



# *Renewable Energy Assessment*

*Submitted as part of the Outline Planning Application for  
Land to the east of Clitheroe Road (Lawsonsteads Farm), Whalley*

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COMMERCIAL ESTATES GROUP

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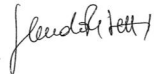
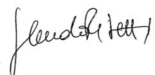
# LAND EAST OF CLITHEROE ROAD, WHALLEY

Renewable Energy Assessment

Commercial Estates Group

08/02/2013

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# LAND EAST OF CLITHEROE ROAD, WHALLEY

## Renewable Energy Assessment

08/02/2013

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## Executive Summary

This report is issued as part of the outline planning application for the land east of Clitheroe Rd, Whalley. The target for the development is to provide 10% of the estimated energy from low carbon and renewable sources which is based on the local authority policy that covers the borough of Ribble Valley, Lancashire County Council, and expected energy consumption assuming the development is constructed to current Building Regulations 2010.

In addressing these requirements, the report follows the well proven practical methodology that may be summarised as “use less, then supply efficiently”. Thus, a series of recommendations are provided to assist in reducing the energy demand of the properties.

An initial energy demand approximation was carried out using SAP modelling based on a generic dwelling and CIBSE TM46 benchmarks for the non-residential elements. The benchmarks are likely to give an overestimate of overall demand but this should lead to conservative assumptions for carbon savings. Best practice then requires energy efficiency to be considered to reduce the development energy demand by passive and energy efficiency measures such as improvements in thermal insulation, building services and controls. A new reduced development energy demand is then used to determine what low or zero carbon technologies need to be applied to achieve target reduction in CO<sub>2</sub> emission.

A complete range of renewable energy supply technologies are reviewed in the report together with the low carbon technology of combined heat and power and applied to the remaining energy demand. A number of options are suitable for the development and meet the required target. The recommended technologies suggested for the development in order to meet 10% on site renewable energy are solar PV, solar thermal and Air Source heat Pumps. These are summarised in the following table:

| Technology            | Description                                                    | Comments/Recommendation                                                                                                                                                                                                                                                                                                                      |
|-----------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Photovoltaic          | Approx. 1,775 m <sup>2</sup> of PV roof mounted panels         | <ul style="list-style-type: none"><li>- Good technical solution but to make any real contribution require installation of a large number of panels.</li><li>- The roof arrangement for the dwellings would need to be carefully selected to make sure that photovoltaic panels were orientated in the optimum southward direction.</li></ul> |
| Solar thermal         | Approx. 400m <sup>2</sup> of roof mounted solar thermal panels | <ul style="list-style-type: none"><li>- Can be a cost effective solution and on this site could make a significant contribution in terms of on-site renewable energy as a large.</li><li>- System sizing and application across the most applicable dwellings needs be carefully considered to achieve the required target.</li></ul>        |
| Air Source heat Pumps | 78kWe ASHP                                                     | <ul style="list-style-type: none"><li>- Can be used as part of a mix of technologies on site and where dwellings are not suitable for the installation of solar technologies</li><li>- Have the advantage of being the least aesthetically intrusive on the design of the buildings if this was an issue for the development.</li></ul>      |

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Natural Gas CHP, Biomass boilers and Biomass CHP are not considered to be viable due to the size of the development not being sufficient to justify the installation of a district heating network with which these technologies would feed. Wind turbines are unviable for the site due to the close proximity of other residential buildings. Ground Source Heat Pumps can practically only serve a small portion of the site heating energy demand whilst the area required is a significant proportion of the entire site, hence practical considerations rule out ground source heating as a viable option.

A complete range of renewable energy supply technologies are reviewed in the report together with the low carbon technology of combined heat and power and applied to the remaining energy demand.

## Next Steps

This report describes the individual merits of each technology which has been investigated in terms of achieving the 10% on-site renewable energy generation set for the project. It is recommended that at the appropriate stage full feasibility studies should be carried out to decide between the possibilities suggested and combinations of them. This should include additional studies to confirm the investment cost and technical issues of connection with public utility services.

# 1 INTRODUCTION

WSP Environment and Energy are commissioned by Commercial Estates Group to complete an energy strategy considering low carbon and renewable technologies for Lawsonsteads site, Land East to Clitheroe Road, Whalley. The scheme is for 260 dwellings, one form entry primary school and associated infrastructure and landscaping.



Figure 1 – Site plan (in red retained area)

## 1.1 Site location and development features

The site is located to the north east of Whalley and subtended by the A671, Clitheroe Rd, and existing residential areas north and east of Whalley.



Figure 2 - Site location for the land east of Clitheroe Rd, Whalley

## 1.2 Approach and methodology

For planning applications in the UK local and national policy drives a requirement to identify how proposed developments can achieve a reduction of carbon dioxide emissions from the energy use. Reductions are identified against a base site energy demand assuming compliance with UK Building Regulations 2010.

This report provides a statement of the anticipated energy consumption of the development on the land east of Clitheroe Rd, Whalley and identifies strategies and technologies that can reduce the overall energy consumption beyond the business as usual case. The procedure followed in this report is a logical development from a baseline to possible solutions, incorporating the principles defined by the energy hierarchy.

### 1.2.1 Energy Hierarchy

The visible face of sustainable energy services includes the application of renewable technologies such as wind turbines, solar systems, heat pumps and biomass boilers. However there are many elements to be considered to reduce the base energy demand that should be investigated first.

The energy hierarchy is a methodology that identifies which elements of a project should be considered and at what stage to obtain maximum benefit for minimum effort. An illustration of the various stages is indicated in the

figure below, with the biggest savings made through energy conservation (1. Lean) through to carbon offsetting, which should be the last consideration after all other options (2. Clean and 3. Green) have been exhausted.

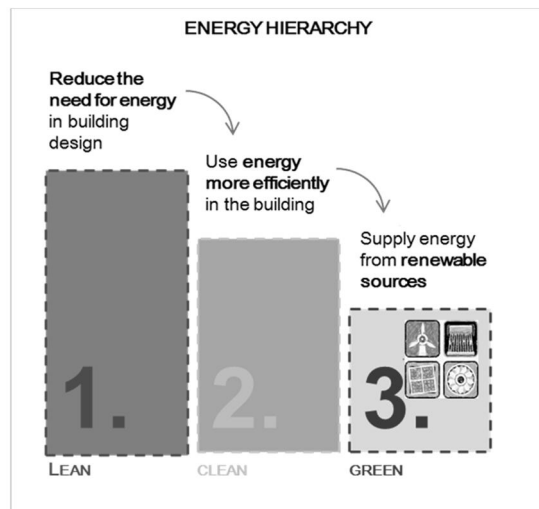


**Figure 3 – Representation of Energy Hierarchy (WSP)**

### 1.2.2 Methodology

The methodology adopted in this report comprises a number of steps, from energy demand assessment to renewable energy options feasibility. These steps are described below.

- Energy demand assessments: Firstly assess the energy demand based on existing minimum legal requirements (i.e. Building Regulations current at the time of planning application submission – Part L1A 2010 edition).
- CO<sub>2</sub> emissions calculation: Convert the baseline energy demand to equivalent carbon dioxide emissions
- Energy efficiency measures: Identify energy conservation measures to reduce the baseline energy demand
- Identify low carbon technologies: Assess low carbon measures to supply the required energy in an efficient manner as possible.
- Renewables assessment: Identify and select the renewable energy supply options to meet the required reduction of the development's carbon dioxide emissions
- Develop and verify energy strategy: Finally revise the energy demand and equivalent carbon dioxide emissions resulting from the strategy developed to meet the required reduction of the development's carbon dioxide emissions and confirm compliance with Planning Authority requirements.

From this procedure a coherent strategy is produced, matched to the energy and carbon reduction requirements and to the particular features of the development.

The domestic energy demands are derived using the Standard Assessment Procedure (SAP) modelling to generate demand figures and a baseline to calculate the 10% energy from renewables. The non-residential element, the school, is based on industry benchmarks, CIBSE TM46 with a 20% improvement assumed in

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thermal efficiency in all cases. This is to allow for the fact that TM46 baselines are based on existing buildings, not new.

