Property and Energy Services Ltd.

# Carbon Reduction and Local Energy Generation Options Report

199 - 207 Henley Road, Caversham, RG4 6LJ
42 new build flats and houses
June 2017 v2-0

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## EXECUTIVE SUMMARY

### Introduction

Property and Energy Services Ltd. has been commissioned to produce a report to identify the options available to enable the introduction of renewable energy technologies to a development at 199 - 207 Henley Road, Caversham, RG4 6LJ, to produce a minimum of 19% reduction in the annual site regulated CO2 output for the flats and houses from 2013 regulations. This report will consider the maximum potential of each technology to achieve these targets, examine cost, visual appearance and installer & end-user issues and conclude with recommendations for action.

In line with best practice, the first step is to reduce demand by design, which will be done by setting lower u-values for all elements than building regulations. Using appropriate thermal junction details and lower air pressure targets.

### Energy demand & associated carbon emission data calculations

The energy demand for the properties has been based on calculations undertaken by the BRE for similar types of properties, as fully modelled energy data for these specific properties is not currently available. The BRE data is published in tables 1 & 2 of the Energy Saving Trust document CE190, 'Meeting the 10% target for renewable energy in housing - a guide for developers and planners' and extrapolated according to the respective property floor areas. These have been provided by the developer as being 70 – 86 m2 for the 30 proposed new flats and 142 m2 for the 12 houses. For the tables below, we have grouped the units into four average floor areas.

The energy data is broken down into what are considered to be the four main areas of domestic usage, space heating, water heating, lights & appliances and cooking. It should be noted that cooking and appliances do not feature under Part L1A of the Building Regulations, so the data is more inclusive of potential annual energy demand and reflects average usage patterns and occupancy levels.

This data is broken down per property type as follows:

| Type | No | Area sq m | Est. space heating kwh | Est. hot water kwh | Est. lights and appliances kwh | Est. Cooking kwh | Total kwh | |
|---|---|---|---|---|---|---|---|---|
| A | 12 | 142 | 65,685 | 65,474 | 58,661 | 25,215 | 215,034 | House |
| C | 6 | 86 | 19,233 | 23,834 | 18,649 | 9,939 | 71,655 | Flat |
| D | 6 | 77 | 17,221 | 21,340 | 16,697 | 8,899 | 64,157 | Flat |
| E | 18 | 70 | 46,966 | 58,200 | 45,538 | 24,269 | 174,972 | Flat |
| | | | | | | | | |
| Total | 42 | | 149104 | 168848 | 139545 | 68321 | 525818 | |
| | | | | 317,952 | | | | |

Table 1: Initial Assessment of Site Energy Demand in Kwh

| Type | No. | Area sq m | Est. space heating | Est. hot water | Est. lights and appliances | Est. Cooking | Total | |
|---|---|---|---|---|---|---|---|---|
| A | 12 | 142 | 12,742 | 12,703 | 24,754 | 4,893 | 55,092 | House |
| C | 6 | 86 | 3,728 | 4,626 | 7,871 | 1,923 | 18,149 | Flat |
| D | 6 | 77 | 3,338 | 4,142 | 7,048 | 1,722 | 16,250 | Flat |
| E | 18 | 70 | 9,103 | 11,297 | 19,221 | 4,697 | 44,317 | Flat |
| | | | | | | | | |
| Total | 42 | | 28911 | 32768 | 58894 | 13235 | 133808 | |
| | | | | 61679 | | 19 pc | 11719 | from 2013 |

Table 2: Initial Assessment of Site $CO_2$ emissions in $kgCO_2/yr$

## Assessment of renewable energy options

The potential for employing a range of renewable energy technologies on this site have been examined. Estimated installed costs are presented net of VAT and any grants that may be available.

The technologies are:

- District heating
- Community heating
- Biomass heating (BIO)
- Ground Source Heat Pumps (GSHP)
- Air Source Heat Pumps (ASHP)
- Solar photovoltaics (PV)
- Solar thermal (ST)
- Wind turbines (WT)
- Combined Heat and Power (CHP)

