

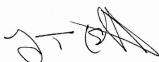
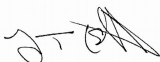


Renewable Energy Assessment

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

COMMERCIAL ESTATES GROUP

Contents

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Executive Summary

This report is issued to support the 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.

The technologies considered comprise low (combined heat and power) and zero (renewable) carbon options for the supply of energy to the proposed development.

An initial energy demand assessment was carried out using the accommodation schedule and energy benchmarks based on building areas for developments of this type. Best practice then requires that energy efficiency be considered to reduce the development energy demand by passive 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 contribution in energy. In this particular case the target is 10% of energy consumed on site.

A number of options are suitable for the development some of which meet the required target in isolation. The option also exists to combine number of options to meet the required target for example, air source heat pumps and solar PV. Regardless of which approach is taken, the required contribution to the site's energy demand can be achieved. The following table details the results from the study in order of preference.

Table 1 – Summary of energy

	Energy MWh/yr	
Baseline Condition	1,584	
Energy after energy efficiency	1,438	
Low and zero carbon technologies	Energy provided (MWh/yr)	Potential Contribution in energy (%)
Solar thermal	54	4%
Solar PV	65	5%
GSHP	476	33%
ASHP	476	26%
Natural Gas CHP (Nursing home only)	92(th) + 53(elec)	10%

Technologies not recommended for the site are:

- Biomass fuelled boilers
- Biomass CHP
- Small scale building mounted wind turbines
- Large scale wind turbines

1 Introduction

1.1 GENERAL

WSP Environment and Energy has been commissioned by Commercial Estates Group to conduct a low carbon and renewable energy technology assessment for the purpose of supporting a planning application for the proposed scheme at the land east of Clitheroe Rd, Lancashire.

1.2 SITE LOCATION

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



Figure 1 - Site location for the land east of Clitheroe Rd, Whalley

1.3 DEVELOPMENT PROPOSAL

The proposed scheme will provide:

- Up to 60 new family homes including affordable homes;
- A nursing home with up to 50 bed spaces;
- Associated access, car parking and ancillary landscaping

1.4 REPORT OBJECTIVES

For planning applications in the UK the sustainability agenda now drives a requirement to identify how proposed developments can achieve a reduction of carbon dioxide emissions. Reductions are identified against a base site energy demand assuming compliance with the Building Regulations at the time of the planning application.

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. In order of application the report identifies:

- A baseline annual energy consumption approximately equating to Building Regulations (2010)



- An assessment of the carbon reductions that are achievable by energy efficiency measures incorporated within the building's design
- A description of the appropriate technologies capable of delivering low or zero carbon energy to the development
- The percentage contribution each applicable technology can make to reduction of carbon dioxide emissions from the site due to energy demand
- Identification of the most appropriate technologies that can be integrated on site to serve the development

1.5 METHODOLOGY

The procedure followed in this report incorporates the principles defined by the energy hierarchy:

- Energy demand is first assessed based on existing minimum legal requirements (Building Regulations current at the time of the expected project commencement)
- The baseline energy demand is converted to equivalent carbon dioxide emissions for reporting purposes
- Energy conservation measures are then identified to reduce the energy demand (estimates at this stage so all suggestions must be confirmed at detailed design stage).
- Low carbon measures are assessed to supply the required energy in as efficient a way as possible
- Finally renewable energy supply options to meet the required reduction of the development's energy provision or carbon dioxide emissions are identified
- Revised energy demand and equivalent carbon dioxide emissions are identified to confirm compliance with Planning Authority requirements

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.

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.

1.6 TECHNOLOGIES

The low and zero carbon technologies reviewed in this report include:

- Natural Gas Combined Heat & Power (CHP)
- Biomass CHP
- Energy from wind
- Photovoltaic panels
- Solar water heating
- Energy from biomass
- Ground source heat pumps
- Air source heat pumps



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 national 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 recently approved 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.

2.1.2 Code for Sustainable Homes

The Code for Sustainable Homes is a standard by which new homes are benchmarked. A more detailed description is provided in the appendices. Since 2008 all dwellings have to be assessed against the code and given a rating. Future years will require a certain minimum rating leading ultimately to 'zero carbon homes'. Differing levels set different energy standards.

2.2 REGIONAL POLICY

This section outlines the background information to regional planning requirements.

2.2.2 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 microgeneration

2.2.1 Regional Spatial Strategy (RSS)

The RSS for the North West (Adopted 2008) forms part of the statutory development plan. The policies that were 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



2.2.2 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.

2.3 LOCAL POLICY

This section outlines the background information to local planning requirements.

2.3.1 Ribble Valley Borough Council - Local Development Framework (LDF)

At present there is no specific policy relating to energy in the Ribble Valley Borough Council Local Development Framework although it will feature in the core strategy as it is developed. However, the following is included within the Borough Council's intentions for clean energy deployment:

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.

2.4 TARGETS

Given the policy context detailed above, the targets defined for this site are;

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

3 Site Energy Demand

3.1 AREAS USED IN CALCULATIONS

All areas utilised within calculations undertaken within this report have been completed with reference to the Architects general arrangements and are as listed within wider planning documentation.

Table 1 - Building area schedule

Accommodation Name	Total m ²
60 dwellings (Av. 90m ² per dwelling - CfSH Level 3)	5,400
Nursing home	2,000
Total	7,400

3.2 BENCHMARK DATA

This report uses comparison energy demand figures based on benchmark data for each type of building. By their nature benchmark assessments made are indicative at this stage.

To determine initial estimates of the energy consumption the following benchmark values were used.

Table 2 - Energy Benchmarks

Category	Gas (kWh m ⁻² annum ⁻¹)	Electric (kWh m ⁻² annum ⁻¹)
Dwellings	83	36
Nursing home	375	42

Table 3 – Energy conversion factors used in this report

Energy Source	kg CO ₂ /kWh ⁻¹
Electricity (mains fed)	0.517
Electricity (onsite generation offset)	0.529
Gas	0.198
Biomass	0.028

Table 4 - Baseline annual energy demand and carbon dioxide emissions from development

Energy Source	Delivered Energy in (kWh/year)	Carbon Dioxide Emissions (kg CO ₂ /year)
Gas	1,306	259
Electricity	278	143
Total	1,584	402

3.3 ENERGY DEMAND OVER A YEAR

Figure 2 and Table 5 indicate the energy demand of the site over a typical year.

