RENEWABLE ENERGY STUDY

35 Upper Park Road

NW3
London

Residential Development

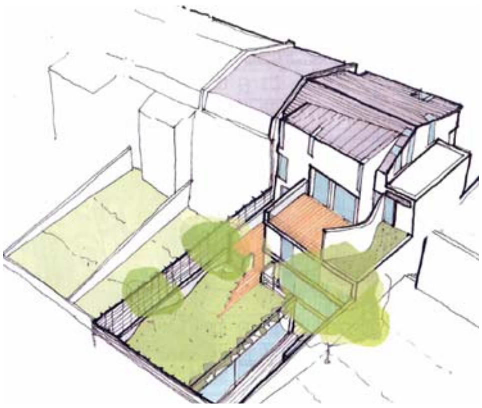
Carried out for

The Heder Partnership

by

XCO2

September 2006



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SUSTAINABILITY REPORT

	ISSUE 01	ISSUE02	ISSUE 03	ISSUE 04
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35 Upper Park Road
Energy efficiency and 10% renewables strategy
Date: September 2006
Issue: Draft

1 Introduction

It is proposed to develop 35 Upper Park Road into a new 6-storey apartment block. The development has the East and West facades exposed whist the North and South facades are directly against the neighbouring buildings. The lower two levels are semi-subterrain with garden courtyards bringing good levels of daylight and ventilation into the spaces.

This document can be used to communicate to the GLA and local planning authorities the measures considered and selected for the proposed development at 35 Upper Park Road specifically with regard to energy efficiency, renewable energy, and low carbon technology.

In line with the London Renewables Toolkit for Planners, Developers and Consultants, this report addresses each of three steps recommended in the London Mayor's Energy Strategy.

Specifically:

1. Improve the energy efficiency of the scheme
2. Offset 10% of the remaining carbon dioxide emissions by using renewable energy technologies
3. Supply as much of the remaining energy requirement with low-carbon technologies such as combined heat and power

A number of renewable energy technologies have been assessed for their potential contribution to reducing emissions from the scheme. These include

- biomass combined heat and power
- communal biomass heating
- solar thermal panels
- photovoltaic panels
- building-mounted wind turbines
- stand alone wind turbines,
- ground source heat pumps.

2 Methodology

In order to quantify improvements in carbon emissions, a baseline scheme is assessed in terms of energy consumption and associated emissions. Energy consumption figures are based on the current Building Regulations Part L, and the Governments Standard Assessment Procedure for Dwellings (SAP 2005). Details of the strategy for exceeding Building Regulations ADL1A (Conservation of Power – Work in New Dwellings) are provided in the following section.

With baseline energy use and emissions estimated, the report considers the likely impact of efficiency measures. Improvements due to efficiency are based on desktop studies using SAP 2005 for representative accommodation types.

Renewable energy technologies are then assessed for their potential to reduce the CO_2 emissions of the more efficient scheme. A shortlist of technologies is drawn up based on site constraints and other considerations (described in greater detail below). Each technology is considered in isolation as well as various combinations of technologies. Finally the report comments on the use of low carbon technology such as CHP and communal heating.

Also, brief notes on rain water harvesting have been included for information.

3 Baseline emissions and energy efficiency

3.1 Summary

Baseline carbon emissions were calculated using SAP calculations for representative accommodation types and square metre rates for landlord lighting and power.

In summary, the analysis shows that carbon dioxide emissions can be reduced by between 5% and 12% depending on the apartment type by energy efficiency measures including improving building fabric and increasing the proportion of dedicated low energy lighting, with around 9% improvement in total for all the apartments. The following specific fabric improvements were used:

	Baseline (2006 Part L)	Proposed (XCO2 recommended improvements)
Wall	0.35	0.20
Roof	0.16	0.14
Window	2.00	1.50
Floor	0.25	0.15
% Low Energy Fixed Lighting	30%	50%

3.2 Background information on ADL1A

The new version of Part L came into force in April 2006 and so it is expected the scheme will meet and exceed a standard equivalent to ADL1A 2006.

We have investigated the implications of meeting the new Part L. The results of this study are included in the following section.

The procedure for compliance with Part L1 2006 is more involved than the previous version of Part L and includes the following five criteria.

