining the installation with other building works can reduce costs.

Air and water source heat pumps

Air and water source heat pumps use air or water respectively. They do not rely on a collection system and simply extract the heat from the source at the point of use.

Air source heat pumps can be fitted outside a house or in the roof space and generally perform better at slightly warmer air temperatures. Water source heat pumps can be used to provide heating in homes near to rivers, streams, lakes and lochs for example.

Costs and savings

A typical 8 - 12kW system costs £6,000 - £12,000 (not including the price of distribution system). This can vary with property and location. When installed in an electrically heated home a ground source heat pump could save as much as £880 a year on heating bills and almost 7 tonnes of carbon dioxide a year. Savings will vary depending on what fuel is being replaced.

Where can I find out more about installation?
Ground source heat pump savings assume installation in a fully insulated detached house located off the gas grid.

The BERR funded low carbon buildings programme provides grants to help with the costs of installing a ground source heat pump.

The Scottish Community Householder Renewable Initiative (SCHRI) provides grants for properties in Scotland. This is funded by the Scottish Government and managed by the Energy Saving Trust. If you live in Scotland you can choose to have a SCHRI or a low carbon buildings programme grant. However, you can only apply for one grant per technology from either of these programmes

To be eligible for a grant you will need to use a certified installer and products.

Available grants

Phase 1 - Householder Stream.
At present, grants are available for non-reversible closed loop systems, utilising a borehole or trenches. A grant of up to £1,200 is available for domestic systems. For details of how to apply for grants, and of energy efficiency measures that must be in place before the grant can be accessed, please visit www.lowcarbonbuildings.org.uk.

Phase 2 - Community Stream.
Phase 2 of the LCBP is for the installation of micro generation technologies in public sector buildings (including schools, hospitals, housing associations and local authorities) and charitable bodies. Grants are available for up to 50% for installations with a maximum of £30,000. Phase 2 is administered by the BRE, for further information please visit www.lowcarbonbuildingsphase2.org.uk.

3.7 CHp & Micro CHP

Combined heat and power (Chp) and Micro combined heat and power (Micro Chp)
CHP (combined heat and power) the earlier ones where basically diesel engines converted to run on oil or gas, electricity been the primary output and heat been the secondary.
They have been around for many years, but mainly used in larger buildings like hotels and large blocks of flats etc. For CHP systems to be economically viable they need to run for at least 4,000 hours per year. They are more suitable for leisure centres with swimming pools and hospitals that have a high, year round
heat demand or in mixed use developments with suitable heat demands However, new housing or office developments may be able to make use of existing CHP schemes nearby

Fuel types for Chp / Micro Chp

Natural Gas

Micro CHP units are currently being developed for the domestic market by Potterton Baxi, and Powergen (Whispergen) and it shouldn't be long before they become commercially available.
Micro CHP boilers work using similar principle to their older commercial counterparts, an engine produces heat and electricity, the heat is used in the home much like heat from a conventional boiler and the electricity is either used in the *home or exported into the national grid.*

Typical estimated boiler efficiencies for use with natural gas

100% Gas	78% heat 12% electricity 10% waste

Biogas

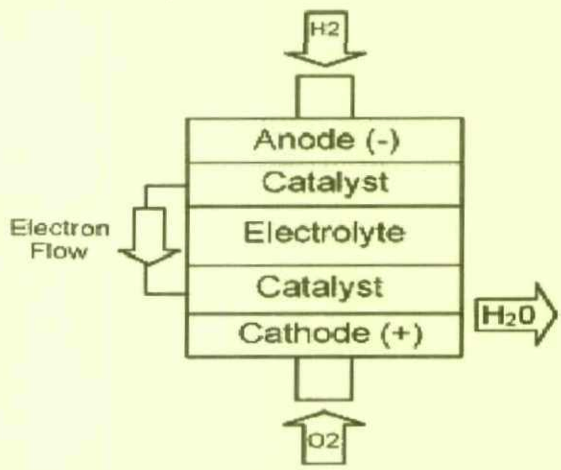
Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas *originates from biogenic material and is a type of bio fuel. One type of biogas is produced by anaerobic digestion or* fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, and energy crops. This type of biogas comprises primarily methane and carbon dioxide. The other principal type of biogas is wood gas which is created by gasification of wood or other biomass. This type of biogas is comprised primarily of nitrogen, hydrogen, and carbon monoxide, with trace amounts of methane.
The gases methane, hydrogen and carbon monoxide can be combusted or oxidized with oxygen. Air contains 21% oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a low-cost fuel in any country for any *heating purpose, such as cooking. It can also be utilized in modern waste management facilities where it can be used to run* any type of heat engine, to generate either mechanical or electrical power. Biogas is a renewable fuel and electricity produced from it can be used to attract renewable energy subsidies in some parts of the world.