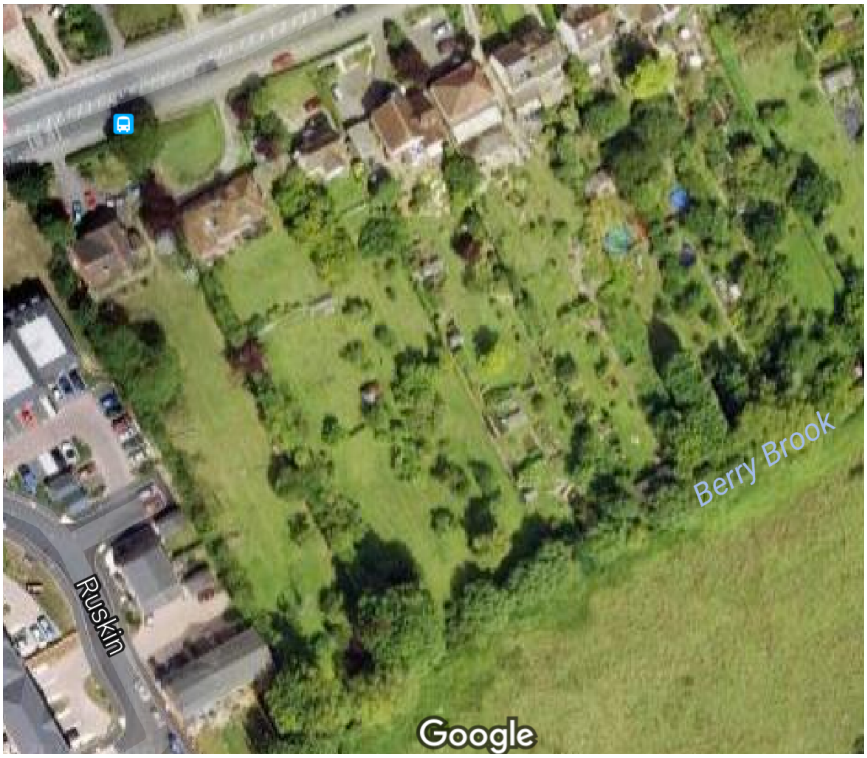
**Conclusion**

The suitability is subjective and based on the author's opinion of each technology against the following issues: ease of installation, ease of end user operation and maintenance, installation and running costs and impact on the local generation and CO2 reduction requirements. Note that the energy usage figures are estimates based on Energy Saving Trust documents and not actual figures for the design of the building, although they are based on average occupancy and usage of standard property types. Following a full SAP modelling of the properties, we usually show a 5% reduction in CO2 output from the EST baseline by using better insulation values than required by building regulations and following detailed thermal junctions.
The best option is the use of solar PV systems which can meet the target of 19% less CO2 than the 2013 building regulations standard. We recommend this option.

## 1. INTRODUCTION

Property and Energy Services Ltd (PES) have been providing advice and guidance on reducing carbon output and methods of generating energy at a local level for eight years. They have reviewed over 160 existing properties and hundreds of new build properties. As such, PES is well placed to analyse and assess local energy and carbon reduction requirements relating to planning conditions. PES are also licensed Elmhurst & Stroma SAP, Elmhurst Commercial assessors, and ATTMA Air tightness testers. PES are regularly engaged by MCS accredited suppliers for help in building thermal models of properties.

This report will assess the expected annual energy demand and carbon output of this development and investigate the various options available to the developers to achieve a 19% reduction in CO2 output for the site. This proposed development consists of 42 units with total floor areas of 70 – 86 m2 for the 30 proposed new flats and 142 m2 for the 12 houses. The site is located in an urban area to the East of the centre of Caversham, near Reading, Berkshire - see Google Maps image below.




The outline energy demand of the site has been calculated using 'rule of thumb' figures provided by the Building Research Establishment (BRE) and Energy Savings Trust (EST) for the varying housing types, based on standardised UK dwelling occupancy usage patterns. All figures are therefore hypothetical and the finalised designs/constructions usually perform better than those stated here.
The LZC technologies will be assessed with regard to their suitability for this type of

development; their energy offset potential and their capital and running costs.

The following technologies are considered:

- District heating
- Community heating
- Biomass heating (BIO)
- Ground Source Heat Pumps (GSHP)
- Air Source Heat Pumps (ASHP)
- Solar photovoltaics (PV)
- Solar thermal (ST)
- Wind turbines (WT)
- Combined Heat and Power (CHP)

## 2. Energy and Carbon Dioxide

### 2.1Energy demand

The energy demand for the properties has been based on calculations undertaken by the BRE for similar type properties, as fully modelled SAP energy data for these specific properties is not yet available. The BRE data is published in the Energy Saving Trust document CE190, 'Meeting the 10% target for renewable energy in housing - a guide for developers and planners' and extrapolated according to the respective property floor areas. These have been provided by the developer as being between 70 – 86 m2 for the 30 proposed new flats and 142 m2 for the 12 houses. These have been averaged into groups and for each of the dwelling types proposed for the site and are shown in more detail below in Table 3. The proposed site layout is shown below:

