Unviable Renewable Technologies

3.78 The following technologies are deemed unviable for the Proposed Development at this stage of development:

Solar Water Heating

3.79 The installation of Solar Water Heating (SWH) could be used to offset a proportion of the domestic hot water demand (DHW) within the top floor residential units.

3.80 However, due to the complexities of installing such a system and the space required on the roof (which the PV arrays will need) and also taken up by the piping, longer term maintenance issues and the lack of thermal stores in the flats, the use of SWH has not been deemed technically feasible for the Proposed Development at this stage.

Hybrid Photovoltaics and Thermal (PV-T)

3.81 PV-T is an integrated panel which provides both water heating and electricity. These combined units operate more efficiently than separate units because excess heat which builds within the PV array is then used by a Solar Water Heating element to provide hot water – the PV can then operate at a greater efficiency than a standard PV panel due to being cooled by the SWH.

3.82 For the purposes of this statement, the Volther Powertherm panel[11] will be used as an example of a PV-T panel. This panel measures 1.66m x 0.86m x 0.105m, has an electrical output of ~175kWp and is expected to generate ~450 kWh/yr/m^2 of thermal energy (assumed 90% is absorber area).

3.83 As with SWH, the total number of panels that can be used on a building is limited by the DHW load. With PV-T, the additional downside of this is that this limits the amount of PV that is also installed. PV-T is an immature technology in the UK and limited supply means that it is only really suited to large installations. PV-T is unsuitable for the development due to the PV needed to reach the planning policy requirements which would result in over sizing the DHW Load required for the development.

Ground Source Heat Pump

3.84 GSHP are most suited to providing space heating (and cooling) within buildings, and a closed loop, borehole system would be the most appropriate in this instance due to the site layout and available external/ground areas.

3.85 There are technical issues with installing GSHP collectors (boreholes or arrays) beneath buildings due to the inability of the ground to 'recharge' with solar irradiation over time, and it is generally not to be recommended.

3.86 For this technical reason, as well as the fact that the foundations and superstructure are already installed, the high associated capital costs and low CO_2 offset compared to gas heating, GSHP have been excluded as a viable option for both the commercial and residential units.

[11] Example only, this does not constitute a product endorsement.

Biomass Boiler

3.87 The use of a biomass boiler system to supply hot water and space heating has been deemed unfeasible due to the complications in design of providing adequate space on the ground floor/basement area for a large enough plant room to contain the boiler, associated fuel storage and BoS. Additionally fuel-delivery/supply and the associated changes in transport infrastructure that biomass would depend on would need to be accommodated into the Site.

3.88 As such this technology is not deemed as suitable as other renewable technologies in this instance.

3.89 Additionally, as Richmond falls within a Smoke Control Area, it would also need to be confirmed that the make and model of any boilers used on site are classified as exempt under the Clean Air Act.

Wind Power

3.90 Due to the location and nature of the site, it is not likely to lend itself to the use of wind turbines.

3.91 The system performance will be reduced by the low, erratic wind speeds and air turbulence caused by the surrounding buildings and trees.

Renewable Energy Summary

3.92 SRE proposes the following renewable energy technology solution as technically viable for the Proposed Development in order for it to go as far as reasonably practical in order to achieve the LBRUT SCC requirement of a 20% CO_2 offset/reduction through the use of on-site renewable technologies.

3.93 Further offset is not deemed practical at this stage:

- The building envelope performance has been improved as far as is practical energy efficient heating, lighting and ventilation systems are used throughout.
- The assessment has shown that installation of a larger PV array could achieve greater CO_2 offset, however this would result in the loss of the green roof areas.

3.94 Final specification will be undertaken at detailed design stage.

Renewable Energy Technology Solution

System	CO_2 reduction ($kgCO_2/yr$)	% Reduction	Technically Feasible	Financially Viable	Benefits	Weakness
Photovoltaics 79.71 kWp Module	34,469	20.0%	✓	~	Known technology – high CO_2 offset	Loss of green roof areas Expensive PV system required and majority of flat roof areas
ASHP for Commercial units	~1,600	0.8%	✓	✓	Central Plant not required – very efficient method for supplying commercial space	Space required for outdoor unit. Cannot provide Domestic Hot Water efficiently.
Total	**36,069**	**20.8%**	✓	~	-	-

Table 13: Proposed Renewable Energy Solution

4.0 Summary

4.1 The Proposed Development at The Diary, Richmond will comprise 45 No. new build flats and 1,966m^2 of commercial space.

4.2 In doing so it will deliver energy efficiency measures throughout and, by the installation of PV, will offset 20.0% of the predicted CO_2 emissions of the dwelling.

4.3 Through the inclusion of an energy conscious design, energy efficiency measures and renewable energy generation, the Proposed Development will achieve in excess of 25% improvement in Dwelling Emission Rate (DER) over Building Regulations 2010, (equivalent to 44% improvement over Building Regulations 2006), in-line with the requirements of the LBRUT Development Management DPD.

4.4 The % reduction is greater than as calculated in Table 13 as this assessment does not include the unregulated energy load (as this is not assessed under Building Regulations).