Bio Mass

(Please see previous description)

3.8 Hydrogen Fuel cells

In principle, a fuel cell operates like a battery. Unlike a battery, a fuel cell does not run down or require recharging. It will produce energy in the form of electricity and heat as long as fuel is supplied.
A fuel cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.
A fuel cell produces electricity.
The fuel cell is similar to a battery. It produces electricity using chemicals. The chemicals are usually very simple, often just hydrogen and oxygen. In this case the hydrogen is the "fuel" that the fuel cell uses to make electricity.
Another very important difference is that fuel cells do not run down like batteries. As long as the fuel and oxygen is supplied to the cell it will keep producing electricity for ever.
The oxygen needed by a fuel cell is usually simply obtained from air.
Although the majority of fuel cells use hydrogen as the fuel, some fuel cells work off methane, and a few use liquid fuels such as methanol.
Fuel cells that use hydrogen can be thought of as devices that do the reverse of the well known experiment where passing an electric current through water splits it up into hydrogen and oxygen. In the fuel cell hydrogen and oxygen are joined together to produce water and electricity.
Fuel cells can be made in a huge range of sizes. They can be used to produce quite small amounts of electric power, for devices such as portable computers or radio transmitters, right up to very high powers for electric power stations.



Hydrogen fuel is fed into the "anode" of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.
A fuel cell system which includes a "fuel reformer" can utilize the hydrogen from any hydrocarbon fuel - from natural gas to methanol, and even gasoline. Since the fuel cell relies on chemistry and not combustion, emissions from this type of a system would still be much smaller than emissions from the cleanest fuel combustion processes.

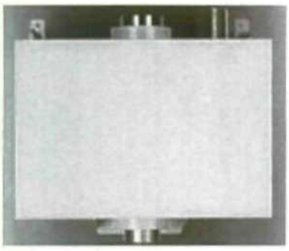
FUEL CELLS USING HYDROGEN FROM RENEWABLE SOURCES

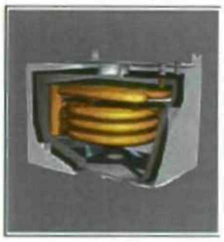
Fuel cells can be used as CHP systems in buildings. There are currently several different systems under development using different chemical processes, which operate at different temperatures. They currently use natural gas as the fuel, which is 'reformed' to produce hydrogen, the required fuel for the fuel cell. When and if hydrogen becomes available from renewable sources, e.g. as the storage medium of wind generated
energy, fuel cell CHP from renewable sources may be possible in buildings.

4. Other innovative technologies

The following technologies are not yet classified as LZC technologies; in reality they provide a large reduction in both CO_2 emissions and provide a good end user benefit in terms of energy savings.
This list of technologies will expand over the following years, and this section will expand to include any new available innovative technologies.

4.1 Flue Gas Heat recovery Systems (FGHRS)





The Flue Gas Heat Recovery System is not yet considered as a low carbon technology although it will be included in a draft consultation by the Energy Saving Trust which is due to be published in April 2009.
In reality the FGHRS provides a good reduction in CO_2 emissions compared to some technologies that are classified and listed as LZC technologies yet do not provide a reduction in CO_2 emissions when compared to a Natural Gas energy model.

Background

Condensing combination boilers only condense when the flow and return water temperature differential is large enough, generally 11°C, during hot water mode the primary heating water is just circulated around the boiler through a secondary heat exchanger and the temperature differential between flow and return water will be very low and therefore the boiler will not condense.

How it works

The FGHRS is fitted above the boiler and is connected to the boiler flue outlet; the flue is the terminated from the FGHRS as normal.
Cold mains water enters the FGHRS and is pre heated by the waste flue gasses via an air to water heat exchanger, the preheated water is then feed to the inlet cold connection on the boiler therefore reducing the amount of gas required to heat the hot water to a sufficient usable temperature.

Costs and maintenance

FGHRS cost between £500-£650 and according to the manufacture will require none or very little maintenance.

Land use

FGHRS requires no specific land use requirements.

Planning

FGHRS require no additional planning requirements.

4.2 Waste Water Heat Recovery Systems (WWHRS)

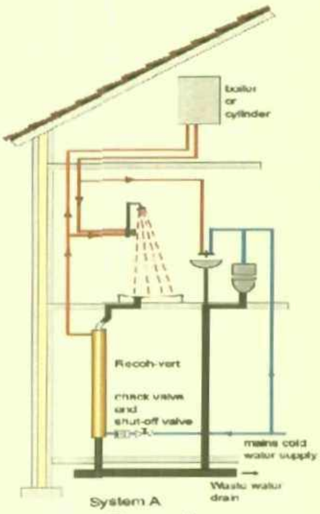


Figure 1

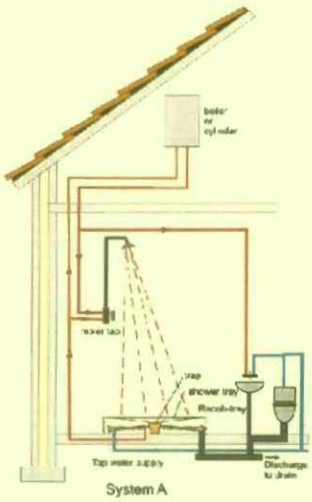


Figure 2

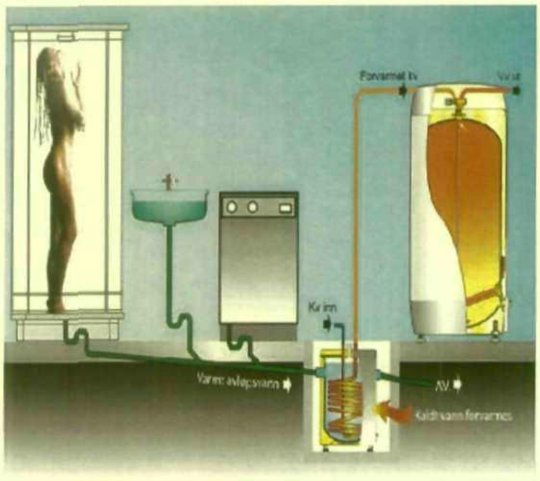


Figure 3

Shower Saver (figure 1 & 2)

