# 5.0 renewable energy measures...

## PRELIMINARY SELECTION OF RENEWABLE TECHNOLOGIES

### Background

This section of the report briefly describes the renewable energy technologies considered for use at the Waldegrave Arms development site.

Six renewable energy technologies are put forward in the supporting text to Policy 4A in The London plan as being suitable for consideration in developments within London, these being solar water heating, photovoltaic panels, biomass fuel heating, wind turbines and ground source heating/Cooling. In the Energy Strategy, Policy Planning Statement 22 Companion Guide on renewables, this list is expanded to encompass waste combustion and landfill gas - a technology not directly applicable to individual buildings.

### Note on Biomass CHP

Combined Heat and Power (CHP) plant (except when run on biomass sources) is not generally considered a renewable energy technology, although it can offset carbon emissions significantly.

Biomass CHP systems simultaneously produce electricity that can be used in a building or exported to the grid, and heat as a by-product for space, water and even process heating. As with all CHP systems, the key issue determining the viability of a Biomass CHP plant is the presence of a consistent heat and/or power load on a year round basis. This load is not present across the Waldegrave Arms site.

Since there are currently very few working examples of CHP systems using biomass as the fuel, it may be argued that the level of technical risk that such a system will expose the project to is beyond that which any commercial developer would find acceptable. In addition to this, logistical reasons apply, as detailed in the later Biomass Heating section, concerning fuel availability, delivery and handling.

Due to the lack of proven plant commercially available and the problems already established in the 'biomass heating section' over fuel sources and storage this technology is not considered at this stage, however the option exists for incorporation at a later date should technology and fuel logistics improve.

### Decision Trees

To illustrate the selection process used to determine the most suitable renewable energy technologies for implementation on the site, a decision tree has been shown for each technology. This shows the key points applied to verify the basic viability of the various renewable technologies.

The following legend applies to the path taken through the decision trees:

| | |
|---|---|
| text | Decision Stage – Not Used |
| text | Decision Stage – Used |
| text | Decision Stage – Positive Response |
| text | Decision Stage – Negative Response |
| Yes/No | Decision Path Step – Not Followed |
| Yes/No | Decision Path Step – Followed |

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## WIND TURBINES

### Definition

Wind power generation is the conversion of the kinetic energy in the wind to mechanical energy, which in turn is used to generate electricity.

### Technology Description

The energy in the wind is captured by the blades of a wind turbine, which are normally mounted on a horizontal shaft (although vertical axis turbines also exist). The wind causes the shaft to turn, which drives the electrical generator.

The size of wind turbines varies greatly, from a few hundred watts to 3MW. Wind turbines are sized according to their rated power, that is the power output at a given wind speed, usually 12 m/s.

The relation between wind speed and power output is not linear. In fact, the energy content of the wind varies with the cube of the wind speed – twice the wind speed would give eight times as much energy. The speed of the wind increases with height above the ground, so it is therefore important to have a good understanding of local wind conditions before specifying a turbine. For larger turbines, an anemometer will have to be mounted on a mast at the site of the proposed turbine in order to have reliable wind speed and direction data over the course of a year.

On average, a wind turbine generates electricity for 70-85% of the time, although not always at the rated power. Its load factor, the proportion of a turbine's theoretical energy output over a year, is around 30%, compared to 50% for a conventional power station.

### Benefits

Wind power is one of the more cost effective renewable energy technologies. For grid-connected systems, any excess electricity that is produced can be sold back to the grid. If the site is well chosen, wind power can be a reliable source of power.

### Technical Considerations

Most wind turbines start operating ('cut in') at around 3-4 m/s. Larger wind turbines are viable where the average wind speed is 6-7 m/s. Smaller turbines can still produce useful amounts of electricity at an average wind speed of 4 m/s.

Turbines should be sited away from obstacles that could disrupt the wind pattern e.g. buildings, trees etc. The wind regime in urban areas is also an area of concern due to the likelihood of high wind turbulence which will potentially reduce electricity output.

Planning consent is required for the installation of a wind turbine. It is important to involve the public in the consultation process. The noise levels vary from machine to machine but roof-mounted turbines, which have been specially developed to operate at low noise levels and with low vibration are now available.

In a building integrated or building mounted wind turbine system, the turbine is connected through appropriate electrical switchgear to the building's electrical system and both of these are connected to the electricity grid such that all generated energy can be used regardless of the building demand fluctuations.