1. Criterion 1: the predicted rate of carbon dioxide emissions from the dwelling (the Dwellings Emission Rate DER) is not greater than the Target Emissions Rate (TER).
2. Criterion 2: the performance of the building fabric and the fixed building services should be no worse than the design limits. These are minimum U-value, air-tightness, and efficiency standards.
3. Criterion 3: the dwelling has appropriate passive control measures to limit the effect of solar gains on indoor temperatures in summer.
4. Criterion 4: the performance of the dwelling, **as built**, is consistent with the DER.
5. Criterion 5: the necessary provisions for energy efficient operation of the dwelling are put in place. This is the provision of O&M information to occupants and users.

For accommodations such as those in the 35 Upper Park Road scheme, the TER is calculated for each dwelling type by carrying out a SAP assessment on of identical dimensions with standard design characteristics intended to represent an equivalent dwelling of Part L 2002 standard. The resulting emissions rate is then reduced by an improvement factor to give the TER. Specifically, the TER is calculated as:

$$TER = (C_H \times \text{fuel factor} + C_L) \times (1 - \text{improvement factor})$$

Where the fuel factor is the carbon intensity of the fuel in $kgCO_2/kWh$, C_H is the CO_2 emissions arising from the provision of heating and hot water, and C_L is the use of internal fixed lighting. The improvement factor for this revision of Part L (2006) is 20%. The DER is then calculated for the proposed accommodations also using SAP. As noted above, the DER must be less than or equal to the TER.

3.3 SAP analysis for baseline and efficiency

For our analysis, each apartment (dwelling) was modelled and a preliminary SAP 2005 assessment was carried out, in which the TER was calculated and the design modified to bring the DER equal to or less than the TER.

- The "TER" calculation as stated above uses a notional dwelling of the same size and shape as the actual dwelling (excluding window size and shape) and which is constructed according to the reference values.

- The "Standard" accommodation calculation also is constructed according to reference values, however, the "Standard" accommodation uses actual dimensions (including window size and shape, ventilation, heating standard, water heating, internal gains, solar gains, space heating etc).

- The "Proposed" accommodations exceed Part L 2006 requirements by incorporating the proposed design characteristics (i.e. improved U-values, improved lighting efficiency).

For consistency in construction the same design parameters (i.e. U values, % of efficient lighting etc) have been used through out the each of the buildings. The results of the calculations can be found in Appendix 1.

As far as the performance of the current design, the "Standard" design parameters were such that the TER was not achieved on five of the six apartments (specifically apartment 1,2,3,4,5). The large window to wall ratio (WWR) on the exposed facades contributes to these results. Improving the window U-values from 2 to 1.5 W/m^2K improves the building performance such that all the apartments exceed the TER, however, it is recommended that the entire building fabric (walls, roof, floors, windows etc) be improved as described above.

4 Renewable energy

A brief summary is provided below of the technologies considered for the 35 Upper Park Road scheme. A general description of the technologies and their application is not provided here; please see the London Renewables Toolkit for this information.

4.1.1 Stand alone wind turbines

Wind turbines convert the power in the wind into electrical energy using rotating wing-like blades which drive a generator. They can either be grid connected or used to charge batteries for on site use. Wind turbines can range from small domestic turbines producing hundreds of watts to large offshore turbines with capacities of 3MW and diameters of 100m. Wind velocities are the key factor in the location of wind turbines as a result of the cube relationship between the wind velocity and the energy generated. Favourable locations for wind turbines can harness the wind from sea breezes or mountain valley winds.

Turbines have a cut in and shut down wind speed in between which the turbine is able to generate power. These usually range from 3m/s cut in to 25m/s shut down which optimum output around 12-15m/s.

There is insufficient land on the development to allow the placement of the turbines away from the building. Therefore, stand alone turbines were not included on the short list of technologies.

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4.1.2 Roof mounted wind turbines

Building mounted turbines will work in lower wind speeds than larger turbines, in some cases as low as 3.5m/s. Wind. Roof mounted wind turbines have been included in the short list of technologies.

4.1.3 Solar thermal panels

Solar thermal panels harness solar radiation to heat water that can then be used for either space heating or, more commonly, domestic hot water heating.

The system consists of solar collectors that are often roof mounted. In a typical system, water is passed through the solar collectors and then to a heat exchanger in a domestic hot water cylinder, which will also have a top-up heat source (gas, biomass, or electricity) to ensure reliability of supply.

