SVM
Consulting Engineers

63-71 High Street
Hampton Hill
TW12 1LZ
Energy Statement

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1 Executive Summary

This energy statement has been produced by SVM Consulting Engineers. The energy statement demonstrates that the proposed new development at 63-71 High Street, Hampton Hill adheres to the current Building Regulations – Part L 2013 and London Borough of Richmond Local Plan Policies relating to energy and carbon reduction targets.

The energy assessment clearly identifies the carbon footprint of the development after each stage of the hierarchy. Regulated emissions are provided and, separately, those emissions associated with uses not covered by Building Regulations i.e. unregulated energy uses.

Regulated emissions include the energy consumed in the operation of the space heating / cooling, hot-water systems, ventilation and internal lighting. Unregulated emissions include energy associated with electrical appliances (including catering) and other small power applications.

The design has focused on enhanced passive design measures, and incorporated active design measures to reduce CO_2 emissions. The following summarises the demand reduction measures that have been included within this scheme:

- Enhanced fabric efficiency of the building envelope
- Air tightness better than Part L 2013 standards
- High efficiency lighting systems
- Highly efficient plant and systems

All potential renewable energy technologies which might be applicable to a development of this type in this location have been considered for integration with the scheme. Photovoltaics and Air Source Heat Pumps have been selected as being the most appropriate low to zero carbon technology to provide electricity and cooling for the site. Other technologies are concluded to be inappropriate for the reasons stated.

The design intent of the sculptured roof with integrated Photovoltaics shall provide a low carbon electrical total output of approximately 32kWp serving the residential and parts of the development. This roof shall be detailed further at a later stage in liaison with specialist building integrated photovoltaic manufacturers.

The below tables demonstrate the Carbon Dioxide Emissions and Savings for each stage of the energy hierarchy for the residential and non-domestic areas of the proposed development. The domestic areas achieve a 37.8% reduction and the non-domestic areas achieve a 37.4% reduction. A zero-carbon payment to offset the 1,011 Tonnes of CO_2 over a 30-year period amounts to £60,663.

1.1 Domestic Carbon Dioxide Emissions After Each Stage of the Energy Hierarchy

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2
After Be Lean	49.6	58.2
After Be Clean	47.1	58.2
After Be Green	33.7	58.2

Table 1: Carbon Dioxide Emissions After Each Stage of the Energy Hierarchy for Domestic Building

1.2 Domestic Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy

	Regulated Domestic Carbon Dioxide Savings	
	(Tonnes CO2 per annum)	(%)
Savings from Be Lean	4.6	8.6
Savings from Be Clean	2.5	4.6
Savings from Be Green	13.4	24.7
Cumulative on site savings	**20.5**	**37.8**
Annual Savings from off-set payment	33.7	
	(Tonnes CO_2)	
Cumulative savings for off-set payment (Offset Payment based upon 33.7 Tonnes per annum for 30 years at £60 per Tonne)	1,011	£60,663

Table 2: Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Domestic Buildings

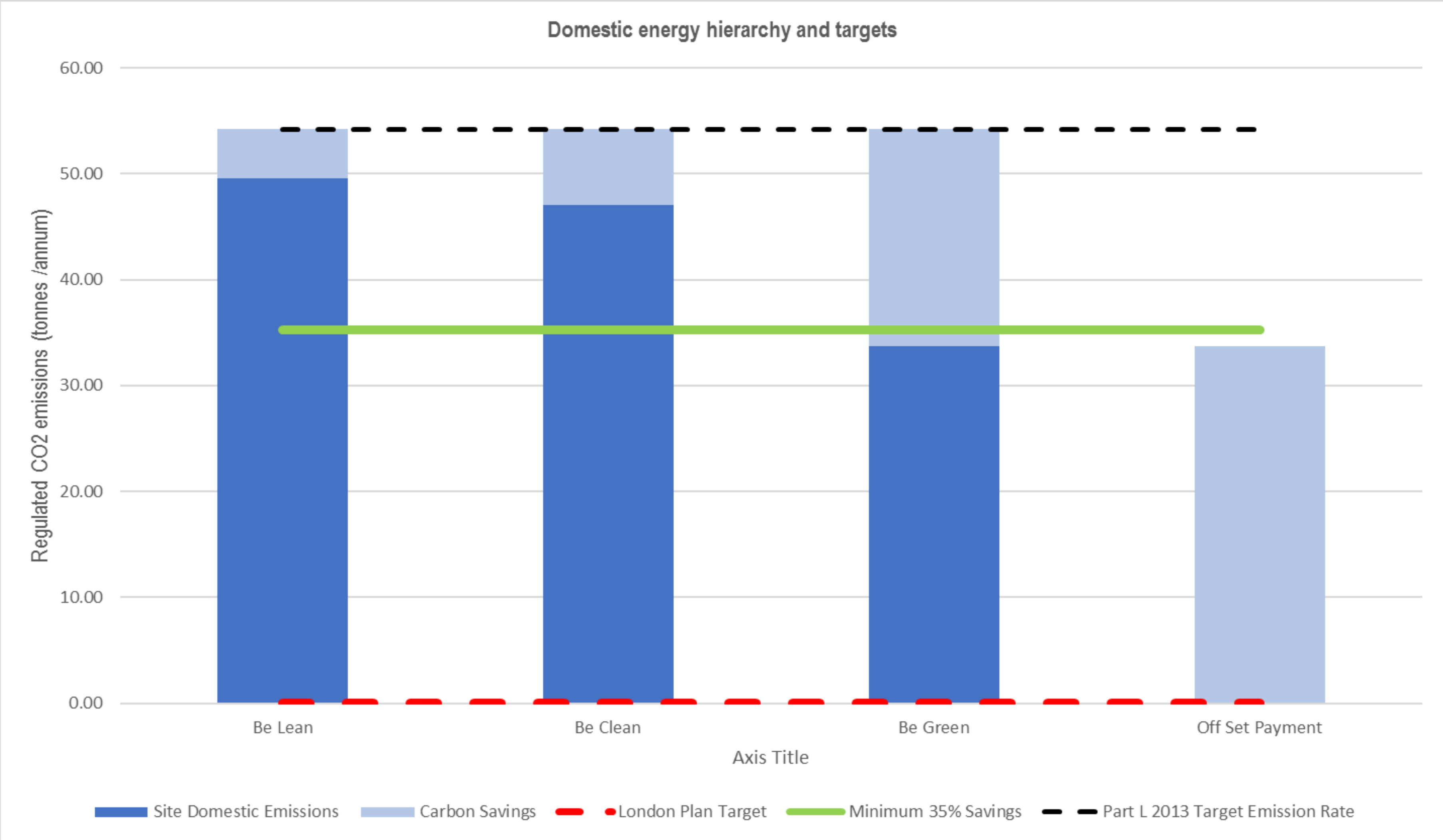

Figure 1: Domestic Energy Hierarchy

1.3 Non – Domestic Carbon Dioxide Emissions After Each Stage of The Energy Hierarchy

	Carbon Dioxide Emissions for Non-Domestic Buildings (Tonnes CO2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9
After Be Lean	18.9	26.9
After Be Clean	18.5	26.9
After Be Green	18.5	26.9

Table 3: Carbon Dioxide Emissions After Each Stage of The Energy Hierarchy for Non-Domestic Buildings

1.4 Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Non-Domestic Buildings

	Regulated Non-Domestic Carbon Dioxide Savings	
	(Tonnes CO2 per annum)	(%)
Savings from Be Lean	10.6	35.8
Savings from Be Clean	0.5	1.6
Savings from Green	0.0	0.0
Total Cumulative Savings	**11.0**	**37.4**

Table 4: Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Non-Domestic Buildings

1.5 Non-Domestic Shortfall in Regulated Carbon Dioxide Savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	10.3	
Shortfall	-0.7	-21.2

