Anderson Goddard Ltd eco

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Preston Road, Longridge

Energy Statement
&
Low or Zero Carbon (LZC) technology feasibility study

AG-71530-LZCR-Rev B

3rd December 2017

Abacus House, 450 Warrington Road, Culcheth, Cheshire, WA3 5QX

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1. Executive Summary

LZC technology

The following technologies would not be technically viable and/or would not provide the required 10% -20% reduction in either CO_2 emissions or energy, this is further verified in this report on pages 51-61.

- Solar thermal
- Micro wind
- Heat pump technology
- District heating, CHP

As part of our investigations into technical viability, PV has been determined to be the most appropriate technology which has allowed quantities of Photovoltaic panels to be calculated for the purpose of assessing Technical & financial viability, please refer to sections 1.3 & 1.4 on Pages 12 & 13 of this report for details of quantities required.

PV has been chosen as the most appropriate technology for the following reasons as compared to **OTHER** LZC technologies.

- Most cost effective solution from a lifetime cost perspective as compared to other technologies
- Would provide the largest reduction in CO_2 emissions for the least capital cost
- Would provide the largest reduction in fuel costs as experienced by the occupant
- Would not require any user operation
- Would require minimal change of habit by the occupant
- Would not require any additional land use
- Would be silent in operation
- Would require very little maintenance when compared against other LZC technologies

Option 1 – PV

The amount of PV required to achieve a 10% reduction in primary energy and Carbon emissions is estimated to require 3Kw Peak PV systems installed to 37 N° dwellings. The dwellings will be considered based on available roof area in a southern orientation and whenever possible the rear elevation will be preferred. A detailed assessment will be carried during the design stage assessment.

Option 2 – FGHRS / Flowsmart system

Flue Gas Heat Recovery System – Alpha Gas saver Mk2 / Flowsmart on larger dwellings

“Fabric first”

Our standard approach is to reduce emissions through fabric improvements and not by the use of technology and therefore show a net saving in both carbon and energy for the life of the dwellings and not just the life of the technology.

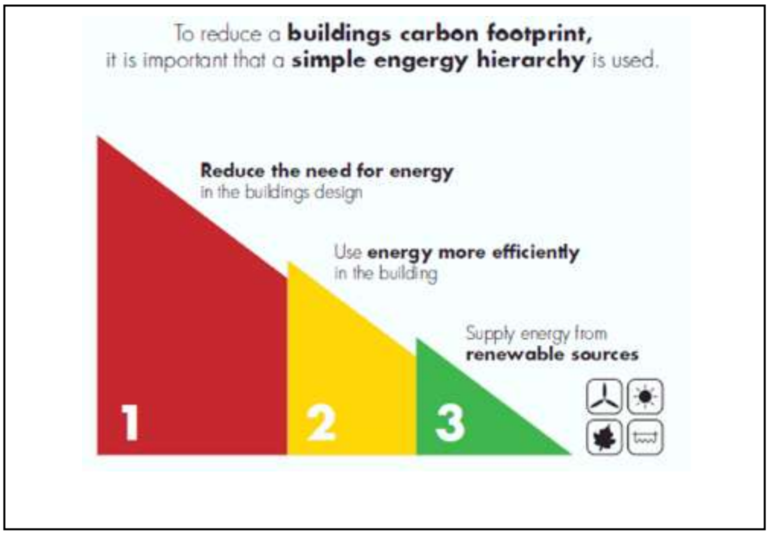
We do not want to burden occupants with on-going maintenance cost associated technology or trap them into purchasing energy/heat from one company or ESCO.

Energy Hierarchy

In line with best practice, the proposed buildings energy strategy should adhere to the principles of the Energy Hierarchy;

- **Be Lean** – reduce the need for energy.
- **Be Clean** – supply and use energy in the most efficient manner.
- **Be Green** – supply energy from renewable sources.

The Energy Hierarchy



Adhering to the principles of the Energy Hierarchy has a number of benefits;

- By reducing the energy requirement of the building, the burden of renewable requirement shrinks in proportion. This has obvious financial benefits, and will help meet part L of building regulations and any further reductions in carbon emissions required.

- The sustainable credentials of the development are enhanced and are not validated by simply bolting on expensive renewable equipment. By focusing on fabric performance and the provision of efficient heating/cooling systems the building is intrinsically “green”.

The lean measures are those measures which cumulatively reduce the energy requirement of the development through the construction of a thermally efficient building envelope. The measures included in this section of the report constitute the lean efforts.

1.1. Building regulation requirements

Approved Document Part L1a of the Building Regulations 2013 (England)

Regulation 25 – Fabric perimeters used to calculate the Target Emission Rate (TER) & Target Fabric Energy Efficiency (TFEE)

Table R1: From SAP2012, Appendix R1, U-Values, M&E requirements		
Roof	0.13	W/m² K
Walls	0.18	W/m² K
Party Cavity Wall	0.00	W/m² K
Floor	0.13	W/m² K
Windows	1.40	W/m² K
Doors	1.20	W/m² K
Thermal Mass	250	KJ/m²K
Thermal Bridging	0.05	
Air permeability	5.00	m³
Boiler	89.5%	
Controls	Time and temperature Zone Control	
Ventilation	System 1	
Low energy Lights	100%	

Criterion 1 Regulation 26 and 26a

Regulation 26. Where the building is erected it shall not exceed the target CO_2 emission rate for building that has been approved pursuant to Regulation 25

Dwelling Emission Rate (DER) =< Target Emission Rate (TER)

Regulation 26a. Where the building is erected it shall not exceed the target fabric efficiency rate for the dwelling that has been approved pursuant to Regulation 25

Dwelling Fabric Energy Efficiency (DFEE) =< Target Fabric Energy Efficiency (TFEE)

Criterion 2 – Limits on design flexibility

Table 2: Building Regulations Part L1a 2013 Limiting fabric parameters		
Roof	0.20	W/m² K
Walls	0.30	W/m² K
Party Cavity Wall	0.20	W/m² K
Floor	0.25	W/m² K
Windows	2.00	W/m² K
Doors	2.00	W/m² K
Air permeability	10.00	m³

Criterion 3 – Limiting the effect of heat gains in summer

SAP overheating assessment

Criterion 4 – Building performance consistent with DER and DFEE

As built checks, commissioning certificates for heating and ventilation and air test results

Criterion 5 – Provision for energy-efficient operation of the dwelling

Provision for providing the owner of the dwelling with sufficient information about the buildings fixed building services and correct maintenance requirements so that the building can be operated in such a manner as to use no more fuel and power than is reasonable in the circumstances.

Zero Carbon Standards

Zero Carbon Standards are yet to be defined although the Zero Carbon Hub suggested the following parameters.

DER =< 11kg CO_2 per m^2
DFEE =< 39Kw/m^2/Year (Mid terrace, Flats), 46Kw/m^2/year (Semi-detached, detached)

1.2. Proposed Baseline Specification & Assessment

The objective of this section of the report is to provide more information on specific requirements and details of the proposed fabric and heating and solutions, from this initial assessment and specific technical requirements a detailed heating design will need to be provided by a specialist who may be required to work with manufacturers. Technical information from the manufacturers will be included as an Appendix to this main report when available.

The actual final manufacturers specification may differ to the one proposed because of cost, supply chain, procurement or technical issues unknown at the time of writing, therefore further calculations maybe required to determine that compliance with planning will still be achieved should the manufacturers specification differ to the one provided below.

Proposed Fabric specification for both Option 1 and option 2

Table 2: Proposed fabric specification		
Roof	0.11	W/m² K
Walls	0.25	W/m² K
Party Cavity Wall	0.00	W/m² K
Floor	0.16	W/m² K
Windows	1.40	W/m² K
Doors	1.20	W/m² K
Thermal Bridging	Thermally modelled (for more detail please see section 3.2)	
Air permeability	5.00	m³

Proposed Mechanical specifications

Table 3a: Mechanical Specification Option 1	
Boiler	ErP Boiler
Controls	Programmer, Room thermostat and TRV, Dwellings > 150m² Time and Temperature Zone control
Compensator	None
Ventilation	AD. Part F System 1, Intermittent fans
Lighting	100% Low energy Lighting

Table 3b: Mechanical Specification Option 2	
Boiler	Alpha E-Tec Combi
Controls	Programmer, Room thermostat and TRV, Dwellings > 150m² Time and Temperature Zone control
Compensator	None
Ventilation	AD. Part F System 1, Intermittent fans
Lighting	100% Low energy Lighting

Baseline assessment of Energy, Primary Energy, Carbon and running costs

Energy (Primary)		
Heating	1836365.46	Kw
Hot water	621296.30	Kw
Fans and Pumps	162668.59	Kw
Lighting	325337.19	Kw
Total Energy use	2945667.54	Kw
Energy Kw per m² of floor area	101.60	Kw/m²
CO2 emissions		
Heating	325127.00	Kg
Hot water	110000.00	Kg
Fans and Pumps	27500.00	Kg
Lighting	55000.00	Kg
Total CO2 emissions	517627.00	Kg
Annual predicted carbon emissions per m² of floor area	17.85	KgCO2/m²
Running Cost		
Heating	£51,327.92	Pa
Hot water	£17,365.74	Pa
Fans and Pumps	£6,851.16	Pa
Lighting	£13,702.31	Pa
Total Running Costs	£89,247.13	Pa
Average annual Running Costs per residential unit	£324.54	Pa

Key Sustainability Items

- Development will maximise passive solar gain through providing adequate window sizes and improved daylight, correct g-Value and orientation
- Water butts installed to each dwelling (please refer to planning layout for positions of water buts)
- Bicycle storage provision to each dwelling (please refer to planning layout for positions of cycle store or garages)
- Reduce surface-water run off
- To comply with Approved Document Part G, Water use less than 125ltres per person per day

1.3. Option 1

As part of our investigations into betterment of energy efficient measures and CO_2 reduction, we have calculated quantities of Photovoltaic panels as a solution to achieve a 10% reduction in Carbon emissions and Primary Energy. The following calculations are based on the installation of PV as follows.

Table 4: Low or Zero Carbon Specification	
LZC	250watt Photovoltaic PV panels either polycrystalline or Môn crystalline

12N° 250watt Panels providing 3.00Kw Peak PV installed to all 37 suitable dwellings with south facing roof aspect, exact plots to be confirmed.

Energy (Primary)	**N° of Plots**	**Kw**	
Heating			1709489.30
Hot water			578370.37
Fans and Pumps			151429.67
Lighting			302859.34
Total standard case energy requirements based on proposed specification			2742148.69
Reduction through LZC			
Reduction in energy through LZC technology	37	7905.86	292516.97
Percentage reduction			**10.67%**
Carbon emissions	**N° of Plots**	**CO2**	
Heating			302663.68
Hot water			102400.00
Fans and Pumps			25600.00
Lighting			51200.00
Total standard case carbon emissions based on proposed specification			481863.68
Reduction through LZC			
Reduction in Carbon emissions through LZC technology	37	1336.53	49451.57
Percentage reduction			**10.26%**

Other considerations, the District Network Operator (DNO) will need to be notified of the intension to install the PV systems which can be done through a G83 application. There may be costs associated with upgrade requirements of the existing electrical network and distribution.