TER	36.42
DER	24.07
Improvement	**33.91%**

Table 14: 25% DER Improvement (Building Regulations 2010)

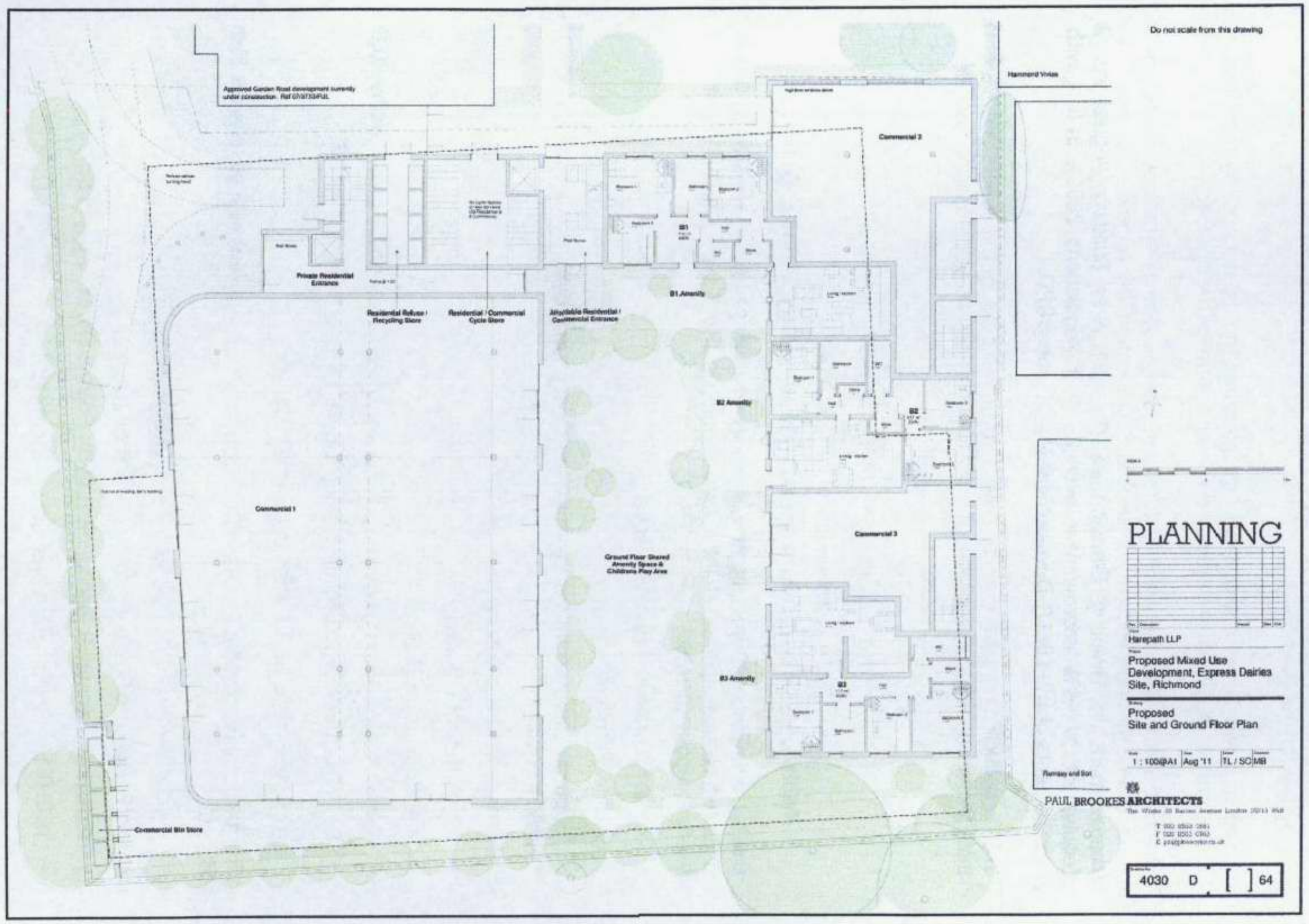
4.5 Overall, the Proposed Development will provide modern, resource efficient, sustainable units, which comply with all the relevant planning policy (where possible), and include the following measures:

- Code for Sustainable Homes – 'Level 3'.
- BREEAM 'Excellent'
- Improved building envelope performance through improved U-Values and decreased Air Permeability.
- Resource Efficient Heating.
- Energy Efficient Lighting.
- Water Conserving Fittings.
- On-site renewable energy generation, offsetting/reducing CO_2 emissions by 20.8%.
    - 79.71 kWp Photovoltaic Array (Modules) across Block A and B
    - Air Source Heat Pumps in commercial units.

4.6 Through this approach the Proposed Development is compliant with all relevant Planning Policy:

- The London Plan 2011: Policies 5.2 – 5.13 & 5.15.
- LBRUT LDF Core Strategy: Policies CP1 & CP2.
- LBRUT Development Management DPD: Policies DM SD 1 & DM SD 2.
- LBRUT SPD – Sustainable Construction Checklist.

Appendix A - Site Layout Plan



Appendix B – Planning Policy and Guidance

National Policy Requirements

The national policy requirements are outlined in PPS 22: Renewable Energy, from which the following observations are drawn:

- The energy to be displaced through renewable sources is electrical energy as this represents the highest proportion of CO_2 emissions.
- The policy is primarily framed around the need for discrete renewable energy sites although local policies "may" require local renewable energy generation provided this is viable and not burdensome

PPS1 - Delivering Sustainable Development (February 2005)

PPS1 seeks to ensure that sustainable development is pursued in an integrated manner by Development Plans, in line with the principles for sustainable development set out in the UK strategy. The policy states that Regional Planning bodies and Local Planning Authorities should ensure that development plans promote outcomes in which environmental, economic and social objectives are all delivered over time.

There are 4 main themes to PPS1:

- Climate Change is a very important issue for sustainable development and the causes and the impacts must be considered through development policies.
- Planning policies must promote high quality inclusive design in the layout of new developments and individual buildings in terms of function and impact, not just for the short term but over the lifetime of the development.
- Development plans are to contain clear, comprehensive and inclusive access policies (such policies should consider people's diverse needs and aim to break down unnecessary barriers and exclusions in a manner that benefits the entire community).
- Community involvement is an essential element in delivering sustainable development and creating sustainable and safe communities. As such in developing the vision for their areas, planning authorities are to ensure that communities are able to contribute to ideas about how that vision can be achieved, have the opportunity to participate in the process of drawing up the vision, strategy and specific plan policies, and to be involved in development proposals.