The energy data is broken down into what are considered to be the four main areas of domestic usage, space heating, water heating, lights & appliances and cooking. It should be noted that cooking and general electrical appliances do not feature under Part L1A of the Building Regulations, so the data is more inclusive of potential annual energy demand and reflects average usage patterns and occupancy levels.
This data is broken down into three property types, based on average floor area. The floor area shown represents an average floor area for each type of flat and is as follows:

| Type | No | Area sq m | Est. space heating kwh | Est. hot water kwh | Est. lights and appliances kwh | Est. Cooking kwh | Total kwh | |
|---|---|---|---|---|---|---|---|---|
| A | 12 | 142 | 65,685 | 65,474 | 58,661 | 25,215 | 215,034 | House |
| C | 6 | 86 | 19,233 | 23,834 | 18,649 | 9,939 | 71,655 | Flat |
| D | 6 | 77 | 17,221 | 21,340 | 16,697 | 8,899 | 64,157 | Flat |
| E | 18 | 70 | 46,966 | 58,200 | 45,538 | 24,269 | 174,972 | Flat |
| | | | | | | | | |
| Total | 42 | | 149104 | 168848 | 139545 | 68321 | 525818 | |
| | | | | 317,952 | | | | |

Table 3:Initial Assessment of Site Energy Demand

The total estimated energy consumption for the development is 525,818 kWh/yr made up of 149,104 kWhs for space heating, 168,848 kWhs for water heating, 139,545 kWhs for lights and appliances and 68,321 kWhs for cooking. Individually, each property is projected to use between 9,721 to 17,920 kWhs of energy per annum.

**2.2. Carbon Dioxide Emissions**

The estimated data for the $CO_2$ emissions comes from table 2 of the Energy Saving Trust document CE190, 'Meeting the 10% target for renewable energy in housing - a guide for developers and planners' and extrapolated according to the respective property floor areas.

The following extrapolation for the respective average floor areas below also shows the total $CO_2$ emissions for the site.

| Type | No. | Area sq m | Est. space heating | Est. hot water | Est. lights and appliances | Est. Cooking | Total | |
|---|---|---|---|---|---|---|---|---|
| A | 12 | 142 | 12,742 | 12,703 | 24,754 | 4,893 | 55,092 | House |
| C | 6 | 86 | 3,728 | 4,626 | 7,871 | 1,923 | 18,149 | Flat |
| D | 6 | 77 | 3,338 | 4,142 | 7,048 | 1,722 | 16,250 | Flat |
| E | 18 | 70 | 9,103 | 11,297 | 19,221 | 4,697 | 44,317 | Flat |
| | | | | | | | | |
| Total | 42 | | 28911 | 32768 | 58894 | 13235 | 133808 | |
| | | | | 61679 | | 19 pc | 11719 | from 2013 |

Table 4: Initial $CO_2$ emissions for the site in $kgCO_2$/year

The baseline CO2 generated by these properties is 61,679 $kgCO_2$/year for the regulated supply. This is reduced initially by applying the latest building methods of thermal junction detailing and excellent insulation values for all areas of the fabric. When SAP calculations have been completed for the proposed flats and the result is usually a reduction of 5% in CO2 from these estimated values, however for this report we will work with the EST values. The target is to reduce CO2 output by 19% from 2013 building regulations, which is 11,719 $kgCO_2$/year. (this being the equivalent energy reduction to a Code for Sustainable Homes Level 4 property)

## 3. Centralised heating systems

### 3.1 District Heating

A district heating system would consist of an industrial unit that generates a large amount of surplus heat, such as an incinerator plant. This waste heat is converted in to high temperature water or steam and sent to the houses / flats / offices by pipe.
There would be a charging system for each flat / unit that measures the amount of hot water they take. At the local level – flat for example – the very hot water or steam is passed through a heat exchanger to heat the local water in the flat. This is then used internally just like a normal boiler based hot water system would be.

There is no district heating system in this area of Berkshire and none in planning at the time of writing. As there are no district heating systems available in the locality this choice can be discarded.

### 3.2 Community heating

A community heating system is made up of a large boiler and hot water store (accumulator) in a central location. This generates hot water, which is passed through heat mains pipe work to each unit.
At the unit level, the water will pass through a meter directly in to the heat emitters (radiators) and into the local hot water tank. This intake is measured by a heat meter so that each unit can be charged individually. There is usually a small hot water(100 - 150 litre) tank in each flat to reduce time to get hot water to individual units.

3.2.1 Community heating at Henley Road

A community heating system could be installed in this development. The boilers and central hot water store require a large room and there is a suitable place within the building though no land outside the building. Assuming there is a suitable area within the building structure to site the large boilers that would be necessary to support a local community heating system. Each flat would be supplied with a heat meter and a hot water cylinder that is fed from the community system.
The three likely sources of heating to be investigated are gas, biomass and ground source heat pumps. All three would require a room size of approximately 3m by 5m for the heating and hot water. The hot water accumulator is likely to be at least 2m tall and over 1m wide.

**Mains gas community boilers**

Mains gas when used with community heating delivers savings in $CO_2$ usage. The initial cost of the boilers and installing heat meters will be lower than installing individual boilers per flat. This goes some way to achieving the 19% $CO_2$ savings we require. The boilers will supply hot water to a large thermal store. This acts as a buffer for the smaller flat based hot water cylinders and enables the boilers to run in their most efficient mode.