1.4. Option 2

Alpha Gas saver 2 or Flow smart installed to each dwelling subject to Domestic Hot water requirements

Energy (Primary)	**N° of Plots**	**Kw**	
Heating			1709489.30
Hot water			578370.37
Fans and Pumps			151429.67
Lighting			302859.34
Total standard case energy requirements based on proposed specification			2742148.69
Reduction through FGHRS			
Reduction in energy through LZC technology	256	1202.32	307794.48
Percentage reduction			**11.22%**
Carbon emissions	**N° of Plots**	**CO2**	
Heating			302663.68
Hot water			102400.00
Fans and Pumps			25600.00
Lighting			51200.00
Total standard case carbon emissions based on proposed specification			481863.68
Reduction through FGHRS			
Reduction in Carbon emissions through LZC technology	256	212.87	54494.76
Percentage reduction			**11.31%**

2. Introduction

Anderson Goddard Ltd has been commissioned by Kier Living to provide an energy statement and Low or Zero Carbon (LZC) feasibility assessment for the proposed development at Preston Road, Longridge.

This report is carried out at RIBA stage C and the objective of this feasibility assessment is to identify suitable Low or Zero Carbon technologies (LZC) which could be capable of providing a reduction in energy demand of 10% as required by the following policies

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

For dwellings assessed against the Code for Sustainable Homes (CSH) there is also a mandatory requirement to satisfy Energy 1 (ENE1) which would require a reduction in the Target Emission Rate (TER) for the dwelling depending on the proposed Code level required. The reduction in CO_2 above AD.L1a2013 building regulations would be as follows.

- **Code 3   0% (A.D. Part L1a 2013)**
- **Code 4   19%**
- **Code 5   100%**
- **Code 6   Zero carbon**

2.1. 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).
The percentage reduction of CO_2 emissions provided by the technology is assessed against the total CO_2 emissions for the dwelling or the development and includes emissions from heating, lighting, cooking and household appliances.
Installers of LZC technologies must be members of a Micro Certification Scheme (MCS), a MCS certification ensures LZC technologies are properly installed and commissioned. Grants and other financial incentives such as FIT and RHI will not available if the installer is not a member of the appropriate MCS scheme.

2.2. Calculation methodology

As discussed in more detail in other sections of this report a SAP calculation SAP 2012 takes no account of the CO_2 emissions associated with cooking or appliances therefore a Zero carbon dwelling will need to produce energy which would offset the CO_2 emissions associated with cooking and appliances.

The calculations and methodology used in this study have been taken from the Nov 2010 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 benefit 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) revised November 2010.

2.3. Assessment methodology

The following methodologies approved documentation and practices have been used in the compilation of this report.

- SAP 2012 (SAP)
- Approved document Part L1a of the building regulations 2013
- Domestic Building Services Compliance Guide 2013
- Chess best practice part L 2013
- Code for Sustainable Homes (CSH)
- London renewable Tool Kit 2004

SAP, the governments “Standard Assessment Procedure” for calculating the energy performance of a dwelling and is used primarily for the purpose of satisfying approved document Part L1 of the Building regulations 2006 CSH Energy 1 and 2 requirements and is also is the calculation engine which is used to generate an Energy Performance Certificate (EPC). The calculation assesses energy, CO_2 emissions and running costs of a dwelling but takes no account energy, CO_2 emissions and operating costs associated with appliances and cooking.

Occupants

The calculation to determine estimated CO_2 emissions associated with cooking and appliances is in three parts, the first part takes account of standard occupancy ref SAP2012 Table 1b.

If TFA > 13.9: $N=1+ [1-\exp(-0.000349 \times (TFA-13.9)^2)] + 0.0013 \times (TFA-13.9)$
If TFA < 13.9: N=1

Where TFA is the total floor area and N is the number of occupants

Appliances

The second part of the calculation takes into account electrical use from appliances ref appendix L2 SAP 2012

$E_a = 207.8 \times (TFA \times N)^{0.4714}$

$E_a \times EF_{electricity}$ /TFA

Were TFA is the total floor area in m² and N is the assumed number of occupants

Cooking

(119 + 24N)/TFA

Where TFA is the total floor area and N is the number of occupants
All assessments of benefit in terms of CO_2 reduction provided by upgrade measures or LZC technologies including heating and innovative technologies will be assessed as a percentage of the total estimated CO_2 emissions which will include heating, ventilation, lighting, pumps and fans from SAP 2005 and also CO_2 emissions provided by the calculation process above for Cooking and appliances.

SAP 2012 CO_2
- Heating
- Ventilation
- Lighting
- Pumps and fans

SAP 2012 appendix L
- Cooking
- Appliances

A SAP calculation generates four ratings a SAP rating and potential SAP rating and Environmental Impact (EI) rating and potential EI rating, all ratings are out of 100.

A SAP rating is an indication of heating and lighting costs, the higher the rating the lower the fuel costs will be.

Environmental Impact (EI) rating is an indication of CO_2 emissions produced by heating and lighting, the higher the rating the lower the Carbon emissions will be.
An assessment of the total CO_2 emissions will be established using the guidelines and methodology from the Code for Sustainable Homes (CSH) section Energy 7 (ENE7) as described above and will be used to assess the benefit provided by the proposed Low or Zero Carbon technology or innovative technology solution.

The methodology used by Energy 7 (ENE7) of the Code for Sustainable Homes (CSH) is a calculation process that assesses the benefit of the proposed LZC technology against a notional gas heated dwelling following minimum heating specifications provided by the minimum heating compliance guide. In the UK natural gas would considered as the main fuel used for domestic heating and hot water and therefore provides a good base line for comparison purposes.

Fuel prices have been taken from the BEDF database, this database is used in the formulation of the Energy Performance Certificate (EPC).

Estimates on payback period and cost in £ per Kg CO_2 saved have been calculated based on current fuel prices and do not take account of unknown factors such as increases in fuel costs. Known financial incentives such as the Feed In Tariff (FIT) and Renewable Heat Incentive have been included in the calculations to determine the benefit provided by micro generation technologies and other available grants and financial incentives have not been included. All calculations have been based on 0% inflation and 0% fuel cost increases.

2.4. 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 long term energy and 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.

The recommendations made by the Zero Carbon Hub (ZCH) 'Defining a fabric energy efficiency standard' which was published in November 2009 and has been adopted by both SAP2012 and the November 2010 version of the Code for Sustainable Homes as well as Planning authorities such as Merton, Croydon to name but a few.

Fabric specification recommended by the Zero Carbon Hub

Fabric specification recommended by the Zero Carbon Hub		
	Part L2010	ZCH Fabric Specification W/m²K
External Walls	0.30	0.18
Party Cavity Wall	0.20	0.00
Semi exposed walls	0.30	0.18
Ground Floor	0.25	0.18
Roof Insulation (Cold)	0.16	0.13
Windows	1.60	1.60
Doors	1.80	1.80
Thermal Bridging	0.115	0.04
Air permeability	10.00	4.00

Mandatory Zero Carbon FEE levels	Mid/apartment	39 Kw/m²/pa
	End Terrace, Semi & Detached	46 Kw/m²/pa

The benefit from LZC technologies to reducing carbon emissions will vary in the future and will depend on changes to the specific carbon factors associated with the type of fuel being displaced.

For example electricity currently has a high carbon factor and therefore LZC technologies that produce electricity have a large effect in reducing CO_2 emissions, in the future as the carbon factor of electricity reduces the effect of these technologies to reduce carbon will also reduce.

All LZC technologies require some form of maintenance and in the case of a sealed solar thermal installation the costs associated with maintenance would be much higher than any savings made through energy reduction. Forcing developers to fit LZC technologies essentially forces the developer to impose liabilities and financial burden associated with upkeep and maintenance onto the consumer.

LZC technologies will not provide energy or CO_2 reduction indefinitely and probably for only a short period of time when measured against the potential life span of the property, when the technology eventually requires repair if the property owner cannot afford the repair then as a minimum the net result would be an increase in both energy and CO_2 emissions and in extreme cases loss of basic provisions such as heating and hot water.

2.5. Unregulated emissions, Energy monitoring, Voltage optimisation and handover

Unregulated emissions

It can be seen in the Carbon split pie graph in section 1.1 that unregulated emissions account for over half of all carbon generated by the development . The following would reduce carbon emissions and energy in excess of that proposed by the current LZC proposal as should be considered as an alternative to renewables.

If the following were used in conjunction with a fabric first methodology then the carbon savings would be in excess of 20%.

Energy Monitoring

It has been proven that seeing where energy is used helps energy to be reduced, we estimate that this would represent a 5% carbon reduction as per industry recognised standard reduction.

Energy monitoring devices can be reviewed at the following sites.

Electric monitoring - http://www.theowl.com/products/owlmicro.php
Gas and electric monitoring including water - https://www.ewgeco.com/company/smart-metering

Most energy providers are installing smart meters as standard

Voltage optimisation

Independent tests of voltage optimisation have shown typical savings of 12% of electrical consumption which would represent a 6.68% overall carbon reduction.

Voltage can vary between 220volts to 260volts however only 230volts is all that is required by electrical appliances. Voltage optimisation limits the voltage to 230volts and therefore reduces energy.

http://www.vphase.co.uk/faqs/what-savings-can-i-expect-

http://www.vphase.co.uk/

Soft Landings Handover

It has been proven that without proper handover that estimated design energy predictions of a development can be wildly inaccurate and in realty could be up to twice the design prediction.
It is our intention therefore to propose a soft landing approach to handover.

Estimates of energy reduction through a soft landing approach to energy reduction could be as high as 50% although for the purpose of this report we estimate a 9% energy saving overall.

For the purposes of this feasibility assessment notional site emissions have been grossed up by a very conservative 10% this would equate to a 9% overall carbon reduction.

Refer to soft landings web site for further information.

http://www.bsria.co.uk/services/design/soft-landings/

3. The development

The residential development at Preston Road will comprises a total of 256 dwellings which are to achieve compliance with approved document PartL1a of the building regulations 2013.