There is often a tendency with new developments for the focus to be entirely on environmental issues which neglects the integrated consideration of the wider range of issues associated with economic and social objectives that need to be properly considered for sustainable development.

PPS1 is a practical and realistic policy statement which, whilst aiming to achieve a significant amount of the environmental agenda, is also aware that development mostly takes place in the context of commercial reality and economic and social factors are important issues. The following extracts from PPS1 highlight this approach;

In proposing development;

- plans should not impose disproportionate costs, in terms of environmental and social impacts, or by unnecessarily constraining otherwise beneficial economic or social development. (Para 26 (iii))
- plans should have regard to the resources likely to be available for implementation and the costs likely to be incurred, and be realistic about what can be implemented over the period of the plan.

Regional Policy

The London Plan - Spatial Development Strategy for Greater London – July 2011:

Major Developments are defined as these:

- For dwellings: where 10 or more are to be constructed (or if number not given, area is more than 0.5 hectares).
- For all other uses: where the floor space will be 1000 sq metres or more (or the site area is 1 hectare or more). The site area is that directly involved in some aspect of the development. Floor space is defined as the sum of floor area within the building measured externally to the external wall faces at each level. Basement car parks, rooftop plant rooms, caretakers' flats etc. should be included in the floor space figure.

Policy 5.2: Minimising carbon dioxide emissions

Planning decisions

A. Development proposals should make the fullest contribution to minimising carbon dioxide missions in accordance with the following energy hierarchy:

 1 Be lean: use less energy
 2 Be clean: supply energy efficiently
 3 Be *green*: use renewable energy

B. As a minimum, all major development proposals should meet the following targets for carbon dioxide emissions reduction in buildings. These targets are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations leading to zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019.

Residential Buildings:	
Year	**Improvement on 2010 Building Regulations**
2010 - 2013	25% (CSH Level 4)
2013 – 2016	40%
2016 - 2031	Zero Carbon
* To be calculated using a 'Flat 25 per cent' approach for new homes in accordance with 2010 Part L Building Regulations.	

Non-Domestic Buildings:	
Year	**Improvement on 2010 Building Regulations**
2010 - 2013	25%
2013 – 2016	40%
2016 – 2019	As per building regulations requirements
2019 - 2031	Zero Carbon
* To be calculated using an 'Aggregate 25 per cent' approach new non-domestic buildings in accordance with the final 2010 Part L Building Regulations.	

C. Major development proposals should include a detailed energy assessment to demonstrate how the minimum targets for carbon dioxide emissions reduction outlined above are to be met within the framework of the energy hierarchy.

D. As a minimum, energy assessments should include the following details:

   a. Calculation of baseline energy demand and carbon dioxide emissions on a 'whole energy' basis, showing the contribution of emissions both from uses covered by building regulations and those that are not (see paragraph 5.22);

   b. Proposals to reduce carbon dioxide emissions through the energy efficient design of the site, buildings and services;

   c. Proposals to further reduce carbon dioxide emissions through the use of decentralised energy where feasible, such as district heating and cooling and combined heat and power (CHP); and

   d. Proposals to further reduce carbon dioxide emissions through the use of onsite renewable energy technologies.

E. The carbon dioxide reduction targets should be met onsite. Where it is clearly demonstrated that the specific targets cannot be fully achieved onsite, any shortfall may be provided offsite or through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere.

Policy 5.3: Sustainable design and construction

Strategic

A. The highest standards of sustainable design and construction should be achieved in London to improve the environmental performance of new development.

Planning decisions

B. Development proposals should demonstrate that sustainable design standards are integral to the proposal, including its construction and operation, and ensure that they are considered at the beginning of the design process.

C. Major development proposals should meet the minimum standards outlined in the Mayor's supplementary planning guidance on Sustainable Design and Construction and this should be clearly demonstrated within a design and access statement. The standards include measures to achieve the following sustainable design principles:

a. minimising carbon dioxide emissions across the site, including the building and services (such as heating and cooling systems)

b. avoiding internal overheating and contributing to the urban heat island effect

c. efficient use of natural resources, including making the most of natural systems both within and around buildings

d. avoiding pollution (including noise, air and urban runoff)

e. minimising the generation of waste and maximising reuse or recycling

f. avoiding impacts from natural hazards (such as flooding)

g. ensuring developments are comfortable and secure for users, including avoiding the creation of adverse local climatic conditions

h. securing sustainable procurement of materials, using local supplies where feasible, and

i. promoting and protecting biodiversity and green infrastructure.

Policy 5.4: Retrofitting

A. The environmental impact of existing urban areas should be reduced through policies and programmes that bring existing buildings up to the Mayor's standards on sustainable design and construction. In particular programmes should reduce carbon dioxide emissions, improve the efficiency of resource use (such as water) and minimise the generation of pollution and waste from existing building stock.

Policy 5.5: Decentralised Energy Networks

Strategic

A. The Mayor expects 25 per cent of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025. In order to achieve this target the Mayor prioritises the development of decentralised heating and cooling networks at the development and area wide level, as well as larger scale heat transmission networks. The Mayor has developed a London Heat Map tool to help boroughs and developers identify decentralised energy opportunities in London.

Policy 5.6: Decentralised Energy in Development Proposals

Planning decisions

A. Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites.