The energy demand assessment used in this report was carried out using a tool based on the methodology described in the toolkit produced by 'London Renewables'. Although originally designed to assist in implementing the energy policy of the Greater London Council the methodology is applicable to assessment of renewable energy supply technology options throughout the UK. Consequently the methodology is recognised by the majority of councils in the UK as an appropriate method for determining the site energy demand and resulting carbon dioxide emissions.

A qualitative analysis is then undertaken with regard to each low- and zero-carbon technology covering such issues as space, planning permission and the match of the technology to the demands. Results from the calculation tool where relevant, are presented for each technology in the following chapters of the report.

Recommendations are based on the result of this quantitative and qualitative analysis. In some cases a mixture of technologies will be applicable and this will be clearly explained.

In terms of low carbon energy supplies, this report considers a high level appraisal to determine if further investigation is required concerning the viability of installing natural gas fired combined heat and power unit/s on site.

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## 2 POLICY CONTEXT

The energy options investigated in this report have been developed in line with the overall Government objectives in terms of energy and sustainable development at the land east of Clitheroe Rd, Whalley and the relevant planning policy.

### 2.1 Government Guidance

This section outlines the background information to local planning requirements.

#### 2.1.1 Government Energy Policy and Targets

Increased development of renewable energy resources is vital to facilitating the delivery of the Government's commitments on both climate change and renewable energy. The Government's renewable energy strategy aims to put the UK on a path to cut its carbon dioxide emissions by some 80% by 2050, (Climate Change Act 2008), with real progress, 34% reduction against 1990 baseline, by 2020, and to maintain reliable and competitive energy supplies.

The UK Low Carbon Transition Plan published on July 15, 2009, details the actions to be taken to cut carbon emissions by 34% by 2020 including:

- Upgrading the efficiency of 7 million homes, with over 1.5 million of them generating renewable energy.
- 40% of electricity from low carbon sources (renewables, nuclear power and clean coal).

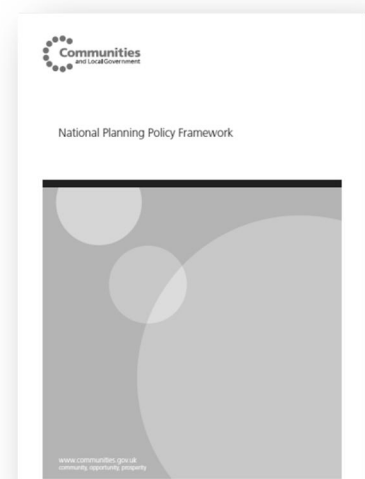
In addition the Low Carbon Transition Plan of 2009 specifies that by 2020 the UK would need to produce 30% of its electricity from renewables.

Moreover, the Energy Act (18 October 2011) provides for a step change in the provision of energy efficiency measures to homes and businesses, and makes improvements to the UK energy framework to enable and secure low-carbon energy supplies, fair competition in the energy markets and achieve these renewable energy targets.

'Zero' carbon targets for all new housing by 2016 and for all new non-residential development by 2019 should be taken into consideration and preparation will be required.

#### 2.1.2 The National Planning Policy Framework (NPPF)

The NPPF was published in March 2012. It is the government's vision for sustainable development and replaces all Planning Policy Statements (PPS) and Planning Policy Guidance (PPG). It has been designed to make the planning system less complex and more accessible, to stimulate growth and promote sustainable development. One of the core planning principles of the NPPF is encouraging the use of renewable resources and supporting renewables growth.



### 2.1.3 Building Regulations – Part L

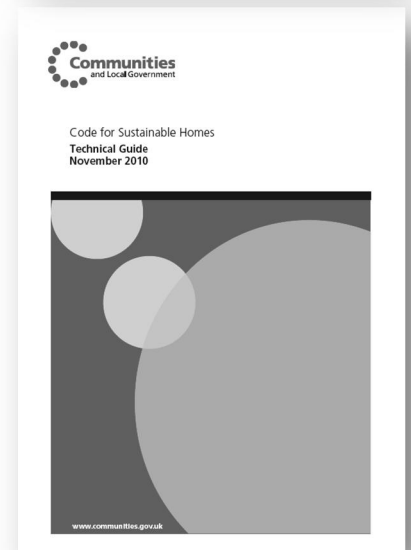
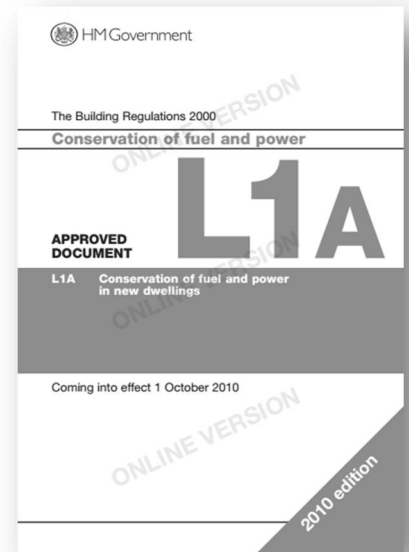
Part L (Conservation of Fuel and Power) governs the energy efficiency and carbon emission requirements with regard to new and existing dwellings (Part L1A and L2A) and to new and existing buildings other than dwellings respectively. Part L1A and L2A set, inter alia, the requirement for a carbon emission threshold for new buildings, referred to as the target emission rate (TER). Part L1B and L2B does not set specific targets with regard to carbon emissions but does propose limits to the performance of thermal elements, for example walls and windows and services such as boilers.

The Department for Communities and Local Government (DCLG) currently has a consultation open on changes to the 2013 Building Regulations (Part L) in England. It should be expected that the CO<sub>2</sub> limit would be set approximately halfway between the current level and the 2016 target of 'zero carbon'. The Government's preference (Dec 2012) is for that an 8% uplift on 2010 standards, with a more ambitious 26% uplift also offered for views. Fuel factor for homes without access to mains gas is also under discussion suggesting a partial relaxation in CO<sub>2</sub> standards.

### 2.1.4 Code for Sustainable Homes

The Code for Sustainable Homes (CfSH) is a standard by which new homes are benchmarked. From 2008 all dwellings must now be assessed against the code and given a rating. Each Code level sets an energy benchmark as part of the larger appraisal. The levels range from 1-6.

In this case a target of Code Level 3 has been used which is in line with 2010 UK Building Regulations. The Barnet Council recommends to Sets a quality standard for the environmental performance and the sustainability of buildings using the CfSH rating and encourages using the CfSH as sustainability guidance during the design process.



## 2.2 Regional Policy

This section outlines the background information to regional planning requirements.

### 2.2.1 4NW Climate Change Action Plan

The Clean and Secure Energy chapter of the Climate Change Action Plan for the North West states its action points as:

- Action 1 - Support the development of a low carbon energy infrastructure to facilitate the future challenges of smart grids, larger scale energy projects, increased electrification and connectivity of low carbon energy assets

- Action 2 - Facilitate the development of low carbon energy generation schemes through support to local planning authorities
- Action 3.3 - Market development and supply chain opportunities for micro-generation

## 2.2.2 Regional Spatial Strategy (RSS)

The RSS for the North West (Adopted 2008) forms part of the statutory development plan. The policies that are relevant to renewable energy generation included:

- EM 17 - In line with the North West Sustainable Energy Strategy, by 2010 at least 10% (rising to at least 15% by 2015 and at least 20% by 2020) of the electricity which is supplied within the Region should be provided from renewable energy sources
- EM18 - ...all residential developments comprising 10 or more units should secure at least 10% of their predicted energy requirements from decentralised and renewable or low-carbon sources

## 2.2.3 Lancashire County Council Climate Change Strategy 2009

Lancashire County Council indicates that it seeks to reduce by 2020, its carbon dioxide emissions by 30% against a 1990 baseline. Although this reduction does not specifically cite a minimal amount of abatement from renewable energy technologies, the strategy indicates that the reduction will be achieved by expected contributions of 5% from energy supply and 18% from domestic energy.

## 2.1 Local policy

This section outlines the background information to local planning requirements.

### 2.1.1 Core Strategy 2008 – 2028 A Local Plan for Ribble Valley Regulation 22 (Submission Draft)

At present there the specific policy relating to energy in the Ribble Valley Borough Council, featured in the core strategy, is DME5.