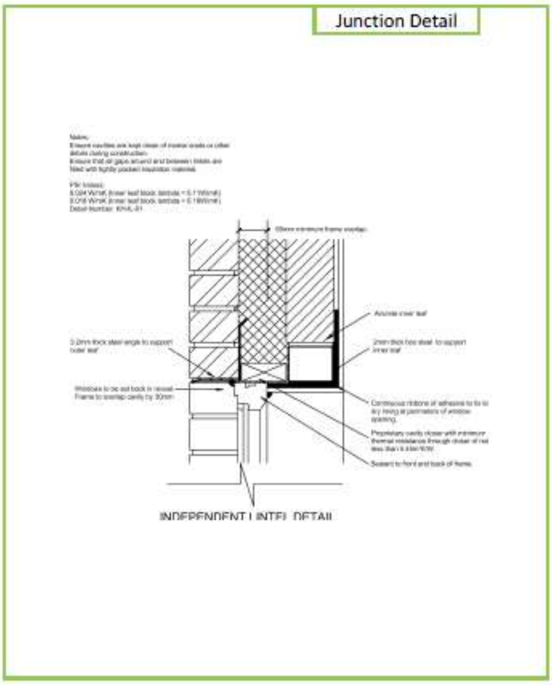
3.1. Housing mix

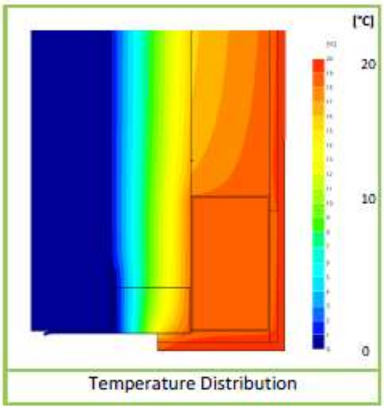
House types	Number	Area fT²	Area m²	Total area m²
Bungalow	38	633	58.81	2234.62
Denton	20	692	64.29	1285.74
Cedarwood	37	800	74.32	2749.84
Elderwood	13	892	82.87	1077.27
Holmewood	22	906	84.17	1851.68
Hopwood	18	928	86.21	1551.80
Chelmsford	9	1250	116.13	1045.13
NT1	12	1446	134.33	1612.00
Hareford	12	1268	117.80	1413.57
Mapleford	15	1376	127.83	1917.46
Cranford 2	19	1446	134.33	2552.33
Pensford	14	1575	146.32	2048.45
Ellesworth	17	1765	163.97	2787.46
Ravensworth	10	2256	209.58	2095.82
Total	256			26223.16

3.2. Thermal Bridging

Heat loses associated with non-repetitive thermal bridging have been considered in detail and have been improved through modelling by the use of specialist 2D/3D thermal modelling software to BR433.

Example of a window lintel detail

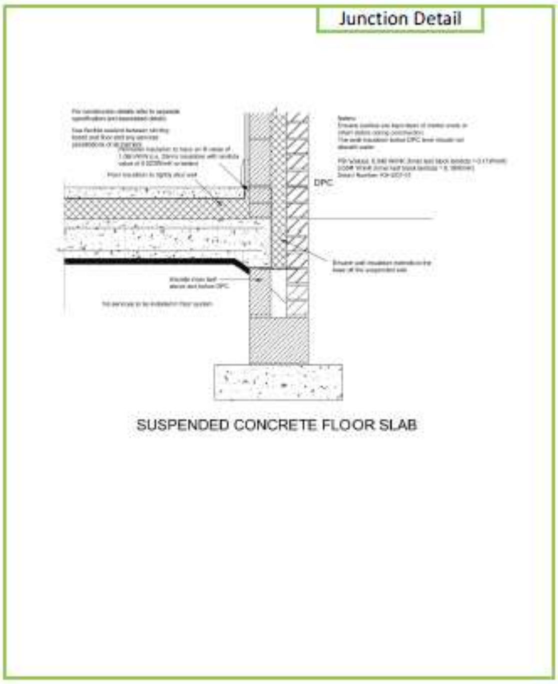


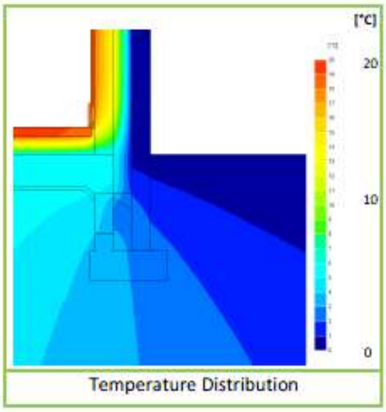


Linear Thermal Transmittance W/m.K	
Ψ =	0.018

Temperature Factor[3] for Humidity and Mould	
f =	0.939

Example of an exposed ground floor / wall bridging detail.





Linear Thermal Transmittance W/m.K	
Ψ =	0.040

Temperature Factor[3] for Humidity and Mould	
f =	0.924

4. Low or Zero Carbon 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
- PV-Thermal
- Small scale hydro power
- Wind turbines
- Solar Air heating

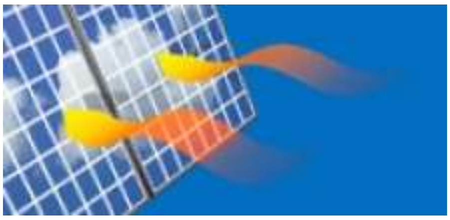
Low carbon technologies

- 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
- Sunwarm
- Geothermic storage

4.1. Solar Water



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.

Fuel Displaced	£ Saving per year	CO_2 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 semidetached 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 regular maintenance. A yearly check by the householder and a more detailed check by a professional installer every 3-5 years should be sufficient.

4.2. 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 10² 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.

4.3. Solar PV / Thermal

PV-T is an integrated panel that produces both electricity and heat.

Benefit

Traditional PV systems produce heat as a bi product of the electric production which causes the PV collector to reduce in efficiency, as a rule of thumb a PV collector will reduce in efficiency by 0.5% for every 1°C increase in temperature above normal operating temperatures, PV temperatures can exceed 85°C. PV-T systems are designed to cool the collectors and use the collected heat for water and space heating.

How it works

By cooling the PV panel with either water or air the collector will operate up to 25% more efficiently resulting in a smaller area of PV required to generate the same amount of energy compared to a typical PV collector, the heated water or air can then be used to provide the dwelling with heating and or hot water depending on system design.

Cost and Maintenance

The cost of the PV-T system will be very similar to the combined cost of Solar thermal and solar PV and the technology is more suited to Code 5 or code 6 plots because of the reduced area of PV required which would free up available roof area.

4.4. Hydro

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.

4.5. 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 convert 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.

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.

4.6. Bio Mass

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 CO_2 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

Standalone 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 semidetached 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.

4.7. Heat Pumps

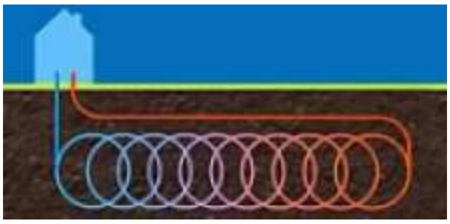
There are two types of heat pumps, ground source and air source.
Heat pumps work in a very similar way to fridges and air conditioners and absorb heat from the ground or from the air.
Ground or air source heat pumps are mainly designed to work with under floor heating systems because of the lower design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

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.

4.8. CHP

Combined heat and power (Chp) and Micro combined heat and power (Micro Chp)
CHP (combined heat and power) earlier CHP units 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

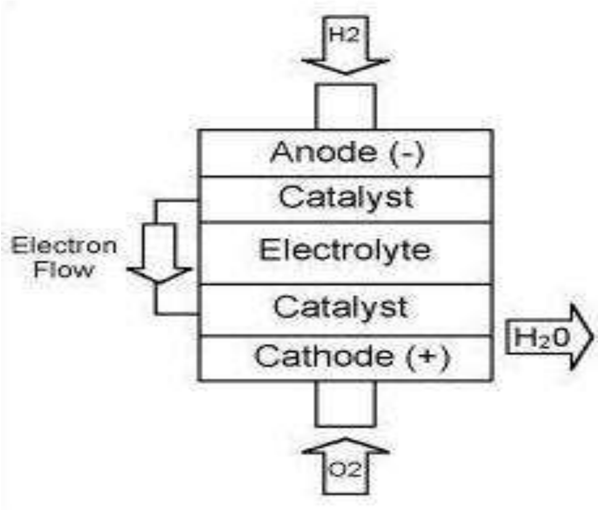
Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of bio fuel. One type of biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure 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)

4.9. 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.

5. 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.

5.1. Flue Gas Heat Recovery Systems (FGHRS)

The Flue Gas Heat Recovery System is not considered as a low carbon technology although it will be included in a draft consultation by the Energy Saving Trust.
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.

5.2. Waste Water Heat Recovery Systems (WWHRS)

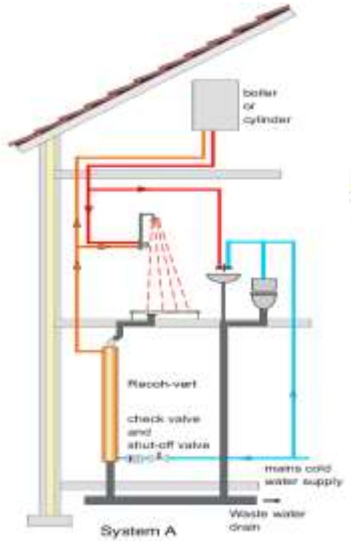


Figure 1

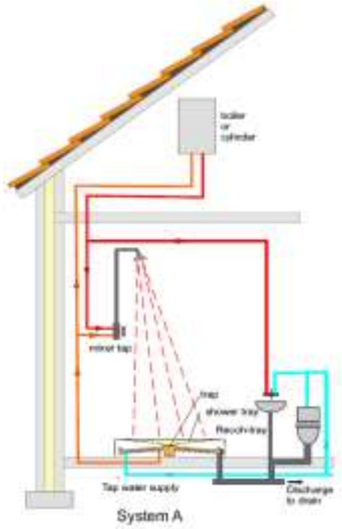


Figure 2

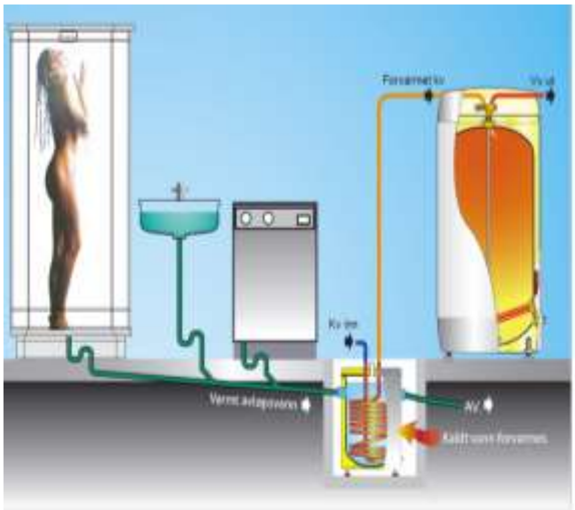


Figure 3

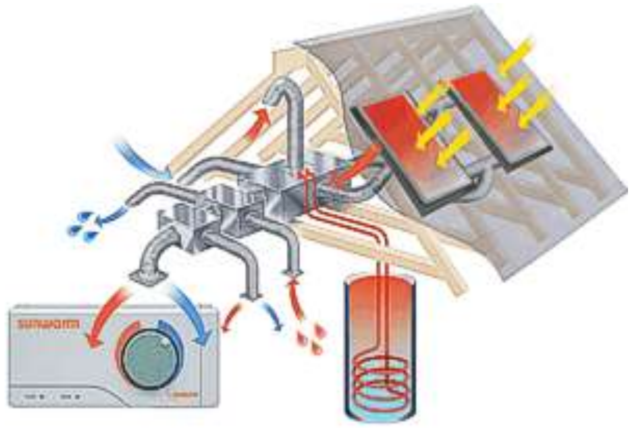
Shower Saver (figure 1 & 2)

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.