Waste Water Heat Recovery Systems (WWHRS) are new to the UK and Appendix Q, following successful experience in The Netherlands where they are fitted to 20% of new dwellings. Although generically classified as a WWHRS the Shower-Save device is primarily applicable to heat recovery from warm shower waste water. Figure 7 shows the most common configuration known as Reco-vert, applicable to upstairs showers, whilst Figure 8 shows the Recoh-tray which can be used in apartments, bungalows or other single storey properties.
The principle of heat recovery is the same in both cases:
Warm shower water passes through the 'grey' water side of a copper counter-flow heat exchanger
Mains pressure water simultaneously passes through the fresh water side of the heat exchanger, where it is pre-heated before passing into both the 'cold' inlet of the mixer shower and the 'cold' inlet to the hot water cylinder, combi boiler or other water heater.
The use of pre-heated water (orange line in Figures 1 and 2) reduces the total volume of hot water required per shower, whilst also pre-heating the cold feed to the hot water heater which increases potential flow rates for combi or shortens the re-heat time of cylinders.
The energy saving applies to whichever fuel is used for water heating, which is therefore not limited solely to gas boilers.
Whilst technically applicable to instantaneous electric showers, these aren't currently modelled by SAP, so it is not possible to apply in Appendix Q either.
Does not save energy from baths, in which hot water use is in advance of grey water disposal, but is applicable to the shower over a bath.

Waste water heat recovery System

Figure 3 depicts a whole house Waste Water Heat Recovery System (WWHRS) which is being developed in the Netherlands and is expected to be available in this country during the next year. It is estimated that the system will provide a reduction in energy consumption of approximately 2500Kw pa or approximately 475 Kg/ CO_2 pa for an average dwelling.

5. Excluded LZC Technology

Low or Zero Carbon not thought appropriate for use on the proposed development.

- Small scale hydro power
- Large Mast Wind turbines
- Biomass
- Combined Heat and Power (CHP) and micro CHP, fuelled by Gas, Biomass, Biogas.
- Heat pumps, Ground source heat pumps (GSHP) Geothermic heating systems, horizontal pipe system
- Community heating, including utilising waste heat from processes such as large scale power generation where the majority of heating comes from waste heat
- Other technologies, Fuel cells using hydrogen from any of the above renewable sources
- Air – Water heat pumps (Electric)
- Ground to water heat pups (electric)

LZC technology and reasons for their exclusion

Small scale hydro power

Small scale hydro would not be inappropriate for integration into the proposed development due to the geographical location of the proposed site and its increased proximity to a natural water feature which would be capable of accommodating this type of technology.

Wind turbines

The UK Department of Trade and Industry used to publish a database of average wind speed data for every 1km grid square in the country, known as the NOABL database. The database no longer appears on the DTI website. The data is estimated rather than measured, and takes no account of local features such as walls, buildings, trees and hilltops, which occur at a scale of much less than 1km. These features make a major difference to the wind. To quote the DTI web page: "The data can only be used as a guide and should be followed by on-site measurements for a proper assessment".

In any case, average wind speed is not a reliable predictor of wind turbine output, because the relationship between wind speed and power output is not linear. For example, compare two days: one when the wind blows steadily at 8 mph all day, and another when the wind blows at 16 mph for 12 hours and there is no wind at all for the other 12 hours. Both days have an average wind speed of 8mph, but most turbines would produce more than twice as much power on the second day. One way to approach the problem is to embark on complex statistical calculations involving the 'Rayleigh wind speed distribution'; a simpler method is to carry out a wind survey in the exact spot where the turbine is to be mounted.
The average wind speed for the proposed development is 4.**9 meters per second**, 10 meters above ground level according to the NOABL database; therefore large mast wind turbines are thought not be suitable for use at the proposed site. As previously indicated a detailed an on-site assessment to establish the actual average wind speed would be required to determine the potential suitability of the site for the installation of a large mast wind turbine.

for the 1km grid square 431 535 (NZ3135)

Wind speed at 10m agl (in m/s)

4.9	4.9	5
4.9	4.9	5.1
5.2	5.1	5.2

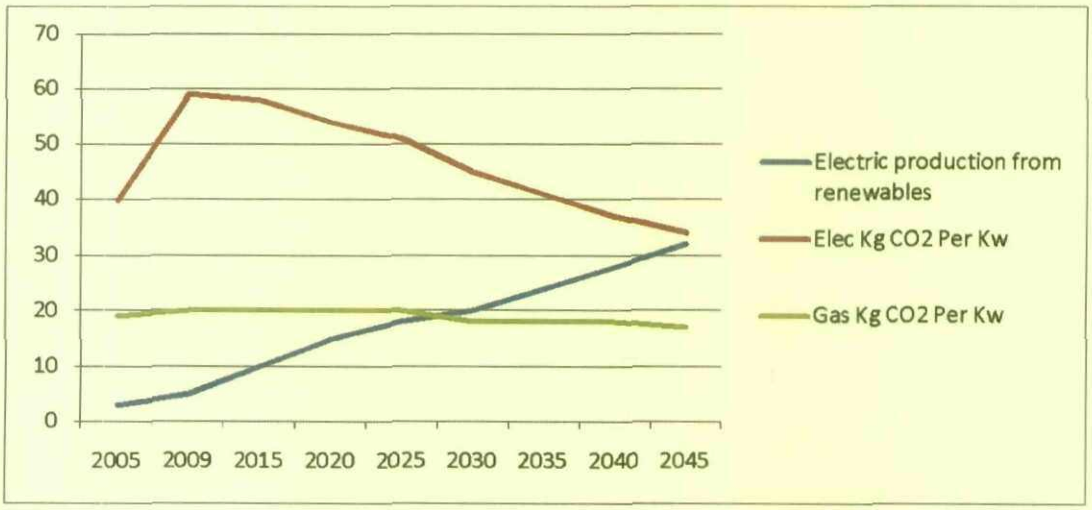
http://www.renew-reuse-recycle.com/noabl.pl?n=503