The 35 Upper Park Road scheme includes residential units and so there will be a high hot water demand year-round. On the 35 Upper Park Road scheme, solar thermal panels could be installed on the roof. It should be noted that in this type of arrangement, safe access would be required to the panels for maintenance. The roof angle and orientation at Upper Park Road are ideally suited to solar thermal panels. Solar thermal panels have been short listed as a possible renewable option.

4.1.4 Photovoltaic panels

Photovoltaic panels convert solar radiation into direct current electricity. In principle, they are an ideal source of renewable energy as they harness the most abundant source of energy on the Earth, the sun, and they produce electricity which is the most useful form of energy. PV's are silent in operation, have no moving parts and have a long life with low maintenance levels. PV systems can either be connected to the grid.

Grid connected systems consist of PV arrays which are connected to the grid through a charge controller and an inverter which converts the direct current (DC) into alternating current (AC). This means that electricity can be sold back to the grid.

PV cells are more efficient at lower temperatures so good ventilation should be allowed around the PV modules where possible. Clearly overshadowing depresses energy production and I more detailed site survey would be recommended to assess this. However, direct sunlight is not necessary for energy output. Output is measured in kWp (kilowatts peak) which is the maximum output a module will have under standard test conditions. The orientation and angle of the arrays also affects the output, the difference is shown in the indicator below.

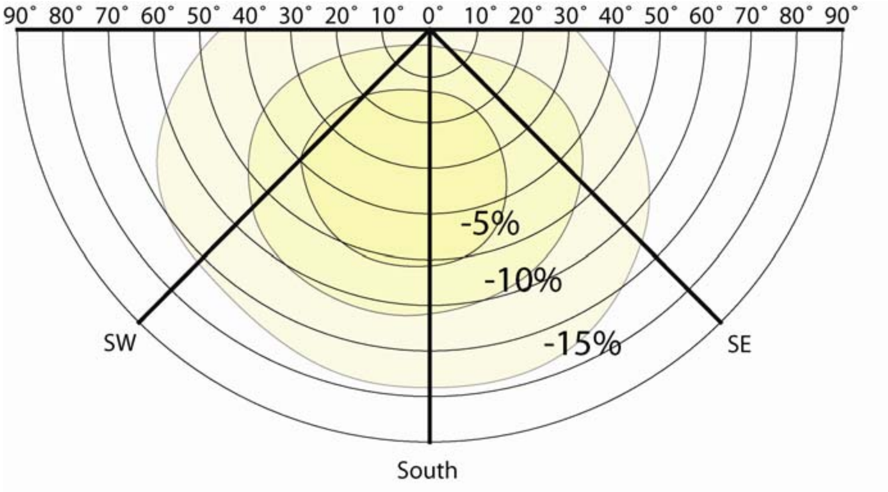
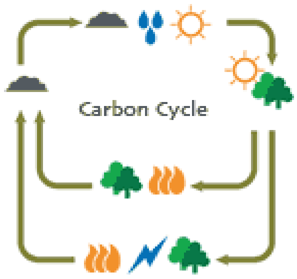


Fig 6 - Solar performance indicator

PV panels could be mounted on the roof. PV panels were selected for the short list of renewable energy technologies. As with the solar thermal further analysis of site conditions (such as the impact of the over shading from the surrounding vegetation) will need to be considered when more detailed design takes place.

4.1.5 Biomass space and water heating



In the context of energy generation, the term "biomass" can refer to any organic substance that can be processed to produce energy, either solid matter or liquid biofuel. Biomass fuels are an alternative to conventional fossil fuels and are often near carbon neutral. This is because the growing plant or tree absorbs the same quantity of CO_2 in its lifetime as is released upon energy conversion.

Biomass is a renewable form of energy as it can be replaced over a short period of time. Biomass or biofuels are currently being produced from plantations of a variety of plant types, as well as from waste materials like cooking oil and waste wood. If waste wood is used, care must be taken to maintain fuel standards and exclude wood treatments such as preservatives and paint.

Biomass heating is simple and proven technology, widely used in mainland Europe, and which compares well in running cost with gas. It can be implemented on a variety of scales from systems for small buildings up to systems of several MW capacities, with the capital cost of larger installations decreasing per unit of heat output.

