whitbybird

American Church

Renewable Energy Feasibility Study and Sustainability Statement

for

THE AMERICAN CHURCH IN LONDON

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project no. 3029

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CONTENTS

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1 EXECUTIVE SUMMARY

This report analyses the opportunities for improved energy efficiency and onsite renewable heat and power generation for the American Church development, located at Tottenham Court Road, W1T, London. This new development consists of a church extension and a separate residential unit.

The GLA Toolkit methodology has been used to select the most appropriate technologies and calculate the carbon dioxide (CO_2) emission reductions of the proposed development. Seven technologies are considered: photovoltaics, solar hot water, wind turbines, biomass heating, CHP and ground source heating and cooling.

Biomass CHP is eliminated owing to the low summer heat demand and the insufficient reliability of this technology. Wind speeds and surrounding obstacles prohibit stand alone wind power and roof mounted systems. Other technically feasible options include PV for the residential units and ground source heating for the church and its extension. However, PVs are considered too expensive and lacking in energy production, while ground source heat pumps require underfloor heating, fossil fuel use and would cost considerably more than the biomass heating solution for the same carbon reduction.

It is concluded that in addition to an energy efficient design, the most realistic and feasible option is the implementation of a solar hot water system for the residential unit and a biomass boiler for the Church and its extension.

A solar hot water system supplying 50% of the water demand of the residential units will lead to 14% CO_2 emission reduction for this unit.

There is no technically suitable renewable energy system which could be implemented in the extension. However, as the heating system of church is to be replaced, it is recommended that biomass boilers are installed in addition to conventional condensing boilers to provide heating for the existing church and its extension. Biomass heating, supplying 22% of the space heating and domestic hot water demand of the church and its extension, will result in carbon emissions reduction greater than the carbon emissions resulting from the entire new extension.

Additionally, an EcoHomes pre-assessment checklist was carried out for the residential units, and it is foreseen that a "Very Good" EcoHomes could be achieved, through a variety of sustainable features. These include water efficient design, energy efficient design and sustainable materials selection.

2 INTRODUCTION

2.1 Introduction

This report assesses the feasibility of utilising various forms of renewable and sustainable energy technologies for the purpose of onsite power generation at the proposed American Church extension and residential development on Tottenham Court Road W1T, London.

This renewable energy feasibility study is based on the GLA's Renewable Energy Toolkit[1], described in section 2.2. The Toolkit itself relates onsite renewable power provision in London to the requirements of the London Plan, the Mayor's Energy Strategy and planning controls.

This report uses the toolkit to identify the technologies most suited to the proposed site and discusses the technical and financial implications of achieving the Toolkit's target of 10% carbon emissions reduction. The figures provided for emissions reduction and the associated costs are a guide only and should be used only as the basis of further study. The findings should not be used for design and costing purposes in isolation, as this is not the intended outcome of a Toolkit study.

2.2 The GLA Renewable Energy Toolkit

The Toolkit document is issued by *London Renewables*, in conjunction with the GLA, and "has been produced to help developers, their consultants and all planners implement relevant Mayoral and related borough planning policies"[2] with regards to renewable energy provision. This is in response to two paragraphs in the London Plan and the Mayor's Energy Strategy:

- London Plan policy 4A.9 "The Mayor will and boroughs should require major developments to show how the development would **generate a proportion of the site's electricity or heat needs from renewables, wherever feasible**"[3]

- The Mayor's Energy Strategy proposal 13 "To contribute to meeting London's targets for the generation of renewable energy, the Mayor will expect applications referable to him **to generate at least ten per cent of the site's energy needs (power and heat) from renewable energy on the site where feasible.** Boroughs should develop appropriate planning policies to reflect this strategic policy"[4]

Thus, the Toolkit has been designed as a route map to help developers, planners, consultants etc meet the requirements of legislation and planning guidance in order to receive planning permission. The following paragraphs from the Toolkit help underline its intended impact on new developments:

"Developers will be expected to demonstrate that they have explored all renewable energy options for a particular development. The Mayor will be expecting the building form and construction to be adapted to take on renewable energy to make its installation (more) feasible. Strong justification from developers will be required if they do not think they can provide the required proportion.

If it is believed not to be feasible to provide the applicable target proportion of renewable energy in a particular development, developers will be expected to explain their reasoning to planners and to include in their proposals the proportion they judge feasible."[5]

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[1] "Integrating renewable energy into new developments: Toolkit for planners, developers and consultants" (London Renewables) September 2004
[2] *Ibid* p9
[3] *Ibid* p9
[4] *Ibid* p9
[5] *Ibid* p19

The Mayor's Energy Strategy also contains a hierarchy to promote efficient use of energy:

1. Use less energy (Be lean)
2. Use renewable energy (Be green)
3. Supply energy efficiency (Be clean)[6]

All these areas must be addressed in a development's energy strategy, but the Toolkit, and thus this report, deal only with the "Be Green" requirement. Sections 1 and 2 of the Toolkit cover its relevance and importance in more detail.

2.3 The Renewable Technologies

The guidance offered by the Toolkit allows the user to reject inappropriate technologies using basic site information. The selected technologies are then analysed to give an indication of the reduction in carbon emissions which they can offer. The toolkit also offers a basic method of comparing the costs of the various options.

The technologies presented in the Toolkit are listed below:

- Stand alone wind turbines – Roof mounted wind turbines
- Photovoltaics
- Solar water heating
- Biomass heating
- Biomass CHP
- Ground source heating
- Ground cooling

An overview of these technologies is included in section 3 of the Toolkit and the reader is referred to these for further details.

2.4 The Site

The 1550 m² development site is located on the west side of Tottenham Court Road; W1T in the borough of Camden (See **Figure 1**).

The proposed development consists of a church extension and a separate residential unit.

Figure 1: Site location

[6] *Ibid* p14

2.5 The Extension

The proposed extension is composed of a chapel and a two storey unit located at the south east end of the existing American Church (See **Figure 2**) with direct links to its basement and ground floor (See **Figure 3**). The extension includes several meeting rooms as well a laundry, an office and WCs.

The existing site context has been fully analysed and the proposed scheme responds to this by respecting and enhancing the immediate area.

2.6 The Residential development

On the northwest side of the existing American Church, a five storey residential unit will be developed consisting of one, two and four bedroom flats (See **Figure 3**).

Figure 2: Existing Building

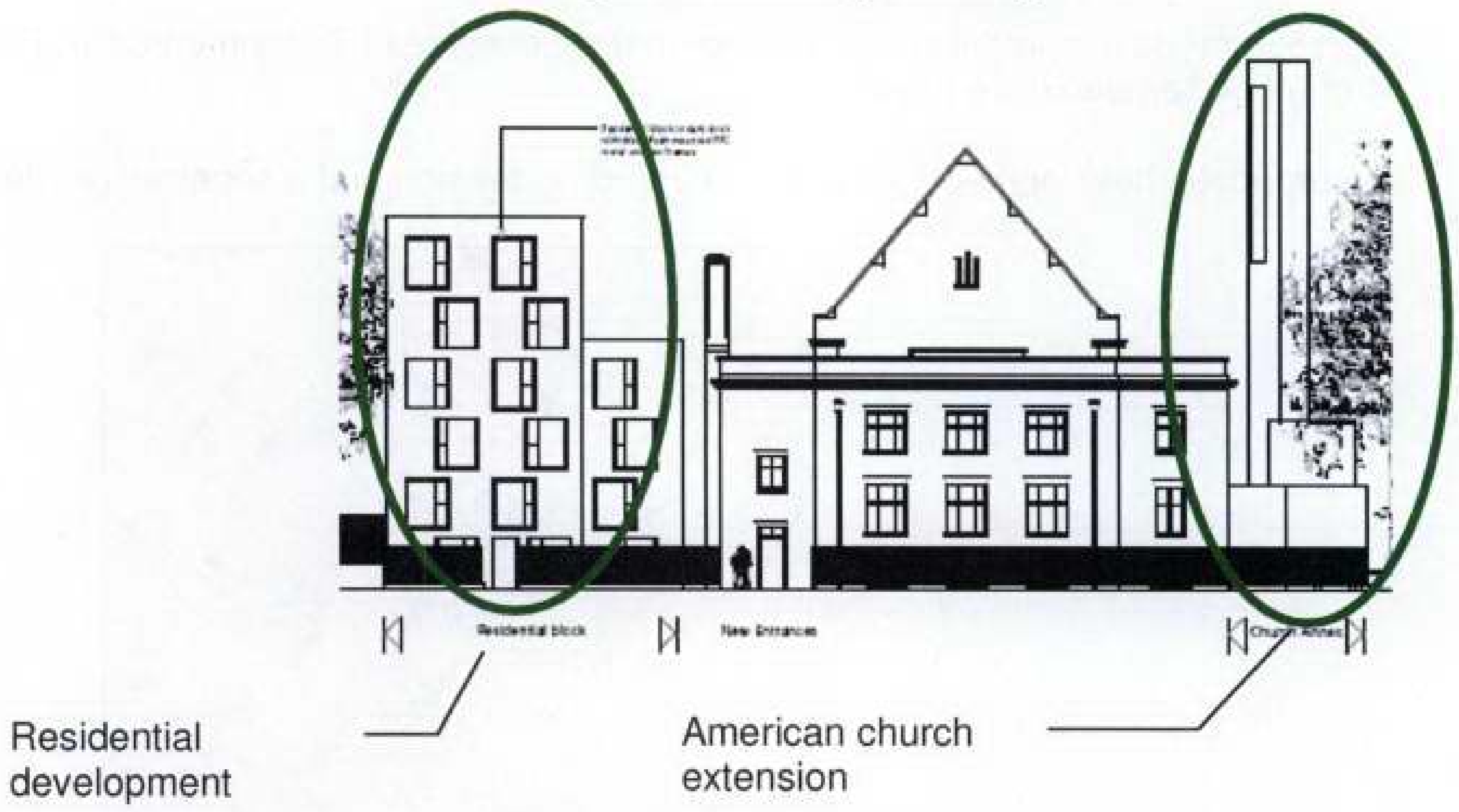


Figure 3: Proposed development

3 ENERGY USE

3.1 Energy Efficiency Features

A reduction in anticipated energy consumption, through good passive building design and the specification of energy saving features within the services design, will inherently lower the amount of renewable energy to be installed.

The following energy efficient features will be implemented in the residential development:

- Energy efficient building fabric: high performance facades, windows (U ≤ 2); walls (U ≤ 0.3); heat loss through the building fabric will be reduced with high standard of insulation and low U values;
- Energy efficient lighting;
- Efficient solar control to avoid overheating;
- Very good air tightness, air permeability ≤10 $m^3/(h/m^2)$ at 50Pa;
- Good heating control: programmable, Thermostatic Radiator Valves;
- Energy efficient appliances (Ecolabelled White Goods);
- Hot water demand reduced through efficient appliances;
- Energy efficient condensing boilers ($\eta \geq 90\%$)

An EcoHomes pre Assessment has been carried out to provide an indication of the attainable EcoHomes rating for the residential unit. .The checklists (see Appendix 8.4) conclude that targeted scores of 'Very Good' for the EcoHomes is attainable and realistic within the constraints of the site and design brief.

The following additional energy efficient features will be implemented in the church extension:

- Energy efficient community system;
- High frequency dimmable ballasts on lights;
- Energy efficient cooling system.

These different measures will reduce the energy used onsite and hence the associated CO_2 emissions.

3.2 Site Energy Use

To estimate the possible carbon reductions available from the various renewable technologies, an estimation or calculation is needed of the energy use in the new development (extension and residential units).

3.2.1 Residential Units:

Heating and electrical systems have not been designed for this development and no thermal modelling, load/demand estimations or SAP/NHER/Part L calculations have been completed. Therefore, benchmarks are used for energy demand estimations in the absence of project specific information.

The GLA toolkit offers established benchmarks for situations where more accurate data is not available. However, due to the inherently high variation in domestic building types, occupation patterns and energy use profiles, no standard benchmarks are available for domestic properties.

Therefore, energy use estimates from other similar developments will be used. Whitbybird have completed numerous SAP and NHER assessments on high density apartment developments in London, under the 2006 Building Regulations Part L. Table 2 and Table 3 below offer average figures from these assessments which will be used for this study. These figures assume standard U-values and do not include CHP or renewable energy contributions. The carbon intensities used are taken from Part L of the buildings regulations (2006) and the area used is taken from the most recent area schedule (See Table 1).

- Carbon intensity for gas: 0.053kg/C/kWh
- Carbon intensity for electricity: 0.115kg/C/kWh

Indicative net area of apartments: ~552 m^2

Floor	Type of flats
Basement	4 bedroom (duplex) (103m2)
Ground	4 bedroom(duplex)(39m2) + one bedroom (39m2)
First	2 bedroom (50 m2) + 1 bedroom (37m2)
Second	2 bedroom (50 m2) + 1 bedroom (37m2)
Third	2 bedroom (50 m2) + 1 bedroom (37m2)
Fourth	2 bedroom (55m2)
Fifth	2 bedroom (55m2)

Table 1: Type of flats

electricity	43	kWh/m^2
heating	40.3	kWh/m^2
hot water	52.14	kWh/m^2

Table 2: Annual Energy consumption

	Annual energy consumption		Annual carbon emission	
electricity demand	23,736	kWh/year	2,730	kgC/year
heating demand	22,246	kWh/year	1,179	kgC/year
hot water demand	28,781	kWh/year	1,525	kgC/year
Total electricity delivered	23,736	kWh/year	2,730	kgC/year
Total gas delivered	56,697	kWh/year	3,005	kgC/year
Total energy delivered	80,433	kWh/year	5,735	kgC/year
Total energy delivered	137,129	kWh/year	21,027	$kgCO_2$/year

Table 3: Annual energy consumption and carbon emission for the whole residential development

3.2.2 Church extension:

An IES simulation has been carried out for the church's extension. Table 4 summarizes the main results of this simulation regarding heating and electricity demand.

