HOARE LEA

Stag Brewery, Mortlake

Energy Strategy

For Reselton Properties

February 2018

Audit sheet

Rev.	Date	Description	Prepared	Verified
00	13.02.2018	For Submission	R. Harper	K. Adair

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1. Executive summary

The Application

This Energy Strategy has been prepared by Hoare Lea on behalf of Reselton Properties Limited ('the Applicant') in support of three linked planning applications for the comprehensive redevelopment ('the Proposed Development') of the former Stag Brewery Site in Mortlake ('the Site') within the London Borough of Richmond Upon Thames ('LBRuT').

The former Stag Brewery Site is bounded by Lower Richmond Road to the south, the river Thames and the Thames Bank to the north, Williams Lane to the east and Bulls Alley (off Mortlake High Street) to the west. The Site is bisected by Ship Lane. The Site currently comprises a mixture of large scale industrial brewing structures, large areas of hardstanding and playing fields.

The redevelopment will provide homes (including affordable homes), a Care Village for an older population, complementary commercial uses, community facilities, a new secondary school alongside new open and green spaces throughout. Associated highway improvements are also proposed, which include works at Chalkers Corner junction.

The three planning applications are as follows:

- Application A – hybrid planning application for comprehensive mixed use redevelopment of the former Stag Brewery site consisting of:
  - Land to the east of Ship Lane applied for in detail (referred to as 'Development Area 1' throughout); and
  - Land to the west of Ship Lane (excluding the school) applied for in outline detail (referred to as 'Development Area 2' throughout).
- Application B – detailed planning application for the school (on land to the west of Ship Lane).
- Application C – detailed planning application for highways and landscape works at Chalkers Corner.

Full details and scope of all three planning applications are described in the submitted Planning Statement, prepared by Gerald Eve LLP.

This report sets out the Energy Strategy for the Proposed Development in three parts

1. A whole site appraisal in outline terms encompassing Application A and B,
2. Further detail for the areas of Application A that will be subject to an application for full planning permission (Development Area 1)
3. Detail for Application B, the School.

This report sets out the Energy Strategy for the Proposed Development for the whole site encompassing Applications A and B, with a greater level of detail for the areas of Application A that will be subject to full planning permission (Development Area 1) and Application B, the School presented in Appendix B.

The Energy Strategy for Development Area 2 is provided in outline. Application C includes landscaping and highways works and therefore is not assessed in this Energy Strategy.

1.1.1 Policies & Drivers

This document summarises the pertinent policies and requirements applicable to the Proposed Development. Of these, the principal target is to achieve a reduction in regulated CO_2 emissions of 35% beyond the requirements of the Building Regulations Part L (2013) for the non-domestic elements of the Proposed Development and 'zero carbon' for the residential aspects, corresponding to a 100% reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013), as set out in the London Plan (2016) and set out in the emerging LBRuT Local Plan (2017).

1.1.2 Approach

The residential elements of the Proposed Development have been assessed using Part L1A 2013 approved SAP v9.92 (2012) methodology. Non-residential spaces have been modelled using Part L2A compliant software or benchmarked using Part L 2013 compliant results from similar building types. This has provided the basis for the analysis of the designed building and services and the consideration of all applicable passive design, energy efficiency and Low or Zero Carbon (LZC) technologies.

The assessment makes use of the Mayor of London's Energy Hierarchy and the cooling hierarchy from the London Plan (2016).

1.2 Be Lean - Passive Design & Energy Efficiency Measures

Passive design measures to be implemented at the Proposed Development include:

1. Suitable glazing ratio and glass g-value (0.35) to balance heat losses, heat gains and daylight ingress.
2. Fabric insulation levels achieving improvements over Building Regulations Part L (2013) requirements of 25% - 100%.
3. Fabric air permeability achieving improvements over Building Regulations Part L (2013) requirements of 75% and 70% for dwellings and commercial spaces respectively.

Energy efficiency measures to be implemented at the Proposed Development include:

1. Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water.
2. Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use.
3. Efficient mechanical ventilation with heat recovery which will limit the need for space heating in winter months, aid the mitigation of high internal temperatures in summer months (where openable windows cannot be used due to ambient acoustic conditions), and maintain good indoor air quality.
4. Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains.
5. Variable speed pumps and fans to minimise energy consumption for distribution of services

The above measures would also be considered for the areas within the outline application of the Proposed Development.

1.2.1 Whole Site – Application A and B

It is anticipated that the areas within the whole site will perform to a comparable level to the calculations undertaken for Development Area 1.

Based on this level of performance the areas of the Proposed Development would be expected to achieve **~2%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' on a site wide basis.

1.2.2 Application A – Development Area 1

These measures are anticipated to achieve **~3%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' for the areas within the application. When considering the residential elements alone, it is anticipated that a **~1%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' will be achieved.

Furthermore, it has been calculated based on the parameters outlined within this report and the SAP calculations undertaken that the dwellings will improve upon the requirements of Target Fabric Energy Efficiency (TFEE) included in Part L 2013.

As a result, the Proposed Development will achieve compliance with the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

1.2.3 Application A – Development Area 2

The passive design measures are anticipated to achieve a reduction in regulated CO_2 emissions to demonstrate compliance with the Building Regulations Part L (2013) 'baseline' for the areas within the application at the Be Lean stage. Opportunities to implement passive design measures to achieve a reduction in CO_2 emissions at the Be Lean stage would be considered in detailed design.

As a result, the Proposed Development will achieve compliance with the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

1.2.4 Application B - School

These measures are anticipated to achieve **~6%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' for the school.

As a result, the Proposed Development will achieve compliance with the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

1.3 Be Clean - Infrastructure and Low-Carbon Supply of Energy

The Proposed Development is proposing a staggered approach across the two Development Areas of Application A. An energy centre is proposed to be provided within the basement of each area as per discussions at the Pre-App stage with the GLA. This will provide flexibility for the areas that will be subject to a reserved matters application (Development Area 2) to maximise the availability of CO_2 emissions reductions when this area is brought forward for development.

The school will be serviced by its own energy centre independently from the heat networks associated with Application A. The programme for construction of the school is anticipated to be brought forward at the same time as Development Area 1. The development of the school site is not under the applicants control and therefore the energy strategy allows for Application B to be brought forward independently.

The townhouses within Development Area 2 are also to be serviced separately with individual boilers located within each town house.

1.3.1 Whole Site – Application A and B

On the basis that the CHP engines within the two energy centres would supply 91% of the hot water requirements and up to 30% of the space heating requirements of the areas within the whole site, it is expected that a reduction in regulated CO_2 emissions of **443tonnes** per annum can be achieved using Part L 2013 carbon factors. This is equivalent to a further **17.2%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 'baseline'.

When considering the dwellings in Application A separately, the contribution of the CHP engines is equivalent to **~17.5%** reduction beyond the Building Regulations Part L 2013 'baseline' and **242tonnes** of CO_2.

1.3.2 Application A – Development Area 1

The energy centre within Development Area 1 is deemed to be better placed to supply the areas of Development Area 1 only, via the implementation of a single energy centre. When considering the dwellings within Development Area 1 separately and on the basis that the CHP engine will supply 97% of the hot water requirements (anticipating that point of use electric water heaters will be used in A1 retail and office spaces) and up to 30% of the space heating requirements of the Proposed Development, it is expected that a reduction in regulated CO_2 emissions of **144tonnes** per annum can be achieved. This is equivalent to a further **18.5%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 'baseline'.

When considering all of the areas within the Development Area 1 of Application A the contribution of the CHP engine is equivalent to **~16.0%** reduction beyond the Building Regulations Part L 2013 'baseline' for the dwellings, equivalent to **197tonnes** of CO_2 emissions.

1.3.3 Application A – Development Area 2

On the basis that CHP would provide for 99% of the domestic hot water demand in Development Area 2 and up to 26% of the space heating demand the energy centre would require a CHP engine with rated output of **378kW$_e$ and 401kW$_{th}$**.

It is anticipated that with CHP of this size, allowing for losses and pumping associated with the heat network, would reduce regulated CO_2 emissions by approximately **212** tonnes per annum. This is equivalent to a reduction of **~18.5%** beyond the Building Regulations Part L 2013 'baseline'.

At reserved matters submission an energy strategy that provides beneficial CO_2 emissions reductions in accordance with policy and building regulations at the time of the reserved matters submission would be submitted for consideration with the application at that time. This would seek to avoid the scenario whereby the entire site is locked into an energy strategy that may not deliver optimum life-cycle CO_2 benefits. This approach would provide more flexibility in the longer term with respect to energy sources, and maximising carbon emissions reductions throughout the lifetime of the development.

1.3.4 Application B - School

For the school a CHP engine has been assessed to supply 100% of the hot water and 30% of the space heating demands. It is expected that if a CHP is feasible for the school a reduction in regulated CO_2 emissions of **31tonnes** per annum can be achieved. This is equivalent to a further **17.6%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 'baseline'.

1.4 Be Green - On-Site Renewable Energy Generation

The inclusion of on-site renewable energy generation has been assessed.

1.4.1 Whole Site – Application A and B

It is anticipated that a PV array with a total area of 520m^2 would be provided on the roof area of the Proposed Development. Based on the solar irradiance data for London, an array of this size would generate approximately 57,200kWh of electricity per annum, reducing CO_2 emissions by **30tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **1.2%** beyond the Building Regulations Part L (2013) 'baseline' for the anticipated emissions of the Proposed Development (Application A and B). Further opportunities to increase the area of the PV array will be provided in the reserved matters submission(s).

When considering the domestic use areas separately if this array was to be connected to the supply to the dwellings the contribution is equivalent to a **2.1%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'.

PV is therefore anticipated to be a suitable addition to the Proposed Development in pursuit of further reductions in regulated CO_2 emissions.

1.4.2 Application A – Development Area 1

Considering the available roof space of Development Area 1, and allowing for access and maintenance requirements, a total solar PV system size in the region of 520m^2 array area will be included in the Proposed Development as shown in Appendix D.

Based on the solar irradiance data for London, an array of this size would generate approximately 57,200kWh of electricity per annum, reducing CO_2 emissions by **30.0 tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **2.4%** beyond the Building Regulations Part L (2013) 'baseline' on the CO_2 emissions of Development Area 1. When considering the residential elements separately, the contribution is equivalent to a **3.7%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'. It is proposed that the whole array is connected to the distribution to the dwellings subject to detailed design considerations.

PV is therefore deemed to be a suitable addition to the Proposed Development in pursuit of further reductions in regulated CO_2 emissions.

1.4.3 Application A – Development Area 2

At the reserved matters submission the available roof space of Development Area 2, for the installation of a solar PV system size would be considered. It is anticipated that this array would contribute to a reduction in CO_2 emissions of at least 1% beyond Part L 2013.

1.4.4 Application B – School

PV is not proposed to be located on the school building as the roof area is being used to provide a multi-use games area and is also allocated for plant.

1.5 Overall Carbon Dioxide Emissions Reduction

A summary of the anticipated CO_2 emissions and reduction at each step of the energy hierarchy is given in Table 1.1 below. This captures the CO_2 emissions that would be used to calculate a potential offset payment for the whole site including the areas associated with Application A and B. The calculation of the Carbon Offset payment needs to be dealt with on a bespoke basis for a mixed use scheme of the scale.

1.5.1 Application A

Table 1.1 Summary of CO_2 emissions reductions and offset payment for the Application A.

Domestic Use Areas	Estimated Regulated Carbon Dioxide Emission Savings for Domestic Use Buildings	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	15	1.1%
Savings from heat network / CHP (Clean)	242	19.2%
Savings from renewable energy (Green)	30	2.1%
Total Cumulative Savings	**288**	**20.7%**
Total Target Reduction	**1381**	100%
Non-Domestic Areas	Estimated Regulated Carbon Dioxide Emission Savings for Non-Domestic Buildings	
	(tonnesCO_2/yr)	(%)
Savings from energy demand reduction (Lean)	23	2.0%

Savings from heat network / CHP (Clean)	184	19.0%
Savings from renewable energy (Green)	-	-
Total Cumulative Savings	**207**	**21.0%**
Total Target Reduction	**347**	35%

Application A	Total Regulated Emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage Savings (%)
Part L 2013 baseline	2,386	-	-
Be Lean	2,348	38	1.6%
Be Clean	1,920	428	17.9%
Be Green	1,890	30	1.3%
Total Cumulative Savings	**496**	**496**	**20.8%**

1.5.2 Application A – Development Area 1

A summary of the anticipated CO_2 emissions and reductions at each step of the energy hierarchy is given in Table 1.2 below. The Proposed Development achieves an overall 21% reduction in regulated CO_2 emissions when considering the Development Area 1 of Application A.

Table 1.2 Summary of CO_2 emissions reductions for Development Area 1.

Development Area 1 Total	Total Regulated Emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage Savings (%)
Part L 2013 baseline	1,238	-	-
Be Lean	1,205	33	2.7%
Be Clean	1,007	198	16.4%
Be Green	977	30	2.9%
Total Cumulative Savings	**261**	**261**	**21.0%**

1.5.3 Application B – The School

A summary of the anticipated CO_2 emissions and reduction at each step of the energy hierarchy is given in Table 1.3 below. The application for the School achieves an overall **24%** reduction in regulated CO_2 emissions when considering the School.

Table 1.3: Summary of CO_2 emissions reductions for the School (Application B).

School Areas		Estimated Regulated Carbon Dioxide Emission Savings for Residential Buildings	
	Total Regulated Emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage Savings (%)
Part L 2013 baseline	176	-	-
Be Lean	166	11	6.3%
Be Clean	135	31	17.6%
Be Green	135	-	-
Total Cumulative Savings	**42**	**42**	**23.8%**
Total Target Reduction	**-**	**62**	**35%**

1.5.4 Carbon Offset

Application A and B Total	
Potential Annual Off-set (Residential Areas)	1,093 tCO_2
Potential Annual Off-set (Non-residential Areas)	137 tCO_2
Potential Annual Off-set (School)	20 tCO_2
Total Annual Off-set (Application A and B)	1,250 tCO_2

Table 1.3: Carbon Offset

1.6 Minimising Cooling Demand and Limiting the Effects of Heat Gains in Summer Months

The Proposed Development has been designed in accordance with the cooling hierarchy to minimise cooling demand and limit the likelihood of high internal temperatures. Mitigation measures such as suitable glazing ratio and g-value, appropriate ventilation levels and minimisation of internal heat gains will be implemented. Through these measures, relevant areas of the Proposed Development will achieve compliance with Criterion 3 of the Building Regulations Part L (2013).

An overheating risk assessment has been carried out on the proposals for Development Area 1, in accordance with recent GLA policy, using the CIBSE TM59 methodology. A completed overheating checklist has also been provided in this report. Active cooling will not be provided for the residential areas of Development Area 1.

The following mitigation measures have been implemented in the design of the Proposed Development:

a. Energy efficient lighting (such as LED or compact fluorescent) with low heat output
b. Insulation to heating and hot water pipework and minimisation of dead-legs to avoid standing heat loss (from pipework to dwellings) including no-hot water storage in the dwellings
c. HIUs located away from main living spaces
d. Environmental controls within the common corridors to provide ventilation

e. Increased mechanical ventilation rates beyond minimum Building Regulations requirements.

The results show a hybrid ventilation strategy which enables more than 83% of living rooms, kitchens and bedrooms assessed to meet the CIBSE TM59 requirements of the first criteria of the adaptive thermal comfort model and over 91% of bedrooms meet the second criteria.

All dwellings will be provided with opening windows and therefore the adaptive thermal comfort model has been used as the benchmark in this analysis. The ventilation design includes MVHR to all units to extract stale air and provide fresh background air, with enhanced ventilation rates to provide additional mechanical ventilation during periods of warmer ambient conditions.

As a result of the above considerations, the risk of high internal temperatures in summer has been minimised as far as practically possible from passive measures for the residential dwellings, within architectural and practical constraints, and this has been demonstrated via overheating calculations in compliance with current CIBSE guidance.

2. Introduction

2.1 The Application

This Energy Strategy has been prepared by Hoare Lea on behalf of Reselton Properties Limited ('the Applicant') in support of three linked planning applications for the comprehensive redevelopment ('the Proposed Development') of the former Stag Brewery Site in Mortlake ('the Site') within the London Borough of Richmond Upon Thames ('LBRuT').

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2.2 Policies & Drivers

This section summarises the pertinent policies and requirements applicable to the Proposed Development. Of these, the principal target is to achieve a reduction in regulated CO_2 emissions of 35% beyond the requirements of the Building Regulations Part L (2013) for the non-domestic elements of the Proposed Development and 'zero carbon' for the residential aspects, corresponding to a 100% reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013), as set out in the London Plan (2016) and set out in the LBRuT emerging Local Plan (2017). The Proposed Development is referable to the Mayor of London.

2.2.1 Current Policy Framework

The policies considered when preparing this strategy are contained in the London Plan (Greater London Authorities (GLA), March 2016) and the Local Plan documents of LBRuT. These policies are reviewed in further detail in Appendix A and summarised below.

2.2.2 Building Regulations Part L 2013

The assessment of the Proposed Development against policy targets has been carried out using Part L 2013 benchmarks.

Criterion One of the Building Regulations Part L (2013) requires that the building as designed is not anticipated to generate CO_2 emissions in excess of that set by a Target Emission Rate (TER) calculated in accordance with the approved National Calculation Methodology (NCM).

On aggregate, Part L 2013 requires the following CO_2 emissions reductions:

- 6% beyond the requirements of Part L 2010 for dwellings.
- 9% beyond the requirements of Part L 2010 for non-domestic buildings.

Criterion Two places upper limits on the efficiency of controlled fittings and services for example, an upper limit to an external wall U-value of $0.35W/m^2.K$ (new non-domestic buildings).

Criterion Three requires that spaces are not subject to excessive solar gains. This is demonstrated using the procedure given in the National Calculation Methodology.

2.2.3 The London Plan (March 2016) Consolidated with Alterations Since 2011

The regional policies of the GLA are contained within the London Plan (2016), and the relevant SPGs.

The latest version of the consolidated London Plan (2016) was published and adopted in March 2016 and is current for any Stage 1 submissions to the GLA. This constitutes the London Plan 2011 consolidated with:

- Revised Early Minor Alterations to the London Plan (October 2013)
- Further Alterations to the London Plan (March 2015)
- Housing Standards Minor Alterations to the London Plan (March 2016)
- Parking Standards Minor Alterations to the London Plan (March 2016)
- Housing Supplementary Planning Guidance (March 2016)
- GLA guidance on preparing energy statements (March 2016)

The target reduction in CO_2 emissions for Residential Buildings is to achieve ‘zero carbon homes’ for Stage 1 applications. The definition of this is clarified in the GLA’s publication G*uidance on Preparing Energy Assessments*. The target for ‘Non-Domestic Buildings’ is to achieve 35% reduction in CO_2 emissions.

Use Type	CO_2 Reduction Target (beyond Part L 2013)	
	2013 – 2016	2016 – 2019 (1st October 2016)
Residential Buildings	35%	**‘Zero Carbon’**
Non-Domestic Buildings	35%	35%

Table A1: Uplift in CO_2 emissions targets

2.2.3.1 London Plan Policy

Development within LBRuT is subject to the policy requirements of the London Plan 2016. The following policies of the London Plan (2016) have informed this strategy.

Policy 5.2: Minimising CO_2 Emissions

Policy 5.2 sets out the target CO_2 emission reductions as described above.

Policy 5.6: Decentralised Energy in Development Proposals

Policy 5.6 requires development proposals to evaluate the feasibility of Combined Heat & Power (CHP) systems and where a new CHP system is appropriate, examine opportunities to extend the system beyond the Site boundary. Developments should select energy systems on the following hierarchy:

a. connection to existing heating or cooling networks
b. site wide CHP network
c. communal heating and cooling

Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7: Renewable Energy

Policy 5.7 requires that developments should provide a reduction in expected CO_2 emissions through the use of on-site renewable energy generation, where feasible.

2.2.3.2 London Plan Policy 5.9: Overheating and Cooling

The GLA have produced a ‘Domestic Overheating Checklist’ (Appendix 5 of the ‘Energy Planning’ guidance) for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The ‘Energy Planning’ guidance document also includes an update to the guidance on compliance with overheating policy that design teams should be aware of when undertaking risk analysis and thermal comfort modelling for dwellings.

It is the GLA’s expectation that dynamic thermal modelling should be undertaken to determine overheating risk and demonstrate compliance with London Plan Policy 5.9. This should be in addition to the Building Regulations ‘Criterion 3’ assessment of heat gains in summer months.

The GLA has set out that dynamic modelling should be carried out in accordance with the guidance and data sets in CIBSE TM49 ‘Design Summer Years’ for London (2014) using the three design weather years as follows:

- 1976: a year with a prolonged period of sustained warmth.
- 1989: a moderately warm summer (current design year for London).
- 2003: a year with a very intense single warm spell.

For developments in high density urban areas (e.g. Canary Wharf) and the ‘Central Activity Zone’ the ‘London Weather Centre’ data set should be used. In lower density urban and suburban areas the ‘London Heathrow’ dataset should be used. These data sets have been adjusted to account for future climate effects.

The modelling should also consider the additional guidance contained in CIBSE TM52 ‘The Limits of Thermal Comfort: Avoiding Overheating in European Buildings’.

2.2.3.3 GLA Sustainable Design and Construction SPG (April 2014)

This SPG provides more detailed guidance to aid implementation that cannot be covered in the London Plan. It updates the standards that were developed for the Mayor’s SPG on Sustainable Design and Construction in 2006 and identifies these as priorities for the Mayor. The SPG provides guidance and practical advice for those designing schemes including architects, developers and engineers as well as those developing planning policy and neighbourhood plans.

2.2.4 LBRuT Policy

The pertinent targets of the LBRuT policies are:

2.2.4.1 Local Development Framework: Core Strategy (2009)

CP2 Reducing Carbon Emissions
All new developments are required to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation, unless it can be demonstrated that this is not feasible.

CP3 Climate Change – Adapting to the Effects
Development will need to be designed to take account of the impacts of climate change over its lifetime, including:

- Water conservation and drainage
- The need for Summer cooling
- Risk of subsidence
- Flood risk from the River Thames and its tributaries

2.2.4.2 Local Development Framework Development Management Plan (2011)

DM SD 1 Sustainable Construction
All development in terms of materials, design, landscaping, standard of construction and operation should include measures capable of mitigating and adapting to climate change to meet future needs.

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 to 2013, 40 per cent improvement from 2013 to 2016, and 'zero carbon' standards (2) from 2016.

New non-residential buildings over 100sqm will be required to meet the relevant BREEAM 'excellent' standards.

Policy DM SD 2 Renewable Energy and Decentralised Energy Networks
New developments are required to 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.

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

2.2.4.3 Emerging Local Plan (anticipated adoption Spring 2018)

Policy LP22 Sustainable Design and Construction
LP22 B - Reducing Carbon Dioxide Emissions
1. All new major residential developments should achieve zero carbon standards in line with London Plan policy.
2. All other new residential buildings should achieve 35% reduction
3. All major non-residential buildings should achieve a 35% reduction. From 2019 all major non-residential should achieve zero carbon standards in line with London Plan Policy.

LP22 C - Decentralised Energy Networks
1. All new development required to connect to existing DE network where feasible (including planned DE networks operational within 5 years of development completion).
2. Major developments will need to provide an assessment of the provision of on-site DE networks and CHP.
3. Where feasible, major developments will need to provide on-site DE and CHP. Provision for future connection should be incorporated where required.

2.3 Site Context

The site plan shows the former Stag Brewery Site is bounded by Lower Richmond Road to the south, the river Thames and the Thames Bank to the north, Williams Lane to the east and Bulls Alley (off Mortlake High Street) to the west. The Site is bisected by Ship Lane. The Site currently comprises a mixture of large scale industrial brewing structures, large areas of hardstanding and playing fields.

2.3.1 Aim

The aim of this strategy is to detail a robust energy demand reduction and supply strategy to enable the Proposed Development to meet the targets set out in the emerging LBRuT Local Plan (2017), and GLA London Plan (2016).