**Ground source heat pumps**
These will only be viable for the community heating approach due to the number of flats and the vertical rises required. The use of a ground source heat pump saves large amounts of CO2 output and they generally give enough saving to meet the 19% CO2 saving that is required. Because of the nature of the site, the only option for the heat gathering array is to use boreholes. There would be several of these and they are likely to be 50m to 80m deep. This is a costly choice due to the bore hole drilling costs and along with other logistical considerations means this option is unlikely to be used. It is likely that piling will be required for the construction, which will reduce the cost impact of drilling heat boreholes.

**Biomass community boilers**
Biomass boilers are available in the sizes required for heating this block of flats. They require a large store of pellets, which have to be kept in a dry and secure location. This would require a space of at least 3m x 3m x 2.5m (height). The store would need to be located within 25m of the road or other lorry access route. There is space in the landscaped grounds for the boilers and the buffer tanks, plus thermal store and the pellet store. Given the lack of internal or covered space for this system, it is likely that a packaged solution would be best. This takes all the heat generation equipment and store into a single separate building. There are suppliers that ship the entire system ready to be connected to a flow and return pipe. This source of heating would need to supply 9 units and is an average option.

## 4. RENEWABLE ENERGY OPTIONS APPRAISAL

### 4.1 Biomass Heating

4.1.1 Background
The CO2 that is released when wood fuel is burnt is equivalent to that taken from the atmosphere through photosynthesis during tree growth. Even allowing for CO2 generated during planting, harvesting, processing and transport of the wood, replacement of fossil fuel with wood fuel will typically reduce net CO2 emissions by over 99%, assuming that the wood is managed sustainably. Whilst wood fuel has been utilised for centuries, technological applications for its use have progressed rapidly in recent years, with Austria and the Scandinavian countries leading the way.
Wood fuel can be split into three categories; wood chips, wood pellets and logs. Woodchips arise mainly from woodland management or dedicated wood-fuel crops, such as coppice willow. They are best suited to a building or buildings with a consistent '24/7' heat requirement throughout the heating season, such as schools, halls of residence, old peoples' homes, hospitals, prisons etc., or for district heating/CHP schemes. They require large storage spaces which makes them unsuitable for single houses and will therefore not be considered for individual use.
Wood pellets are mainly produced from untreated wood waste, such as sawdust, pulverised pallets or reclaimed timber. They are more expensive then wood chips, however, they are easier to store and handle, require less storage space and have a higher calorific value. Pellets are typically used in smaller systems, down to the domestic level, Pellet fuelled systems are operated much like oil or LPG based boilers, with a small time lag when first starting up. Logs are a well known fuel and tend to be used in smaller heating systems and domestic

stoves. They normally require a higher manual input that pellets and chips, so are not under consideration for this site.

### 4.1.2 Domestic Wood Fuel Boiler Systems

Wood fuel heating can be undertaken in one of two ways; district/communal heating or individual property based boilers. In this instance, it will be the latter that is considered, as a communal system is not deemed to be economically viable for this site due to the need for a dedicated plant room, fuel storage facility and heat main to all the dwellings. The focus regarding fuel source will be on pellet fired systems due to storage space constraints and operational issues, which render wood chip and logs an unrealistic option at the individual property level.

Wood fuel heating systems typically comprise the boiler (and flue); in some instances, a thermal store; a circulation/distribution pump & associated mechanical services; electrical services; controls package and a fuel storage facility connected to the boiler, either internal or from a hopper or bunker via a screw feed auger.

System set up is essentially the same as for a conventional domestic boiler, with a programmer controlling when heat is required. The issues that need addressing at the earliest stage of design are whether to install a thermal store and how/where fuel will be stored and fed into the boiler.

The thermal store allows the boiler to operate efficiently during the periods when the heat demand is low or experiences unpredictable peaks. This is likely to be the case during the seasons of spring and autumn and when providing domestic hot water (DHW) only during the summer (if this option is selected over solar thermal or electrical heating options). Most biomass boilers tend to operate at their maximum efficiency when they are working at full load, therefore, a heat distribution with many peaks is not conducive to optimum operational efficiency. A thermal store will enable the boiler to run at full load until the tank is at the required temperature. The buffer tank will then feed the demand of the central heating system and DHW until the temperature of the water in the tank drops below a set point and the boiler needs to fire up again.

There are a number of options for fuel storage and these are governed by space restrictions and desired frequency of delivery. In most cases a prefabricated hopper located adjacent to the building (and boiler) filled by a tanker blowing pellet in directly or an excavated bunker fed the same way would be the preferable solutions. The advantage of these methods is that a hopper or bunker allows for the pellets can be automatically fed into the boiler and, if adequately sized, reduces number of deliveries per annum.