Figure 2 - Energy and carbon dioxide emissions summary

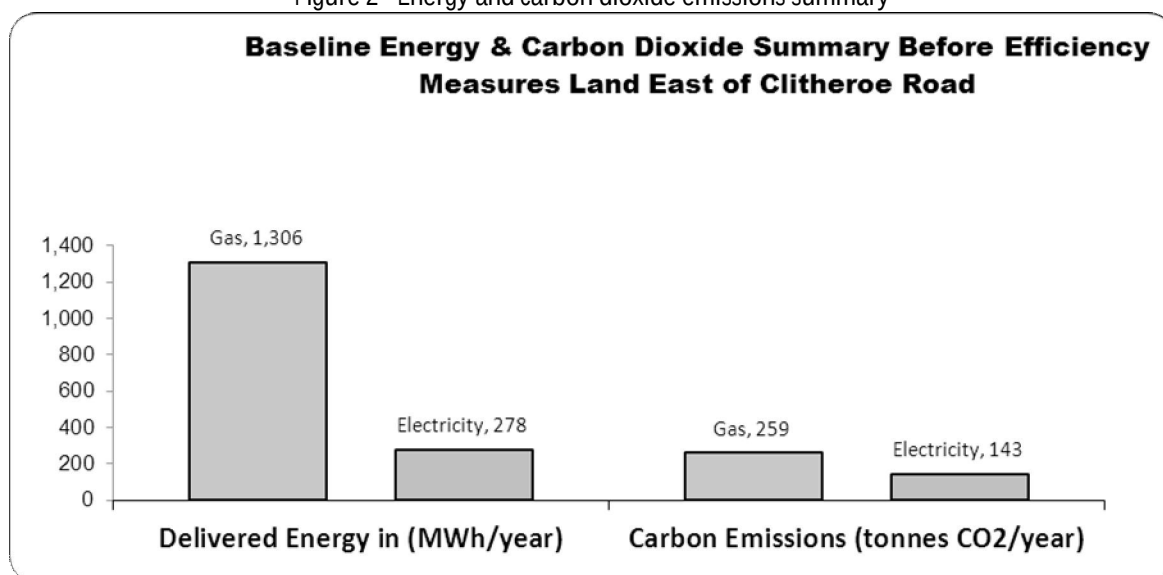


Table 5 - Site energy demand split across service type

Fuel	Energy end uses	Delivered energy in MWh
Gas	Space heating and hot water	1,199
	Space heating gas	727
	Hot water gas	472
	Other gas	108
	Total gas	1,306
Electric	Space heating and hot water	0
	Hot water electric	0
	Space heating electric	0
	Cooling (refrigeration) electric	25
	Fans, pumps & controls	8
	Other electricity	245
	Total electricity	278

Multiplication of each area by the relevant benchmark annual energy consumption provides the total energy consumption per annum. The sum of all building types then provides the total site energy consumption.



Table 6 - Baseline site energy demand and carbon dioxide emissions split across accommodation type

Summary of Loads	Predicted annual delivered energy requirements for:		Baseline CO ₂ arising from:		
	Electricity	Gas	Electricity	Gas	Total CO ₂
	Fuel carbon emission factor (CO ₂ /kWh)		0.517	0.198	
Units	MWh/year	MWh/year	Tonnes CO ₂ /year	Tonnes CO ₂ /year	Tonnes CO ₂ /year
All Dwellings	194	556	100	110	210
Nursing home	84	750	43	149	192
Site Total	278	1,306	143	259	402

4 Energy Efficiency - Energy Efficiency Measures

4.1 GENERAL CONSERVATION MEASURES

To reduce the energy of a building below Building Regulation requirements, the design team may wish to consider employing the following example methodology which is consistent with the energy hierarchy provided in Appendix B. The following points list the energy measures that should be considered by the design team in order to limit the energy consumption and the carbon footprint of the Development.

Step One

Initial energy demand reduction via passive measures to the building envelopes:

- Reduce the air permeability of the building envelope and
- Optimise the U-Values of the external fabric. This may be realised by improving on the requirements of Part L of the Building Regulations for dwellings

Step Two

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

- Selecting boilers with high efficiency e.g. SEDBUK A rated
- Delayed-start controls including optimisation and compensation heating controls
- Zone time and temperature control to heating system for different parts of the building via a building energy management systems
- Timed and thermostatic control to hot water system via a building management system
- Passive design to encourage daylighting and reduce artificial lighting demand and
- Thermal design to reduce overheating and the need for cooling chillers

Step Three

Robust supply strategy by combining efficient delivery of energy with low and zero carbon technologies:

- Installation of on-site renewable energy sources where viable (Refer to Section 6)

Step Four

It should be recognised that the points raised in this report are strictly applicable to parts of the development under the direct control of the Developer.

Assuming conservative reductions as a result of application of the above measures an overall estimated energy reduction of 2% is identified. The new energy demand across the site becomes:

Table 7 - Site energy demand split across service type

Fuel	Energy end uses	Delivered energy in kWh
Gas	Space heating and hot water	602
	Space heating gas	456
	Hot water gas	1,058
	Other gas	108
	Total gas	1,166
Electric	Space heating and hot water	0
	Hot water electric	0
	Space heating electric	0
	Cooling (refrigeration) electric	24



	Fans, pumps & controls	8
	Other electricity	240
	Total electricity	272

5 Low Carbon Technology – Combined Heat and Power

5.1 INTRODUCTION

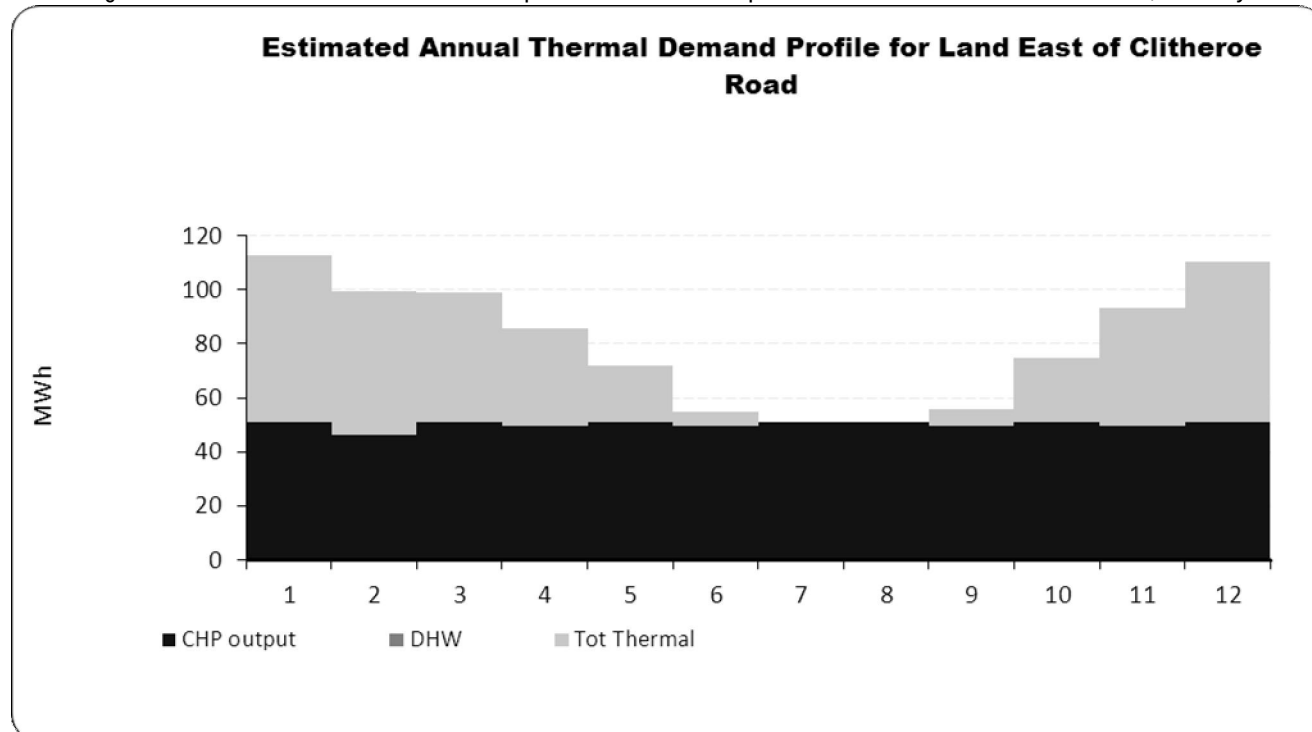
This technology comprises installation of an electrical generator on site which uses an engine fuelled by natural gas as the prime mover. Low grade waste heat is recovered to generate hot water thereby increasing the overall efficiency.