B. Major development proposals should select energy systems in accordance with the following hierarchy:

1. Connection to existing heating or cooling networks;
2. Site wide CHP network;
3. Communal heating and cooling;

C. Potential opportunities to meet the first priority in this hierarchy are outlined in the London Heat Map tool. Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7: Renewable Energy

Strategic

A. The Mayor seeks to increase the proportion of energy generated from renewable sources, and expects that the minimum targets for installed renewable energy capacity outlined in Table 5.1 *(of The London Plan)* will be achieved in London.

Planning Decisions

B. Within the framework of the energy hierarchy, major development proposals should provide a reduction in carbon dioxide emissions through the use of onsite renewable energy generation, where feasible.

Policy 5.8: Innovative Energy Technologies

Strategic

A. The Mayor supports and encourages the more widespread use of innovative energy technologies to reduce use of fossil fuels and carbon dioxide emissions. In particular the Mayor will seek to work with boroughs and other partners to:

a. maximise the uptake of electric and hydrogen fuel cell vehicles

b. plan hydrogen supply and distribution infrastructure

c. maximise the uptake of advanced conversion technologies such as anaerobic digestion, gasification and pyrolysis for the treatment of waste.

Policy 5.9: Overheating and Cooling

Strategic

A. The Mayor seeks to reduce the impact of the urban heat island effect in London and encourages the design of places and spaces to avoid overheating and excessive heat generation, and to mitigate overheating due to the impacts of climate change and the urban heat island effect on an area wide basis.

Planning Decisions

B. Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. minimise internal heat generation through energy efficient design

2. reduce the amount of heat entering a building in summer through shading, albedo, fenestration, insulation and green roofs and walls
3. manage the heat within the building through exposed internal thermal mass and high ceilings
4. passive ventilation
5. mechanical ventilation
6. active cooling systems (ensuring they are the lowest carbon options).

C. Major development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet its cooling needs. New development in London should also be designed to avoid the need for energy intensive air conditioning systems as much as possible. Further details and guidance regarding overheating and cooling are outlined in the London Climate Change Adaptation Strategy.

Policy 5.10: Urban Greening

Strategic

A. The Mayor will promote and support urban greening, such as new planting in the public realm (including streets, squares and plazas) and green infrastructure, to contribute to the adaptation to, and mitigation of, the effects of climate change.

B. The Mayor seeks to increase the amount of surface area greened in the Central Activities Zone by at least five per cent by 2030, and a further five per cent by 2050

Planning decisions

C. Development proposals should integrate green infrastructure from the beginning of the design process to contribute to urban greening, including the public realm. Elements that can contribute to this include tree planting, green roofs and walls, and soft landscaping. Major development proposals within the Central Activities Zone should also demonstrate how they are contributing to the target outlined above.

Policy 5.11: Green roofs and development site environs

Planning decisions

A. Major development proposals should be designed to include roof, wall and site planting, especially green roofs and walls where feasible, to deliver as many of the following objectives as possible:

a. adaptation to climate change (i.e. aiding cooling)
b. sustainable urban drainage
c. mitigation of climate change (i.e. aiding energy efficiency)
d. enhancement of biodiversity
e. accessible roof space
f. improvements to appearance and resilience of the building
g. growing food.

Policy 5.12: Flood risk management

Planning decisions

A. Development proposals must comply with the flood risk assessment and management requirements set out in PPS25 over the lifetime of the development and have regard to measures proposed in TE2100 and Catchment Flood Management Plans.

B. Developments which are required to pass the PPS25 Exceptions Test will need to address flood resilient design and emergency planning by demonstrating that:

1. the development will remain safe and operational under flood conditions
2. a strategy of either safe evacuation and/or safely remaining in the building is followed under flood conditions
3. key utilities including electricity, water, lifts etc will continue to be operational under flood conditions
4. buildings are designed for quick recovery following a flood.

C. Development adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible be set back from those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost effective way.

Policy 5.13: Sustainable drainage

Planning decisions

D. A Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so and should aim to achieve greenfield run-off rates and ensure that surface water runoff is managed as close to its source as possible in line with the following drainage hierarchy:

1. store rainwater for later use
2. use infiltration techniques, such as porous surfaces in non-clay areas
3. attenuate rainwater in ponds or open water features for gradual release
4. attenuate rainwater by storing in tanks or sealed water features for gradual release
5. discharge rainwater direct to a watercourse
6. discharge rainwater to a surface water sewer/drain
7. discharge rainwater to the combined sewer.

Policy 5.15: Water use and supplies

Planning decisions

B. Development should minimise the use of treated water by:

1. a incorporating water saving measures and equipment
2. meeting water consumption targets of 105l/p/d in residential development.
3. New development for sustainable water supply infrastructure will be supported.

Local Planning Policy

The key policies and guidance directly concerning the Proposed Development are

London Borough of Richmond upon Thames' Local Development Framework (LBRUT LDF):

- Core Strategy – Adopted April 2009
- Development Management DPD (Publication Version).
- London Borough of Richmond upon Thames' Supplementary Planning Document[1] – Sustainable Construction Checklist (and Interim Amendments).

The LBRUT CS states the following relevant policies:

- Policy CP1 - Sustainable Development:

1.A - *'The policy seeks to maximise the effective use of resources including land, water and energy, and assist in reducing any long term adverse environmental impacts of development. Development will be required to conform to the Sustainable Construction checklist, including the requirement to meet the Code for Sustainable Homes level 3 (for new homes), Ecohomes "Excellent" (for conversions) or BREEAM "excellent" (for other types of development)...'*

- Policy CP2 Reducing Carbon Emissions

2.B – 'The Council will require the evaluation, development and use of decentralised energy in appropriate development.'

2.C – 'The Council will increase the use of renewable energy by requiring all new development to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation unless it can be demonstrated that such provision is not feasible, and by promoting its use in existing development.'