	Annual energy consumption		Annual Carbon emission	
Gas demand	11,660	kWh/year	618	kgC/year
Electricity delivered	52,800	kWh/year	6,072	kgC/year
Total energy	64,460	kWh/year	6,690	kgC/year
Total energy	64,460	kWh/year	24,530	$kgCO_2$/year

Table 4: Annual energy consumption and carbon emission for the extension

4 RENEWABLE ENERGY TECHNOLOGY SELECTION

4.1 The GLA Renewable Energy Toolkit

Flowcharts in the Toolkit are used to remove those technologies which are not suitable for the site and its intended use. These are included in Appendix 8.1. Once potential technologies have been selected in this way, they are subjected a brief desktop feasibility study, as detailed in the Toolkit (Appendix 8.2). This involves making assumptions regarding base building energy use and renewable energy system sizing to obtain estimates of possible carbon reduction and costs. Although these figures cannot be considered accurate (due to the lack of design detail at this stage and the generic make up of the Toolkit), they offer a good platform for selecting technologies for detailed assessment at a later design stage. The sections below summarise the findings.[7]

4.2 Stand Alone Wind Turbines – Roof mounted wind turbines

Figure 4: Stand alone wind turbines

Without a detailed survey, it is impossible to state the wind speed on site, but in London it is possible to reach 6m/s, as recommended in the flowchart.

However, the site is in an urban area and surrounded by tall commercial and residential developments. Not only would the wind regime be affected by the resulting turbulence, but the potential for planning objections is significant. The resulting noise and visual impact would be considerable.

Another significant problem is that the site itself will have much of its footprint covered in buildings, leaving little room for the turbine tower. Finally, the surrounding area is likely to be developed in the near future, but exact plans are not currently available. Any wind study would be invalidated by later developments and the wind regime may be adversely affected.

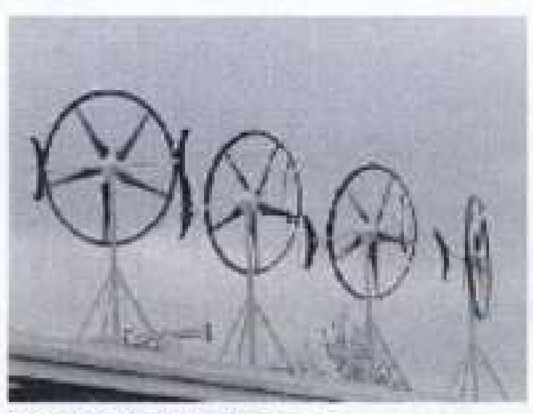


Figure 5: Roof mounted wind turbines

A roof mounted wind turbines would be more appropriate than a stand alone turbine for this application as it can work with lower wind speed and in turbulent conditions. However, the highest roof of the development is not the tallest building in the surrounding area and therefore is not suitable for roof mounted wind turbine application. Besides, the area available on this roof for wind turbines is very likely to be limited due to the implementation of other renewable technologies such as PV panels or solar collectors.

Therefore, for such a dense urban site surrounded by close and tall buildings, neither a stand alone wind turbine nor a roof mounted wind turbines is recommended for this application.

[7] Cost and energy production figures are modeled on yearly demand figures, not peak loading requirements. This is based on the use of energy benchmarks in the GLA Toolkit and lack of data on expected loads at this design stage.

4.3 Photovoltaics

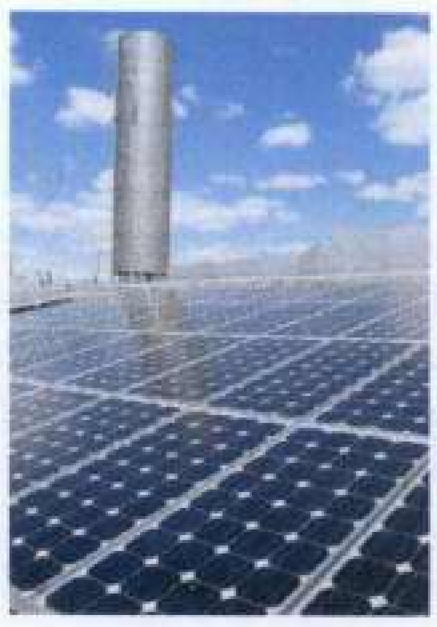


Figure 6: PV panels

There are limited unshaded areas available for PV modules implementation. Use of the roof for different application such as solar collectors and plant location will limit further the available area for PV modules implementation.

Part of the rooftop of the residential unit is the only possible location for the PV units. Overshadowing and roof orientation have to be carefully considered to enable an optimum PV output. The unit proposed is the highest buildings of the development; its roof area should not be shaded, as it is higher than the closest obstacles located at the south end of the development.

The modules on the roof could be fitted horizontally or could be tilted at the optimum angle (30°). Although the output reduction due to the horizontal orientation of the modules is quite small (10%), tilting the modules is important for the rain water drainage and self cleaning.

PVs are technically feasible for this site and have many benefits: they are low maintenance and highly reliable/robust, they are a mature technology with limited impact on the surrounding area.

However, PV is currently very expensive due to a scarcity of world wide silicon wafer production and they produce relatively little energy for the required size/investment. This is exacerbated by the low ratio of roof area to net floor area and the limited roof area available and suitable for PV. Besides, PVs generate most of their power during the middle of the day when many residential properties are empty or using relatively little power.

While PVs are technically suitable for the site, they are considered uncompetitive with other technologies. However, they might be kept as an optional solution if no other renewable energy solution is viable. Preliminary calculations have been carried out for a PV array covering half of the roof of the residential units (See Appendix 8.2.1).

4.4 Solar Hot Water

Figure 7: Solar collectors

The new residential unit offers a year round hot water demand particularly suited to solar hot water (SHW) use.

A solar water heating system could be installed on the rooftop of the residential unit of the American Church development to meet a part of this demand.

As the residential unit's roof space is limited (and is the only practical location for solar collectors), evacuated tube systems are recommended owing to their higher efficiency. The rooftop of the residential unit is higher than the closest obstacles located at the south end of the development, there should not be therefore any significant shading issue.

Pre heating cold water for the flats of the residential development could be a possible application of this system (See **Figure 8**). Technologies such as centralised condensing boilers, biomass system should provide the base heating load.

We would recommend the installation of separate systems for each flat with direct connection to the individual boilers. We have carried out an estimate calculation of the roof area needed for each solar collector supplying 50% of the hot water demand for each flats (See Table 5 and **Figure 8** and **Figure 9**).

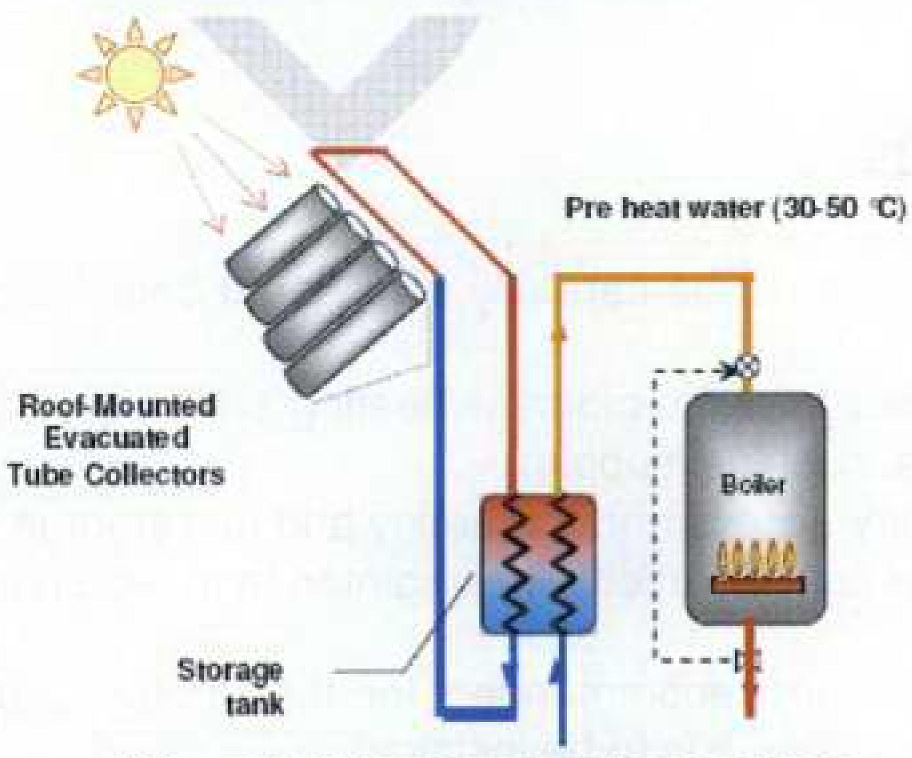


Figure 8 Proposed solar system

	Floor Area (m^2)	Hot water demand (kWh/year)	Solar collector area (m^2)
Four bedroom	142	3,147	6.29
Two bedroom	50	1,108	2.22
Two bedroom	50	1,108	2.22
Two bedroom	50	1,108	2.22
Two bedroom	55	1,219	2.44
Two bedroom	55	1,219	2.44
One bedroom	37	820	1.64
One bedroom	37	820	1.64
One bedroom	37	820	1.64
One bedroom	39	864	1.73
Total	552	12,232	24.46

Table 5: Estimated area of flats and area of solar collectors associated

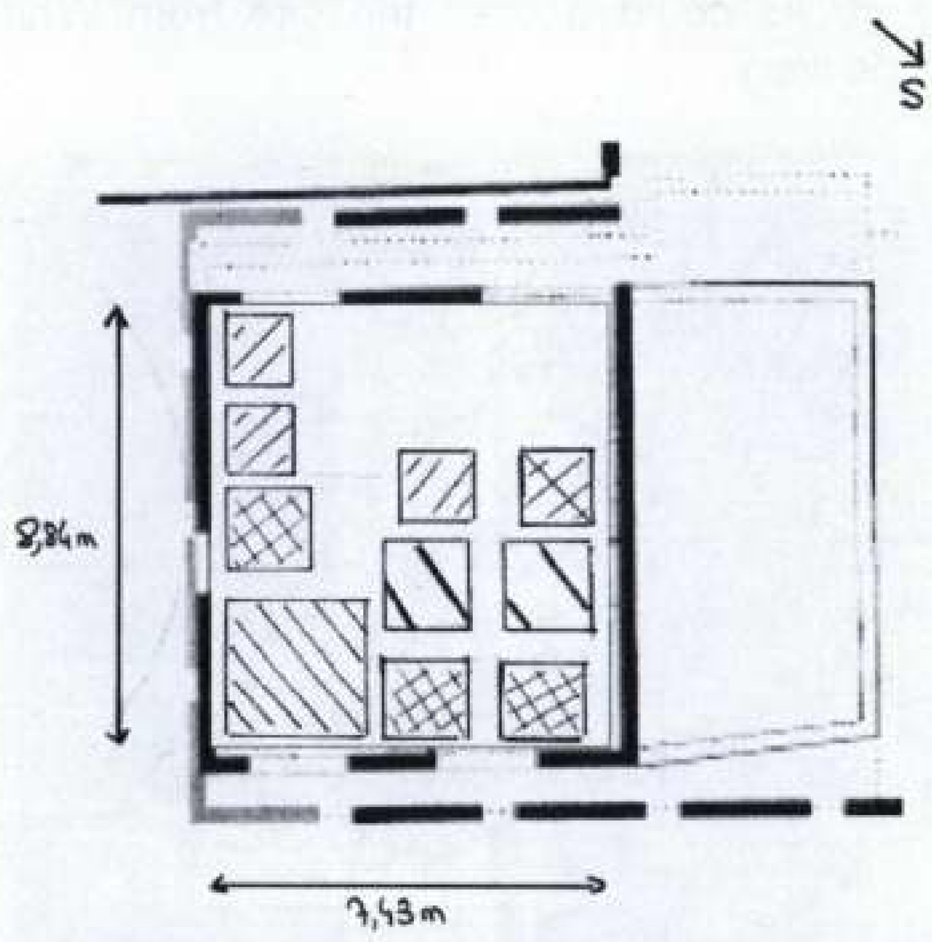


Figure 9: Indicative location for solar collectors

Given its excellent technical suitability to this site and its good ratio of investment to energy output, SHW systems for the hot water supply of the residential units are looked at in more detail in Appendix 8.2.2 and in section 5.

4.5 Biomass Heating

The following issues must be carefully considered before biomass heating can be included in the design:

- Use and design of the biomass heating system;
- Sourcing a local fuel supply;
- Fuel delivery access and frequency and fuel storage requirements;
- Plant room considerations and maintenance requirements.

Biomass heating is not recommended for the energy supply of the residential units as no community heating scheme is to be installed.

Sufficient space is not likely to be found in the extension for the location of biomass boilers and biomass pellets. Moreover, only a system providing 100% of the heating demand of the extension (which is not recommended) could lead to 10% CO_2 emission reduction (See Appendix 8.2.3). A biomass heating system for the extension only is therefore not feasible.

However, biomass heating using wood fuel is a viable option for the energy supply of the American church and its extension. Indeed, as the old oil fired boilers of the existing church are to be replaced, biomass boilers could be installed in addition to conventional condensing boilers in the church.

The boilers to be installed for the existing church and its extension will have a capacity of approximately 340 kW. Biomass boilers of 75 kW could be installed, in addition to 290 kW conventional condensing boilers. This system will provide the heating requirement of the existing church and of its extension.

Dedicated storage space for the biomass resource could be found in the basement in the room near to the existing plant room (See **Figure 10 and Figure 11**). The delivery point should be in the same location. A specific access point must be chosen to allow easy access for the delivery trucks. The delivery trucks could access the site from Whitfield Street which is the street presently used for oil delivery.