### 4.1.3 Fuel Supply

Pellet supply is a rapidly maturing market and there are many suppliers both locally and nationally that could supply this site, both with bulk and smaller delivery options. Bulk purchase has good economies of scale over regular deliveries, with the acceptable size of the external pellet store giving the restriction in capacity.

4.1.4 Biomass Heating at the Henley Road Site
The size of wood pellet systems is too large for using individual units in these flats. See discussion above for use of biomass heating in a community system.

| $CO_2$saving per flat | Number of flats required to meet target | Total reduction % | Locally generated Energy per flat | Number of flats required to meet target | Total generated locally % |
|---|---|---|---|---|---|
| 1300 | 9 | 19.2 | 6800 | 9 | 19.2 |

Table 5: Energy implications for total site use of wood pellet system

The lack of space in both the flats and the houses for the size of the smallest wood pellet stove make this option not applicable (N/A).

## 4.2 Ground Source Heat Pumps

4.2.1 Background
In the UK, the earth at a depth of 2 metres and below has a constant temperature of around 11-12 °C throughout the year. Due to the ground's high thermal mass, it stores heat from the sun during the summer. A ground source heat pump (GSHP) can upgrade this heat from the ground to provide space heating and, in many cases, heating for DHW. For every unit of electricity used to generate the useful heat, 3-4 units of heat are produced. Whilst not truly a renewable energy technology because of the requirement to input electricity, heat pumps do still have a significant impact in reducing CO2 emissions and are cost competitive in terms of running costs against direct electricity, oil and LPG fuelled systems and in some instances mains gas. They can therefore be regarded as a sustainable energy solution.

4.2.2 The Technology
In the case of GSHP systems there are three important elements to consider:

The Ground loop - comprises lengths of plastic pipe buried in the ground, either in vertical boreholes or horizontal trenches. The pipe is a closed circuit and is filled with a special liquid, which is pumped round the pipe absorbing heat from the ground. A horizontal trench of about 30m length will provide for about 1kW of heating load. Trenches are normally a minimum of 5m apart and 1.5 - 2m deep. Borehole based collectors will be at depths of between 60 and 80m. On this site, the only option is boreholes.

Heat pump — these are similar in operation to refrigerators and air conditioners. By vaporising and condensing a refrigerant a heat pump is able to move heat from one place to another. In the case of ground source heat pumps, the evaporator takes heat from the water in the ground loop and consequently, the condenser gives up heat to the heating distribution system. A compressor within the heat pump compresses the gaseous refrigerant to increase the temperature to that needed for the distribution circuit.

Heat distribution system — GSHPs are suited to low temperature (35 - 40C) heating systems as less energy is needed to upgrade from the source temperature. Under-floor heating, ducted warm air and low temperature radiator heating systems are therefore particularly suited for heat pumps. Use of conventional radiator systems is possible but needs careful analysis before proceeding, although split systems involving under-floor heating downstairs and radiators upstairs are increasingly popular in new-build properties. Heat pumps can also supply all, or a fraction of DHW and an element of summer cooling, if the installation is designed correctly.

As already stated, energy is needed to run the heat pump cycle and to compress the vapour and expand the liquid to vapour for the production of useful heat. The efficiency of this process is measured by the ratio of the useful heat delivered and the energy used by the compressor. This ratio is called the Coefficient of Performance (CoP). The CoP of the current generation of ground source based heat pumps varies from 3.5 to 5. Since the CoP shows performance for a single set of parameters, a second measure is included to show the performance of the heat pump over an entire year. It is called the Seasonal Performance Factor (SPF), which is the ratio of annually delivered useful heat over annually used driving energy. The calculations for SPF are now included in a SAP calculation known as Appendix Q, which is publicly available.

4.2.3 GSHPs at the Henley Road Site

The use of GSHPs at the Henley Road site is worth considering technically, as this is a new development and a heat pump can be installed to feed a suitable heat distribution system such as under-floor heating or mixed under-floor/radiator systems, which would allow for optimum performance. This would only be possible if the bore holes are drilled when the foundations are being prepared. This also assumes the system includes the GSHP providing the Domestic Hot Water (DHW) and space heating requirements, but no cooling, and working to a CoP of 4.5

| **$CO_2$saving per flat** | **Number of flats required to meet target** | **Total reduction %** | **Locally generated Energy per flat** | **Number of flats required to meet target** | **Total generated locally %** |
|---|---|---|---|---|---|
| 580 | 21 of the 30 | 19.7 | 4500 | 21 of the 30 | 29.7 |

Table 6: Energy implications for total site with GSHP

The figures show that installing GSHP systems to provide the heating and hot water for 21 units within the development reduces CO2 by 19.7%.