Turbines rely on a minimum wind speed to 'cut in' and start generating power, but from this minimum upwards the output increases as a cube function of the wind speed. In periods of above average wind speed, the power generated increases significantly. Since wind resource varies all the time, it is difficult to make precise calculations of the power output of a turbine but average figures indicate that in reasonably windy areas (average wind speed of 6 m/s or higher – this figure being generally accepted as the minimum average local wind speed to make turbines feasible) the expected output from each 1kW installed turbine capacity is about 2500kWh annually.

### Economic Considerations

An increasing number of products are now available 'off the shelf' with proven performance and durability characteristics from UK and EU manufacturers. Horizontal axis wind turbines as shown in the picture on the left are best suited to ground mounted locations, whereas vertical axis wind turbines can be ground or building mounted.

Although there is some scope for the addition of larger wind generators in some urban sites, turbines of a capacity between 1kW and 500kW are best suited to these locations.

Although the initial capital outlay can be quite high, a well-positioned wind turbine can recoup this cost relatively quickly. Installed costs are size dependent: £500/100W for small, battery charging turbines; £3000/kW for medium sized, grid-connected turbines; £700/kW for large 2MW turbines.

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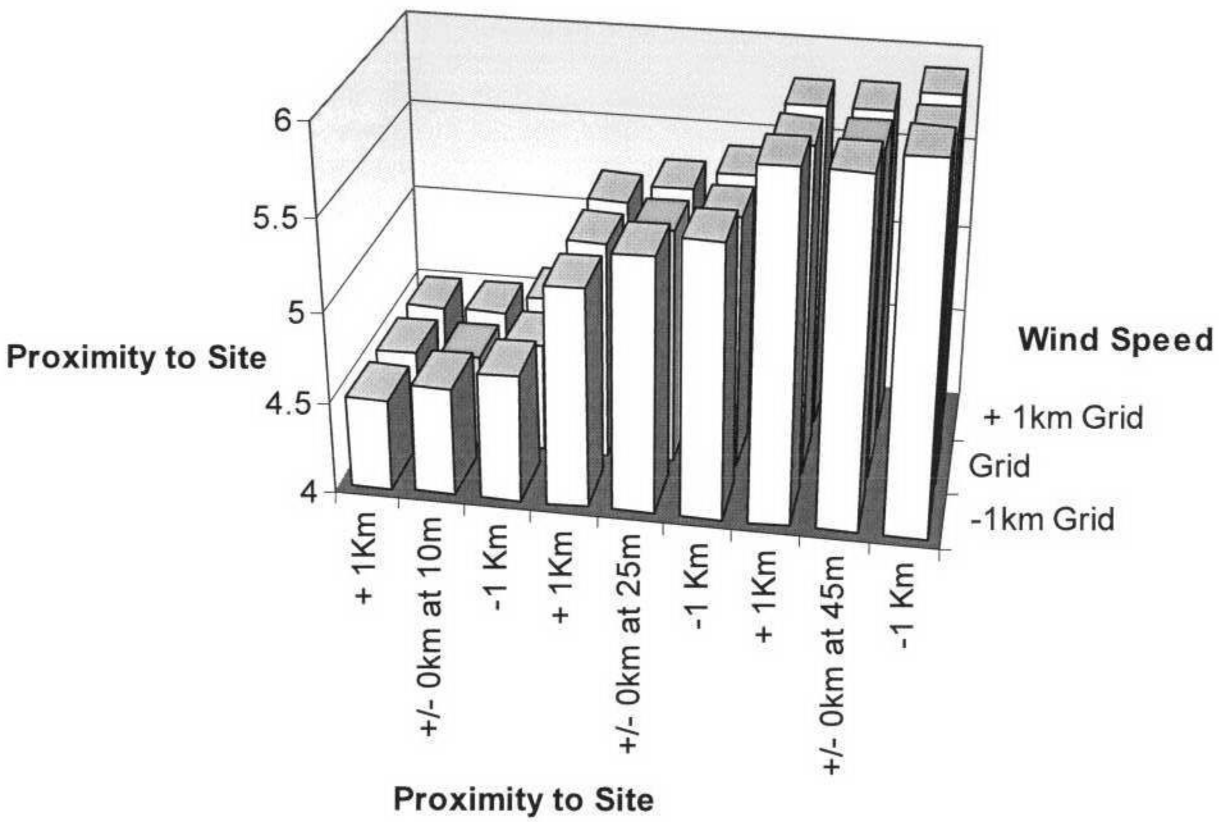
**Applicability to Waldegrave Arms Site**

As shown in the decision tree opposite, conventionally wind turbines are not specified where average wind speeds are less than 6m/s.