[1] Adopted 18th August 2006 – Amended in Interim

Development Management DPD - Policy DM SD 1:

"Minimising the Borough's impact on climate change including promoting the use of renewable energy, making effective use of land and resources, minimising any adverse impacts of development, encouraging sustainable building and travel."

"...New buildings should be flexible to respond to future social, technological and economic needs by conforming to the Borough's Sustainable Construction Checklist.
New homes will be required to meet or exceed requirements of the Code for Sustainable Homes Level 3.

They also must achieve a minimum 25 per cent reduction in Carbon Dioxide emissions over Building Regulations (2010) in line with best practice from 2010-13, 40 per cent improvement from 2013 – 2016, and 'zero carbon' standards from 2016..."

Development Management DPD - Policy DM SD 2:

New development will be required to comply with the Sustainable Construction Checklist and:

(a) Maximise opportunities for the micro-generation of renewable energy. Some form of low carbon renewable and/or de-centralised energy will be expected in all new development, and

(b) Developments of 1 dwelling unit or more, or 100sqm of non-residential floorspace or more will be required to reduce their total carbon dioxide emissions by following a hierarchy that first requires an efficient design to minimise the amount of energy used, secondly, by using low carbon technologies and finally, where feasible and viable, including a contribution from renewable sources.

(c) Local opportunities to contribute towards decentralised energy supply from renewable and low-carbon technologies will be encouraged where there is no over-riding adverse local impact.

(d) All new development will be required to connect to existing or planned decentralised energy networks where one exists.

LBRUT Supplementary Planning Document[2] – Sustainable Construction Checklist

All developments over 1-bed and $100m^2$ in size are expected to comply with the London Borough of Richmond upon Thames Sustainable Construction Checklist (SCC), in line with the LBRUT Supplementary Planning Document – Sustainable Construction Checklist (August 2011).

[2] Adopted August 2011

Appendix C – Code for Sustainable Homes Pre-Assessment

breglobal

Results

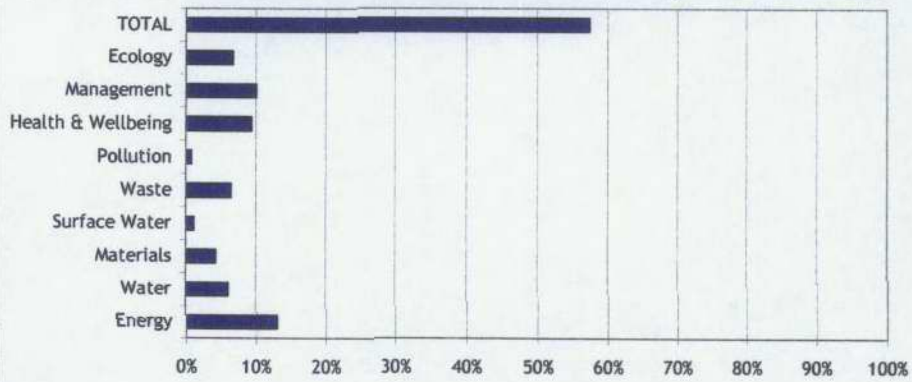
Development Name:	The Dairy, Market Road, Richmond, Greater London.
Dwelling Description:	45 Dwellings (1,2, and 3 bed)
Name of Company:	SRE Ltd
Code Assessor's Name:	Iain Turrell
Company Address:	SRE LTD Stoner Hill Road, Froxfield, Petersfield, Hampshire GU32 1DY
Notes/Comments:	-

PREDICTED RATING - CODE LEVEL: 3

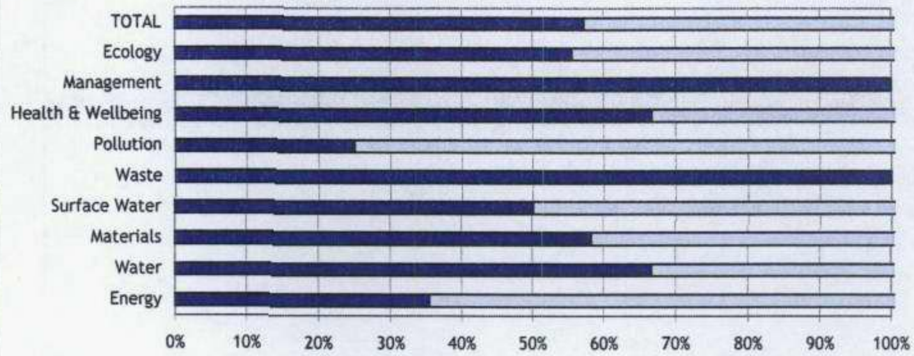
Mandatory Requirements: All Levels

% Points:	57.30%	- Code Level: 3
Breakdown:	Energy	- Code Level: 4
	Water	- Code Level: 4

Graph 1: Predicted contribution of individual sections to the total score and percentage of total achievable score



Graph 2: Predicted percentage of credits achievable: Total and by Category



NOTE: The rating obtained by using this Pre Assessment Estimator is for guidance only. Predicted ratings may differ from those obtained through a formal assessment, which must be carried out by a licensed Code assessor.

Appendix D – BREEAM Pre-Assessment

BREEAM

BREEAM 2011 New Construction Pre-Assessment Estimator

This assessment and indicative BREEAM rating is not a formal certified BREEAM assessment or rating and must not be communicated as such. The score presented is indicative of a buildings potential performance and is based on a simplified pre-formal BREEAM assessment and unverified commitments given at an early stage in the design process.