Air and ground Heat pumps (electric)

The results from previous feasibility studies concluded that Air and ground source heat pumps do not provide any benefit when compared to the gas standard case energy model and actually may increase both CO_2 emissions, energy consumption and running costs as experienced by the occupier and therefore will not be considered further in this study.

The carbon emissions associated with electric production and distribution are currently very high in the UK due to the small amount of electricity produced by renewable sources and therefore even with the type of efficiencies associated with heat pumps (250-400%) the amount of carbon produced would be similar to that of a standard condensing gas boiler.

The Governments target of 15% electric production from renewable sources by 2020 will have the effect of lowering the CO_2 emissions associated with electricity production and therefore heat pumps will become a viable alternative to natural gas installations.
The graph below represents an estimate of CO_2 emissions for both gas and electricity and how they may change over the following years, data has been taken from SAP 2005 and the draft SAP 2009 document for 2005 and 2009 figures.



Biomass

The proposed development is situated in a smoke control zone; the Clean Air Acts of 1956 and 1968 were introduced to deal with the smog's of the 1950s and 1960s which were caused by the widespread burning of coal for domestic heating and by industry. This smog's were blamed for the premature deaths of hundreds of people in the UK. The Acts gave local authorities powers to control emissions of dark smoke, grit, dust and fumes from industrial premises and furnaces and to declare "smoke control areas" in which emissions of smoke from domestic properties are banned. Since then, smoke control areas have been introduced in many of our large towns and cities in the UK and in large parts of the Midlands, North West, South Yorkshire, North East of England, Central and Southern Scotland. The implementation of smoke control areas, the increased popularity of natural gas and the changes in the industrial and economic structure of the UK lead to a substantial reduction in concentrations of smoke and associated levels of sulphur dioxide (SO2) between the 1950s and the present day.

Pollutants associated with biomass combustion include particulate matter ($PM_{10}/PM_{2.5}$) and nitrogen oxides (NO_x) emissions. These pollution emissions can have an impact on local air quality and affect human health, a report provided by DEFRA concluded that the negative effects on air quality associated with biomass installations especially in urban developments may out way any benefit associated with CO_2 reduction.

For these reasons Biomass will not be coincided suitable as a primary heat source.

http://www.uksmokecontrolareas.co.uk/index.php#app

Small scale hydro power

Small scale hydro would be inappropriate for integration into the proposed development due to the geographical location of the proposed site and its increased proximity to a natural water feature which would be capable of accommodating this type of technology.

Biogas

Biogas is generally associated with large scale anaerobic digestion units for agricultural and industrial applications and has not yet been fully developed for integration on small domestic developments.
Biogas fuels would be inappropriate for integration in their current form on the proposed development due to the geographical location of the site and the inadequate space for housing anaerobic digestion units which would be required for this type of technology.

Combined Heat and Power (CHP), fuelled by gas

Micro Chp

As previously stated the developments of Micro CHP units are still in their infancy although products like the Baxi Ecogen should be available from late 2009.

CHP

Please see community heating

Community heating

From wasted heat

Community heating including utilising waste heat from processes such as large scale power generation or industrial heat *generation where the majority of heating comes from waste heat would be inappropriate for integration at the proposed* development due to the geographical location of the proposed site and its increased proximity to an industrial heating or power generation source that would be capable of accommodating this type of technology.

From Gas, Combined heat and power or other LZC technologies

Community heating systems would provide an ideal match between the heating load requirements of a typical code dwelling and the ability of a boiler to work at its optimal efficiency. The average maximum heating load of a code 3 apartment is approximately 2-3 Kw and for a 3 bed semi approximately 4-6Kw and therefore most individual heating systems with independent condensing gas boilers would be incapable of working at optimal efficiencies or achieving their stated SEDBUK rating due to boiler cycling.

Community heating systems are generally more suited to high density developments such as low or high rise apartments where the losses associated with distribution can be kept to a minimum and therefore community heating would not be considered suitable for integration at the proposed development due to the housing mix, site density and suitable location for a central plant room or building.

In SAP 2009 it is expected that the ratio between the maximum ratings of a gas condensing boiler compared to the load requirements of a dwelling will affect the overall assessed efficiency of the boiler and therefore the use of community heating systems would provide an ideal solution for the reasons previously stated. It is therefore recommended that the use of community heating on any future developments is considered early in the design and planning stage of the development.