Key Statement DME5

“The Borough Council will support the development of renewable energy schemes, providing it can be shown that such developments would not cause unacceptable harm to the local environment or local amenity.(...) In terms of the use of decentralised and renewable or low carbon energy in new development the authority will request that on new non-residential developments over 1000m<sup>2</sup> and all residential developments of 10 or more units that at least 10% of their predicted energy requirements should come from decentralised and renewable or low carbon sources unless the applicant can demonstrate that this is not feasible or viable”.

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## 2.2 Project Targets

Given the above policy information the target defined for this site is:

- Provide 10% of the development's energy demand from renewable sources;

The energy strategy described in this report is prepared to meet these specific energy and carbon dioxide emissions requirements.

## 3 SITE ENERGY DEMAND

### 3.1 Baseline information

#### 3.1.1 Development mix and area used in calculations

This is a mixed residential development comprising of 260 dwellings and one form entry primary school. All areas utilised within calculations undertaken within this report have been confirmed with Indigo planning and are as listed within wider planning documentation.

**Table 1 – Site areas**

| Building type | Land Area (m <sup>2</sup> ) | GIA (m <sup>2</sup> ) |
|---------------|-----------------------------|-----------------------|
| Residential   | 90,000                      | 26,000*               |
| School        | 11,400                      | 1,199                 |
| Landscape     | 44,800                      | 0                     |
| Total         | 146,200                     | 27,199                |

*\*It has been assumed the average area per dwelling is 100m<sup>2</sup>.*

### 3.2 Annual Energy demand and CO<sub>2</sub> emissions

The following sections describe the results of the energy demand calculation for this development. This defines the baseline for this study.

#### 3.2.1 Residential buildings

To obtain the predicted energy demand for the houses, a SAP 2009 calculation for a typical house in this development has been carried out using NHER Plan Assessor software (see Appendix A for SAP outputs). This is the actual methodology of calculating performance for demonstrating compliance with Building Regulations. As well as giving the energy demand and carbon emissions of the proposed dwelling, (Dwelling Emission Rate, DER) the software calculates the emission rate required to achieve compliance with the building regulations, (target emission rate, TER). This is used to set the overall target for the development.

The chosen building is a two storey 3-bedroom house with a total floor area of approximately 100m<sup>2</sup>. To set the baseline demand certain fabric values and system efficiencies have been allowed, generally in line with minimum standards (Appendix B). The energy demand for the residential component of this development is shown in Table 2 and is broken down per type of energy used in dwellings.

**Table 2 – Energy demand residential buildings**

| Energy Usage Type                | Energy Consumption |          | CO <sub>2</sub> emissions         |                        |
|----------------------------------|--------------------|----------|-----------------------------------|------------------------|
|                                  | kWh/m <sup>2</sup> | MWh/year | kgCO <sub>2</sub> /m <sup>2</sup> | tCO <sub>2</sub> /year |
| Space Heating                    | 58.69              | 1,526    | 11.6                              | 302                    |
| Domestic Hot Water               | 25.49              | 663      | 5.0                               | 131                    |
| Lighting                         | 5.05               | 131      | 2.6                               | 68                     |
| Pumps & Fans                     | 1.74               | 45       | 0.9                               | 23                     |
| Total (unregulated not included) | 90.96              | 2,364.85 | 20.17                             | 524.48                 |

### 3.2.2 Primary School

For the school, as these have not been defined at this stage, with only floor areas available, reference energy demand figures have been taken from the CIBSE<sup>1</sup> TM46 benchmarks. The total energy demand estimated for the non-residential buildings is 408.8MWh/year. The CO<sub>2</sub> emissions caused by the energy use are therefore 113tCO<sub>2</sub>/year. The energy conversion factors to calculate the carbon dioxide emissions can be found in Appendix B.

### 3.2.3 Overall Energy Demand and Emissions

The energy demand and carbon dioxide emissions for the proposed development at Land East to Clitheroe Road, Whalley are shown in Table 3 is broken down per type of building.

**Table 3 – Baseline Annual Energy demand**

| Building type | Source     | Fossil Fuel<br>MWh/year | Electricity<br>MWh/year | Fossil Fuel<br>tCO <sub>2</sub> /year | Electricity<br>tCO <sub>2</sub> /year |
|---------------|------------|-------------------------|-------------------------|---------------------------------------|---------------------------------------|
| Houses        | SAP Model  | 2,189                   | 176                     | 433                                   | 91                                    |
| School        | CIBSE TM46 | 308                     | 101                     | 61                                    | 52                                    |
| Total         |            | 2,497                   | 277                     | 494                                   | 143                                   |

Based on the rational above, the total energy demand estimated for the site is 2,774MWh/year. The CO<sub>2</sub> emissions caused by the energy use are therefore 638CO<sub>2</sub>/year. The energy conversion factors to calculate the carbon dioxide emissions can be found in Appendix B.

### 3.2.4 Building Regulations – Part L 2010

After calculating the energy demand for the site, the first task is to ensure that the model meets Building Regulations criteria (Part L1A 2010). The methodology applied to calculate the energy demand for the site, SAP and SBEM (including best practice Benchmarks form CIBSE) are the recommended for estimating CO<sub>2</sub> emissions rates for Building Regulations compliance.

The energy demand calculated includes both regulated and unregulated emissions. These are those caused by systems not covered by Building Regulations; typically systems which are plugged in, such as washing machines, televisions, computers, lamps. Although it is a requirement in an energy statement to include the unregulated emissions, these are not part of the TER and BER.

### 3.2.5 Baseline energy demand

Initial SAP calculations were performed using the recommended values in Appendix R of SAP 2009; however the DER obtained was lower than TER. Further improvements have been applied to the backstop values of Part L 2010 to meet the building regulations criteria. The energy demand calculated from this SAP sets the initial baseline for which the renewable energy target is calculated. It is not possible to ensure that these energy uses are reduced during construction as these will vary from dwelling to dwelling dependent on the occupants. However it is understood that a guide to the EU energy labelling scheme is proposed to be left for new occupants to advise them on the purchase of energy efficient appliances.

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<sup>1</sup> Energy Benchmarks TM46:2008

For the school, 20% thermal demand reduction has been assumed since these measurements are for existing buildings and therefore will probably overestimate the energy consumption and carbon emissions of new buildings. In this instance these benchmarks have been assumed to represent the building regulations limits for defining how the 25% reduction in CO<sub>2</sub> emissions will be calculated. This is considered to be a conservative approach.

The total estimated energy demand and carbon emissions for this project are respectively 2,167MWh/year and 503tCO<sub>2</sub>/year and are shown in the table below. The renewable energy target for Land east of Clitheroe Road development is therefore 217MWh/year.

**Table 4 – Site baseline annual energy and CO<sub>2</sub> emissions**

| Building type | Source              | Fossil Fuel<br>MWh/year | Electricity<br>MWh/year | Fossil Fuel<br>tCO <sub>2</sub> /year | Electricity<br>tCO <sub>2</sub> /year |
|---------------|---------------------|-------------------------|-------------------------|---------------------------------------|---------------------------------------|
| Houses        | SAP Model           | 1,689.9                 | 150.1                   | 334.6                                 | 77.6                                  |
| School        | Adjusted CIBSE TM46 | 246.5                   | 80.6                    | 48.8                                  | 41.7                                  |
| Total         |                     | 1,936.4                 | 230.6                   | 383.4                                 | 119.2                                 |

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## 4 BE LEAN: ENERGY SAVING MEASURES

### 4.1 Measures taken

To reduce the energy demand of a building to meet Building Regulation requirements, the following methodology, which is consistent with the energy hierarchy, has been applied.

The points below list the energy measures that are considered by the design team in order to limit the energy consumption and the carbon footprint of this development.

#### **Step 1 – Reduce energy demand**

It is possible to reduce the energy demand of the buildings through a number of measures such as:

- Maximise passive solar gain
- Maximise natural light
- Increase the use of natural ventilation
- Reduce the air permeability of the building envelope
- Increase building insulation

Initial energy demand reductions that can be achieved via passive measures to the building envelope are:

- Reduce the air permeability
- Optimise the U-Values of the external fabric.
- Optimise glazing area and solar factor

#### **Step 2 – Supply energy efficiency**

Initial energy demand reduction via systems by implementation of low-cost energy-efficient measures such as:

- Selecting most efficient heating/cooling systems;
- Delayed-start controls including optimisation and compensation heating controls
- Hot water heat recovery
- Timed and thermostatic control to hot water system via a building management system
- Passive design to encourage daylighting and reduce artificial lighting demand.