Table 5: Shortfall in Regulated Carbon Dioxide Savings – Non-Domestic Buildings

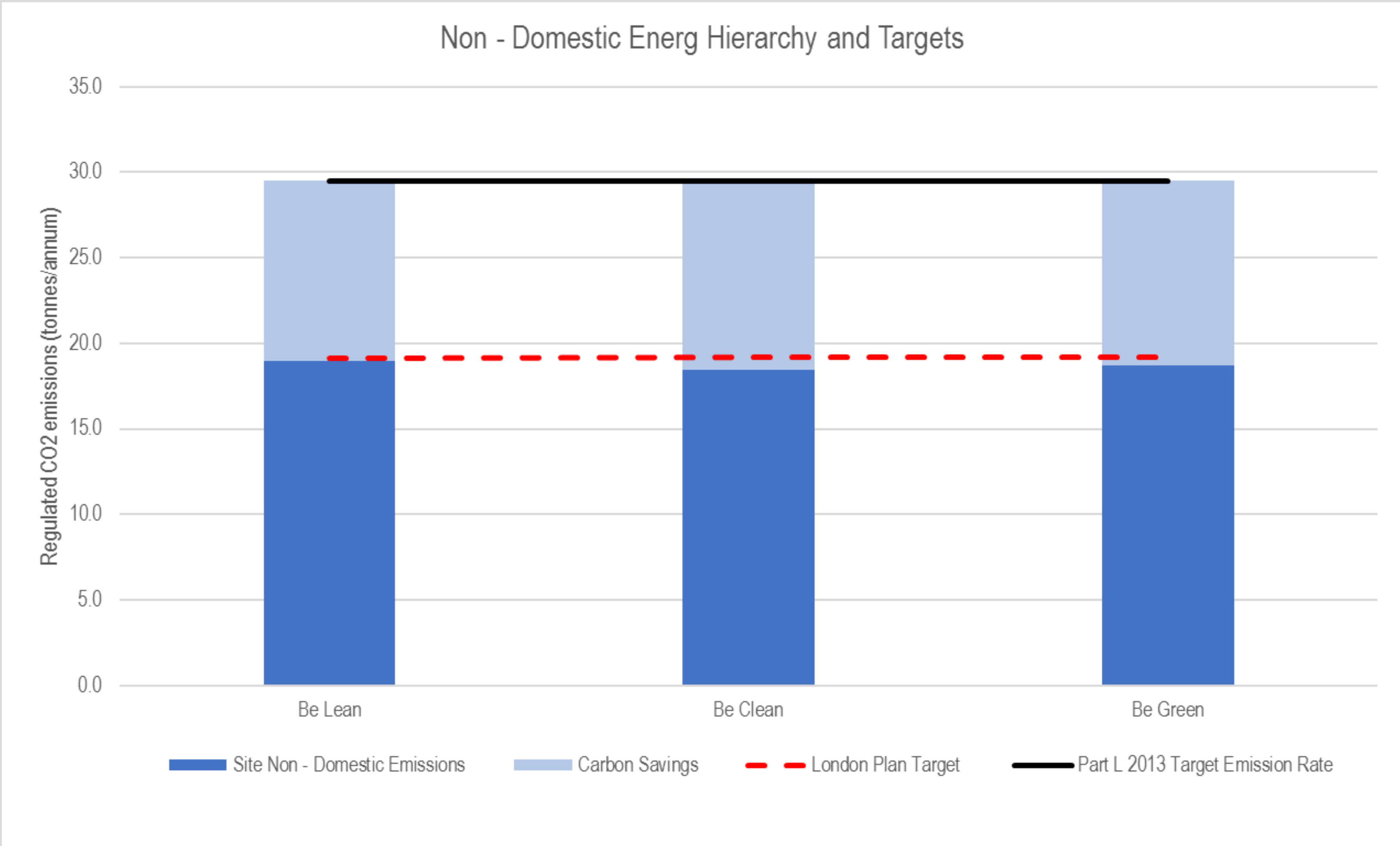

Figure 2: The Non-Domestic Energy Hierarchy

1.6 Site Wide Regulated Carbon Dioxide Emissions and Savings

	Total regulated emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage saving (%)
Part L 2013 baseline	83.7		
After Be Lean	68.5	15.2	18.1
After Be Clean	65.5	3.0	3.6
After Be Green	52.2	13.4	16.0
		CO2 savings off-set (Tonnes CO2)	
Off-set		989.8	

Table 6: Site Wide Regulated Carbon Dioxide Emissions and Savings

2 Introduction

The energy strategy for 63-71 High Street, Hampton Hill has been developed with sustainability and low energy at the heart of the design. The development comprises a mixture of townhouses, residential apartments and retail units on the High Street frontage.

The design approach has adopted the Mayor of London's Energy Hierarchy using advanced dynamic simulation computer modelling. This has assisted in optimising our solutions to blend elegantly into the architecture. Working closely with the design team, integrated design solutions that respond positively to the site's character whilst being policy compliant have been developed.

One of the key targets shall be achieving a 35% improvement over the Building Regulations Part L 2013. The following have been taken into consideration; appropriate National Planning guidelines, BREEAM and London Borough of Richmond upon Thames local planning requirements. The non-domestic areas shall aim to achieve a minimum BREEAM 'Excellent' rating.

A zero-carbon target has been applied to the residential portion of the development.

2.1 Description of Site

The site is located to the west side of High Street Hampton Hill in a mixed use urban area with the extensive open expanse of Bushey Park to the east.

The site which is largely rectangular and is currently occupied by 3 buildings. Two office buildings located on the frontage to the High Street and a third office building located in the south west corner of the site adjacent to the access road to the St Clare Business Park. The proposed development will involve the demolition of the existing buildings and the construction of the new development.

The front half of the site will comprise a part three part, four storey linked block of residential apartments set about an entrance court. These will comprise a mix of studios, one and two-bedroom units. There will be retail units on the ground floor fronting the High Street. To the rear will be a group of six townhouses set around a landscaped inner court.

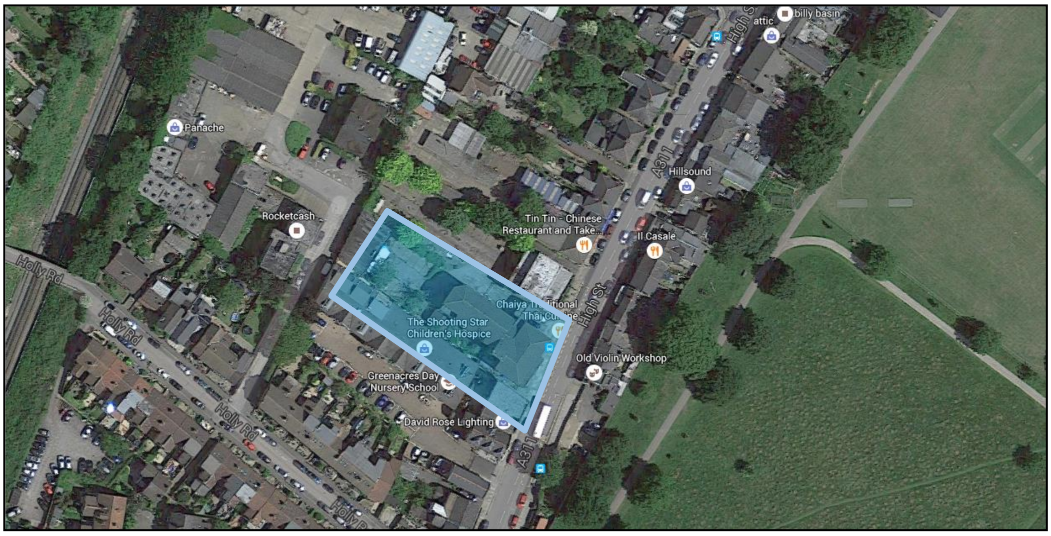

Figure 3: Location of proposed development

3 Targets

3.1 Key Documents

This energy statement for the proposed new development has referred to the following documents for guidance.

- Building Regulations - Approved Document Part L2A - Conservation of Fuel and Power in Buildings other than Dwellings 2013 with 2016 Amendments.
- Approved Document Part L1A – Conservation of Fuel and Power in Dwellings, 2013 with 2016 Amendments.
- National Planning Policy Framework
- London Borough of Richmond upon Thames Local Development Framework Core Strategy Adopted April 2009.
- London Borough of Richmond upon Thames Local Development Framework Development Management Plan Adopted November 2011.
- London Borough of Richmond upon Thames Local Plan Pre-publication version for consultation 8th July - 9th August 2016
- London Borough of Richmond - Sustainable Construction Checklist - January 2016
- BREEAM UK New Construction 2014 Technical Manual.
- The project is not referable to the GLA, however, guidance has been taken from the Mayor of London Sustainable Design and Construction Supplementary Planning Guidance, to inform the energy statement.

3.2 Key Policies

The following outlines key policies that have guided the design of the proposed scheme, together creating the Target Emission Rate (TER) and Target Fabric Energy Efficiency (TFEE) benchmark for the development:

3.2.1 Building Regulations 2013 with 2016 Amendments Part L1A: Conservation of Fuel and Power in New Dwellings:

> **"Regulation 26 – Minimum Energy Performance Requirements for New Buildings"**
> Where a building is erected, it shall not exceed the target CO_2 emission rate for the building that has been approved pursuant to regulation 25."
>
> **"Regulation 26A – Fabric Energy Efficiency Rates:"**
> Where a dwelling is erected, it shall not exceed the target fabric energy efficiency rate for that as has been approved pusuant to regulation 25, applying the methodlogy of calculation and expression of the energy performance of buildings approved pursuant to regulation 24.

3.2.2 Building Regulations 2013 with 2016 Amendments Part L2A: Conservation of Fuel and Power in New Buildings other than Dwellings:

"Regulation 26 – CO_2 Emission Rates for New Buildings"

Where a building is erected, it shall not exceed the target CO_2 emission rate for the building that havs been approved pursuant to regulation 25 applying the methodology of calculation and expression of the energy performance of buildings approved pursuant to regulation 24.

3.2.3 Local Planning Authority – London Borough of Richmond - Sustainable Construction Checklist - January 2016

New homes to achieve a 35% reduction in CO_2 emissions over Building Regulations requirements (2013).

3.2.4 Zero Carbon Target

A zero-carbon target has been applied to the residential parts of the development.

4 Baseline Energy Consumption and Carbon Dioxide (CO_2) Emissions

4.1 Residential

The residential areas regulated energy consumptions have been calculated using the Government's Standard Assessment Procedure (SAP). The licensed and accredited software JPA version 6.03b1 has been used.

SAP analyses were carried out to the majority of residences to demonstrate compliance with the necessary targets. The SAP analyses were based upon the general architectural layouts, which are listed in Appendix A.

Townhouses have been modelled with the mid terrace results duplicated for the other terrace Townhouses as the floor area, orientation and exposed wall area have been deemed to be the same and therefore accurate calculations can be based upon the results.

From this analysis, the regulated energy emissions (Dwelling Emission Rates – DER) have been calculated. Regulated energy emissions include for carbon emissions for heating and cooling, hot water systems, ventilation and internal lighting.