5.1.1 Selection Criteria

Although combined heat and power (CHP) is considered a low carbon technology and not a renewable energy supply 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. If this report identifies that gas fired CHP might be viable a more detailed assessment will be required when the thermal and electrical energy demands of the development can be accurately assessed.

Figure 4 below illustrates the variation in space heating demand over the course of a year within the development. Space heating demand varies with the seasons but domestic hot water demand remains constant throughout the year. It should be noted here that the CHP has been sized in order to satisfy 80% of the heat in the nursing home only and not for the wider development, which is why its contribution to meeting the thermal demand shown here for the site is small. To be economically viable gas fired CHP units need to operate a minimum of 5,000 hours each year. In order to achieve the minimum operating hours CHP units are normally configured to serve base thermal energy demand. The sizing constraint therefore lies in the summer months and as evident in the chart below comprises the site domestic hot water (DHW) demand. CHP should not over produce and reject heat to atmosphere; if it does so the installation risks losing its' Good Quality status which qualifies the operators for Climate Change Levy exemption. When considering a larger development containing a number of houses district heating networks become viable with the energy being provided from a CHP. As a general rule this only becomes viable at approximately 200 homes at a medium density of 60-80 homes/hectare¹. This particular development falls below these two figures.

Figure 4 - Estimated annual heat demand profile for the development at the land east of Clitheroe Rd, Whalley



When CHP and district heating network is viable, the installation of a site wide distribution system supplying hot water to all the buildings within the site would be required. A gas-fired CHP unit could be installed within a central plant room, backed up by gas-fired boilers to meet peak loads and provide cover during maintenance periods. The hot water produced can be distributed to the scheme via a network of heat distribution pipe-work. The use of hot water can be separately metered at the point of use

¹ Commission for Architecture and the Built Environment (CABE) – Establishing local energy supply/CHP networks.

or an average charge could be made to each dwelling. The electricity produced on-site could be used to meet some of the proposed development's demand or be exported from the site to the local electricity network.

5.1.2 Viability

As detailed above for CHP and a district network to be viable a minimum of 200 homes is required with a density of 60-80 homes/hectare. As detailed earlier, this development falls below these figures, there is however the possibility of including this technology on the site for use within the nursing home. The nursing home is likely to have high annual heating demand and therefore suitable for a technology such as this. The following table details the calculation when considering this option.

Table 8 – Viability of natural gas CHP at the development on the land east of Clitheroe Rd, Whalley

Low Carbon Technology Summary: Natural Gas Combined Heat and Power		
Description	1 CHP unit sized to meet 80% of the Nursing home's thermal energy requirements, equivalent to 11% of the Site's thermal energy requirements	
Annual thermal energy provided by this source	95,000	kWh pa
Annual electrical energy provided by this source	53,000	kWh pa
Availability	Constant throughout year, running for 5000 hours	
On-site energy contribution		10%

CHP and district heating is not recommended for further consideration in the context of the Proposed Development.

A CHP unit is recommended for further consideration in the context of the Nursing home within the Proposed Development.



6 Renewable Energy Sources

6.1 RENEWABLE OPTIONS APPRAISAL

There are a range of renewable energy technologies available and the list below identifies those generally considered the most promising for a development such as this. A brief description of each technology is provided in the appendices of this report but not all will be applicable to this project.

- Wind turbines
- Photovoltaic panels
- Solar thermal water heating
- Biomass heating
- Biomass combined heat and power
- Ground source heat pumps
- Air source heat pumps

6.2 WIND TURBINES

6.2.1 Selection Criteria

Integration of wind turbines on developments requires consideration of many factors. Dependent on the scale of wind turbine considered viable they may be either stand alone or building integrated. However there are 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 recommend the installation of wind turbines onto buildings.

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.

6.2.2 Viability

This technology is not recommended for this development due to proximity of residential properties (less than 500m away) and building density on site.

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

6.3 PHOTOVOLTAIC PANELS

Photovoltaic panels comprise flat panels that convert sunlight into an electrical supply.

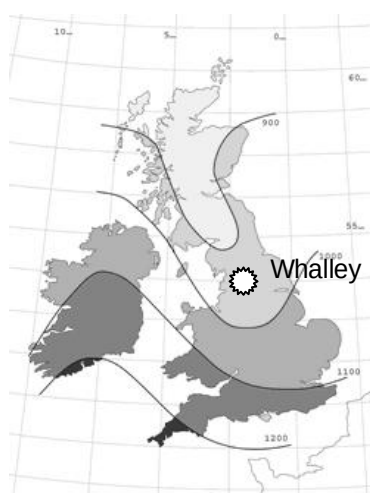
6.3.1 Selection Criteria

Photovoltaic panels (PV) can be incorporated into the design and provide an electrical power output used to offset incoming electrical energy.

When assessing the potential benefit of photovoltaic panels allowance must be made for overshadowing from adjacent buildings. Overshadowing can substantially reduce the output from photovoltaic panels.



Figure 5 – UK solar resource



6.3.2 Viability

Installation of photovoltaic panels involves a high capital cost. However the Feed in Tariff (FiT) introduced by the UK Government in April of 2010 provides an incentive to install this type of technology and is designed to make the technology financially attractive.

Table 9 – Viability of photovoltaic panels at the development on the land east of Clitheroe Rd, Whalley

Renewable Energy Summary: Photovoltaic Panels	
Description	Half of the dwellings being suitably orientated with Approximately 25m ² (2.5kW) per dwelling. A total of 750m ² .
Annual electrical energy provided by this source	65,000 kWh pa
Availability	Limited output during winter months rising to maximum output in summer months on bright days.
Onsite energy contribution	5%

The accommodation on site comprises of dwellings, consequently the installation of photovoltaic panels is recommended for more detailed consideration on this type of buildings.