GSHP systems are not a cheap option (particularly if using boreholes), but have little to no on-going operation and maintenance issues. Installation for each individual flat would be difficult as the bore holes would be at ground level. As with the biomass option, this

technology is best suited to a community heating system, so it is discounted on the individual basis. Costing the systems for this development is not easy due to a lack of detailed design at this stage, so outline costs are very roughly estimated to be in the region of £16,000+ for each dwelling.
This technology is technically difficult to install in multiple flats and is regarded as a poor option for this site.

## 4.3 Air Source Heat Pumps

4.3.1 Background
ASHPs work on the same principal as a GSHP, however, the medium from which heat is extracted is the external air rather than the ground. ASHPs will generally have a lower seasonal CoP compared to GSHPs due to the generally lower air temperatures compared to the ground. They may require additional backup in extremely cold conditions and this facility is normally provided by an electric booster built into the system. Its requirement will be limited, but it can provide peace of mind to the end user, although it can lead to large electricity bills in the depths of winter.

ASHPs can either be monoblock units or split systems. The external unit is normally next to a wall of the building they serve. It is advisable to locate the unit to protect it from high winds. In addition, the fans and compressors do make a small noise (40 - 50 dB), so it is worth considering locating the plant away from windows and adjacent buildings. It is also possible to reduce this noise by mounting the unit on a noise-absorbing base. Manufacturers display the noise levels of the units to enable an informed selection.

In a split system the outdoor unit can be located up to 10-50 meters away from the indoor heat exchanger. The external unit absorbs heat from the air and transfers this to a refrigerant which is transferred via refrigeration pipe-work to the heat exchanger. The external unit will be between 80 - 120cm high, 90 - 110cm wide and 30 - 40cm deep. Acoustically, they tend to have noise levels of around 40 - 50dB, therefore they are normally mounted on rubber spacers to counter any issues of disturbance.

The indoor unit is a wall mounted compact unit that can be located anywhere in the property. It does not require flues or ventilation. Its main function is to transfer the heat in the refrigerant from the outdoor unit to the property heating and hot water system. Dimensions are typically 90- 120cm high, 50 - 65cm wide and 35 - 60cm deep. The domestic hot water tank is the final key component and is normally complete with recirculation connection, tank sensor, tank heater overload and the usual controls.

4.3.2 ASHPs at the Henley Road Site
The use of ASHPs at the Henley Road site is worth considering technically as this is a new development and the heat pumps can be installed to feed under-floor heating or mixed under-floor/radiator systems, which would allow for optimum performance. Table 7 shows the potential impacts on energy if installed in 26 units at the site. Assumptions include the ASHP

providing the DHW and space heating requirements, but no cooling, and working to a CoP of 3.5.

The average CoP in SAP software is around 3.5, which is marginally less than the CoP used for ground source heat pumps. The figures in Table 7 show that installing an ASHP system in 26 of the properties will allow the development to meet the planning condition requiring at least a 19% reduction in CO2 output compared with 2013 building regulations.

| **$CO_2$saving per flat** | **Number of flats required to meet target** | **Total reduction %** | **Locally generated Energy per flat** | **Number of flats required to meet target** | **Total generated locally %** |
|---|---|---|---|---|---|
| 451 | 26 of the 30 | 19.0 | 3510 | 26 of the 30 | 28.7 |

Table 7: Energy implications for total site with ASHP

Based on recent review of quotes and installed costs, a price of £5,000+ per system installed should be expected.
As with GSHPs, there is little maintenance required with an ASHP system.
While this option can technically meet the 19% reduction in CO2, there will be several technical issues to address because each heat pump requires an external fan unit. They could be hung on walls for the lower floors and placed on the roof for upper floors. Both these options will have noise implications both externally and internally. The fans also need to be accessible should any maintenance be required. The ASHP units could also be fitted to the houses, though they would need to be larger units as the house sizes are 142m2. Therefore this is an average option.

## 4.4 Solar Photovoltaics

4.4.1 Background

Solar generated electricity is created by the technology of photovoltaics (PV) — solid state semi-conductors that convert light into electricity. When light (a photon) hits a PV cell it gives energy to an electron. The electron moves away from the cell into an electrical circuit. The electricity created is direct current (DC). This can either be used to charge batteries or in this case it will be converted to alternating current (AC) via an inverter to meet some of the electrical demands of the site/building and also enable it to be tied into the grid.

Systems are easily incorporated into new roofs, the technology being simple to install. The panels themselves when connected together form an array. The capacity is measured in kilowatts hours peak (kWh). A rating calculated using a defined theoretical set of conditions rather than maximum or typical output.

Solar PV panels are available in a variety of different forms including;

- Mono-crystalline

- Poly-crystalline
- Thin film
- Hybrid

Mono-crystalline and hybrid panels are the most efficient at turning daylight into energy, but it may be easier to install thin film panels in the form of solar roof tiles rather than fitting a standard roof and in roof panels.
The key location requirements for a PV array are to avoid shading and to face within 45° of south, although they will work at a reduced efficiency facing east/west. A tilt of between 30 & 45 degrees is also preferable, but not essential.