5.3. Sunwarm



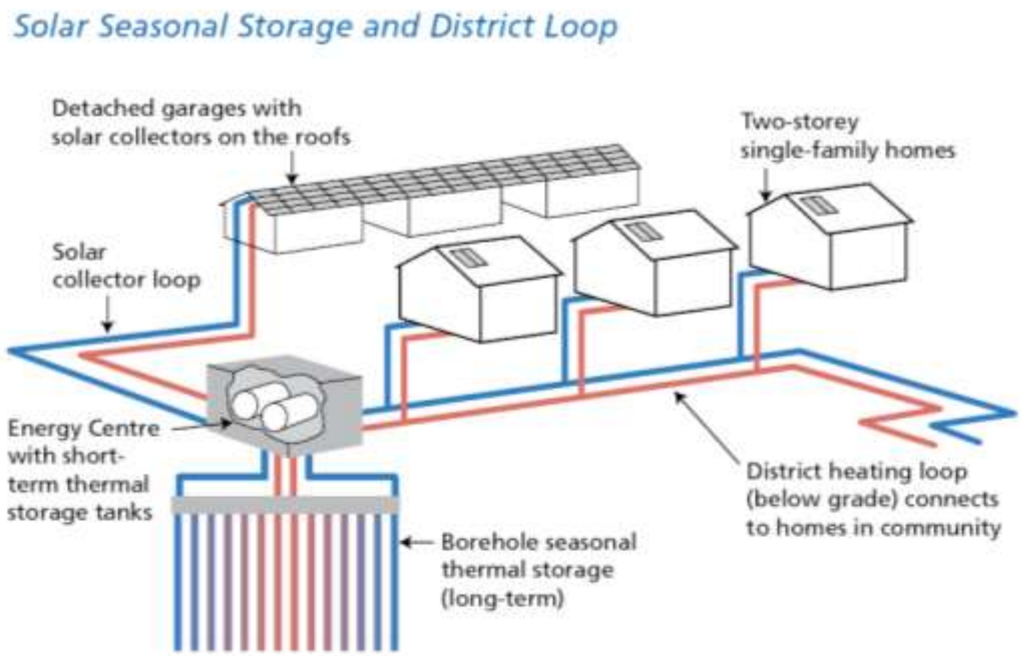
The Sunwarm System developed by Nuaire could be classified as a LZC technology and was listed on the DTI clear skies renewable energy grant scheme, the technology has been included in this innovative section subject to confirmation of its exact classification.

The Sunwarm system is a system that uses solar radiation in the same way Solar thermal uses solar radiation to heat water, the Sunwarm system uses solar radiation to heat air which is then introduced through the ventilation ducting and into the dwelling, the Sunwarm system can also be used to heat water by way of an air to water heat exchanger.

The unit is in the process of being tested by the BRE and will be eventually included in the appendix Q database.

The manufactures claim that the energy saved by the unit as assessed over a winter period will be approximatley1500 Kw and therefore the unit should provide in excess 1500 Kw if assessed over the full year. For the purpose of this feasibility assessment the conservative figure of 1500Kw has been used in the calculation process although this may change when the unit has been entered on the appendix Q database

5.4. Geothermic Storage



Geothermic storage systems are and are intended to be used in conjunction with Solar thermal or PV-T systems. The heat produced by both systems can be stored in boreholes in the ground and the heat can then be used throughout the winter period to provide heating through community heating circuits.

The concept was conceived by the Canadian Government and implemented at Drake Landing Okotoks, Alberta, Canada and has successfully integrated the technology and an unlimited solar energy supply feeding 52 homes.

Borehole thermal energy storage allowed water to be heated and collected in large quantities for use in winter, at the end of summer the water was measured to reach temperatures of 80°C and even at the low temperatures associated with the Canadian winters the water temperature at the end of the winter period had been measured at 50°C.

Currently there is no way of assessing the benefit of the Geothermic storage system because of limited test data and therefore the system has not been considered further in this study.

For more information on the Drake landing Solar community please visit www.dlsc.ca

6. Excluded technology

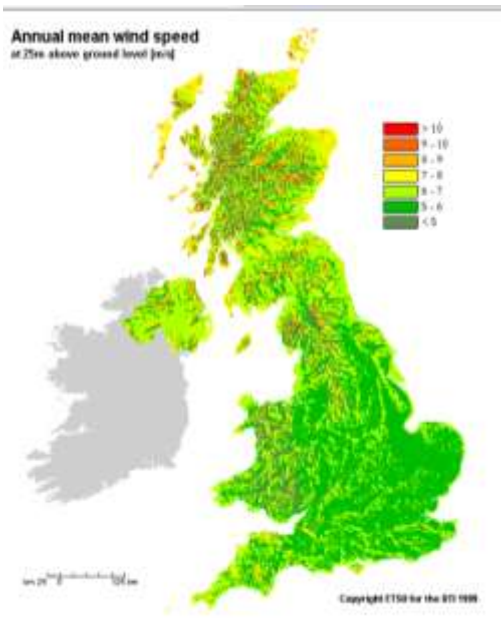
Low or Zero Carbon not thought appropriate for use at the proposed development.

- Large Mast Wind turbines
- Small scale hydro power
- 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)

LZC technology and reasons for their exclusion

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 **5 meters per second**, 10 meters above ground level according to the NOABL database; therefore large mast wind turbines may 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 although it is thought that the land use requirements would be Impractical.

5.2	5	4.6
5	5	4.6
4.6	4.8	4.9

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

Air Source Heat pumps ASHP (electric)

The results from previous ENE7 feasibility studies and planning reports for residential dwellings where CO_2 emissions from a dwelling fitted with an ASHP were compared to the CO_2 emissions from a gas heated notional dwelling concluded that Air source heat pumps do not provide a reduction in CO_2 emissions and may actually increase both CO_2 emissions, energy consumption and running costs as experienced by the occupier.

Air Source heat pumps may provide a reduction in CO_2 emissions for offices, hotels and commercial applications where a cooling load is also required.

Planning authorities may allow ASHP to contribute towards CO_2 reductions for residential or mixed use all electric developments where gas is not available.

The Code for Sustainable Homes section 7 (ene7) compares the benefit in terms of CO_2 of all Low or Zero Carbon Technologies (LZC) against notional gas heated dwellings and therefore ENE7 would not be available.

As discussed in section 6.2 the majority of electricity produced in the UK is provided by the burning of fossil fuels and therefore the pollution associated with the use of electricity and increased electrical consumption associated with ASHP would increase. For this reason Code for Sustainable Homes (CSH) section Pollution 2 (pol2) credits would not be available.

After taking into account the high efficiencies associated with ASHP there would be still an increase in pollution and CO_2 emissions associated with increase in electric consumption and electric demand, together with the following CSH ENE7 and POL2 credits that would not be available ASHP will not be considered a suitable LZC technology.

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.

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 supporting this type of technology.

Specific details relating to the new commercial / retail element of the scheme is so far unknown, energy from wasted heat from use of these building may be able to contribute towards the heat requirements of residential units and this should be considered in greater detail one this information becomes available.

Other technologies
Fuel cell etc, not yet fully commercially available.

7. Considered technology

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

- Solar Hot Water
- Solar Photovoltaic
- Micro wind (roof mounted)
- Biomass
- Micro Chp
- FGHRS*
- WWHRS*
- Sunwarm*
- Ground Source Heat Pump (GSHP)
- Biogas community heating

* Not classified as LZC technologies but an assessment has been carried out for comparison purposes.

7.1. Standard case

Information for this feasibility study has been provided by standard case SAP calculations, CO_2 emissions for cooking and appliances have been calculated following the procedures outlined in section 1.2.

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

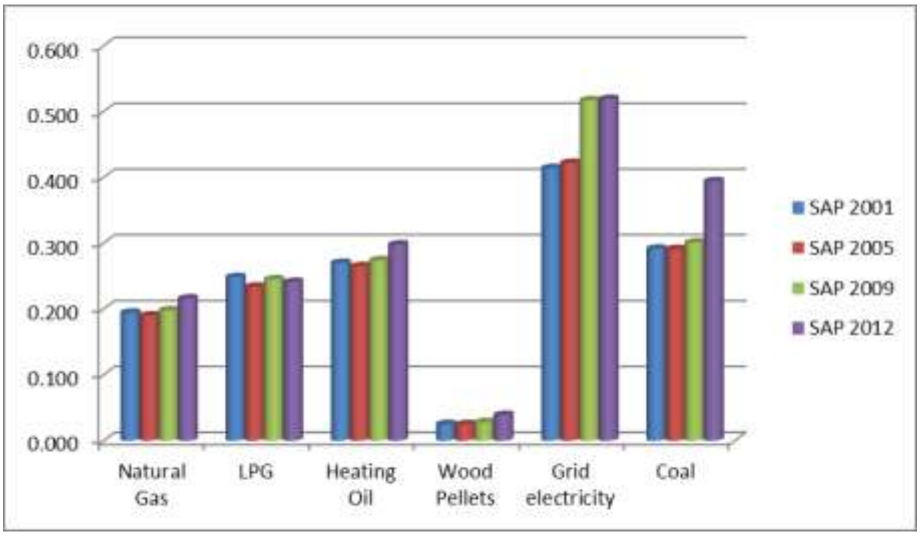
From these initial calculations a base line emission rate for the development has been established and the benefit provided by each LZC technology compared to the notional gas model in order to provide a realistic comparison.

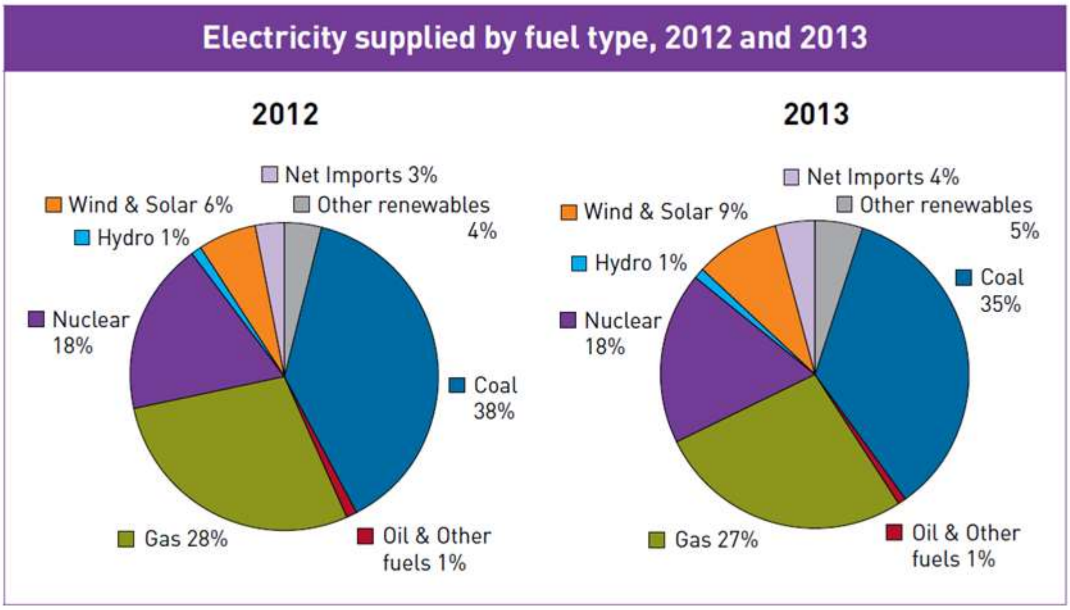
Fuel costs used in the comparison have been taken from the SEDBUK fuel cost database.