One of the main advantages of biomass fuels are they can create industry in rural communities by offering an alternative to conventional farming methods. Although biomass heating requires some space for the storage of fuel this space is significantly falling due to the lower heating demand of houses built with greater energy efficiency and to the tighter building regulations.

Communal space and water heating based on biomass is included on the short list in order to assess the possible costs and benefits of such a system. Space requirements for the fuel store have also been considered. Given 4 fuel deliveries a year, 5m^3 of fuel storage space would be required. In addition, access for fuel delivery would need to be provided. This option would supplement a gas-fired communal heating system. Heat costs to occupants is likely to be slightly higher than the equivalent heat provided by mains gas according to current fuel prices, though it will be less costly than electric heating.

4.1.6 Biomass CHP

Biomass CHP was briefly considered for the scheme. However, this technology is still in its infancy and brings a number of cost and technological risks. It was therefore not included on the short list of technologies.

4.1.7 Ground source heat pump

A ground source heat pump (GSHP) harnesses the energy from the ground and upgrades it for use within buildings. Whereas ambient air temperatures can have a large swing throughout the year the temperature of the ground a few metres below the surface stays relatively stable. This makes it possible to use the heat in the ground during the winter months to meet our heating needs. In the summer months it is also possible to cool buildings using the lower ground temperatures.

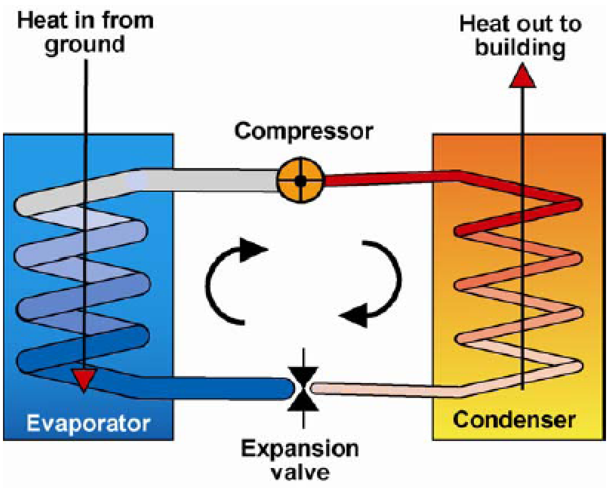


Diagram showing a GSHP system

A typical system consists of a ground to water heat exchanger (often called the 'ground loop' or 'ground coil'), a heat pump and a distribution system. Water (or other solution) is passed round the system 'absorbing' heat from the ground and relaying this heat via the heat pump into the building. Two heat exchange systems are commonly used; a horizontal coil 'slinky' system or a borehole system, where long pipes are driven deep into the ground.

With a space requirement of about 100m of trench for each kW capacity of the system, there is insufficient space for horizontal buried pipe on the site.

For the borehole option, it is not known at this stage if the ground is free from ground obstructions such as sewers, tunnels, etc and a survey would be required to assess conditions.

At this stage, it is not considered feasible to put GSHP forward as a renewable technology as more information will be required about the ground and conditions. However, at detailed design stage, GSHP will be reviewed again. It may be possible that the photovoltaic installation could power the heat pumps making the system very energy efficient.

Results of analysis

The 10% requirement could be met by any of the following options. More detailed calculations are provided below.

- About 42m^2 of photovoltaic panels
- Around 13m^2 of solar thermal panels
- Biomass heating to meet about 24% of the space and water heating requirement of the scheme
- A 3kW building mounted wind turbine

Photovoltaic Panels		
Annual irradiation at location	1022	kWh/yr
Efficiency and and system losses factor	7.5%	
Resulting annual kWh system electrical output from 1m^2 of panel	76.65	kWh/yr
Carbon emissions factor for electricity (taken from Part L2(2002) table 6)	0.422	kgCO_2/kWh
Annual carbon saving from 1m^2 of panel	32.3	kgCO_2/yr
Panel area of proposed rooftop PV array	42	m^2
Delivered electricity requirement offset by PV output	3219.3	kWh/yr
CO_2 emissions reduction	**1358.5**	kgCO_2/yr
Base total carbon emissions	13473	kgCO_2/yr
Total building carbon emissions in bulding with proposed PV panels	12114.1	kgCO_2/yr
Percentage carbon emissions reduction due to proposed PV panels	**10.1%**	