#### **Step 3 – Use sustainable energy**

This provides a robust supply strategy by combining efficient delivery of energy with low and zero carbon technologies. There is a range of low and zero carbon technologies available for this site and those generally considered the most economically and technically feasible are identified and analysed in chapter 5.

## 5 BE CLEAN: DELIVERING ENERGY EFFICIENTLY

### 5.1 Gas fired CHP

#### 5.1.1 Selection Criteria

Although Combined Heat and Power (CHP) is considered a low carbon technology and not a renewable energy (or zero carbon) technology it is appraised for this site as many local authorities require consideration of this technology. Due to the information available the appraisal undertaken here can do no more than identify if gas fired CHP should be considered further. In that case a more detailed assessment will be required when the thermal and electrical energy demands of the development can be accurately assessed.

A conventional approach to integration of a CHP unit on a site would be to maximise the energy demand met by the unit and apply the maximum variety of different load types. For this particular scheme there are only two building types and none of them have a large electrical and thermal demand.

In order to achieve the minimum operating hours CHP units are normally configured on the basis of the thermal energy demand. Space heating demand varies with the seasons; with domestic hot water demand remaining substantially constant throughout the year. The sizing constraints therefore lie in the summer months.

The other element that should be considered is the distribution system. Usually CHP units are installed to provide heat and power for more than one building therefore issues related to location and heating network are considered.

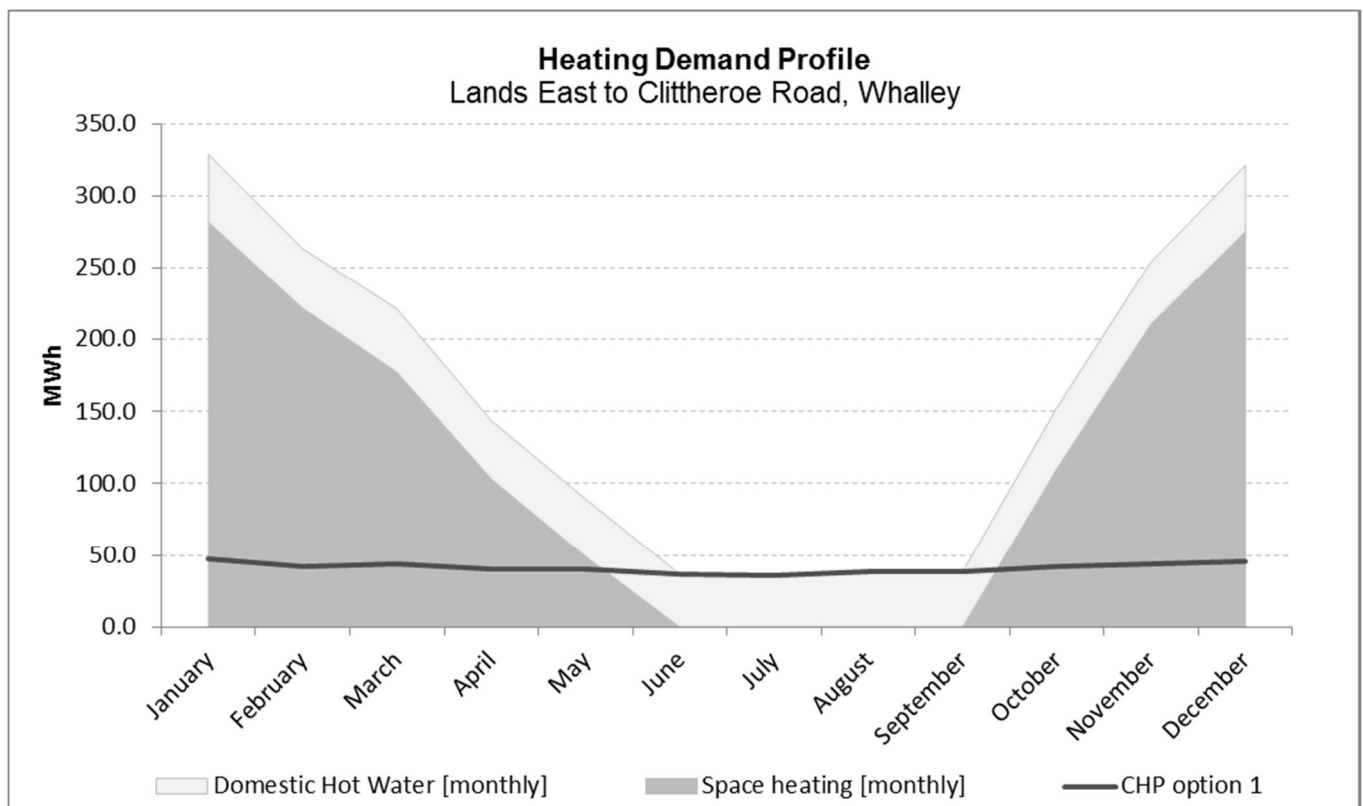


**Figure 4 – Annual demand profile for Land East of Clittheroe Rd and base-load heating demand for CHP sizing**

### 5.1.2 Viability

A full feasibility study is outside the scope of this report; however an initial assessment of a CHP installation in this development can be made. The most economic option for the use of CHP is based on full utilisation of the heat and power within the building with a unit operating for as many hours a year as possible. A good guideline is at least 5,000 hours a year, but more are preferable.

An analysis of site demand for heating and hot water was undertaken to assess the potential for CHP on this site. A CHP unit of 89kWth of thermal output and 60kWe of electrical output is sufficient to provide around 26% of the site demand for heat and overall this size could generate more than 35% of the site total energy demand. This calculation is preliminary and it is based on:

- Minimum running hours: 14 hours per day
- Heat efficiency of 45%
- Electrical efficiency of 30%.

Based on the initial demand estimates for this project, the CHP could reduce overall carbon emissions by 11.3%. The extent to which this is possible will depend on the daily and seasonal variations in the demand for heat.

**Table 5 - Viability of CHP for Land East of Clitheroe Rd**

| Summary: Combined Heat and Power                                                   |                                      |                                                        |       |
|------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------|-------|
|  | Description                          | 89kWth/60kWe natural gas fired Combined Heat and Power |       |
|                                                                                    | Potential annual energy contribution | 457 MWh/year (heat)<br>304 MWh/year (power)            | 35%   |
|                                                                                    | CO <sub>2</sub> emission saving      | 57 tCO <sub>2</sub> /year                              | 11.3% |

Because of the residential nature of this development, although the water demand is fairly constant during the year, the overall demand remains quite low for this type of solution, therefore the CHP unit size it is not recommended for a district network solution. In addition gas boilers are still required to provide the part of the heating demand.

**This technology is not recommended for further consideration in the context of the proposed site wide development.**

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## 5.2 Wind turbines

### 5.2.1 Selection criteria for wind power

Integration of wind turbines on a development requires consideration of many factors. Depending on the scale of wind turbine considered viable they may be either stand-alone or building integrated. However there are many issues associated with integrating wind turbines onto buildings. Recent large scale trials have shown that wind speeds in urban environments are generally much lower than those predicted by the models available, therefore the energy output from small scale (<50kW) turbines can be as low as 1% of the expected value. Consequently WSP do not generally recommend the installation of wind turbines on buildings at present.

For the installation of wind turbines the following issues need to be considered:

- Average wind velocity at hub height should be greater than 6m/s;
- The installation locations will need to be free from obstructions that could cause turbulence e.g. structures, trees;
- There should be sufficient land available within or adjacent to the development to allow placement of turbines away from residential areas; and
- Proximity to occupied areas with regards to flicker of blades.
- Proximity of conservation areas, ecology and impact on wild life.

Locating large-scale wind turbines near to residential units is not recommended due to noise and visual impacts. Initial spacing constraints limit the positioning of large scale wind turbines to more than 500m away from residential properties.