For the residential parts of the development, the unregulated energy emissions were calculated using the BREDEM (BRE Domestic Energy Model) methodology from the SAP analyses. Unregulated energy has been defined as the energy emissions for those relating to cooking and electrical appliances.

4.2 Non-Domestic

The non-residential areas of the building regulated energy have been calculated using the licensed and accredited dynamic simulation program EDSL – TAS version 9.4.1. These calculations were carried out to identify the building's energy consumption and carbon dioxide savings (Building Emission Rate – BER).

The unregulated energy was calculated based on the National Calculation Methodology (NCM) database.

4.3 Baseline

The following tables demonstrates carbon dioxide emissions calculated using the above methodologies and shall be used as the baseline emission reduction.

4.3.1 Domestic

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2

Table 7: Be Lean: Residential CO_2 Emissions (Tonnes per annum)

4.3.2 Non-Domestic

	Carbon Dioxide Emissions for Non-Domestic Buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9

Table 8: Be Lean: Non-Domestic CO_2 Emissions (Tonnes per annum)

5 Reductions in Energy Consumption and Carbon Dioxide emissions resulting from energy efficiency measures (Be Lean)

In accordance with the energy hierarchy, the first step in developing our energy strategy has sought to reduce energy demand by passive means. A thermally efficient building envelope has been provided which is deemed to be the primary climatic modifier.

5.1 Passive Design

The full description of passive design measures is set out in the Architects Design Statement.

- ✓ Enhanced building elements thermal transmittance (U values) over current Building Regulations Part L1A and L2A 2013.
- ✓ Low air permeability value of 3 $m^3/hr.m^2$ @ 50Pa to reduce heating demand during winter periods.
- ✓ Low solar energy transmittance values (g value) for all glazing systems to limit the impact of solar gain during the summer and reduce the overheating risk.
- ✓ The geometry of the building has facilitated passive ventilation with most of the apartments having dual aspect which allows for cross ventilation.

5.1.1 Thermal Transmittance (U – Values)

5.1.1.1 Residential

Building Element	U-Value ($W/m^2.K$)		G-Value / Light Transmittance
	2013 Part L1A Req.	Proposed Design	
External Wall	0.30	0.15	
Ground Floor	0.25	0.12	
Roof	0.20	0.12	
Glazing (incl. frame)	2.00	1.50/1.20	0.5/0.7

Table 9: Residential Thermal Properties

5.1.1.2 Non – Domestic

Building Element	U-Value (W/m².K)		G-Value / Light Transmittance
	2013 Part L2A Req.	Proposed Design	
External Wall	0.35	0.15	
Ground Floor	0.25	0.12	
Roof	0.25	0.12	
Glazing (incl. frame)	2.2	1.5	>0.5/0.7
High Usage Entrance Doors	3.5	1.5	0.5

Table 10: Non - Domestic Thermal Properties

5.1.2 Air Permeability

	Infiltration ($m^3/hr.m^2$) @ 50 Pa	
	Part L1A Req.	Proposed Design
Air Permeability	10.0	3

Table 11: Air Permeability

5.1.3 Target Fabric Energy Efficiency/ Dwelling Fabric Energy Efficiency

In accordance with Regulation 26A – Fabric Energy Efficiency Rates L1A the target fabric energy efficiency and Dwelling Fabric Energy Efficiency are demonstrated in the table below:

Dwelling	TFEE	DFEE
Apartments	50.61	54.80
Townhouses	55.94	53.98

Table 12: Fabric Energy Efficiency

5.2 Active Design Measures

The following active design measures have been incorporated into the design.

- Daylight harvesting systems will be adopted with appropriate lighting controls.
- All electro-mechanical plant will be highly efficient and the main plant will be linked to a Building Energy Management System (BEMS). The BEMS will also assist in the operational management of energy consumption on the site.

- High efficient mechanical heat recovery ventilation systems to achieve at least 80% efficient heat recovery and, at least, 20% improvement to Non-Domestic Building Compliance Guide 2013 low specific fan power (SFP) ratings.
- Mechanical ventilation controls and the provision of metering (i.e. out-of range values and separately sub-metered).
- Heating systems controls with programmer and room thermostats.
- High efficient plant and systems are to be specified to be integrated into a Building Management System
- Power quality control system will have a power factor greater than 0.95.
- High efficient lighting throughout the building with absence detection and daylight sensing for non-domestic areas and manual switching on-off controls for domestic areas.
- Lighting systems to have provision for metering which warns of 'out-of-range' values.
- The development would also feature smart meters to enable tenants/residents to monitor the running of non-essential equipment.
- LED energy efficient luminaires are to be used throughout the building to reduce heating loads from lighting. All electrical appliances shall be energy efficient to reduce heat gains.

5.2.1 Cooling

Through the ‘Be Lean’ design principles, the Mayor of London’s cooling hierarchy to minimise cooling has been adopted, with a preference given to passive design techniques to the apartments.

A mixture of openable windows and enhanced mechanical ventilation will be used to help mitigate against overheating within the apartments and Townhouses. Residences shall be fitted with mechanical ventilation with energy recovery systems and allow for ‘free cooling’ where possible to provide good levels of indoor air quality whilst being energy conscious. The system shall also be fitted with a summer by-pass to minimise internal heat generation.

Balconies have also been integrated into the design and high-performance glazing has been utilised within the proposed development to reduce unwanted solar gains. This should help to mitigate against heat entering the building in the summer.

The top floor apartments shall be equipped to have high efficiency renewable air source heat pumps for cooling.

Average Domestic Cooling Load for July (kWh/m2)	Maximum Domestic Cooling demand for July (kWh/m2)
1.11	1.38

It is anticipated that the non-domestic component of the development, which is relatively limited in area, when fully fitted out, will require heating and cooling in some areas.

5.3 Results

The below tables show the associated CO_2 for the proposed development. These figures have been taken from the SAP calculations and BRUKL reports.

5.3.1 Domestic

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2
After Be Lean	49.6	58.2

Table 13: Be Lean: Residential CO_2 Emissions (Tonnes per annum)

5.3.2 Non-Domestic

	Carbon Dioxide Emissions for Non-Domestic Buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9
After Be Lean	18.9	26.9

Table 14: Be Lean: Non-Domestic CO_2 Emissions (Tonnes per annum)

6 Reductions in Energy Consumption and Carbon Dioxide resulting from Supplying Energy Efficiently (Be Clean)

6.1 Combined Heat and Power Technology (CHP)

The proposed development includes residential units and non-domestic areas. Planning policies require that developments with over 50 residential units or 1000sqf of non-residential developments should consider the use of a CHP to provide heating and power. As the proposed development is for less than 50 the load is minimal and a CHP is therefore not considered to be technically viable.

6.2 Existing and Planned District Heating Networks.

The London Heat Map has been reviewed to establish if there are planned or existing District Heat Networks (DHN) in the vicinity of the proposed development. Figure 2 below illustrates that there are no planned or existing DHN near to the proposed development.

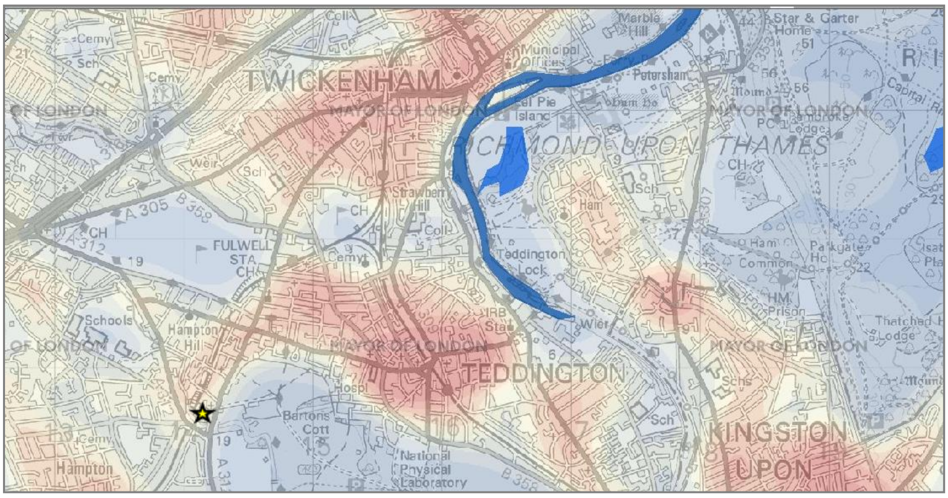

Figure 4: London Heat Map: Existing Networks shown in yellow, proposed networks shown in red.

Site Location (★)

The scheme design includes the installation of a centralised low temperature hot water (LTHW) heating system to serve the apartments. This system will incorporate provisions to enable it to connect into a District Heat Network in the future if such a network were planned and implemented in the area. The provisions are shown on a Heating Schematic which can be found in Appendix E.

6.3 Centralised Heating System

A centralised gas boiler heating system has been deemed to be appropriate to serve the apartments and non-domestic areas, with individual heat interface units included in each residential apartment and non-domestic areas to provide heating and domestic hot water. The Townhouses will be fitted with individual gas fired boilers.

Apartments will be individually metered so that residents are able to monitor their energy consumption.

6.3.1 Results

The below table shows the associated CO_2 for the proposed development. These figures have been taken from the SAP calculations and BRUKL reports.