Photovoltaic panels installed on most buildings could provide a small contribution to the site electrical energy demand and can be installed at the same pace of development as the site. However the energy produced is at its peak at mid day in the summer months, when domestic demand is usually low, falling off substantially through the winter. Excess electricity can be exported for a price that is fixed by the feed-in tariff arrangements. The feed-in tariff will also provide a payment for all of the electricity generated.

There are several ways in which a PV installation like this could be managed, ranging from each individual householder owning the panels and taking the relevant income and paying maintenance charge, through to a central organising company (an ESCo) owning the panels and renting the roof space from the householder. This would require further discussion as the project develops.

For the purposes of this report it has been assumed that half of the dwellings will be orientated in a suitable way for PV and that 25m² (~2.5kW) has been installed on each. This gives a total area of PV panels of 750m² (75kW). With these assumptions the energy contribution from PV is 5%.

The exact number of dwellings that could have PV needs to be determined at design stage if the option is taken forward.

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

6.4 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.

6.4.1 Selection criteria

The solar collectors need unrestricted access to sunlight without overshadowing. The area required for installation of the panels needs to be co-ordinated with the provision of roof mounted environmental control plant and equipment.

6.4.2 Viability

Table 10 – Viability of Solar Water Heating at the development on the land east of Clitheroe Rd, Whalley

Renewable Energy Summary: Solar Hot Water Heating	
Description	Half of the dwellings being suitably orientated with Approximately 4m ² per dwelling. A total of 120m ² .
Annual thermal energy provided by this source	54,000 kWh pa
Availability	Limited output during winter months rising to maximum output in summer months on bright days.
Onsite energy contribution	4%

This technology offers a commercially attractive solution when applied at plot level to individual dwellings. As the target is energy related it is the more efficient solar technology. The technology is well proven and can save a reasonable proportion of the site thermal energy demand for hot water generation.

When considering the total area required to achieve the 10% on site energy target it equates to 5m² per building. Similarly to PV it is unlikely that all houses will be suitable for the installation of solar thermal panels. Therefore, for the purposes of this exercise an area of 4m² on half of the dwellings has been considered. This gives a total area of 120m². With these assumptions the energy contribution from solar thermal is 4%.

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

6.5 BIOMASS HEATING

In the context of this report biomass heating is the direct combustion of biomass wood fuels in a boiler located on site.

6.5.1 Selection Criteria

In a development such as this biomass boilers can be used to replace central boiler systems, utilising fuel from local sources. A secure local source would have the advantage of reducing the transportation required for the fuel supply, and also benefit the local community by providing an additional source of revenue from existing waste wood.

The advantage of using biomass is that it could reduce the size of a gas connection to the site, thereby presenting a saving in utility infrastructure costs. A disadvantage is that the fuel would have to be delivered to, and waste collected from, the site. The fuel supply would also need to be secured over a period of time.

These installations are able to reduce the CO₂ emissions considerably. The developer can install the plant and then recover costs from the owners through metering strategies. However, using this technology, there are other factors such as fuel delivery traffic and NO_x emissions that make it less desirable than the CHP option.

6.5.2 Viability

Although biomass boilers can modulate down to 25% of maximum output there is high thermal inertia leading to a slow response. Biomass boilers are therefore best suited to serving a base load using natural gas fired boilers to accommodate the variable element of site demand. 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.

Table 11 – Viability of Biomass Heating at the development on the land east of Clitheroe Rd, Whalley

Renewable Energy Summary: Biomass Heating	
Description	1 No biomass boilers are required rated at 707kW (thermal). Calculated to provide 74% of energy and sized for 50% of maximum heat demand
Annual thermal energy provided by this source	571,000 kWh pa
Availability	Available throughout year subject to routine maintenance.
Onsite energy contribution	74%

Application of biomass heating to this site does have some potential issues. The flue gases from biomass boilers contain oxides of nitrogen and particulates which impact on the local air quality.

Space in and adjacent to the energy centre would be required for fuel handling and storage facilities and this may require a revision of the site masterplan as there is little space available on site.

Furthermore, the biomass boiler would be installed as part of an energy centre serving a district heating network. Similarly to Gas CHP, a biomass boiler and district heating network also requires a certain number (200-250) and density of buildings to make it viable.

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

6.6 BIOMASS COMBINED HEAT AND POWER

6.6.1 Selection Criteria

This technology is an extension of biomass heating described above but with the addition of an electrical generator.

6.6.2 Viability

This technology has the same issues identified above for biomass boilers. Generally biomass CHP is considered viable for installations in the MW range of equipment sizes which, although is within the scope of characteristics of this development, the regulatory environment does not yet justify the installation of a site-wide biomass CHP unit which has a considerable logistical footprint.

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

6.7 GROUND SOURCE HEAT PUMPS

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 4.

Ground source heat pumps extract energy via a ground linked heat exchanger.

1.1.1 Selection Criteria

Heat pumps can utilise a sealed water loop connected to ground heat exchangers or groundwater can be directly abstracted via bore holes fed direct through a heat pump and then returned to the groundwater via a second borehole. 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.

Advice from the Environment Agency suggests that a temperature balance will be required in future licensing of groundwater schemes. This means that any heat taken from the ground must be replaced over the course of a year. On small schemes this can be achieved by natural means – higher ambient temperatures in summer warm the earth and below ground water movements transfer heat.

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.

Two different forms of ground loop are commonly used, vertical and horizontal. Although more cost effective horizontal loops require a large land area which is not available on this Development. Consequently the calculations are based on a sealed system using vertical boreholes.

1.1.2 Viability

Ground linked heat exchangers for this technology can be installed in either horizontal format or vertical boreholes. Horizontal pipes require an extensive amount of ground and for this scheme the ground heat exchanger must be vertical boreholes to provide the required heat exchange area.

Table 12 – Viability of GSHPs at the development on the land east of Clitheroe Rd, Whalley

Renewable Energy Summary: Ground Source Heat Pumps	
Description	The GSHP system rating is 397kW using a Vertical borehole ground loop system. The number of boreholes is estimated at 40No covering an area of 1,433 m ² .
Annual thermal energy provided by this source	476,000 kWh pa
Annual electrical energy consumed by this source	136,000 kWh pa
Availability	Available throughout year subject to routine maintenance.
Onsite energy contribution	33%

Application of ground source heat pumps to individual dwellings would require a large plot area per dwelling which may be available on this site but the exact area would need to be determined at the next design stage. Furthermore, if a mix of technologies was a preferred option the dwellings that were not suitable for the solar technologies could have GSHPs installed which would contribute to the overall 10% onsite renewable energy. 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.

6.8 AIR SOURCE HEAT PUMPS

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.

Air source heat pumps extract energy from either ambient air or from air extracted from a building.

1.1.3 Selection Criteria

This technology is applied on a dwelling (or building) by dwelling basis. No central site management is required.

The technology can provide cooling although this increases the overall energy consumption for the site especially for dwellings.