4.4.2 Generation & Tariffs

In terms of generation capability, lkWp installed of PV should produce around 800kWh / year of electricity per annum situated in a southerly-facing, un-shaded location. A lkWp array made up of conventional panels will need around 4m2 of space on a roof with around 0.5 m2 of internal space required for the inverter and associated equipment.
The electricity generated will be used within the house first, which will offset electrical requirements, leading to saving for the occupiers. In addition to this, payment can be received from utilities for the simple fact of generating renewable electricity. This is known as the feed-in tariff. This will guarantee a payment for every unit of electricity generated by a PV system up to a rated capacity of 4 kWh peak for a period of 25 years. The amount paid in feed in Tariffs is changing during the course of this project and the actual amount that will be paid is not currently published for October 2015 onwards.
The property owner will also receive a small payment from the electricity supply company for any excess electricity generated. This is likely to happen during the day when the house is unoccupied.

4.4.3 Solar PV at the Henley Road Site

The proposed development at the Henley Road site is technically suitable for solar PV technology as there are two roof area available. If 18 of the new flats had 2kW of panels fitted (approximately 8 panels), they would deliver the aspirational target of 19% reduction in CO2 output for the development.

| **$CO_2$saving per flat for 2kWh** | **Number of flats required to meet target** | **Total reduction %** | **Locally generated Energy per flat – 2Kwh** | **Number of flats required to meet target** | **Total generated locally %** |
|---|---|---|---|---|---|
| | | | | | |
| 680 | 18 of the 30 | 19.8 | 1600 | 18 of the 30 | 9.1 |

Given the suitable flat roof space, this option will be considered. The panels would require the roof to be strengthened to take the weight of panels plus any fixing structure used. The

output could be fed to specific flats, which can then be marketed as lower energy properties. This can be regarded as a good option for this site and we show the benefit of exceeding the CO2 target with a 19% reduction when 18 of the flats has 2kW of panels on the flat roof areas. The flat roof of the flats is an excellent location for solar panels and approximately 255 m2 of roof space is available. The area needed for the 36kW of solar PV panels would be from 250 to 300 m2 depending on the output of each panel. This is a good option as there is space on the flat roof of the flats. There is also space on the South facing roof of the houses. Each house could fit around 1kW of panels. This makes installing solar panels a good option.

## 4.5 Solar Thermal

4.5.1 Background

Solar thermal heating systems (STHS) utilises energy from the sun, in the form of heat, to supply heat to hot water systems. This is achieved by using a solar collector filled with a liquid medium, which absorbs heat from the radiation of the sun (it does not have to be sunny to work) and transfers this heat, via a heat exchange system in a dual coil hot water tank. Collector technology is split between flat plate collectors and evacuated tube systems. In new build site like Henley Road, the flat plates can be mounted directly on the flat roof, supported by either a dedicated framework or individual triangular plastic supports filled with ballast.

STHS will provide a portion of the annual domestic hot water requirements depending on the details of the end use and size of solar collector system installed, and is generally guaranteed at 50% of hot water requirements over the course of a year (on a southerly facing roof), although in many instances this is often higher. This will be around 95% of hot water requirements from the end of May through to mid-September, whilst in winter a 20% contribution can be expected on average.

There are now a number of solar thermal tile products entering the market and these allow for total roof integration options, although, like photovoltaics (PV — see previous section), the product is still only available in a traditional grey/blue slate type colouring and is more expensive than both flat-plate and evacuated tube systems.
The hot water from a solar thermal system is normally supplied as a pre-heat to a twin coil hot water storage tank linked to the main heating system for the home. There will also be a drain-back unit (on some systems), pumps, controllers and pipe-work to interface with the existing boiler system.

Both flat-plate and evacuated tube collectors tend to be guaranteed for around 20 years but are known to last well over 30 years. Other parts such as pumps have standard time guarantees associated with standard plumbing products. Annual maintenance requirements are minimal and it would be reasonable to check the system on a 2 year cycle, although it could be included with standard annual boiler servicing.

STHS collectors are best located on un-shaded, pitched roofs, facing south for optimum performance, although other orientations within 45° either direction from due south or horizontal mounting do not significantly affect output. Even at east/west facing alignments,

the system will still perform to around 75% of efficiency.

STHSs have the same locational requirements as solar PV, although shading issues are not as critical and space requirements are significantly less. There is, therefore, space to locate collectors on the flat roofs of the flats. It is suggested that around 4.0m2 of roof space is taken as a standard size for panel based systems per flat, but this will need confirmation by suppliers/system design team.

It is also worth noting that a renewable heat payment may be available to new property owners.