### 5.2.2 Viability of wind power

Excluding small roof-mounted wind turbines for the reasons explained above the other option is stand-alone turbines. Locating large-scale wind turbines near to residential units is not recommended due to noise and visual impacts. Initial spacing constraints limit the positioning of large scale wind turbines to more than 500m away from existing residential properties.

**This technology is NOT recommended for further consideration in the context of the proposed development.**



## 5.3 Photovoltaic panels (PV)

Photovoltaic panels comprise flat panels that convert sunlight into an electrical supply. The cells produce DC (direct current) electricity and are typically arranged in modules that include an inverter to convert the electricity into AC (alternating current) that can be used by the building systems. The amount of electricity generated by the panels varies depending on the external light conditions.

### 5.3.1 Selection Criteria for PV

Photovoltaic (PV) panels can be incorporated into the design and provide an electrical power output used to offset incoming electrical energy. They can either be mounted external to the building or be integrated into the building cladding (known as Building Integrated Photovoltaic or BIPV).

When assessing the potential benefit of photovoltaic panels allowance must be made for overshadowing from adjacent buildings, trees or other tall elements that can obstruct the panels during the day. Overshadowing can substantially reduce the output from photovoltaic panels.

### 5.3.2 Viability of PV

The site location falls within one of the good areas of the UK with a solar potential that of around 1,090kWh/m<sup>2</sup> per year, as indicated in Figure 8.

From preliminary calculations, it was found that to achieve the 10% target the total PV area required is 1,775m<sup>2</sup> assuming a mix of south and SE/SW facing roofs. Approximately 35-40% the dwellings of this development should be provided with roof-mounted PV panels, assuming that 1.2 kW is installed per dwelling. It is also possible to utilise the remaining roof area for other technologies such as solar thermal (see next section).



Figure 5 – UK solar resource

The roofs need to be selected carefully in order to avoid overshadowing and to optimise orientation and tilt. The analysis is based on south-west/south-east roof orientation and a tilt of 20 degrees. These parameters require further investigation in the next phase of the project.

The type of photovoltaic panel recommended for this development is the PV tile, which is easy to integrate in the roof and visually less intrusive. In addition installing PV tiles can save the cost of roof tiles where the solar technology is required. The Feed in Tariffs (FiTs) also guarantees a reasonable price for exported electricity to offset that which will not be used on site. Although the return on investment has been reduced by the recent changes in FiT, the technology still generally offers a positive payback much shorter than the lifespan of the equipment.

**Table 6 – Viability of roof mounted PV for for Land East of Clitheroe Rd, Whalley**

| Summary: Solar PV                                                                                                   |                                      |                                                                                                                                 |                   |
|---------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-------------------|
|  <p><i>Example of PV tiles</i></p> | Description                          | Photovoltaic panel area is 1,775m <sup>2</sup> using mono-crystalline PV panels. The total installed capacity is around 209kWp. |                   |
|                                                                                                                     | Potential annual energy contribution | 217MWh/year (electricity)                                                                                                       | 10% energy output |
|                                                                                                                     | CO <sub>2</sub> emission saving      | 115 tCO <sub>2</sub> e/year                                                                                                     | 23%               |
|                                                                                                                     | Availability                         | Limited output during winter months rising to maximum output in summer months on bright days.                                   |                   |

This technology is recommended for further consideration in the context of the proposed development.

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## 5.4 Solar thermal

Solar thermal collectors comprise fluid filled panels mounted at roof level that collect solar energy to heat water. In the UK these panels are conventionally used to provide hot water rather than heating. As for PV, the solar collectors need unrestricted access to sunlight without overshadowing and the site layout is designed to favour not shaded and exposed roofs.



### 5.4.1 Selection criteria for solar thermal

There are a number of different types of panels that can be used, which vary in cost and efficiency: flat plate collector, evacuated tube and building integrated solar collectors.

The majority of heat output from solar hot water systems is achieved during the summer and mid seasons, with the least heat energy obtained during the winter.

To correctly situate the panels, the following issues should be considered:

- The building is required to have a year round hot water demand.
- Sufficient roof space for the installation of the panels is required.
- The building should have an open SE-SW facing roof.
- Space for hot water cylinders close to the panels is required.

This technology can conflict with and reduce the viability of combined heat and power. The area required for installation of the panels needs to be co-ordinated with the provision of roof mounted environmental control plant and equipment.

The technology is well proven, well understood, and will benefit from the Government's Renewable Heat Incentive (RHI), which provides a payment per kWh generated.

### 5.4.2 Viability of solar thermal

As the supply of solar energy does not match well with typical hot water use patterns, it is not generally advisable to attempt to provide more than 50-60% of the hot water use by this means as this creates stagnation and underuse.

When considering the total area required to achieve the 10% on site energy target it equates to 4m<sup>2</sup> per building. Similarly to PV it is unlikely that all houses will be suitable for the installation of solar thermal panels. Furthermore, the optimum area for a residential property is in the region of 4m<sup>2</sup>.

If hundred houses out of 260 have a 4m<sup>2</sup> solar thermal array fitted the target would be met. This is just up to 18% of site domestic hot water demand.

**Table 7 - Viability of Solar Water Heating for Land East of Clitheroe Rd, Whalley**

| Summary: Solar Hot Water Heating                                                  |                                      |                                                                                               |                            |
|-----------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------|
|  | Description                          | Solar hot water collector area is 400m <sup>2</sup>                                           |                            |
|                                                                                   | Potential annual energy contribution | 217 MWh/year (heat x hot water)                                                               | 10% of total energy demand |
|                                                                                   | CO <sub>2</sub> emission saving      | 68 tCO <sub>2</sub> e/year                                                                    | 9%                         |
|                                                                                   | Availability                         | Limited output during winter months rising to maximum output in summer months on bright days. |                            |

In selecting the roof area for solar collectors, overshadowing, PV allocation (if planned to be installed) and hot water distribution should be considered.

**This technology is recommended for further consideration in the context of the proposed development since is incompatible with the CHP units.**

## 5.5 Biomass heating

Biomass can be utilised in a number of ways. This report considers the direct combustion of biomass wood fuels in a boiler located on site.

### 5.5.1 Selection Criteria for biomass heating

With a high and consistent demand for heat, biomass boilers can be used to generate most of the thermal demand utilising fuel from local sources, avoiding or substantially reducing the need for fossil fuels.

An advantage of biomass is that it has very low net carbon emissions as most of the carbon dioxide generated in its combustion is offset by that absorbed during its growth. Fuel storage, delivery and availability of fuel near to the site are the key factors when considering this technology.

Depending on the size of plant there will be a requirement for frequent fuel deliveries by road especially in winter. A disadvantage is that the fuel would have to be delivered to, and ash collected from, the site. The fuel supply would also need to be secured over an extended period of time.

Biomass boilers are approximately five times the cost of gas boilers and usually work on a district basis, which may be another additional cost.



### 5.5.2 Viability of biomass heating

In a development such as this, biomass boilers can be used in partnership with the chosen central heating systems, utilising fuel from local sources. However delivery and access to the boiler room and storage are constraints that make this a challenging option for this site. Application of biomass heating to this site does have also some other potential issues that require to be dealt with sensibly: the flue gases from biomass boilers contain nitrogen oxides (NO<sub>x</sub>) and particulates which impact on the local air quality.

For this analysis the size of the system is notionally 109kW to deliver the carbon emission reductions target. This is based on a runtime of 2,000 hours full load equivalent and would require a buffer tank and top-up/stand-by boilers. This boiler can supply 13% of the overall heating demand (equivalent to space heating for approximately 34 houses). It requires would require 78 tonnes of wood chip per year.

**Table 8 - Viability of Biomass Heating for Land East of Clitheroe Rd, Whalley**

| Summary: Biomass Heating                                                            |                                      |                                                                                                                    |                       |
|-------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------|
|  | Description                          | 109kW (thermal).                                                                                                   |                       |
|                                                                                     | Potential annual energy contribution | 217 MWh/year (heat)                                                                                                | 10% on-site renewable |
|                                                                                     | CO <sub>2</sub> emission saving      | 40 tCO <sub>2</sub> e/year                                                                                         | 8%                    |
|                                                                                     | Availability                         | Available throughout year subject to routine maintenance. Adequate storage and access is required for fuel supply. |                       |

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Assuming that a fuel storage with a volume of 70m<sup>3</sup> is available, the delivery frequency required would be of about one or two lorry trips per month.