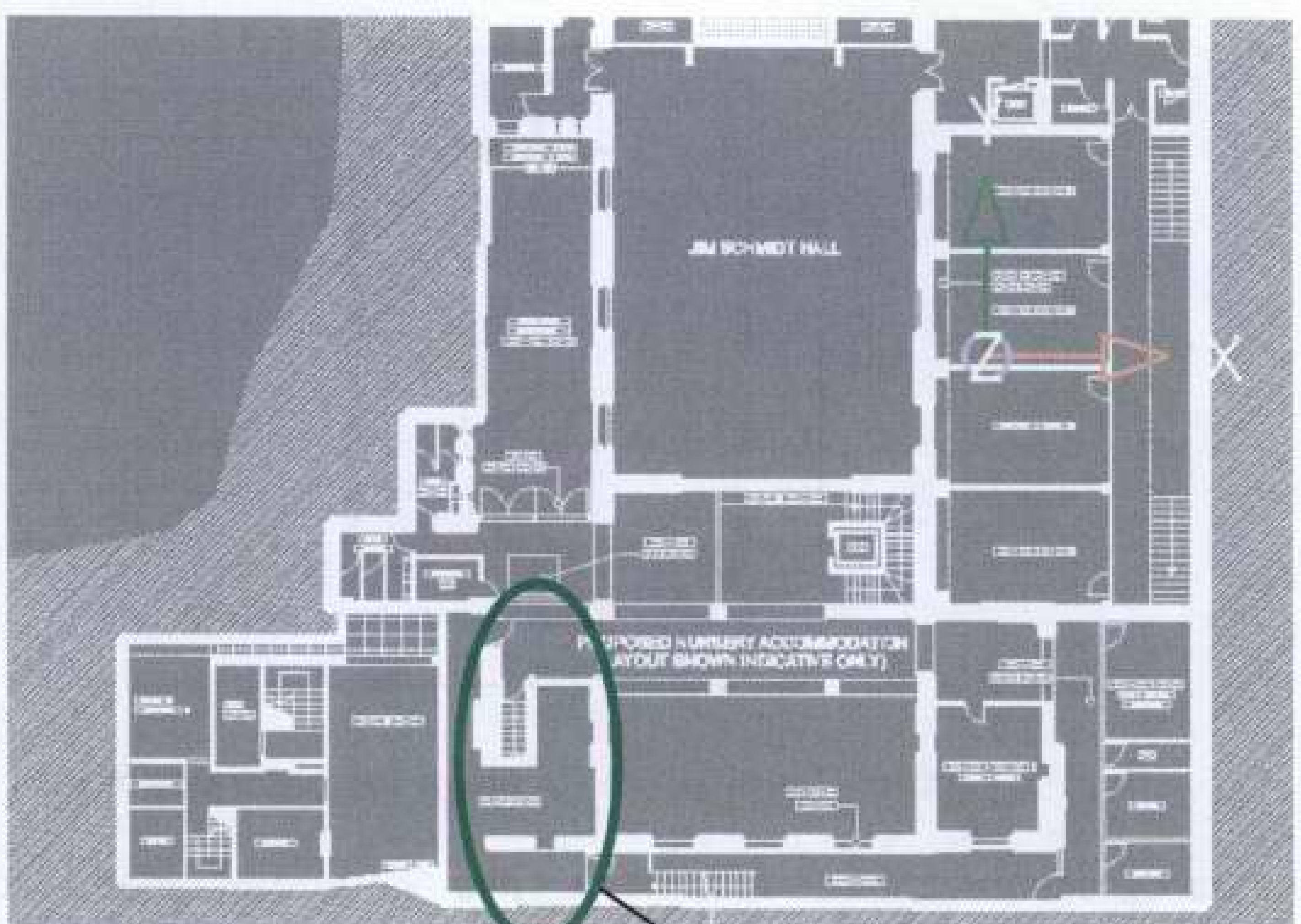


Figure 10: Plan of the basement

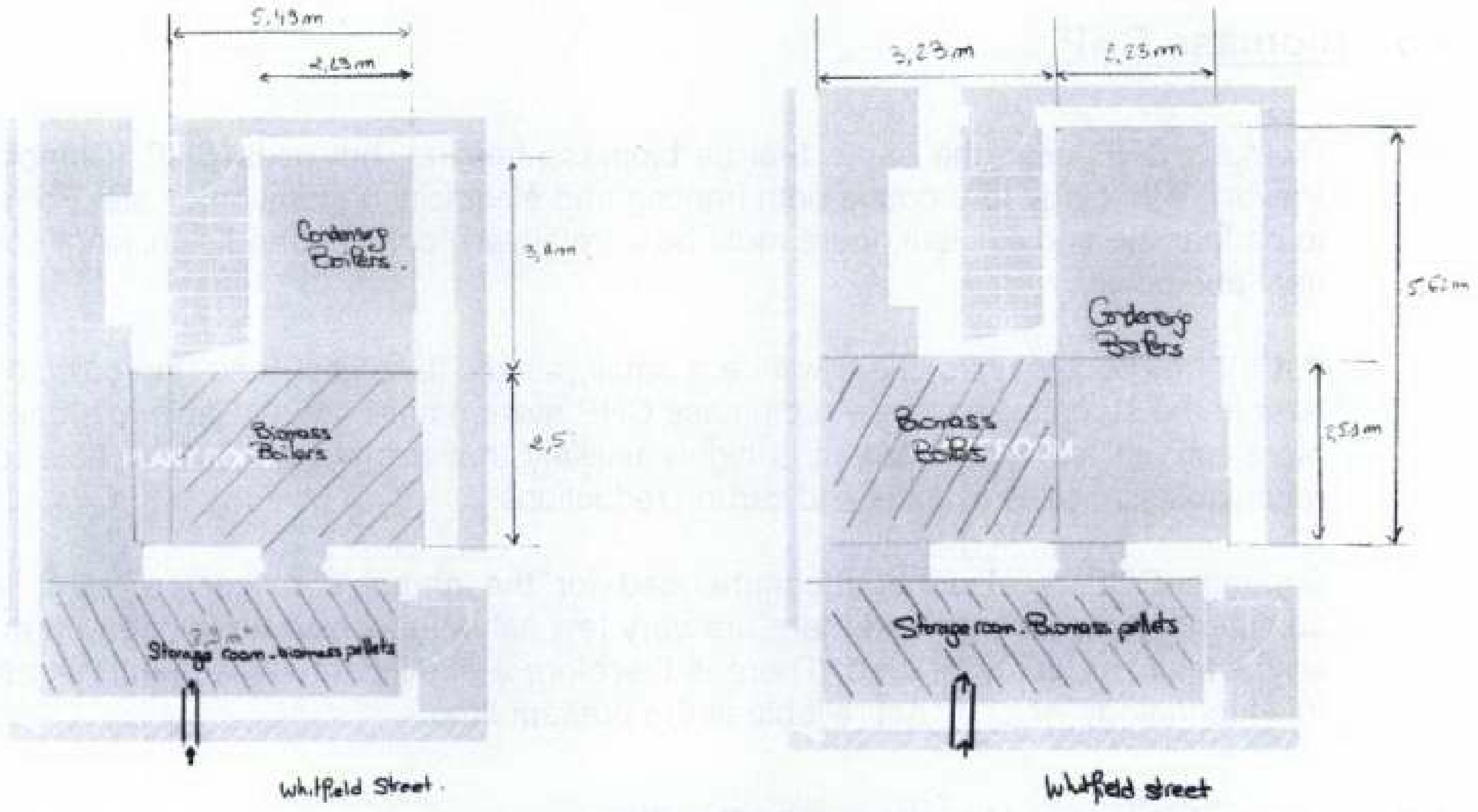


Figure 11: Possible location for the biomass boilers and the storage room

For wood pellets, assumed as having a moisture content of 10%, a calorific value of 17MJ/kg and a bulk density of 650 kg/m^3, 3 deliveries are necessary to provide the biomass resource needed for a system providing 22% of the heating demand of the development (52m^3). For wood chips, assumed as having a moisture content of 25%, a calorific value of 14MJ/kg and a bulk density of 200 kg/m^3, 10-11 deliveries would be needed (202m^3).

The price of wood pellets and wood chips are estimated to be 3.0 to 3.5p/kWh and 1.5 to 2.2p/kWh[8] respectively. The cost comparison favours wood chips slightly, however, a system using this type of resource will present several drawbacks such as deliveries needed every week during the winter months and wood smoke pollution implied by the transfer of the resource from the truck to the storage place (See **Figure 12**).

Thus, wood pellets are strongly recommended for this urban application. The fuel cost for a system using wood pellets and providing 15% of the heating demand is approximately £3,470 per year.

Figure 12: Photos of wood pellets(1), wood chips (2), unloading of wood chips from a truck (3), unloading of wood pellets via a pipe (4)

The delivery trucks could access the site from Whitfield Street which is the street presently used for oil delivery. Pellets could be blown in the storage room very easily as the storage room is located in immediate proximity to this street. Chimneys exiting from the roof of the plant room will vent the exhaust flue gases to the outside. The biomass resource should be found in an area close to the site, if not the advantages of using a renewable energy source might be offset by the CO_2 emissions due to transport. This should not be an issue as there are several biomass pellets supplier located near London city centre.

Biomass heating is a low cost technology that is a very good option for the energy supply of the Church and of its extension. Further calculations are developed in section 5.2 and Appendix 8.2.

8 The Log Pile website: http://www.nef.org.uk/logpile/pellets/cost.htm

4.6 Biomass CHP

Biomass CHP uses the same fuel as biomass heating, but uses CHP (Combined Heat and Power) technology to produce both heating and electricity generation onsite. For such a system to be feasible and efficient, there must be a (relatively) constant and significant demand for both heat and power.

For the residential units, there will be a small, rapidly fluctuating and unpredictable demand for heat in the summer months. As biomass CHP systems are not available in small sizes and are more efficient at large loads, it is highly unlikely that this system will be able to match other renewables in terms of costs and carbon reductions.

Biomass CHP is also not recommended for the church's extension, as it is a relatively complicated technology and there are very few schemes which have been up and running for any significant length of time. There is therefore a significant investment risk associated with this technology which is not reliable at the present time.

4.7 Ground Source Heating and Cooling

4.7.1 Closed Loop

At this stage of the design the heating strategy has not been finalised. However a communal system would be required to make a ground source system technically feasible and efficient. Ground source heating also requires the development to be fitted with low temperature radiators (which are larger than standard radiators) or, preferably, underfloor heating.

A horizontal system, where the ground piping is laid in trenches 1-3m below the surface, is unlikely to be possible at this site owing to a lack of open space. For a vertical system, vertical boreholes will require bores to be drilled specifically for the ground piping or structural piles will have to be used. Ground source heating uses electrical power to drive its pumps means that it only offsets half the carbon per unit of heat energy supplied that biomass heating does. Indeed, a ground source system must heat twice as much space as a biomass system to achieve the same carbon reduction.

For this project, vertical bores would be required, given the lack of space. Given the particular location of the site, it is foreseen that such an underground structure would be very difficult to integrate, and its cost will be particularly high. Ground source heating is technically feasible for this site if communal heating and underfloor heating are to be used which is very unlikely to be the preferred case for this type of development. Ground source heating (closed loop) is only recommended should biomass heating prove to be unsuitable.

4.7.2 Open Loop

Open Loop systems directly use ground water in their heat exchange systems, rather than pumping fluids through closed pipe circuits. The used water is then rejected back to the water table.

The open loop system does not need the extensive underground piping system, but does require special licenses from the Environment Agency and requires monitoring to establish any impacts on the ground water. The licenses can be revoked at a future date. Open loop system will lead to the same restrictions for the type of heating and cooling system to be installed than a close loop system. Moreover, this system would lead to a cost per CO_2 savings higher than a biomass system which will reduce for a higher installation cost less CO_2 than a biomass system (See Appendix 8.2 and 8.3). Open loop systems are normally not installed for systems of a small size such as for the load of the church extension. Therefore, ground source heating (open loop) is only recommended should biomass heating prove to be unsuitable at a more detailed stage of the project.

5 SOLUTION DEVELOPMENT

5.1 Technology Selection

Use of the GLA Toolkit decision flowcharts and the consideration of the technical implementation issues for the various renewable technologies have resulted in biomass heating and solar hot water systems being selected as offering the greatest potential.

A Ground Source Heat Pump for the extension and PV for the residential unit were not ruled out, but they were not recommended for further study unless biomass heating and SHW prove to be unfeasible. Ground source heat pumps are more expensive than Biomass Heating, require fossil fuel use i.e. offer less carbon emission reduction, and require underfloor heating. PV is currently restricted by high installation costs and requires an expanse of unshaded roof area (this will also affect SHW use).

5.2 CO_2 Emission Reductions

To assist in the analysis of the two preferred options; solar hot water and biomass heating, the GLA Toolkit calculation methods are used to indicate the possible carbon reductions from both technologies.

5.2.1 CO_2 emission reduction for the residential units / Solar hot water collectors

The calculations have been made for evacuated tubes installed on the roof of the residential unit and supplying 50% of the hot water demand of the building. Such a system would reduce the CO_2 emission of the residential unit by 14% (See Appendix 8.2).

5.2.2 CO_2 emission reduction for the church extension / Biomass

It is proposed that a biomass heating system is installed in the plant room of the existing church providing heating for the church and its extension. A small system of 75 kW would be sufficient to meet 100% of the heating demand of the extension.

If the biomass boiler was used for the extension only a 10% CO2 emission reduction would be achieved, as the extension mainly requires cooling (See Appendix 8.2). Therefore, it is recommended that the biomass boiler provides heat for both the extension and the Church.

A biomass heating system of 75 kW would produce:

Biomass boilers	75	kW
Biomass boilers output	141,750	kWh/year
Gas substituted by biomass boiler	157,500	kWh/year
Carbon emission substituted by biomass	8,348	kgC/year
CO_2 emission substituted by biomass	30,608	$kgCO_2$/year

Table 6: Estimated CO_2 emission reduction for a 75kW biomass boilers

The biomass heating system proposed of 75 kW system will substitute 30,608 $kgCO_2$/year representing 125% of the CO_2 emission of the extension.