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Solar thermal

$kWh/m^2.yr$ incident	993	kWh/yr
System efficiency	50%	
$kWh/m^2.yr$ of panel	496.5	kWh
Size of system	13	m^2
Total output	6455	kWh/yr
Max allowable solar fraction	50.00%	
% of total heat demand assumed DHW (commercial only)	30.00%	
Alternative system (boiler) efficiency	90%	
Primary gas energy offset by solar thermal	7172	kWh/yr
CO_2 emissions factor for gas	0.19	kgCO2/kWh
CO_2 emissions reduction	**1362.6**	kgCO2/yr
Base total CO_2 emissions	13473	kgCO2/yr
Percentage CO_2 emissions reduction due to proposed solar thermal panels	**10.1%**	

Biomass space and water heating

Proportion of heat supplied by biomass	24%								
Biomass system efficiency	90%								
Backup system efficiency	90%	**Biomass**				**Backup systems**			
	Useful energy demand (kWh)	Demand met (kWh)	Primary energy	CO2 kg/kWh	kgCO2/yr	Demand met	Primary energy	CO2 kg/kWh	kgCO2/yr
Heat	31014	7443.5	8271	0.025	207	23571.0	26190.0	0.19	4976.1
Electricity	16410	16410	16410	0.422	6925	0.0	0.0	0.422	0.0
					7132				4976.1
								Total kgCO2	12108.0
								Saving	**10.1%**

Note that while biomass communal heating could satisfy the 10% requirement by supplying around 24% of the space and water heating requirement of the scheme, there is little point in meeting only this portion of demand. Much of the cost of a biomass communal heating scheme will be in the distribution pipework, meters, and heat exchangers for accommodation and commercial units; the biomass boiler itself is likely to be a small proportion of the total cost. With the infrastructure installed, it makes sense to provide as much heat as possible from biomass.

Building Mounted Wind Turbine		
Annual energy output based on weather files, atmospheric boundary conditions, and Cp curves for typical small turbine	1390.0	kWh/kW.yr
Inverter efficiency	90%	
Resulting annual kWh turbine electrical output from 1kW rated output	1251.0	kWh/yr
Carbon emissions factor for electricity	0.422	kgCO_2/kWh
Annual carbon emissions reduction from 1kW rated output	527.9	kgCO_2/yr
Rated power output of proposed turbines	3	kW
Delivered electricity requirement offset by turbine output	3753.0	kWh/yr
CO_2 emissions reduction	**1583.8**	kgCO_2/yr
Base total carbon emissions	13473	kgCO_2/yr
Total building carbon emissions in building with proposed wind turbine	11888.9	kgCO_2/yr
Percentage carbon emissions reduction due to proposed wind turbines	**11.8%**	

4.2 CHP and communal heating

4.2.1 Communal heating

According to SAP 2005, the use of communal heating achieves better carbon emissions standards than the equivalent unit-based gas scheme because SAP does not include the energy for communal pumps and fans in the dwelling emissions. In reality there is likely to be little difference in the emissions from a communal system as compared to a unit-based scheme.

However, communal heating brings the enormous potential of connecting to a district heating network at a future date. Once the heat distribution pipe work and metering infrastructure is installed to each accommodation and commercial unit, the energy source can be changed to a low-carbon technology without affecting occupants. The gas boilers in the plant room could be supplemented or replaced by hot water from a district heating network or alternative fuels without making any changes downstream of the plant room. In this way, emissions from the scheme could be drastically reduced in future.

The cost of communal heating may add £1500 per unit of accommodation over baseline costs for unit-based gas boilers.

4.2.2 CHP

Combined heat and power could be used on the scheme and the GLA have indicated that they expect it to be considered as a potential part of the services strategy. Prediction of CHP performance is considerably more complex than assessing output from most renewable energy systems because it is sensitive to the particular patterns of heat and power consumption throughout the day. Based on initial rough calculations and performance on other projects, we estimate:

- CHP will cost around £6500 - £8500 per accommodation CHP plant, backup boilers, distribution pipe work, heat and power metering, and heat exchanger units in the apartments.