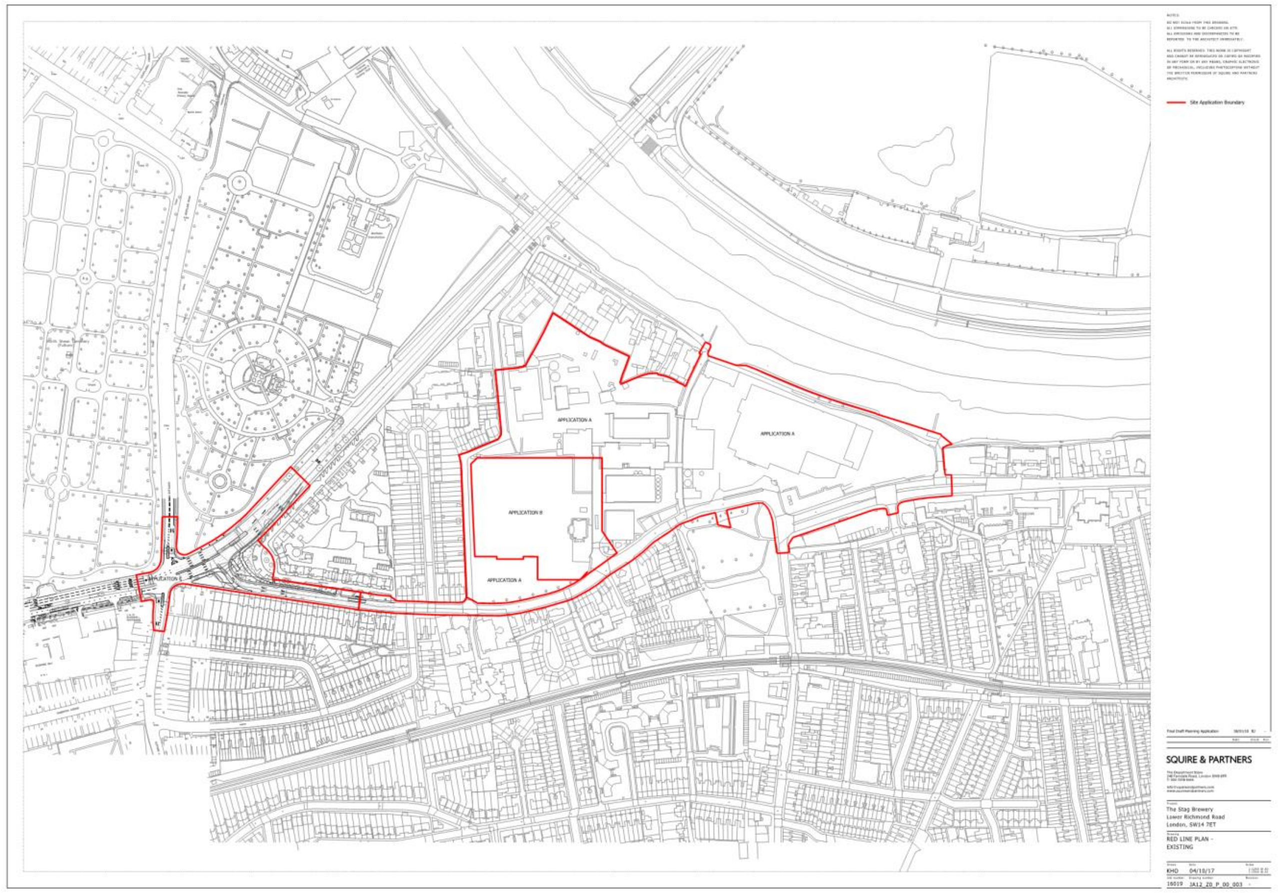


Figure 2.1: Site Plan

3. Approach and Methodology

3.1 Definitions

The following definitions should be understood throughout this strategy:

- **Energy demand** – the 'room-side' amount of energy which must be input to a space to achieve comfortable conditions. In the context of space heating, this is the amount of heat which is emitted by a radiator, or other heat delivery mechanism.
- **Energy requirement** – the 'system-side' requirement for energy (fuel). In the context of a space heating system using a gas boiler, this is the amount of energy combusted (e.g. gas) to generate useful heat (i.e. the energy demand).
- **Regulated CO_2 emissions** – the CO_2 emissions emitted as a result of the combustion of fuel, or 'consumption' of electricity from the grid, associated with regulated sources (those controlled by Part L of the Building Regulations).

3.2 Limitations

The appraisals within this strategy are based on Part L calculation methodology and should not be understood as a predictive assessment of likely future energy requirements or otherwise. Occupants may operate their systems differently, and / or the weather may be different from the assumptions made by Part L approved calculation methods, leading to differing energy requirements.

3.3 Approach

This strategy outlines how the Proposed Development could have a reduced effect on climate change by reducing CO_2 emissions associated with energy use in buildings.

Figure 3.1 outlines the route followed by the Proposed Development when reducing CO_2 emissions and defines the structure of this statement.

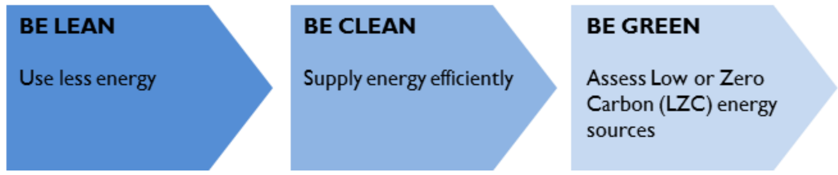


Figure 3.1: Energy Hierarchy

The strategic approach to the design of the proposed development has been to maximise the energy efficiency of the development through the incorporation of passive design led solutions during the construction process, with the integration of low carbon technology to maximise reduction of carbon emissions from the development.

Further reductions are ensured through the specification of high-efficiency building services to limit losses in energy supply, storage and distribution.

After the inclusion of passive design and energy efficiency measures, various options have been investigated to reduce CO_2 emissions associated with energy supply. The feasibility of LZC technologies has been investigated in line with the policy aspirations.

3.4 Methodology

The areas outlined in Table 3.1 have been used to undertake the appraisals described within this strategy as advised by the architect. Please note that these areas refer to conditioned spaces only and excludes the basement car park, energy centres and other non-conditioned spaces that are subject to the CO_2 emissions calculations of Part L of the building regulations.

It should be noted that some flexible commercial floor space is proposed as part of the scheme (Class A1/A2/A3/A4/B1/D1/Boathouse). In the calculations the maximum floor area has been allocated to these uses in the following order to generate a 'worst case' energy demand and CO_2 emissions:

1. A3,
2. A1,
3. B1

This is not to be taken as a suggestion that these areas are set in the Proposed Development. This Energy Strategy is an assessment of Application A and B. Further information on the energy strategy for full applications for Development Area 1 of Application A and Application B the School, is presented in Appendix B. Application C includes landscaping and highways works and therefore is not assessed in this Energy Strategy.

Flexible use spaces are set within the following maximum floor area per use with the maximum floor area for flexible uses at 4,664m^2.

Use	Maximum floorspace (m^2)
Retail (A1)	2,500
Financial and Professional services (A2)	200
Cafes/restaurants (A3)	2,200
Drinking Establishments (A4)	1,600
Offices (B1)	2,000
Community Use (D1)	1,148
Boathouse (Sui Generis)	351

Table 3.1: Flexible Use Maximum Areas

From this proposal the areas used in the calculation of energy use and CO_2 emissions in this Energy Strategy are set out in the table below.

3.4.1 Whole Site Application

Calculations demonstrating the energy requirements and associated CO_2 emissions for the dwelling areas have been undertaken using SAP assessment results from the calculations undertaken for the full application of Development Area 1. Calculations for the commercial uses have been carried out using benchmarks from similar Part L2A 2013 compliant buildings. The Whole Site (Applications A & B) areas include all areas of the Proposed Development as set out in table 3.2.

Use	Area (m^2)
Dwellings (Development Area 1)	47,943
Refurbishment Dwelling Area	2,968
Retail (Flexible Use space)	2,500
Restaurant (Flexible Use space)	2,164
Hotel	1,668
Office	2,424
Cinema	2,120
Gym	740
Management Office	33
Total Development Area 1	**61,764**
Townhouses	3,912
Dwellings (Development Area 2)	25,005
Flexible Residential/Assisted Living Apartments	14,737
Care Home	9,472
Total Development Area 2	**49,214**
School	**9,319**
Overall Total	**120,297**

Application A

Table 3.2: Area Schedule.

The following Part L 2013 compliant carbon factors in table 3.3 were used to convert the energy consumption figures into CO_2 emissions for the Proposed Development.

Fuel	Emission Factor ($kgCO_2/kWh$)
Gas	0.216
Electricity	0.519

Table 3.3: Building Regulations Part L 2013 CO_2 Emission Factors.

4. Appraisal – Whole Site (Application A & B)

4.1 Be Lean – Passive Design & Energy Efficiency Measures

The following sections outline the considerations of the passive design and energy efficiency measures that could be implemented at the Proposed Development.

4.1.1 Passive Design Measures

Passive Design measures are those which reduce the demand for energy within buildings, without consuming energy in the process.

These are the most robust and effective measures for reducing CO_2 emissions as the performance of the solutions, such as wall insulation, is unlikely to deteriorate significantly with time, or be subject to change by future property owners. In this sense, it is possible to have confidence that the benefits these measures would continue at a similar level for the duration of their installation.

4.1.1.1 Building Envelope

A 'fabric first' approach would be taken in order to reduce the energy demand and CO_2 emissions from the Proposed Development. The overriding objective for the façade design of each building would be to achieve the optimum balance between providing natural daylighting benefits to reduce the use of artificial lighting, the provision of passive solar heating to limit the need for space heating in winter, and limiting summertime solar gains to reduce space cooling demands.

4.1.1.2 Glazing Energy & Light Transmittance

With the glass technology currently available on the market, glazing ratio is an important metric to drive efficiency, whilst carefully balancing design and daylight / sunlight requirements.

Glazing ratio to dwellings would be balanced to maximise the benefit that solar gains can bring in winter months, whilst recognising that with glazing to northerly orientations, heat loss becomes a more critical consideration as these dwellings do not benefit from solar gains in winter.

The focus of the office facade design would be to maximise the benefits of passive solar heating in winter months whilst limiting the risk of summertime overheating within the building. Percentages of glazing in combination with the use of external solar shading systems and / or solar control glazing and appropriate g-values would be considered.

Other non-domestic elements of the Proposed Development are less sensitive to the extent of glazing. In a retail context, glazing to the street level would be 'display' windows for A1 units for the purposes of allowing retailers to display goods and services. As such, the retail façades would be designed to achieve a balance between the display requirements of the tenants and the requirement to insulate the buildings and control insolation. Areas such as the care home would consider increased glazed areas to provide the benefits of natural light and views out for the residents of the accommodation.

The school would be designed to provide daylight into the occupied spaces which are situated where possible on the outer edge of the building. The internal areas have been set aside for core areas and areas which are sensitive to daylight, such as lecture theatres. This design maximises the use of the available daylight in the building.

4.1.1.3 Thermal Insulation

It is anticipated that the Proposed Development would benefit from an efficient thermal envelope. Heat losses and gains would be controlled by the optimisation of the fabric of each building, i.e. ensuring appropriate levels of glazing to control winter heat loss and summer heat gain. Reducing the thermal transmittance of the building envelope where appropriate would help to reduce both heating and cooling requirement and result in lower energy requirements.

Improvements upon the U-value performance standards required by Building Regulations Part L 2013 would be implemented in the non-domestic areas and the school where determined to be beneficial and viable.

4.1.1.4 Thermal Mass

Thermal mass is the term given to describe the ability of a structure to absorb and emit heat. It is a product of the physical properties of materials. A low thermal mass would mean that internal heat gains and solar gains could not be absorbed by the fabric. Where these gains are not exhausted through ventilation, these could lead to a risk of overheating in summer months. A medium or a high thermal mass can assist to mitigate the risk summertime overheating.

The thermal mass of exposed concrete or masonry in a building can be used in a similar way. The high heat capacity of these materials can be used to absorb heat during the daytime operation of a building thus reducing cooling requirements. This heat can then be released during the following night. As well as attenuating the cooling load this could also reduce heating requirements at night, particularly during spring and autumn. A high thermal mass parameter (TMP) could lead to the 'response' of heating systems being reduced, as the heating system would need to heat both the air within the dwelling, and the fabric of the dwelling in order to provide for the thermal comfort of the occupant.

The use of a medium thermal mass where appropriate in the dwellings, non-domestic areas and the school would be assessed in order to reduce the peak cooling loads or improve thermal comfort.

4.1.1.5 Fabric Air Permeability

Fabric air permeability is a measure of the volume of air that can penetrate through the fabric of a building, leading to ventilation heat loss and gain.

High air permeability can lead to uncomfortable draughts and dramatically increase the demand for space heating in winter, and space cooling in summer, when the air-flow works in reverse i.e. cool air escaping from the building. Each building would be designed to achieve a high standard in order to reduce air infiltration rates through the incorporation of robust building detailing and high quality construction techniques.

The Proposed Development would target an air permeability rate of $3m^3/h.m^2$ at 50Pa for the dwellings and the school. This is a 70% reduction beyond that required by Building Regulations Part L 2013. The non-domestic areas would target a rate of $5m^3/h.m^2$ at 50Pa.

4.1.2 Energy Efficiency Measures

Energy efficiency measures are those which seek to service the demand for energy (i.e. the remaining demand after implementation of passive design measures) in the most efficient way.

4.1.2.1 Heating

The Proposed Development would benefit from connections to on site energy centres serving a heat network to the areas of Development Area 1 and Development Area 2 respectively (the school will be independent of each heat network with its own energy centre). This network would be served by high efficiency gas boilers of at least 90% efficiency, and Low or Zero Carbon (LZC) technology, i.e. CHP (please refer to section 4.2 for details on CHP). It is proposed that each area of the Proposed Development will have an energy centre that will serve the heat network for the buildings of the respective area.

Buildings would connect to the network via heat substations linked to building-side distribution. Where appropriate the non-domestic units and dwellings within each building would connect to their respective building side networks via Heat Interface Units (HIU) (Figure 4.1). The school will use primary distribution pipework connected to the onsite energy centre to supply heat to the relevant heat emitters throughout the building.

Figure 4.1: Typical Heat Interface Unit.

HIUs would be insulated in accordance with the guidelines in the Building Regulations and the Mayor of London's District Heating Manual for London (2013). This would maximise system efficiency by reducing as far as practically possible the heat loss from the pipework.

Consideration will be given at the point of any reserved matters submissions for Development Area 2 of Application A to the most appropriate heat generating technologies in accordance with LBRuT and GLA planning policies and their connection to a district heat network for a distinct number of dwellings and commercial areas.

A means to connect the heat networks for each area and to connect to a wider district heat network would also be provided to allow for future connection should this be technically, economically and legally viable to do so.

All Low Temperature Hot Water (LTHW) network and primary pipework would be insulated to maximise system efficiency and guard against excessive distribution heat loss.

The fit out of the non-domestic spaces would be the responsibility of the individual tenants. The tenants would be required to implement highly efficient systems and in line with the standards outlined in the Non-Domestic Building Services Compliance Guide (2013). Sufficient plant space would be provided for each tenant to install their own plant (at roof or basement level as appropriate).

4.1.2.2 Hot Water

Similarly, it is anticipated that the domestic hot water associated with the apartments and non-domestic areas that have high usage of hot water such as the care home, flexible residential/assisted living and hotel would be satisfied through a connection to the respective heat network.

During detailed design, dead-legs would be minimised to ensure the efficiency of the system is maximised. All spaces would include the provision of water efficient fixtures and fittings, including WCs with low flush volume and flow reducers in the taps of wash hand basins.

It is anticipated that tenants of the office space would use point-of-use electric water heaters or similar in tea points to reduce distribution losses where hot water use is low. Furthermore, tenants would be encouraged to select water efficient fixtures and fittings where possible, and would be required to meet the performance stipulations within the Building Regulations Part G at the time of fit-out.

The fit out of the commercial spaces would be the responsibility of the individual tenants. The tenants would be advised to implement highly efficient systems and in line with the minimum standards outlined in the Non-Domestic Building Services Compliance Guide (2013). Sufficient plant space would be provided for each tenant to install their own plant (at roof or basement level as appropriate).

4.1.2.3 Cooling

It is currently proposed that the dwellings and assisted living apartments would not be provided with cooling. Internal temperatures would be modulated through passive and energy efficient design, mechanical ventilation and the opportunity to utilise opening windows.

It is anticipated that the requirement for space cooling within the office space would be satisfied by a VRF system to provide peak lopping of internal temperatures during summertime. Consideration would be given for commercial areas such as the care home, hotel and school to be provided with openable windows for use by occupants. This could enable a 'mixed mode' strategy to be employed when external conditions allow as well as the ability for night purging to further reduce energy use and running costs.

The fit out of the retail space would be the responsibility of the individual tenants. Tenants would be required to implement efficient systems in line with the standards outlined in the Non-Domestic Building Services Compliance Guide (2013). Sufficient plant space would be provided for each tenant to install their own plant (at roof or basement level as appropriate).

4.1.2.4 Lighting

Dwellings, assisted living apartments and the care home would be provided with low-energy, efficient light fittings throughout. External lighting for dwelling amenity areas would also be low-energy efficient fittings, and will be linked to daylight sensors and / or presence detectors to prevent unnecessary use. In all cases, lighting will be provided to meet the requirements of the Building Regulations Part L.

Tenants of commercial areas would be encouraged to select high-efficiency lighting systems wherever possible, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013).

Considering the importance of efficient lighting in terms of reducing CO_2 emissions from commercial uses, tenants would be advised of the targets quoted in luminaire lumens per circuit Watt (lml/Wc) in Table 4.1 as follows:

Lighting	Lighting Efficacy (lm/W_c)	
	'Good Practice' Requirement	'Best Practice' Option
General	55	70
Display	22	80

Table 4.1: Commercial Lighting Efficacy.

Therefore, it is anticipated that the Proposed Development would be supplied with efficient electric lighting that could include 'Compact Fluorescent Lamps' (CFL), 'Light Emitting Diodes' (LED) or similar low energy lamps with efficiencies of >45lm/W. Typically, CFL and LED lights far exceed the 45lm/W target and can achieve ~70lm/W to ~90lm/W.

The specification of lighting would be carried out in conjunction with lighting control systems incorporating daylight linkage and presence detection.

As well as reduced energy requirement that would be achieved by implementing these strategies, the contribution to the cooling requirements, particularly within the commercial areas would be reduced. This would further reduce the total energy requirements and CO_2 emissions of each building.

The fit out of the retail space would be the responsibility of the individual tenants. The tenants would be advised to implement efficient lighting in line with the minimum standards outlined in the Non-Domestic Building Services Compliance Guide (2013).

4.1.2.5 Ventilation

It is possible that the ventilation strategy would vary across the various space uses at the Proposed Development. The benefits of both natural and mechanical ventilation shall be appraised during the detailed design stages.

It is anticipated that mechanical ventilation would be employed in all areas of the Proposed Development, such as dwellings, flexible residential/ assisted living apartments, the care home, non-domestic areas including offices, hotel, and school, with efficient heat recovery to recoup heat from outgoing air and supply this to incoming fresh air. The re-use of waste heat would enable reductions in both energy requirements and CO_2 emissions.

The fit out of the retail space would be the responsibility of the individual tenants. The tenants would be required to implement efficient installations in line with the standards outlined in the Non-Domestic Building Services Compliance Guide (2013).

4.1.2.6 Variable Speed Pumps

Variable speed pumps and controls allow the respective systems (heating, hot water, ventilation) to modulate during periods of low demand. Using variable speed pumps therefore uses less energy than traditional pumps, which run at a constant speed. The use of variable speed pumps throughout the building services systems incorporated into each energy network would be considered.

4.1.2.7 Controls

The control of the heating, cooling, ventilation and lighting systems would be fundamental to the energy efficiency of each area.

The use of the following measures would be considered:

- Zoned thermostatic control;
- Time control;
- Variable flow control;
- BMS (Building Management System) automated control;
- Lighting PIR (Passive Infra-Red Sensor) control;
- Daylight linked lighting control;
- CO_2 detection (for requirement controlled ventilation); and
- Energy management control.

It is possible that demand controlled ventilation would be provided to car parks, linked to air quality/CO_2 sensors to trigger ventilation where air quality or CO_2 exceeds acceptable limits. This would safeguard air quality and reduce the energy requirement.

4.1.3 Energy Metering

Metering and sub-metering would be considered to promote the efficient use of resources. This would enable each occupier to monitor their energy requirements. The energy metering would focus on the following energy uses for each building:

- Space heating;
- Domestic hot water;
- Cooling;
- Major fans;
- Lighting;
- Small power;
- Contribution from LZC technologies; and
- Any other major energy uses.

4.1.4 Unregulated Energy

Unregulated energy includes small power electricity use (computers, plug in devices, washing machines, refrigeration) and catering energy consumption.

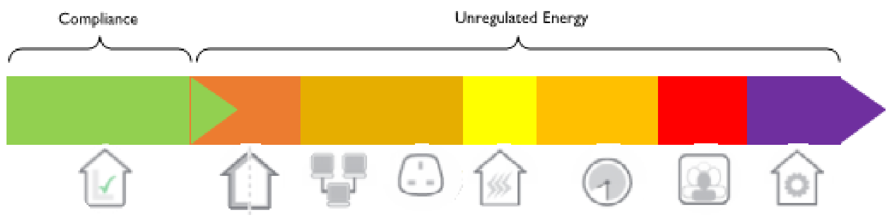


Figure 4.2: Regulated Energy and Unregulated Emissions Summary.

It is anticipated that the proportion of unregulated energy would gain in significance when compared to regulated energy as each revision of Building Regulations Part L comes into force and regulated energy is reduced.

It is therefore foreseeable that energy efficiency and the rising cost of energy would play an increasing role when future building users are deciding which appliances to purchase and the frequency of their use. However, it is not possible at present to quantify the extent of this potential reduction.

Given the uncertainty, measures to educate the future building users on how they can reduce their equipment energy use would be encouraged. This can be provided in the form of building user guides and tenant fit-out guides. The guidance measures detailed within these types of documents would consider:

- Use of A / A+ rated white goods;
- Energy star rated computers and flat screen monitors;
- Energy efficient lifts; and
- Voltage optimization and power factor correction.

Figure 4.3: Energy Efficient White Goods.

4.1.5 Summary of Passive Design & Energy Efficiency Measures

Table 4.2 and 4.3 summarises the anticipated passive design and energy efficiency targets for the dwellings, commercial, school, care home and flexible residential/assisted living areas at the Proposed Development. These parameters have been used to inform the initial energy strategy.

	Parameter	Dwellings	Non-Dwellings
Passive Design	Roof U-value (W/m².K)	0.15	0.20
	External Wall U-value (W/m².K)	0.12	0.20
	Floor U-value (W/m².K)	0.15	0.20
	Party Wall U-value (W/m².K)	0.00 (fully filled cavity with effective edge sealing)	N/A
	Sheltered Wall U-value (W/m².K)	0.20	N/A
	Window U-value (W/m².K)	1.40 – 1.30	1.60 5.56 – retail display glazing
	Glazing g-value	0.35	040-0.60
	Fabric Air Permeability ((m³/m².h) at 50 Pa)	3.00	3.00-5.00
	Thermal Bridging	Approved	-

Table 4.2: Summary of Passive Design Measures for Domestic and Non-Domestic Spaces.

	Parameter	Dwellings	Non-Dwellings
Energy Efficiency	Space Heating	DEN fuelled by CHP and high-efficiency condensing gas boilers (94% efficiency) with Heat Interface Units (HIU) per dwelling coupled to hot water systems and fan coil units / underfloor heating.	High-efficiency (94%) centralised condensing gas-boilers coupled to hot water systems. Heating delivered to space via fan coil units
	Hot Water	Water efficient fixtures and fittings to minimise water demand. HIU with minimal heat loss	
	Space Cooling	No cooling.	High-efficiency chillers with an SEER of 5.0.
	Lighting	High efficiency lighting. Daylight and presence detection in common areas / roof terraces.	Target efficacy of >70 luminaire lumens per circuit Watt.
	Ventilation	MVHR with specific fan power 0.4-0.53 with Heat Recovery of 91-94%	Target SFP of 1.6W/l/s and HR of 75%
	Metering & Controls	Zonal, programmable thermostatic controls for heating. Separate programmable control for hot water. Electricity meter and heat meter with potential link to energy display device.	To be provided in accordance with the requirements of the Building Regulations.
	Pipework & Ductwork Insulation	To be provided in accordance with the requirements of the Building Regulations.	To be provided in accordance with the requirements of the Building Regulations
	Variable Speed Pumping	To be provided.	To be provided.
	O&M Manuals	Systems overview and detailed descriptions in plain and clear English.	To be provided in accordance with the requirements of the Building Regulations.

Table 4.3: Summary of Energy Efficiency Measures for Domestic and Non-Domestic Spaces.

4.1.6 Energy Requirements and CO_2 Emissions Appraisal

The following is an appraisal of the anticipated energy requirements and resultant CO_2 emissions that could arise as a result of the Proposed Development, after the inclusion of the passive design and energy efficiency measures described above.

The appraisal has been based on approved calculation methodology and should not be understood as a predictive assessment as occupants may operate their systems differently, and / or the weather may be different from the assumptions made within the calculations.

In the areas defined as flexible use the use type selected has been based on that which would result in the greatest CO2 emissions to present what could be attributed to be a worst case scenario for CO_2 emissions and the Proposed Development is likely to achieve lower when the use types are occupied.

4.1.6.1 Regulated Sources

Regulated sources of energy requirement are those controlled by the Building Regulations, as follows:

a. space heating
a. hot water
b. space cooling
c. lighting
d. auxiliary (combining fans, pumps and controls)

4.1.6.2 Unregulated Sources

Unregulated sources of energy requirement include small power electricity use (computers, plug in devices) and cooking. Currently, unregulated energy is not included within the Building Regulations Part L assessment requirements. It is anticipated that the proportion of unregulated energy will gain in significance when compared to regulated energy as each revision of Building Regulations Part L comes into force and regulated energy is reduced.

It is therefore foreseeable that energy efficiency and the rising cost of energy will play an increasing role when future residents and building occupants are deciding which appliances to purchase and the frequency of their use. However, it is not possible at present to quantify the extent of this potential reduction.