6.3.1.1 Residential

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2
After Be Lean	49.6	58.2
After Be Clean	47.1	58.2

Table 15: Be Clean: Residential CO_2 Emissions (Tonnes per annum)

6.3.1.2 Non-Domestic

	Carbon Dioxide Emissions for Non-Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9
After Be Lean	18.9	26.9
After Be Clean	18.5	26.9

Table 16: Be Clean: Non-Domestic CO_2 Emissions (Tonnes per annum)

7 Estimation of CO_2 reduction through use of renewable energy technologies (Be Green)

7.1 Renewable Energy Technologies Evaluation

An evaluation of suitable renewable energy technologies has been undertaken. The full evaluation can be found in Appendix B of this statement. The evaluation has been based upon the suitability of the Low/Zero Carbon technology for the proposed development.

From the renewable energy technology feasibility analysis, a photovoltaic system and air source heat pump have been identified as being the only appropriate technologies that can be implemented as part of the proposed development.

7.2 Photovoltaic Cells (PVs)

7.2.1 Description

Photovoltaic cells generate electricity from daylight. Photons of light impact the surface of the panels causing electricity to flow and the higher the intensity of the daylight the greater the energy created. PV cells are available in various forms such as flat panels for mounting on roofs, or films which could be incorporated into other building fabrics such as glass or cladding or integrated into components such as roof tops. These modular units are then connected together by cables and the current generated is then passed through an inverter unit to connect to the building power supply. The efficiency of the PV cells is based on a number of factors, including the physical type of PV cell, the angle the PV arrays are fixed. PV's generate clean electricity and complement the use of boilers.

The optimum mounting arrangement for PV arrays in south facing (within 45° of south) with the array tilted at 30 to 40 to 'point' towards the predominant positions of the sun. The basic PV types are:

- Mono-crystalline; these have an efficiency of 15%
- Poly-crystalline; these have an efficiency of 13%
- Thin film, these have an efficiency ranging from 7-20% and could be used to integrate into other building materials.

The design proposes the incorporation of Photovoltaic film to complement the roof design. The design intent of the sculptured roof with integrated Photovoltaics shall provide a low carbon electrical output of approximately 32kWp. The intended integration of thin film photovoltaic as part of the overall roof design (as opposed to individual free-standing roof top mounted panels) is entirely feasible. The design team in conjunction will develop the final design and specification with the chosen manufacturing specialist during the preparation of the detailed technical design (RIBA stage 4). This shall aim to achieve a minimum technical performance output of 32KWp.

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The proposed articulated roof design incorporates at least 50% of the roofscape with orientation and pitch to favour south / south west and south east aspects. The final pitch and orientation will vary across the scheme and is subject to detail technical design as noted above.

Based upon the geographic location of the site and the site conditions, it is anticipated that the integrated solar roof shall generate 25,600 kWhrs of clean electricity per annum (subject to detailed design of the solar roof structure).

7.2.2 Maintenance and Life Span

PV's have minimal maintenance costs and do not emit any harmful emissions. However, they should be kept clean from debris and without anything overshadowing them. The inverter should also be monitored for signs of faults. PV's have an anticipated lifespan of 25 years; the inverter may need to be changed before this though.

7.3 Air Source Heat Pumps (ASHP)

7.3.1 Description

Heat pumps are devices that transfer heat energy from a source to a heat sink through a working fluid. The working fluid is subjected to compression and evaporation to achieve this heat transfer via the heat pump. The process is fully reversible allowing heat pumps to provide either heating or cooling. Unit efficiency ratings are calculated from the units Coefficient of Performance (COP). This is a measure of the unit's heat delivery for each unit of electricity used to operate the pump. ASHPs operate on a closed loop system where the heat energy is either absorbed or rejected to the atmosphere via an evaporator depending upon if the conditioned space is being heated or cooled. The plant for these systems typically contains an indoor heat pump and outdoor evaporator. Air Source Heat pumps run on electricity. They do not emit harmful emissions from the outdoor units. However, they have less useful economic life compared to centralised boilers and chiller systems.

The Air Source Heat Pumps shall only provide cooling to the top floor apartments. These shall be served by local low carbon air source heat pump units which shall have an energy efficiency ratio of 3.75.

7.3.2 Maintenance and Life Span

Air Source Heat Pumps have minimal maintenance costs and do not emit any harmful emissions. Air source can provide efficient cooling services and have a useful life of around 15 years. Reasonable payback periods compared to alternative cooling technologies. They are versatile and robust and are suitable for the relatively low cooling loads required to serve the top floor apartments. Therefore, this technology shall be considered further.
Outdoor plant can be incorporated into dedicated plant spaces at ground or roof level. Being compact in size, they can be integrated into the building design without causing visual intrusion.

7.4 Results:

The below tables show the associated CO_2 for the proposed development. These figures have been taken from the SAP calculations and BRUKL reports.

7.4.1 Residential

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes Co_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2
After Be Lean	49.6	58.2
After Be Clean	47.1	58.2
After Be Green	33.7	58.2

Table 18: Be Green: Residential CO_2 Emissions (Tonnes per annum)

7.4.2 Non-Domestic

	Carbon Dioxide Emissions for Non-Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9
After Be Lean	18.9	26.9
After Be Clean	18.5	26.9
After Be Green	18.5	26.9

Table 18: Be Green: Non-Domestic - CO_2 Emissions (Tonnes per annum)

8 Conclusion

The design intent of the sculptured roof with integrated Photovoltaics shall provide a low carbon electrical total output of approximately 32kWp serving the residential parts of the development. This roof shall be detailed further at a later stage in liaison with specialist building integrated photovoltaic manufacturers.

The below tables demonstrate the carbon dioxide emissions for the proposed development based upon calculations in accordance with the GLA energy hierarchy.

This shows that a 37.8% carbon dioxide reduction is achieved through implementing the stages of the energy hierarchy. A zero-carbon payment to offset the 1,011 Tonnes of CO_2 over a 30-year period amounts to £ £60,663.

8.1 Domestic

8.1.1 Regulated Carbon Dioxide Emissions from Each Stage of The Energy Hierarchy for Domestic Buildings

	Carbon Dioxide Emissions for Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.2	58.2
After Be Lean	49.6	58.2
After Be Clean	47.1	58.2
After Be Green	33.7	58.2

Table 19: Carbon Dioxide Emissions After Each Stage of The Energy Hierarchy for Domestic Buildings

8.1.2 Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Domestic Buildings

	Regulated Domestic Carbon Dioxide Savings	
	(Tonnes CO2 per annum)	(%)
Savings from Be Lean	4.6	8.6

	Regulated Domestic Carbon Dioxide Savings	
	(Tonnes CO2 per annum)	(%)
Savings from Be Clean	2.5	4.8
Savings from Be Green	13.4	24.5
Cumulative on site savings	**20.5**	**37.8**
Annual Savings from off-set payment	33.7	
	(Tonnes Co2)	
Cumulative savings for off-set payment (Offset Payment based upon 33.7 Tonnes per annum for 30 years at £60 per Tonne)	1,011	£60,663

Table 20: Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Domestic Buildings

8.2 Non-Domestic

8.2.1 Carbon Dioxide Emissions After Each Stage of The Energy Hierarchy for Non-Domestic Buildings

	Carbon Dioxide Emissions for Non - Domestic Buildings (Tonnes CO_2 Per Annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	29.5	26.9
After Be Lean	18.9	26.9
After Be Clean	18.5	26.9
After Be Green	18.5	26.9

Table 21: Carbon Dioxide Emissions After Each Stage of The Energy Hierarchy for Non-Domestic Buildings

8.2.2 Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Non-Domestic Buildings

	Regulated Non-Domestic Carbon Dioxide Savings	
	(Tonnes CO2 per annum)	(%)
Savings from Be Lean	10.6	35.8
Savings from Be Clean	0.5	1.6
Savings from Be Green	0.0	0.0
Total Cumulative Savings	**11.0**	**37.4**

Table 22: Regulated Carbon Dioxide Savings from Each Stage of The Energy Hierarchy for Non-Domestic Buildings

8.3 Site Wide Regulated Carbon Dioxide Emissions and Savings

	Total regulated emissions (Tonnes CO2/year)	CO2 Savings (Tonnes CO2/year)	Percentage saving (%)
Part L 2013 Baseline	83.7		
After Be Lean	68.5	15.2	18.1
After Be Clean	65.5	3.0	3.6
After Be Green	52.2	13.4	16.0
		CO2 savings off-set (Tonnes CO2)	
Off-set		989.8	

Table 23: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

9 Appendix

9.1 Appendix A: Drawing Schedule

Drawing Name	Drawing Number
Proposed Elevation A High Street East Elevation	T20E01
Proposed Elevation B South Side Elevation	T20E02
Proposed Elevation C West Garden Elevation	T20E03
Proposed Elevation D North Side Elevation	T20E04
Proposed Elevation E Courtyard South Elevation	T20E05
Proposed Section F	T20E06
Proposed Elevation G Courtyard North Elevation	T20E07
Proposed Elevation H Courtyard East Elevation	T20E08
Proposed Elevation Section I Courtyard West Elevation	T20E09
Proposed Town House Elevation	T20E10
Proposed Ground Floor Plan	T20P00
Proposed First Floor Plan	T20P01
Proposed Basement Floor Plan	T20P-1
Proposed Second Floor Plan	T20P02
Proposed Third Floor Plan	T20P03

9.2 Appendix B: Evaluation of Renewable Energy Technologies

9.2.1 Biomass

Wood pellets are a type of wood fuel, generally made from compacted sawdust. They are usually produced as a by-product of sawmilling and other wood transformation activities. The pellets are extremely dense and can be produced with a low humidity content (below 10%) that allows them to be burned with a very high combustion efficiency. Further, their regular geometry and small size allow automatic feeding with very fine calibration. They can be fed to a burner by auger feeding or by pneumatic conveying. Their high density also permits compact storage and rational transport over long distance. They can be conveniently blown from a tanker to a storage bunker or silo on a customer's premises. With the surge in the price of fossil fuels, the demand for pellet heating has increased in UK, and when a sizable industry is emerging the cost per kWh is very similar (if not higher) than the equivalent of Natural Gas boilers.

Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

Export Energy - Not applicable –see feasibility.

Life Cycle Costs / Emissions- Not applicable –see feasibility.

Available Grants -Not applicable –see feasibility.

Feasibility
The location of the site is within an Air Quality Management area; this therefore limits the feasibility of utilising Biomass as during operation Biomass produces NOx emissions, which can reduce air quality unless pollution abatement equipment is installed.
The load demand of the site is less than the desired load required to make an installation of Biomass warrant the expensive pollution abatement equipment necessary to maintain air quality.
There are also storage and delivery considerations No on-site vehicular service bay is incorporated in the proposed development which would mean that delivery would take place from the High Street which would result in unacceptable disruption to traffic movement on the High Street.
Therefore, this technology is not considered appropriate for this site and the proposed development and shall not be considered further.

9.2.2 Biofuel Combined Heat & Power (CHP) Systems

Biofuels are a wide range of fuels which are derived from biomass. Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. Ethanol can be used as a fuel for CHP units in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered CHP units. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in UK.

Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

Export Energy - Not applicable –see feasibility.

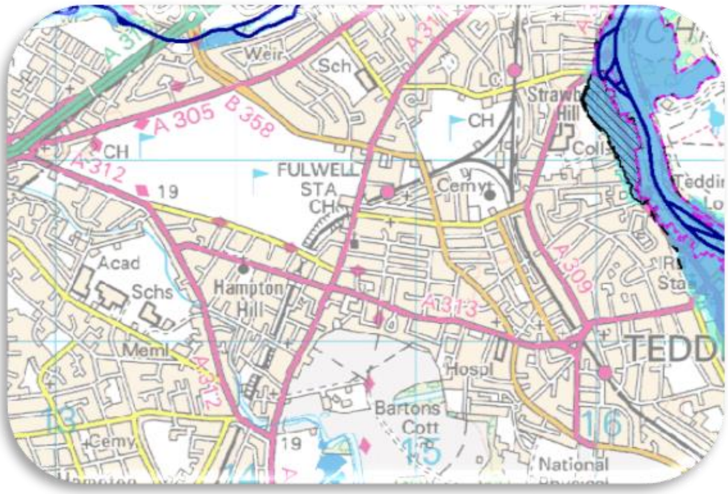
Life Cycle Costs / Emissions- Not applicable –see feasibility.

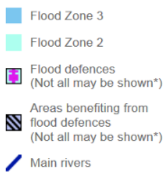
Available Grants -Not applicable –see feasibility.

Feasibility
Similar to biomass technology, biofuel use for either combined heat or power use or standalone boilers are not deemed feasible for this site.
The use of biofuels would increase the NOx emissions compared to conventional boilers and therefore have a negative impact on the surrounding air quality.
There would be logistical issues associated with the delivery and storage of the fuel. No on-site vehicular service bay is incorporated in the proposed development which would mean that delivery would take place from the High Street which would result in unacceptable disruption to traffic movement on the High Street.
Therefore, this technology is not considered appropriate for this site and the proposed development and shall not be considered further.

9.2.3 Ground Source Heat Pumps (GSHP)

In the case of GSHP heat energy is either absorbed or rejected from / to the ground depending upon if the conditioned space is being heated or cooled. The plant itself comprises of a heat pump within the building linked to a loop of buried pipework through which refrigerant or water is circulated. The buried pipework for GSHP's can either be horizontal via trenches or vertical via boreholes. Trenches are typically 2m deep and boreholes can be up to 100m deep. GSHP typically achieve COP between 3-5 conversely, they are the most expensive type of pump to install due to the groundwork required.





Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

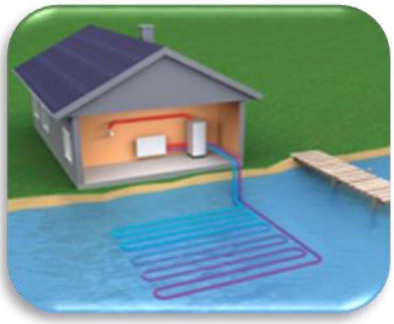
Export Energy - Not applicable –see feasibility.

Life Cycle Costs / Emissions- Not applicable –see feasibility.

Available Grants -Not applicable –see feasibility.

Feasibility
The site is not in a flood risk zone. However, a suitable area for either a horizontal or a vertical system is not present on the site due to the inclusion of basement parking and storage in the proposed scheme.
Therefore, ground source heat pumps is not considered appropriate for this site and shall not be considered further.

9.2.4 Water Source Heat Pumps (WSHPs)



WSHPs can operate on either an open or closed loop cycle. In open loop cycles the working fluid is taken from a local river, the heat is then extracted from the heat pump and then released back into the river. Whereas closed loop systems operate on the same principles as ground source heat pumps however, the heat transfer process is convection through a local water source e.g. pond, compared to ground source heat pumps which use conduction through the ground. WSHPs typically have higher COP values compared to ground and air source heat pumps because the heat transfer with water is far greater than ground and air sources.

An extraction licence from the Environmental Agency is required for open loop systems above 4kW. The water quality for open loop systems is of concern particularly if the pH value is not neutral as corrosive resistant pipes, pumps and exchangers will be required. In open-loop systems the water source annual mean temperature must be above 8deg.C as water below these temperatures can cause ice to form, freezing the heat exchanger and causing the pump to fail. As with both closed and open loop systems if the water source dries up then no heat transfer can take place.

Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

Export Energy - Not applicable –see feasibility.

Life Cycle Costs / Emissions- Not applicable –see feasibility.

Available Grants -Not applicable –see feasibility.

Feasibility
This technology is deemed unfeasible due to site constraints. Therefore, this technology shall not be considered further.

9.2.5 Solar Hot Water

Solar Hot Water (SHW) absorbs solar heat energy to generate hot water. These systems typically account for 50% of the annual hot water demand. In the UK, the peak solar radiation is about 1kW/m2, this can be harnessed to provide heat for hot water systems. Solar thermal systems conduit of solar collectors, typically on a building roof, filled with liquid which is then pumped to a storage vessel, i.e. hot water tanks where it is used to heat the contents of the tank via an incident coil. The tank is normally a dual cylinder where a secondary coil, supplied from a separate heat source (typically a boiler), provides additional heating to the cylinder during periods of little solar radiation. There are two main types of collector; either flat plate collectors which are simply a dark plate in an insulated box with a transparent cover or evacuated to be collectors which are more efficient, more effective in differing weather conditions but more expensive.

Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

Export Energy - Not applicable –see feasibility.

Life Cycle Costs / Emissions- Not applicable –see feasibility.

Available Grants -Not applicable –see feasibility.

Feasibility
Due to the limited amount of roof space available which faces south/south west, Photovoltaic cells have been selected over solar panels to be the most appropriate renewable energy source for the site. This is because photovoltaic cells produce electricity and therefore a greater amount of carbon emissions are saved compared to alternative low to zero carbon technologies. Therefore, this technology shall not be conserved further.

9.2.6 Wind Source

Wind energy transfers kinetic energy to electrical energy through mechanical work. The technology is very simplistic typically containing a tower, rotor/blades, gearbox, generator and controller. The power generation is determined by the wind speed and swept area of the blades. Conversely, as the swept area increases the height of the tower must also increase this again provides higher wind speeds to the turbine.

There are two common types of turbine categorised as horizontal axis and vertical axis. The axis denotes the direction the turbine blades are facing in relation to the wind. Horizontal axis is the most efficient type of turbine because more of the wind hits the blades swept area than vertical axis types. Both small scale types can be mounted to buildings but heavy structural design considerations must be considered due to vibration generated from the turbine.

Energy Generated from LZC Energy Source Per Year- Not applicable –see feasibility.

Land Use - Not applicable –see feasibility.

Payback - Not applicable –see feasibility.

Local Planning Criteria - Not applicable –see feasibility.

Export Energy - Not applicable –see feasibility.

Life Cycle Costs / Emissions- Not applicable –see feasibility.

Available Grants -Not applicable –see feasibility.