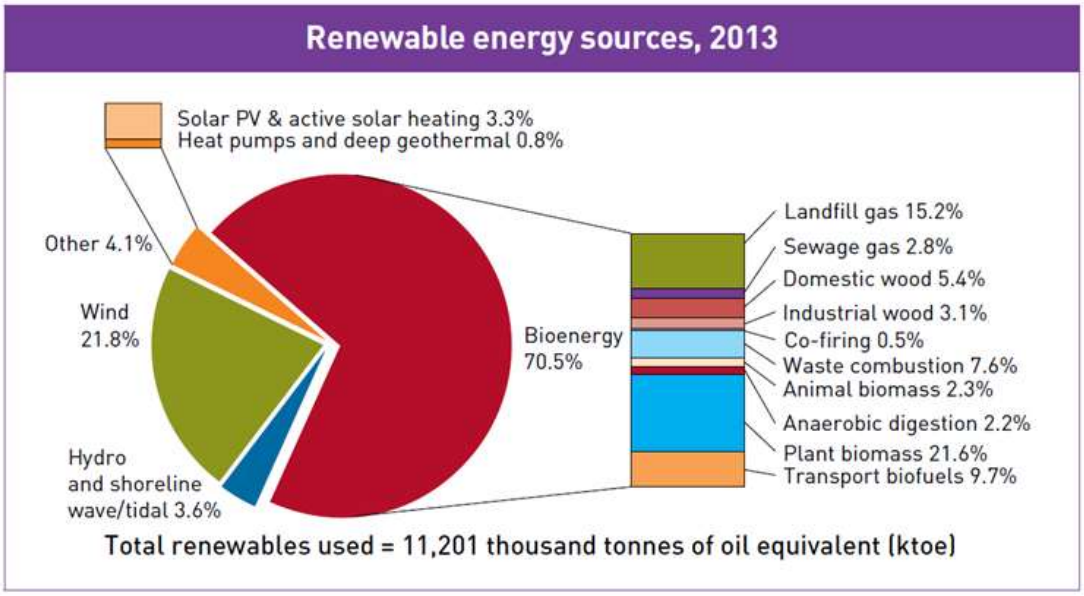
7.2. Fuel choice

All assessments with exception of Bio fuel assessments have assumed mains natural gas is available in preference to LPG and therefore compared like for like against the standard case and table 1 assessment.

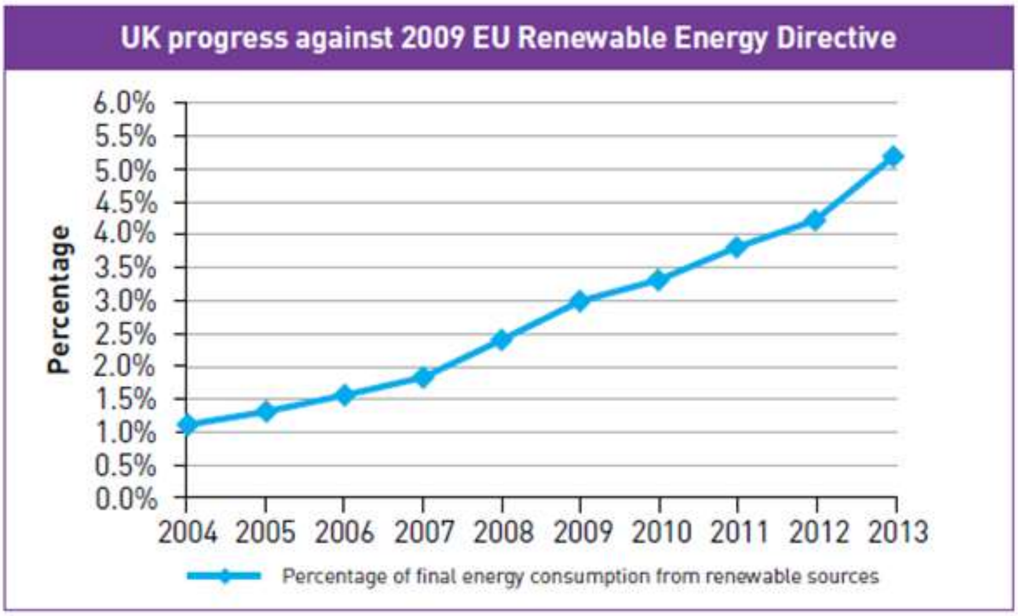
Electricity as a fuel choice would increase both CO_2 emissions and fuel cost as experienced by the occupier, as previously discussed air source heat pumps would not provide a reduction in CO_2 emissions and may even increase CO_2 compared to the standard case mains gas energy model and therefore heat pumps should only be considered when mains gas was not available. LPG would produce slightly more CO_2 than natural gas but would have increase running costs as experienced by the user, please refer to the following table which also shows CO_2 emissions associated with the different fuels used in SAP 2012.



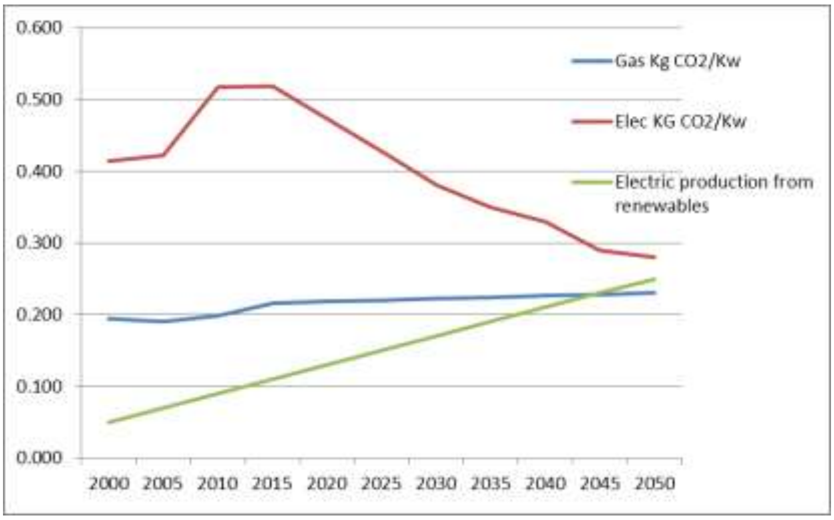




The CO_2 emissions associated with electric production in the UK are very high due to the fact that 63% of electricity production in the UK is produced by high carbon fossil fuels and 14% is produced from renewable resources therefore the cost of electricity is largely dependent on the fuel costs of base fuels such as oil, coal and gas and electric prices will increase in line with these primary fuel prices.



Whilst the contribution by renewables is 15% of Electrical generation the total contribution from renewables technologies for all energy used in the UK is 5.2% which is well below the EU target of 20% and UK Government's commitment of 15% by 2020.

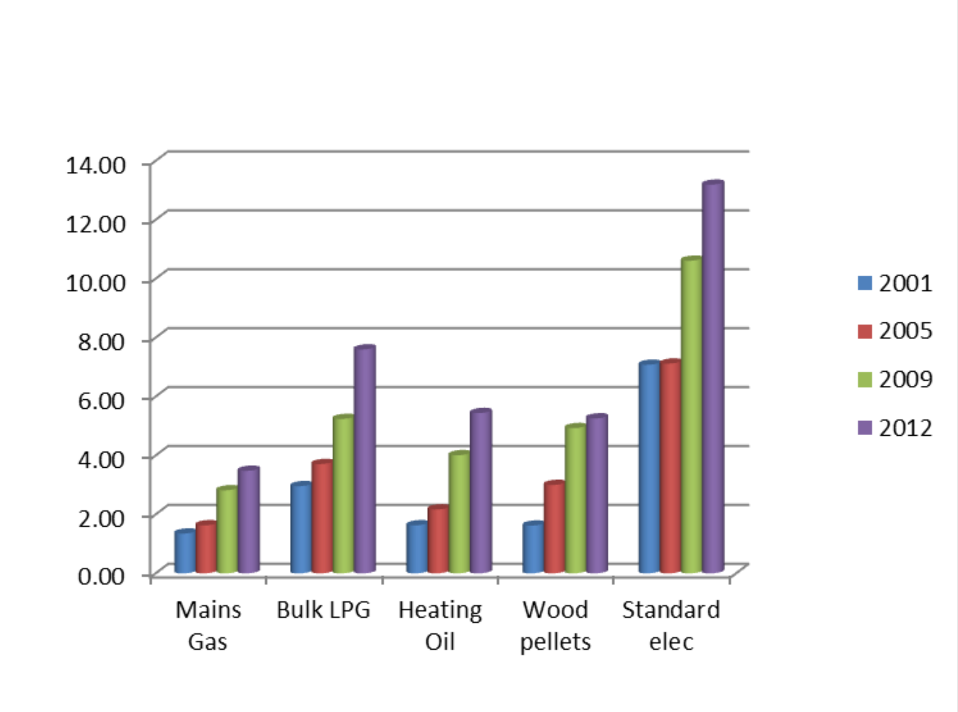


The graph represents an estimate of CO_2 emissions for both gas and electricity and how they may change over the following years; data has been taken from SAP 2001, 2005, 2009 and 2012 documents as well as the Government's 15 Year projection for emission factors and primary energy factors.

7.3. Fuel costs and Fuel Security

Gas and oil imports are expected to rise from 16% in 2005 to 73% by 2020 and there is a major concern over both price and security of supply.

The graph shows the current cost of fuel in pence compared to fuel prices in 2001.



Percentage increases in fuel costs in 2009 compared to 2001 fuel prices

Mains Gas	157.78%
Oil	223.74%
Electric	224.69%

Gas has overtaken coal over recent years and is currently the major energy source in power stations providing over 43% of electric production therefore any significant increase in gas or coal prices will also increase the cost of Electricity and other fuels that rely on Electricity for production.

The cost of fuel and associated CO_2 reduction do not always go hand in hand for example bio fuels provide the greatest reduction in CO_2 emissions but at an increased running cost when compared to the cost of natural gas.

7.4. Feed In Tariff (FIT)

Feed In Tariffs (FIT) were introduced in April 2010 to encourage Micro Generation, the tariffs will replace previous grants and provide an income per Kw of electricity produced depending type and size of generation equipment.