5 Selected strategy

- Efficiency measures have been adopted to exceed ADL1A in domestic units by around 9%. These include wall U-values of 0.20 W/m^2K, window U-values of 0.15 W/m^2K roof U-values of 0.14 W/m^2K, ground floor U-values of 0.15 W/m^2K, 50% low energy fixed lighting.

- Solar thermal panels are the most cost effective and practical solution to this scheme. As stated above the impact of over shadowing from surrounding vegetation needs to be carefully considered. This is predicted to achieve a 10% reduction in CO_2 emissions from the scheme.

- This development has an ambitious target to exceed the proposed Camden Council 10% renewable target. This will be achieved by the installation of a photovoltaic array on the South facing roof, adjacent the solar thermal array. The PV installation will provide an **additional** 10% on site energy production. **Therefore as a target, the development aims to have a minimum of 20% on site renewable energy production**.

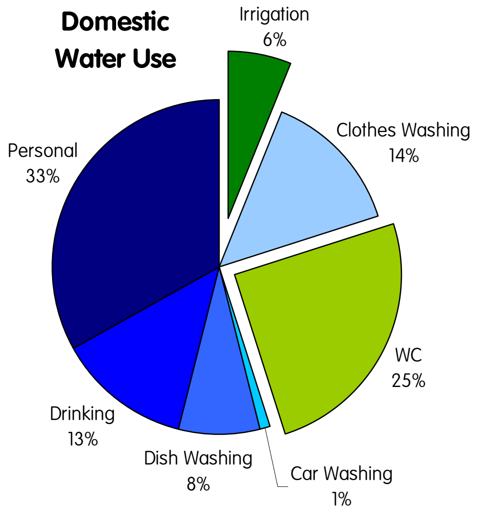
- In addition, and to improve the overall energy performance of the building, the air tightness for the development will **exceed** the current Part L 2006 building air tightness rate of $10m^3/m^2/hr$ at 50 Pascal's. The developer aims to achieve $5m^3/m^2/hr$ at 50 Pascal's.

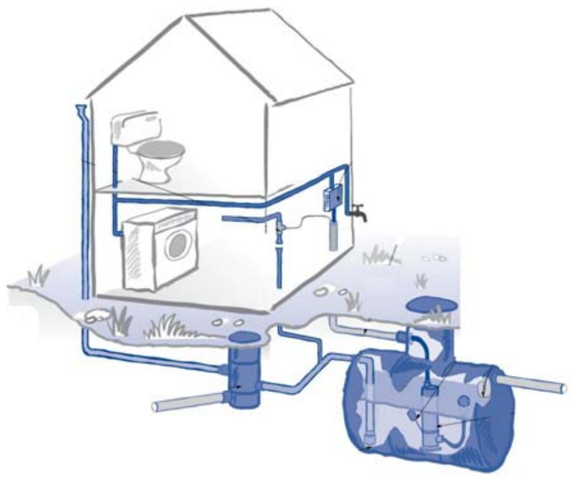
APPENDIX 1

Rain Water Harvesting

There are two options for the harvesting of rainwater. The first is a more active approach that involves an underground tank being installed. This is then connected to the rainwater down pipes. The water is then pumped though a series of filters depending on the desired end use of the water, this could range from being used for WC flushing through to be treated for drinking purposes. The second option involves the simple installation of water butts to collect the rainwater. The rainwater can then be used externally for garden irrigation.

Even though rain water harvesting does not contribute to the 10% renewable requirement it can contribute to the over sustainability of the site, reduce household water consumption and reduce load on drainage from run-off. The proposed scheme will incorporate an extensive rainwater collection system for a variety of uses within the site – irrigation, WC's, and car washing. There is also the option of using the water for clothes washing.





Harvesting Potential

Rainwater Yield (litres per year) = Roof Area (m^2) x Annual Rainfall (mm) x Run-off Coefficient x filter efficiency

Approximate Roof Area Available for harvesting = 250m^2
Annual Rainfall for London Area= 799mm
Run-off Coefficient = 0.6
Filter Efficiency = 90%

250 x 0.6 x 0.9 x 799 =107,865 litres (107.9 m^3)

A proven and workable rule of thumb sizes the tank to store 5% of the annual rainwater yield. This has been shown to give a reliable optimum tank size:

5% of 107,865 = 5,393 litres (5.4 m^3)

It is wise to select a tank slightly larger as there is always some 'dead space' at the top of the tank; also the bottom 20cm or so is never used. As the developer wishes to maximise on rain water harvesting, an over sized tank of capacity 7m^3 is recommended at this stage.