For example in the case of the proposed development at Thurnscoe a single domestic gas boiler would be quite capable of satisfying the heating load requirement of a pair of semi detached plots or row of terrace plots. The heating boiler could be sited in a purpose built structure and heat meters installed in each plot, although ownership and the maintenance responsibility of the heating plant would need to be addressed and for that reason will not be considered further in this *study.*

Other technologies

Fuel cell etc, not yet commercially available.

6. Considered LZC technology

The following Low or Zero carbon technologies and innovative technologies which are to be considered for integration at the proposed development.

- Solar Hot Water
- Solar Photovoltaic
- Micro wind (roof mounted)
- FGHRS
- WWHRS

6.1 The development (Standard case)

Information for the feasibility study has been provided by standard case SAP calculations and entered into Table 1: LZC from ENE 7 using the following standard case assessment data.

The 'Standard' case includes the minimum space and Water heating services as set out in the Domestic Heating Compliance Guide, and are as follows:

- Primary Heating Fuel (space & water) – Mains Gas
- Boiler: SEDBUK 86 per cent, room-sealed, fanned flue
- Secondary space heating: Electric heater assumed
- Cylinder volume: 150 litres
- Maximum permitted cylinder loss: 2.62kWh/day
- Primary Pipe work: Insulated
- Space Heating Control: Programmer, room thermostat, and TRV's
- Hot water Control: Boiler interlock, cylinder thermostat, separate water control

From these initial SAP calculations a base line emission rate for the development has been established and each LZC technology added to the standard case SAP calculations in order to provide a realistic comparison between each technology.

Fuel costs used in the comparison have been taken from the SEDBUK database and therefore are more up to date than fuel costs taken from SAP 2005.

6.2 Fuel choice

All assessments have assumed mains natural gas as the main fuel choice and therefore compared like for like against the standard case and table 1 assessment.

Electricity as a fuel choice would increase both CO_2 emissions and fuel cost as experienced by the occupier, as previously discussed ground or air source heat pumps would not provide a reduction in CO_2 emissions and may even increase CO_2 compared to the standard case mains gas energy model and therefore heat pumps should only be considered when mains gas was not available but would not satisfy the 10% planning condition.

Carbon emissions factors	SAP 2005	Estimated SAP 2009
Grid electricity	0.422 Kg CO_2 / Kw	0.591 Kg CO_2 / Kw
Manufactured smokeless fuel	0.392 Kg CO_2 / Kw	0.402 Kg CO_2 / Kw
Coal	0.291 Kg CO_2 / Kw	0.38 Kg CO_2 / Kw
Heating Oil	0.265 Kg CO_2 / Kw	0.28 Kg CO_2 / Kw
LPG	0.234 Kg CO_2 / Kw	0.25 Kg CO_2 / Kw
Natural Gas	0.19 Kg CO_2 / Kw	0.206 Kg CO_2 / Kw
Wood	0.025 Kg CO_2 / Kw	0.018 Kg CO_2 / Kw
Bio Diesel	NA	0.098 Kg CO_2 / Kw
Bio Gas	NA	0.019 Kg CO_2 / Kw

7 The development standard case emissions

Development		
Gross Internal Floor area of the development Energy used Kw/h per year	64168.20 8039428.20	m² Kw/h
Energy per m² of floor area	125.29	Kw/m²
Total standard case CO2 emissions for the development	2282683.61	Kg
Annual predicted carbon emissions per m² of floor area	35.57	KgC/m²

7.1 Solar water heating

For the purpose of the feasibility study an area of 5m² of flat plate south facing collector has been added to the standard case energy model, all other specification remains the same as the standard case.

Energy		
Energy used Kw/hours	6464723.40	Kw/h pa
Energy generated by the LZC	1574704.80	Kw/h pa
Percentage energy saved	19.59%	
Emissions		
Total estimated CO2 emissions for the development using this LZC	2016145.01	Kg
Total percentage reduction of CO2	11.68%	
Total saved Carbon emissions	266538.60	Kg
Annual carbon emissions	31.42	KgC/m²
Total estimated life time cost		
Estimated costs for installation, approximately £1500 per dwelling	£1,215,000.00	
Estimated service and maintenance over a fifteen year period	£486,000.00	
Total costs	£1,701,000.00	
Total carbon savings over 15 years	3998079	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.43	
Average User savings £ Payback period Years	£47.83 43.91	Per year Years

Noise
Solar collectors are considered to be silent in operation.

Land use
The solar collectors would be fitted to the roof structure therefore they would not require any further land use or special provision of land.

Planning requirements
Solar water is regarded as a permitted development although a pre planning application will be required for submission to *the local planning department for their approval*

7.2 Solar Photovoltaic

For the purpose of the feasibility study an area of south facing PV collector has been added to the standard case energy model that will produce 1 Kw peak of electricity, all other specification remains the same as the standard case.

Energy		
Energy used Kw/hours	6148823.40	Kw/h pa
Energy generated by the LZC	1890604.80	Kw/h pa
Percentage energy saved	23.52%	
Emissions		
Total estimated CO2 emissions for the development using this LZC	9925.22	Kg
Total percentage reduction of CO2	16.80%	
Total saved Carbon emissions	383526.90	Kg
Annual carbon emissions	23.14	KgC/m²
Total estimated life time cost		
Estimated costs for installation, approximately £6000 per dwelling	£4,860,000.00	
Estimated service and maintenance over a fifteen year period	£202,500.00	
Total costs	£5,062,500.00	
Total carbon savings over 15 years	5752903.5	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.88	
Average User savings £	£83.65	Per year
Payback period Years	74.72	Years

Other considerations

Noise

Solar collectors are considered to be silent in operation.