5.3 Implementation

5.3.1 Load balance

Biomass heating is rarely used as the only source of heating, to allow for shut downs, de-ashing and the fact that biomass systems operate more effectively with constant loads. Gas boilers are usually added as a "top up" to the biomass boilers which operate as the base load. The gas boilers also operate without the biomass system in summer when demand is low, as biomass boilers do not generally function well below around 30% of their peak capacity. This can be avoided by using a modular design, but this complicates the automatic feeding of biomass fuel stock.

To provide 22% of the annual demand is therefore very feasible, by using the biomass system as base load provider. Detailed calculations (of load profiles) are required, but sizing the BH system to around 22% of peak load should provide this.

5.3.2 Fuel sourcing and delivery

Fuel sourcing and delivery is also critical. It may be possible, if using pellets at this site, to only have one delivery per year, or at most 3-4. The delivery vehicle used is obviously dependent on the mass of fuel being delivered, and can involve large "dumper" trucks. If chips are used, then access to the actual storage vessel must be available to the truck for "tipping". If pellets are used, these can be "blown" through a hose and all that is required is a suitable screw fit connection on the wall. Obviously, the access strategy must account for the delivery vehicle entering, dropping and exiting the site.

Fuel should also be sourced from as close to the development as possible. Finding sources of pellets and chips in the UK is relatively easy in all areas, however ensuring the fuel is locally grown is not as simple. However, there are several firms based in and around London, responding to the increase in demand owing to new environmental legislation (GLA requirements, Part L changes etc).

Currently, supply is plentiful in the UK, but care should be taken to ensure the origin of the fuel is UK based.

5.4 System Cost

5.4.1 Biomass Heating system

At this early stage of design, detailed costings are not possible or appropriate, but estimates can be produced. For the biomass boiler itself, a price of £200-300/kW can be used as a guide and thus a 75kW boiler would range from £15,000 to £22,500 (if appropriate, savings on gas boilers can be subtracted from this). This price can vary depending on the complexity of the flue[9] arrangement and the size of the fuel store. Wood pellets cost 1.5 to 2.2p/kWh, with chips being about half this cost. Presently, this makes pellets the same price or slightly cheaper than gas (based on £/kWh), and chips are significantly cheaper. This equates to an annual fuel bill (for pellets) of ~£3,470.

5.4.2 Solar Hot Water system

24m^2 of SHW collectors would cost in the range of £14,500 to £17,000, dependent on supplier, system type and bulk purchase discounts.

[9] It should be noted that modern biomass boilers are designed to comply with all relevant air pollution legislation, such as the Clean Air Act, and flue gases are usually colourless.

6 SUSTAINABILITY STATEMENT

The residential units will achieve a "Very Good" EcoHomes standard through the sustainable design items described below.

6.1 Energy

- Energy efficient building fabric (Low U values, Good air tightness…);
- Energy efficient hot water and heating system;
- Ecolabelled White goods;
- Energy efficient internal and external lighting.

6.2 Transport

- Proximity to public transport;
- Proximity to local amenities;
- Cycle storage provided for all the dwellings.

6.3 Pollution

- The heating and hot water system will have an average NOx emission rate of less than or equal to 70 NOx mg/kWh;
- All insulation for the building fabric and pipework / ductwork will have an Ozone Depleting Potential (ODP) of zero and a Global Warming Potential (GWP) of less than 5;
- Development site in an area of low flood risk probability.

6.4 Materials

- Where possible, the materials of the structural and non-structural elements of the extension will be responsibly sourced;
- Materials specifications for the roof, windows, external and internal walls will meet the Green Guide for Specification (BRE) A ratings. This rating takes into consideration the life cycle impact and embodied energy of materials and constructions. Recycled content and the re-use of materials in the façade and structure will contribute significantly to this;
- Recycling facilities will be provided for all the dwellings.

6.5 Water

- All appliances will be chosen so that they will be low water use;
- A rainwater collection will be installed for watering gardens and landscaped areas.

6.6 Land Use and Ecology

- The footprint of the residential development will largely fall within the boundary of the footprint of the land previously developed;
- High Floor area : Footprint ratio as it is a multiple storey building;
- The site where the new extension is going to be constructed does not present any feature of ecological value, therefore the extension will not have any negative impact on the local ecology.

6.7 Health and Well Being

- Good daylight and view of sky provided for the majority of the dwellings;
- Pre-completion testing will be carried out for sound insulation; the acoustic performance will comply with building regulations Part E.

6.8 Management

- Provision of a Home User Guide covering information on the environmental performance of the dwelling and information relating to the site and its surroundings;
- Commitment to go beyond best practice site management principles;
- Commitment to work with an Architectural Liaison Officer and achieve Secured by Design Award.

7 CONCLUSION

This report presents a summary of energy efficiency and renewable energy options, which will benefit the American Church development. As relevant areas of the scheme design are still in their early stages, these recommendations should be investigated during detailed design before a final decision on their suitability is taken.

A basic review of common renewable technologies and estimated CO_2 emission reduction has been undertaken using the GLA Toolkit Methodology.

Solar hot water is found to be the most suitable main renewable system for the hot water supply of the residential part of the development, leading to 14% CO_2 emission reduction for these units.

There is no technically suitable and recommended renewable energy system which could be implemented in the extension only. However, as the heating system of the Church is to be replaced, it is recommended to install biomass boilers in addition to conventional condensing boilers which could provide heating for the existing church and its extension. Biomass heating, supplying 22% of the space heating and domestic hot water demand of the church and its extension, will result in a carbon reduction greater than that resulting from the entire new extension.

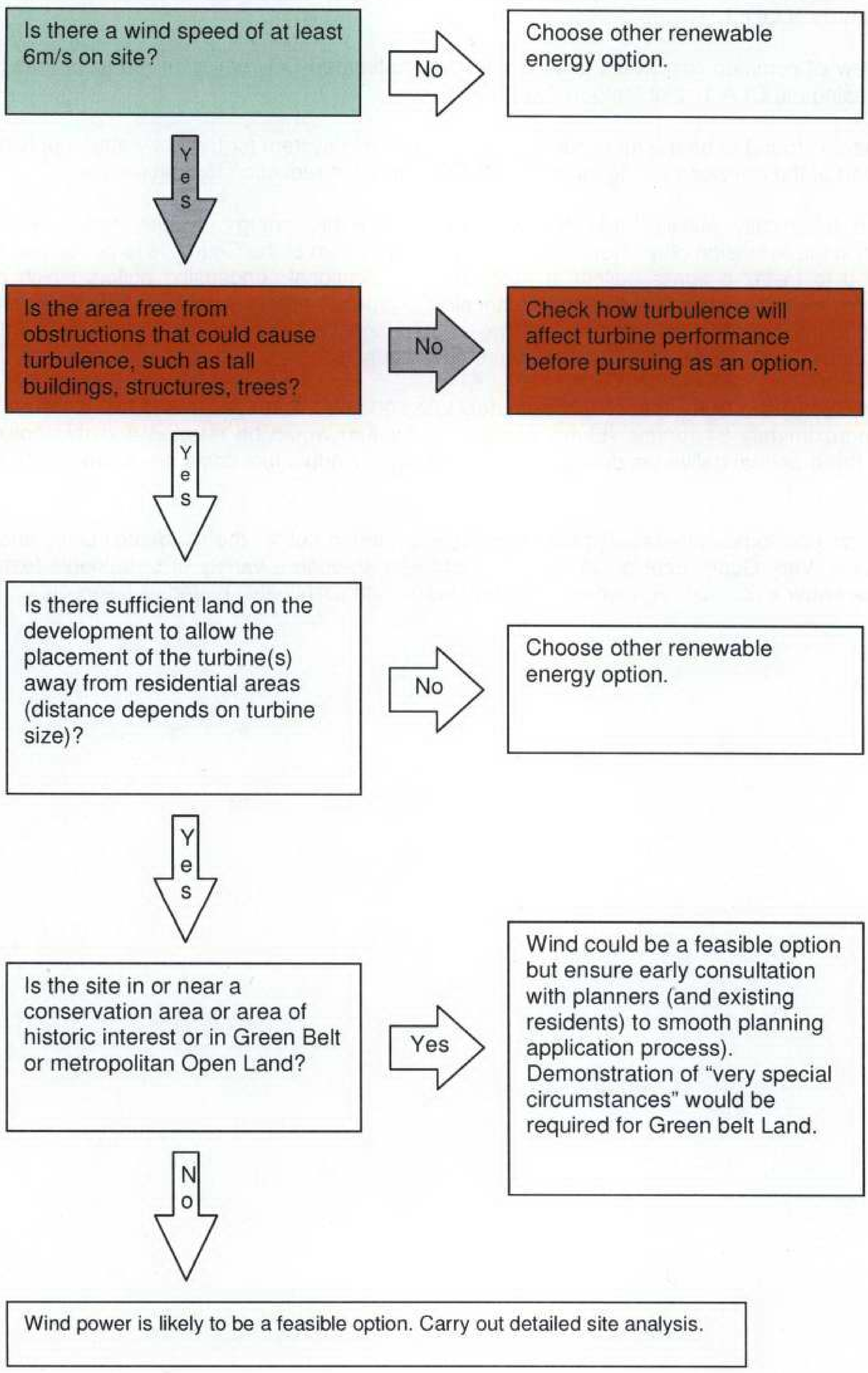
Such a biomass boiler is likely to cost approximately £22,500 and a flue system and fuel store are also required. Approximately 34 tonnes ($52m^3$) of wood pellet fuel would be needed and this could be delivered in three annual deliveries during the winter months. Annual fuel costs are estimated to be of £3,470.

Additionally, an EcoHomes pre-assessment checklist was carried out for the residential units, and it is foreseen that a "Very Good" EcoHomes could be achieved, through a variety of sustainable features. These include water efficient design, energy efficient design and sustainable materials selection.