Building name	The Diary
Indicative building score (%)	63.18%
Indicative BREEAM rating	Pre-Assessment result indicates potential for BREEAM Very Good rating
Indicative minimum standards level achieved	Pre-Assessment result indicates the minimum standards for Excellent level

Environmental Section	Indicative % Score Available	Indicative % Score Achieved
Management	12.00%	7.64%
Health & Wellbeing	15.00%	6.43%
Energy	19.00%	10.56%
Transport	8.00%	8.89%
Water	6.00%	4.67%
Materials	12.50%	8.33%
Waste	7.50%	4.29%
Land Use and Ecology	10.00%	6.00%
Pollution	10.00%	5.38%
Innovation	10.00%	1.00%

Appendix E – Renewable Energy Summary

Photovoltaics (PV)

Bolt on Array (Module PV)

Building Integrated PV Array (Tile)

Summary:

Photovoltaic (PV) arrays convert solar energy into electricity that is either used directly within the development or exported to the national grid, offsetting mains electricity used on-site.

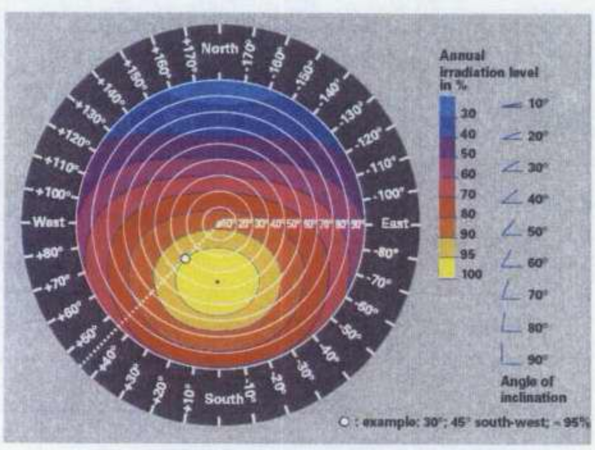
How it works:

Each solar module is made up of a series of silicon cells. Photons (packets of solar energy) striking the surface of the cell are absorbed by the semi-conducting silicon. The absorbed energy 'excites' an electron of a particular atom into a higher energy band (valence -> conduction) creating a 'hole'. An electron from a neighbouring atom can then move into this 'hole' (due to a missing covalent bond). Thus continuous exposure to photons (solar energy) creates a 'flow' of electrons through the silicon cell and a voltage difference between the upper and lower side of the panel - electrical generation.

Silicon is manufactured in ingots - wafers are then sliced from this to form the cells, which are then grouped together to form the panel. The more cells in a module (and the more efficient each cell is), the higher the rated peak wattage (Wp). Module capacity is measured in kWp and performance is measured as kWh.

Ensuring Efficiency:

Three factors effecting the efficiency of a PV installation are the orientation, inclination and potential shading of the system. Greatest efficiencies are achieved with an orientation of due south with an inclination of 30 degrees. Shading should be considered in each instance as it can reduce system efficiency significantly and should be avoided where practicable.



Relationship Between Efficiency and Orientation

Derivatives:

There are 4 main types of PV cell available:

- **Monocrystalline -** Expensive, but highest efficiency (10-15%) and longevity (80% of rated output after 20/25 years)
- **Polycrystalline** - Cheaper than Monocrystalline, but lower efficiency (9-13%) with similar longevity
- **Amorphous Multi Junction** - Most expensive, average efficiency (8-10%) but works well in areas of diffuse radiation. Longevity - 80% of rated output for 10/20 years.
- **Amorphous Thin Film** - Least expensive. However, low efficiency (3-6%) and generally only suited for small applications. Can be fragile and degrades 10% in first 3 months.

Commercial and Residential applications in the UK tend to use Mono or Polycrystalline panels (although thin film is used in some integrated systems such as in standing seam roofs).

Applications:

- **Traditional Modules** - most commonly used PV application for 'bolt-on' or retrofit and for commercial uses. Modules generally tend to use mono or polycrystalline cells and have an output of 180-220W

- **Building Integrated** (Slate, Tile or Façade) - generally used for new-build. Allows for low aesthetic intrusion but lower kWp/m^2 than modules and greater cost. Systems are also available that are mounted into roofing felt (Alwitra).

- **Glass-Glass Laminates** - PV Cells set into glass (e.g. for conservatories). These are generally bespoke and expensive, but adaptable — for instance the cell spacing can be set to control light transmission.

- **Cylindrical** - Pioneered by the 'Solyndra' system. Effectively a module system, but similar in appearance to Evacuated Tube SWH and able to be mounted horizontally flat roof. Offers good performance at a similar cost to an integrated system

- **Hybrid** - PV film under laid by solar water heat collectors; cooling effect increases efficiency of PV and provides additional benefit achieved through solar water heat.

Noise:

A PV system does not feature moving parts and is silent during operation.

Technology Summary Table:

Bolt On (Module PV)	**Building Integrated (Slate, Tile or Facade)**
~6m^2/kWp	~8-9m^2/kWp
Performance - 800-900 kWh/yr/kWp	
~£5,500/kWp	~£6,500/kWp

Solar Water Heating (SWH)

Evacuated Tubes Collectors

Flat Plate Collectors

Summary:

Solar Water Heating (SWH) arrays convert solar radiation into hot water which is then passed through a coil within the hot water tank, thus reducing demand from fossil fuelled hot water systems.

How it works:

There are two types of collector for heating although working on similar principles. An average family house would feature a SWH system made up of 2-3 individual collectors:

Evacuated Tube (ET) - consist of a copper pipe running down the centre of an evacuated glass tube along an absorber plate, the under side of the glass is painted black to increase temperature. The vacuum reduces the convective heat loss from the tube, increasing efficiency. It is also possible to turn the tubes the frame to reduce the effects of poor orientation.