Application of biomass heating requires using a central plant-room with other devices (boilers or CHP) to supply all the space heating and the hot water required; a centralised plant room and distribution heating system would be required along with storage and allowance for delivery vehicles on a regular basis adding complexity and costs.

**This technology is NOT recommended for further consideration in the context of the Proposed Development.**

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## 5.6 Biomass Combined Heat and Power (CHP)

### 5.6.1 Selection Criteria for Biomass CHP

Another way of utilising biomass as a fuel source is with a Biomass CHP. This technology is a CHP, as described in Section 5.1, fired with biomass fuel instead of gas. It is basically an extension of biomass heating described above but with the addition of an electrical generator.

### 5.6.2 Viability of Biomass CHP

In addition to a number of constraints that this system has in common with biomass boilers and that make this option difficult to implement, it can be anticipated that the hypothetical size of a Biomass CHP unit for this site would be much smaller (see CHP section) than 2MW that is considered a technically proven and commercially viable size. Below this size biomass CHP are still seen as insufficiently proven.

Similarly to biomass heating and CHP a central solution serving the entire site may present practical problems with regards to ownership and metering for each dwelling and the associated costs that would arise from providing a central loop connecting all dwellings, though it may be possible to install smaller scale units supplying groups of dwellings which would require a smaller central heating loop, provided such an installation is large enough to be economic

**This technology is NOT recommended for further consideration in the context of the Proposed Development.**

## 5.7 Ground Source Heat Pumps (GSHPs)

Ground source heat pump (GSHP) provide an efficient way to extract stored solar- ground source heat and increase the useful temperature to serve the building heating system. In the summer months heat can be extracted from the building and deposited in the ground thereby cooling the building. Generally using electric motors, heat pumps can convert the energy supplied by a factor (COP) between 2.5 to 4.5.



### 5.7.1 Selection Criteria for GSHPs

Heat pumps can utilise a sealed water loop connected to ground heat exchangers (closed loop) or groundwater can be directly abstracted via boreholes fed directly through a heat pump and then returned to the groundwater via a second borehole (open). Although groundwater abstraction has the potential to extract much more thermal energy there are regulatory requirements controlled by the Environment Agency that prevent damage to groundwater resources and this would require an abstraction licence and geological assessment. The analysis here is based on a closed system.

The most appropriate application of this technology is achieved when cooling, as well as heating, takes place. This balances the overall ground temperature across a year. The thermal energy extracted during the heating season balanced by the thermal energy deposited during a cooling season, although only the heating provision would be considered renewable. When considering closed loop systems, two different forms of closed loop ground collector are commonly used, vertical and horizontal. Although more cost effective, horizontal loops require a larger land area.

GSHPs are most efficient when supplying heat at lower temperatures, for example underfloor heating and this type of system should be assumed when using heat pumps. In addition, a buffer tank would be required with top-up systems commonly used to provide higher water temperatures for legionella protection or hot water.

### 5.7.2 Viability of GSHPs

In order to generate 10% of the energy demand for the site (18% of space heating) it would be necessary to drill 16x5kW boreholes between 60-80m deep depending on local conditions. Application of ground source heat pumps to individual houses would require a large plot area per dwelling which may be not available on this site; the exact area would need to be determined at the next design stage.

**Table 9 - Viability of Ground Source Heat Pump for Land East of Clitheroe Rd, Whalley**

| Summary: Ground Source Heat Pump |                                      |                                                               |                       |
|----------------------------------|--------------------------------------|---------------------------------------------------------------|-----------------------|
|                                  | Description                          | The GSHP system rating is 78kW                                |                       |
|                                  | Potential annual energy contribution | 225MWh/year (heat)                                            | 10% on-site renewable |
|                                  | CO <sub>2</sub> emission saving      | 16 tCO <sub>2</sub> e/year                                    | 3%                    |
|                                  | Availability                         | Available throughout the year subject to routine maintenance. |                       |

This technology is NOT recommended for further consideration in the context of the Proposed Development.

## 5.8 Air Source Heat Pumps (ASHP)

Heat pumps take a resource at one temperature and increase the temperature. Generally using electric motors heat pumps can convert the energy supplied by a factor between 2.5 to 3. This is the co-efficient of performance, (COP). Air source heat pumps extract energy from either ambient air or from air extracted from a building. A COP of 2.7 has been used in our analysis

### 5.8.1 Selection Criteria for ASHP

Air source heat pumps (ASHPs) extract energy from either ambient air or from air extracted from a building. They are normally used to provide space heating but not hot water. ASHPs are normally applied on a dwelling (or building) by dwelling basis but can be provided communally. The technology can provide cooling although this increases the overall energy consumption for the site especially for dwellings and dwellings are assumed not to require it.

### 5.8.2 Viability of ASHP

Although a smaller capital cost compared to ground source heat pumps, air source heat pumps are generally slightly less efficient than GSHPs due to the increased temperature variation of the source. This means that they are less effective in generating energy as efficiently than the ground source equivalent.

A calculation for this development indicates that a 10% on site renewable energy generation is achievable from the use of this technology. ASHPs are a good alternative to gas boilers however these use the more carbon-intensive electricity to drive them. When PV is installed the solar power generated from the roof can be used to power the heat pumps making this option more attractive.

**Table 10 - Viability of Air Source Heat Pump for Land East of Clitheroe Rd, Whalley**

| Summary: Air Source Heat Pumps |                                      |                                |                 |
|--------------------------------|--------------------------------------|--------------------------------|-----------------|
|                                | Description                          | 78kW heat pump                 |                 |
|                                | Potential annual energy contribution | 225 MWh/year (heat)            | 10% (renewable) |
|                                | CO <sub>2</sub> emission saving      | 6 tCO <sub>2</sub> /year       | 1.5%            |
|                                | Availability                         | Available throughout the year. |                 |

If just ASHPs were used on site all dwellings would be required to be fitted with them to meet the target. However, if some of the dwellings had solar technologies fitted for example then this figure could be reduced. The details of exact numbers would need to be determined at the next stage of the development.

**This technology is recommended for further consideration in the context of the Proposed Development.**

## 6 CONCLUSIONS

The most sustainable form of energy is that which is not required in the first place. Consequently the energy demand reduction achieved by energy efficiency measures and good design standards is considered more sustainable than renewable energy. Energy demand reduction achieved by energy efficiency measures and good design standards generally has a lower cost than renewable energy and is required by the energy hierarchy. Thus energy efficiency measures should be incorporated wherever they are cost effective as this reduces the burden of all energy supplied by both conventional and renewable means. Only after this the low and zero carbon technologies were considered.

The baseline data for this were generated using indicative SAP calculations and CIBSE benchmarks, based on the building models. A complete range of renewable energy supply technologies were reviewed together with energy efficiency and low carbon technologies such as combined heat and power.

The technologies considered viable for the site are:

- Solar photovoltaic panels
- Solar hot water heating
- Air source heat pumps

These technologies can be considered in isolation but the viability of this may become difficult i.e. finding enough space on dwelling roofs to fit the required amount of solar thermal or solar PV panels. This is where the other heat pump technologies can be used to add to the percentage of renewable energy installed on site. The exact number of dwellings fitted with each technology needs to be realised at the next stage of the design. Figure 6 shows the savings in CO<sub>2</sub> emissions that can be achieved through the recommended options.