Water Saving Potential

150 litres per person per day can be taken as an average UK national figure, and with around 31% of this being used for irrigation and WC's, there is potential to save up to 46.5 litres/person/day.

With potentially 24 people living in the proposed development the average water demand would be:

46.5 x 24 x 365 x 0.75 = 305,505 litres (305 m^3)

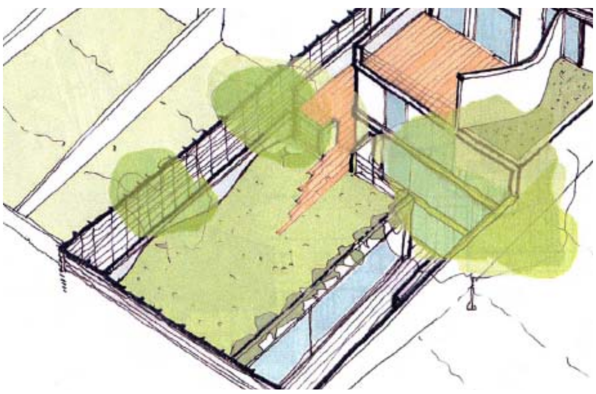
(0.75 is the diversity applied to each dwelling)

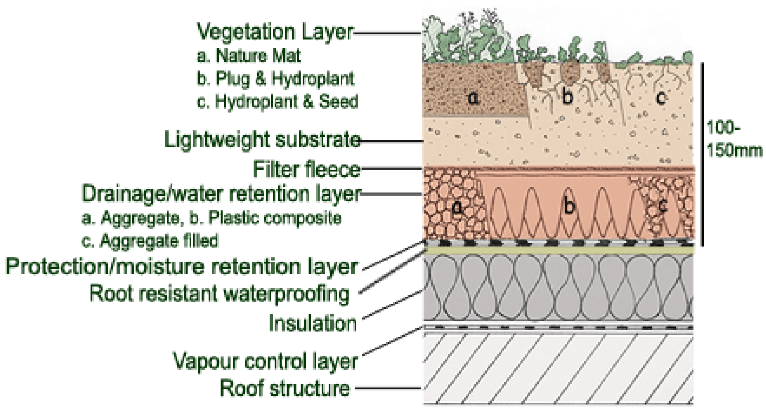
The rainwater harvesting system supplies 107,865 litres (107.9 m^3)) giving an annual saving of 35% of the water required for the WC's and irrigation.

This % will increase dramatically with low flush toilet cisterns utilised in each apartment.

Green Roof

The proposed scheme at Upper Park Road also incorporates a green roof above gym area. Besides providing additional habitat for flora and fauna, a green roof improves insulation capacity, reduces urban peak runoff flows, reduces urban air borne dust, improves air quality and reduce glare; breathing grass roofs are also good CO_2 sinks.





The proposed green roof will significantly add to the sustainability of the development and reduce the risk of over capacity of the existing drainage system.