Land use

The solar collectors would be fitted to the roof structure therefore they would not require any further land use or special provision of land.

Planning requirements

Solar PV is regarded as a permitted development although a pre planning application will be required for submission to the local planning department for their approval.

Grants

Grants are available of 50% towards the cost of installation LZC technologies to the property owner under phase 2 of the low Carbon Buildings Program (LCBP) providing that the property owner is a "not for profit organisation" or organisations including schools, hospitals, housing associations, and local authorities. The LCBP grants are not available to profit making companies

7.3 Micro wind, roof mounted wind turbines

For the purpose of this feasibility and assessment 2 micro wind turbines with a rotor diameter of 2m and hub height above ridge of 3m have been entered into SAP 2005 and compared against the Standard case energy model using table 1 assessments.

Energy		
Energy used Kw/hours	7052337.90	Kw/h pa
Energy reduction by the LZC	987090.30	Kw/h pa
Percentage energy increase	12.28%	
Emissions		
Total estimated CO2 emissions for the development using this LZC	2180615.51	Kg
Total percentage reduction of CO2	4.47%	
Total saved Carbon emissions	102068.10	Kg
Annual carbon emissions	33.98	KgC/m²
Total estimated life time cost		
Estimated costs for installation, approximately £3500 per dwelling	£2,835,000.00	
Estimated service and maintenance over a fifteen year period	£202,500.00	
Total costs	£3,037,500.00	
Total carbon savings over 15 years	1531021.5	Kg
Total cost per Kg of saved carbon over a fifteen year period	£1.98	
Average User savings £	£36.88	Per year
Payback period	101.68	Years

Other considerations

Noise

Micro wind turbines may have some noise implications although silent micro wind turbines are available

Land use
Micro wind turbines would be fitted to the roof structure therefore they would not require any further land use or special provision of land.

Planning requirements
Micro wind turbines currently require planning approval although they may be considered as a permitted development later next year under changes to planning policy.

Grants
Grants are available of 50% towards the cost of installation LZC technologies to the property owner under phase 2 of the low Carbon Buildings Program (LCBP) providing that the property owner is a "not for profit organisation" or organisations including schools, hospitals, housing associations, and local authorities. The LCBP grants are not available to profit making companies.

7.4 Flue Gas Heat Recovery Systems (FGHRS)

For the purpose of the feasibility study an gas saver has been added to the standard case SAP calculation, savings have *been calculated using appendix Q dataset*, all other specification remains the same as the standard case.

Energy		
Energy used Kw/hours	7573524.30	Kw/h pa
Energy generated by the LZC	465903.90	Kw/h pa
Percentage energy saved	5.80%	
Emissions		
Total estimated CO2 emissions for the development using this LZC	2204453.81	Kg
Total percentage reduction of CO2	3.43%	
Total saved Carbon emissions	78229.80	Kg
Annual carbon emissions per m2	34.35	KgC/m²
Total estimated life time cost		
Estimated costs for installation, approximately £600 per dwelling	£486,000.00	
Estimated service and maintenance over a fifteen year period	£0.00	
Total costs	£486,000.00	
Total carbon savings over 15 years	1173447.00	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.41	
Average User savings £	£13.16	Per year
Payback period	45.59	Years

Note 1, the FGHRS is a sealed unit and according to the manufacture does not require any servicing or maintenance and is expected to last the lifetime of the boiler. Due to insufficient data relating to the expected life time of the unit no maintenance costs have been *included in this assessment.*

Noise

FGHRS are considered to be silent in operation.

Land use

FGHRS requires no specific land use requirements.

Planning requirements

FGHRS require no additional planning requirement

Grants

No grants are presently available for FGHRS

7.5 Waste Water Heat Recover System (WWHRS)

For the purpose of the feasibility study a waste water heat recovery device has been added to the standard case SAP calculation, savings have been calculated using appendix Q dataset, all other specification remains the same as the standard case.

Energy		
Energy used Kw/hours	7381125.00	Kw/h pa
Energy generated by the LZC	658303.20	Kw/h pa
Percentage energy saved	8.19%	
Emissions		
Total estimated CO2 emissions for the development using this LZC	2214036.11	Kg
Total percentage reduction of CO2	3.01%	
Total saved Carbon emissions	68647.50	Kg
Annual carbon emissions per m2	34.50	KgC/m²
Total estimated life time cost		
Estimated costs for installation, approximately £400 per dwelling	£324,000.00	
Estimated service and maintenance over a fifteen year period	£0.00	
Total costs	£324,000.00	
Total carbon savings over 15 years	1029712.50	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.31	
Average User savings £	£15.80	Per year
Payback period	25.32	Years

Noise

WWHRS are considered to be silent in operation.

Land use

WWHRS requires no specific land use requirements.