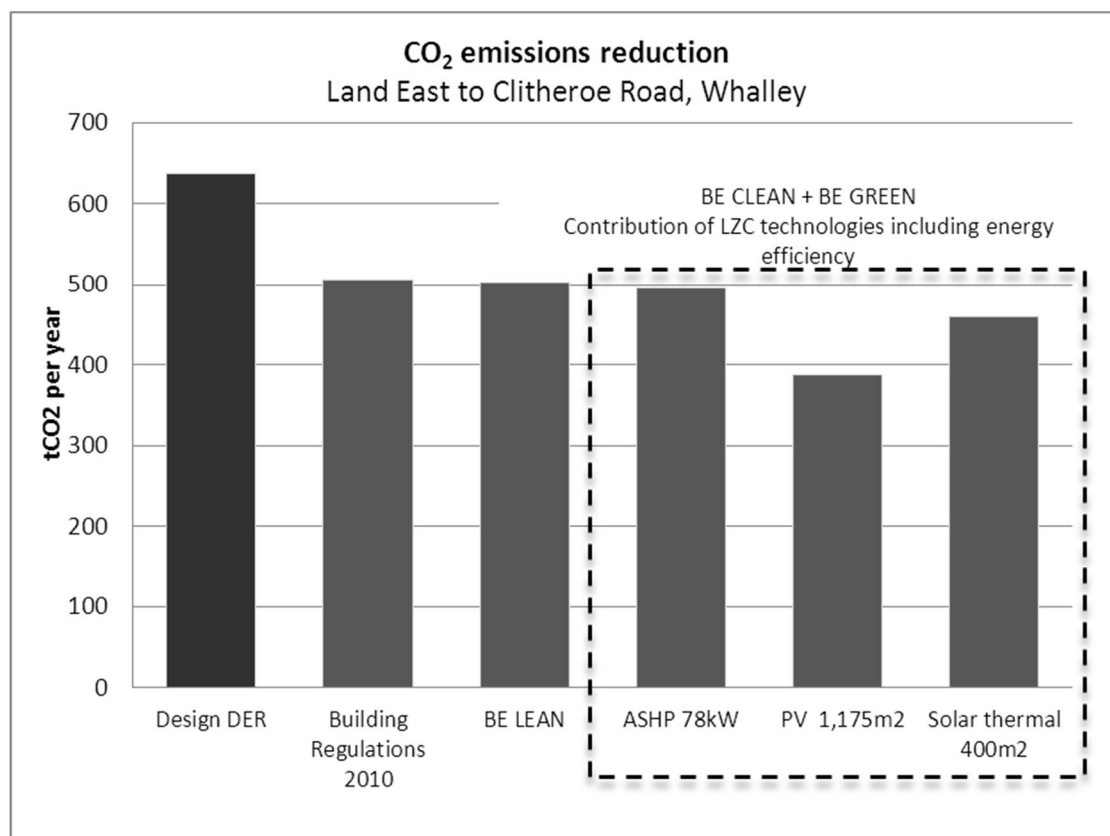


Figure 6 – CO<sub>2</sub> emissions reduction options for Land East of Clitheroe Rd, Whalley

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Technologies not considered viable for the site are:

- Natural gas fired combined heat and power
- Biomass fuelled boilers
- Biomass CHP
- Small scale building mounted wind turbines
- Large scale wind turbines

### **Next Steps**

The report findings identify the individual merits of each technology investigated in terms of achieving a target of 10% provision of site energy demand through renewable technologies. It is recommended that at the appropriate stage further analysis are undertaken to assess the viability of the options presented here or a combination of options as recommended above. This should include additional studies to confirm the investment cost and technical issues of connection with M&E services for the scheme.

- In particular, a detailed feasibility study should be carried out for the solar technologies, which should include overshadowing studies at the appropriate stage in order to select eligible roofs.
- It is also recommended that a microclimate analysis be carried out to determine the implications of the local environment and the building form/layout to optimise the sizing and applications of the different types of renewables. The microclimate analysis will also guide the design team to utilise passive solutions in reducing the development's energy consumption.

# Appendix A

## SAP Output

### DER 2009 Worksheet

#### Design - Draft



This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

|               |                    |                 |            |
|---------------|--------------------|-----------------|------------|
| Assessor name | Ing Glenda Rivetti | Assessor number | 2          |
| Client        |                    | Last modified   | 04/02/2013 |
| Address       | 1 1 1, Whalley     |                 |            |

#### 1. Overall dwelling dimensions

|                  | Area (m <sup>2</sup> )             | Average storey height (m)          | Volume (m <sup>3</sup> ) |
|------------------|------------------------------------|------------------------------------|--------------------------|
| Lowest occupied  | 50.40 (1a) x                       | 2.70 (2a) =                        | 136.08 (3a)              |
| +1               | 50.40 (1b) x                       | 2.70 (2b) =                        | 136.08 (3b)              |
| Total floor area | (1a) + (1b) + (1c) + (1d)...(1n) = |                                    |                          |
| Dwelling volume  | 100.80 (4)                         | (3a) + (3b) + (3c) + (3d)...(3n) = | 272.16 (5)               |

#### 2. Ventilation rate

|                                                                                                                                |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------------|-------------------------|-------|
|                                                                                                                                |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | m <sup>3</sup> per hour |       |
| Number of chimneys                                                                                                             | <div>0</div>                                     |                 |                 |                 |                 |                 |                 |                 |                 |                 | x 40 =               | <div>0</div>            | (6a)  |
| Number of open flues                                                                                                           | <div>0</div>                                     |                 |                 |                 |                 |                 |                 |                 |                 |                 | x 20 =               | <div>0</div>            | (6b)  |
| Number of intermittent fans                                                                                                    | <div>2</div>                                     |                 |                 |                 |                 |                 |                 |                 |                 |                 | x 10 =               | <div>20</div>           | (7a)  |
| Number of passive vents                                                                                                        | <div>0</div>                                     |                 |                 |                 |                 |                 |                 |                 |                 |                 | x 10 =               | <div>0</div>            | (7b)  |
| Number of flueless gas fires                                                                                                   | <div>0</div>                                     |                 |                 |                 |                 |                 |                 |                 |                 |                 | x 40 =               | <div>0</div>            | (7c)  |
|                                                                                                                                |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | Air changes per hour    |       |
| Infiltration due to chimneys, flues, fans, PSVs                                                                                | (6a) + (6b) + (7a) + (7b) + (7c) = <div>20</div> |                 |                 |                 |                 |                 |                 |                 |                 |                 | ÷ (5) =              | <div>0.07</div>         | (8)   |
| If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)             |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| Air permeability value, q <sub>50</sub> , expressed in cubic metres per hour per square metre of envelope area                 |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | <div>10.00</div>        | (17)  |
| If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)                                       |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | <div>0.57</div>         | (18)  |
| Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| Number of sides on which dwelling is sheltered                                                                                 |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | <div>1</div>            | (19)  |
| Shelter factor                                                                                                                 |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 | 1 - [0.075 x (19)] = | <div>0.92</div>         | (20)  |
| Adjusted infiltration rate                                                                                                     |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 | (18) x (20) =        | <div>0.53</div>         | (21)  |
| Infiltration rate modified for monthly wind speed:                                                                             |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
|                                                                                                                                | Jan                                              | Feb             | Mar             | Apr             | May             | Jun             | Jul             | Aug             | Sep             | Oct             | Nov                  | Dec                     |       |
| Monthly average wind speed from Table 7                                                                                        |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| (22)m                                                                                                                          | <div>5.40</div>                                  | <div>5.10</div> | <div>5.10</div> | <div>4.50</div> | <div>4.10</div> | <div>3.90</div> | <div>3.70</div> | <div>3.70</div> | <div>4.20</div> | <div>4.50</div> | <div>4.80</div>      | <div>5.10</div>         |       |
|                                                                                                                                | Σ(22)1...12 = <div>54.10</div>                   |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         | (22)  |
| Wind Factor (22a)m = (22)m ÷ 4                                                                                                 |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| (22a)m                                                                                                                         | <div>1.35</div>                                  | <div>1.27</div> | <div>1.27</div> | <div>1.12</div> | <div>1.02</div> | <div>0.98</div> | <div>0.92</div> | <div>0.92</div> | <div>1.05</div> | <div>1.12</div> | <div>1.20</div>      | <div>1.27</div>         |       |
|                                                                                                                                | Σ(22a)1...12 = <div>13.52</div>                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         | (22a) |
| Adjusted infiltration rate (allowing for shelter and wind speed) = (21) × (22a)m                                               |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| (22b)m                                                                                                                         | <div>0.72</div>                                  | <div>0.68</div> | <div>0.68</div> | <div>0.60</div> | <div>0.54</div> | <div>0.52</div> | <div>0.49</div> | <div>0.49</div> | <div>0.56</div> | <div>0.60</div> | <div>0.64</div>      | <div>0.68</div>         |       |
|                                                                                                                                | Σ(22b)1...12 = <div>7.17</div>                   |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         | (22b) |
| Calculate effective air change rate for the applicable case:                                                                   |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      |                         |       |
| If mechanical ventilation: air change rate through system                                                                      |                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                      | <div>N/A</div>          | (23a) |