APPENDIX 2

SAP, TER and DER Results Summary

Standard Performance

35 Upper Park Road

Carbon Emissions from Dwellings

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Name	**APT 01**	**APT 02**	**APT 03**	**APT 04**	**APT 05**	**APT 06**
Communal system	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Floor area (inserts as ground floor for TFA calc only)	100.00	140.00	85.00	50.00	90.00	100.00
Pressure testing results: q_{50}/10 (m^3/m^2)	0.5	0.5	0.5	0.5	0.5	0.5
Number of sides on which sheltered	2	2	2	2	2	2
Low energy light fittings in high use areas	30%	30%	30%	30%	30%	30%
door area (m2)	2	2	0	0	2	2
doors U-value (W/m^2.K)	2.00	2.00	2.00	2.00	2.00	2.00
windows (type 1) area (m2)	18.00	33.40	34.50	19.20	18.00	12.30
windows (type 1) U-value (W/m2.K)	2.00	2.00	2.00	2.00	2.00	2.00
ground floor area (m2)	50.00	0.00	0.00	0.00	0.00	0.00
ground floor U-value (W/m2.K)	0.25	0.25	0.25	0.25	0.25	0.25
walls (type1) excluding windows & doors area (m2)	57.00	34.60	25.50	6.80	38.00	42.70
walls (type1) excluding windows & doors U-value (W/m2.K)	0.35	0.35	0.35	0.35	0.35	0.35
roof (type 1) excluding rooflights area (m2)	0.00	0.00	0.00	0.00	45.00	50.00
roof (type 1) excluding rooflights U-value (W/m2.K)	0.16	0.16	0.16	0.16	0.16	0.16
volume of DHW cylinder(l)	125.00	125.00	125.00	125.00	125.00	125.00
North windows m^2	0	9.4	4.5	2.2	3.2	2.2
North East windows m^2	0	0	0	0	0	0
East windows m^2	18	6	0	15	0	8.5
South East windows m^2	0	0	0	0	0	0
South windows m^2	0	2	0	2	4.8	1.6
South West windows m^2	0	0	0	0	0	0
West windows m^2	0	16	30	0	10	0
North West windows m^2	0	0	0	0	0	0
Rooflights windows m^2	0	0	0	0	0	0
Efficiency of space and water heating system	90%	90%	90%	90%	90%	90%
TER	**18.51**	**14.96**	**17.98**	**20.54**	**18.84**	**18.04**
DER	**18.85**	**15.90**	**19.74**	**20.56**	**19.04**	**17.87**
Margin	**1.8%**	**6.3%**	**9.8%**	**0.1%**	**1.1%**	**-0.9%**

Proposed Performance

35 Upper Park Road

Carbon Emissions from Dwellings

	Option 7	Option 8	Option 9	Option 10	Option 11	Option 12
Name	**APT 01 - Proposed**	**APT 02 - Proposed**	**APT 03 - Proposed**	**APT 04 - Proposed**	**APT 05 - Proposed**	**APT 06 - Proposed**
Communal system	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Floor area (inserts as ground floor for TFA calc only)	100.00	140.00	85.00	50.00	90.00	100.00
Pressure testing results: q_{50}/10 (m^3/m^2)	0.5	0.5	0.5	0.5	0.5	0.5
Number of sides on which sheltered	2	2	2	2	2	2
Low energy light fittings in high use areas	50%	50%	50%	50%	50%	50%
door area (m2)	2	2	0	0	2	2
doors U-value (W/m^2.K)	2.00	2.00	2.00	2.00	2.00	2.00
windows (type 1) area (m2)	18.00	33.40	34.50	19.20	18.00	12.30
windows (type 1) U-value (W/m2.K)	1.50	1.50	1.50	1.50	1.50	1.50
ground floor area (m2)	50.00	0.00	0.00	0.00	0.00	0.00
ground floor U-value (W/m2.K)	0.15	0.15	0.15	0.15	0.15	0.15
walls (type1) excluding windows & doors area (m2)	57.00	34.60	25.50	6.80	38.00	42.70
walls (type1) excluding windows & doors U-value (W/m2.K)	0.20	0.20	0.20	0.20	0.20	0.20
roof (type 1) excluding rooflights area (m2)	0.00	0.00	0.00	0.00	45.00	50.00
roof (type 1) excluding rooflights U-value (W/m2.K)	0.14	0.14	0.14	0.14	0.14	0.14
volume of DHW cylinder(l)	125.00	125.00	125.00	125.00	125.00	125.00
North windows m^2	0	9.4	4.5	2.2	3.2	2.2
North East windows m^2	0	0	0	0	0	0
East windows m^2	18	6	0	15	0	8.5
South East windows m^2	0	0	0	0	0	0
South windows m^2	0	2	0	2	4.8	1.6
South West windows m^2	0	0	0	0	0	0
West windows m^2	0	16	30	0	10	0
North West windows m^2	0	0	0	0	0	0
Rooflights windows m^2	0	0	0	0	0	0
Efficiency of space and water heating system	90%	90%	90%	90%	90%	90%
TER	**18.51**	**14.96**	**17.98**	**20.54**	**18.84**	**18.04**
DER	**16.39**	**14.11**	**16.68**	**18.62**	**16.94**	**16.04**
Margin	**-11.5%**	**-5.6%**	**-7.2%**	**-9.3%**	**-10.0%**	**-11.1%**