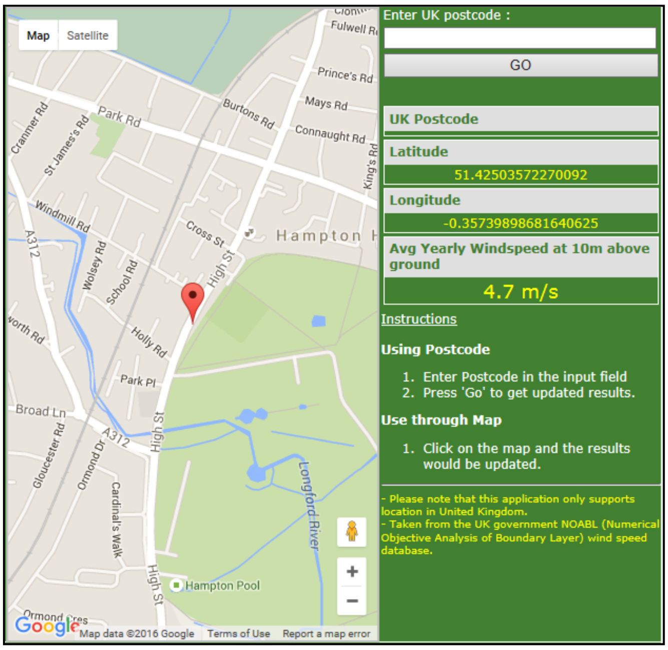


Figure 5: Wind Speed Prediction Tool

Feasibility

For optimum efficiency many wind turbines typically generate optimum power at wind speeds of 14-20m/s making them ideal for offshore locations. For inland purposes, where the wind speed typically ranges from 2-10m/s, a minimum recommended seasonal wind speed of 5m/s is desired to make these LZC technologies feasible. Generated power can be connected to either the local power grid or, for smaller systems, diverted to a building electrical distribution board. The biggest design considerations for utilising wind turbines are the local wind speed and flow characteristics. Turbulent flow can impede the turbines performance making these technologies uncommon for urban environments due to turbulence generated from building obstructions. As can be seen above the predicted wind speed is slightly below 5 m/s. Wind technology would be located at roof level and would need possible intervention to the roof structures to mitigate against noise and vibrational nuisance. Furthermore, there are alternative solar technologies that are deemed easier to integrate into the building scheme. Therefore, this technology has not been considered further.

9.3 Appendix C: Results

9.3.1 SAP Results

Residence Number	Be Lean		Be Clean		Be Green		
	TER	DER	TER	DER	TER	DER	Reduction
A001	24.02	20.40	24.02	19.29	24.02	15.46	35.6%
A002	24.48	21.71	24.48	20.53	24.48	16.44	32.8%
A003	23.32	18.69	23.32	17.73	23.32	13.46	42.3%
A004	24.24	20.91	24.24	19.78	24.24	16.68	31.2%
A005	23.66	20.08	23.66	19	23.66	15.00	36.6%
A006	26.25	21.64	26.25	20.46	26.25	16.18	38.4%
A101	16.70	15.17	16.7	14.39	16.70	10.93	34.6%
A102	17.15	14.19	17.15	13.48	17.15	9.64	43.8%
A103	19.20	16.60	19.2	15.76	19.20	11.93	37.9%
A104	16.60	13.93	16.6	13.27	16.60	10.15	38.9%
A105	18.27	15.88	18.27	15.05	18.27	10.78	41.0%
A106	15.76	13.56	15.76	12.91	15.76	9.86	37.4%
A107	21.03	20.03	21.03	18.94	21.03	14.70	30.1%
A108	18.13	15.72	18.13	14.91	18.13	10.90	39.9%
A109	18.11	15.64	18.11	14.83	18.11	10.90	39.8%
A110	16.90	14.84	16.9	14.09	16.90	11.50	32.0%
A111	17.33	15.72	17.33	14.98	17.33	10.94	36.9%
A112	15.75	15.74	15.75	14.99	15.75	12.31	21.8%
A201	21.89	20.32	21.89	19.22	21.89	14.61	33.3%
A202	21.98	18.88	21.98	17.87	21.98	13.57	38.3%
A203	20.40	17.65	20.4	16.74	20.40	12.91	36.7%
A204	16.61	13.76	16.61	13.11	16.61	9.99	39.9%
A205	17.25	14.86	17.25	14.1	17.25	9.83	43.0%
A206	16.06	13.69	16.06	13.03	16.06	9.98	37.9%
A207	22.18	20.77	22.18	19.63	22.18	15.38	30.7%
A208	18.88	16.10	18.88	15.26	18.88	11.25	40.4%
A209	18.83	16.55	18.83	15.68	18.83	11.75	37.6%
A210	16.37	15.23	16.37	14.79	16.37	11.86	27.6%
A211	17.89	16.38	17.89	5.53	17.89	11.50	35.7%
A212	17.17	16.87	17.17	15.98	17.17	13.08	23.8%
A301	19.00	17.46	19	16.54	19.00	13.33	29.8%
A302	17.42	15.74	17.42	14.96	17.42	12.36	29.0%
A303	20.00	18.44	20	17.49	20.00	13.91	30.5%
A304	19.78	17.99	19.78	17.07	19.78	13.21	33.2%
A305	14.40	13.46	14.4	12.79	14.40	11.18	22.4%
T01	18.79	18.71	18.79	18.57	18.79	12.10	35.6%
T02	16.19	16.15	16.19	16.04	16.19	11.02	31.9%
T03	15.75	15.80	15.75	15.69	15.75	10.67	32.3%
T04	15.75	15.80	15.75	15.69	15.75	10.67	32.3%
T05	15.75	15.86	15.75	15.75	15.75	10.73	31.9%

Residence Number	Be Lean		Be Clean		Be Green		
	TER	DER	TER	DER	TER	DER	Reduction
T06	17.73	18.06	17.73	17.93	17.73	12.91	27.2%
Average	18.24	16.68	18.24	15.84	18.24	11.34	

9.3.2 Example of SAP worksheet – Be Green

Project Information

Building type	Top-floor flat
Plot number	A202
Reference	A202
Date	6 September 2016
Project	63-71 High Street, Hampton Hill TW10 6DQ

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

1. Overall dwelling dimensions

	Area (m^2)	Av. Storey height (m)	Volume (m^3)	
Second floor	50.00	3.12	156.00	(3a)
Total floor area	50.00			(4)
Dwelling volume (m^3)			156.00	(5)

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

2. Ventilation rate

	main + seondary + other heating		m³ per hour	
Number of chimneys	0 + 0 + 0	x 40	0.00	(6a)
Number of open flues	0 + 0 + 0	x 20	0.00	(6b)
Number of intermittent fans	0	x 10	0.00	(7a)
Number of passive vents	0	x 10	0.00	(7b)
Number of flueless gas fires	0	x 40	0.00	(7c)

		Air changes per hour	
Infiltration due to chimneys, fans and flues		0.00	(8)
Pressure test, result q50	3.00		(17)
Air permeability		0.15	(18)
Number of sides on which sheltered		2.00	(19)
Shelter factor		0.85	(20)
Infiltration rate incorporating shelter factor		0.13	(21)

Infiltration rate modified for monthly wind speed

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70

52.50 (22)

Wind Factor

1.27	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18

13.13 (22a)

Adjusted infiltration rate (allowing for shelter and wind speed)

0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15

1.67 (22b)

air change rate through system	0.50	(23a)
efficiency in % allowing for in-use factor	76.50	(23c)

Ventilation : balanced whole house mechanical with heat recovery

Effective air change rate

0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(25)

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²	U-value W/m²K	A x U W/K	kappa-value kJ/m²K	A x K kJ/K	
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled			**3.000**	**1.42 (1.50)**	4.25			(27)
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled			**4.500**	**1.42 (1.50)**	6.37			(27)
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled			**1.500**	**1.42 (1.50)**	2.12			(27)
Solid door Double Glazed Air filled			**2.180**	**1.50**	3.27			(26)
Walls South West Wall			20.92	0.15	3.14	190.00	3974.80	(29)
Walls North West Sheltered			16.54	0.11	1.82	190.00	3142.60	(29)
Walls North East Sheltered			27.53	0.11	3.03	190.00	5230.70	(29)
Pitched roofs with integrated insulation			50.00	0.12	6.00	9.00	450.00	(30)
Party wall South East			16.00	0.00	0.00	180.00	2880.00	
Party wall South Wall			3.27	0.00	0.00	180.00	588.60	
Party floor			50.00	0.00	0.00	40.00	2000.00	

Total area of external elements Sigma A, m²	126.17	(31)
Fabric heat loss, W/K	29.99	(33)
Heat capacity	18266.70	(34)
Thermal mass parameter, kJ/m²K	365.33	(35)
Effect of thermal bridges	8.89	(36)
Total fabric heat loss	38.88	(37)

Ventilation heat loss calculated monthly

14.42	14.25	14.09	13.27	13.10	12.28	12.28	12.12	12.61	13.10	13.43	13.76	(38)

Heat transfer coefficient, W/K

53.30	53.14	52.97	52.15	51.99	51.17	51.17	51.00	51.50	51.99	52.32	52.64

52.11 (39)

Heat loss parameter (HLP), W/m²K

1.07	1.06	1.06	1.04	1.04	1.02	1.02	1.02	1.03	1.04	1.05	1.05

HLP (average) 1.04 (40)

Number of days in month (Table 1a)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	31	30	31	31	30	31	30	31

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

4. Water heating energy requirements		**kWh/year**	
Assumed occupancy, N		1.69	(42)
Annual average hot water usage in litres per day Vd,average		74.34	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month	81.77	78.80	75.83	72.85	69.88	66.91	66.91	69.88	72.85	75.83	78.80	81.77	(44)
Energy content of hot water used	121.27	106.06	109.45	95.42	91.56	79.01	73.21	84.01	85.01	99.08	108.15	117.44	
Energy content (annual)												1169.66	(45)
Distribution loss	18.19	15.91	16.42	14.31	13.73	11.85	10.98	12.60	12.75	14.86	16.22	17.62	(46)
Cylinder volume, l								110.00					(47)
Manufacturer's declared cylinder loss factor (kWh/day)								0.03					(48)
Temperature Factor								1.0000					(49)
Energy lost from hot water cylinder (kWh/day)												0.03	(55)
Total storage loss	0.93	0.84	0.93	0.90	0.93	0.90	0.93	0.93	0.90	0.93	0.90	0.93	(56)
Net storage loss	0.93	0.84	0.93	0.90	0.93	0.90	0.93	0.93	0.90	0.93	0.90	0.93	(57)
Primary loss	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)
Total heat required for water heating calculated for each month	145.46	127.91	133.64	118.83	115.75	102.42	97.40	108.20	108.43	123.27	131.56	141.63	(62)
Output from water heater for each month, kWh/month	145.46	127.91	133.64	118.83	115.75	102.42	97.40	108.20	108.43	123.27	131.56	141.63	(64)
												1454.50	(64)
Heat gains from water heating, kWh/month	59.68	52.75	55.74	50.46	49.80	45.00	43.70	47.29	47.00	52.30	54.69	58.40	(65)