8 APPENDICES

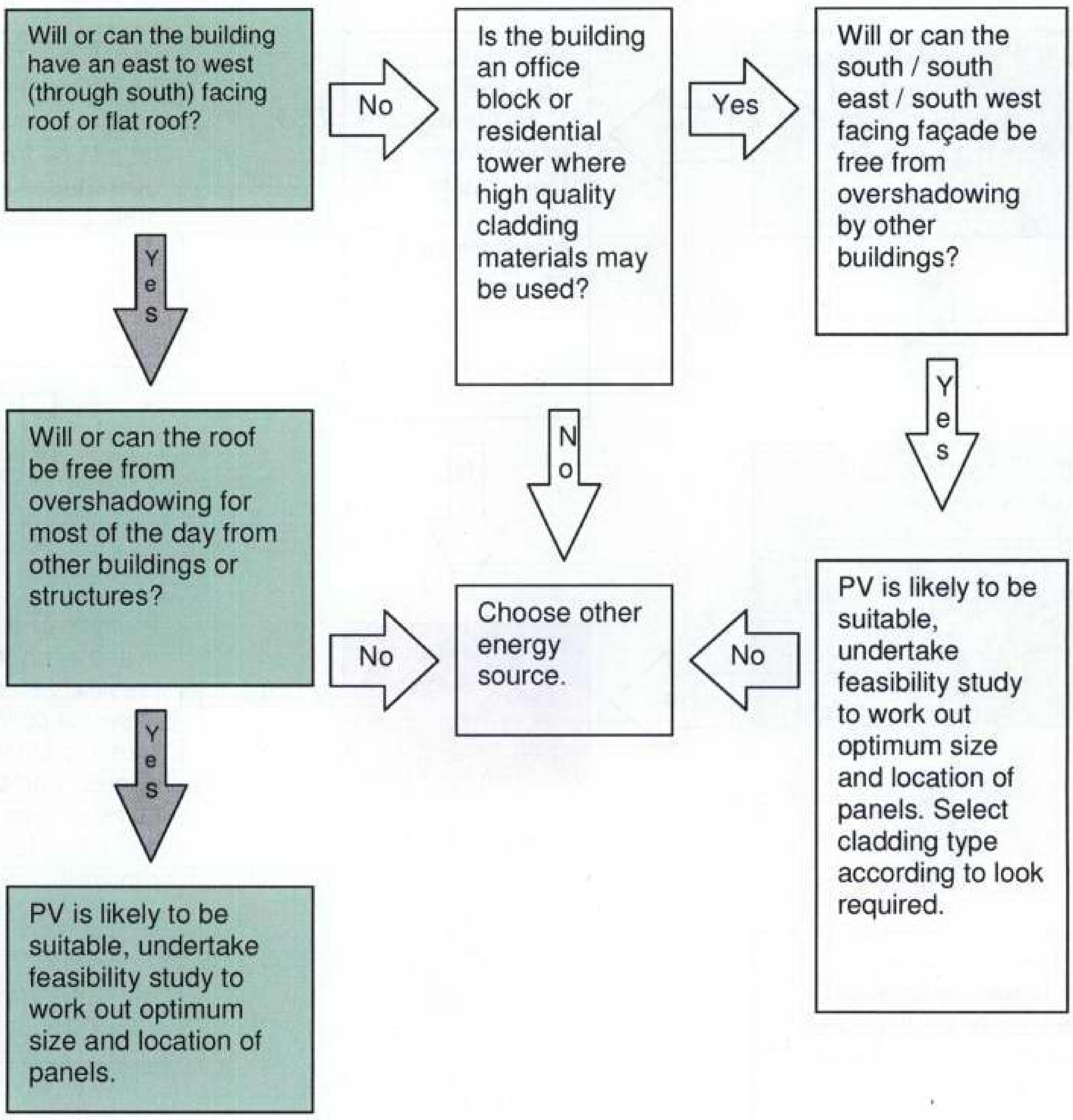
8.1 Selection Flowcharts

8.1.1 Guidelines for Suitable Locations for Wind Turbines[10]

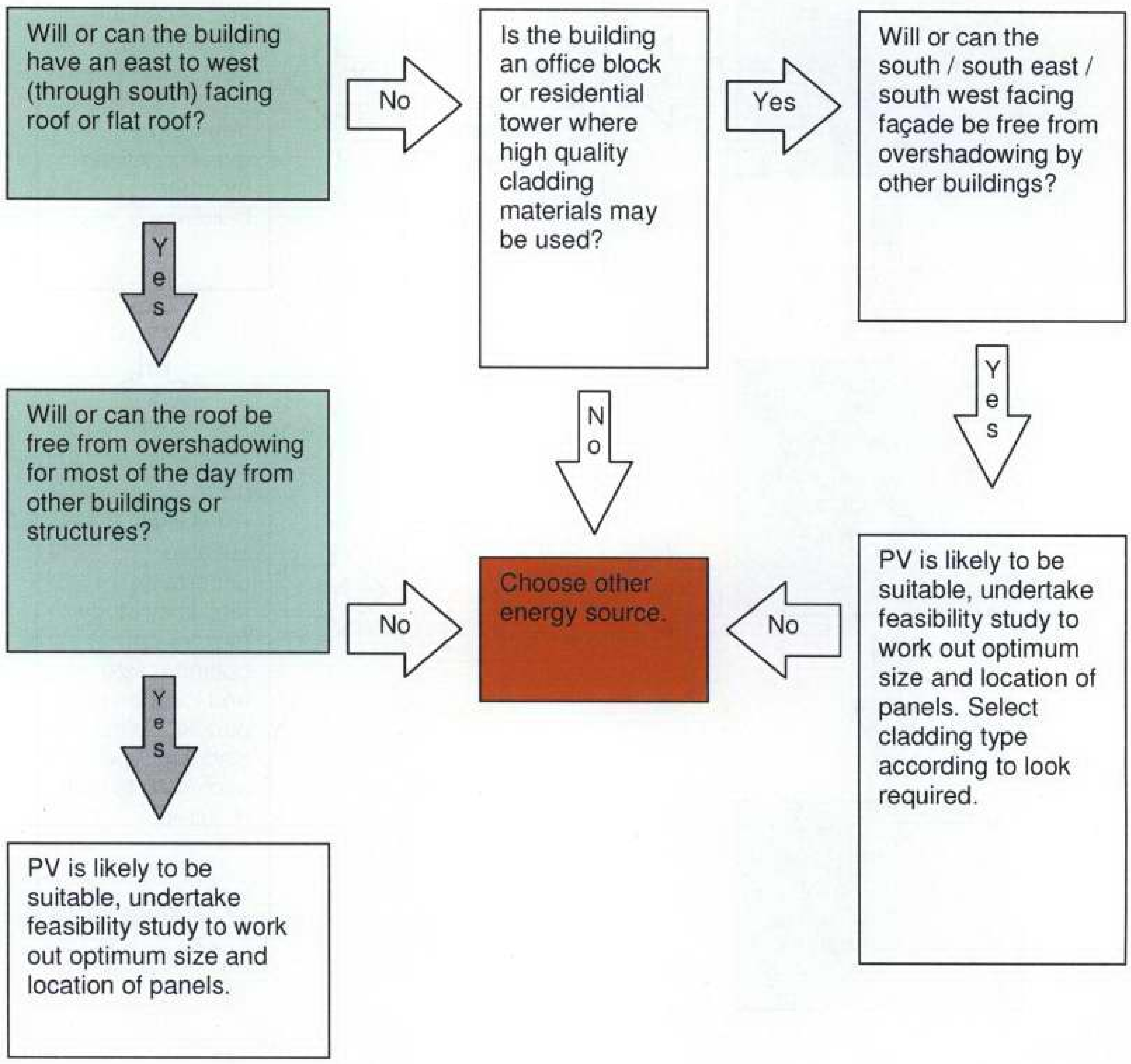


[10] It is assumed that 6m/s may be possible, but this has not been measured

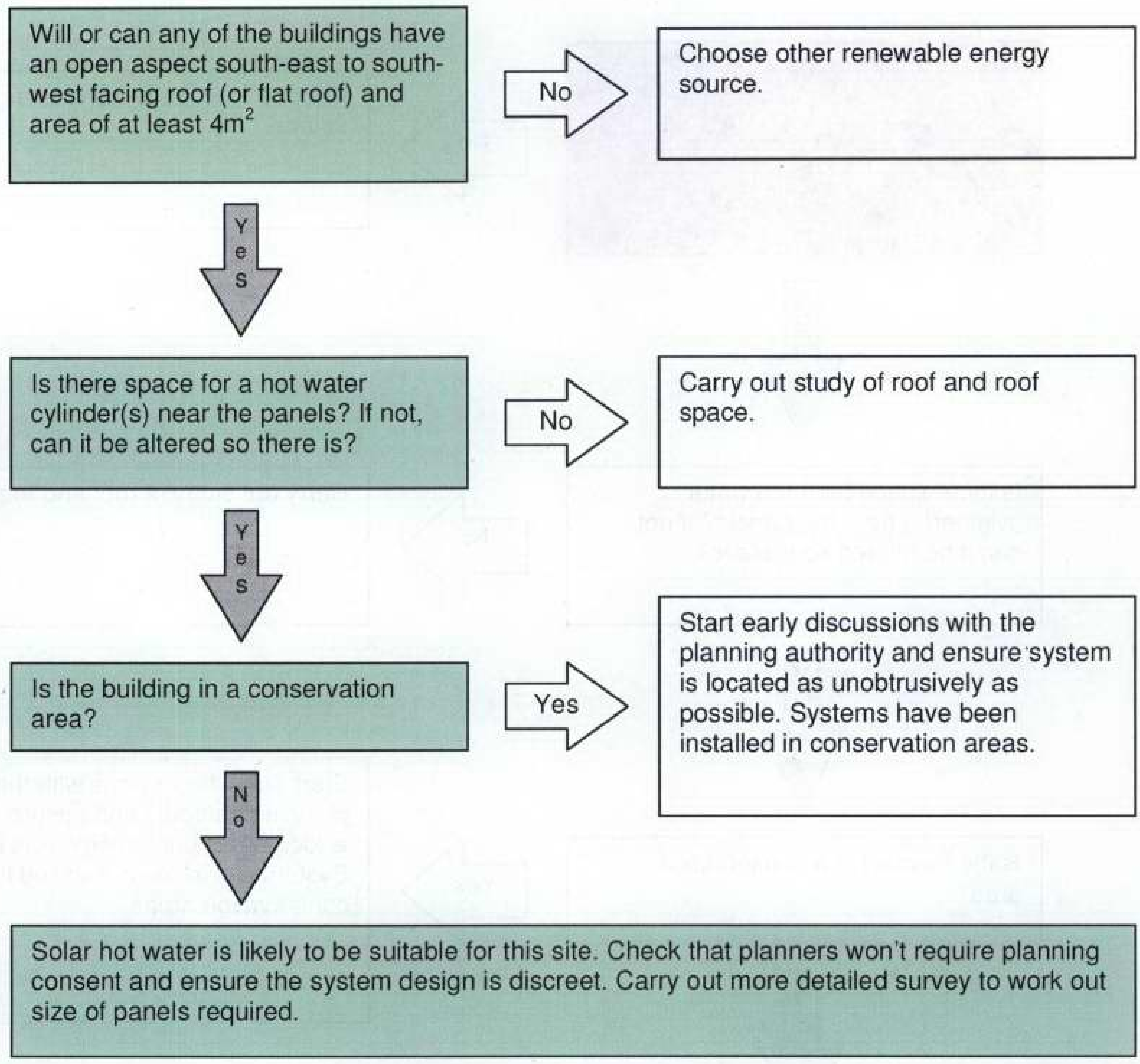
8.1.2 Guidelines for Suitable Locations for Photovoltaics for the residential units



8.1.3 Guidelines for Suitable Locations for Photovoltaics for the extension



8.1.4 Guidelines for Suitable Locations for Solar Thermal Systems for the residential units



8.1.5 Guidelines for Suitable Locations for Solar Thermal Systems for the extension

Will or can any of the buildings have an open aspect south-east to south-west facing roof (or flat roof) and area of at least $4m^2$

- No → Choose other renewable energy source.
- Yes ↓

Is there space for a hot water cylinder(s) near the panels? If not, can it be altered so there is?

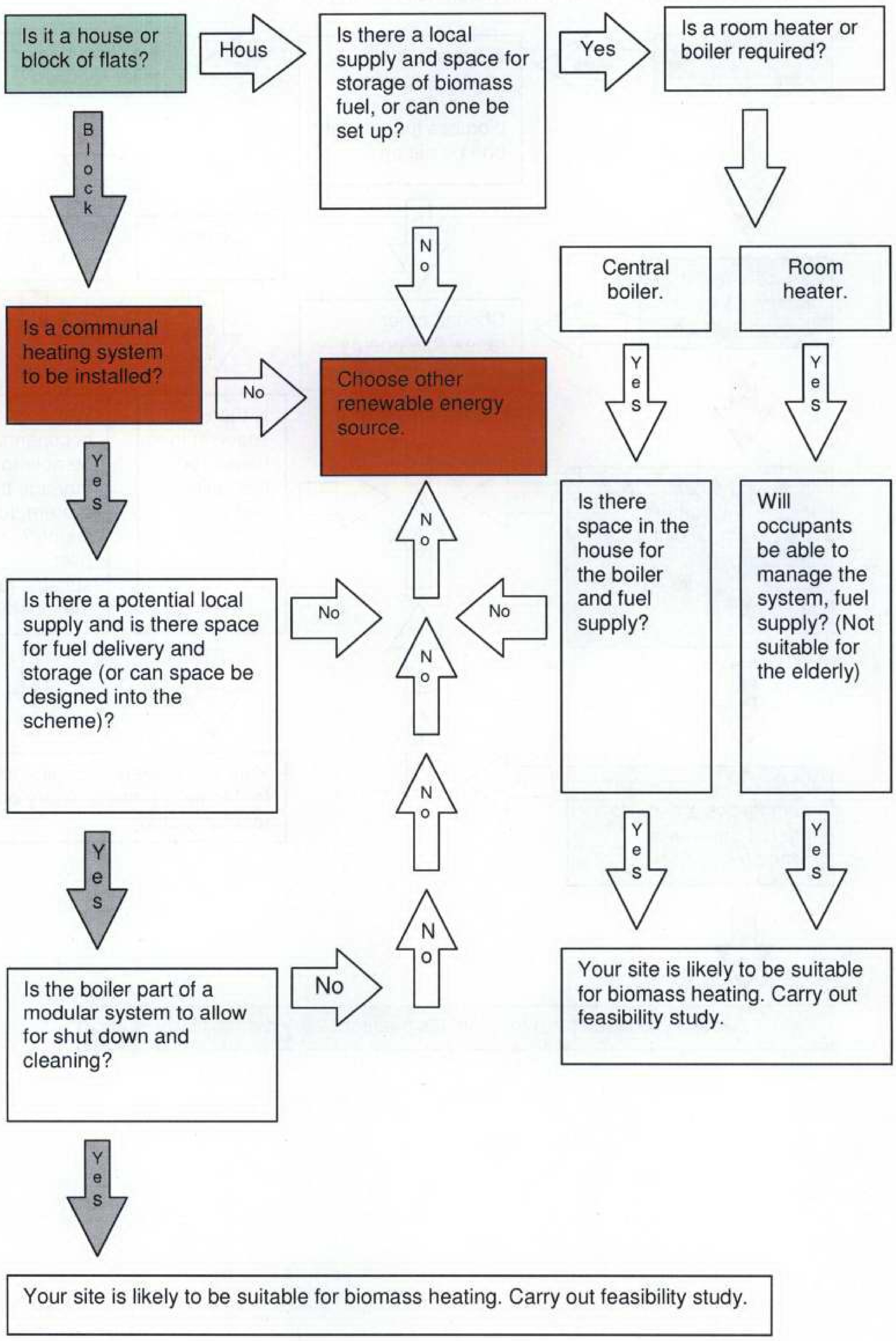
- No → Carry out study of roof and roof space.
- Yes ↓

Is the building in a conservation area?