Given the uncertainty, measures to educate the future building users on how they can reduce their equipment energy requirements will be encouraged. This can be provided in the form of building user guides and tenant fit-out guides. The guidance measures detailed within these types of documents will consider:

e. use of A / A+ rated white goods
f. energy star rated computers and flat screen monitors
g. energy efficient lifts
h. voltage optimization and power factor correction

4.1.6.3 Results

The results presented below are based on Building Regulations Part L1A 2013 compliance modelling carried out on the dwellings of Development Area 1 of Application A. The results have been applied to the residential areas of the whole ‘Application A’ site on an area weighted basis. The calculations demonstrating the energy requirements and associated CO_2 emissions for dwellings have been carried out using Building Regulations Part L1A approved SAP 2012 v9.92 methodology.

Calculations for the non-domestic uses have been carried out using software in compliance with Part L2A of the building regulations for school, office, hotel and cinema and for the remaining areas benchmarks from similar Part L2A 2013 compliant buildings have been used.

The results summarised overleaf demonstrate that prior to the implementation of any ‘be clean’ or ‘be green’ measures, on a **site wide (Application A and B)** basis the annual regulated energy requirement of the Proposed Development is anticipated to be approximately **9,387 MWh** with associated regulated CO_2 emissions of **2,513tonnes**.

The majority of the regulated energy requirement, approximately 83%, is as a result of thermal energy requirements (domestic hot water and space heating), of which hot water is the most significant contributor. It is anticipated that the cooling requirement would be minimised through the implementation of passive design and energy efficiency measures, and represent approximately 1% of the total regulated annual energy requirement.

It is anticipated that based on the calculations undertaken on a **site wide (Application A and B)** basis, **~1.9%** reduction in annual regulated CO_2 emissions would be made beyond the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

Therefore, the Proposed Development achieves Part L 2013 compliance via Be Lean measures, i.e. prior to the consideration of any LZC technologies.

When considering the **domestic** uses in isolation, an anticipated annual regulated energy requirement of **5,586 MWh** with associated CO_2 emissions of **1,380 tonnes** has been calculated. This includes the area of flexible residential/assisted living floor space that will have a domestic profile whether it is defined as residential or assisted living.

The majority of the regulated energy requirement (~90%) for the residential uses is associated with thermal energy requirements (domestic hot water and space heating). Consequently, thermal loads contribute most to regulated CO_2 emissions from the domestic uses (~78%).

It is anticipated that the **domestic** uses would achieve **~1.1%** reduction in annual regulated CO_2 emissions beyond the requirements of the Building Regulations part L 2013 through passive design and energy efficiency measures alone.

It would be demonstrated that on an area weighted basis, the dwellings fabric energy efficiency levels calculated alongside the CO_2 emissions calculation would improve upon the requirements of the Building Regulations Part L 2013.

When considering the **non-domestic elements (excluding the school)** in isolation, these spaces have been calculated to have an annual regulated energy requirement of **3,183 MWh** with associated CO_2 emission of **967 tonnes**.

The majority of the regulated energy requirement (~72%) for the non-domestic uses is associated with heating and hot water requirements. Heating and hot water also contribute the greatest proportion of CO_2 emissions (~52%).

When considering the **school** in isolation, it has been calculated to have an annual regulated energy requirement of **617MWh** with associated CO_2 emission of **91tonnes**.

The majority of the regulated energy requirement (~82%) for the school is associated with heating and hot water requirements. Heating and hot water also contribute the greatest proportion of CO_2 emissions (~66%).

4.1.6.4 Summary Tables & Charts

The following tables and figures provide a summary of the anticipated the annual energy requirement and associated CO_2 emissions by service and space use at the Proposed Development.

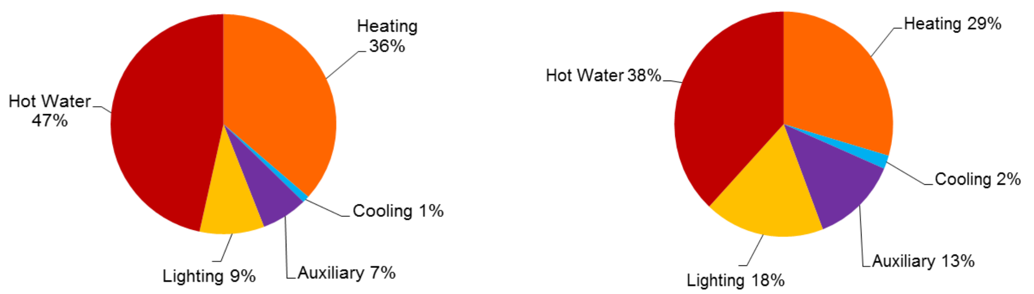


Figure 4.4: Summary of Regulated Energy Requirement (left) and CO_2 emissions (right) for the Whole Site, Application A and B.

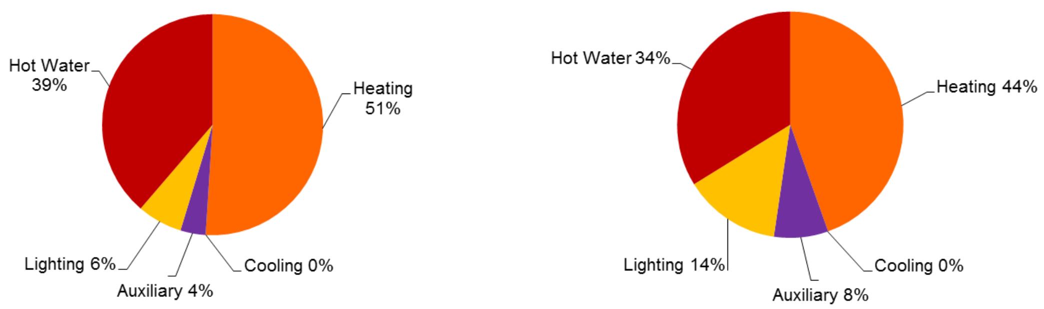


Figure 4.5: Summary of Regulated Energy Requirement (left) and CO_2 emissions (right) for the domestic uses on the Whole Site, Application A.

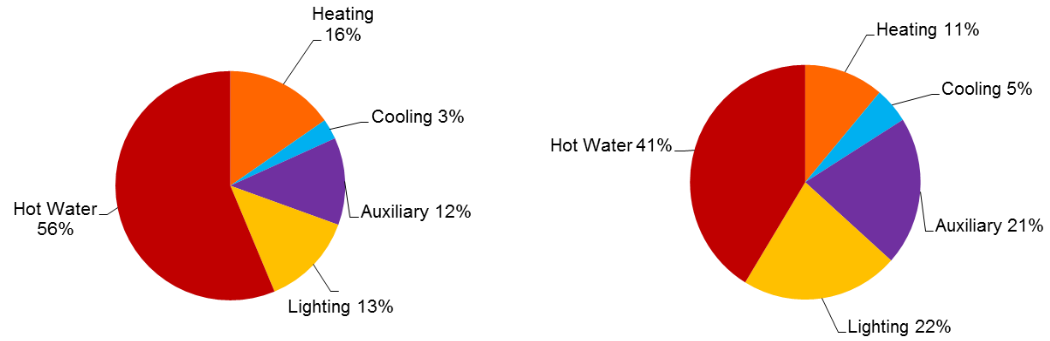


Figure 4.6: Summary of Regulated Energy Requirement (left) and CO_2 emissions (right) for the non-domestic uses of the Whole of Application A.

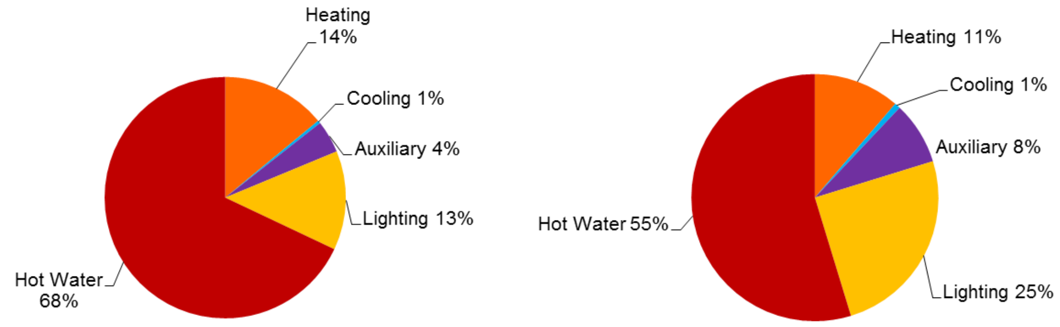


Figure 4.7: Summary of Regulated Energy Requirement (left) and CO_2 emissions (right) for the school (Application B).

Figure 4.8 demonstrates that the majority of the CO_2 emissions that would arise from the Proposed Development are associated with thermal sources. For the domestic areas only, emissions are significantly associated with thermal loads as shown in figure 4.9. For the non-domestic areas alone the CO_2 emissions are more evenly associated with electrical loads. The distribution for the school is shown in Figure 4.10.

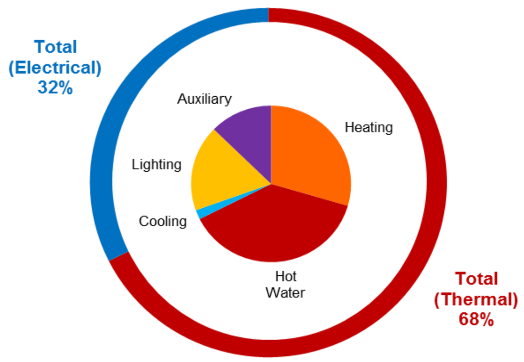


Figure 4.8: Annual CO_2 Emissions by Type (Whole Site).

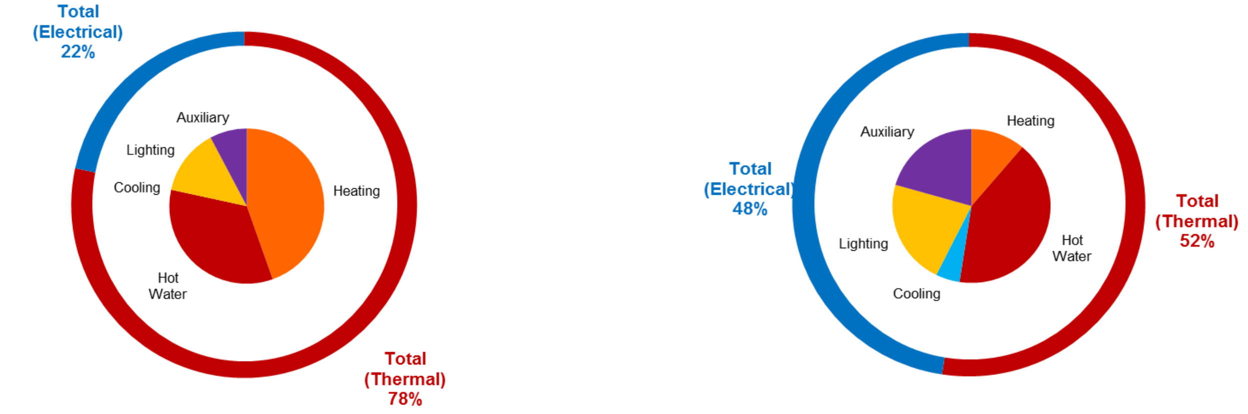


Figure 4.9: Annual CO_2 Emissions by Type (Domestic Areas Left; Non-domestic areas right).

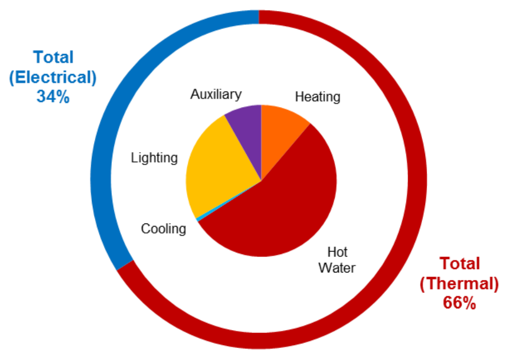


Figure 4.10: Annual CO_2 Emissions by Type (School)

	Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
		(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)
Domestic uses	Dwellings (Dev Area 1)	1,399,800	0	130,200	196,500	1,137,600	2,864,200	1,421,700
	Refurb	102,800	0	2,900	13,000	83,400	202,100	92,900
	Townhouses (Dev Area 2)	210,400	0	300	6,600	17,900	235,200	43,700
	Dwellings (Dev Area 2)	626,300	0	58,300	87,900	508,900	1,281,400	636,000
	Flex Resi/Assisted Living	510,300	0	14,600	64,500	414,000	1,003,400	461,200
Non-domestic uses	Retail A1	7,700	900	26,300	108,100	40,000	182,900	80,200
	Hotel	28,500	600	6,400	8,200	227,600	271,400	9,700
	Office	8,700	10,500	3,600	30,600	8,900	62,500	97,200
	Cinema	22,700	8,900	7,500	30,100	66,400	135,700	72,100
	Gym	30,000	200	6,800	9,600	168,100	214,800	47,400
	Care Home (Dev Area 2)	336,800	42,200	261,700	127,600	1,096,700	1,865,000	201,600
	Retail A3	53,700	28,400	79,700	105,300	184,100	451,200	291,900
	School	86,400	2,400	26,800	81,900	419,400	616,900	196,400
	Total	**3,424,100**	**94,100**	**625,100**	**869,900**	**4,373,000**	**9,386,700**	**3,652,000**

Table 4.4: Whole Site (Application A and B) Annual Energy Requirement.

	Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
		($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)
Domestic uses	Dwellings (Dev Area 1)	302,400	0	67,600	102,000	245,700	717,700	737,900
	Refurb	22,200	0	1,500	6,700	18,000	48,500	48,200
	Townhouses (Dev Area 2)	45,400	0	200	3,400	3,900	52,900	22,700
	Dwellings (Dev Area 2)	135,300	0	30,200	45,600	109,900	321,100	330,100
	Flex Resi/Assisted Living	110,200	0	7,600	33,500	89,400	240,700	239,400
Non-domestic uses	Retail A1	4,000	500	13,600	56,100	20,700	94,900	41,600
	Hotel	6,200	300	3,200	4,200	49,200	63,000	5,000
	Office	1,900	5,500	1,800	15,500	1,900	26,600	50,500
	Cinema	4,900	4,600	3,800	15,300	14,300	42,900	37,400
	Gym	6,500	100	3,400	4,900	36,300	51,200	24,600
	Care Home (Dev Area 2)	72,800	21,900	132,400	64,600	236,900	528,600	104,600
	Retail A3	11,600	14,700	40,300	53,300	39,800	159,700	151,500
	School	18,700	1,300	13,600	41,500	90,600	165,500	101,900
	TOTAL	**742,100**	**48,900**	**319,200**	**446,600**	**956,600**	**2,513,300**	**1,895,400**

Table 4.5: Whole Site (Application A and B) Annual CO_2 Emissions.

4.2 Be Clean – Whole Site (Application A and B)

The following sections detail considerations of the infrastructure and low-carbon energy supply measures that have been considered, and those which would be implemented at the Proposed Development.

4.2.1 Infrastructure

Infrastructure at the Proposed Development would be the key to achieving the target reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L 2013.

4.2.2 Decentralised Energy Networks

By reference to the London Heat Map (http://www.londonheatmap.org.uk), the proposed development is not in close proximity to an existing energy network, the closest being some 5.4miles away in Westminster. This is an unavailable connection, with no known plans to develop or extend as far as Richmond. There are opportunities for potential networks in the Hammersmith area although this remains at a distance that is beyond what could be considered reasonable to connect to at 2.3miles. Figure 4.10 shows the area of the site and the potential networks from the London Heat Map.

From viewing the current London Heat Map data for the area, we understand that there are no current plans to create new or extend existing networks to the proximity of the site. Consideration would therefore be given for the Proposed Development to develop a heat network on the site with an on-site CHP and district energy network (DEN)

4.2.3 Technology Appraisal

This section considers the relative merits of providing a stand-alone on-site heat network for the Proposed Development served by dedicated energy centres with either CHP or CCHP. The Proposed Development will be split between Development Area 1 and Development Area 2 with an energy centre provided within the basement of each area.

Considering the high proportion of CO_2 emissions arising from thermal sources in particular with reference to the dwellings, a Combined Heat and Power (CHP) system could be suitable for the scheme.

Figure 4.11 and Figure 4.12 demonstrate that these systems can work more efficiently than their traditional counterparts, i.e. grid electricity and gas boilers. It is estimated that where thermal demand is adequate, CHP can achieve reductions in primary energy demand relative to traditional sources.

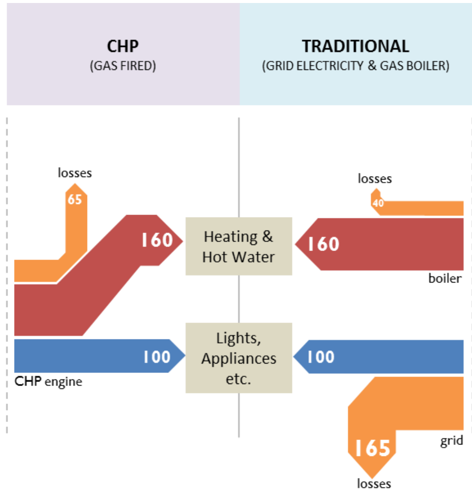


Figure 4.11: CHP Efficiency.

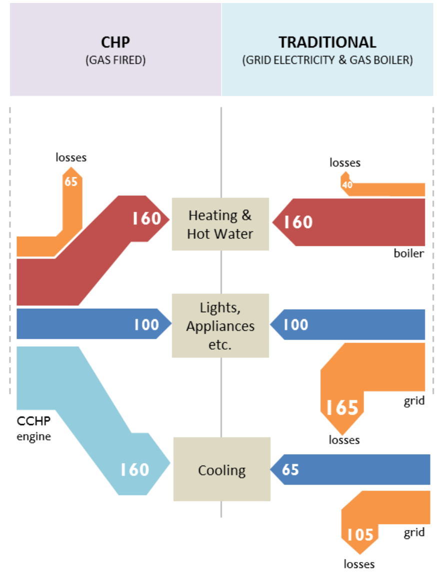


Figure 4.12: CCHP Efficiency.

An assumption has been made that the distribution losses of the heat network would be designed to achieve best practice performance levels and has been calculated based on 90% distribution efficiency. However if the distribution losses increased then this would have a significant impact on the ability of the CHP and heat network to achieve CO_2 emissions calculated in this report. A 75% distribution efficiency could result in an increase in CO_2 emissions of approximately 10%.

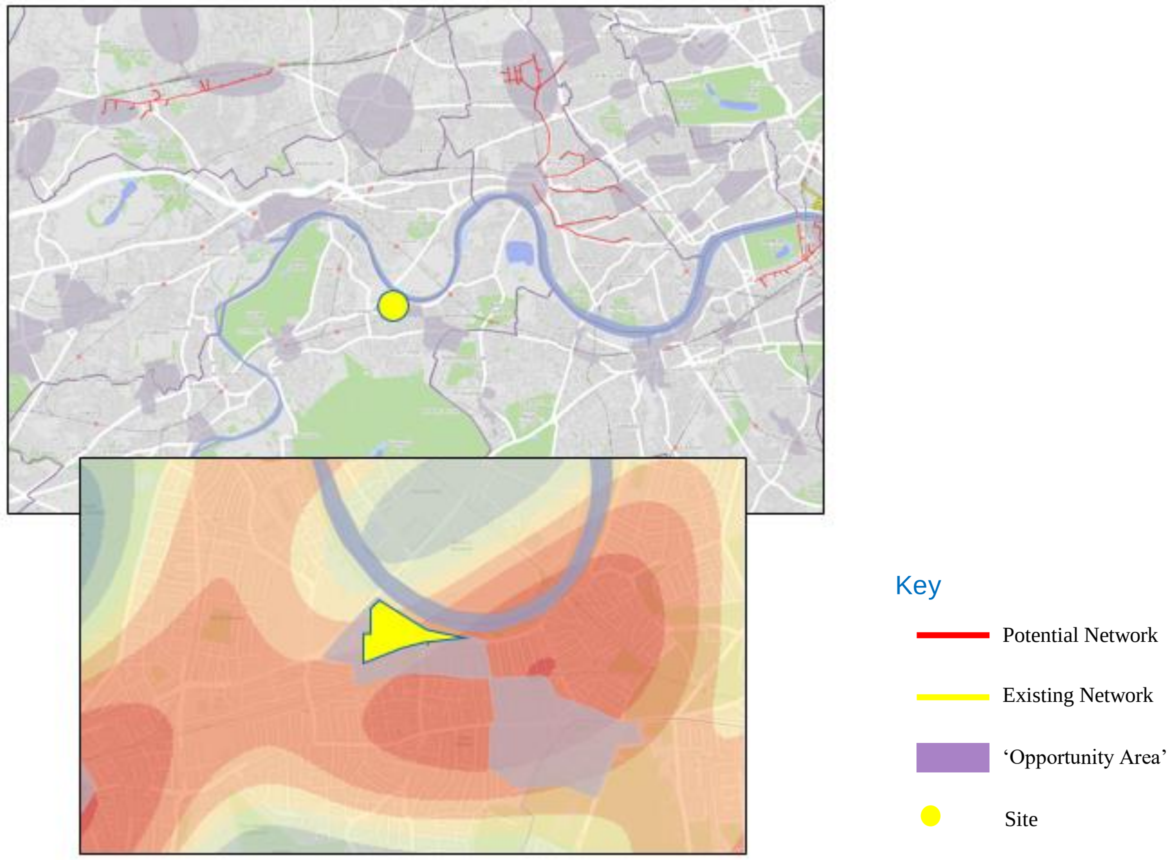


Figure 4.13: Extract from London Heat Map

Future emissions scenarios indicate that gas-fired CHP may not be an effective method of reducing CO_2 over electrically based heating systems such as air source heat pumps. This is likely to become relevant within the timescales of the Proposed Development.

In order to deliver lowest life-cycle CO_2 emissions within an evolving energy landscape, it would be preferable for available technologies to be assessed for their ability to provide reductions in regulated CO_2 as and when each of the Development Areas are brought forward, and subject to commercial viability. This will allow the most appropriate heat generating plant to be chosen in the face of the changing energy landscape, particularly if any revision to the carbon factor specified in the Building Regulations is made, as has been proposed in recent consultations and as per the actual emissions associated with electricity from the National Grid.

Given the timescales, the nature of development phasing, and taking consideration for decarbonisation of the grid, it is currently anticipated that Development Area 2 would be delivered with a separate energy centre located within the Proposed Development. However, the energy strategy that provides beneficial CO_2 emissions reductions in accordance with policy and building regulations at the time of the reserved matters submission would be submitted for consideration with the application at that time. This would seek to avoid the scenario whereby the entire site is locked into an energy strategy that may not deliver optimum life-cycle CO_2 benefits. This approach would provide more flexibility in the longer term with respect to energy sources, and maximising carbon emissions reductions throughout the lifetime of the development.

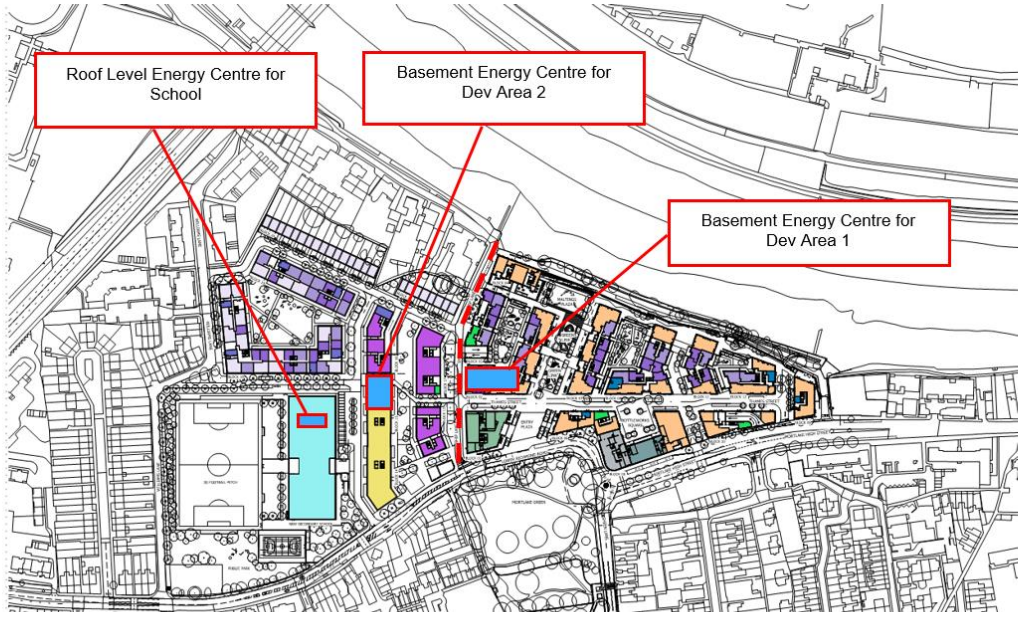


Figure 4.12: Indicative Energy Centre locations for Development Area 1 and 2 (i.e Application A) and the school (Application B), shaded blue with red outline. Indicative layouts of the Energy Centres are provided in Appendix E.