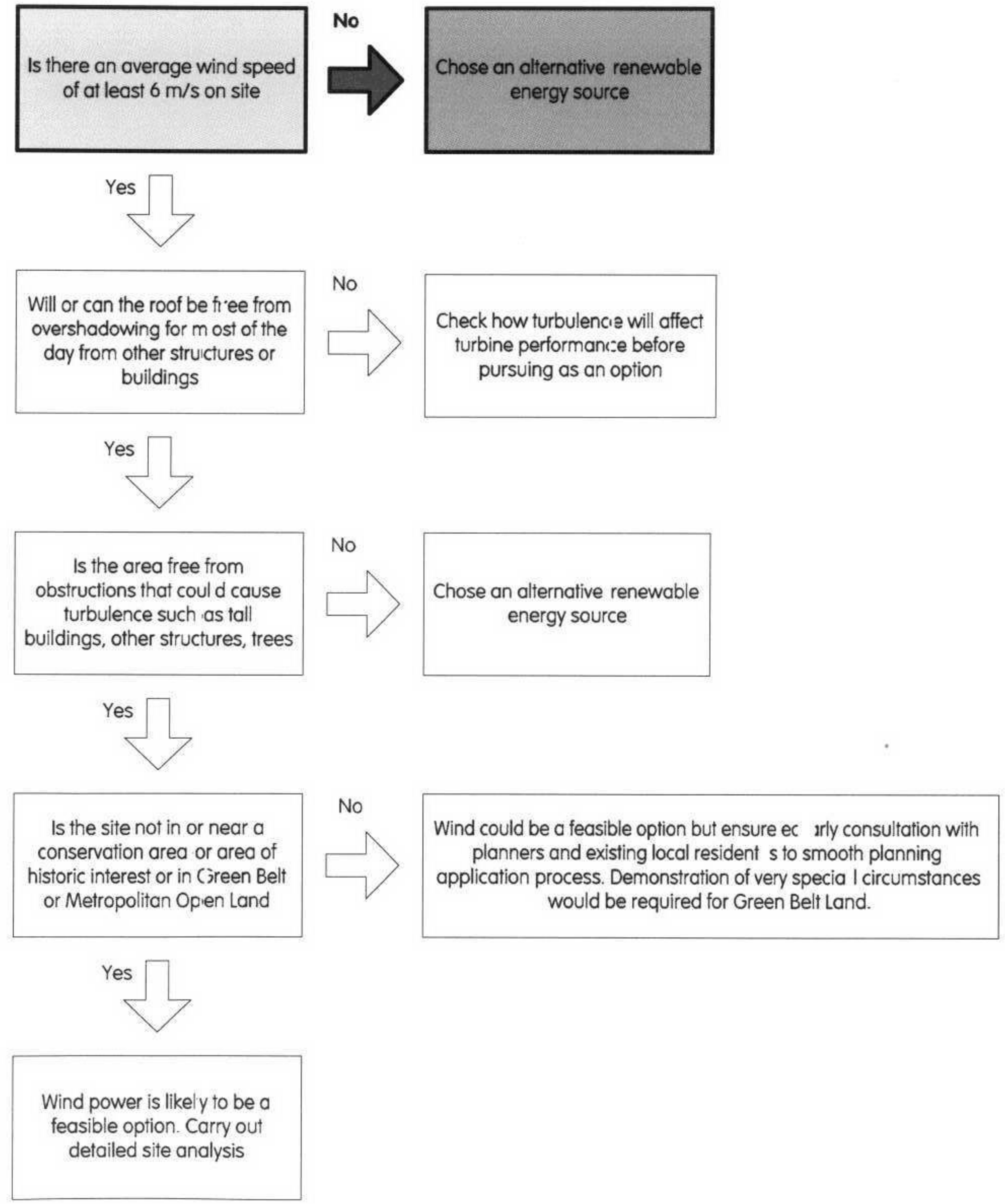
Data from the DTI's NOABL wind speed database shows that this speed is just likely to be present on or around the site, with 4.5m/s 5.3m/s and 5.8m/s wind speeds predicted for 10m, 25m and 45m from the ground respectively.




This wind data has been applied to the output curve of a typical wind turbine designed for use in building-based applications, the Proven WT15000 under this wind regime, as discussed in 'Contribution of Renewable Energy Technologies below. This indicates that the output of the turbine on this site is likely to be substantially below its rated output.