Additionally, there are two derivatives of the ET system:

- Direct Flow (DF) - the glycol mix is pumped throughout the system, through each pipe in turn and through the manifold. This allows the system to be mounted at any inclination.
- Heat Pipe (HP) - each tube is a sealed, separate circuit which are connected 'dry' into the manifold. Allows for easier installation but relies on a minimum inclination level for the system *to operate correctly.*

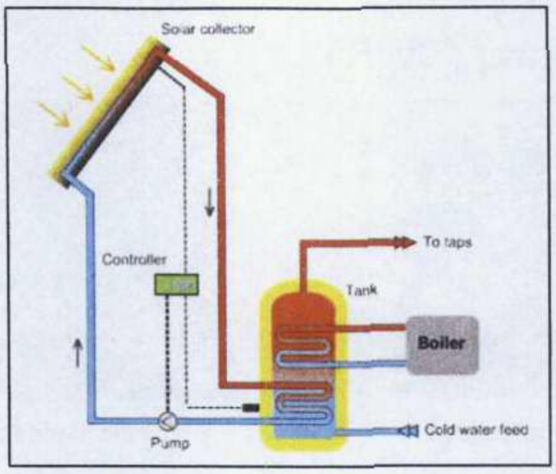
Flat Plate (FP) - have a layer of insulation covered by a black absorber plate with water/glycol pipes running through the collector. Heat is then absorbed by the fluid within the pipes, again, normally glycol. Protective glass covers the system although a vacuum is generally not created, therefore convective heat losses are greater than that from evacuated tubes.

There are also Integrated SWH systems available—these work on the same principle as a Flat Panel but are made up of separate 'Tiles', containing the required pipework, which are linked together to form a larger collector. These offer a much lower level of aesthetic intrusion but are more complex and as they are integrated into the roof, more difficult to maintain,

With either system type, the fluid heated by the collector is circulated through a dual coil hot water cylinder.

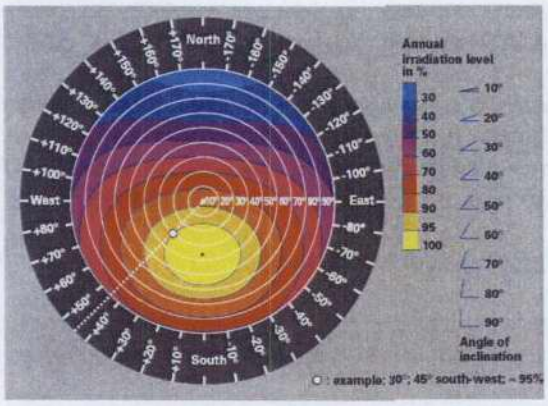
The systems are generally sized to meet a maximum of 60% of the unit's DHW load—this is to reduce the risk of the SWH collectors overheating the hot water system during periods of high solar insolation and/or low hot water demand. Heat dump radiators (such as a towel rail) are sometimes *used to 'vent' excess hot water.* The outstanding hot water load is provided by the larger heating system.

Example Schematic:



Ensuring Efficiency:

Three factors effecting the efficiency of a SWH installation are the orientation, inclination and potential shading of the system. Greatest efficiencies are achieved with an orientation of due south with an inclination of 30 degrees. Shading from vegetation and neighbouring buildings should be considered for all installations as it can reduce system efficiency significantly and should be avoided where practicable.



Relationship Between Efficiency and Orientation.

In order to ensure system efficiency the aim must be to minimise the use of additional immersion heater. Reducing domestic hot water use through water efficient fittings/appliances, and minimising heat loss through pipe lagging are two methods.

Evacuated tubes are more efficient although the initial cost of the system is higher and the visual impact is perceived as being greater than that of the flat panel collectors. These are additional considerations to be taken into account when deciding which installation is most appropriate.

Noise

Noise will not be an issue with SWH – the only moving part is the circulation pump, which is inside the property and should not be noticeable.

Technology Summary Table:

Evacuated Tube Collector	Flat Panel Collector
Typically 2.2m x 0.8m each	Typically 2.1m x 1.1m each
550 kWh/m^2/yr	450 kWh/m^2/yr
~£6,000/system	~£4,000/system

Ground Source Heat Pumps (GSHP)

Internal Unit (Cover Removed)

External Collection Trench

Summary:

Ground Source Heat Pump (GSHP) systems extract latent heat from the ground through the use of a ground loop and heat condenser. This heat is then able to be used within the house for space or water heating.

How it works:

Heat Pump systems operate by extracting thermal energy from a renewable energy 'reservoir' (such as the ground, air or water) and upgrade it to a higher, more useful temperature. The system (collector -> heat pump -> thermal store) is a sealed, pressurised loop containing a water/glycol mix.

In an GSHP, the 'collector' comprises of ground loop - plastic pipework either buried in 'trenches' or boreholes

The collector allows transfer of available energy (heat) from the source (in the case of GSHP, the ground) into the glycol mix. The pre-heated glycol transfers this energy into the Heat Pump itself, where it is 'upgraded' to a more useful temperature through increasing the pressure of the liquid and utilising the energy released when a liquid changes state to become a gas. This heat is transferred into the thermal store through a separate coil.

Performance is measured as a value of energy input against the energy output to provide a ratio know as the coefficient of performance (CoP). This is affected by a number of factors, including system design, solar irradiation, local geology and patterns of use.

GSHP is capable of providing space heat at CoP's of 3.2 - 5, but due to the *increased* electrical consumption associated with producing high grade domestic hot water (DHW), the CoP is reduced to 2.24 for the DHW fraction. The system can work with external temperatures (–10°C), although at these temperatures the CoP will be reduced and there is the risk of freezing the soil as the GSHP will pull all the remaining energy (heat) from the ground.