4.2.3.1 Combined Heat and Power

The Proposed Development would seek to utilise a Combined Heat and Power engine within each energy centre as the lead generator of heating, hot water and also supplying some electricity to landlord uses. This would be backed up by high efficiency gas fired condensing boilers.

The calculations include for the school (Application B) to be serviced by a CHP of its own.

The townhouses within Development Area 2 are also considered to be serviced separately with individual heat generation located within each town house. The system to be implemented will be set out in the reserved matters submission for Development Area 2.

For Application A on the basis that CHP engines would provide for approximately 99% of the domestic hot water demand and up to 28% of the space heating demand of the Proposed Development, the two energy centres would require a number of CHP engines to create a total rated output of **756kW$_e$ and 802kW$_{th}$.**

It is anticipated that with CHP of this size in Application A, allowing for losses and pumping associated with the heat network, would reduce regulated CO_2 emissions by approximately **410** tonnes per annum. This is equivalent to a reduction of **~16.3%** beyond the Building Regulations Part L 2013 'baseline'. The anticipated thermal profile of the Proposed Development is shown in figure 4.13.

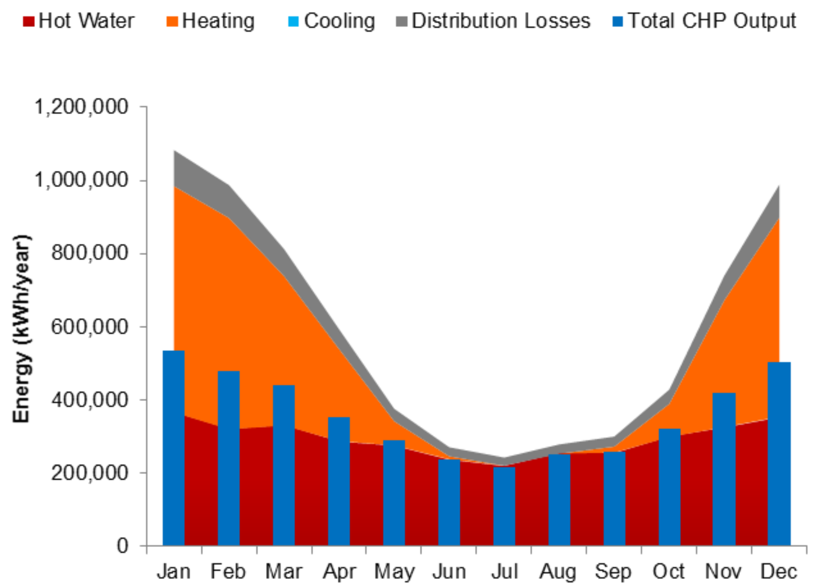


Figure 4.13: Annual Thermal Load Profile and Potential CHP Contribution (Application A).

When considering the dwellings in isolation, where the thermal demand is most prevalent, it is anticipated that the energy centres connected to the respective heat network supplied by CHP would reduce regulated CO_2 emissions by approximately **242 tonnes** per annum. This is equivalent to a reduction of **17.5%** beyond the Building Regulations Part L 2013 'baseline'.

For the school (Application B) the anticipated CHP size would be 50kWe and 79kWth. It is anticipated that with a CHP engine of this size, allowing for distribution losses, would reduce regulated CO_2 emissions by approximately **31** tonnes per annum. This is equivalent to a reduction of **~17.6%** beyond the Building Regulations Part L 2013 'baseline'. The anticipated thermal profile of the Proposed Development is shown in figure 4.14.

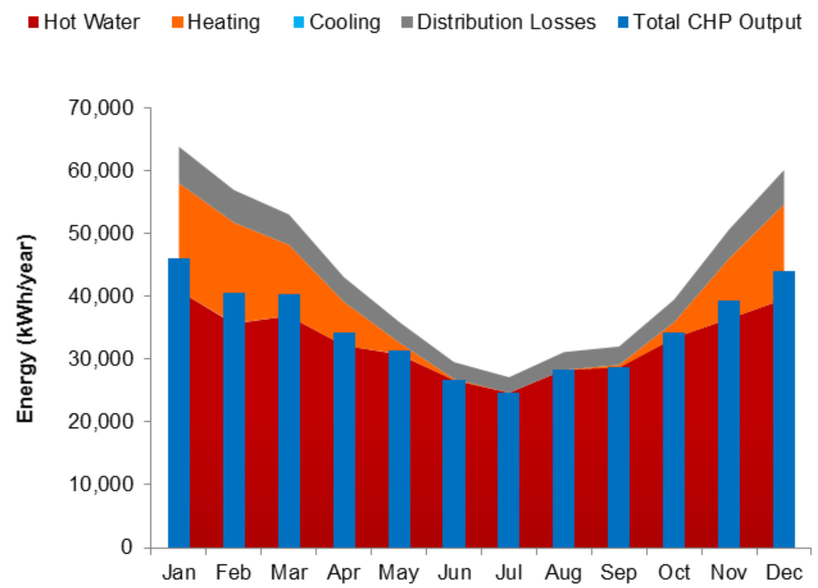


Figure 4.14: Annual Thermal Load Profile and Potential CHP Contribution (Application B).

4.2.3.2 Combined Cooling Heat and Power

CCHP is the use of a CHP engine as described above, with a matched absorption chiller, which produces chilled water for cooling from the CHP waste heat.

However, as the cooling demand for the development is expected to be minimal (less than 1%), a CCHP would not be suitable.

4.2.3.3 Summary

Considering the relative merits of the options appraised above, it is considered that the Proposed Development would utilise multiple CHP engines within the respective energy centres to supply heating and hot water, with the capacity for future connection to a District Heating Network.

System	Peak Output (kW)		Annual Output (MWh)		CO_2 Emissions Reduction		Notes
	Electrical	Thermal	Electrical	Thermal	Total (tonnes)	% Beyond 'Baseline'	
Application A	756kWe	928kWth	4,055	4,302	410	16.3%	99% HW 29% SH
Application B	50kWe	79Kwth	265	419	31	17.6%	100% HW 30% SH
Overall	-	-	4,320	4,721	443	17.2%	-

Table 4.6: CHP Appraisal Summary.

Key:

(h) heating and hot water output
(c) cooling output
hw hot water
sh space heating
sc space cooling

4.3 Be Green

The following sections detail the renewable energy generation measures that have been considered, and those which would be implemented at the Proposed Development.

Renewable technologies harness energy from the environment and convert this to a useful form. Many renewable technologies are available. However, not all of these are commercially viable, suitable for city-centre locations or appropriate for the Proposed Development.

Technologies considered include:

a. heat pumps (ground-source / air-source)
b. biomass boilers
c. photovoltaic
d. solar thermal
e. wind turbines

4.3.1 Renewable Technology Appraisal

4.3.1.1 Air / Ground Source Heat Pumps

Air Source Heat Pumps (ASHP) and Ground Source Heat Pumps (GSHP) work to extract heat from the air or the ground. Generally, GSHPs are more efficient as the ground temperature is more stable over the course of the year relative to the air temperature.

GSHPs have three common varieties:

a. horizontal, closed loop
b. vertical, closed loop
c. vertical, open loop

ASHPs have two common varieties:

a. air to water
b. air to air

The performance characteristics and technical requirements of each vary. Typically however, vertical open loop GSHP systems operate at the highest efficiencies and are capable of producing the most thermal output.

Open loop boreholes require an abstraction license from the Environment Agency. To gain a licence, a scheme is typically required to operate in balance such that over the year, the amount of heat extracted from the ground is equivalent to the amount of heat rejected to the ground.

Given the low amount of cooling at the Proposed Development (Application A and B) (approximately 1% of the overall regulated energy requirement), if a large amount of heat were to be extracted in winter there would be a large imbalance between amount of heat extracted and heat rejected to the ground over a yearly cycle, which could lead to permafrost, rendering the system unusable and potentially damaging nearby structures and local ecology.

Impacts to ground conditions are also valid considerations for all GSHP technologies, meaning a balanced heating and cooling strategy should be applied.

When assuming a GSHP could operate at Seasonal Energy Efficiency Ratio (SEER) of 5.0 (i.e. five units of useful heat or coolth for every unit of electricity consumed), to deliver 100% of space cooling and balanced to deliver an equivalent amount of heating (approx. 12% of requirement) but no hot water, it is estimated that a reduction in CO_2 emissions of **60.8 tonnes** per annum could be achieved.

This is equivalent to a reduction in regulated CO_2 emissions of **2.5%** beyond the Building Regulations Part L (2013) 'baseline'.

Considering the low potential CO_2 emissions reduction, the use of GSHP will not be implemented at the Proposed Development.

ASHPs do not operate as efficiently as GSHPs. Moreover, during times of peak demand (i.e. during winter months) the ambient air temperatures are at their minimum, meaning the ASHP needs to work harder to extract the desired amount of heat. Systems have been noted to perform poorly in operation, in particular those systems which are also providing hot water.

To accommodate the demands at the Proposed Development, large external condenser units would be required. These would need to be accommodated sensitively to minimise the visual impact on-site, and would be a source of noise that would possibly require attenuation to prevent nuisance.

When assuming an ASHP could operate at Seasonal Energy Efficiency Ratio (SEER) of 4.0 (i.e. four units of useful heat for every unit of electricity consumed), to deliver 100% of space heating, and 100% of space cooling, but no hot water, it is estimated that a reduction in CO_2 emissions of **344.8 tonnes** per annum could be achieved.

This is equivalent to a reduction in regulated CO_2 emissions of **14.5%** beyond the Building Regulations Part L (2013) 'baseline'.

A significant proportion of roof area has been allocated to green roof leaving limited area to locate sufficient external plant to accommodate ASHP for the whole development it is expected that this would not be taken forward. However, the significant potential for ASHP to reduce CO_2 emissions would be considered at the detailed design stages if appropriate for parts of the Application A at reserved matters submission(s). As an electric system it is likely to be more beneficial in the proposed changes to the carbon factors in building regulations in the future.

4.3.1.2 Biomass Heating

Biomass boilers burn wood fuel, or other bio-fuel sources, to generate heat. These boilers can operate at high efficiencies, comparable to condensing gas boilers. However, they require a large fuel store to maintain continuous operation during the winter months. As such, area take for such plant is high. Furthermore, fuel deliveries in city-centre locations can prove difficult and security of fuel supply is an important consideration.

Biomass boilers also result in higher emission of Nitrous Oxide (NOx) in comparison with gas boilers. This can have a negative impact on the local air quality. Policies in London seek to protect and enhance local air quality. Any proposal for biomass heating would be required to demonstrate the scheme would be 'air quality neutral'.

If a biomass boiler was to be implemented to provide 99% of the hot water demand, and 28% of the space heating demand, requiring a large fuel store, a reduction in CO_2 emissions of **771 tonnes** per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of **32.3%** beyond the Building Regulations Part L (2013) 'baseline'.

However, due to the constraints of this site, the potential negative impact on air quality, and large store footprint of ~40m², biomass heating is not favoured for the Proposed Development.

4.3.1.3 Photovoltaic Panels

An appraisal of the available roof space at the Proposed Development has been undertaken. The roof layouts have been designed in response to the need to balance many factors such as:

a. area required for plant (chillers, flues from boilers, CHP and generator)
b. area required for access
c. building heights in respect of the parameter plan thresholds
d. potential area for PV arrays
e. location of green roofs

Considering the available roof space, and allowing for access and maintenance requirements, a total solar PV system size in the region of 520m² array area could be included on Development Area 1 at the Proposed Development. At reserved matters stage for the outline element of Application A consideration would be given to include a further area of PV to reduce CO_2 emissions for Development Area 2.

Based on the solar irradiance data for London, an array of this size would generate approximately 57,200kWh of electricity per annum, reducing CO_2 emissions by **29.7 tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **1.2%** beyond the Building Regulations Part L (2013) 'baseline'. When considering the residential elements separately, the contribution is equivalent to a **2.1%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'.

PV is therefore anticipated to be a suitable addition to the Proposed Development in pursuit of further reductions in regulated CO_2 emissions.

The school has limited roof space available for the installation of a PV array due to the location of plant, roof lights and the location of the Multi Use Games Area (MUGA) on the roof. Therefore PV is not currently proposed for the school application.

4.3.1.4 Solar Thermal Panels

The appraisal of solar thermal panels has been undertaken with the same approach as for PV.

Considering the available roof space, and allowing for access and maintenance requirements, a total solar thermal system size of 260kWp could be installed at the Proposed Development.

Based on the solar irradiance data for London, an array of this size would generate approximately 237,000kWh of heat per annum. This level of thermal generation is equivalent to 5% of the annual hot water demand, reducing CO_2 emissions by **58.3 tonnes** per annum.

This is equivalent to a reduction in regulated CO_2 emissions of **2.4%** beyond the Building Regulations Part L (2013) 'baseline'.

However, in providing solar thermal panels, a portion of the hot water baseload (7%) would be offset, meaning a CHP engine would generate less heat and electricity. As a result, CO_2 emissions reductions associated with a CHP would be reduced.

The reduction in use of a CHP engine would lead to an overall increase in net CO_2 emissions from the Proposed Development owing to the high carbon content of grid electricity (0.519kgCO_2/kWh compared with 0.216kgCO_2/kwh for gas).

As such, the use of solar thermal panels is not suitable where CHP is included and would not be implemented at the Proposed Development.

4.3.1.5 Micro Wind Turbines

The installation of micro wind turbines at the Proposed Development could generate useful electricity. On the basis of providing 25No. 6kW vertical axis wind turbines, it is estimated that approximately 13,400kWh of electricity could be generated annually, reducing CO_2 emissions by **7.0 tonnes** per annum.

This is equivalent to a reduction in regulated CO_2 emissions of **0.3%** beyond the Building Regulations Part L (2013) 'baseline'.

Despite manufacturer claims that vertical axis wind turbines work well in city-centre locations, turbulent air flow patterns caused by the rough and irregular urban landscape are not conducive to high annual yields from wind turbines.

Moreover, mounting wind turbines on the roofs of the Proposed Development could result in unacceptable vibration and resonance being felt within top floor apartments. This scenario is likely to result in the turbines being switched off.

As such, the use of micro wind turbines would not be implemented at the Proposed Development.

4.3.2 Summary

Table 4.7 provides a summary of the estimated emissions reductions for Application A and B associated with each of the suitable technologies identified above.

	Annual Output		Annual Regulated CO_2 Emission Reduction		Sizing Notes	Suitable?
	Thermal (kWh/yr)	Electrical (kWh/yr)	Tonnes per year	% Beyond Part L 'baseline'		
~756kWe CHP to be met by multiple engines with DEN	4,302,000	4,055,000	410	16.3%	Running for ~5500 hours per year to provide 28% of the space heating and 99% of the hot water demand.	✓
Application B ~50kWe CHP	419,000	265,000	31	17.6%	Running for ~5200 hours per year to provide 230of the space heating and 100% of the hot water demand.	✓
~74kWp (520sqm) Photovoltaic (PV) Panels	-	57,200	30	1.2%	Estimated to require a roof area of approximately 1000sqm.	✓
~260kWp (520sqm) Solar Thermal Heating	237,400	-	58	2.4%	Estimated to require a roof area of approximately 1000sqm.	✗
~1200kW Wood Pellets Boilers	4,317,000	-	771	32.3%	Running for ~4800 hours per year to provide 28% of the space heating and 99% of the hot water demand.	✗
~831kW Air Source Heat Pump	2,926,000	-	345	14.5%	Sized to provide 100% of the space heating and cooling and 0% of the hot water demand.	✗
~128kW ground Source Heat Pump	709,000	-	61	2.5%	Sized to provide 12% of the space heating 100% of cooling and 0% of the hot water demand.	✗
25 No. 6kW Vertical axis wind turbines	-	13,417	7	0.3%	Based on NOABL wind speed data for the site at 30m above ground level.	✗

Table 4.7: Summary of LZC Technology Appraisal for Whole Site.

Key:
(h) heating and hot water output
(c) cooling output
hw hot water
sh space heating
sc space cooling

4.4 Anticipated CO_2 emissions reduction – Whole Site (Application A and B)

4.4.1 Domestic Uses (Application A)

Table 4.8 shows the equivalent reductions in regulated CO_2 emissions when considering the domestic uses alone for the whole site. These results account for the benefit of connecting to the on-site CHP, and the PV array.

When considering the domestic uses alone, an overall reduction of ~1.1% beyond the Building Regulations Part L 2013 'baseline' can be achieved through passive design and energy efficiency measures. The CO_2 emission savings for the domestic uses are represented graphically in Figure 4.15 as follows. CO_2 emissions reductions are represented cumulatively in the graph.

	Carbon Dioxide Emissions for Dwelling Uses (tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	1,396	1,392
After Be Lean	1,381	1,378
After Be Clean	1,137	1,378
After Be Green	1,102	1,378

Table 4.8: CO_2 Emissions after Each Stage of the Energy Hierarchy for the **Domestic Uses**.

Domestic Use Areas	Estimated Regulated Carbon Dioxide Emission Savings for Residential Buildings	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	15	1.1%
Savings from heat network / CHP (Clean)	242	19.2%
Savings from renewable energy (Green)	30	2.1%
Total Cumulative Savings	**288**	**20.7%**
Total Target Reduction	1,381	100%
Annual Carbon Off-set	1,093	-

Table 4.9 Summary of CO_2 emissions reductions and carbon emissions to be offset for **Domestic Uses**.

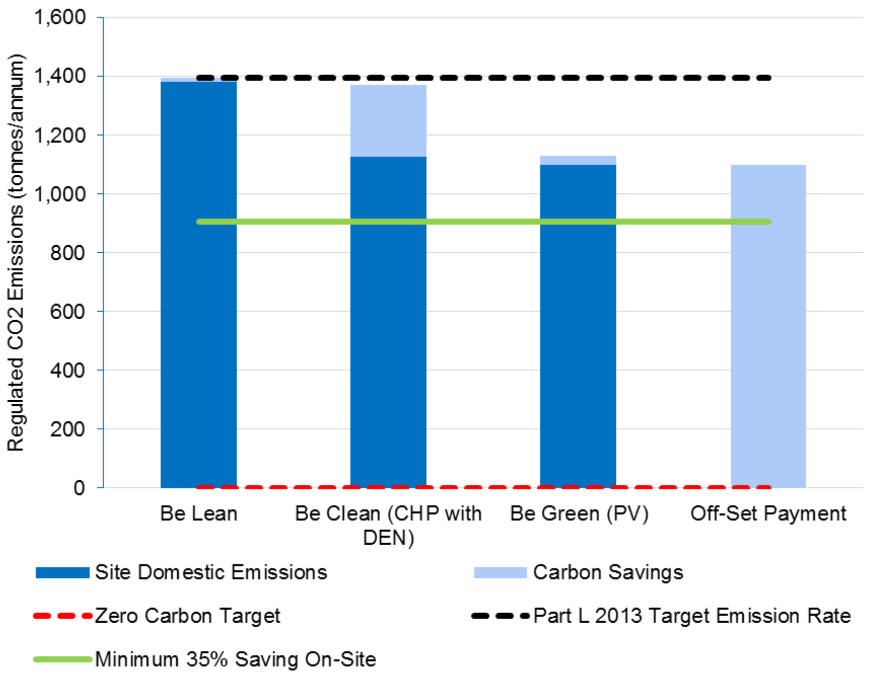


Figure 4.15: Summary of Regulated CO_2 Emissions Reduction for Domestic use areas of the Whole Site (Application A).

4.4.2 Non-Domestic Uses – Application A

Table 4.10 shows the equivalent reductions in regulated CO_2 emissions when considering the non-residential uses alone. These results account for the benefit of connecting to the proposed energy centres and the inclusion of on-site CHP within the respective energy centres but excluding the school.

When considering the non-domestic uses alone, an overall reduction of 2% beyond the Building Regulations Part L 2013 'baseline' can be achieved through passive design and energy efficiency measures. The CO_2 emission savings for the non-domestic uses are represented graphically in Figure 4.16 as follows. CO_2 emissions reductions are represented cumulatively in the graph.

	Carbon Dioxide Emissions for Non-Domestic Uses (tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	990	415
After Be Lean	967	415
After Be Clean	783	415
After Be Green	783	415

Table 4.10: CO_2 Emissions after Each Stage of the Energy Hierarchy for the Non-residential areas.

Non-Residential Areas (Application A)	Estimated Regulated Carbon Dioxide Emission Savings for Non-Residential Buildings	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	23	2.0%
Savings from heat network / CHP (Clean)	184	19.0%
Savings from renewable energy (Green)	-	-
Total Cumulative Savings	**207**	**21.0%**
Total Target Reduction	347	35%
Annual Carbon Off-set	140	-

Table 4.11 Summary of CO_2 emissions reductions and offset payment for non-residential areas.

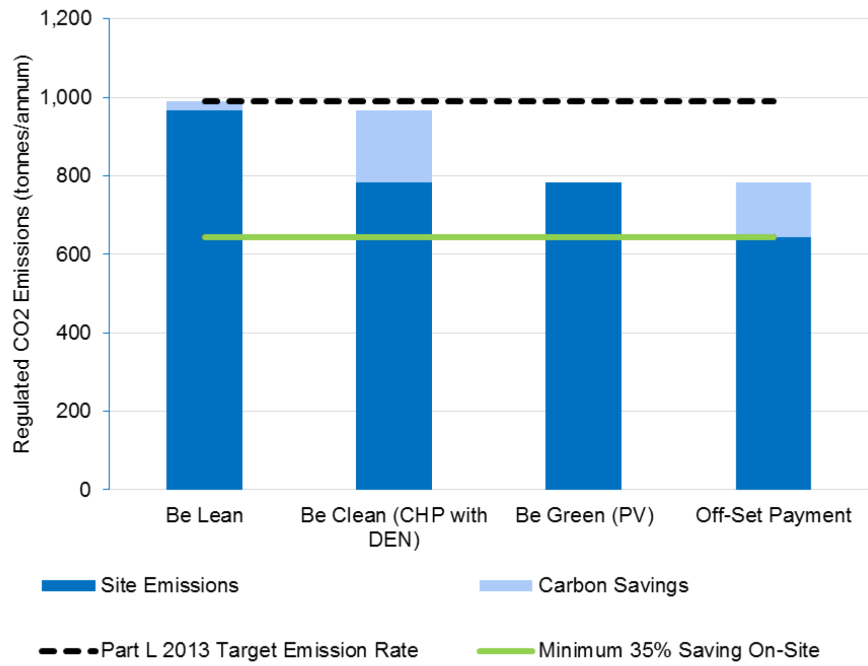


Figure 4.16: Summary of Regulated CO_2 Emissions Reduction for non-residential areas of Application A.

4.4.3 Non-Domestic Uses – School (Application B)

Table 4.12 shows the equivalent reductions in regulated CO_2 emissions when considering the school use alone. These results account for the benefit of connecting to the proposed on-site CHP.

When considering the school alone, an overall reduction of 6% beyond the Building Regulations Part L 2013 'baseline' can be achieved through passive design and energy efficiency measures. The CO_2 emission savings for the non-domestic uses are represented graphically in Figure 4.17 as follows. CO_2 emissions reductions are represented cumulatively in the graph.

	Carbon Dioxide Emissions for Non-Domestic Uses (tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	176	102
After Be Lean	166	102
After Be Clean	135	102
After Be Green	135	102

Table 4.12: CO_2 Emissions after Each Stage of the Energy Hierarchy for the school.

School (Application B)	Estimated Regulated Carbon Dioxide Emission Savings for the School	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	11	6.0%
Savings from heat network / CHP (Clean)	31	19.0%
Savings from renewable energy (Green)	-	-
Total Cumulative Savings	**42**	**24.0%**
Total Target Reduction	62	35%
Annual Carbon Off-set	20	-

Table 4.13 Summary of CO_2 emissions reductions and offset payment for non-residential areas.

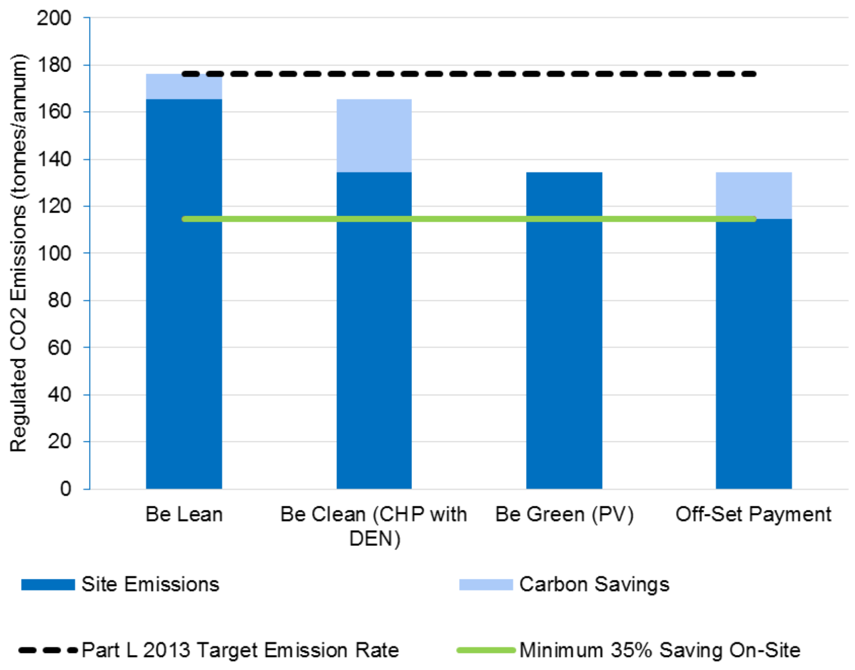


Figure 4.17: Summary of Regulated CO_2 Emissions Reduction for the school (Application B).