Feed-in Tariff (FIT) Generation & Export Payment Rate Table

1 April 2016 - 31 March 2019

Description		2016/17				2017/18				2018/19			
		1 Apr to 30 Jun 2016	1 Jul to 30 Sep 2016	1 Oct to 31 Dec 2016	1 Jan to 31 Mar 2017	1 Apr to 30 Jun 2017	1 Jul to 30 Sep 2017	1 Oct to 31 Dec 2017	1 Jan to 31 Mar 2018	1 Apr to 30 Jun 2018	1 Jul to 30 Sep 2018	1 Oct to 31 Dec 2018	1 Jan to 31 Mar 2019
Hydro generating station with total installed capacity of less than 100kW		7.68	7.66	7.65	7.63	7.61	7.61	7.59	7.58	7.56	7.55	7.53	7.52
Hydro generating station with total installed capacity greater than 100kW but not exceeding 500kW		6.14	6.13	6.12	6.11	6.11	6.10	6.09	6.09	6.08	6.07	6.06	6.06
Hydro generating station with total installed capacity greater than 500kW but not exceeding 2 MW		6.14	6.13	6.12	6.11	6.11	6.10	6.09	6.09	6.08	6.07	6.06	6.06
Hydro generating station with total installed capacity greater than 2 MW		4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43	4.43
Solar photovoltaic (other than stand-alone) with total installed capacity of 10 kW or less	Higher	4.32	4.25	4.18	4.11	4.04	3.97	3.90	3.83	3.76	3.69	3.62	3.55
	Middle	3.89	3.83	3.76	3.70	3.64	3.57	3.51	3.45	3.38	3.32	3.26	3.20
	Lower	0.74	0.68	0.63	0.58	0.52	0.47	0.41	0.37	0.32	0.26	0.21	0.15
Solar photovoltaic (other than stand-alone) with total installed capacity greater than 10 kW but not exceeding 50kW	Higher	4.53	4.46	4.39	4.32	4.25	4.19	4.12	4.05	3.98	3.91	3.85	3.78
	Middle	4.08	4.01	3.95	3.89	3.83	3.77	3.71	3.65	3.58	3.52	3.47	3.40
	Lower	0.74	0.68	0.63	0.58	0.52	0.47	0.41	0.37	0.32	0.26	0.21	0.15
Solar photovoltaic (other than stand-alone) with total installed capacity greater than 50 kW but not exceeding 250kW	Higher	2.38	2.32	2.26	2.21	2.15	2.10	2.04	1.98	1.93	1.87	1.82	1.76
	Middle	2.14	2.09	2.03	1.99	1.94	1.89	1.84	1.78	1.74	1.68	1.64	1.58
	Lower	0.74	0.68	0.63	0.58	0.52	0.47	0.41	0.37	0.32	0.26	0.21	0.15
Solar photovoltaic (other than stand-alone) with total installed capacity greater than 250 kW but not exceeding 1 MW		1.99	1.94	1.88	1.83	1.77	1.72	1.67	1.60	1.55	1.49	1.44	1.39
Solar photovoltaic (other than stand-alone) with total installed capacity greater than 1 MW		0.74	0.68	0.63	0.58	0.52	0.47	0.41	0.37	0.32	0.26	0.21	0.15
Stand-alone solar photovoltaic		0.74	0.68	0.63	0.58	0.52	0.47	0.41	0.37	0.32	0.26	0.21	0.15

Description		2016/17				2017/18				2018/19			
		1 Apr to 30 Jun 2016	1 Jul to 30 Sep 2016	1 Oct to 31 Dec 2016	1 Jan to 31 Mar 2017	1 Apr to 30 Jun 2017	1 Jul to 30 Sep 2017	1 Oct to 31 Dec 2017	1 Jan to 31 Mar 2018	1 Apr to 30 Jun 2018	1 Jul to 30 Sep 2018	1 Oct to 31 Dec 2018	1 Jan to 31 Mar 2019
Wind with total installed capacity of 50kW or less		8.46	8.39	8.33	8.26	8.19	8.13	8.06	7.99	7.93	7.86	7.79	7.73
Wind with total installed capacity greater than 50kW but not exceeding 100 kW		7.61	7.61	7.50	7.43	7.37	7.32	7.25	7.19	7.14	7.07	7.01	6.96
Wind with total installed capacity greater than 100kW but not exceeding 1.5 MW		4.89	4.89	4.83	4.81	4.79	4.76	4.73	4.71	4.68	4.65	4.63	4.61
Wind with total installed capacity exceeding 1.5MW		0.85	0.85	0.83	0.82	0.81	0.79	0.78	0.77	0.76	0.75	0.74	0.73
Anaerobic digestion with total installed capacity of 250kW or less		8.21	8.21	8.21	8.21	8.21	8.21	8.21	8.21	8.21	8.21	8.21	8.21
Anaerobic digestion with total installed capacity greater than 250kW but not exceeding 500kW		7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58
Anaerobic digestion with total installed capacity greater than 500kW		7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81
Combined Heat and Power with total installed capacity less than 2kW		13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45
Export Tariff		4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91

Note: FIT Payment rates for solar photovoltaic installations have been determined by the Gas and Electricity Markets Authority (Ofgem) under Article 13 of the Feed-in Tariffs Order 2012, in accordance with Annex 3 to Schedule A to Standard Licence Condition 33.

All tariff rates are specified as pence per kilowatt hour at 2016/17 values.

https://www.gov.uk/feed-in-tariffs

7.5. Renewable Heat Incentive (RHI)

The domestic RHI scheme opened on 9 April 2014.

It is a financial incentive scheme designed to encourage uptake of renewable heating among domestic consumers. The domestic RHI is targeted at, but not limited to, homes off the gas grid. Those without mains gas have the most potential to save on fuel bills and decrease carbon emissions.

The scheme will cover single domestic dwellings and will be open to homeowners, private landlords, social landlords and self-builders. It will not be open to new build properties other than self-build.

The domestic RHI will pay the following tariffs per unit of heat generated for seven years:

Applications submitted	Biomass boilers and stoves	Air source heat pumps	Ground source heat pumps	Solar thermal
01/04/2016 - 30/06/2016*	5.20p	7.51p	19.33p	19.74p
01/07/2016 - 30/09/2016*	If any new tariff changes are to be made due to degression, the next announcement by DECC would be by 1 June 2016.			

The tariffs have been set at a level that reflects the expected cost of renewable heat generation over 20 years. Payments will be made on a quarterly basis.

The Government is proposing an amendment to the Infrastructure Bill 2014/15 which will introduce an amendment to the primary legislation governing the Renewable Heat Incentive (RHI) schemes. The proposed amendment would allow participants to allocate their RHI payments to third parties and allow the Secretary of State to appoint an alternative body to deliver the schemes in the future. The amendment would also allow some future changes to the scheme to be made by the negative resolution procedure.

https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi

7.6. Community heating

Community heating systems are obviously not considered as LZC technologies although can provide an ideal match between the heating load requirements and allow the boiler regardless of fuel choice to work at optimal efficiency and therefore provide a reduction in CO_2 emissions, energy use and running costs.

Community heating systems are generally more suited to high density developments such as low or high rise apartments and sheltered accommodation where the losses associated with distribution can be kept to the minimum and therefore community heating may not be considered suitable for low density housing developments.

The following fuels and technologies could be used in conjunction with community heating systems, installation savings and potential CO_2 savings would apply to all assessed technologies and fuels should the development and housing occupation suit such a scheme.

- Bio fuels including Biomass, Bio Oil, Biogas
- Gas
- LPG
- Ground source Heat pumps
- PV/T
- CHP

Stigma associated with community and district heating schemes in relation to controllability and ownership would be a major factor in choosing this as a solution, however these concerns are unfounded and are generally drawn from prior experience of district heating schemes installed in the 1960's when the availability of controls and heat meter billing was very primitive.

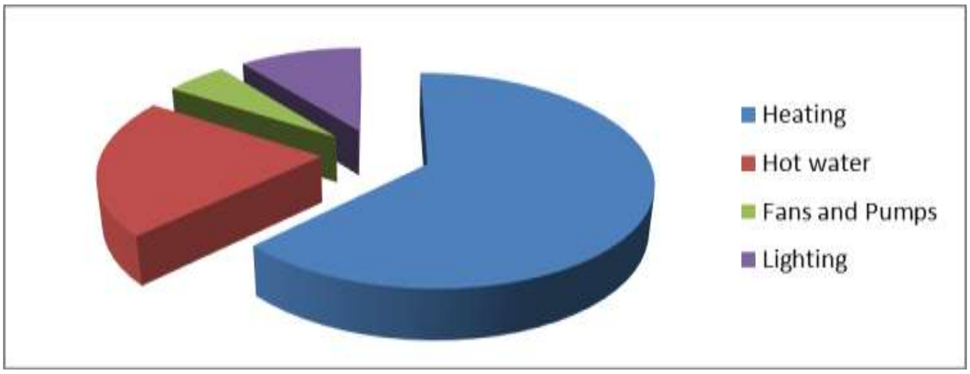
Case Study (Aberdeen)

The District Heating Scheme at Aberdeen supplies 198 domestic dwellings and cost the local authority £700K; the remaining funding was obtained from the Government Community Energy Programme.

http://www.dalkia.co.uk/docs/case/localauthorities/Aberdeen%20City%20Council.pdf

8. Assessment, The development Baseline emissions

The estimated baseline emissions and energy requirement of the proposed development has been calculated using the specification provided in section 2.2 and the specification for the heating has been taken from the minimum heating requirement from the heating compliance guide as listed in section 6.1.



Energy (Primary)		
Heating	1836365.46	Kw
Hot water	621296.30	Kw
Fans and Pumps	162668.59	Kw
Lighting	325337.19	Kw
Total Energy use	2945667.54	Kw
Energy Kw per m² of floor area	101.60	Kw/m²
CO2 emissions		
Heating	325127.00	Kg
Hot water	110000.00	Kg
Fans and Pumps	27500.00	Kg
Lighting	55000.00	Kg
Total CO2 emissions	517627.00	Kg
Annual predicted carbon emissions per m² of floor area	17.85	KgCO2/m²
Running Cost		
Heating	£51,327.92	Pa
Hot water	£17,365.74	Pa
Fans and Pumps	£6,851.16	Pa
Lighting	£13,702.31	Pa
Total Running Costs	£89,247.13	Pa
Average annual Running Costs per residential unit	£324.54	Pa

8.1. Solar thermal

The following calculations have assessed the benefit of installing 5m² of flat plate south facing solar collector connected into a solar store located within each dwelling, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will be s sealed system with the need for regular servicing and glycol replacement.

A detailed assessment which will include the practical implications of installing the required amount of Solar thermal to achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	44336.59	Kw pa
Percentage energy saved	4.92%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	8606.52	Kg
Total percentage reduction of CO2	5.20%	
Total estimated life time cost		
Estimated costs for installation	£152,500.00	
Estimated service and maintenance over a fifteen year period	£90,164.10	
Total costs	£242,664.10	
Summary		
Total carbon savings over 15 years	129097.73	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.81	
Average User savings £	£22.09	Per year
Estimated income from FIT / RHI	£7,824.10	Per year
Payback period Years	26.46	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.

Grants

The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.2. Solar Photovoltaic

The following calculations have assessed the benefit of installing 1kw peak of south facing photovoltaic array connected into a total generation meter located within each dwelling, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require no routine maintenance and it is estimated that if the system is designed correctly inverters should not need replacement within the 15 year lifetime assessment period. This being said a prevision for inverter repair has been allowed in the assessment process based on an inverter lifetime period of 10 years and assessed pro rata over the 15 year lifetime assessment.