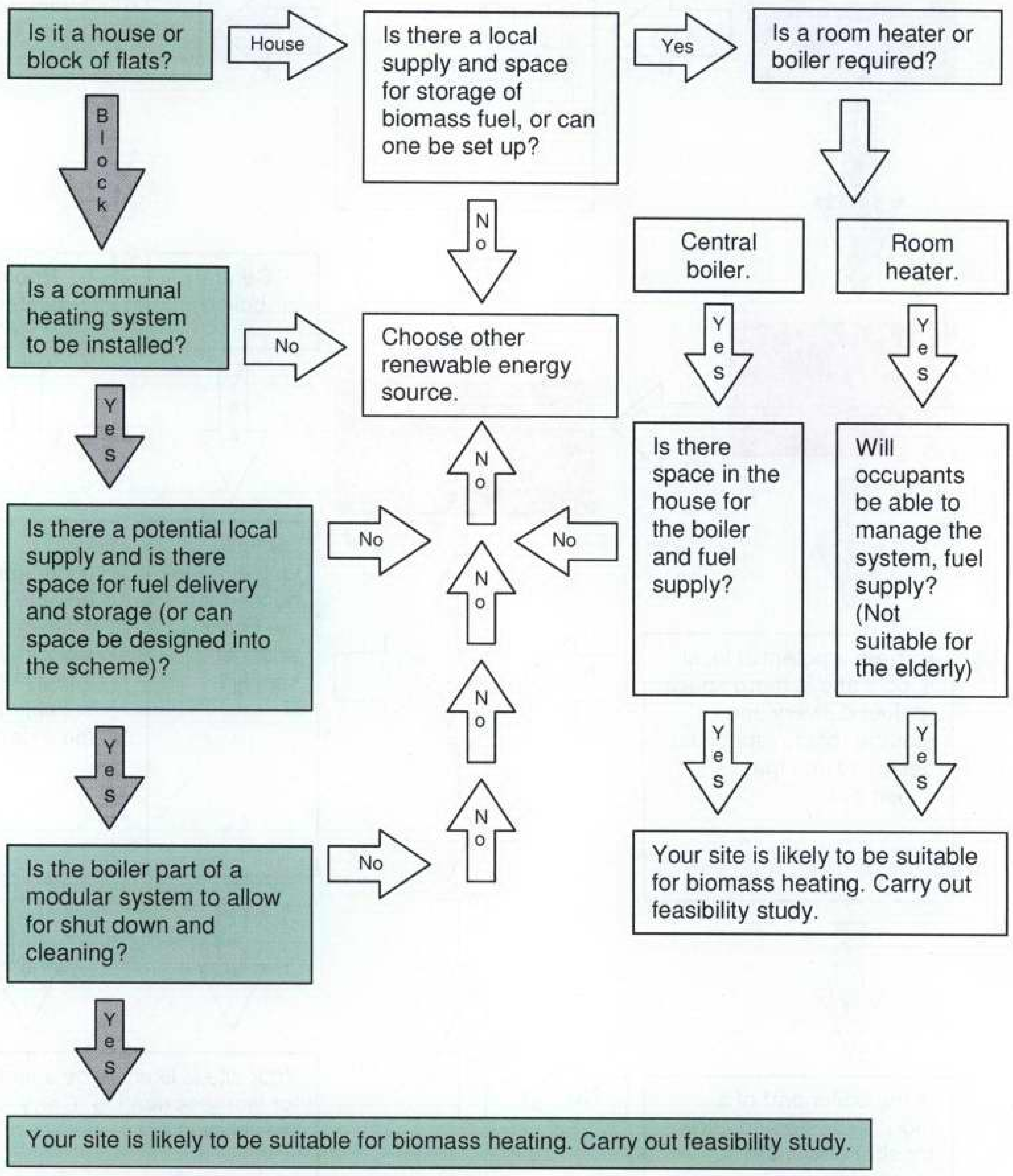
- Yes → Start early discussions with the planning authority and ensure system is located as unobtrusively as possible. Systems have been installed in conservation areas.
- No ↓

Solar hot water is likely to be suitable for this site. Check that planners won't require planning consent and ensure the system design is discreet. Carry out more detailed survey to work out size of panels required.

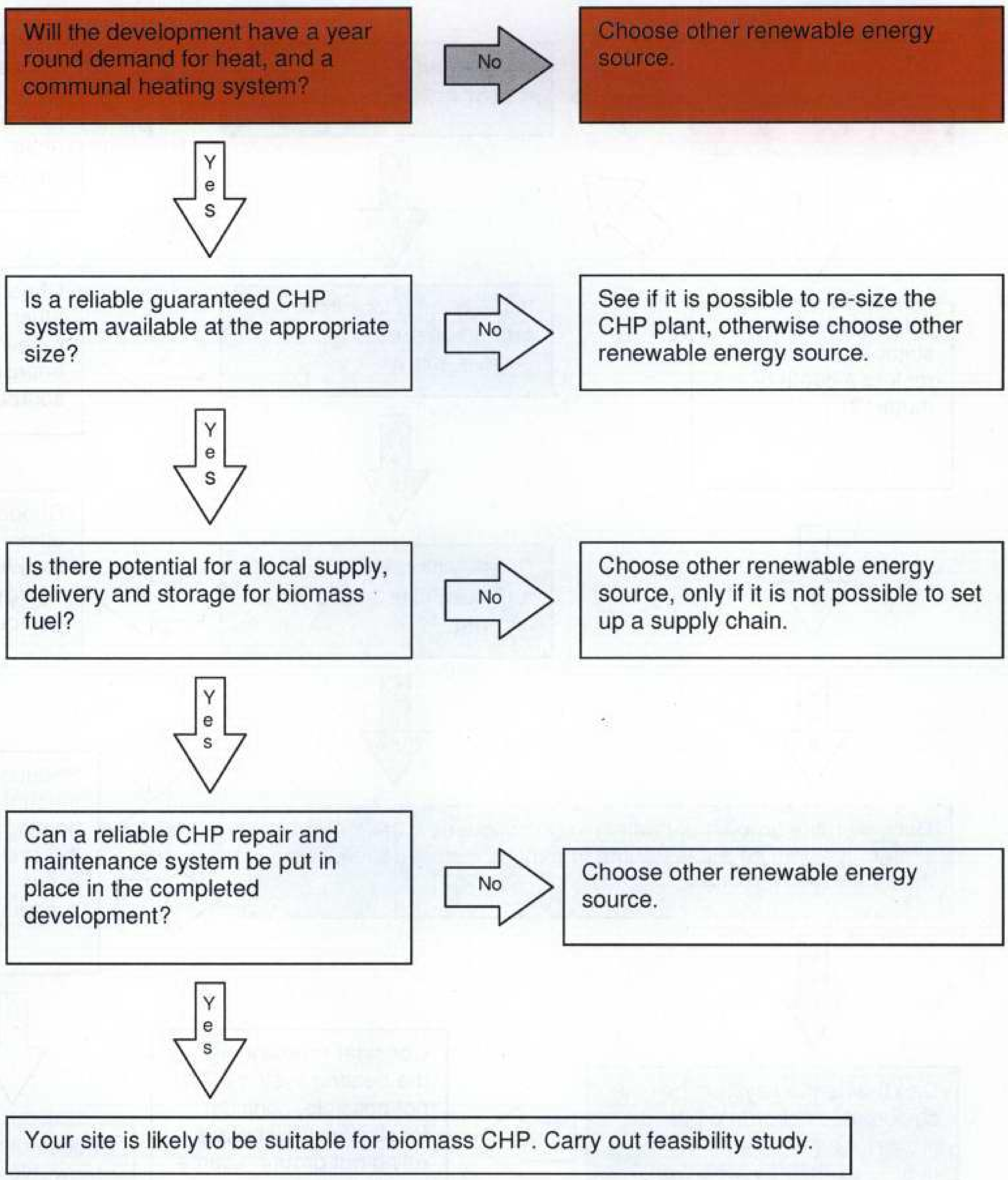
8.1.6 Guidelines for Suitable Locations for Biomass Heating for the residential units



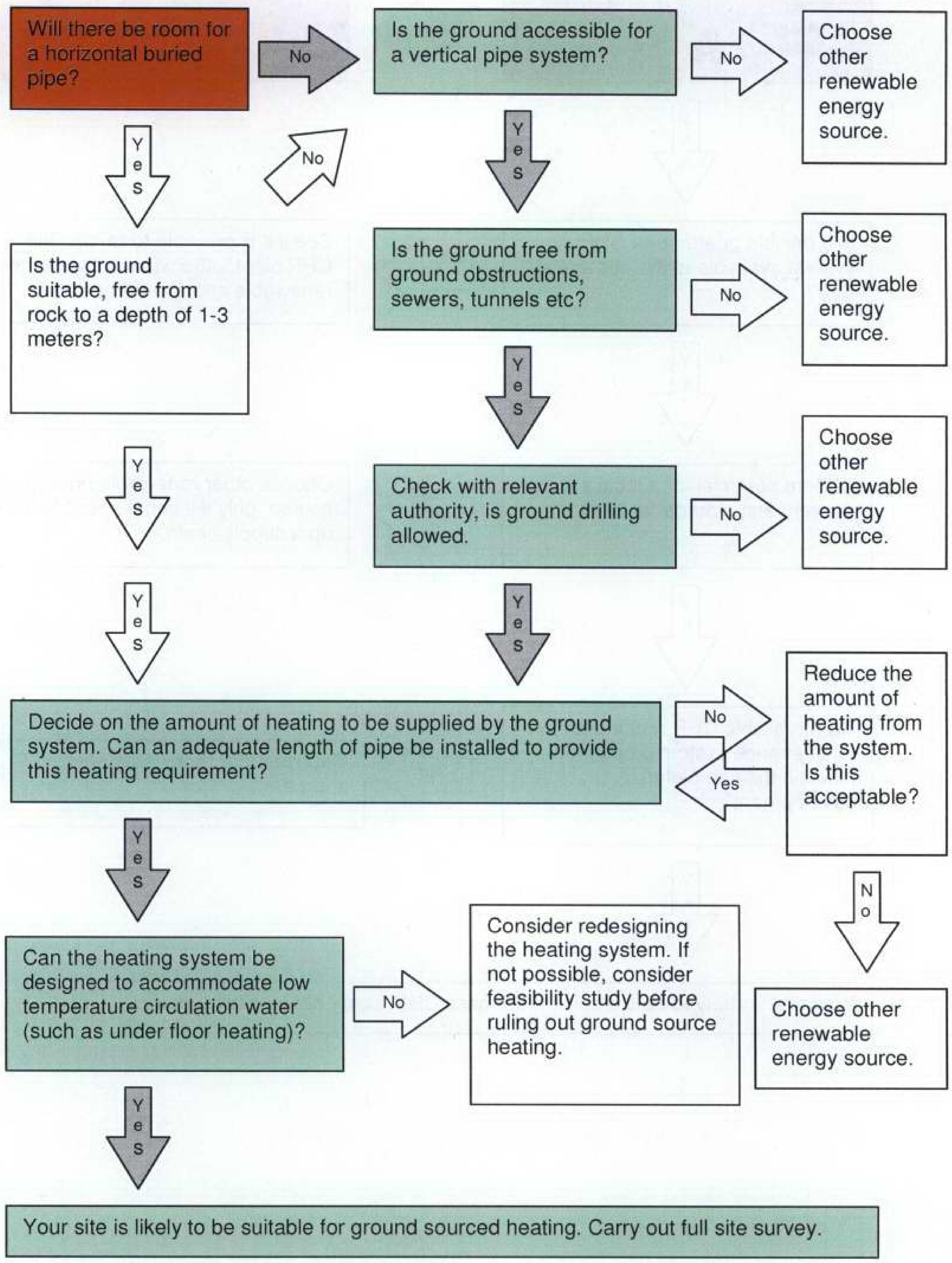
8.1.7 Guidelines for Suitable Locations for Biomass Heating for the extension



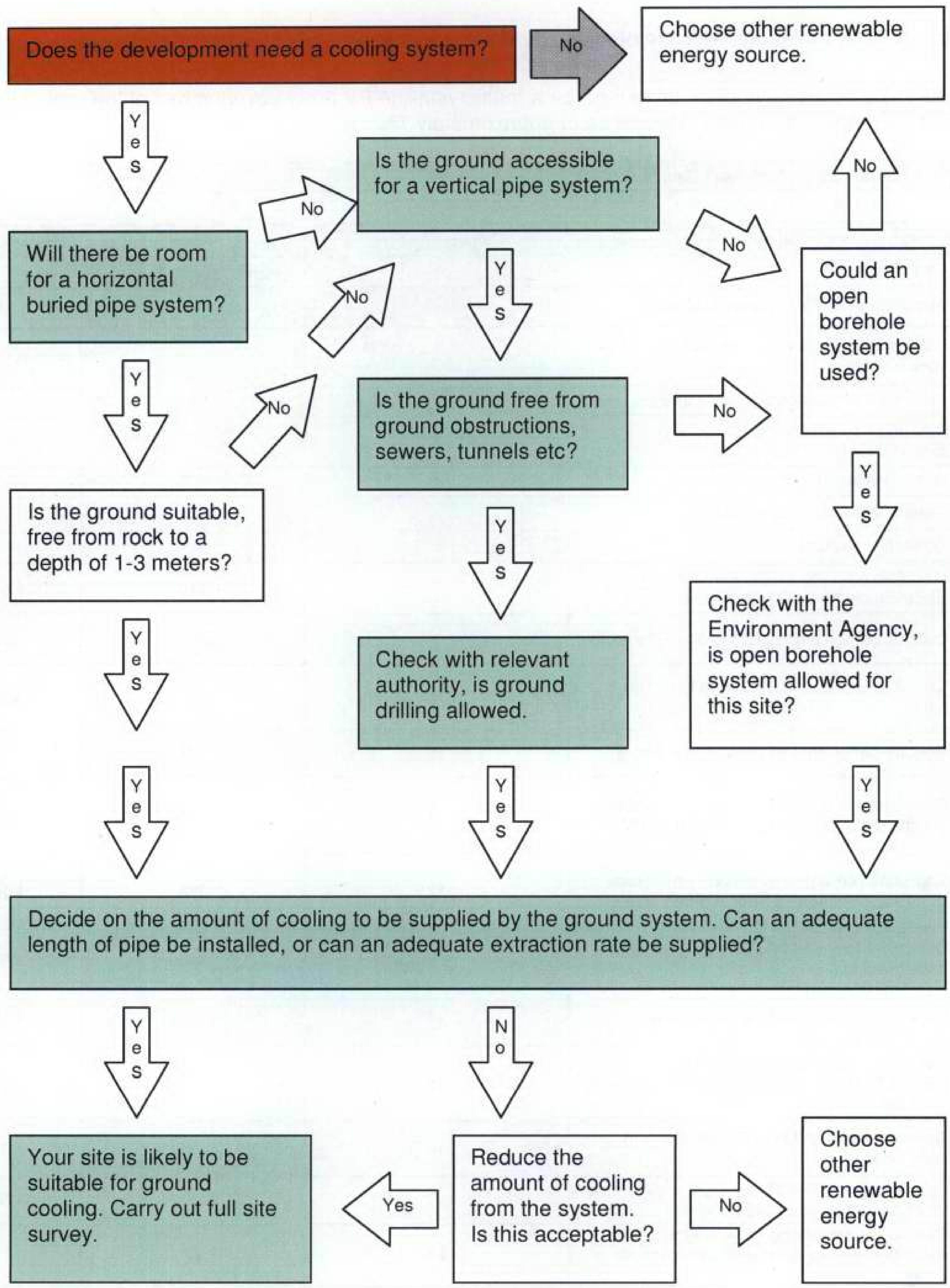
8.1.8 Guidelines for Suitable Locations for Biomass CHP



8.1.9 Guidelines for Suitable Locations for Ground Source Heating



8.1.10 Guidelines for Suitable Locations for Ground Cooling Systems



8.2 Carbon Reductions

8.2.1 CO_2 emission reduction provided by a PV array on the roof of the residential units:

The calculations have been done here for a multicrystalline PV array covering half of the roof of the residential units. The CO_2 emission reduction would be of approximately 7%.