4.4.4 Whole Site Total (Application A and B)

Following the energy hierarchy, reductions in regulated energy requirements and associated CO_2 emissions have been made at each stage as demonstrated by Table 4.14

When considering the whole site, it is anticipated that a **20.3%** overall reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline' can be achieved.

The CO_2 emissions savings for the whole site are represented cumulatively in Figure 4.18 and table 4.15.

	Carbon Dioxide Emissions for Whole Site (tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	2,562	1,909
After Be Lean	2,514	1,895
After Be Clean	2,073	1,895
After Be Green	2,043	1,895

Table 4.14: CO_2 Emissions after Each Stage of the Energy Hierarchy for the whole site.

Site Wide	Estimated Regulated Carbon Dioxide Emission Savings for Whole Site	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	48	1.9%
Savings from heat network / CHP (Clean)	441	17.2%
Savings from renewable energy (Green)	30	1.5%
Total Cumulative Savings	**519**	**20.3%**

Table 4.15 Summary of CO_2 emissions reductions and offset payment for the whole site.

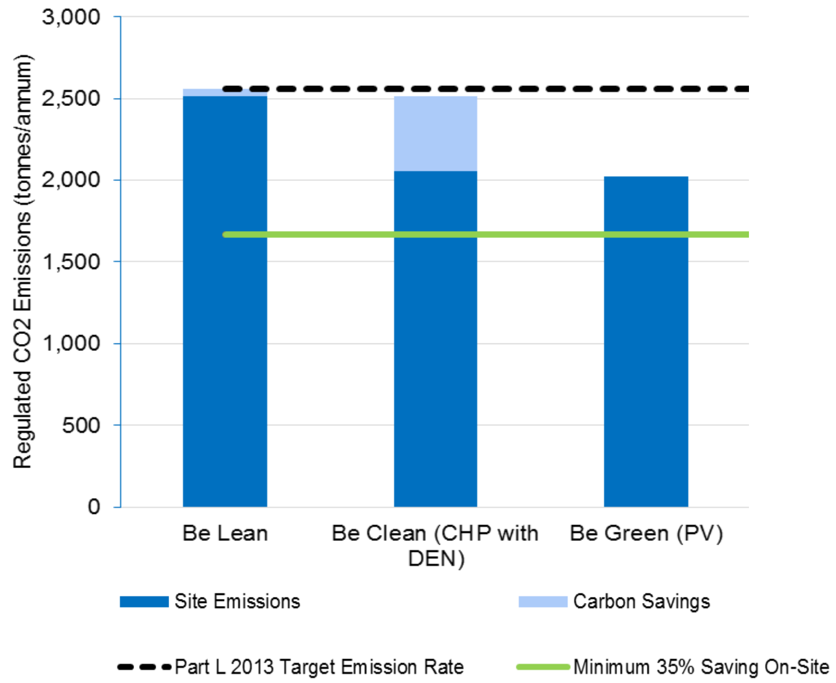


Figure 4.18: Summary of Regulated CO_2 Emissions Reduction for the Whole Site.

4.5 Carbon Offset Payment

The Proposed Development is anticipated to yield a reduction in regulated CO_2 emissions of 537 tonnes beyond the Part L 'baseline'. In this case it would be necessary to offset the remaining 1,253 tonnes for 30 years. The GLA has set the price for Carbon Offset at £60 per tonne per year.

The calculation of the Carbon Offset payment needs to be dealt with on a bespoke basis for a mixed use scheme of this scale.

Whole Site (Application A and B) Total	
Annual Off-set (Residential Areas)	1093 tCO_2
Annual Off-set (Non-residential Areas)	140 tCO_2
Annual Off-set (School)	20 tCO_2

Table 4.16: CO_2 Emissions Offset for the **Whole Site**

4.6 Minimisation of Cooling Demand & Limiting the Effects of Heat Gains

In tandem with the energy and CO_2 emissions appraisal, an iterative approach has been undertaken to limit the effects of heat gains in summer (Part L Criterion 3) and to minimise the cooling demand.

4.6.1 Basis of the Assessment

The London Plan Policy 5.9 details that development proposals should reduce potential overheating and reliance on air conditioning systems. A 'cooling hierarchy' is provided and the Proposed Development has sought to follow this hierarchy.

4.6.2 Cooling Hierarchy

The following cooling hierarchy has been followed to limit the effects of heat gains in summer:

a. minimise internal heat generation through efficient design and efficient equipment selection
b. reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration and insulation
c. natural ventilation
d. mechanical ventilation
e. active cooling systems

4.6.3 Summary of Mitigation Measures

The following mitigation measures would be implemented at the Proposed Development.
Internal heat gains would be minimised by the following:

a. Energy efficient lighting (such as LED or compact fluorescent) with low heat output
b. Insulation to heating and hot water pipework and minimisation of dead-legs to avoid standing heat loss (from pipework to dwellings) including no-hot water storage in the dwellings
c. If applicable, selection of energy efficient white goods with low heat output
d. HIUs located away from main living spaces
e. Environmental controls within the common corridors

External heat gains would be minimised by providing:

a. Suitable glazing ratio including an efficient façade design that has considered over heating from the outset
b. Glazing with internal shading and suitable g-value (0.35) to limit solar heat gains
c. High levels of insulation and low fabric air permeability which will retain cool air within the dwellings in summer months

Dwellings will be able to use natural ventilation to purge heat from dwellings. It is anticipated that during the day-time, occupants could utilise openable windows for natural ventilation. In the majority of the dwellings windows could be left open without concern for security or rain ingress.

At night, if occupants wish to keep windows closed then the increased mechanical ventilation flow rates available from the energy efficient mechanical ventilation units can be utilised. These will be designed to provide sufficient volume of air to achieve compliance with criterion three of the Building Regulations Part L1A 2013.

4.6.4 Summary of Results

Through the mitigation measures listed above, all dwellings at the Proposed Development achieve compliance with criterion three of the Building Regulations Part L1A 2013, and none of the corresponding SAP assessments show a 'high' likelihood of high internal temperatures in summer months.

The cooling requirement at the Proposed Development has been minimised representing approximately 1% of the overall energy requirement site wide.

Fit-out of commercial spaces would be the responsibility of tenants. Tenants would be required to determine the cooling demand and Building Regulations compliance for their respective spaces. In all instances, the commercial spaces will achieve compliance with criterion three of the Building Regulations and the requirements of the Non-Domestic Building Services Compliance Guide, at the time of construction.

The Care Home and flexible residential / Assisted Living areas that are part of Application A, Development Area 2 would be designed in reference to the overheating checklist and an overheating assessment would be undertaken and reported in accordance with GLA and LBRuT policy at the time of the reserved matters submission.

4.6.5 Summary of Overheating Assessments

In addition to the Criterion 3 compliance calculations outlined above, an overheating risk assessment has been completed for a sample of dwellings.

In line with GLA guidance, an overheating checklist has been completed and this is provided in section 4.6.6.

4.6.6 GLA Overheating Checklist

GLA energy policy guidance includes a requirement for all developments with residential uses to respond to a 'Domestic Overheating Checklist' for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The responses from the design team are outlined in tables 4.17 and 4.18 as follows.

Section 1 – Site Features Affecting Vulnerability to Overheating		Yes or No?
Site Location	Urban – within central London or high density conurbation	No
	Peri-urban – on the suburban fringes of London	Yes - Richmond
Air Quality and/or Noise sensitivity – are any of the following in the vicinity of the building	Busy roads / A roads	Yes
	Railways / Overground / DLR	No
	Airport / Flight Path	Yes
	Industrial uses / waste facility	No
Proposed Building Uses	Will any buildings be occupied by vulnerable people (e.g. elderly, disabled, young children)?	Yes
	Are residents likely to be at home during the day (e.g. students)?	In specific use types such as Care Home/flexible residential /Assisted Living.
Dwelling Aspect	Are there any single aspect units?	Yes
Glazing ratio	Is the glazing ratio (glazing: internal floor area) greater than 25%?	Yes
	If yes, is this to allow acceptable levels of daylighting?	Yes
Security – Are there any security issues that could limit opening of windows for ventilation?	Single storey ground floor units	Yes
	Vulnerable areas identified by the Police Architectural Liaison Officer	TBC
	Other	No

Table 4.17: Overheating Checklist Section 1.

Section 2 – Design Features Implemented to Mitigate Overheating Risk		Please Respond
Landscaping	Will deciduous trees be provided for summer shading (to windows and pedestrian routes)?	Yes
	Will green roofs be provided?	Yes
	Will other green or blue infrastructure be provided around buildings for evaporative cooling?	Yes
Materials	Have high albedo (light colour) materials been specified?	Yes – preference of material selection with high albedo
Dwelling Aspect	% of total units that are single aspect	Refer to architect's drawings and DAS.
	% of single aspect with N/NE/NW orientation	
	% single aspect with E orientation	
	% single aspect with S/SE/SW orientation	
	% single aspect with W orientation	
Glazing Ratio – What is the glazing ratio (glazing – internal floor area) on each façade?	N/NE/NW	Refer to architect's drawings and DAS.
	E	
	S/SE/SW	
	W	
Daylighting Window Opening	What is the average daylight factor range	*TBC*
	Are windows openable?	Yes
	What is the average percentage of openable area for the windows?	90% - accounting for frame factor
Window Opening – what is the extent of the opening?	Fully openable	Yes - sliding doors and french doors
	Limited (e.g. for security, safety, wind loading reasons)	Yes - restrictions on top hung and side hung windows of 300mm opening.

Section 2 – Design Features Implemented to Mitigate Overheating Risk		Please Respond
Security	Where there are security issues (e.g. ground floor flats) has an alternative night time natural ventilation method been provided (e.g. ventilation grates)?	No – MVHR provides ventilation
Shading	Is there any external shading?	Yes – accounted in the massing e.g. balconies
	Is there any internal shading?	Yes – Blinds to be included in the base build.
Glazing Specification	Is there any solar control glazing?	Glazing with g-value of 0.35 will be specified.
Ventilation – what is the ventilation strategy?	Natural - background	Yes – openable windows
	Natural – purge	Yes – openable windows
	Mechanical – background (e.g. MVHR)	Yes - MVHR
	Mechanical – purge	Yes –boost via MVHR and mechanical extract fans
	Average Design ACH	Up to 4 ACH
Heating System	Is communal heating present?	Yes – connections via HIU
	What is the flow/return temperature?	Subject to detailed design
	Have horizontal pipe runs been minimized?	Yes
	Do the specifications include insulation levels in line with the London Heat Network Manual?	Yes

Table 4.18: Overheating Checklist Section 2.

4.6.7 Design Development

During the pre-planning design development stages preliminary apartment layouts and elevations were provided by the architect and these were assessed for potential risk using the TM59 assessment methodology. Design development then took place on the draft layouts and elevations to mitigate the risk of overheating paying particular attention to the fenestration and the impact on the internal environment of the dwellings, with respect to daylighting and overheating.

The following measures were discussed and it was agreed following assessment that these would be incorporated:

- Reducing the amount of glazed area, particularly to the pent house south facing elevations (these are replaced with opaque panels)
- Automatic Opening Vents (AOV) to be used to ventilate communal corridors at an increased rate to alleviate corridor overheating and the effect this has on the potential overheating in the dwellings
- Internal blinds to be incorporated in the base build design
- Increased mechanical ventilation rates through MVHR with additional local extract fans to provide a higher rate of ventilation to living areas.

4.6.8 Overheating Risk Analysis

Dynamic simulation modelling (DSM) results have been completed using the most appropriate, CIBSE approved TM59 compliant weather file for the site, which is 'London_LHR_DSY1_2020High50'. This file is used as the minimum requirement to determine overheating risk as per CIBSE TM59 guidance in this part of the UK, and is a projection, based on historical data, of typical weather in the 2020s in a high emission 50% percentile scenario.

CIBSE TM59 provides a standardised methodology for assessing and reporting overheating risk in new and refurbished homes, and is now the industry standard for assessing overheating risk in residential projects.

The guidance includes a set of prescriptive internal gains and their associated timed profiles that represent reasonable usage patterns for a home suitable for evaluating overheating risk.

4.6.9 CIBSE TM59 Assessment Criteria

Table 4.19 provides a summary of the assessment criteria outlined in CIBSE TM59. For the purposes of this analysis, the building has been assessed against the predominantly naturally ventilated criteria. This is representative of 'free running' type buildings where people expect internal temperature to track external temperature, hence can adapt and tolerate in accordance with the adaptive comfort model.

Table 4.19: Summary of CIBSE TM59 Assessment Criteria

	CIBSE TM59 Requirements
Adaptive Thermal Comfort Model (Predominantly Naturally Ventilated Dwelling)	‣ Criterion 1 - no more than 3% of occupied hours operative temperature exceed the threshold comfort temperature (May – Sept). and ‣ Criterion 2 (bedrooms) do not exceed 26ºC operative temperature for more than 1% of annual hours between 2200-0700 (32 hours or less).
Fixed Thermal Comfort Model (Predominantly Mechanically Ventilated Dwelling)	‣ CIBSE Guide A fixed temperature test: ‣ Occupied spaces should not exceed operative temperature of 26ºC for more than 3% of annual occupied hours.
Communal Corridors (where communal heating present)	Fixed temperature test where corridors should not exceed operative temperature of 28ºC for total annual hours (262 hours or less)

It should be noted that whilst industry guidance has been followed, results in practice are likely to be dependent on factors which are highly user dependent, such as occupancy levels, internal gains from equipment and user behaviour such as operation of windows and blinds.

The results include all background parameters used within each assessment and presents results for multiple ventilation scenarios, as follows:

4. Mechanical ventilation only
5. Natural ventilation only
6. Hybrid ventilation i.e. mechanical and natural ventilation operating concurrently

Light coloured internal blinds have been included in the analysis.

4.6.10 Zones Assessed

A total of 20 dwellings have been assessed which are considered representative of the dwellings at the Proposed Development. This includes accounting for changes in orientation, glazing ratio, internal layouts and external environmental conditions.

The dwellings assessed are shown in the figure 4.19. Adjacent dwellings have also been included in the model with the appropriate templates assigned. The model is shown in figure 4.20.

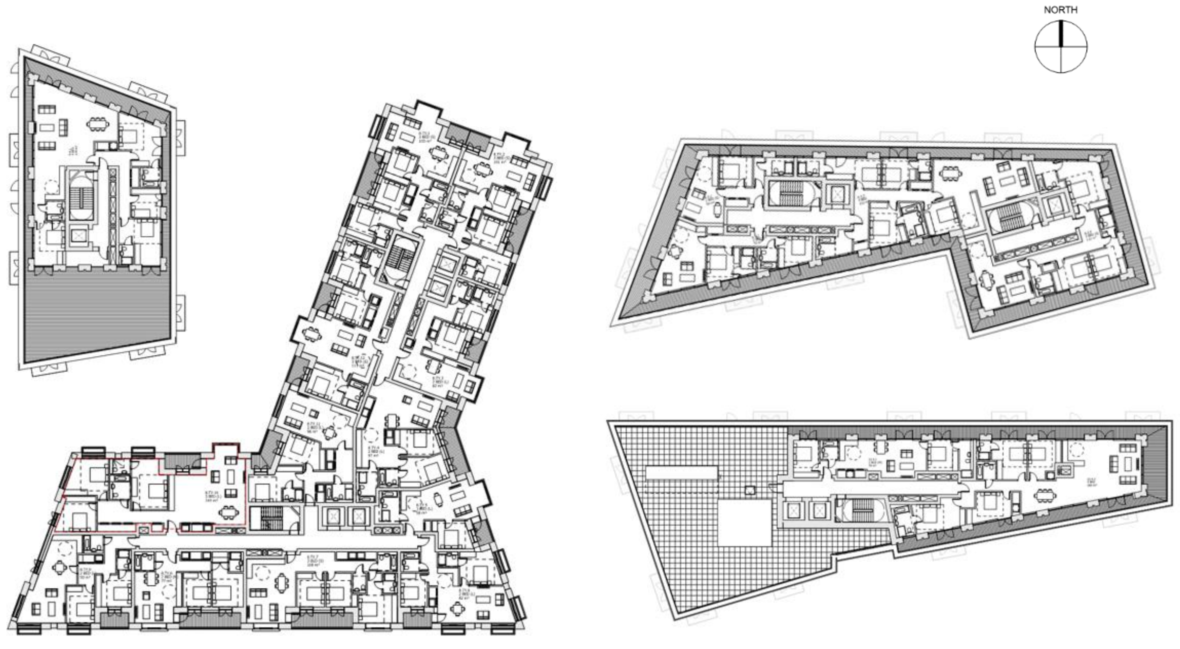


Figure 4.19: Assessed residential spaces including top floor of block 06 (top right), typical floor of block 08 (bottom left), top floor of block 09 (top left) and top floor of block 10 (bottom right).

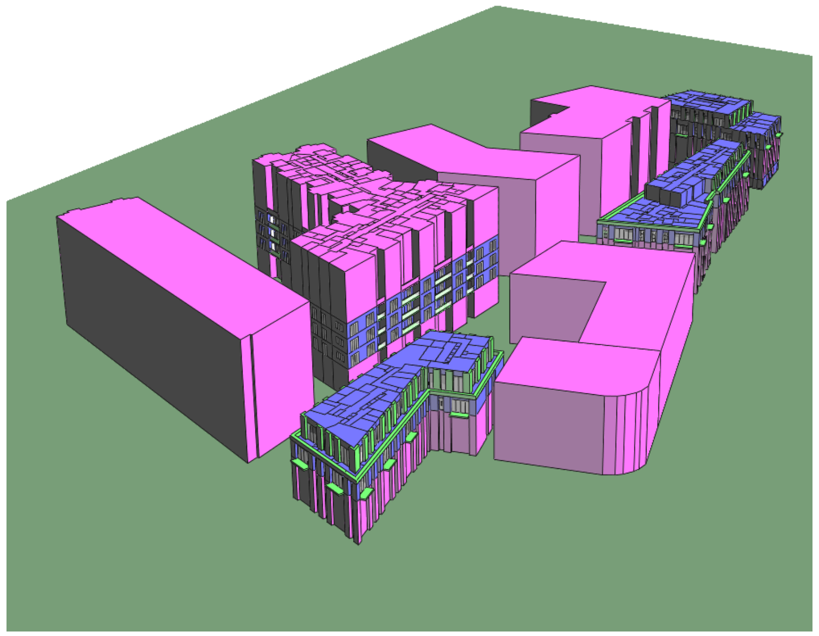


Figure 4.20: Extract from IES Model.

4.6.11 Building Fabric

The building fabric specification including air permeability and U-values are in line with the parameters used for the Building Regulations Part L 2013 SAP calculations.

4.6.12 Window Opening Types

For the purpose of the analysis, window openings have been assumed a combination of sliding door/windows, top-hung and side hung windows. A 300mm opening restriction has been considered as was advised by the architect. The windows are shown in figure 4.21.

Balcony doors have been assumed to be fully openable side hung or sliding/roller door with 100% free area.

Figure 4.21: Typical Window Openings of Block 08 and 10 South Elevation (Source: Squire and Partners).

4.6.13 Results

For the purposes of this analysis, the building has been assessed against each of the criteria for each scenario. This is representative of 'free running' type buildings where people expect internal temperature to track external temperature, hence can adapt and tolerate higher internal temperatures in accordance with the adaptive comfort model.

The results show a combined hybrid ventilation strategy enables the majority of rooms assessed to meet the CIBSE TM59 Criterion 1 requirements. In comparison with the natural ventilation scenario the mechanical ventilation scenario demonstrates similar results with the same TM59 criteria assessed.

As all dwellings will be provided with openable windows, the occupants will have the opportunity to adapt their environment during hot periods. Therefore, the risk of overheating shown in the mechanical ventilation scenario would only occur during times when external ambient noise is above tolerable limits and the occupant has determined that it is necessary to close the windows. This is subjective and largely driven by the home user. Ultimately, the occupants will have the choice to open windows during hot periods.

All dwellings will be provided with mechanical ventilation with heat recovery and openable windows, allowing the occupant to adapt their internal environment according to their own needs. The mechanical ventilation systems in the Proposed Development have increased flow rates to assist in reducing the risk of overheating. Of the rooms that do not meet the criteria these present a marginal exceedance of the criteria.

As a result of the above considerations, the risk of high internal temperatures in summer has been minimised as far as practically possible from passive measures for the residential dwellings, within architectural and practical constraints, and this has been demonstrated via overheating calculations in compliance with current CIBSE guidance. Table 4.20 provides an overview of the results.

	% Meeting Adaptive Comfort Model Criteria		Corridors
	TM59 Criterion 1 Kitchens, Living Rooms and Bedrooms <3% occ hours exceed comfort temp (May-Sept)	TM59 Criterion 2 Bedrooms only <26°C for <1% occ. hours.	28°C operative temperature
Scenario 1: Natural Ventilation with blinds	76%	52%	n/a
Scenario 2: Mechanical ventilation with blinds	73%	44%	Corridor meets target
Scenario 3: Hybrid ventilation with blinds	84%	92%	Corridor meets target

Table 4.20: Summary of Occupied Spaces that meet CIBSE TM59 Targets.

5. Conclusion

5.1 Meeting Pertinent Targets

Energy and CO_2 Emissions

This Energy Strategy has demonstrated that through implementation of passive design and energy efficiency measures and the installation of a CHP engine and on-site PV array, that overall the Proposed Development is anticipated to achieve a **20.3%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline'.

The Energy Strategy has responded to the policy requirements of the GLA and LBRuT in seeking to maximise the CO_2 emission reductions for the whole site (Application A and B) at the Be Lean, Be Clean and Be Green stages of the energy hierarchy. The Energy Strategy has also set to provide flexibility for the areas that will be subject to a reserved matters application (Development Area 2) to maximise the availability of CO_2 emissions reductions when this area is brought forward for development.

5.1.1 Be Lean

Passive design measures and energy efficiency measures which would be implemented at the Proposed Development include:

a. Suitable glazing ratio and glass g-value to balance heat losses and gains and daylight ingress
b. Fabric insulation levels achieving improvements over Building Regulations Part L (2013) requirements of 25% - 100%
c. Fabric air permeability achieving improvements over Building Regulations Part L (2013) requirements of 75% and 70% for dwellings and commercial spaces respectively
d. Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water
e. Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use and reduce light pollution
f. Efficient mechanical ventilation with heat recovery which will limit the need for space heating in winter months, aid the mitigation of high internal temperatures in summer months (where openable windows cannot be used due to ambient acoustic conditions), and maintain good indoor air quality
g. Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains
h. Variable speed pumps and fans to minimise energy consumption for distribution of services

These passive design measures are anticipated to achieve 1.9**%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013). As a result, the Proposed Development would achieve compliance with the requirements of the Building Regulations Part L (2013) through passive design and energy efficiency measures, i.e. before the use of LZC technologies.

5.1.2 Be Clean

In addition to the above, the Proposed Development would consider the benefit of an on-site CHP engine that would connect to the domestic uses and commercial spaces. The CHP engine would be sized based on providing 99% of the hot water and up to 30% of the space heating requirements of the Proposed Development. In this mode of operation, it is expected that regulated CO_2 emissions savings of 441 tonnes per annum can be achieved. This is equivalent to a **17.2%** reduction in CO_2 emissions beyond the Building Regulations Part L (2013) 'baseline'.

In order to deliver lowest life-cycle CO_2 emissions within an evolving energy landscape, it would be preferable for available technologies to be assessed for their ability to provide reductions in regulated CO_2 as and when each area is brought forward, and subject to commercial viability. This will allow the most appropriate heat generating plant to be chosen in the face of the changing energy landscape, particularly if any revision to the carbon factor specified in the Building Regulations is made.

The school (Application B) is anticipated to be served by a CHP of its own.

5.1.3 Be Green

It is anticipated that a PV array with a total area of 520m^2 would be provided on the roof area of the Proposed Development. Based on the solar irradiance data for London, an array of this size would generate approximately 57,200kWh of electricity per annum, reducing CO_2 emissions by **30tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **1.2%** beyond the Building Regulations Part L (2013) 'baseline' for the anticipated emissions of the Proposed Development. Further opportunities to increase the area of the PV array will be provided in the reserved matters submission(s) for Development Area 2.

When considering the residential elements separately if this array was to be connected to the supply to the dwellings the contribution is equivalent to a **2.5%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'.

PV is therefore anticipated to be a suitable addition to the Proposed Development in pursuit of further reductions in regulated CO_2 emissions.

5.1.4 Total

Following the energy hierarchy, reductions in regulated energy requirements and associated CO_2 emissions have been made at each stage as demonstrated by Table 5.1 as follows.