Compared to a traditional gas boiler, GSHP systems can reduce energy consumption for space heating by ~30-40%, however, CO_2 offset is dramatically lower due to the high CO_2 factor of the electricity used to run the ASHP.

Ensuring Efficiency:

In order to ensure system efficiency the use of additional immersion heating should be avoided if possible. Reducing heat loss by maximising insulation levels and reducing air permeability and reducing the target temperature of the hot water tank (from 60°C to 45°C for example) by using underfloor heating or low temperature radiators, rather than traditional radiators can help to achieve this.

As a consequence heat pump systems are generally considered to be more applicable to new developments rather than retrofits.

Additionally, due to the low emitter temperatures, heat pump systems suffer from not having the 'huddle-around-the-radiator' effect of conventional, high temperature systems. Although the temperature of the building will be sufficient, there isn't the instant heat of a radiator and as such, the occupant may feel cold. The inclusion of a small biomass stove as a direct heat feature can be used to negate this.

Noise

The compressor makes a similar level of noise to a refrigerator when operating.

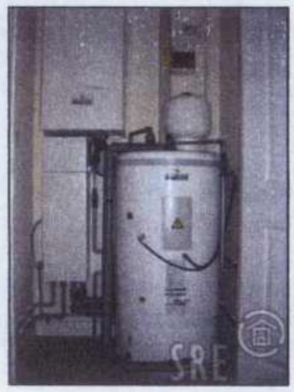
Technology Summary Table:

Ground Source Heat Pump
Typically £5,000—10,000, although drilling/ groundwork costs can double plant costs
CoP - 3.5 to 5 (limited at 3.2 by current SAP)
Offsets ~30-40% of energy usage
Reduces CO_2 emissions by ~8-10%

SRE

Air Source Heat Pump (ASHP)

External Collector



Internal Control Unit and Thermal Store

Summary:

Air Source Heat Pump (ASHP) systems extract latent atmospheric heat through the use of a heat condenser. This heat is then able to be used within the house for space or water heating.

How It Works:

Heat Pump systems operate by extracting thermal energy from a renewable energy 'reservoir' (such as the ground, air or water) and upgrade it to a higher, more useful temperature. The system (collector -> heat pump -> thermal store) is a sealed, pressurised loop containing a water/glycol mix.

In an ASHP, the 'collector' comprises a heat exchanger and an electrically driven fan - the fan increases airflow across the heat exchanger to increase energy transfer.

The collector allows transfer of available energy (heat) from the source (in the case of ASHP, the ambient air) into the glycol mix. The pre-heated glycol transfers this energy into the Heat Pump itself, where it is 'upgraded' to a more useful temperature through increasing the pressure of the liquid and utilising the energy released when a liquid changes state to become a gas. This heat is transferred into the thermal store through a separate coil.

Performance is measured as a value of energy input against the energy output to provide a ratio know as the coefficient of performance (CoP). This is affected by a number of factors, including system design, solar irradiation and patterns of use.

ASHP is capable of providing space heat at CoP's of 2.5 - 3.5 but due to the increased electrical consumption associated with producing high grade domestic hot water (DHW), the CoP is reduced to 2.24 for the DHW fraction. The system can work with external temperatures as low as –15°C.

Compared to a traditional gas boiler, ASHP systems can reduce energy consumption for space heating by ~30%, however, CO_2 offset is dramatically lower due to the high CO_2 factor of the electricity used to run the ASHP.

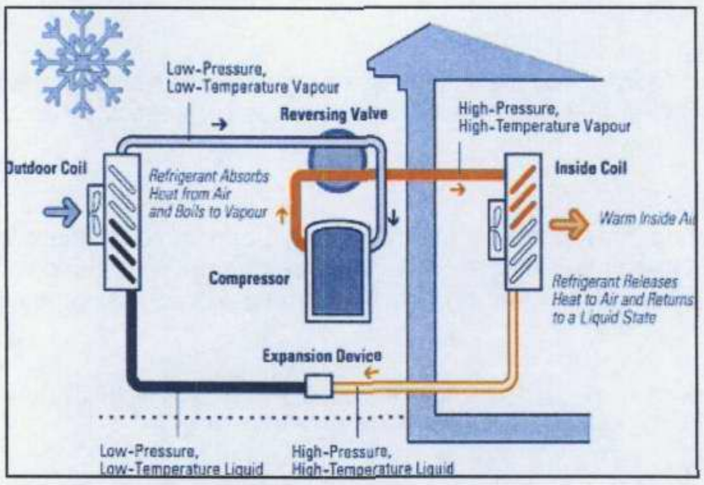
Ensuring Efficiency:

In order to ensure system efficiency the use of additional immersion heating should be avoided if possible. Reducing heat loss by maximising insulation levels and reducing air permeability and reducing the target temperature of the hot water tank (from 60°C to 45°C for example) by using underfloor heating or low temperature radiators, rather than traditional radiators can help to achieve this.

As a consequence heat pump systems are generally considered to be more applicable to new developments rather than retrofits.

Additionally, due to the low emitter temperatures, heat pump systems suffer from not having the 'huddle-around-the-radiator' effect of conventional, high temperature systems. Although the temperature of the building will be sufficient, there isn't the instant heat of a radiator and as such, the occupant may feel cold. The inclusion of a small biomass stove as a direct heat feature can be used to negate this.

System Schematic:



Noise

As it features moving parts (an electrically driven fan) the external unit will make some noise – expected to be minimal and should not be noticeable to the surrounding area (~50dB Max). The compressor makes a similar level of noise to a small refrigerator.

Technology Summary Table:

Air Source Heat Pump
Typically £2 - 5,000
CoP - 2.5 to 3.5 (limited at 2.5 by current SAP)
Offsets ~30% of energy usage
Reduces CO_2 emissions by ~5%