4.5.2 Solar Thermal and Henley Road site

ST collectors have the same location requirements as solar PV, although shading is less of an issue. If a collector area of 4m2 is assumed, then the calculations can be prepared assuming this is connected to a 210 litre cylinder.
As the table below shows, the CO2 savings can be met.

| **$CO_2$saving per flat** | **Number of flats and houses required to meet target** | **Total reduction %** | **Locally generated Energy per flat** | **Number of flats and houses required to meet target** | **Total generated locally %** |
|---|---|---|---|---|---|
| 230 | 42 of the 42 | 15.7 | 1200 | 42 of the 42 | 15.9 |

Individual ST systems for these sizes of property would cost approximately £2000 per flat to supply and install. This does not include the hot water cylinder, which would need to be a twin coil model (generally £200 - 300 more expensive than the single coil model). This choice is an average option as there would be heat loss between the panels and the lower floor units. The maximum number of panels does not meet the target reduction of 19% CO2. Therefore, this is considered a poor option for this site.

## 4.6 Building Mounted Wind Turbines

4.6.1 Background

A building mounted turbine is one that is attached to the side of a building using mounting brackets. They typically range in rated output from 100W to 1.5Kw. They should always be several meters above the roof line and must have a clear, unimpeded draw on the wind coming from the south west, which is the prevailing direction of the wind in the UK. The amount of energy generated is determined by the nature and velocity of the wind and the area swept by the blades. Blade shape and rotation speed determine efficiency.
Grid connection and tariff structures operate in the manner described for PV under section

4.4.2

4.6.2 Wind Power at the Henley Road Site
The problem with installations in urban environments is the uneven flow of the wind as it is disturbed by roof shapes and trees. As this location has buildings within 100m to 300m to all sides this type of system will not work efficiently. Therefore this system is considered an unsuitable option.

## 4.7 Combined Heat and Power

4.7.1 Backgound
Combined Heat and Power (CHP) is generally considered a commercial product, however, there are two ways this can be incorporated within this site.
Micro CHP - a single property system, which acts like a system boiler, but uses spare energy to drive a generator. This can provide electricity directly to the flats and as the boiler runs most often in the morning and evening (the same times as peak electricity demand), the most effective use is made of the electricity.

The second approach would be to build a single CHP unit for the site, which would provide heat and power for all 30 flats. This would require a large CHP unit and water store, which could fit in the plant room.

4.7.2 Feed in tariff and fees

The current payments for a CHP unit of a household size (e.g. MicroGen from Baxi) would be 13.45p per unit. The manufacturers estimate is that in a typical property, this would generate 2242 kWh per year. The CO2 calculation is taken as an estimate from the Baxi Ecogen boiler, which shows that for a band B boiler, there is a typical reduction in CO2 of 21.5%, which is a positive benefit.

| **$CO_2$saving per flat** | **Number of flats required to meet target** | **Total reduction %** | **Locally generated Energy per flat** | **Number of flats required to meet target** | **Total generated locally %** |
|---|---|---|---|---|---|
| No figure from EST | | 21.5 - estimate | 2242 | | |

The only products available for micro CHP are designed for use in a typical 4 bed house, so would not be suitable for use within a the varying flat sizes of this development. For the whole block CHP option, these systems work best when they have a constant heat load, which domestic flats do not. Therefore the system would not generate enough electricity to pay for itself.
This makes it a poor option.

## 5. Conclusion.

Summary of units and savings

| Type | **Number of flats required to meet target** | CO2 - % reduction from EST | **Number of flats required to meet target** | kW/h - % | Choice |
|---|---|---|---|---|---|
| Regulated total | | 72,222 | | 377,611 | |
| Biomass stand alone | N/A | N/A | N/A | N/A | N/A |
| Biomass community | 9 | 19.0 | 9 | 19.2 | Average |
| Ground source | 21 | 19.7 | 21 | 29.7 | Poor |
| Air source | 26 | 19.0 | 26 | 28.7 | Average |
| Solar PV | 18 | 19.8 | 18 | 9.1 | Good |
| Solar thermal | 42 | 15.7 | 42 | 15.9 | Poor |
| CHP – micro per flat | | 21.5 over Band B | | | Poor - N/A |

There are three choices available for this development. The biomass community, ASHP and solar PV. Each has benefits and drawbacks.

The biomass community boiler would require a separate building as it is not likely to fit in the existing plant room.

The solar PV meets the CO2 reduction target and is easy to install and maintain

The use of air source heat pumps would be possible on the top floor flats as the outdoor unit could be placed on the roof, though access for maintenance would require a suitably trained person only, as a mansafe system is proposed. There is also the noise aspect of the fans to be considered. Other units could be installed on the 12 houses.

Fitting 36kW of solar panels is the best option. This could all be fed to 18 flats, preferably on the upper floors. Some PV could easily be fitted on the South facing roof area of the houses and the remainder allocated to the flats. This is the preferred option.