GLA PV Energy Contribution Calculation Method

Description of calculation step	Calculation Step	Value	Units
PV array	-	**Pollycristaline**	
Approximated PV Installed Capacity	-	**4.1**	**kWp**
Determine maximum annual irradiation at the specific location	1	1022	kWh/m2/year
Determine module conversion efficiency	2	15%	%
Determine positioning factor based on system's tilt and orientation	3	96%	%
Determine inverter efficiency	4	93%	%
Determine system losses factor	5	94%	%
Determine packing density factor	6	90%	%
Calculate resulting annual kWh system Electrical output from 1m^2 of panel	7	116	kWh/year
Look up carbon emissions factor for electricity	8	0.115	kgC/kWh
Calculate annual carbon saving from 1m^2 panel	9	13	kgC/year
Specify panel area of proposed PV array	**10**	**29**	**m2**
Calculate DELIVERED electricity requirement substituted by electricity generated by PV	11	3,358	kWh/year
Calculate reduction in carbon emissions due to application of photovoltaic array	**12**	**386**	**kgC/year**
Determine total DELIVERED gas energy in base building	13	56,697	kWh/year
Look up carbon emissions factor for gas	14	0.053	kgC/kWh
Calculate carbon emissions due to DELIVERED gas in building with PV (same as base building)	15	3,005	kgC/year
Determine total DELIVERED electricity in base building	16	23,736	kWh/year
Calculate DELIVERED electricity requirement for building with proposed PV array	17	20,378	kWh/year
Calculate percentage carbon emissions reduction due to proposed photovoltaic array	**21**	**7.22%**	**%**
Installed Cost*	22	850	£/m^2
Cost system	23	24,650	£
CO_2 emission reduction	24	1,416	kgCO_2/year
cost / CO_2 emission reduction	25	17.41	£/kgCO_2.year

8.2.2 CO_2 emission reduction provided by the solar collectors on the roof of the residential units:

The calculations have been done here for a system which would provide 50% of the hot water demand of the residential units. The CO_2 emission reduction would be of approximately 14%.

GLA SHW Energy Contribution Calculation Method

Description of calculation step	Calculation Step	Value	Units
Total SHW collector area		29	m^2
Number of collector modules		5	
Determine total DELIVERED gas energy in base building for end uses that are to be served by SWH	1	28,781	kWh/year
Determine heating system efficiency in base building	2	0.85	%
Calculate end use DEMAND met accounting for system efficiency	3	24,464	kWh/year
Specify proportion of end use DEMAND met by SWH	4	50%	%
Calculate annual energy DEMAND for hot water met by solar water heating	5	12,232	kWh/year
Determine total DELIVERED gas energy in base building	6	56,697	kWh/year
Calculate DELIVERED gas requirement substitued by SWH	7	14,391	kWh/year
Calculate remaining required for DELIVERED gas after application of SWH	8	42,306	kWh/year
Look up carbon emissions factor for gas	9	0.0530	kgC/kWh
Carbon emissions due to DELIVERED gas in building with SWH	10	2,242	kgC/year
Total DELIVERED electricity in base building	11	23,736	kWh/year
DELIVERED electricty required by pump	12	555	kWh/year
DELIVERED electricity requirement for building with SWH	13	24,291	kWh/year
Emission factor for electricty	**14**	**0.115**	kgC/kWh
Carbon emission due to DELIVERED electricty in building with SWH	15	2,794	kgC/year
Total building carbon emissions in building with SWH	16	5,036	kgC/year
Base building total carbon emissions	17	5,735	kgC/year
Reduction in carbon emissions due to application of SWH	18	699	kgC/year
Percentage carbon emissions reduction due to application of SWH	**19**	**13.88%**	**%**
Installed Cost	20	650	£/m2
Cost system	21	18,708	£
CO_2 emission reduction	22	2,797	$kgCO_2$/year
cost / CO_2 emission reduction	23	6.69	£ / $kgCO_2$ .year

8.2.3 CO_2 emission reduction provided by a biomass heating system for the extension only:

The calculations have been done here for a system which would provide 100% of the heating demand of the extension. The CO_2 emission reduction would be of approximately 10%.

GLA Biomass Heating Energy Contribution Calculation Method

Description of calculation step	Calculation Step	Value	Units
Determine total DELIVERED gas energy in base building for end uses that are to be served by biomass heating	1	11,660	kWh/year
Determine the heating system efficiency in base building	2	90%	%
Calculate end use DEMAND met accounting for system efficiency	3	10,494	kWh/year
Specify the proportion of end use DEMAND met by biomass heating	4	100%	%
Calculate annual energy DEMAND for heating and hot water met by biomass heating	5	10,494	kWh/year
Determine total DELIVERED gas energy in base building	6	11,660	kWh/year
Calculate DELIVERED gas requirement substituted by biomass heating	7	11,660	kWh/year
Calculate the remaining requirement for DELIVERED gas after application of biomass heating	8	0	kWh/year
Look up for carbon emission factor for gas	9	0.053	kgC/kWh
Calculate carbon emission due to DELIVERED gas in building with biomass heating	10	0	kgC/year
Calculate total DELIVERED electricity in base building	11	52,800	kWh/year
Look up for carbon emission factor for electricity	12	0.115	kgC/kWh
Calculate carbon emssion due to DELIVERED electricity in building with biomass heating (same as base building)	13	6,072	kgC/year
Calculate total building carbon emissions in building with biomass heating	14	6,072	kgC/year
Calculate base building total carbon emission	15	6,690	kgC/year
Calculate reduction in carbon emissions due to application of biomass heating	16	618	
Calculate percentage carbon emissions reduction due to application of biomass heating	**17**	**10.18%**	**%**
Installed Cost*	18	300	£/kW
Size system	19	50	kW
Cost system	20	15,000	£
CO_2 emission reduction	21	2,266	$kgCO_2$/year
cost / CO_2 emission reduction	22	6.62	£ / $kgCO_2$ .year

8.3 Quote from Total Concept Solutions for a ground source heating system

Total Concept Solutions

Total Concept Solutions
Air Conditioning, Geothermal and VRF Systems

Whitby Bird

17th January 2007

Attention: Andrew Thompson

Re: American Church & Ground Source Heating & Cooling Bore Hole Solutions
Our Ref 74008
Further to our recent discussions I can confirm the following

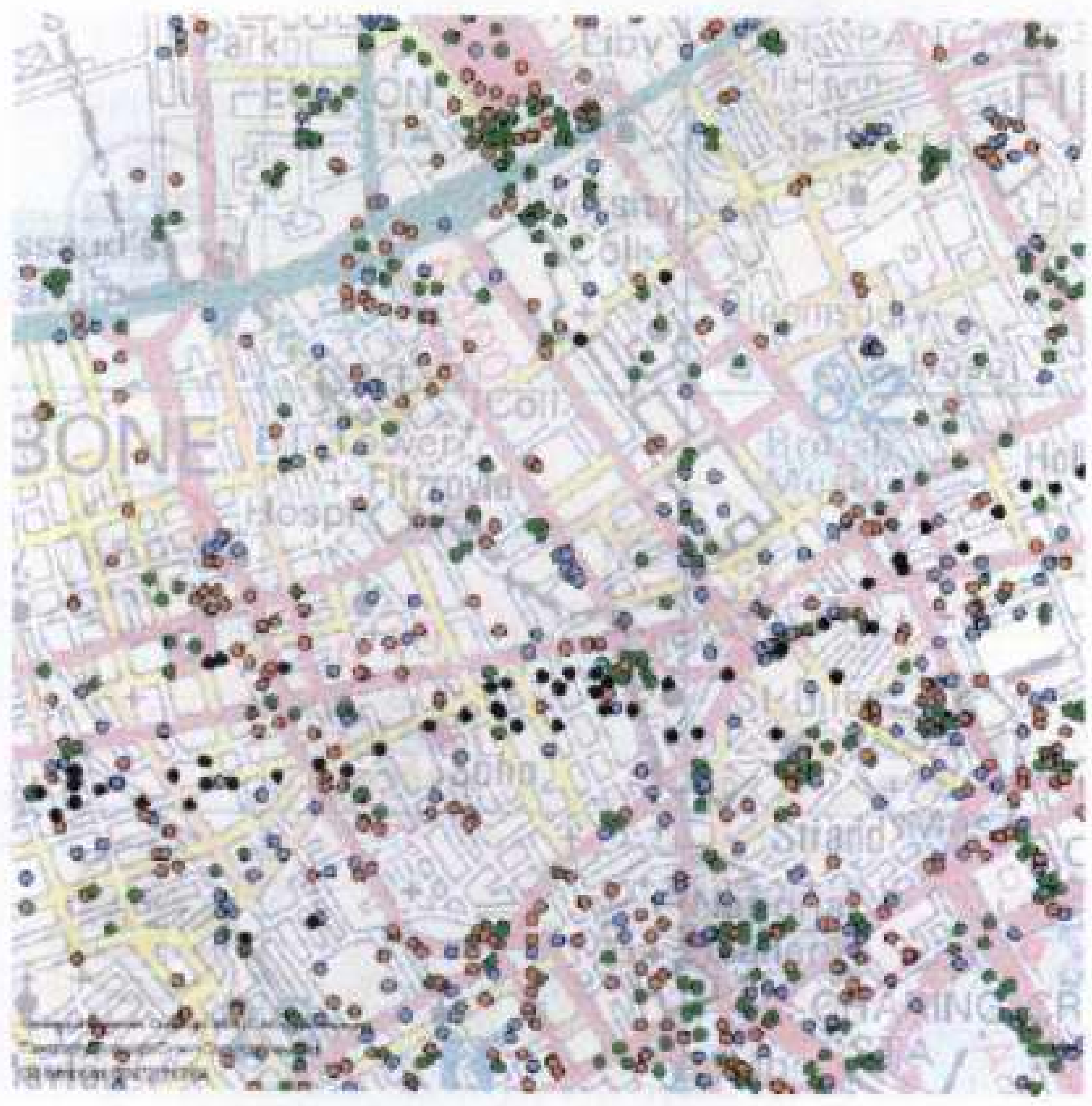
After initial investigations the volume of water at the lower strata levels within the W1 area is good.
The area shows good yielding water abstraction and systems for use with Ground Source Heating & Cooling Bore Hole Systems would be possible.
Please see map below with a "well map" overlay which identifies the active wells within the project area.
As the strata appears to be able to support the water volumes
But due to the low heat rejection values required even though an open system would be more efficient we would recommend a closed loop system purely on a commercial cost basis (please see below)
The closed loop design comprises of a number of flow and return vertical loops within the site area to the required depth of 100 meters or more within bore holes as a matrix borefield.

Open Well / Loop
You will require approximately 1 l/s for the 40kw heat rejection load
At the present time we can provide a budget cost of £164k .
Note this cost would be much the same if you were to add the apartments as this cost comprises of one abstraction and one rejection well and the total duty would be achievable from these.
The cost includes for the geothermal bore hole wells - drilling , sleeving ,all underground geothermal pipework valves & fittings , submersible pumps ,connected to plate heat exchangers at ground level within the building (see open loop base schematic below) all supplied, installed tested and commissioned as a package.

Closed Vertical Loop in Strata
This design comprises of a number of flow and return vertical loops within the site area to the required depth of 100 meters or more within bore holes as a matrix borefield. Total area required 15mt x 15mt
A multitude of vertical bore holes would need to be drilled on the plot.
At the present time we can provide a budget cost of £61k
The cost includes for the geothermal bore holes ,bore field all loops , distribution pipework and valved header arrangements -supplied and installed all to suite the preliminary design load
After assessing the site plot we can provide a borefield layout to suite the project

COMPANY REGISTRATION NO: 5372994
46 ALDGATE HIGH STREET, LONDON, EC3 1AL
TEL: 0207 744 7803 FAX: 0207 744 7800

Map & Well Active Well Map Overlay



TCS geothermal systems provide the following benefits :

Green PR as extremely energy efficient system and is classed as a renewable energy by the government with efficiencies 7+ compared to chillers at 2.5 and boilers at 1.

No "design , logistical ,planning or excessive cost limitations" as the other renewable energy sources such as Wind Generation ,Photovotalic Cells , Solar Water Heating & Biomass Heating , CHP or TriGen.

No annual testing & certification requirements to local authority as required by other systems as above

While CHP & TriGen are reasonably high efficient systems they are not classed as a "renewable" by central Government as large volumes of gas are still used but with Geothermal there is no requirement for gas.

Provides a cost effective solution to obtaining a minimum of 10 % renewable energy requirement on projects as required by government & planning approval.(10% to be 15% in the future)

System can be heating only or cooling only or heating and cooling.

No weight on roof or walls for coolers , condensers or heat rejection machines
Reduced structural support in building - reduced cost & reduced construction programme times
No noisy heat rejection equipment as listed above therefore – simple planning applications & approvals
.Reduced project cost as no costly acoustic screens ,lovers or compounds required.

No external equipment therefore no "line of sight" or "rights to light" problems or ugly equipment to hide therefore simple planning applications & approvals

No cost requirement in the future for equipment replacement in 15 years time when worn out as heat rejection source is underground water which will not run / wear out.