Application A	Estimated Regulated Carbon Dioxide Emission Savings for the Whole Site	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	35	1.5%
Savings from heat network / CHP (Clean)	410	17.2%
Savings from renewable energy (Green)	30	1.2%
Total Cumulative Savings	**519**	**20.0%**

Table 5.1: Summary of Regulated CO_2 Emissions Reduction.

The CO_2 emissions are represented graphically in Figure 5.1 as follows:

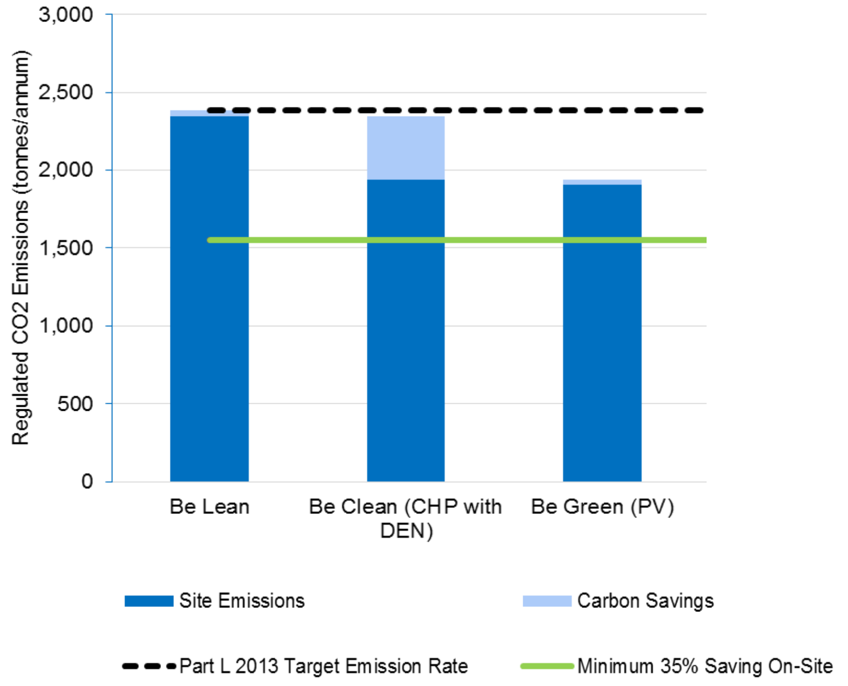


Figure 5.1: Summary of Regulated CO_2 Emissions Reduction - Application A

When considering the school alone, an overall reduction of 6% beyond the Building Regulations Part L 2013 'baseline' can be achieved through passive design and energy efficiency measures. The CO_2 emission savings for the non-domestic uses are represented graphically in Figure 5.2 as follows. CO_2 emissions reductions are represented cumulatively in the graph.

School (Application B)	Estimated Regulated Carbon Dioxide Emission Savings for the School	
	(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)	11	6.0%
Savings from heat network / CHP (Clean)	31	19.0%
Savings from renewable energy (Green)	-	-
Total Cumulative Savings	**42**	**24.0%**

Table 5.2 Summary of CO_2 emissions reductions and offset payment for non-residential areas.

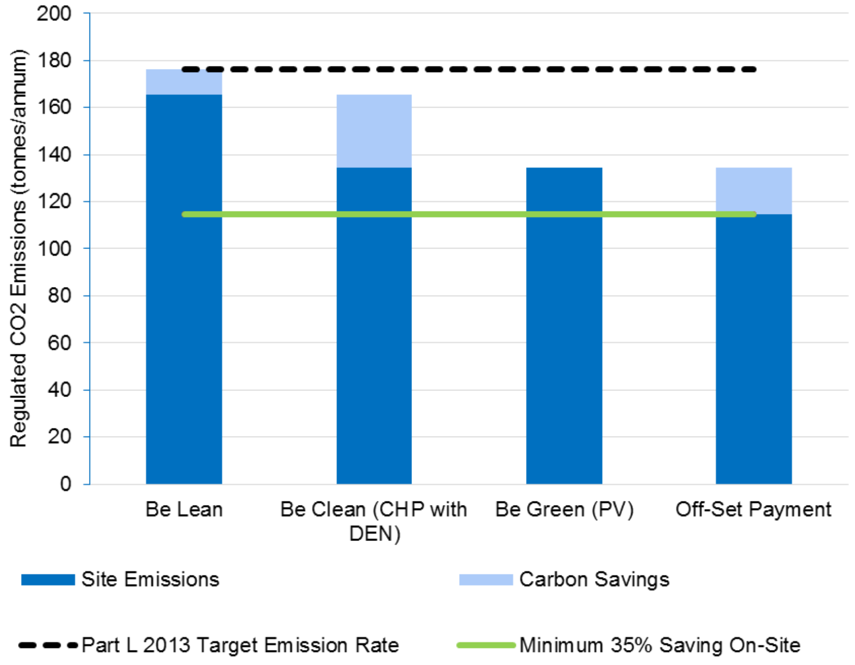


Figure 5.2: Summary of Regulated CO_2 Emissions Reduction for the school (Application B).

In this energy strategy the Applicant seeks to set out that the Proposed Development has implemented passive design, energy efficiency and LZC technologies effectively and where feasible, to levels that are beyond the minimum levels required by Part L of the Building Regulations. The Applicant recognises that the CO_2 emissions reduction does not meet the targets provided in the GLA London Plan (2016) and will seek a discussion on an appropriate level of a Carbon Offset payment to be made to the Local Authority. The calculation of the Carbon Offset payment needs to be dealt with on a bespoke basis for a mixed use scheme of the scale.

5.1.5 Limiting the Effects of Heat Gains in Summer

The Proposed Development has been designed in accordance with the cooling hierarchy to minimise cooling demand and limit the likelihood of high internal temperatures. Mitigation measures such as suitable glazing ratio and g-value, appropriate ventilation levels and minimisation of internal heat gains will be implemented. Through these measures, relevant areas of the Proposed Development will achieve compliance with Criterion 3 of the Building Regulations Part L (2013).

It is not anticipated that active cooling will be provided for the residential areas of Development Area 1. An overheating risk assessment has been carried out on the design proposals in accordance with recent GLA policy, using the CIBSE TM59 methodology. A completed overheating checklist has also been provided in this report.

The following mitigation measures have been implemented in the design of the Proposed Development.

a. Energy efficient lighting (such as LED or compact fluorescent) with low heat output

b. Insulation to heating and hot water pipework and minimisation of dead-legs to avoid standing heat loss (from pipework to dwellings) including no-hot water storage in the dwellings
c. HIUs located away from main living spaces
d. Environmental controls within the common corridors to provide ventilation
e. Increased mechanical ventilation rates beyond minimum Building Regulations requirements.

The results show a hybrid ventilation strategy enables more than 83% of living rooms, kitchens and bedrooms assessed to meet the CIBSE TM59 requirements of the first criteria of the adaptive thermal comfort model and over 91% of bedrooms meet the second criteria. All dwellings will be provided with opening windows and therefore the adaptive thermal comfort model has been used as the benchmark in this analysis.

6. Appendix A: Regulatory and Policy Context

The following outlines the regulatory and planning policy requirements applicable to the Proposed Development.

6.1 National Policy

6.1.1 Current Policy Framework

The Proposed Development is referable to the Mayor of London. The policies considered when preparing this strategy are contained in the London Plan (GLA, 2016) and the Local Development Plan of LBRuT. The Supplementary Planning Guidance (SPG) has also been reviewed and taken into consideration in the Energy Strategy.

6.1.2 Building Regulations Part L 2013

Approved Document Part L

Part L of the Building Regulations is the mechanism by which government is driving reductions in the regulated CO_2 emissions from new buildings.

Current Requirements: Part L 2013

Part L has five key criteria which must be satisfied as follows:

a. Criterion 1 - Achieving the Target Emission Rate (TER)
b. Criterion 2 - Limits on design flexibility
c. Criterion 3 - Limiting the effects of solar gains in summer
d. Criterion 4 - Building performance consistent with the Dwelling Emission Rate (DER)
e. Criterion 5 - Provision for energy efficient operation of the dwelling

Criteria one, two and three are addressed within this strategy.

Criterion one requires that the building as designed is not predicted to generate CO_2 emissions in excess of that set by the Target Emission Rate (TER) calculated in accordance with the approved Standard Assessment Procedure (SAP) 2012. Part L (2013) requires the following reductions:

a. A 6% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for dwellings; and
b. A 9% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for non-domestic buildings.

Criterion two places upper limits on the efficiency of controlled fittings and services for example, an upper limit to an external wall U-value of 0.30W/m^2.K (dwellings).

A Fabric Energy Efficiency Standard (FEES) has been introduced for new dwellings although no definitive targets have been set in this regard. Part L 2013 requires the following Fabric Energy Efficiency performance targets to be met:

a. Target Fabric Energy Efficiency (TFEE). The TFEE is calculated independently for each dwelling, based upon an elemental recipe of efficiency parameters, applied to the geometry of the dwelling in question. This would generate a notional value which would then be relaxed by 15% to generate the TFEE

Criterion three requires that dwellings are not at 'high' likelihood of high internal temperatures in summer months (June, July & August) and that zones in commercial buildings are not subject to excessive solar gains. This is demonstrated using the procedure given in SAP 2012 Appendix P for dwellings, and Simplified Building Energy Model (SBEM) or Dynamic Simulation Method (DSM) for non-residential buildings.

6.2 GLA Planning Policy

6.2.1 The London Plan (March 2016) Consolidated with Alterations Since 2011

The regional policies of the GLA are contained within the London Plan (2016), and the relevant SPGs.

The latest version of the consolidated London Plan (2016) was published and adopted in March 2016 and is current for any Stage 1 submissions to the GLA. This constitutes the London Plan 2011 consolidated with:

- Revised Early Minor Alterations to the London Plan (October 2013)
- Further Alterations to the London Plan (March 2015)
- Housing Standards Minor Alterations to the London Plan (March 2016)
- Parking Standards Minor Alterations to the London Plan (March 2016)

The target reduction in CO_2 emissions for Residential Buildings is to achieve 'zero carbon homes' for Stage 1 applications. The definition of this is clarified in the GLA's publication G*uidance on Preparing Energy Assessments*. The target for 'Non-Domestic Buildings' is to achieve 35% reduction in CO_2 emissions.
Energy Planning - Greater London Authority guidance on preparing energy assessments (March 2016)
This document was produced by the GLA to provide further detail on how to prepare an energy assessment to accompany strategic planning applications. Within this, the definition of 'zero carbon homes' is made as follows:

'Zero carbon' homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site. The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere (in line with policy 5.2E).

The cash in lieu payment is currently set at £1,800 per tonne of CO_2 (equivalent to £60 per tonne per year over 30 year period).

Use Type	CO_2 Reduction Target (beyond Part L 2013)	
	2013 – 2016	2016 – 2019 (1st October 2016)
Residential Buildings	35%	**'Zero Carbon'**
Non-Domestic Buildings	35%	35%

Table A1: Uplift in CO_2 emissions targets

6.2.2 London Plan Policy

Development within LBRuT is subject to the policy requirements of the London Plan 2016. The following policies of the London Plan (2016) have informed this strategy.

Policy 5.2: Minimising CO_2 Emissions

Policy 5.2 sets out the target CO_2 emission reductions as described above.

Policy 5.6: Decentralised Energy in Development Proposals

Policy 5.6 requires development proposals to evaluate the feasibility of Combined Heat & Power (CHP) systems and where a new CHP system is appropriate, examine opportunities to extend the system beyond the Site boundary. Developments should select energy systems on the following hierarchy:

b. connection to existing heating or cooling networks
c. site wide CHP network
d. communal heating and cooling

Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7: Renewable Energy

Policy 5.7 requires that developments should provide a reduction in expected CO_2 emissions through the use of on-site renewable energy generation, where feasible.

Policy 5.9: Overheating and Cooling

The GLA have produced a 'Domestic Overheating Checklist' (Appendix 5 of the 'Energy Planning' guidance) for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The 'Energy Planning' guidance document also includes an update to the guidance on compliance with overheating policy that design teams should be aware of when undertaking risk analysis and thermal comfort modelling for dwellings.

It is the GLA's expectation that dynamic thermal modelling should be undertaken to determine overheating risk and demonstrate compliance with London Plan Policy 5.9. This should be in addition to the Building Regulations 'Criterion 3' assessment of heat gains in summer months.

The GLA has set out that dynamic modelling should be carried out in accordance with the guidance and data sets in CIBSE TM49 'Design Summer Years' for London (2014) using the three design weather years as follows:

- 1976: a year with a prolonged period of sustained warmth.
- 1989: a moderately warm summer (current design year for London).
- 2003: a year with a very intense single warm spell.

For developments in high density urban areas (e.g. Canary Wharf) and the 'Central Activity Zone' the 'London Weather Centre' data set should be used. In lower density urban and suburban areas the 'London Heathrow' dataset should be used. These data sets have been adjusted to account for future climate effects.

The modelling should also consider the additional guidance contained in CIBSE TM52 'The Limits of Thermal Comfort: Avoiding Overheating in European Buildings'.

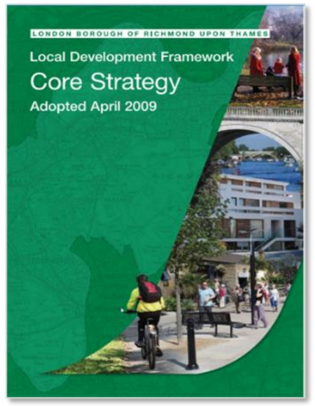
6.2.3 GLA Sustainable Design and Construction SPG (April 2014)

This SPG provides more detailed guidance to aid implementation that cannot be covered in the London Plan. It updates the standards that were developed for the Mayor's SPG on Sustainable Design and Construction in 2006 and identifies these as priorities for the Mayor. The SPG provides guidance and practical advice for those designing schemes including architects, developers and engineers as well as those developing planning policy and neighbourhood plans.

To support the policies in the London Plan the Sustainable Design and Construction SPG includes guidance on:

- energy efficient design
- meeting the carbon dioxide reduction targets
- decentralised energy
- how to offset carbon dioxide where the targets set out in the London Plan are not met
- retro-fitting measures
- support for monitoring energy use during occupation
- an introduction to resilience and demand side response
- air quality neutral
- resilience to flooding
- urban greening
- pollution control
- basements policy and developments
- local food growing

6.3 London Borough of Richmond upon Thames Local Plan



6.3.1 Local Development Framework: Core Strategy (2009)

CP1 Sustainable Development

BREEAM 'Excellent' is required for all non-residential developments and residential refurbishment.

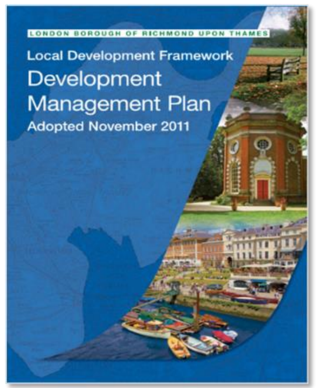
CP2 Reducing Carbon Emissions

All new developments are required to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation, unless it can be demonstrated that this is not feasible.

CP3 Climate Change – Adapting to the Effects

Development will need to be designed to take account of the impacts of climate change over its lifetime, including:

- Water conservation and drainage
- The need for Summer cooling
- Risk of subsidence
- Flood risk from the River Thames and its tributaries



6.3.2 Local Development Framework Development Management Plan (2011)

Policy DM SD 1 Sustainable Construction

All development in terms of materials, design, landscaping, standard of construction and operation should include measures capable of mitigating and adapting to climate change to meet future needs.

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 to 2013, 40 per cent improvement from 2013 to 2016, and 'zero carbon' standards (2) from 2016.

New non-residential buildings over 100sqm will be required to meet the relevant BREEAM 'excellent' standards.

Policy DM SD 2 Renewable Energy and Decentralised Energy Networks

New developments are required to 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.

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

Policy DM SD 3 Retrofitting

High standards of energy and water efficiency in existing developments will be supported wherever possible through retrofitting.

Policy DM SD 4 Adapting to Higher Temperatures and Need for Cooling

All new developments should follow the cooling hierarchy.

Policy DM SD 5 Living Roofs

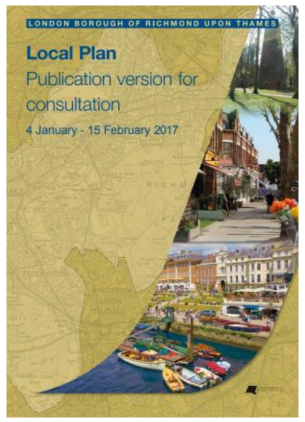
Living roofs should be incorporated into new developments where technically feasible and subject to considerations of visual impact. The onus is on the applicant/developer for proposals with roof plate areas of 100sqm or more to provide evidence and justification if a living roof cannot be incorporated. The aim should be to use at least 70% of any potential roof plate area as a living roof.

Policy DM DC 1 Design Quality

New development must be of a high architectural and urban design quality based on sustainable design principles. Development must be inclusive, respect local character including the nature of a particular road, and connect with, and contribute positively, to its surroundings based on a thorough understanding of the site and its context.

Policy DM DC 5 Neighbourliness, Sunlighting and Daylighting

The Council will generally seek to ensure that the design and layout of buildings enables sufficient sunlight and daylight to penetrate into and between buildings, and that adjoining land or properties are protected from overshadowing in accordance with established standards.



6.3.3 Emerging Local Plan (anticipated adoption Spring 2018)

Policy LP 1 Local Character and Design Quality

The council will require all development to be of high architectural and urban design quality. The high quality character and heritage of the borough and its Villages will need to be maintained and enhanced where opportunities arise. Development proposals will have to demonstrate a thorough understanding of the site and how it relates to its existing context, including character and appearance, and take opportunities to improve the quality and character of buildings, spaces and the local area.

Policy LP 8 Amenity and Living Conditions

Design and layout of buildings enables good standards of daylight and sunlight to be achieved in new development and in existing properties affected by new development.

Policy LP 10 Local Environmental Impacts, Pollution and Land Contamination

Development proposals should not lead to detrimental effects on the health, safety and amenity of existing and new users or occupiers of the development site, or the surrounding land. These potential impacts can include, but are not limited to, air pollution, noise and vibration, light pollution, odours and fumes, solar glare, solar dazzle and land contamination.

Policy LP 17 Green Roofs and Walls

Green/brown roofs should be incorporated into new major developments with roof plate areas of 100sqm or more where technically feasible and subject to considerations of visual impact. If it is not feasible to incorporate a green/brown roof, then a green wall should be incorporated.

Policy LP 20 Climate Change Adaptation

Developments will be encouraged to be fully resilient to the future impacts of climate change in order to minimise vulnerability of people and property. New developments should minimise the effects of overheating in accordance with the cooling hierarchy.

Policy LP 22 Sustainable Design and Construction

LP22A Sustainable Design and Construction

1. Developments of 1 dwelling or more, or 100sqm or more of non-residential floor space (including extensions) will be required to comply with the Sustainable Construction Checklist SPD.
2. Developments with new dwellings must achieve a water consumption of 110l per person per day for homes.
3. New non-residential buildings over 100sqm must achieve BREEAM "Excellent"
4. Change of use residential should meet BREEAM Domestic Refurbishment "Excellent", where feasible.

LP22B Reducing Carbon Dioxide Emissions

1. All new major residential developments should achieve zero carbon standards in line with London Plan policy.
2. All other new residential buildings should achieve 35% reduction
3. All major non-residential buildings should achieve a 35% reduction. From 2019 all major non-residential should achieve zero carbon standards in line with London Plan Policy.

LP22C Decentralised Energy Networks

1. All new development required to connect to existing DE network where feasible (including planned DE networks operational within 5 years of development completion).
2. Major developments will need to provide an assessment of the provision of on-site DE networks and CHP.
3. Where feasible, major developments will need to provide on-site DE and CHP. Provision for future connection should be incorporated where required.

LP22E Retrofitting

High standards of energy and water efficiency in existing developments will be supported wherever possible through retrofitting.

Policy LP 23 Water Resources and Infrastructure

Water resources and supplies will be protected by resisting proposals that would pose an unacceptable threat. Proposals that seek to increase water availability or protect and improve water quality will be encouraged.

Policy LP 30 Health and Wellbeing

Developments that support the following will be encouraged:

- Sustainable modes of travel
- Access to green infrastructure
- Access to local community facilities, services and shops
- Access to local healthy food
- Access to toilet facilities open to all
- Inclusive public realm layout

7. Appendix B – Full Application Energy Strategy – Development Area 1 & Application B, The School.

The section provides the detailed energy strategy for Development Area 1 and Application B, the School, hereafter referred to as the Proposed Development.

7.1 Approach

The approach to the energy strategy for Development Area 1 and the School is in line with the Whole Site strategy presented previously, i.e. the strategic approach to Development Area 1 and the School has been to reduce the demand for energy in the first instance, prior to the consideration of any Low or Zero Carbon Technologies (LZC).

The approach to the energy strategy follows the energy hierarchy:

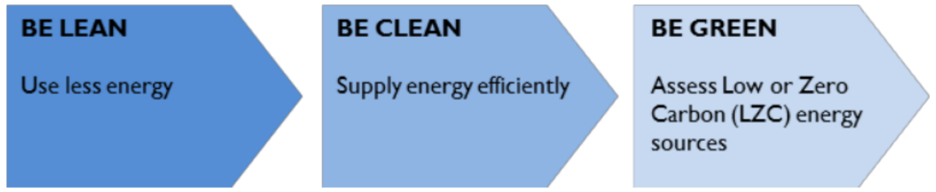


Figure B1: Energy Strategy Hierarchy.

Similar to the Whole Site, the Proposed Development will target a 35% reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline for non-dwelling areas and 100% reduction for Dwellings.

7.1.1 Methodology

Calculations demonstrating the energy requirements and associated CO_2 emissions for dwellings have been carried out using Building Regulations Part L1A approved SAP 2012 v9.92 methodology. A sample of dwellings including a typical floor of Block 2 and sample dwellings from other blocks have been assessed.

For non-dwelling areas calculations have been undertaken using NCM software compliant with Part L2A of the building regulations. This has included the areas of non-domestic space that are significant including, Cinema, Gym, Hotel, Office and the School. Calculations demonstrating the energy use and associated CO_2 emissions for the remaining commercial areas have been carried out using benchmarks from similar Part L2A 2013 compliant buildings.

The areas (Gross Internal Area (GIA)) outlined in Table B1 have been used to undertake the appraisals described within this energy strategy. The Part L 2013 CO_2 emission factors have been used.

Use	Area (m^2)
Dwellings (Development Area 1)	47,943
Refurbishment Dwelling Area	2,172
Retail (Flexible Use space)	2,500
Restaurant (Flexible Use space)	2,164
Hotel	1,668
Office	2,424
Cinema	2,120
Gym	740
Management Office	33
Total Development Area 1	**61,764**
School	**9,319**

Table B1: Area Schedule – Development Area 1 and School

It should be noted that some flexible commercial floor space is proposed as part of the scheme (Class A1/A2/A3/A4/B1/D1/Boathouse). In the calculations the maximum floor area has been allocated to these uses in the following order to generate a 'worst case' energy demand and CO_2 emissions:

1. A3,
2. A1,
3. B1

This is not to be taken as a suggestion that these areas are set in the Proposed Development. Flexible use spaces are set within the following maximum floor area per use with the maximum floor area for flexible uses at 4,664m^2.

Use	Maximum floorspace (m^2)
Retail (A1)	2,500
Financial and Professional services (A2)	200
Cafes/restaurants (A3)	2,200
Drinking Establishments (A4)	1,600
Offices (B1)	2,000
Community Use (D1)	1,148
Boathouse (Sui Generis)	351

Table B2: Flexible Use Maximum Areas

From this proposal the areas used in the calculation of energy use and CO_2 emissions in this Energy Strategy are set out in the table below.

7.2 Appraisal

7.2.1 Be Lean - Passive Design

As included within the outline application, passive design and energy efficiency measures will form the cornerstone of the energy demand reduction for the Site.

Passive design and energy efficiency measures to be implemented for the office space at the Proposed Development can be summarised as follows:

7.2.1.1 Glazing Ratio and Energy / Light Transmittance

Consideration has been given to the extent of glazing to achieve a balance between passive solar heating in winter, whilst recognising the potential for excessive solar gains in summer which could lead to high internal temperatures.

The glazing specification for the dwellings areas of the Proposed Development will target a solar energy transmittance value of 0.35. The office and other commercial spaces that are sensitive to solar gains will use a g-value that balances day light and beneficial solar gains with the need to reduce cooling.

The school would be designed to provide daylight into the occupied spaces which are situated where possible on the outer edge of the building. The internal areas have been set aside for core areas and areas which are sensitive to daylight, such as lecture theatres. This design maximises the use of the available daylight in the building.

7.2.1.2 Thermal Insulation & Air Permeability

The Proposed Development will achieve improvements in the performance of the external fabric beyond the Building Regulations Part L 2013 requirements in order to limit the requirement for energy. Please refer to Table B2 for targeted U-values for external building elements.

Additionally, the dwellings and the school at the Proposed Development will target an air permeability of 3.0 $m^3/(m^2.h)$ at 50Pa. This is a 70% improvement on the Building Regulations Part L 2013 limiting requirements.