1.1.4 Viability

Although a smaller capital cost compared to ground source heat pumps air source heat pump are not so effective due to the increased temperature variation of the source

Table 13 – Viability of ASHPs at the development on the land east of Clitheroe Rd, Whalley

Renewable Energy Summary: Air Source Heat Pumps	
Description	The air source heating pumps system meeting 50% of the end use heating requirement
Annual thermal energy provided by this source	476,000 kWh pa
Annual electrical energy consumed by this source	190,000 kWh pa
Availability	Available throughout year.
Onsite energy contribution	26%

The application of ASHPs is viable to meet the full 10% onsite energy target or part of it by mixing it with other technologies at plot level. 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.

7 Appraisal of Options

Ref	Measure	Description	Advantages / Disadvantages	Recommendations for this Scheme
✓	Energy efficiency measures	Passive design measures to reduce building energy demand Examples are: Improved thermal insulation Improved window and building layout to maximise solar contribution to heat demand Improved building layout to minimise over heating effects during summer	Helps to reduce energy requirement for base building May increase building footprint with no increase in accommodation area reducing site build density	Recommended as primary energy reduction initiative.
✓	Photovoltaic Panels	Collectors on roofs absorb solar energy during summer months and generate electricity	A number of suppliers available Unobtrusive An effective renewable energy technology but relatively expensive	Now a feasible choice as feed-in tariffs mitigate the high capital cost. Recommended as a part of the solution for this development.
✓	Solar Hot Water Heating	Solar hot water collectors mounted on the roofs of dwellings	A cost effective technology Removes energy demand during summer when the heat demand is required by combined heat and power plants to be cost effective	Recommended for this site as a cost effective solution for reducing energy
✓	Air Source Heat Pumps	Technology installed on individual buildings	It might be considered an advantage by the Developer that the on-going management of the equipment falls under the householder's responsibility. Limited visual issues.	Recommended for this scheme on buildings that may be unsuitable for solar technologies and therefore used as part of a technology mix across the site.
✓	Ground Source Heat Pumps	Technology installed on individual buildings	Bore holes or ground loops required which can take up large areas Limited visual issues.	Recommended for this scheme on buildings that may be unsuitable for solar technologies.
✓	Combined heat and power	Electricity is generated on site by a gas engine and alternator. Waste heat is reclaimed and distributed with generated electricity realising an improved efficiency above grid electricity	Improved utilisation of primary fuel when suitable mix of thermal demand available Installation of site wide heat distribution network required Energy centre required on site taking space and requiring on-going management	Recommended for the nursing home as the development will have a high annual heat demand and this option represents a large contribution.



✖	Wind turbine	A single large wind turbine installed locally and electrical output connected directly into DNO network	Proven technology that would make a bold statement. Cannot be located on site due to proximity of dwellings.	Due to proximity of existing dwellings and density of development on site this technology is not recommended
✖	Biomass heating	Biomass boilers installed in central energy centre	Can supplement conventional gas boilers and combined heat and power	Not recommended for the development However installation of an energy centre with appropriate space could enable introduction of biomass boilers at a later stage
✖	Biomass CHP	CHP fed by biomass installed in central energy centre	Fuel supply can be an issue Remains a fairly unproven technology	Not recommended for the development



8 Conclusions

1.2 INTRODUCTION

A complete range of renewable energy supply technologies were reviewed together with energy efficiency and low carbon technologies such as combined heat and power.

Energy demand reduction achieved by energy efficiency measures and good design standards generally has a lower cost and is more sustainable than renewable energy. 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 sources. With these fundamental measures in place it is expected that a 10% energy contribution for planning requirements by the inclusion of low carbon or renewable energy technologies can be achieved.

The accepted benchmark data used was derived before the current Building Regulations came into force and consequently modern constructions are likely to be more efficient than the benchmarking data used. However as this data is also identified in the London Renewable Toolkit which is used as a basis for quantifying the savings from renewable energy technologies the existing benchmark data is used as a basis for the report. Any changes in the data could reduce the energy demand and therefore make compliance easier to achieve.

1.3 DISCUSSION

1.3.1 Natural Gas CHP, Biomass boilers and Biomass CHP

At a district wide scale, installation of these three technologies is not considered to be viable for the entire site due to the size of the development not being of sufficient size to justify the installation of a district heating network with which these technologies would feed. However, a natural gas CHP would be viable to supply the nursing home only due to the regularity of thermal demand in that part of the development.

1.3.2 Wind turbines

Wind turbines are unviable for the site due to the close proximity of other residential buildings.

1.3.3 Photovoltaic Panels

Photovoltaic panels are a good technical solution but to make any real contribution require installation of a large number of panels. The roof arrangement for the dwellings would need to change to make sure that photovoltaic panels were orientated in the optimum southward direction. Therefore, if done correctly a number of buildings could be fitted with this technology to meet the target.

1.3.4 Solar hot water heating

Solar hot water heating can be a cost effective solution and on this site could make a significant contribution in terms of on-site renewable energy. System sizing and application across the most applicable dwellings needs be carefully considered to achieve the required target. The option to mix this technology with another but across individual buildings as an overall mix is possible.

1.3.5 Ground Source Heat Pumps

Ground source heat pumps can practically only serve a small portion of the site heating energy demand. Also the heat output from ground source heat pumps is low grade and more suitable for domestic underfloor heating. The area required is a significant proportion of that of the entire site, hence practical considerations rule out ground source heating as a viable option.

1.3.6 Air Source Heat Pumps

Similarly to GSHPs, ASHPs can be used as part of a mix of technologies on site and where dwellings that are not suitable for the installation of solar technologies this can be used. ASHPs also have the advantage of being the least aesthetically intrusive on the design of the buildings if this was an issue for the development.



1.4 SUMMARY

The technologies considered viable for the site are:

- Solar photovoltaic panels
- Solar hot water heating
- Air source heat pumps
- Ground source heat pumps
- Natural gas fired CHP (for the nursing home only)

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.

Technologies not considered viable for the site are:

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

Appendix A 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 that should be investigated first to reduce the base energy demand. The energy hierarchy is a methodology that identifies what 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 (the base of the triangle) through to carbon offsetting, which should be the last consideration after all other options have been exhausted.