The siting of any wind turbine on the site poses significant problems due to the built up nature of the site and its surroundings. It is generally recommended that turbines are not sited within 30m of a building or wooded area.

**Decision Tree**



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## Conclusion

It is recognised that whilst the contribution from wind generators for this scheme to reduce carbon emissions and assist (in part) in meeting the 10% renewables target, they are considered to be a visibly obtrusive technology.

Due to the low wind speeds predicted for the site from 10m and 25m above the ground, it does not seem a viable option to incorporate wind generation on the site. In addition, the location of the site in a built up area of Teddington make the aesthetics appearance important, and the consideration of distances to neighbouring buildings does not make wind turbines a suitable option at the site.

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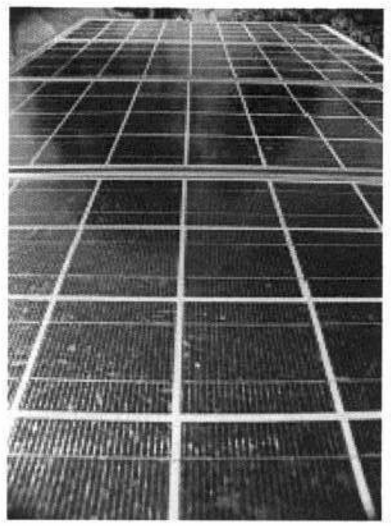
## PHOTOVOLTAICS



### Introduction

Solar photovoltaic (PV) technology is a semi-conductor based technology that converts the energy in sunlight into electricity. A PV system comprises the PV panel (generator) and the associated wiring and electronics or 'balance of system'

### Technology Description

If the energy in the daylight is sufficient, it causes a flow of electrons across the junction of the semi-conductor: electricity is generated. A solar panel is made up of cells, which are connected together in different configurations to give different voltage and current outputs.

The PV panel should be oriented between southeast and southwest (optimally south). The optimal tilt angle (inclination of panel from horizontal) should be calculated to ensure the best possible output of the system during the year. In the UK, the angles of most pitched roofs are suitable for mounting PV panels. Panels can also be mounted on A-frames on flat-roofed buildings. PV technology comes in a range of forms: PV panels that can be retrofitted to the roof of an existing building or equally, sunk to fit flush with the roof line; PV cells that are 'laminated' between sheets of glass to provide shading in a glazed area, and PV cladding.

### Benefits

PV systems are low maintenance as they have no moving parts and panels generally have 25-year warranties, although the life-time of the panel can be expected to be beyond this time.

### Technical Considerations

The PV systems should be unshaded. Shading caused by other buildings, greenery and roof 'furniture' such as chimneys or satellite dishes, even over a small area of the panel, can significantly reducing performance. Excess energy can be exported to the grid. Although the feed-in tariffs are generally not high, exporters can negotiate with their utility company.