Planning requirements

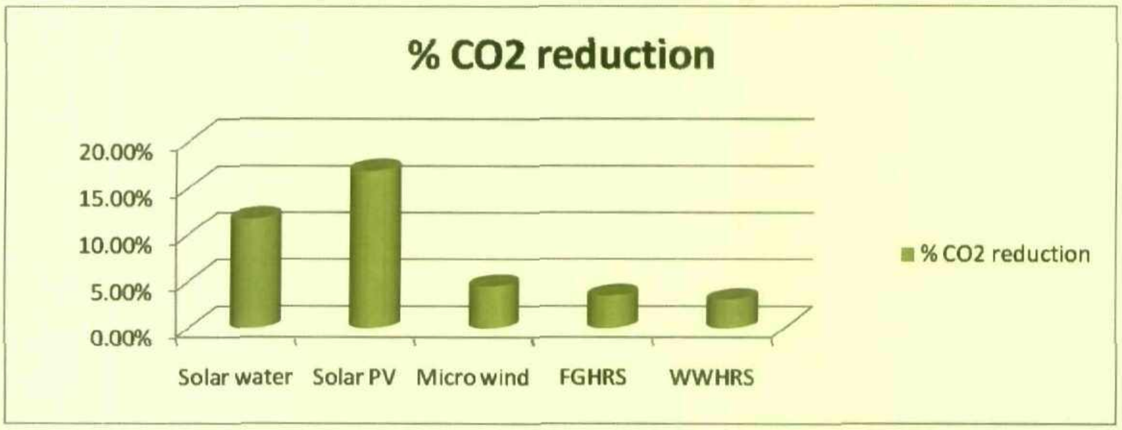
WWHRS require no additional planning requirement

Grants

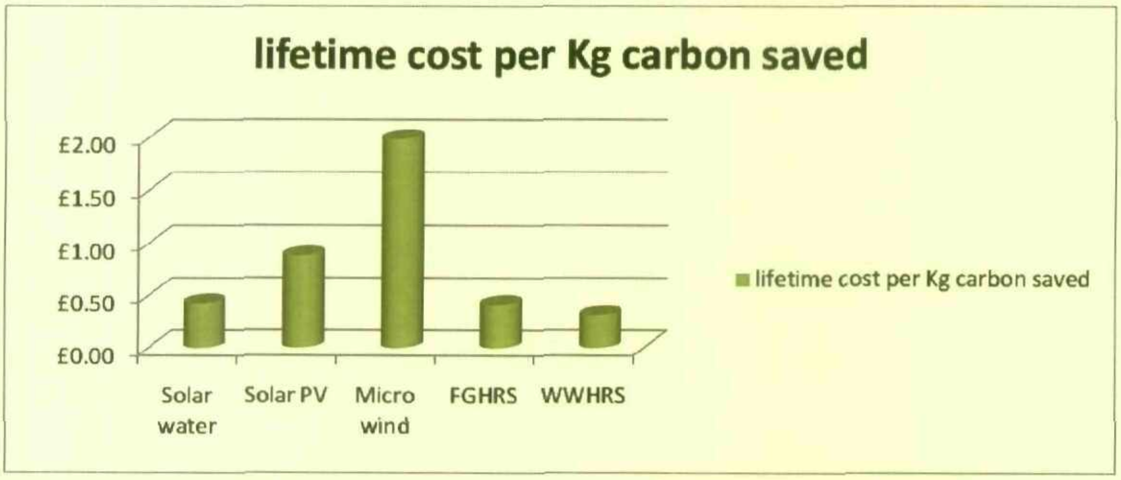
No grants are presently available for WWHRS

7.6 Summary

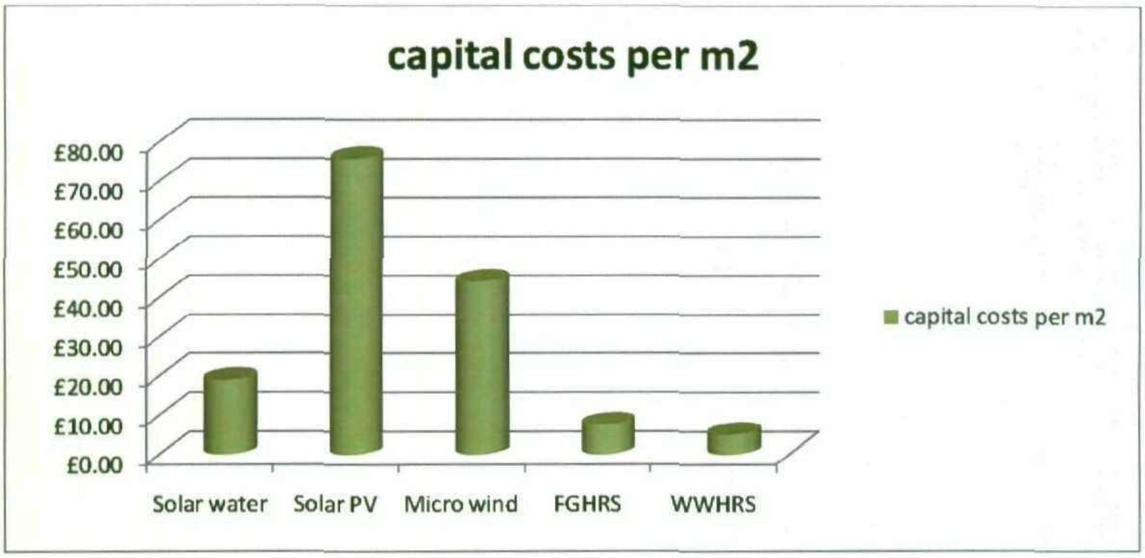
	energy generated Kw/h Pa	% energy saved	% carbon savings	Capita cost m²	Cost per Kg/C saved over 15 years
Solar water	1574704.80	19.59%	11.68%	£18.93	£0.43
Solar PV	1890604.80	23.52%	16.80%	£75.74	£0.88
Micro Wind	987090.30	12.28%	4.47%	£44.18	£1.98
FGHRS	465903.90	5.80%	3.43%	£7.57	£0.41
WWHRS	658303.20	8.19%	3.01%	£5.05	£0.31



The graph above shows the expected percentage reduction in CO2 emissions for each LZC technology compared to the standard case assessment.