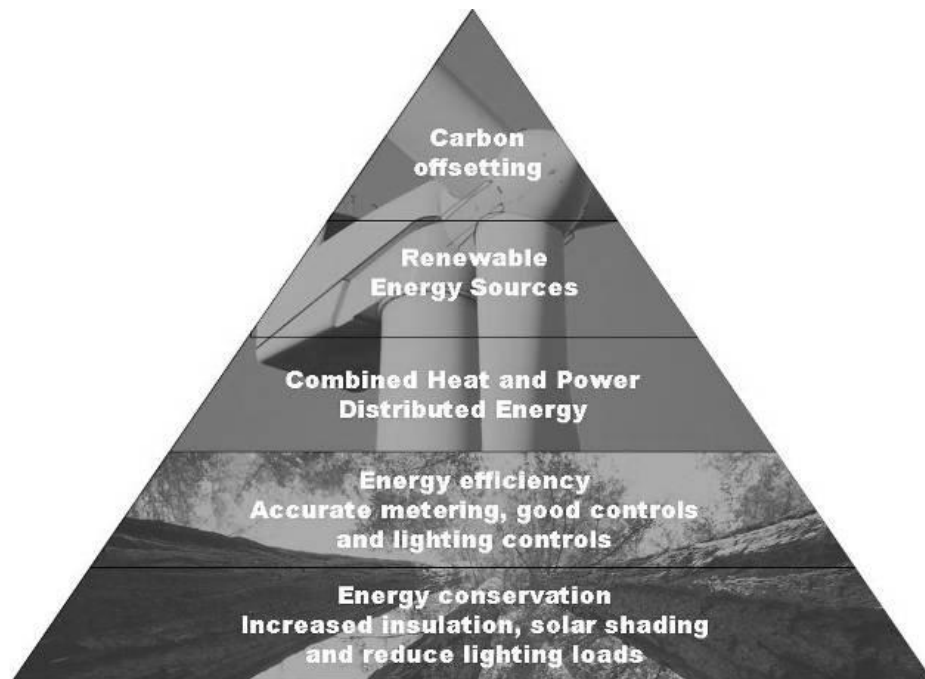


Fig A1 – Representation of Energy Hierarchy



Appendix B Regulations

As national governments and their alliances drive up the importance of fossil fuel conservation and carbon emissions reductions new legislation regularly appears. The following is a summary of the legislation resulting from climate change.

ENERGY WHITE PAPER – 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 Energy Policy, including its policy on renewable energy, is set out in the Energy White Paper. This aims to put the UK on a path to cut its carbon dioxide emissions by some 60% by 2050, with real progress by 2020, and to maintain reliable and competitive energy supplies.

As part of the strategy for achieving these reductions the White Paper sets out:

- The Government's targets to generate 10% of UK electricity from renewable energy sources by 2010; and
- The Government's aspiration to double that figure to 20% by 2020 and suggests that still more renewable energy will be needed beyond that date.

The Energy White Paper indicated that the Government would be looking to work with regional and local bodies to deliver its objectives, including establishing regional targets for renewable energy generation.

REGIONAL TARGETS

Council (and District Councils) request assessment of the energy demand of proposed major developments, which should also demonstrate the steps taken to apply the energy hierarchy by:

- Requiring the inclusion of energy efficient and renewable energy technology.
- Facilitating and encouraging the use of all forms of renewable energy where appropriate including giving consideration to the impact of new development on existing renewable energy schemes.

The energy strategy will therefore review methods of reducing the consumption of carbon dioxide emissions on site by improving energy efficiency, increasing the proportion of energy use generated from renewable sources and ensuring the efficient distribution of energy within the site.

ENERGY PERFORMANCE BUILDINGS DIRECTIVE

In addition to planning policy, other policy initiatives and legislation now exist to promote energy efficient design. Legislation has been introduced from the EU and is incorporated into UK statutes to promote the energy efficient design and operation of buildings.

These include:

- EU Energy Performance of Buildings Directive (implemented in 2008)
- Revisions of Part L of the UK building regulations
- Climate Change Levy

The Energy Performance of Buildings Directive (EPBD) is a concerted effort across the European Union to reduce the energy used in buildings, both domestic and commercial. This strategy springs from the EU signing up to the international Kyoto Protocol, which deals with climate change on a global scale. Under this agreement, the EU member states must collectively reduce greenhouse gas emissions by 8% compared to 1990 levels. The deadline for this is 2012.

As the EU Energy Performance Directive is implemented within UK legislation, there will be additional compliance requirements placed on developers and operators of buildings to adhere to. In particular, the main requirements will be to:

- Calculate the energy performance of the proposed buildings at the design stage with the use of predictive modelling software;

- Apply minimum standards of energy performance to all of the buildings on the development;
- Ensure that boilers, heating systems and air-conditioning are inspected regularly (during the operational phase); and
- Ensure that when a building changes occupants an “energy performance” certificate or label is made available “and” displayed in all public buildings as well as those visited by the public. In addition, landlords will be required to produce a valid energy performance certificate when a new lease is signed or a property is sold or refurbished.

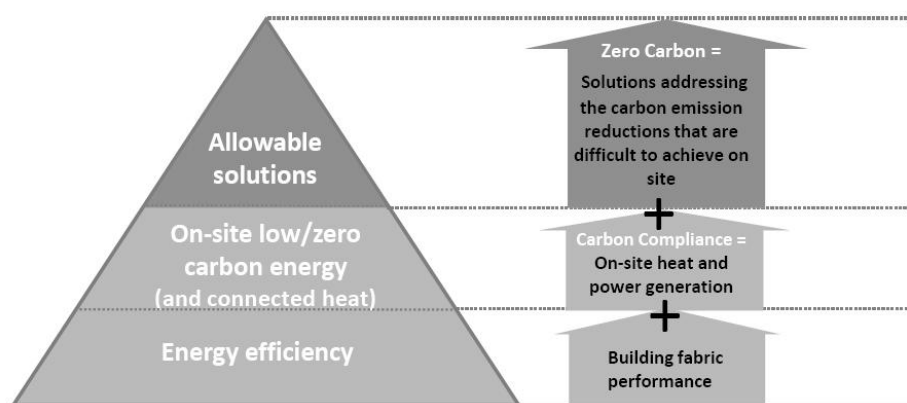
The preceding requirements are incorporated within the requirements of Part L of the building regulations, and energy labelling was implemented during 2008. Consequently all public buildings over 1,000 m² have to permanently display an energy performance certificate.

The performance certificates are based on an energy Asset Rating calculation procedure. An Asset Rating requires details on the layout, activities supported, construction, and servicing of the building and in its simplest form utilises iSBEM as required for Building Regulations Part L compliance. The certificates have a life of ten years.

The certificate works the same way as energy labelling on domestic appliances. A-rated has an excellent energy performance; a G-rating is poor. ‘A’ rated buildings will become more desirable assets, and then more energy efficient buildings will need to be created to meet the demand. The display rating certificate for larger public buildings may be based on the calculation procedure described above, or on an Operational Rating procedure which compares actual metered energy consumption to benchmarks.

ZERO CARBON DEFINITION

The UK Government’s definition of Zero Carbon and time line for implementation have changed and been redefined a number of times. The latest accepted definition (1st February 2011) of achieving zero carbon compliance for 2016 (from operation of the building itself and the appliances within) will require a three-stage approach:



The Zero Carbon Hierarchy – stepped progress towards a workable definition.

- Efficiency – building fabric and design to reduce energy demand
- On site – low/zero carbon energy from renewable technologies
- Allowable solutions – still to be defined



Appendix C Combined Heat and Power

8.2 COMBINED HEAT AND POWER

CHP is not a renewable source, unless it is powered by biofuels. CHP does however offer the potential for considerably improved generation efficiency with implicit carbon and cost savings benefits.