A detailed assessment which will include the practical implications of installing the required amount of PV to achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	120379.58	Kw pa
Percentage energy saved	13.36%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	21313.78	Kg
Total percentage reduction of CO2	12.89%	
Total estimated life time cost		
Estimated costs for installation	£103,700.00	
Estimated service and maintenance over a fifteen year period	£82,350.00	
Total costs	£186,050.00	
Summary		
Total carbon savings over 15 years	319706.73	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.04	
Average User savings £	£77.45	Per year
Estimated income from FIT / RHI	£6,925.95	Per year
Payback period Years	15.97	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 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
The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.3. Micro wind

The following calculations have assessed the benefit of installing one Swift micro wind turbine per dwelling connected to a total generation meter located within each dwelling, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require no routine maintenance and it is estimated that if the system is designed correctly inverters should not need replacement within the 15 year lifetime assessment period. This being said a prevision for inverter replacement has been allowed in the assessment process based on an inverter lifetime period of 10 years and assessed pro rata over the 15 year lifetime assessment.

A detailed assessment which will include the practical implications of installing the required amount of micro wind turbines to achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	24876.54	Kw pa
Percentage energy saved	2.76%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	4404.51	Kg
Total percentage reduction of CO2	2.66%	
Total estimated life time cost		
Estimated costs for installation	£219,600.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£265,350.00	
Summary		
Total carbon savings over 15 years	66067.66	Kg
Total cost per Kg of saved carbon over a fifteen year period	£3.13	
Average User savings £	£16.01	Per year
Estimated income from FIT / RHI	£2,939.18	Per year
Payback period Years	67.77	Years

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
The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.4. Biomass

The following calculations have assessed the benefit of installing individual Biomass heating boilers connected to each dwelling by the way of a low temperature heating circuit, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require no routine maintenance over and above a conventional heating system.

A detailed assessment which will include the practical implications of installing a bio mass communal boiler to achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	-209297.29	Kw pa
Percentage energy saved	-23.23%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	54474.18	Kg
Total percentage reduction of CO2	32.93%	
Total estimated life time cost		
Estimated costs for installation	£274,500.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£320,250.00	
Summary		
Total carbon savings over 15 years	817112.69	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.34	
Average User savings £	-£140.96	Per year
Estimated income from FIT / RHI	£11,240.08	Per year
Payback period Years	121.24	Years

Other considerations

Noise
Biomass would be considered quite in operation

Land use
Biomass would require additional land use and special provision of land for the sitting of fuel hoppers

Planning requirements
Biomass would require planning permission and approval and if it is to be used in smoke controlled areas the boiler would be required to be listed as an approved appliance.

Grants
The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.5. Micro Chp

The following calculations have assessed the benefit of installing a gas fired Baxi Ecogen connected to each dwelling by the way of a low temperature heating circuit, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require no maintenance over and above the cost of boiler servicing requirements.

A detailed assessment which will include the practical implications of installing a Chp communal boiler and achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered as economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	-72914.00	Kw pa
Percentage energy saved	-8.09%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	-12909.77	Kg
Total percentage reduction of CO2	-7.80%	
Total estimated life time cost		
Estimated costs for installation	£213,500.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£259,250.00	
Summary		
Total carbon savings over 15 years	-193646.60	Kg
Total cost per Kg of saved carbon over a fifteen year period	Na	
Average User savings £	-£46.91	Per year
Estimated income from FIT / RHI	£6,100.00	Per year
Payback period Years	-90.60	Years

Noise
The Baxi Ecogen is considered to be silent in operation

Land use
Micro Chp units would not require any further land use or special provision of land.

Planning requirements
Micro Chp would require no planning approval.

Grants
The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.6. FGHRS (not classified as a LZC technology)

The following calculations have assessed the benefit of installing a FGHRS to an individual boiler within the dwelling feeding an individual heating system, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to LZC technologies.

The unit is not a LZC technology and would not contribute towards planning or ENE7 requirements and would only contribute towards CSH section Energy 1 by reducing the Dwelling Emission Rate (DER)

Energy		
Energy used Standard Case Kw	2945667.54	Kw pa
Energy generated by the LZC	330648.67	Kw pa
Percentage energy saved	11.22%	
Emissions		
Total estimated Standard Case CO2 emissions	517627.00	Kg
Total saved Carbon emissions	58541.08	Kg
Total percentage reduction of CO2	11.31%	
Total estimated life time cost		
Estimated costs for installation	£27,500.00	
Estimated service and maintenance over a fifteen year period	£8,250.00	
Total costs	£35,750.00	
Summary		
Total carbon savings over 15 years	878116.14	Kg
Total cost per Kg of saved carbon over a fifteen year period	-£0.12	
Average User savings £	£33.61	Per year
Estimated income from FIT / RHI	£0.00	Per year
Payback period Years	3.87	Years

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, FIT or RHI are available for FGHRS

8.7. WWHRS (not classified as a LZC technology)

The following calculations have assessed the benefit of installing a Waste Water Heat Recovery device feeding a shower within the dwelling, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to LZC technologies.

The unit is not a LZC technology and would not contribute towards planning or ENE7 requirements and would only contribute towards CSH section Energy 1 by reducing the Dwelling Emission Rate (DER).

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	27123.56	Kw pa
Percentage energy saved	3.01%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	5265.16	Kg
Total percentage reduction of CO2	3.18%	
Total estimated life time cost		
Estimated costs for installation	£27,450.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£73,200.00	
Summary		
Total carbon savings over 15 years	78977.43	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.35	
Average User savings £	£49.96	Per year
Estimated income from FIT / RHI	£0.00	Per year
Payback period Years	24.02	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, FIT or RHI are available for the WWHRS

8.8. Sunwarm

The following calculations have assessed the benefit of installing 5m² south facing solar air collector connected into a solar store located within each dwelling, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require regular servicing and an allowance of £20 per dwelling per year has been included in the assessment.

A detailed assessment which will include the practical implications of installing the required amount of Solar thermal to achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered as economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	52160.70	Kw pa
Percentage energy saved	5.79%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	10125.31	Kg
Total percentage reduction of CO2	6.12%	
Total estimated life time cost		
Estimated costs for installation	£158,600.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£204,350.00	
Summary		
Total carbon savings over 15 years	151879.68	Kg
Total cost per Kg of saved carbon over a fifteen year period	£0.77	
Average User savings £	£96.07	Per year
Estimated income from FIT / RHI	£0.00	Per year
Payback period Years	34.87	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 is regarded as a permitted development although a pre planning application will be required for submission to the local planning department for their approval.

8.9. Biogas District Heating

The following calculations have assessed the benefit of installing an Anaerobic Digester (AD) facility on the development, the AD unit would be connected to a Combined Heat and Power (CHP) boiler which would supply the development with district heating. It has been assumed that the unit would provide approximately 10% of the required heat requirements of the site, the remainder of which would be provided by mains gas powered CHP units and back up boilers.

A detailed specialist survey and assessment would be required to determine if the site was capable of providing enough waste material to support adequate gasification or if clean waste could be imported from the local area.

The calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will regular servicing but as an over cost assessment against traditional individual systems this cost would be considerably cheaper and therefore a saving of £20 per dwelling per year has been included in the assessment.

A detailed assessment will be required which will assess the practical implications of this type of installation should this technology be considered to be economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	54342.88	Kw pa
Percentage energy saved	6.03%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	78704.05	Kg
Total percentage reduction of CO2	47.58%	
Total estimated life time cost		
Estimated costs for installation	£351,360.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£397,110.00	
Summary		
Total carbon savings over 15 years	1180560.77	Kg
Total cost per Kg of saved carbon over a fifteen year period	-£0.05	
Average User savings £	£46.15	Per year
Estimated income (Esco) including FIT	£27,514.18	Per year
Payback period Years	14.43	Years

Noise
There may be issues with noise which would need to be addressed depending on a suitable location

Land use
An AD facility would require special land provision the costs of which have not been included within the financial assessment.

Planning requirements
An AD facility would require additional planning considerations and consent

Grants
The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

8.10. Ground Source Heat Pump (wet)

The following calculations have assessed the benefit of installing one GSHP heating boiler per dwelling connected to each dwelling by the way of a low temperature heating circuit, the calculations take no account of the reduction in DER required to satisfy the Code for Sustainable Homes section Energy 1 (ENE1) and have been produced for comparison purposes to determine potential CO_2 savings and cost per Kg of CO_2 compared to other LZC technologies.

The lifetime assessment has assumed that the system will require maintenance over and above what would be expected as normal heating maintenance and an allowance of £10 per year per dwelling has been included.

A detailed assessment which will include the practical implications of installing a GSHP communal boiler and achieve the required mandatory improvement in DER over 2006 building regulations will be discussed in more detail later in this report should this technology be considered as economically viable.

Energy		
Energy used Standard Case Kw	900943.32	Kw pa
Energy generated by the LZC	38887.47	Kw pa
Percentage energy saved	4.32%	
Emissions		
Total estimated Standard Case CO2 emissions	165409.10	Kg
Total saved Carbon emissions	6885.21	Kg
Total percentage reduction of CO2	4.16%	
Total estimated life time cost		
Estimated costs for installation	£274,500.00	
Estimated service and maintenance over a fifteen year period	£45,750.00	
Total costs	£320,250.00	
Summary		
Total carbon savings over 15 years	103278.18	Kg
Total cost per Kg of saved carbon over a fifteen year period	£2.74	
Average User savings £	£25.02	Per year
Estimated income from FIT / RHI	£932.23	Per year
Payback period Years	343.53	Years

Noise

GSHP are considered to be silent in operation and no specific data was available for the assessed unit.

Land use

Depending on the type of GSHP (ground loop or deep bore) GSHP will require the provision of land use.

Planning requirements

GSHP require no additional planning requirement

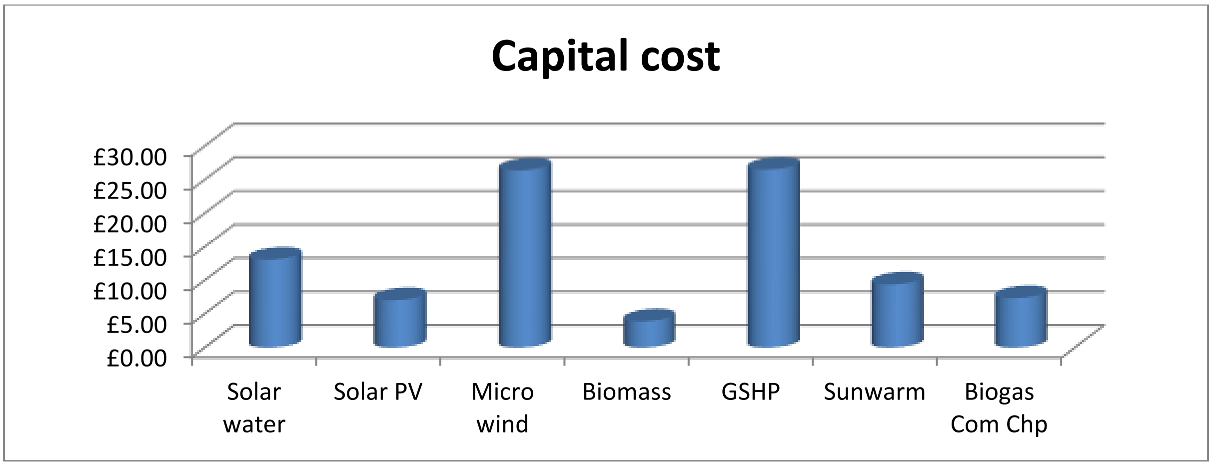
Grants

The current grant system is to be replaced by the Feed in Tariff (FIT) and Renewable Heat Incentives (RHI), the FIT came into effect from the 1st April 2010 and the RHI came into effect from the 9th April 2014 although the RHI will not be available for new build apart from suitable self-build schemes.