The above graph represents a comparison of LZC technologies and the estimated whole life costs, and is represented as costs in £ per Kg of carbon saved over the expected life time of the LZC technology.



The graph above represents a comparison in terms of installation costs per m2, although the comparison does not take into account any grants that may be available towards installation costs.
All capital and installation costs of LZC technologies used in this study have been taken from the Energy Saving Trust although costs may vary depending on volume and specific costs provided by individual manufactures and installers.

8. Conclusion

Innovative technologies

Based on the previous calculations and comparisons with the standard case energy model the Flue Gas Heat Recovery System (FGHRS) and Waste Water Heat Recovery System (WWHRS) would provide the most benefit for the least capital investment and lifetime cost assessment, although at the time writing nether system would be classified as a LZC technology and allow the availability of achieving the required 10% target reduction in CO_2 emissions as per the planning condition.

The FGHRS and WWHRS systems would provide deep cuts in CO_2 emissions and provide positive end user benefit for each individual occupier although the pre planning requirement only considers the site as a whole and not proportioned benefit to individual users.

If these technologies are used on the development they will account for a reduction in total standard case CO_2 emissions for the development and therefore will lower the 10% target required by the chosen LZC technology, they would also provide a proportioned benefit to each unit on the development which may be a lot higher than is currently recognised by CSH, SAP and appendix Q assessments, in the case of the FGHRS as stated by the NUV TEL report the benefit from the unit may be a lot higher than the assumed benefit provided by solar thermal.

LZC technologies

Comparisons of the three LZC technologies, Solar thermal, Photovoltaic and Wind conclude that Solar water heating would provide the required 10% CO_2 reduction at the least capital investment, lifetime costs and provide a positive end user benefit and therefore would be the most appropriate technology for use at the development.

9. Proposed solution and specification

178 CSH level 3 dwellings

Element	CSH Level 3, 25 Dwellings
External Walls	0.23 W/m²K
Ground Floor	0.13 W/m²K
Roof Insulation	0.10 W/m²K
Windows	1.50 W/m²K
Doors	1.50 W/m²K
Y-Value	0.08
Air permeability	6m²
Low energy lighting	75%
Boiler	Alpha CD35C
Controls	Time and temperature zone control
Compensator	Honeywell CM900 with built in load comp
Appendix Q	Gas saver (FGHRS)
LZC	Alpha solar smart 5m² collector

Average house type		836
Cooking and appliances		
TFA		79.22
N		2.60
Kg CO2/year from cooking		1128.57
Table 1: LZC Contribution and CO2 Savings		
1 Space heating and hot water	SAP Box 107 Standard case	1339.89
2 Fans and Pumps	SAP Box 108 standard case	73.85
3 Lighting	SAP Box 109 Standard Case	275.81
4 cooling		0.00
5 Appliances and Cooking		1128.57
6 Total CO2 Standard Case	(1+2+3+4+5)	2818.12
7 Fans and Pumps	(SAP Box 108) (Box 114*) as built	105.50
8 Reductions in emissions for pumps and fans	as built	-31.65
9 Emissions for heating and hot water	SAP Box 107 as built	981.66
10 CO2 Reductions heating and hot water from LZC		358.23
11 CO2 Reduction from elec generated by LZC	(SAP Box 110-111)	0.00
15 CO2 reduction from LZC electric generation		0.00
16 CO2 reduction from LZC thermal generation		358.23
17 Total CO2 reduction from LZC technologies		326.58
18 % CO2 Savings by LZC		11.59%

169 Standard dwellings without solar thermal

Element	Standard Specification
External Walls	0.30 W/m²K
Ground Floor	0.16 W/m²K
Roof Insulation	0.14 W/m²K
Windows	1.80 W/m²K
Doors	2.20 W/m²K
Y Value	0.08
Air permeability	10m²
Low energy lighting	30%
Boiler	Alpha CD35C
Controls	Time and temperature zone control
Compensator	Honeywell CM900 with built in load comp
Appendix Q	Gas saver (FGHRS)
LZC	None

463 Standard dwellings with solar thermal

Element	Standard Specification
External Walls	0.30 W/m²K
Ground Floor	0.16 W/m²K
Roof Insulation	0.14 W/m²K
Windows	1.80 W/m²K
Doors	2.20 W/m²K
Y Value	0.08
Air permeability	10m²
Low energy lighting	30%
Boiler	Alpha CD35C
Controls	Time and temperature zone control
Compensator	Honeywell CM900 with built in load comp
Appendix Q	Gas saver (FGHRS)
LZC	Alpha solar smart 5m² collector

	Plots		Saved CO2	
Total Standard case CO2				2282683.6
Reduction by FGHRS	810.00	x	95.78	77581.80
Reduction by advanced heating controls	810.00	x	138.69	112338.90
Total Development CO2				2092762.91
10% Target				209276.29
CO2 reduction from solar thermal	641.00	x	326.58	209337.78
				10.00%

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The following publications and resources have provided information for the assessment, compilation and completion of this feasibility study.

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