Generating electricity is typically only 40% efficient, almost all of the other 60% is dissipated in the form of heat at the generator before any power whatsoever is delivered to the distribution system, such as the national grid, from where further losses are incurred. Overall, national electricity generation and distribution is only about 35% efficient.

CHP is effectively a mini power station with heat reclaim and minimal distribution losses due to its close proximity to the load. The power and heat usually serve a single building or site, although there are examples of them serving whole towns.

8.3 COMBINED COOLING, HEATING AND POWER (CCHP)

CHP generates on-site electricity using gas-fired engines or turbines. This also generates large amounts of high grade heat which can be used in heating and, via the use of absorption chillers, cooling. The process can be 80% efficient by utilising both the generated electricity and the free waste heat produced. This means that carbon emissions from such a scheme would be significantly less than from a scheme using conventional electrical supplies. UK electricity has a carbon content of 0.43kg/kW, compared to gas with 0.19kg/kW. This ratio is a reflection of the inherent inefficiencies which result from remote generation and transmission of electricity.

For the system to be economically attractive it the system should be sized to use the full output of both electricity (power) and heat for most of the time. This means sizing the plant below the peak demand for either heat or power to service the minimum (or baseload) for the site. Correct sizing of CCHP can produce overall efficiencies of 80%.

Because heat can be stored more easily than electricity, it is usually possible to make a scheme cost effective provided that the hot water produced as a by-product of the electricity generation can be used within a few days: beyond this time the standing heat losses might render the system inefficient. Demand profiling is therefore an important factor in the sizing of a CHP system. For this reason, it is not cost effective to size the plant on the basis of space heating requirements alone when there is little or no demand for several months of the year. Demand profiling is therefore a key factor in the sizing of a CHP system and the year round baseload may be determined by demand for domestic hot water, swimming pools, laundries or industrial heat processes.

Co-generation: this is the term applied when the waste heat is harnessed and used for heating purposes only.

Tri-generation: this is the term applied when the waste heat is harnessed and used for heating purposes and cooling via absorption chillers.

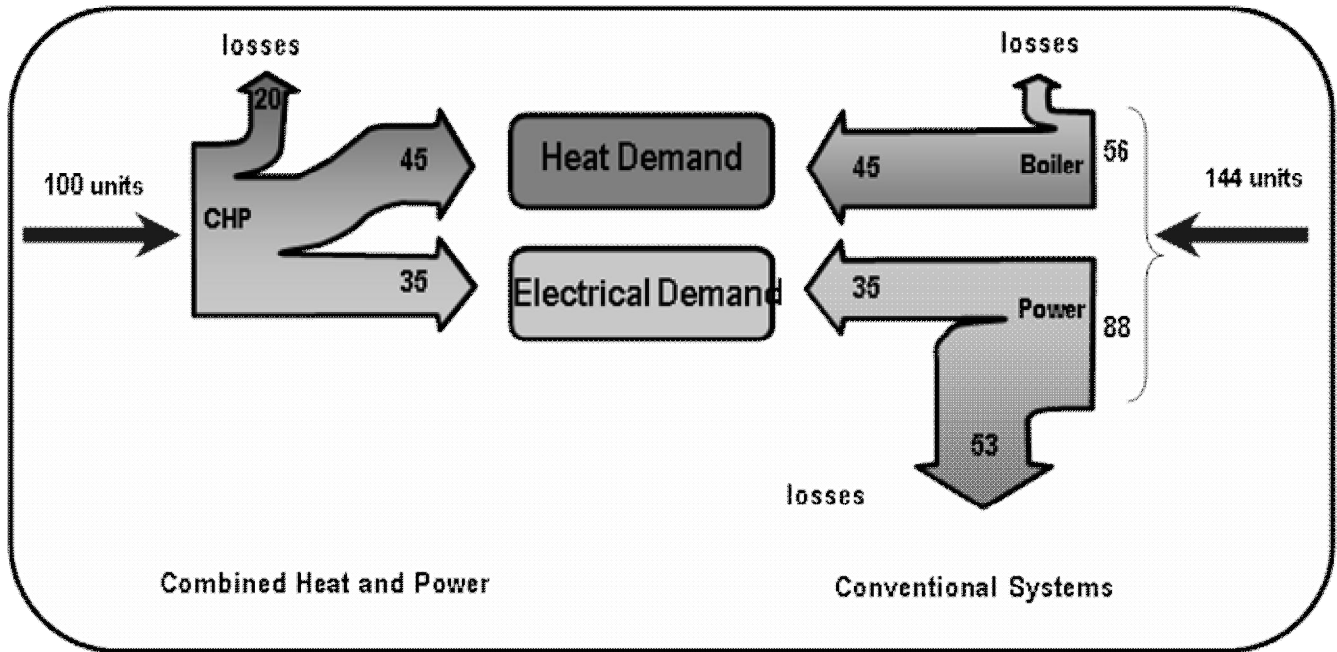
Advantages:

- Reduces energy costs and CO₂ emissions
- Gives additional electrical resilience in case of mains failure or alternatively can avoid the need to reinforce the local utility grid
- A cost effective fuel (usually natural gas) is used to produce valuable electricity as well as heat. Can also be biofuel
- Absorption chillers are very quiet in operation because there are no compressors

Disadvantages:

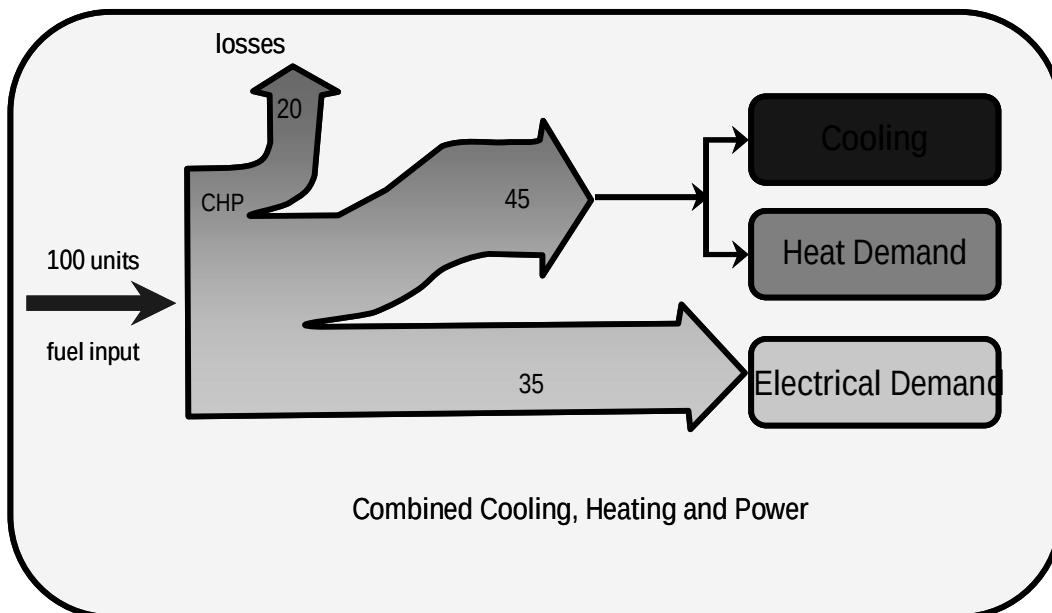
- Expensive, although the extra cost may be mitigated by the reduction in the cost of infrastructure upgrades or the provision of renewable energy supplies
- Requires maintenance

CHP Energy Flow Diagram



CCHP schemes are used successfully in the UK, such as the West Quays shopping centre in Southampton, where all retailers are connected to electricity, hot water and chilled water supplies. This particular scheme is operated from a district heating system within the town but can be successfully applied to individual schemes.