Maximized sale / nett lettable square footage at roof / high level areas as no heat rejection or heating equipment
Regain areas for Penthouses / Roof Gardens / Roof Terrace Bars etc etc

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46 ALDGATE HIGH STREET, LONDON, EC3 1AL
TEL: 0207 744 7803 FAX: 0207 744 7800

Areas normally identified for equipment in the basement can be re assigned as Gyms , Swimming Pools ,car parking or chargeable customer storage areas etc

Life cycle costing & attractive payback as massive reduction in running cost as only bore hole well water pump to run & maintain.
No heat rejection equipment/ condensers or coolers.

Maximum reliability as guaranteed heat rejection process from water underground

Cost of operating system extremely low and guaranteed protection against gas & electricity energy cost rising.

Project capitol costs can be reduced as no requirements for a gas supply or gas distribution system.

The complete system is very neat out of sight under a man hole cover.

well head
under manhole cover

Heating & Cooling Systems Available For Use With Open Well Systems in commercial and residential applications

Domestic hot water services

Packaged ground source heat pump heating & cooling air handling unit packages

Simultaneous heating & cooling via Mitsubishi VRF geothermal water to refrigerant WR2 system
Including internal units - fan coils , cassette units & close control computer units.

Under floor heating and cooling

Over door heaters

Swimming pool heating

Radiator heating

Chilled beam heating and cooling

All the above is does not require gas boilers ,chillers or water heaters as the Geothermal Wells are used.

We look forward to your further instructions.
Please do not hesitate to call if you have any quires.

Best Regards
Simon Simmons

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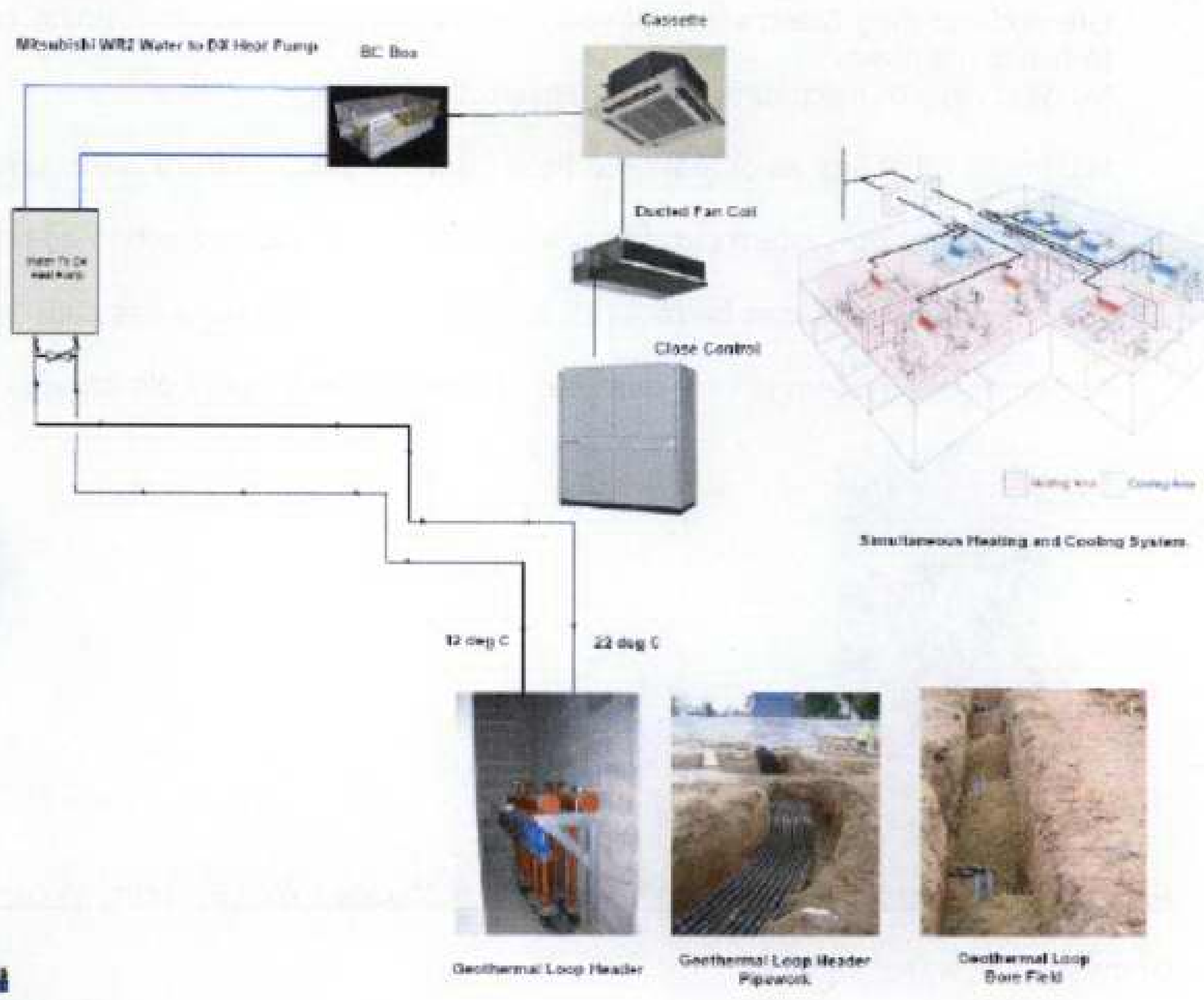
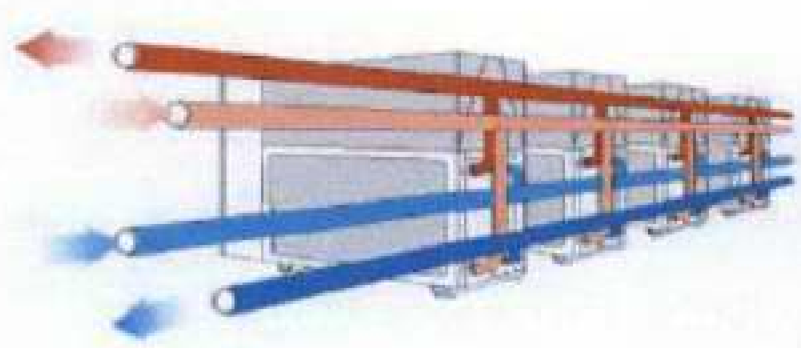
Total Concept Solutions

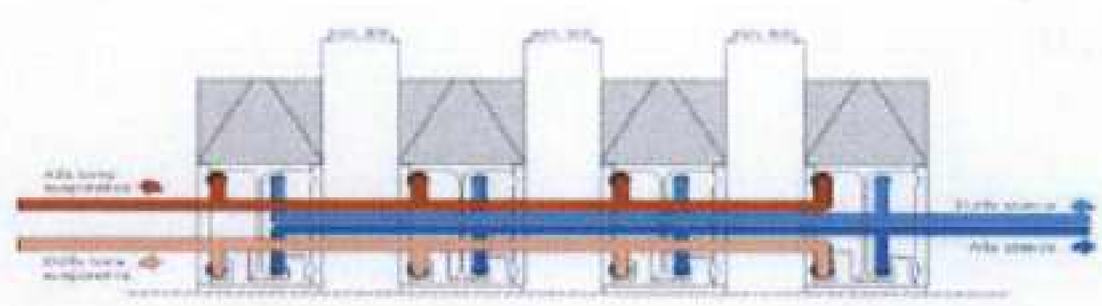
Vertical / Horizontal Close Loop Design



Total Concept Solutions
Tel 0207 744 7803
www.totalconceptsolutions.com

Ground Source Heat Pumps & Layouts





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8.4 EcoHomes Pre-Assessment Checklist

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
Energy	Ene 1	Carbon Dioxide	CO_2 emissions less or equal to 26 kg/m²/year	5.5	13.75
	Ene 2	Building fabric	Heat Loss Parameter (HLP) less than or equal to 1.3 W/m²	0.92	1.83
	Ene 3	Drying space	No drying space provided	0	0.92
	Ene 4	EcoLabelled goods	White goods with A-ratings to be provided for all units.	1.83	1.83
	Ene 5	Internal lighting	75% of lights specified as dedicated low energy lights as a minimum.	1.83	1.83
	Ene 6	External lighting	• All space lighting designed to accommodate CFL or fluorescent strip lights • All intruder lighting to be 150 watts maximum and be fitted with PIR and daylight sensor and • All other type of security lighting to accommodate CFLs or fluorescent strips only and be fitted with dawn to dusk sensors or timers	1.83	1.83
Transport	Tra 1	Public transport	All the dwellings will be located within 500m of a bus stop with 15min peak and half hourly off peak service.	2	2
	Tra 2	Cycle storage	Sufficient cycle storage provided for 95% of all dwellings.	2	2
	Tra 3	Local amenities	Proximity to local amenities: • Within 500m of a food shop and a post box; • Within 1000m of following amenity: food shop, bank/ cash machine, pharmacy, medical centre, leisure centre, public house and children's play area; • Safe pedestrian route to all public amenities.	3	3
	Tra 4	Home office	No space and services for home office provided.	0	1

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
Pollution	Pol 1	Insulant ODP and GWP	Insulation materials specified do not use ozone depleting substances and do not have a global warming potential rgeater than 5, in roof, walls, floor, and for the hot water cylinder	0.91	0.91
	Pol 2	NO_x Emissions	NOx emissions of the boiler will be less or equal to 70 NOx mg/kWh (Class 5 boiler).	1.82	2.73
	Pol 3	Reduction of Surface Runoff	No reduction of peak surface runoff proposed.	0	1.82
	Pol 4	Zero Emission Energy Source	A renewable energy feasibility study has been carried out and 10% of the total energy demand for the development will be supplied by a local renewable energy source.	1.82	2.73
	Pol 5	Flood risk mitigation	Zone defined as having a low probability of flooding	1.82	1.82

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
Materials	Mat 1	Environmental Impact of Materials	Environmental Impact - materials Environmental Rating		
		Roof	A rated according to the Green Guide to Housing Specification	1.35	1.35
		External Walls	A rated according to the Green Guide to Housing Specification	1.35	1.35
		Internal Walls	A rated according to the Green Guide to Housing Specification	1.35	1.35
		Floors - upper and ground	not A rated according to the Green Guide to Housing Specification	0	1.35
		Windows	A rated according to the Green Guide to Housing Specification	0.9	0.9
		External surfacing	not A rated according to the Green Guide to Housing Specification	0	0.45
		Boundary Protection	not A rated according to the Green Guide to Housing Specification	0	0.45
	Mat 2	Responsible sourcing of Materials: Basic Building Elements	Building elements will be sourced from responsible origin (EMS certification for all sources at process and extraction stage) 1. Frame 2. Ground Floor 3. Upper floors (including any loft boarding) 4. Roof (structure and cladding) 5. External walls (including external cladding) 6. Internal walls (including internal partitions) 7. Foundations/substructure 8. Staircase (including the tread, rises and stringers)	0.9	2.71

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
	Mat 3	Responsible sourcing of Materials: Finishing Elements	Building finishing elements will be sourced from responsible origin (EMS certification for all sources at process and extraction stage) 1. Stair (including handrails, balustrades, banisters, other guarding/rails (excluding staircase)) 2. Window (including sub-frames, frames, boards, sills) 3. External & internal door: (including sub-frames, frames, linings, door) 4. Skirting (including architrave, skirting board & rails) 5. Panelling (including any other trim) 6. Furniture (including fitted; kitchen, bedroom, and bathroom) 7. Facias (soffit boards, bargeboards, gutter boards, others) 8. Any other significant use	1.355	1.355
	Mat 4	Recycling Facilities	Compliant recycling facilities provided.	2.71	2.71

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
Water	Wat 1	Internal Water Use	Water efficient fittings (dual flush toilet, water efficient white goods...), water consumption less or equal to 37 m^3/bedspace/year.	6.66	8.33
	Wat 2	External Water Use	Rainwater collection system for watering gardens and landscaped areas provided.	1.67	1.67
Land Use and Ecology	Eco 1	Ecological Value of Site	Land of low ecological value.	1.33	1.33
	Eco 2	Ecological Enhancement	No ecological enhancement.	0	1.33
	Eco 3	Protection of Ecological Features	It is assumed that on the basis that the land will be of low ecological value, this credit will be achieved.	1.33	1.33
	Eco 4	Change of Ecological Value of Site	It is assumed that the site will not change the ecological value of the site significantly.	2.67	5.33
	Eco 5	Building footprint	Total combined floor area: footprint ratio for all dwellings on the site is greater than 3.5:1.	2.67	2.67
Health and Wellbeing	Hea 1	Daylighting	Provision of adequate daylighting and view of the sky for 90% of the dwelligns.	5.25	5.25
	Hea 2	Sound Insulation	Conduct testing as required in column A of the EcoHomes criteria, and acoustic performance will comply with building regulations Part E. If the test is unsuccessful (non compliant) then remedial works will be carried out.	1.75	7
	Hea 3	Private space	No private space provided.	0	1.75

American Church
EcoHomes 2006 Checklist

whitbybird

Section			Credit description	Recommended VERY GOOD	% of total score
Management	Man 1	Home User Guide	Provision, in each dwelling, of a simple guide that covers information to the 'non-technical' tenant/occupant on: •The environmental performance of their home • Information relating to the site and surroundings	3	3
	Man 2	Considerate Constructors	Commitment to obtain a high score at the Considerate Contractors Scheme.	2	2
	Man 3	Construction Site impacts	No monitoring, sorting and recycling of the construction waste on site	0	3
	Man 4	Security	• Commitment to work with an Architectural Liaison Officer and achieve Secured by Design award, AND • Security standards for external doors and windows, to achieve a minimum of either: -LPS1175SR1 (All doors and windows) OR -PAS24-1 (All external pedestrian door-sets falling within scope of PAS24-1) AND BS7950 (All windows falling into the scope of BS7950)	2	2
			Total EcoHomes Score	**65.525**	**100**
				Very Good	