7.2.2 Be Lean - Energy Efficiency Measures

Energy efficiency measures are those which seek to service the demand for energy (i.e. the remaining demand after implementation of passive design measures) in the most efficient way.

The fit out of the flexible retail space will be the responsibility of the tenant and would be advised to comply with the Non-Domestic Building Services Compliance Guide (2013) for all systems that they install. Sufficient plant space would be provided for this tenant.

To determine the performance of the passive design measures, the Part L 2013 calculations are based on the provision of centralised gas boilers.

7.2.2.1 Heating

The Proposed Development is proposed to benefit from connection to a district heating network served by an Energy Centre on the site. It is proposed that the network would be served by high efficiency gas boilers of at least 90% efficiency, and Low or Zero Carbon (LZC) technology, i.e. CHP (please refer to section 4.3 for details on CHP). It is proposed that each area of the Proposed Development will have an energy centre that will serve the district heat network for the buildings of the respective area.

Buildings would connect to the network via heat substations linked to building-side distribution. Where appropriate the Commercial units and dwellings within each building would connect to their respective building side networks via Heat Interface Units (HIU) comprising of a plate heat exchanger.

The school will have an on site energy centre. The school will use primary distribution pipework connected to the onsite energy centre to supply heat to the relevant heat emitters throughout the building.

7.2.2.2 Hot Water

Domestic hot water requirements for the dwellings will be satisfied via the same gas boilers as outlined above, whilst the commercial spaces will either make use of a connection to the heat network where hot water use is high (such as the Gym, Hotel and Cinema) or will be required to install efficient point of use electric water heaters. Dead legs will be minimised to maximise efficiency of the systems. All spaces will reduce water consumption via the provision of efficient fixtures and fittings such as low flow taps and meet Building Regulations Part G.

The school energy centre will provide hot water from centralised gas boilers.

7.2.2.3 Cooling

No cooling is to be provided to the dwellings. The commercial spaces will be fitted out by the occupants of these spaces and are likely to utilise ASHP or VRF to limit internal temperatures during summer with cooling supplied to the space via Fan Coil Units (FCU). The building occupants will also have the opportunity to control their internal environment via access to openable windows which would enable the ‘mixed mode’ strategy to be employed.

The school will utilise cooling in specific areas such as IT suites. High efficiency air cooled chillers will be used to generate the cooling.

7.2.2.4 Lighting

Dwellings will be provided with low-energy, efficient light fittings throughout. External lighting for dwelling amenity areas would also be low-energy efficient fittings, and will be linked to daylight sensors and / or presence detectors to prevent unnecessary use. In all cases, lighting will be provided to meet the requirements of the Building Regulations Part L.

Tenants of commercial areas would be encouraged to select high-efficiency lighting systems wherever possible, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013). Lighting systems will also be linked to daylight controls and presence detection to minimise unnecessary use.

LED lighting will be provided throughout the school in line with best practice and be provided with lighting control to allow the zones within the classrooms to turn off automatically via PIR when there is sufficient daylighting

7.2.2.5 Ventilation

It is anticipated that mechanical ventilation will be employed in all areas of the Proposed Development, such as dwellings, commercial areas including offices, hotel, and school, with efficient heat recovery to recoup heat from outgoing air and supply this to incoming fresh air. The re-use of waste heat will enable reductions in both energy requirements and CO_2 emissions.

The fit out of the retail space will be the responsibility of the individual tenants. The tenants will be required to implement efficient systems in line with the standards outlined in the Non-Domestic Building Services Compliance Guide (2013).

7.2.2.6 Variable Speed Pumps

Variable speed pumps and controls allow the heating and ventilation systems to modulate during periods of low demand. Using variable speed pumps therefore uses less energy than traditional pumps, which run at a constant speed. The use of variable speed pumps throughout the building services systems will be incorporated into each building.

7.2.2.7 Controls

The following measures will be installed:

- Zoned thermostatic control;
- Time control;
- Variable flow control;
- BMS (Building Management System) automated control;
- Lighting PIR (Passive Infra-Red Sensor) control;
- Daylight linked lighting control;
- Energy management control.

The provision of demand control ventilation based on CO_2 sensors will be considered during the detailed design stages.

7.2.2.8 Energy Metering

Metering and sub-metering would be considered in order to promote the efficient use of resources. This would enable each tenant to monitor their energy requirements. The energy metering will focus on the following energy uses for each building:

- Space heating;
- Domestic hot water;
- Cooling;
- Major fans;
- Lighting;
- Small power;
- Contribution from LZC technologies; and
- Any other major energy uses.

In dwellings the occupants will be provided with the ability to view their meter readings and energy usage.

7.2.3 Unregulated Energy

The Proposed Development will also target a reduction in energy consumption and CO_2 emissions as a result of unregulated energy loads i.e. small power electricity use.

Measures to achieve a reduction in unregulated energy use include:

- Use of A / A+ rated white goods;
- Energy star rated computers and flat screen monitors;
- Energy efficient lifts; and
- Voltage optimization and power factor correction.

7.2.4 Summary of Passive Design & Energy Efficiency Measures

Table B2 and B3 summarises the anticipated passive design and energy efficiency targets for the commercial (office and retail) and School at the Proposed Development.

	Parameter	Dwellings	Non-Dwellings and School
Passive Design	Roof U-value (W/m².K)	0.15	0.20
	External Wall U-value (W/m².K)	0.12	0.20
	Floor U-value (W/m².K)	0.15	0.20
	Party Wall U-value (W/m².K)	0.00 (fully filled cavity with effective edge sealing)	N/A
	Sheltered Wall U-value (W/m².K)	0.20	N/A
	Window U-value (W/m².K)	1.40 – 1.30	1.60 5.56 – retail display glazing
	Glazing g-value	0.35	040-0.60
	Fabric Air Permeability (($m^3/m^2.h$) at 50 Pa)	3.00	3.00-5.00
	Thermal Bridging	Approved	-

Table B2: Summary of Passive Design Energy Efficiency Measures for Dwellings, Commercial and School Buildings.

	Parameter	Dwellings	Non-Dwellings
Energy Efficiency	Space Heating	DEN fuelled by CHP and high-efficiency condensing gas boilers (94% efficiency) with Heat Interface Units (HIU) per dwelling coupled to hot water systems and fan coil units / underfloor heating.	High-efficiency (94%) centralised condensing gas-boilers coupled to hot water systems. Heating delivered to space mainly via radiators, but also underfloor heating in the halls and fan coil units in the areas with cooling.
	Hot Water	Water efficient fixtures and fittings to minimise water demand. HIU with minimal heat loss	
	Space Cooling	No cooling.	High-efficiency chillers with an SEER of 5.0.
	Lighting	High efficiency lighting. Daylight and presence detection in common areas / roof terraces.	Target efficacy of >70 luminaire lumens per circuit Watt.
	Ventilation	MVHR with specific fan power 0.4-0.53 with Heat Recovery of 91-94%	Target SFP of 1.6W/l/s and HR of 75%
	Metering & Controls	Zonal, programmable thermostatic controls for heating. Separate programmable control for hot water. Electricity meter and heat meter with potential link to energy display device.	To be provided in accordance with the requirements of the Building Regulations.
	Pipework & Ductwork Insulation	To be provided in accordance with the requirements of the Building Regulations.	To be provided in accordance with the requirements of the Building Regulations
	Variable Speed Pumping	To be provided.	To be provided.
	O&M Manuals	Systems overview and detailed descriptions in plain and clear English.	To be provided in accordance with the requirements of the Building Regulations.

Table B3: Summary of Energy Efficiency Measures for Dwellings, Commercial and School Buildings

7.3 Energy Requirements and CO_2 Emissions Appraisal

7.3.1 Be Lean

The following summarises the anticipated energy requirements and CO_2 emissions after the inclusion of the passive design and energy efficiency measures described previously.

7.3.2 Results – Development Area 1

The results presented below are based on Building Regulations Part L1A and L2A 2013 compliance modelling carried out on the dwellings and commercial spaces in Development Area 1 of the Proposed Development. For the purposes of this energy strategy to calculate 'Be Lean' energy requirements and CO_2 emissions, the modelling was based on the provision of gas boilers.

The calculations outlined below demonstrate that prior to the implementation of any renewable or low carbon measures, the anticipated annual regulated energy requirement of Development Area 1 of the Proposed Development is calculated to be approximately **4,385MWh** with associated regulated CO_2 emissions of **1,206 tonnes**.

Of the total regulated energy requirement of the Proposed Development, approximately 38% is attributable to heating and 44% to hot water. Overall, hot water is the highest contributor to regulated CO_2 emissions of the Proposed Development (35%) followed by heating (30%). Consequently thermal loads dominate the regulated CO_2 emissions arising from the Proposed Development.

It is anticipated that overall the Proposed Development will achieve a ~**3%** reduction in annual regulated CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 via passive design and energy efficiency measures (i.e. before any benefit from low or zero carbon technologies). Within this overall target the dwellings will achieve a **1.3%** reduction beyond the Part L1A 2013 baseline and the school will achieve a **6%** reduction beyond the Part L2A 2013 baseline.

7.3.3 Results – School (Application B)

When considering the **school** in isolation, it has been calculated to have an annual regulated energy requirement of **617MWh** with associated CO_2 emission of **91tonnes**.

The majority of the regulated energy requirement (~82%) for the school is associated with heating and hot water requirements. Heating and hot water also contribute the greatest proportion of CO_2 emissions (~66%).

7.3.4 Summary Tables & Charts

Table B4 summaries the energy and CO_2 reduction achieved through the implementation of passive design and energy efficiency measures.

		Regulated Energy Requirements		Regulated CO_2 Emissions	
		kWh/yr	% Reduction	tonnesCO_2/yr	% Reduction
Development Area 1	Baseline	4,473,000	-	1,238	-
	Be Lean	4,385,000	~2%	1,205	~2.7%
School	Baseline	623,000	-	176	-
	Be Lean	617,000	~1%	165	~6.0%

Table B4: Summary of Minimisation in Energy Requirements and Associated CO_2 Emissions

Tables B5 and B6 and Figures B2 and B3 outline the anticipated annual energy requirement and associated CO_2 emissions by service and space use at the Proposed Development.

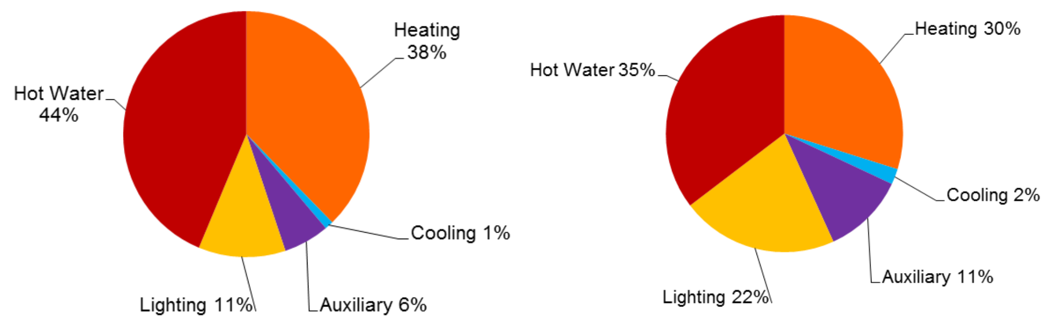


Figure B2: Anticipated Regulated Energy Requirement & Anticipated Regulated CO_2 Emissions - Development Area 1

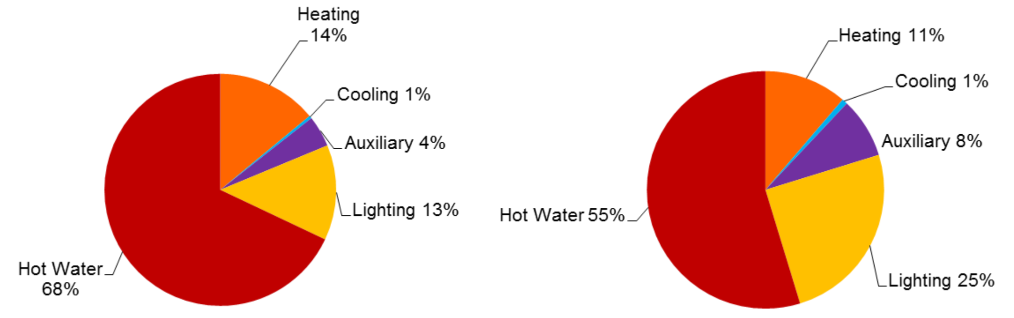


Figure B3: Anticipated Regulated Energy Requirement & Anticipated Regulated CO_2 Emissions - School

Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)
Dwellings (Dev Area 1)	1,399,846	0	130,216	196,545	1,137,592	2,864,198	1,421,683
Refurb	102,780	0	2,934	12,987	83,379	202,079	92,890
Retail A1	7,725	875	26,300	108,050	39,975	182,925	80,200
Hotel	28,523	584	6,405	8,240	227,599	271,350	9,708
Office	8,747	10,541	3,612	30,639	8,919	62,457	97,223
Cinema	22,663	8,904	7,526	30,146	66,420	135,659	72,101
Gym	30,014	215	6,815	9,620	168,135	214,800	47,397
Retail A3	53,745	28,374	79,700	105,300	184,109	451,229	291,928
TOTAL	**1,654,043**	**49,492**	**263,508**	**501,527**	**1,916,127**	**4,384,696**	**2,113,130**
School	86,400	2,400	26,800	81,900	419,400	616,900	196,400

Table B5: Development Area 1 and School Annual Energy Requirement

Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)
Dwellings (Dev Area 1)	319,000	0	71,300	107,600	259,200	757,100	778,300
Refurb	16,200	0	1,100	4,900	13,200	35,500	35,300
Retail A1	4,000	500	13,600	56,100	20,700	94,900	41,600
Hotel	6,200	300	3,200	4,200	49,200	63,000	5,000
Office	1,900	5,500	1,800	15,500	1,900	26,600	50,500
Cinema	4,900	4,600	3,800	15,300	14,300	42,900	37,400
Gym	6,500	100	3,400	4,900	36,300	51,200	24,600
Retail A3	11,600	14,700	40,300	53,300	39,800	159,700	151,500
TOTAL	**359,614**	**25,687**	**135,410**	**257,906**	**425,996**	**1,204,612**	**1,096,714**
School	18,700	1,300	13,600	41,500	90,600	165,500	101,900

Table B6: Development Area 1 and School Annual CO_2 Emissions

7.4 Be Clean

In line with policy aspirations, the following sections detail considerations of the low-carbon energy supply measures that have been considered, and those which will be implemented at the Proposed Development.

7.4.1 Development Area 1

7.4.1.1 Combined Heat and Power (CHP)

This section considers the relative merits of providing a stand-alone on-site heat network served by a dedicated energy centre with either CHP or CCHP. For efficient operation, a CHP engine requires a high base-load. A CHP engine does not operate in the same manner as a traditional gas boiler, and is not well suited to highly variable loads.

As outlined in Figure B3 above, anticipated CO_2 emissions from thermal energy demand for the whole of Development Area 1, account for ~65 of energy requirements. When considering the dwellings in isolation, thermal energy demand accounts for ~77% of anticipated CO_2 emissions arising from the dwellings based on Part L 2013 data.

Considering the high proportion of CO_2 emissions arising from thermal sources shown in Figure B4, in particular with reference to the dwellings, a Combined Heat and Power (CHP) or Combined Cooling, Heat and Power (CCHP) system could be suitable for the scheme. It is estimated that where thermal demand is adequate, CHP and CCHP can achieve reductions in primary energy demand relative to traditional sources of approximately 30%.

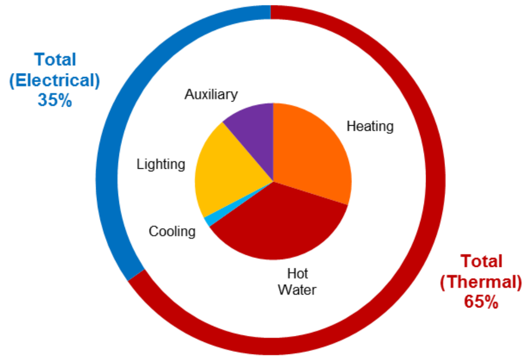


Figure B4: Anticipated Regulated CO_2 Emissions Summary (Development Area 1)

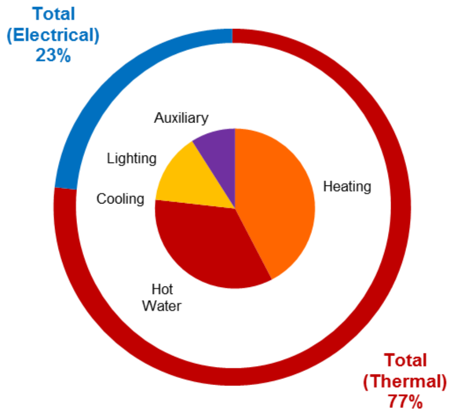


Figure B5: Anticipated Regulated CO_2 Emissions Summary (Dwellings)

The Proposed Development has a high hot water demand throughout the year, with an anticipated even base load. This base-load is ideal for efficient CHP operation and this strategy is therefore likely to be a good solution to further reduce CO_2 emissions.

On the basis that the CHP engine would provide for 98% of the domestic hot water demand and up to 30% of the space heating demand of the Proposed Development would require CHP within the energy centre to create a total rated output of **378kW$_e$ and 401kW$_{th}$.**

It is anticipated that with CHP of this size, allowing for losses and pumping associated with the heat network, would reduce regulated CO_2 emissions by approximately **197** tonnes per annum. This is equivalent to a reduction of **~16.0%** beyond the Building Regulations Part L 2013 'baseline'. The anticipated thermal profile of the Proposed Development is shown in figure B6.

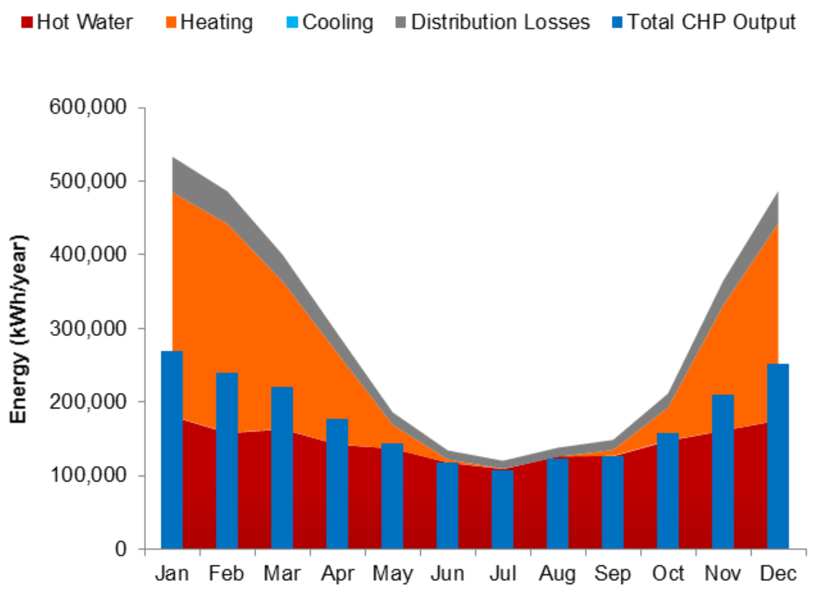


Figure B6: Annual Thermal Load Profile and Potential CHP Contribution (Development Area 1).

When considering the dwellings in isolation, where the thermal demand is most prevalent, it is anticipated that the Development Area 1 energy centre connected to a heat network supplied by CHP would reduce regulated CO_2 emissions by approximately **144tonnes** per annum. This is equivalent to a reduction of **18.5%** beyond the Building Regulations Part L 2013 'baseline'.

7.4.1.2 Combined Cooling Heat and Power (CCHP)

An assessment of CCHP has been undertaken based on supplying a CHP engine and matched absorption chiller to deliver 98% of the annual hot water demand, up to 30% of the space heating demand, 30% of the annual space cooling of the commercial spaces and accounting for losses and pumping.

It is anticipated that a 378kWe engine would be required. A CHP engine of this size with matched absorption chiller would lead to a 13.2**%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'.

Therefore, considering cooling requirement of Development Area 1 of the Proposed Development represents just 1% of the overall energy requirement, and given that no significant CO_2 emission benefit would be achieved compared to a CHP, a CCHP engine is not considered appropriate for the Proposed Development and is therefore discounted.

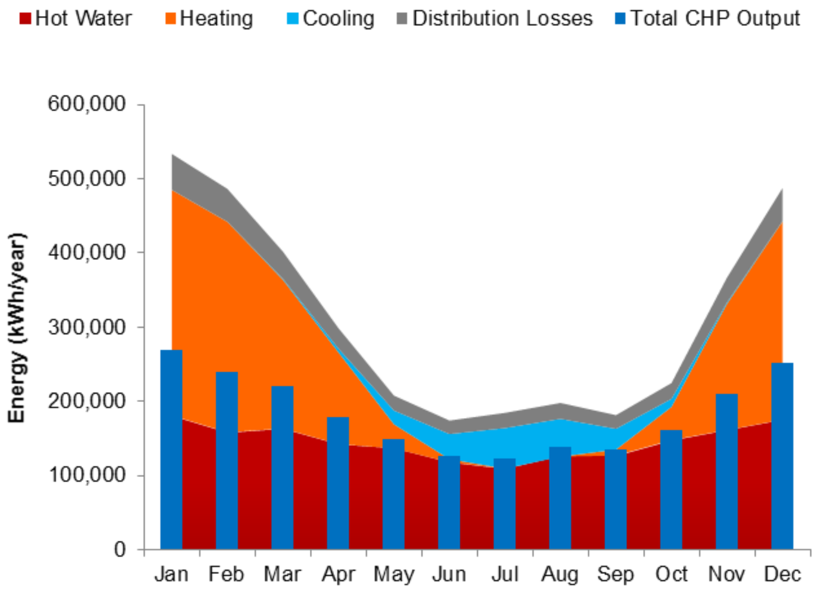


Figure B7: Annual Thermal Load Profile and Potential CCHP Contribution.

Therefore, considering the relative merits of the options appraised above a CHP engine for the provision of heating and domestic hot water with the capacity for potential future connection to a District Heating Network will be implemented.

	Peak Output (kW)		Annual Output (kWh)		CO_2 Emission Reduction		Suitable?	Notes
	Electrical	Thermal	Electrical	Thermal	Total (tonnes)	% Beyond Part L 2013 'baseline'		
CHP	378	401	2,018,000	2,140,000	198	16.0%	✓	100% DHW 30% SH
CCHP	378	401	2,076,000	2,202,000	164	13.2%	✗	100% DHW 30% SH 30% SC

Table B6: Low Carbon Technologies Appraisal.

7.4.2 School

At this stage the School has been considered to include a CHP within the energy centre to serve the school only.

Thermal energy demand accounts for ~66% of anticipated CO_2 emissions arising from the school based on Part L 2013 calculations. This is shown in Figure B8.

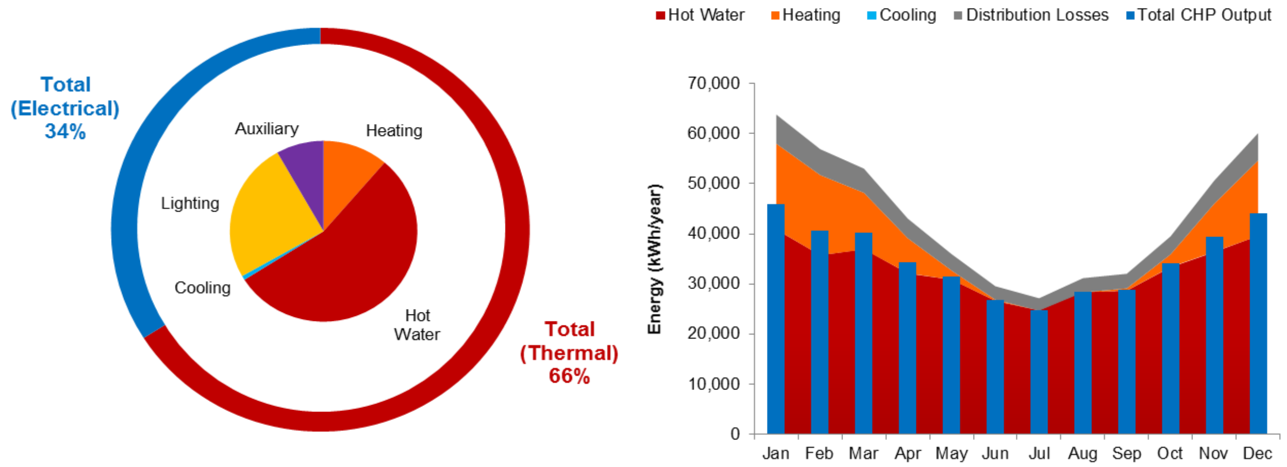


Figure B8: Anticipated Regulated CO_2 Emissions Summary (School) (left) and Annual Thermal Load Profile (right).

This shows that the school has a high thermal demand which is largely from hot water demand. As a result a CHP is likely to be suitable. The feasibility of the CHP engine for the school will be reviewed during detailed design. This will allow the most appropriate heat generating plant to be chosen in the face of the changing energy landscape, particularly if any revision to the carbon factor specified in the Building Regulations is made.