CCHP Energy Flow Diagram





Appendix D Renewable Energy Supply Technologies

The following is a summary of the available renewable energy sources currently available for use in the UK.

WIND

Wind turbines are available in a variety of shapes, sizes and duties, with the most common being a propeller blade/windmill configuration with a horizontal axis. Turbines are also available in vertical axis arrangements in a number of styles, and purpose built rooftop modules or integrated systems are emerging onto the market. The comparative scale of the wind turbines is large in relation to the quantity of electricity generated (and consequent reduction in CO₂ emissions).

Typical sizes of horizontal axis wind turbines range from 6m to 80m rotor diameters, with power generation capability of 600W to 2.5MW respectively. The annual output of the wind turbine is dependent on the average wind velocity.

Due the size of the wind turbines they are typically ground mounted with only small models generally considered for mounting on buildings. Noise and visual impact can be issues associated with wind turbines, and must be considered early during the design if they are incorporated into the development.

The successful application of wind turbines very much depends on the scale of turbine and wind velocities on the site. In urban locations the path of the wind is disrupted by obstructions such as buildings. It is generally accepted that building mounted wind turbines do not provide a satisfactory energy output. However a single large turbine can provide a good solution if sufficient space is available on site.

PHOTOVOLTAIC PANELS

Photovoltaic systems convert solar energy directly into electricity through semiconductor cells. The cells produce DC electricity and are typically arranged in modules that include an inverter to convert the electricity into AC that can be used by the building systems.

The amount of electricity generated by the panels varies depending on the external light conditions. The peak energy generated from 1m² of solar panel is generally in order of 120W. The panels generate electricity from both direct light and diffuse light (i.e. non-direct light scattered via the atmosphere).

Photovoltaic panels can either be mounted external to the building or be integrated into the building cladding (known as Building Integrated Photovoltaic Panels or BIPV). Where the panels are mounted externally, the optimum orientation for the panels is south facing at an inclination of 35°. When integrated into south facing vertical cladding, the solar panels are de-rated by some 30% and provide a reduced peak output and energy contribution.

SOLAR HOT WATER HEATING

Solar hot water heating systems harvest energy from the sun to heat water. This is typically achieved in the UK through the use of solar heating panels positioned on the roof of the building. A fluid, typically water, is passed through tubes within the panels and absorbs the solar radiation that in turn increases the temperature of the fluid.

There are a number of different types of panels that can be used, which vary in cost and efficiency. A fewer number of more efficient panels may achieve the same heat output, but the cost of panels increases significantly as efficiency is increased.

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. For this reason in the UK, this type of system is generally used to provide heating to domestic hot water systems, which typically has a consistent year-round demand.

Heated water that passes through the solar collectors is linked to a well insulated hot water storage cylinder where the heat energy is transferred and stored until needed. The distance between solar collector and storage cylinder should be kept to a minimum to avoid heat losses from the pipework.



SOLAR AIR HEATING

Solar air heating systems utilise glazed solar collectors similar to solar hot water heating, however air rather than water is the medium heated in this case. The warmed air is then used in warm-air space heating systems

BIOMASS HEATING

This involves using fuel from a renewable resource burnt to provide heat directly into the building. The biomass used in these types of systems is typically wood and factory waste, or pellet fuel.

In commercial and industrial buildings, biomass boilers can be used to replace central boiler systems that would typically run on gas. The biomass-fired system requires more fuel handling and storage equipment than is required for typical gas or oil fired boiler systems. A number of large bins are typically provided which can be used on a rotational basis, with a regular top-up of fuel that would be delivered by lorry. The resulting space requirement is likely to be significant and as such not practical and due to the small building footprint and site access constraints.

Wood is the most commonly used form of biomass fuel, and can be used in the form of logs, wood chips and wood pellets.

GROUND SOURCE COOLING AND HEATING VIA HEAT PUMPS

In the UK, soil temperature below a depth of 5 metres stays at a constant temperature throughout the year of around 11-12°C; this being the annual mean air temperature. The soil at this depth is effectively a huge thermal store: storing heat absorbed from the sun in the summer and releasing it during the winter. Ground source heat pumps take this low temperature energy and concentrate it into more useful, higher temperature, energy to heat water or air inside a building.

The heat pump uses the evaporation and condensing cycle of a refrigerant in order to transfer heat from one place to another. This is just like the operation of a refrigerator where heat is extracted from inside the fridge and expelled at higher temperature via the condenser on the back. A compressor is used to move the refrigerant around the system and to compress the refrigerant in order to raise the temperature at which it condenses to that required in the building. It is the compressor which consumes the electricity required by the system.

Ground source heat pumps cool the soil by a fraction of one degree Kelvin and reject (transfer) the heat at about 45°C to the serviced building or system. The condensing temperature can be raised further to enable domestic hot water to be heated above the Legionella risk temperature of 56°C, but this will increase energy consumption.

The coefficient of performance (CoP) is the ratio of the primary energy (usually electricity) to total heat out. The energy transferred out includes most of the primary energy too because the compressor power is ultimately turned into heat and collected. For this reason, the CoP of a refrigeration plant used as a heat pump is one higher than when it is used for cooling and sometimes called CoPH to differentiate it. Typically a ground source heat pump will produce a CoPH of about 4, i.e. for each 1 kW of electrical energy in; 4kW of useful heat is transferred.

Heat pumps are available in a range of installed capacities from several kW right up to several MW (large enough to provide all of the building's heat needs).

Closed loop systems: Lengths of plastic pipe are buried in the ground, either in a borehole or a horizontal trench. The pipe forms a closed loop charged with a water/antifreeze mixture.

Open loop systems: For inner city developments these typically use ground water sourced from bore holes, although water sourced from canals is an option in certain locations. River and sea water are also good sources where available.

Borehole cooling (or heating) is effectively an open loop system which uses the ground water temperature directly. The ground water is pumped to the surface and used for heat extraction and/or heat rejection before it is pumped back into the aquifer via a second (recharge) borehole. The capacity of the system is limited by the amount of water that can be extracted and the allowable rise/fall in temperature of the water before discharge. The use of boreholes is subject to approval of planners and the Environment Agency, and the feasibility depends on local geology, the available water yield, and the presence of other boreholes in the area.