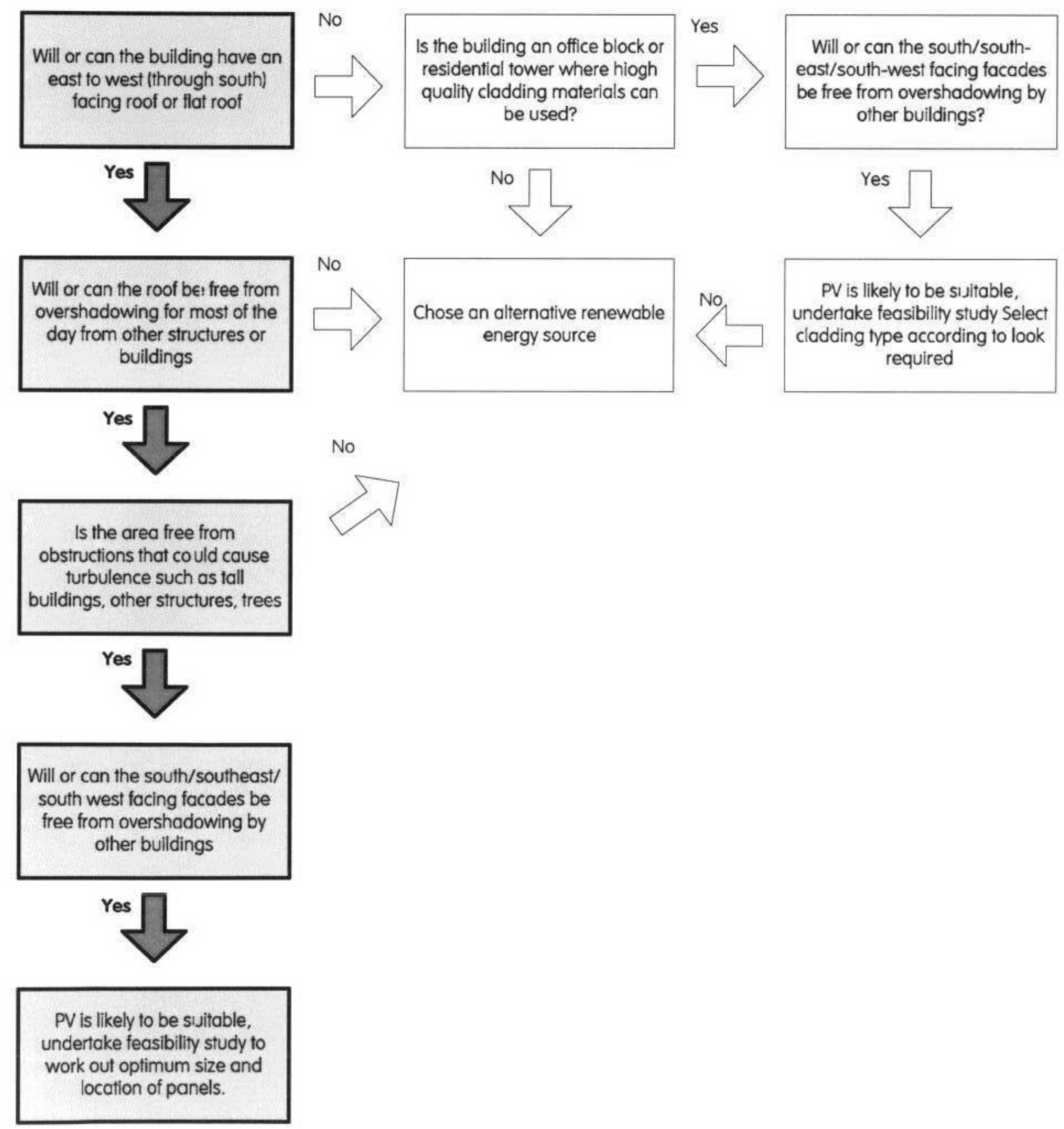
### Economic Considerations

Payback times for this technology are almost always in excess of twenty years; but this is reducing year on year as the technology matures and are set to reduce further as fuel prices increase. The cost can be further offset by integrating PV into a building and replacing other building materials. Current prices are around £6000 for an installed 1kWp system and grants for just under 40% of this cost may be available.

Grant funding is generally required to make PV technology approach 'economically feasible' but it is noted that any such grant funding could not be guaranteed for the site.

As a direct comparison, a single wind generator could provide 2,300kW per year of electrical energy, whilst an array approaching 35m² would be needed for the same capacity. This size of array could cost in the region of £31,500 (assuming no grant availability) against a wind turbine cost of £1,500.

### Decision Tree



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### Applicability to Waldegrave Arms Site

Whereas the decision tree shows that PV is potentially a technically acceptable solution for the site, in practice the cost of the panels required for the desired output of the system need to be calculated to determine whether they are a suitable technology. Using the renewables toolkit, it has been estimated that 340m$^2$ of available roofspace would be required to provide a 10% reduction in $CO_2$ emissions. A system of this size would cost in the region of £340,000. Installing PV would therefore inflate the price of each unit by around £15,000, making them unaffordable to the local population.

### Conclusion

It is not proposed to pursue photovoltaic panels for Waldegrave Arms, Teddington due to the long payback periods of the PV system along with the initial high capital costs.

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**SOLAR WATER HEATING**

**Introduction**

Solar water heating systems use the energy from the sun to heat water, most commonly in the UK for domestic hot water needs. The systems use a heat collector, generally mounted on the roof in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or via a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

**Technology Description**

A solar collector comprises the housing that contains piping through which the carrier fluid circulates and a glass panel to retain the radiation from the Sun. The temperature inside the collector increases and this heat is then transferred to a carrier fluid. In an open loop system, the hot water is heated directly. A heat transfer medium such as glycol is employed in a closed loop system. Solar thermal panels are generally black in appearance for maximising energy adsorption and the glass panels have a special coating in order to retain as much heat as possible.