9. Summary

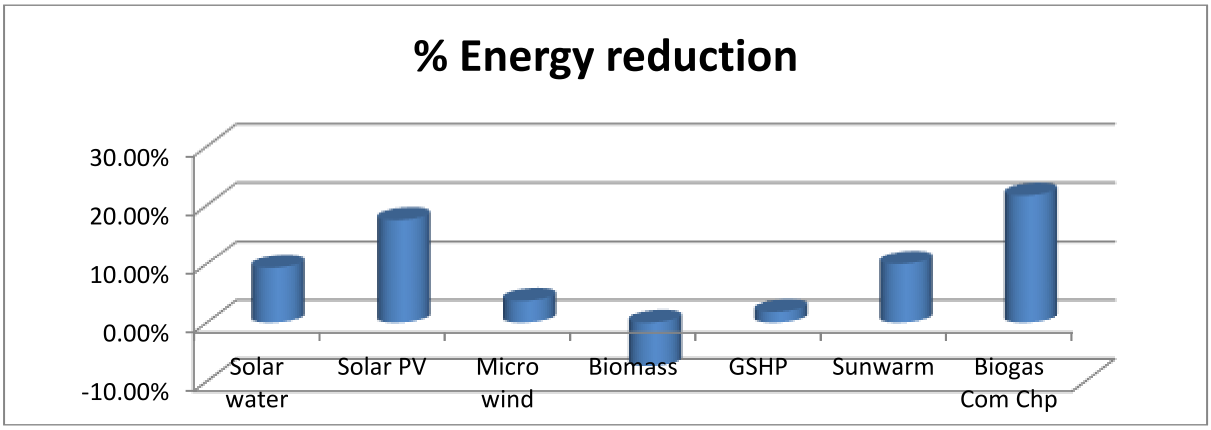
Technology	energy saved Kw/h Pa	% energy saved	% carbon savings	Capita cost m²	Cost per Kg/CO2 saved over 15 years	Cost per Kw Saved over a 15 year period
Solar water	44336.59	4.92%	5.20%	£30.12	£0.81	£0.16
Solar PV	120379.58	13.36%	12.89%	£20.48	£0.04	£0.01
Micro Wind	24876.54	2.76%	2.66%	£43.38	£3.13	£0.55
Biomass	Na	-23.23%	32.93%	£54.22	£0.34	Na
Micro Chp	Na	-8.09%	-7.80%	£42.17	Na	Na
FGHRS	15648.21	1.74%	1.84%	£3.61	£0.83	£2.41
WWHRS	27123.56	3.01%	3.18%	£5.42	£0.35	£1.01
Sunwarm	52160.70	5.79%	6.12%	£31.33	£0.77	£2.23
GSHP	38887.47	4.32%	4.16%	£54.22	£2.74	£0.53
Chp Natural Gas	97619.33	10.84%	17.11%	£57.35	£0.22	£0.09
Chp Biogas District	54342.88	6.03%	47.58%	£69.40	-£0.05	-£0.02

9.1. Cost

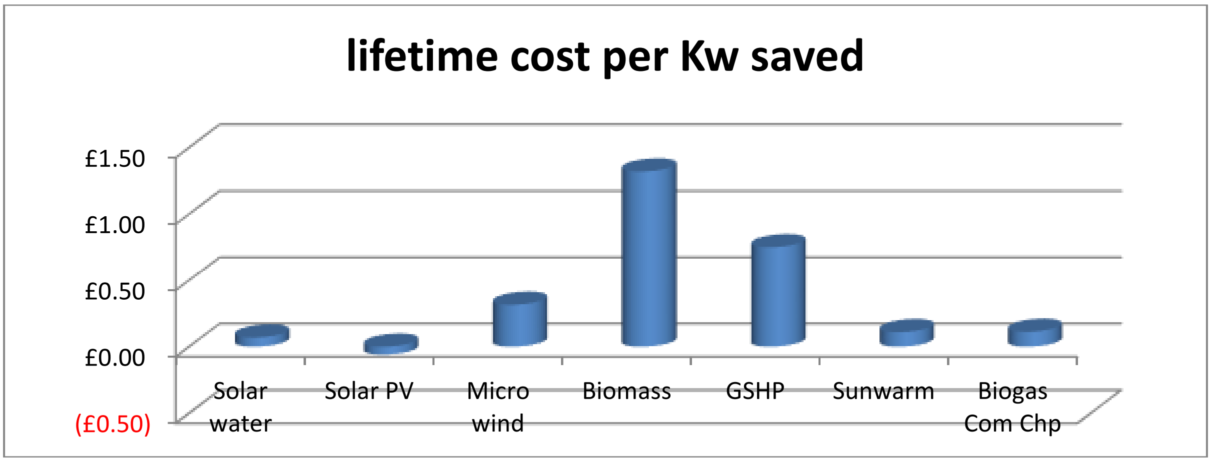


The above graph represents the actual Capital Cost per Kg of Carbon saved. The calculation is not a lifetime assessment and does not include financial benefits such as grants, FIT or RHI revenues.

9.2. Energy



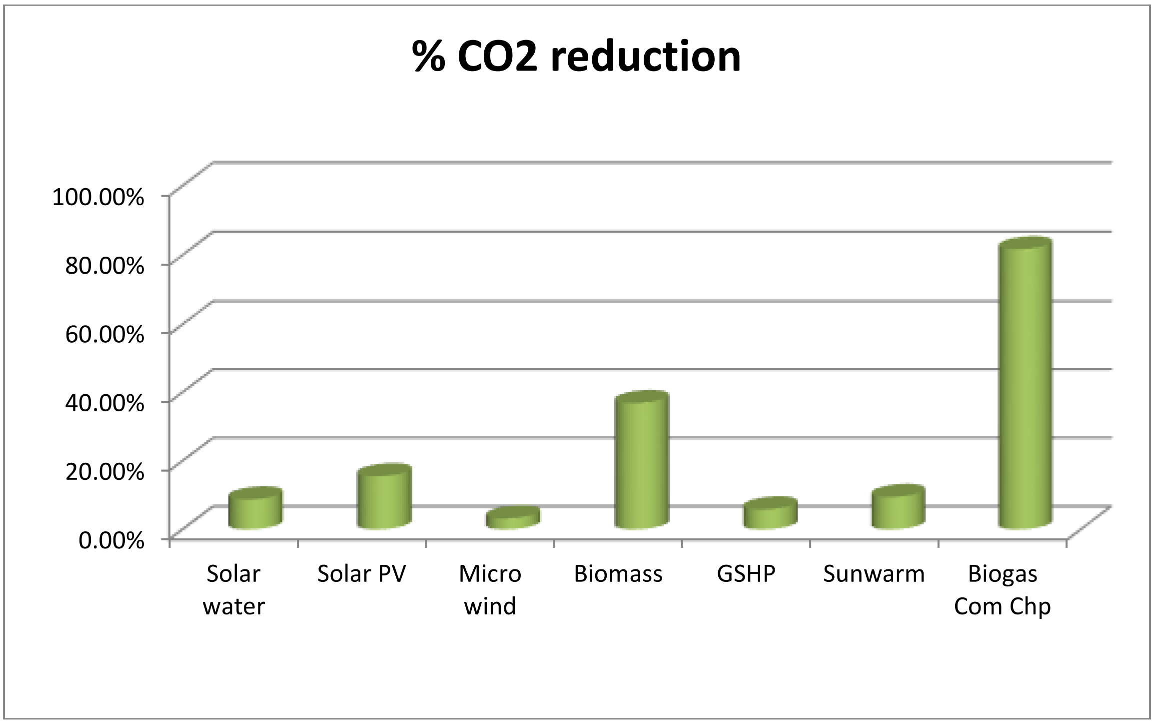
The graph above shows the expected percentage energy reduction for each LZC technology.



The above graph represents a comparison of LZC technologies and the estimated whole life costs, and is represented as costs in £ per Kw of energy saved over the expected life time of the LZC technology. These costs include revenue from FIT, RHI tariffs and user fuel savings.

9.3. CO_2

The graph above shows the expected percentage reduction in CO_2 emissions for each LZC technology.



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.

10. Conclusion

10.1. Innovative Technology

The FGHRS and WWHRS systems would provide cuts in CO_2 emissions and energy reduction; they would also provide positive end user benefit.

POL4 from eco homes, ENE7 from the code and local planning conditions requiring a 10% reduction produced by LZC technologies were all originally devised to promote the use and development of technologies new and existing which assist in the reduction of carbon emissions, ironically the requirement of planning and CSH that the technology must be classified as a LZC technology will have a negative effect on the development of future innovative technologies and ideas.

If these technologies are used on the development they should account for a reduction in the total standard case CO_2 emissions for the development and therefore will lower the 10% target required by the chosen LZC technology, although this may not provide the most cost effective solution in terms of achieving compliance with planning requirement or if this applies CSH energy section 1 and 7.

10.2. LZC technology

The following LZC technologies will provide a reduction in CO_2 emissions above the required 10% planning or Code for Sustainable Homes energy section 7 targets and will be listed in order of most cost effectiveness based on the previous capital cost assessments.

Biomass

If Biomass was to be chosen as a suitable technology based only on potential CO_2 reduction and cost alone then there would be a tendency to ignore any potential negative effects associated with the technology.

As well as the increase in running costs and energy use the fuel would need to be delivered to site and there would be a certain degree of organisation required to source the fuel and arrange for delivery which may cause inconvenience on part of the occupier and or housing management team.

Biomass boilers are very efficient and produce very little waste products even so there would be a requirement to remove and dispose of burnt spent fuel frequently.

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 clean 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 primary installations especially in urban developments could out way any benefit associated with CO_2 reduction.

A permit would be required which would need to be purchased from the local authority and the local authority could refuse or revoke licence at any time in the future.

It is considered that Bio Mass would not be suitable for integration at the proposed development for these reasons.

Appropriate technologies

Photovoltaic

Would provide the required reduction in CO_2 emissions, energy at the lowest capital cost and provide the greatest benefit to occupier in terms of fuel savings and Feed In tariff revenue with very low lifetime costs and therefore is recommended as the most appropriate technology.

11. Bibliography and definitions

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SAP	Standard Assessment Procedure
ENE 1	Energy 1
ENE 7	Energy 7
SAP	Standard Assessment Procedure
LZC	Low or Zero Carbon Technology
CSH	Code for Sustainable Homes
EI	Environmental Impact
FIT	Feed in Tariffs
RHI	Renewable Heat Incentives
DER	Dwelling Emission Rate
TER	Target Emission Rate
DNO	District Network Operator
PV	Photovoltaic
CHP	Combined Heat and Power
AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
GSHP	Ground Source Heat Pump