URN: Whally House version 1  
NHER Plan Assessor version 5.4.2  
SAP version 9.90

Space heating requirement in kWh/m<sup>2</sup>/year (98) + (4) **54.53** (99)

#### 9a. Energy Requirements - Individual heating systems including micro-CHP

##### Space heating:

|                                                                          |              |       |
|--------------------------------------------------------------------------|--------------|-------|
| Fraction of space heating from secondary/supplementary system (Table 11) | <b>0.00</b>  | (201) |
| Fraction of space heating from main system(s) 1 - (201)                  | <b>1.00</b>  | (202) |
| Fraction of main heating from main system 2                              | <b>0.00</b>  | (203) |
| Fraction of total space heat from main system 1 (202) x [1 - (203)]      | <b>1.00</b>  | (204) |
| Fraction of total space heat from main system 2 (202) x (203)            | <b>0.00</b>  | (205) |
| Efficiency of main space heating system 1 (%)                            | <b>92.90</b> | (206) |

(from database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'space efficiency adjustment' column of Table 4c)

|                                                                                     | Jan            | Feb    | Mar    | Apr    | May    | Jun  | Jul  | Aug  | Sep  | Oct    | Nov    | Dec     |       |
|-------------------------------------------------------------------------------------|----------------|--------|--------|--------|--------|------|------|------|------|--------|--------|---------|-------|
| Space heating requirement, kWh/month (as calculated above)                          |                |        |        |        |        |      |      |      |      |        |        |         |       |
| (98)m                                                                               | 1111.36        | 865.36 | 699.98 | 391.46 | 145.15 | 0.00 | 0.00 | 0.00 | 0.00 | 400.67 | 807.54 | 1075.38 |       |
| Space heating fuel (main heating system 1), kWh/month = (98)m x (204) x 100 ÷ (206) |                |        |        |        |        |      |      |      |      |        |        |         |       |
| (211)m                                                                              | 1196.30        | 931.50 | 753.47 | 421.38 | 156.24 | 0.00 | 0.00 | 0.00 | 0.00 | 431.29 | 869.26 | 1157.56 |       |
| Total per year (kWh/year) = Σ(211)1...12 =                                          | <b>5917.00</b> |        |        |        |        |      |      |      |      |        |        |         | (211) |

##### Water heating:

Output from water heater, kWh/month (calculated above)

|               |                |        |        |        |        |        |        |        |        |        |        |        |      |
|---------------|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------|
| (64)m         | 213.84         | 188.49 | 197.99 | 177.53 | 174.00 | 155.52 | 149.40 | 163.88 | 163.58 | 184.08 | 194.59 | 208.71 |      |
| Σ(64)1...12 = | <b>2171.61</b> |        |        |        |        |        |        |        |        |        |        |        | (64) |

Efficiency of water heater per month

|        |       |       |       |       |       |       |       |       |       |       |       |       |  |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
| (217)m | 87.98 | 87.78 | 87.30 | 86.26 | 83.73 | 79.20 | 79.20 | 79.20 | 79.20 | 86.23 | 87.60 | 87.97 |  |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|

Fuel for water heating, kWh/month = (64)m x 100 ÷ (217)m

|                                            |                |        |        |        |        |        |        |        |        |        |        |        |       |
|--------------------------------------------|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| (219)m                                     | 243.05         | 214.73 | 226.79 | 205.79 | 207.81 | 196.36 | 188.64 | 206.92 | 206.53 | 213.47 | 222.13 | 237.25 |       |
| Total per year (kWh/year) = Σ(219)1...12 = | <b>2569.50</b> |        |        |        |        |        |        |        |        |        |        |        | (219) |

##### Annual Totals Summary:

|                                        | kWh/year       | kWh/year |
|----------------------------------------|----------------|----------|
| Space heating fuel used, main system 1 | <b>5917.00</b> | (211)    |
| Water heating fuel used                | <b>2569.50</b> | (219)    |

Electricity for pumps, fans and electric keep-hot (Table 4f):

|                                                                                |                  |                     |
|--------------------------------------------------------------------------------|------------------|---------------------|
| mechanical ventilation fans - balanced, extract or positive input from outside | <b>0.00</b>      | (230a)              |
| warm air heating system fans                                                   | <b>0.00</b>      | (230b)              |
| central heating pump                                                           | <b>130.00</b>    | (230c)              |
| oil boiler pump                                                                | <b>0.00</b>      | (230d)              |
| boiler flue fan                                                                | <b>45.00</b>     | (230e)              |
| maintaining electric keep-hot facility for gas combi boiler                    | <b>0.00</b>      | (230f)              |
| pump for solar water heating                                                   | <b>0.00</b>      | (230g)              |
| Total electricity for the above                                                | Σ(230a)...(230g) | <b>175.00</b> (231) |

Electricity for lighting (calculated in Appendix L):

**508.68** (232)

#### 12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

|                                   | Energy<br>kWh/year |   | Emissions<br>Factor             |   | Emissions<br>(kgCO <sub>2</sub> /year) |       |
|-----------------------------------|--------------------|---|---------------------------------|---|----------------------------------------|-------|
| Space heating - main system 1     | <b>5917.00</b>     | x | <b>0.198</b>                    | = | <b>1171.57</b>                         | (261) |
| Water heating                     | <b>2569.50</b>     | x | <b>0.198</b>                    | = | <b>508.76</b>                          | (264) |
| Space and water heating           |                    |   | (261) + (262) + (263) + (264) = |   | <b>1680.33</b>                         | (265) |
| Pumps, fans and electric keep-hot | <b>175.00</b>      | x | <b>0.517</b>                    | = | <b>90.48</b>                           | (267) |
| Lighting                          | <b>508.68</b>      | x | <b>0.517</b>                    | = | <b>262.99</b>                          | (268) |
| Total carbon dioxide emissions    |                    |   | Σ(261)...(271) =                |   | <b>2033.79</b>                         | (272) |

URN: Wholly House version 1  
NHER Plan Assessor version 5.4.2  
SAP version 9.90

## Appendix B

### Reference Values

The table below shows the energy conversion factors to calculate the carbon dioxide emissions.

**Table 11 – Energy conversion factors used in this report**

| Energy Source                          | kgCO <sub>2</sub> /kWh |
|----------------------------------------|------------------------|
| Electricity (mains fed)                | 0.517                  |
| Electricity (onsite generation offset) | 0.529                  |
| Gas                                    | 0.198                  |
| Biomass                                | 0.028                  |

**Table 12 – Parameters used in SAP 2009 calculations**

| Building Element         | Baseline               | Efficient              | Unit                                    |
|--------------------------|------------------------|------------------------|-----------------------------------------|
| Windows                  | 2.00                   | 1.20                   | W/m <sup>2</sup>                        |
| Ground-floor             | 0.25                   | 0.20                   | W/m <sup>2</sup>                        |
| Doors                    | 2.00                   | 2.00                   | W/m <sup>2</sup>                        |
| Walls                    | 0.30                   | 0.20                   | W/m <sup>2</sup>                        |
| Roof                     | 0.16                   | 0.13                   | W/m <sup>2</sup>                        |
| Thermal Bridging         | 0.11                   | 0.04                   | W/K                                     |
| Chimney                  | none                   | None                   |                                         |
| Open flues               | none                   | None                   |                                         |
| Extract fans             | 2                      | 2                      |                                         |
| Condensing gas boiler    | 86%                    | 89%                    |                                         |
| Water tank               | None (district system) | none (district system) |                                         |
| Main heating fuel        | Main Gas               | Mains Gas              |                                         |
| Heating system           | radiators              | radiators              |                                         |
| Air Permeability (@50Pa) | 10                     | 3                      | m <sup>3</sup> /hm <sup>2</sup> (@50Pa) |
| Low Energy Lights        | 75%                    | 100%                   |                                         |

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