The heated carrier fluid circulates around the system, with a pump in an active system or by natural convection in a passive system, to the hot water cylinder, which ideally should be a twin coil cylinder.

Two types of collector exist: flat plate and evacuated tube. Flat plate collector can be mounted on or flush with the roof. The air in the collection tubes can be evacuated to reduce heat losses within the frame by convection. Evacuated tube collectors need to be re-evacuated every few years. They are more difficult to install but are more efficient and allow higher temperature heating.

**Benefits**

Solar thermal collectors offer a good price-performance ratio. Solar hot water systems are best suited to developments with high hot water requirements, such as hotels, care homes and leisure centres. Many systems have been installed in the UK and they work well, even without direct sunlight.

**Technical Considerations**

Solar thermal systems should be sized to the hot water requirements of the user since any excess heat that is generated cannot be exported elsewhere. The optimal angle for mounting depends on when the water demand is greatest. Ideally, the collectors should be mounted onto an unshaded, south-facing roof.

In a residential block, a communal hot water system with a heat metering system can be implemented although there is a difficulty in metering to the individual flats.

**Economic Considerations**

Solar thermal technology is a cost effective way to reduce carbon emissions, especially if it is replacing electric water heating. A system to provide 45% of the hot water needs for a typical residential unit would cost in the region of £8,500.

**Applicability to the Waldegrave Arms Site**

The water heating demand for Waldegrave Arms, Teddington is relatively high, with 22 residential flats, and the Restaurant/Pub. Therefore, the entire sanitary provision requiring hot water for the building proposed presently consists of wash hand basins, showers, washing machines, dishwashers, sinks etc.

Whereas the decision tree shows that solar water heating is potentially a technically acceptable solution for the site, in practice the output of the system will only produce 6.34%of the total sites energy consumption.

In addition, the splitting of the systems into individual residential flat consumption would be difficult to achieve, as all flats would need to link into one large system.

**Conclusion**

It is not proposed to pursue solar water panels for the Waldegrave Arms site because their contribution for individual flats would be hard to monitor and measure. Installing solar water panels would also increase the price for the affordable residential units, pushing them out of the price range of the local population.

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## GROUND SOURCE HEATING AND COOLING

### Introduction

Heat pumps take in heat at a certain temperature and release it at a higher temperature to provide space and water heating, using a similar process to a refrigerator. Conversely the use of a reverse cycle heat pump can provide cooling capability within the same equipment. Heat pumps offer the lowest-carbon emission method of heating any building.

This technology is now in common use for installations up to 2-4MW capability. Preliminary investigations indicate the system has potential as the cooling and heating source to the general office element of the scheme.

### Technology Description

Ground source heat pumps (GSHPs) extract heat from the ground to provide space and water heating for buildings. As the ground stays at a fairly constant temperature throughout the year heat pumps can use the ground as the source of heat. The ground temperature is not necessarily higher than ambient air temperature in winter but this temperature is more stable whereas air has a wide temperature range.

Ground Cooling uses the ground temperature to cool hot air and/or water from buildings and re use it. It uses a pump to push the water through the pipes but does not use heat pumps. Therefore it is less efficient than Ground Source Heat Pumps. Normally, large areas of open ground are required for the systems.

### Benefits

Whilst a ground source heat pump is not a wholly renewable energy source as it uses electricity, the renewable component is considered as the heat extracted from the ground, measured as the difference between heat outputs, less the primary electrical energy input.

Using this geothermal heat, for every Watt of electrical energy supplied to the system, 4 Watts or more of heating energy can be supplied to a heating system. This 'Coefficient of Performance' (CoP) of 4 is effectively an 'efficiency' of 400% for the system and compares very favourably with even the best gas condensing boiler's efficiency of around 85%.

Unlike boilers, there is no pollution on-site and as the mix of power stations used to supply the electricity grid gets 'cleaner', with more renewable electricity generation being brought on line, so the carbon emissions from the heat pumps system will decrease even further.

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### Technical Considerations

In a ground source heat pump system cold water (or another fluid) is circulated through pipes buried in the ground (the 'ground loop') picking up temperature (from, say, -5°C to + 2°C) as it does so and then passing through the heat exchanger (the evaporator) in the heat pump unit.

There are two methods of extracting the heat from the ground – 'ground loop' or 'borehole'. With the ground loop system, lengths of plastic pipe are buried in the ground in a horizontal trench, usually approximately 1 to 2 metres below ground level. With the borehole system, the pipework is installed in relatively small diameter (150mm diameter) holes drilled anything between 15 to 100 metres into the ground depending on ground type and conditions. With both systems the pipe is a closed loop filled with a water/antifreeze mixture. This mixture circulates in the pipe, absorbing heat from the ground.