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains, Watts	101.41	101.41	101.41	101.41	101.41	101.41	101.41	101.41	101.41	101.41	101.41	101.41	(66)
Lighting gains	32.96	29.27	23.81	18.02	13.47	11.37	12.29	15.97	21.44	27.22	31.78	33.87	(67)
Appliances gains	219.75	222.03	216.29	204.05	188.61	174.10	164.40	162.12	167.87	180.10	195.54	210.06	(68)
Cooking gains	46.83	46.83	46.83	46.83	46.83	46.83	46.83	46.83	46.83	46.83	46.83	46.83	(69)
Pumps and fans gains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (negative values)	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	-67.60	(71)
Water heating gains	80.21	78.49	74.93	70.08	66.93	62.50	58.73	63.56	65.27	70.29	75.96	78.50	(72)
Total internal gains	413.55	410.43	395.65	372.79	349.65	328.60	316.05	322.29	335.21	358.25	383.91	403.06	(73)

6. Solar gains (calculation for January)

	Area & Flux	g & FF	Shading	Gains	
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled	0.9 x 3.000 36.79	0.50 x 0.80	0.77	30.5978	
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled	0.9 x 4.500 36.79	0.50 x 0.80	0.77	45.8966	
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled	0.9 x 1.500 36.79	0.50 x 0.80	0.77	15.2989	
Solid door Double Glazed Air filled	0.9 x 2.180 0.00	0.50 x 0.80	0.77	0.0000	
Total solar gains, January				91.79	(83-1)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	91.79	156.36	213.94	265.08	296.91	294.76	284.18	260.43	231.65	172.81	109.95	78.56	(83)
Total gains	505.35	566.79	609.59	637.86	646.55	623.36	600.24	582.72	566.86	531.06	493.85	481.62	(84)

Lighting calculations

	Area	g	FF x Shading	
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled	0.9 x 3.00	0.80	0.80 x 0.83	1.43
Window - Double-glazed, air-filled (SouthWest) Double Glazed Air filled	0.9 x 4.50	0.80	0.80 x 0.83	2.15

Lighting calculations

	Area	g	FF x Shading	
Window - Double-glazed, air-filled (SouthWest)	0.9 x 1.50	0.80	0.80 x 0.83	0.72

Double Glazed Air filled
GL = 4.30 / 50.00 = 0.086
C1 = 0.500
C2 = 0.964
El = 233

7. Mean internal temperature

Temperature during heating periods in the living area, Th1 (°C) 21.00 (85)
Heating system responsiveness 1.00

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	95.20	95.49	95.79	97.29	97.60	99.17	99.17	99.48	98.53	97.60	96.99	96.38	
alpha	7.35	7.37	7.39	7.49	7.51	7.61	7.61	7.63	7.57	7.51	7.47	7.43	
Utilisation factor for gains for living area	0.99	0.98	0.96	0.88	0.72	0.52	0.37	0.40	0.62	0.89	0.98	0.99	(86)
Mean internal temperature in living area T1	20.46	20.58	20.74	20.90	20.98	21.00	21.00	21.00	20.99	20.91	20.66	20.43	(87)
Temperature during heating periods in rest of dwelling Th2	20.03	20.03	20.03	20.05	20.05	20.06	20.06	20.07	20.06	20.05	20.04	20.04	(88)
Utilisation factor for gains for rest of dwelling	0.99	0.98	0.94	0.84	0.66	0.45	0.30	0.32	0.54	0.85	0.97	0.99	(89)
Mean internal temperature in the rest of dwelling T2	19.34	19.52	19.74	19.95	20.04	20.06	20.06	20.07	20.06	19.96	19.64	19.31	(90)

Living area fraction (25.50 / 50.00) 0.51 (91)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temperature (for the whole dwelling)	19.91	20.06	20.25	20.44	20.52	20.54	20.54	20.54	20.53	20.44	20.16	19.89	(92)
Apply adjustment to the mean internal temperature, where appropriate	19.91	20.06	20.25	20.44	20.52	20.54	20.54	20.54	20.53	20.44	20.16	19.89	(93)

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

8. Space heating requirement

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains												
0.99	0.98	0.94	0.85	0.69	0.49	0.34	0.36	0.58	0.87	0.97	0.99	(94)
Useful gains												
500.18	553.49	575.17	545.22	447.70	303.29	201.63	211.23	328.96	459.62	480.91	477.91	(95)
Monthly average external temperature												
4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature												
832.08	805.72	728.42	601.59	458.36	303.94	201.67	211.29	331.35	511.76	683.36	825.74	(97)
Fraction of month for heating												
1.00	1.00	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	
Space heating requirement for each month, kWh/month												
246.93	169.50	114.02	40.58	7.93	-	-	-	-	38.80	145.77	258.78	

Total space heating requirement per year (kWh/year) (October to May)	1022.31	(98)
Space heating requirement per m² (kWh/m²/year)	20.45	(99)

8c. Space cooling requirement - not applicable

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

9b. Energy requirements

		kWh/year	
Fraction of space heat from secondary system	0.00		(301)
Fraction of space heat from community system	1.00		(302)
Fraction of community heat from Boilers	1.00		(303a)
Fraction of total space heat from Boilers	1.00		(304a)
Factor for control and charging method for community space heating	1.00		(305)
Factor for charging method for community water heating	1.00		(305a)
Distribution loss factor	1.05		(306)
<u>Space heating</u>			
Annual space heating requirement	1022.31		(98)
Space heat from Boilers		1073.43	(307a)
Efficiency of secondary heating system	0.00		(308)
Space heating fuel for secondary system		0.00	(309)
<u>Water heating</u>			
Annual water heating requirement	1454.50		(64)
Water heat from Boilers		1527.23	(310a)
<u>Other energy</u>			
Electrical energy for heat distribution		26.01	(313)
Electricity for pumps and fans within dwelling:			
Electricity for pumps, fans and electric keep-hot			
mechanical ventilation - balanced, extract or positive input from outside (SFP=0.66)		126.09	(330a)
warm air heating system fans		0.00	(330b)
pump for solar water heating		0.00	(330g)
pump for waste water heat recovery		0.00	(330h)
Total electricity for the above, kWh/year		126.09	(331)
Electricity for lighting (100.00% fixed LEL)		232.82	(332)
Energy saving/generation technologies			
PVs 0.80 x 0.600 x 1079.525 x 0.800		414.537	
PVs 0.80 x 0.000 x 0.000 x 0.500		0.000	
PVs 0.80 x 0.000 x 0.000 x 0.500		0.000	
		414.537	(333)
Appendix Q -			
Energy saved or generated ():		0.000	(336a)
Energy used ():		0.000	(337a)
Total delivered energy for all uses		2571.03	(338)

SAP 2012 worksheet for New dwelling as designed - calculation of energy ratings

10b. Fuel costs using Table 12 prices

	kWh/year	Fuel price p/kWh	£/year	
Space heating from Boilers	1073.43	4.240	45.51	(340a)
Space heating (secondary)	0.00	0.000	0.00	(341)
Water heating from Boilers	1527.23	4.240	64.75	(342a)
Mech vent fans	126.09	13.190	16.63	(349)
Warm air heating system fans	0.00	0.000	0.00	(349)
Pump for solar water heating	0.00	0.000	0.00	(349)
Electricity for lighting	232.819	13.190	30.71	(350)
Additional standing charges			120.00	(351)
Electricity generated - PVs	414.537	13.190	-54.68	(352)
Appendix Q -				
Energy saved or generated ():	0.000	0.000	0.00	(353)
Energy used ():	0.000	0.000	0.00	(354)
Total energy cost			222.93	(355)

11b. SAP rating

Energy cost deflator	0.42	(356)
Energy cost factor (ECF)	0.99	(357)
SAP value	86.25	(358)
SAP rating	86.00	(358)
SAP band	**B**	

12b. Carbon dioxide emissions

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year	
Efficiency of Boilers - 96.00%				(367a)
CO2 emissions from Boilers	2709.01	0.2160	585.15	(368)
Electrical energy for heat distribution	26.01	0.5190	13.50	(372)
Total CO2 associated with community systems			598.64	(373)
Total CO2 associated with space and water heating			598.64	(376)
Electricity for pumps and fans	126.09	0.519	65.44	(378)
Electricity for lighting	232.82	0.519	120.83	(379)
Electricity generated - PVs	-414.54	0.519	-215.14	(380)
Electricity generated - µCHP	0.00	0.000	0.00	(380)
Appendix Q -				
Energy saved ():	0.00	0.000	0.00	(381)
Energy used ():	0.00	0.000	0.00	(382)
Total CO2, kg/year			569.77	(383)

	kg/m²/year	
CO2 emissions per m²	**11.40**	(384)
EI value	91.96	(384a)
EI rating	**92**	(385)
EI band	**A**	