The heat exchanger extracts heat from the fluid, using a refrigerant compression cycle to upgrade the heat to a usable temperature (from say +2°C to +55°C) This heat is transferred to the heating (and sometimes the hot water) system via another heat exchanger, the condenser of the heat pump.

The smaller the temperature difference between the source and the output temperature of the heat pump (i.e. the temperature of the distribution system) the higher the heat pump Coefficient of Performance. Accordingly GSHP heating systems generally run at a lower temperature than conventional heating systems. In GSHP systems serving heating loads, water heating provides a year-round load and can improve the load factor for the heat pump. Hot water is usually required to be delivered from the tap at temperatures in the range 35°C to 45°C, which is within the thermal power output of a heat pump system.

### Applicability to the Waldegrave Arms Site

The use of ground source heat pumps providing heating to the residential flats could provide the full load of the heating system to serve these areas.

Technical feasibility for a site generally depends on the ground loop with the ground conditions affecting both the ease of construction and performance of the system, with a need for appropriate soil and ground water conditions for the site. Geothermal heating systems are more expensive to install initially than traditional boiler or electric heating systems. However, as previously discussed they are significantly cheaper to run and maintain against traditional boiler solutions if the ground conditions are correct. As electrically run heat pumps, if the reservoir of energy in the ground requires excessive pumping to access, the energy and carbon emissions from the system rise significantly.

Ground Cooling would require a lot more land than the 1000m$^2$ that is available at the Waldegrave Arms site.

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**Conclusion**

It is considered that the use of ground source heat pumps in a vertical or horizontal application could provide the general residential heating demand. However in order to meet the 10% requirement an extensive area would be required. Although it is likely that this could be accommodated it is felt that the cost of this technology would be economically restrictive to the project.

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## BIOMASS HEATING

### Introduction

Biomass can be burnt directly to provide heat in buildings using wood from forests, urban tree pruning, and farmed coppices or as liquid biofuel, such as biodiesel.

In non-domestic applications, biomass boilers replace conventional fossil fuel boilers and come with automated features to enable reduced user intervention.

### Typical Applications

Wood burning (biomass fuel) boilers are new to the UK market, although they are used widely throughout some parts of Europe, where there is a plentiful supply of suitable fuel. With the long term availability of fossil fuels such as oil and gas, and the short-term price rise of oil and natural gas a growing concern in the UK, alternative heating methods such as wood burning boilers are becoming more popular.

Early wood burning boilers achieved low efficiencies of around only 50%, with high emissions of carbon monoxide due to incomplete combustion. However, due to technical advances in wood burning technology, and improvements in the preparation of wood fuels, efficiencies of new wood pellet burning boilers have increased to around 90%, with carbon monoxide emissions dropping dramatically.

There are three types of wood burning boiler - logs, woodchips and wood pellets. Wood logs are the most readily available, generally produced as a by-product from forestry and woodland from sawmills, tree surgery and wind damage. However wood log boilers tend to be used to serve domestic systems.

Wood chips have a high moisture content and are generally made from almost any spare wood. However wood chip boilers are only 50% efficient and tend to suffer from blockages to the feed to the boiler, and hence we would be cautious about their use on this site. Storage space requirement is also high due to the irregularity of the chips.

Wood pellets are made from dry waste wood, such as used pallets and off-cuts/sawdust from furniture manufacturers. The waste wood is compressed into uniform, high density pellets that are easier to transport, handle and store than other forms of wood fuel. At present there are only two or three companies in Britain who provide wood pellets (delivered), however pellets are imported from Europe in greater quantities with the associated higher costs.

Biomass combustion systems (BCS) are generally more mechanically complex than conventional boiler heating systems, especially when it comes to fuel delivery, storage, handling and combustion. The complexity is necessary because of the different combustion characteristics of biomass as compared to conventional fossil fuels. The increased complexity means higher capital costs than for conventional systems.

BCSs typically require more frequent maintenance and greater operator attention than conventional systems. As a result, the degree of operator dedication to the system is critical to its success. They often require special attention to fire insurance premiums, air quality standards, ash disposal options and general safety issues.