Calculation of stars for heating and DHW

Main heating energy efficiency	, stars = 4
Main heating environmental impact	, stars = 4
Water heating energy efficiency	4.45 = 4.4520, stars = 4
Water heating environmental impact	0.24 = 0.2363, stars = 4

9.3.3 BRUKL worksheets

9.3.3.1 Be Lean

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Hampton Hill — As designed

Date: Wed Jul 12 15:35:43 2017

Administrative information

Building Details

Address: 63-71 High Street, Richmond, London, TW12 1LZ

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.4.1"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.4.1

BRUKL compliance check version: v5.2.g.3

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address: , ,

Criterion 1: The calculated CO_2 emission rate for the building should not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	12.3
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	12.3
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	7.9
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and the building services should achieve reasonable overall standards of energy efficiency

Values not achieving standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	External Wall .448
Floor	0.25	0.12	0.12	Ground Floor
Roof	0.25	0.12	0.12	Roof
Windows***, roof windows, and rooflights	2.2	1.89	2.07	Window .6
Personnel doors	2.2	-	-	No personal doors in project
Vehicle access & similar large doors	1.5	-	-	No vehicle doors in project
High usage entrance doors	3.5	-	-	No high usage entrance doors in project

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

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9.3.3.2 Be Clean

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Hampton Hill

As designed

Date: Thu Jul 13 11:56:39 2017

Administrative information

Building Details

Address: 63-71 High Street, Richmond, London, TW12 1LZ

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.4.1"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.4.1

BRUKL compliance check version: v5.2.g.3

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address: , ,

Criterion 1: The calculated CO_2 emission rate for the building should not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	12.3
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	12.3
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	7.7
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and the building services should achieve reasonable overall standards of energy efficiency

Values not achieving standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	External Wall .448
Floor	0.25	0.12	0.12	Ground Floor
Roof	0.25	0.12	0.12	Roof
Windows***, roof windows, and rooflights	2.2	1.89	2.07	Window .6
Personnel doors	2.2	-	-	No personal doors in project
Vehicle access & similar large doors	1.5	-	-	No vehicle doors in project
High usage entrance doors	3.5	-	-	No high usage entrance doors in project

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

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9.4 Appendix D: Sustainable Design Specification Schedule

9.4.1 Residential

Sustainable Design Parameter	Residential
Building Envelope	
Ground Floor Transmittance	0.12 W/m²/K
Walls Transmittance	0.15 W/m²/K
Roof Transmittance	0.12 W/m²/K
Doors, Windows and Roof lights	1.5 W/m²/K
Light Transmittance	0.7
G-value	0.5
Air Permeability @ 50Pa	3m³/hr/m²
Ventilation	
Ventilation Method	Mechanical Ventilation with Heat Recovery and Natural Ventilation - MRXBOXAB-ECO 3 / MRXBOXAB-ECO 4
Heating and DHW	
Apartments	
Heat Generation Plant	Community Heating System Gas Fired Boilers
Boiler Efficiency	96.00%
Heating Controls	Time and Temperature Zone Control
Heat Emitters	Underfloor
Domestic Hot Water	Plate Heat Exchanger
Declared Loss Factor	0.03
Townhouses	
Heat Generation Plant	Combi - Boiler
Boiler Efficiency	90.3
Condensing	Y
Modulating	N
Heating Controls	Time and Temperature Zone Control
Heat Emitters	Underfloor
Boiler Interlock	Y
Weather Compensator	Y
Enhanced Load Compensator	N
Water Heating	Instantaneous
Cooling Method:	
Top Floor Apartments	
Energy Label Class	A
Cooling Energy Efficiency Ratio EER	3.75
System Type	Split - refrigerant
Compressor Control	Modulating

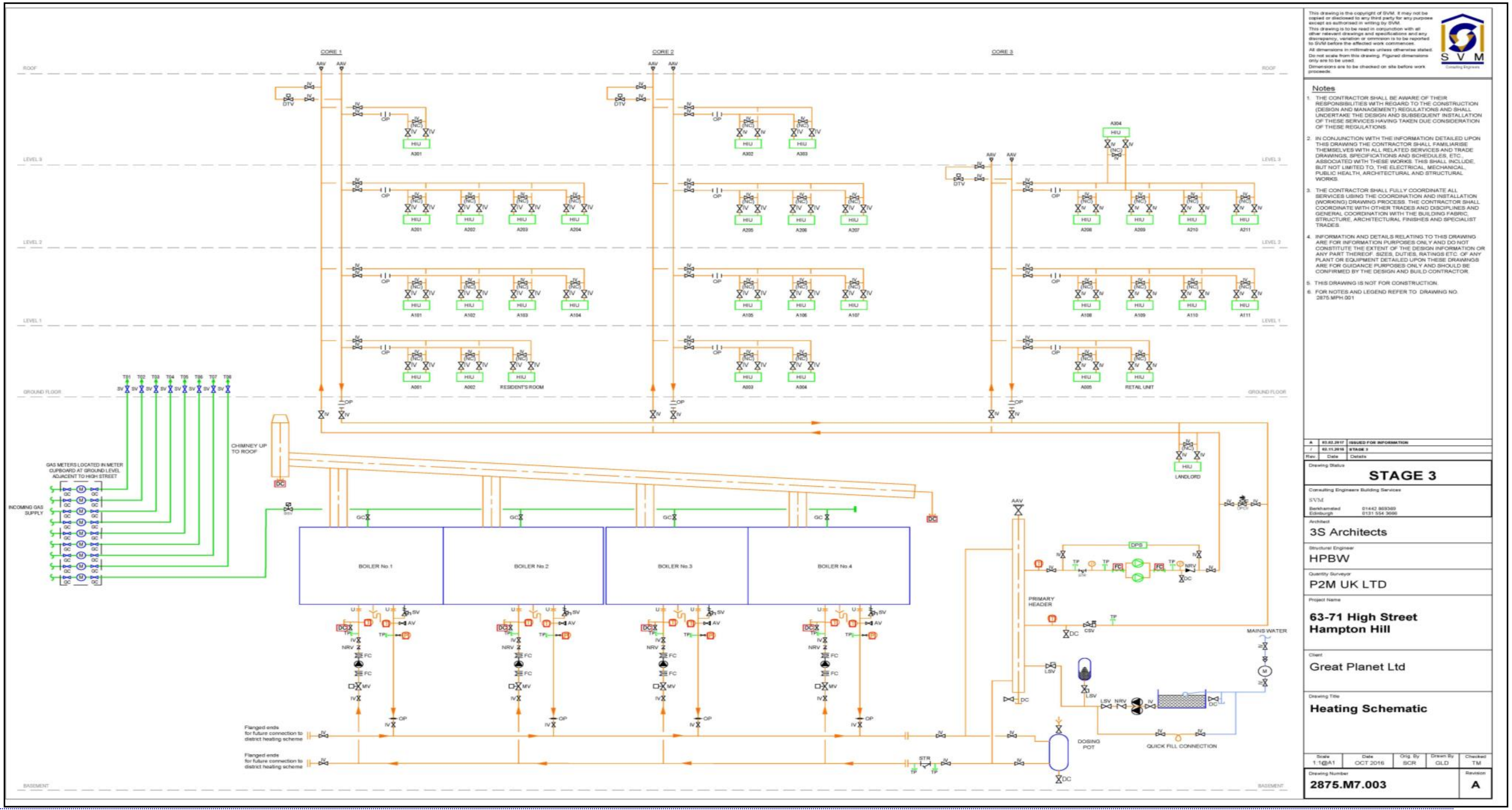
9.4.2 Non-Domestic

Sustainable Design Parameter	Non-Domestic
Building Envelope	
Ground Floor Transmittance	0.12 W/m²/K
Walls Transmittance	0.15 W/m²/K
Roof Transmittance	0.12 W/m²/K
Doors and Windows	
Type	Double Glazed
Doors, Windows and Roof lights	1.5 W/m²/K
Light Transmittance	>0.55
G-value	>0.5
Air Permeability @ 50Pa	3 m³/hr/m²
Electricity Power Factor	>0.95
Ventilation	
Retail	
Ventilation Method	Natural Ventilation
W/C	
Ventilation Method	Extract Only
Specific Fan Power (SFP)	0.3W/l/s
Car Park	
Ventilation Method	Extract Only
Specific Fan Power (SFP)	0.3W/l/s
Plantroom	
Specific Fan Power (SFP)	0.7 (Supply) 0.5 (Extract) W/l/s
Exchanger Sensible Efficiency	0.7
Corridors and Stairs	
Ventilation Method	Natural Ventilation
Lighting	
Retail and Residential Café	
Auto Presence Detection:	Auto on Auto Off
Daylight Control for the zones:	Photocell Control Dimming
Lighting efficacy:	120 Lm/cW

Sustainable Design Parameter	Non-Domestic
Residential Corridors and Stair Cases	
Auto Presence Detection:	Auto on Dimmed
Daylight Control for the zones:	Manual Daylight Control
Lighting efficacy:	130 Lm/cW
W/C	
Auto Presence Detection:	Auto On Auto Off
Daylight Control for the zones:	Manual Daylight Control
Lighting efficacy:	100
Space Heating and DHW	
Heat Generation Plant	Centralised gas fired boiler
Boiler efficiency	96%

9.5 Appendix E: Heating Schematic

The below schematic shows the connection provided allowing for connection to a potential future district heat network.



9.6 Appendix F: Location of Photovoltaics

The roof layout diagram below indicates the location of the proposed building integrated PV roof. Photovoltaics to achieve a circa 32kWp system. Final sizing and details to be confirmed at the technical design stage.