### Applicability to the Waldegrave Arms Site

Due to the scale of the project heating requirements, within the 22 residential flats Biomass heating would be suitable solution in order to provide the 10% renewables required by Richmond Council. From calculations carried out from the renewables Toolkit it has been estimated that 12.71% of the sites total energy consumption could be provided for by Biomass heating for an installation cost of approximately £24,000.

The most appropriate solution would be to provide a community heating scheme enabling all the residential units to be heated from a singe energy source. This system has been discussed in Section 4.0 Sustainability Statement.

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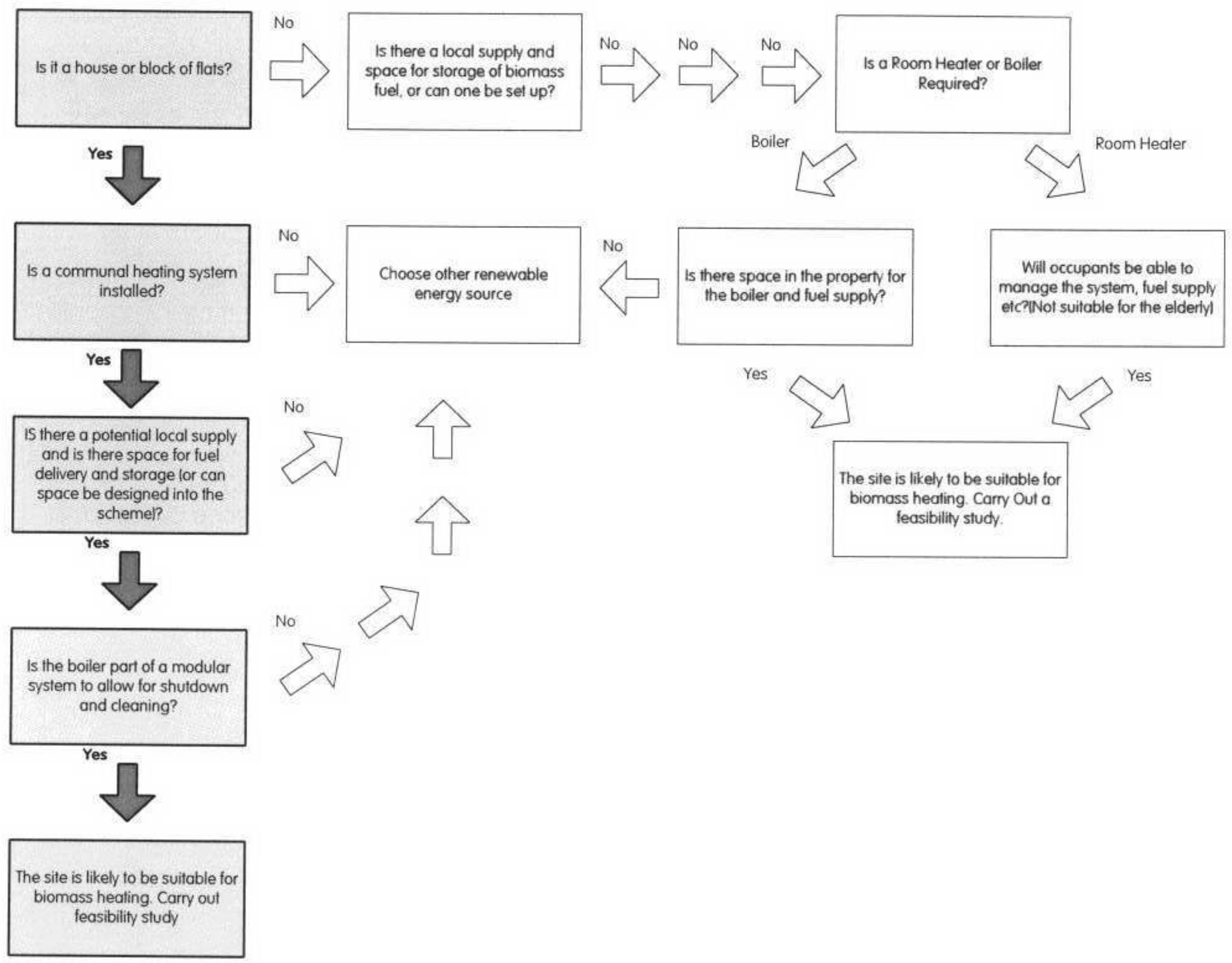
## Decision Tree




## Conclusion

This technology is considered further within this report, as at this stage it is felt that it is an economic and feasible solution to apply to the Waldegrave site.