On the basis that the CHP engine would provide for 100% of the domestic hot water demand and up to 30% of the space heating demand of the School this would require a CHP engine of $50kW_e$ and $79kW_{th}$.

It is anticipated that with a CHP engine of this size, allowing for losses and pumping associated with distribution, could reduce regulated CO_2 emissions by approximately **31** tonnes per annum. This is equivalent to a reduction of **~17.6%** beyond the Building Regulations Part L 2013 'baseline'.

As the cooling demand of the school has been reduced to 1% of the energy required, the use of a CCHP engine is deemed not suitable and has not been assessed.

7.5 Be Green

The following sections outline considerations of the renewable energy generation measures that could be implemented for Development Area 1 of Application A and Application B of the Proposed Development.

7.5.1 Biomass Boilers

If a biomass boiler was to be implemented to provide 100% of the hot water demand, and 30% of the space heating demand of Development Area 1, a reduction in CO_2 emissions of ~**388 tonnes** per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of ~**31.4%** beyond the Building Regulations Part L 2013 'baseline'.

The calculations indicate that the use of a biomass boiler could yield good regulated CO_2 emissions savings however this would also lead to in an increase of NOx emissions from the Proposed Development and require a large store footprint for the biomass fuel (~17.7m^2). In addition, local sourcing of biomass could be difficult and the site accessibility is constrained which would render it difficult for deliveries of biomass. As such, the use of biomass boilers at the Proposed Development is considered to be unsuitable.

7.5.2 Heat Pumps

When assuming a GSHP could operate at Seasonal Energy Efficiency Ratio (SEER) of 6.0 (i.e. six units of useful heat for every unit of electricity consumed), to deliver 100% of the space cooling and balanced to deliver an equivalent amount of space heating (~8%), it is estimated that a reduction in CO_2 emissions of **41** tonnes per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of **3.3%** beyond the Building Regulations Part L (2013) 'baseline'.

If an ASHP system is sized to provide all of the space heating and cooling requirements of Development Area 1, based on an SEER of 4.0 and a cooling efficiency of 4.5 it is anticipated that a reduction in CO_2 emissions of **175 tonnes** per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of **14.1%** beyond the Building Regulations Part L (2013) 'baseline'.

Therefore, considering that the ASHP system can achieve greater CO_2 emissions reduction compared to the GSHP option, GSHP have been discounted as a potential renewable energy technology.

If the School were to install ASHP to provide cooling and heating then it is anticipated that a reduction in CO_2 emissions of **8 tonnes** per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of **4.7%** beyond the Building Regulations Part L (2013) 'baseline'.

ASHP may be considered as the future emissions scenario becomes clearer as these could be implemented on a block by block basis to provide heating to the dwellings and commercial areas of the proposed development.

7.5.3 Photovoltaic Panels

For Development Area 1 roof plans have been provided that provide an indicative area of roof that is available for Green/Brown roof and PV with the current anticipated plant arrangements. These plans are provided in Appendix D. The area of roof available equates to 2,900m^2. As an indicative PV array sizing across the multiple blocks, the available area is reduced due to access, spacing between panels and accounting for those areas subject to significant levels of shading due to the position on the roof. Therefore it is anticipated that an array of approximately **~500m^2 (74kWp)** could be provided on the roof of Development Area 1**.** On the basis of providing a PV array of this size, it is anticipated that 57,200 kWh/year of renewable electricity would be generated annually and reduce regulated CO_2 emissions by **~2.4%** beyond the Building Regulations Part L 2013 'baseline'.

On this basis a PV array is considered appropriate for Development Area 1 of the Proposed Development.

The school has limited roof space available for the installation of a PV array due to the location of plant, roof lights and the location of the Multi Use Games Area (MUGA) on the roof. Therefore PV is not currently proposed for the school application.

7.5.4 Solar Thermal Panels

Based on a Solar Thermal installation of approximately **260kWp** that would deliver 14% of the summer hot water demand of the Proposed Development and would generate approximately 237,000kWh of heat per annum. This level of thermal generation enables a reduction in overall regulated CO_2 emissions by **58 tonnes** which is equivalent to a reduction beyond the Building Regulations Part L 2013 baseline of ~**4.7%.**

However, in providing solar thermal panels, a portion of the hot water baseload would be offset, meaning that a future connection to a wider heat network would have a reduced benefit in terms of CO_2 emissions. Additionally, considering CO_2 emissions are associated predominantly with electrical loads, an on-site PV array is more appropriate than solar thermal. As such, the use of solar thermal panels is not considered suitable.

7.5.5 Wind Turbines

On the basis of supplying **25No 6kW** wind turbine, could achieve a reduction in CO_2 emissions of just **0.6%** beyond the Building Regulations Part L 2013 'baseline'.

Therefore, considering the impacts described above, and the limited CO_2 emission benefit, the use of micro wind turbines will not be implemented at the Proposed Development.

7.5.6 Summary

Table B7 provides a summary of the estimated emissions reduction associated with each of the suitable technologies identified above.

	Annual Output		Annual Regulated CO_2 Emission Reduction		Sizing Notes	Suitable?
	Thermal (kWh/yr)	Electrical (kWh/yr)	tonnesCO_2 per year	% Beyond Part L 'baseline'		
~378kWe CHP with DEN	2,140,000	2,018,000	198	16.0%	30% SH 100% DHW	✓
~74kWp (520sqm) Photovoltaic (PV) Panels	-	57,200	29	2.4%	Panel Area ~500m^2	✓
~260kWp (520sqm) Solar Thermal Heating	237,400	-	58	4.7%	Panel Area ~500m^2	✗
~480kW Wood Pellets Boilers	1,964,200	-	349	31.4%	0% SC 30% SH 100% DHW	✗
~412kW Air Source Heat Pump	1,554,700	-	175	14.1%	100% SC 100% SH 0% DHW	✗
~37kW Ground Source Heat Pump	220,700	-	41,000	3.3%	30% SC 15% SH 0% DHW	✗

25 No. 6kW Vertical axis wind turbines		13,417	7,000	0.6%	30m above ground level	✗

Table B7: Zero Carbon Technologies Appraisal.

Key:
(h) heating and hot water output
(c) cooling output
h/w hot water
s/w space heating
s/c space cooling

7.6 Conclusion

Passive design measures to be implemented in Development Area 1 of the Proposed Development include:

e. Suitable glazing ratio and glass g-value (0.35) to balance heat losses, heat gains and daylight ingress
f. Fabric insulation levels achieving improvements over Building Regulations Part L (2013) requirements of 25% - 100%
g. Fabric air permeability achieving improvements over Building Regulations Part L (2013) requirements of 75% and 70% for dwellings and commercial spaces respectively

Energy efficiency measures to be implemented at the Proposed Development include:

h. Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water
i. Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use
j. Efficient mechanical ventilation with heat recovery which will limit the need for space heating in winter months, aid the mitigation of high internal temperatures in summer months (where openable windows cannot be used due to ambient acoustic conditions), and maintain good indoor air quality
k. Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains
l. Variable speed pumps and fans to minimise energy consumption for distribution of services

7.6.1 Be Lean

These measures are anticipated to achieve **~3%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' for the areas within Development Area 1 of Application A. When considering the residential elements alone, it is anticipated that a **~1%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' will be achieved.

Furthermore, it has been calculated based on the parameters outlined within this report and the SAP calculations undertaken that the dwellings will improve upon the requirements of Target Fabric Energy Efficiency (TFEE) included in Part L 2013.

These measures are anticipated to achieve **~6%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline' for the school.

As a result, the Development Area 1 of Application A and the School will achieve compliance with the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

7.6.2 Be Clean

The energy centre within Development Area 1 is deemed to be better placed to supply the areas of Development Area 1 only, via the implementation of a single energy centre. When considering the dwellings within the Full application for Development Area 1 separately and on the basis that the CHP engine will supply 97% of the hot water requirements (anticipating that point of use electric water heaters will be used in retail, office and community spaces) and up to 30% of the space heating requirements of the Proposed Development, it is expected that a reduction in regulated CO_2 emissions of **144tonnes** per annum can be achieved. This is equivalent to a further **18.5%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 'baseline'.

When considering all of the areas within Development Area 1 the contribution of the CHP engine is equivalent to **~16.0%** reduction beyond the Building Regulations Part L 2013 'baseline' for the dwellings, equivalent to **197tonnes** of CO_2 emissions.

For the school (Application B) a CHP engine has been assessed to supply 100% of the hot water and 30% of the space heating demands. It is expected that if a CHP is feasible for the school a reduction in regulated CO_2 emissions of **31tonnes** per annum can be achieved. This is equivalent to a further **17.6%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 'baseline'.

7.6.3 Be Green

Considering the available roof space of Development Area 1 as shown in Appendix D, and allowing for access and maintenance requirements, a total solar PV system size in the region of 520m^2 array area will be included in Development Area 1 of the Proposed Development.

Based on the solar irradiance data for London, an array of this size would generate approximately 57,200kWh of electricity per annum, reducing CO_2 emissions by **30.0 tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **2.4%** beyond the Building Regulations Part L (2013) 'baseline' on the CO_2 emissions of Development Area 1. When considering the residential elements separately, the contribution is equivalent to a **3.8%** reduction in CO_2 emissions beyond the Building Regulations Part L 2013 'baseline'. It is proposed that the whole array is connected to the distribution to the dwellings subject to detailed design considerations.

PV is therefore deemed to be a suitable addition to the Proposed Development in pursuit of further reductions in regulated CO_2 emissions.

PV is not proposed to be located on the school building as the roof area is being used to provide a multi-use games area and is also allocated for plant.

A summary of the anticipated CO_2 emissions and reductions at each step of the energy hierarchy is given in Table B8 below. Development Area 1 achieves an overall 21% reduction in regulated CO_2 emissions.

Table B8 Summary of CO_2 emissions reductions for Development Area 1.

Domestic Use Areas		Estimated Regulated Carbon Dioxide Emission Savings for Domestic Buildings	
		(Tonnes CO_2/yr)	(%)
Savings from energy demand reduction (Lean)		10	1.3%
Savings from heat network / CHP (Clean)		144	18.5%
Savings from renewable energy (Green)		30	3.7%
Total Cumulative Savings		**183**	**23.6%**
Total Target Reduction		776	100%
Non-Domestic Areas		Estimated Regulated Carbon Dioxide Emission Savings for Non-Domestic Buildings	
		(tonnesCO_2/yr)	(%)
Savings from energy demand reduction (Lean)		23	5.0%
Savings from heat network / CHP (Clean)		54	13.4%
Savings from renewable energy (Green)		-	-
Total Cumulative Savings		**77**	**17.8%**
Total Target Reduction		162	35%
Development Area 1 Total	Total Regulated Emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage Savings (%)
Part L 2013 baseline	1,238	-	-
Be Lean	1,205	33	2.7%
Be Clean	1,007	198	16.4%
Be Green	977	30	2.9%
Total Cumulative Savings	**261**	**261**	**21.0%**

7.6.4 The School

A summary of the anticipated CO_2 emissions and reduction at each step of the energy hierarchy is given in Table B9 below. The application for the School achieves an overall 24% reduction in regulated CO_2 emissions when considering the School.

Table B9: Summary of CO_2 emissions reductions and offset payment for the School

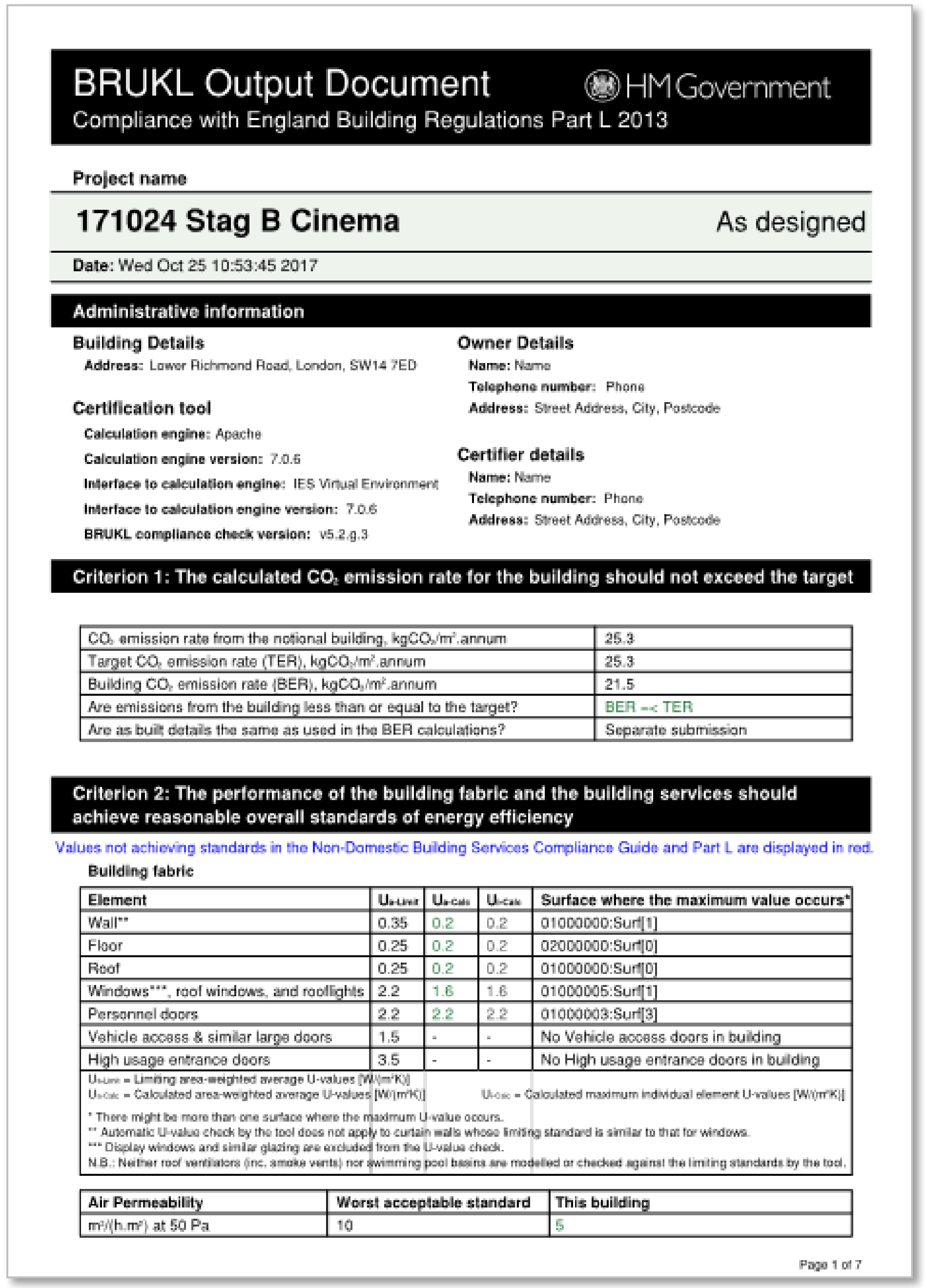
School Areas (Application B)	Estimated Regulated Carbon Dioxide Emission Savings for the School		
	Total Regulated Emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage Savings (%)
Part L 2013 baseline	176	-	-
Be Lean	166	11	6.3%
Be Clean	135	31	17.6%
Be Green	135	-	-
Total Cumulative Savings	**42**	**42**	**23.8%**
Total Target Reduction	**-**	**62**	**35%**

School Total (included within Site Wide total)	
Annual Off-set (School)	20 tCO_2

Development Area 1 Total (included within Whole Site total)	
Annual Off-set (Domestic Use Areas)	593 tCO_2
Annual Off-set (Non-domestic Areas)	85 tCO_2

8. Appendix C – Sample Part L 2013 Compliance Reports

Commercial



BRUKL Output Document HM Government
Compliance with England Building Regulations Part L 2013

Project name

171024 Stag B Cinema As designed

Date: Wed Oct 25 10:53:45 2017

Administrative information

Building Details
Address: Lower Richmond Road, London, SW14 7ED

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.6
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.6
BRUKL compliance check version: v5.2.g.3

Owner Details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

Certifier details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

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	25.3
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	25.3
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	21.5
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	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	01000000:Surf[1]
Floor	0.25	0.2	0.2	02000000:Surf[0]
Roof	0.25	0.2	0.2	01000000:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000005:Surf[1]
Personnel doors	2.2	2.2	2.2	01000003:Surf[3]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = 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
m³/(h.m²) at 50 Pa	10	5

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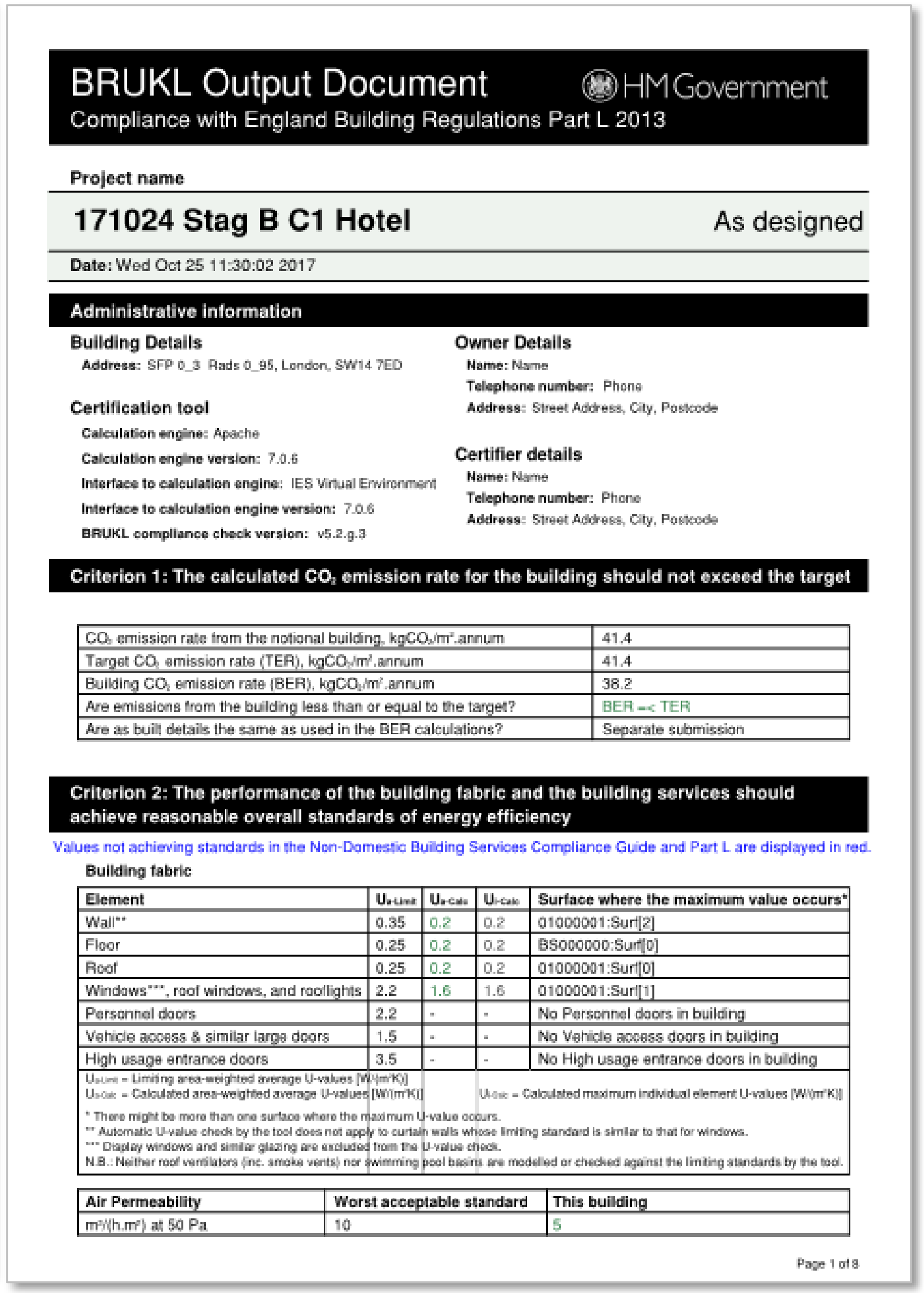


BRUKL Output Document HM Government
Compliance with England Building Regulations Part L 2013

Project name

171024 Stag B C1 Hotel As designed

Date: Wed Oct 25 11:30:02 2017

Administrative information

Building Details
Address: SFP 0_3 Rads 0_95, London, SW14 7ED

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.6
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.6
BRUKL compliance check version: v5.2.g.3

Owner Details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

Certifier details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

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	41.4
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	41.4
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	38.2
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.

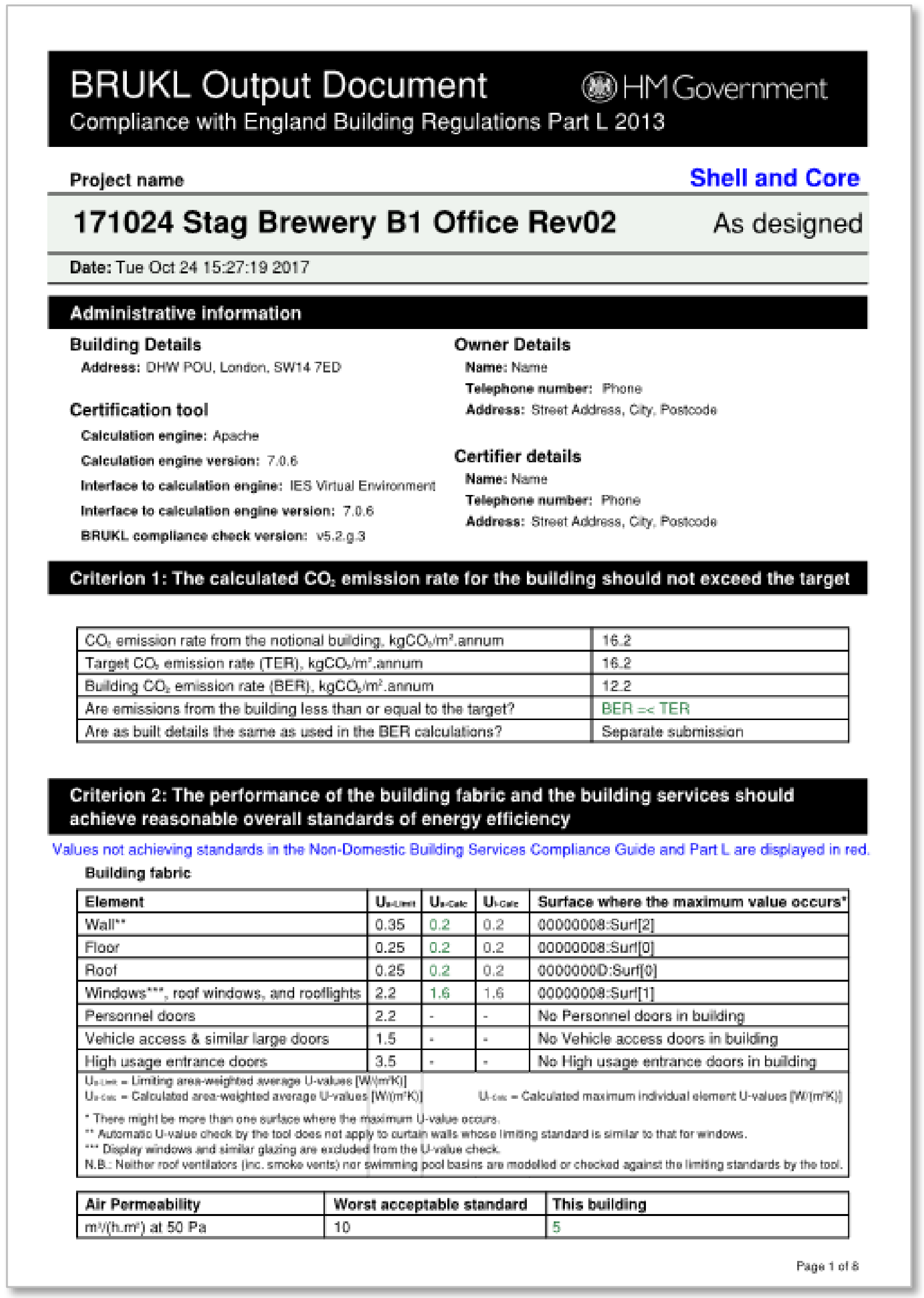
Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	01000001:Surf[2]
Floor	0.25	0.2	0.2	BS000000:Surf[0]
Roof	0.25	0.2	0.2	01000001:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000001:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = 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
m³/(h.m²) at 50 Pa	10	5

Page 1 of 8



BRUKL Output Document HM Government
Compliance with England Building Regulations Part L 2013

Project name Shell and Core

171024 Stag Brewery B1 Office Rev02 As designed

Date: Tue Oct 24 15:27:19 2017

Administrative information

Building Details
Address: DHW POU, London, SW14 7ED

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.6
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.6
BRUKL compliance check version: v5.2.g.3

Owner Details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

Certifier details
Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

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	16.2
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	16.2
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	12.2
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	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	00000008:Surf[2]
Floor	0.25	0.2	0.2	00000008:Surf[0]
Roof	0.25	0.2	0.2	0000000D:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	00000008:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = 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
m³/(h.m²) at 50 Pa	10	5

Page 1 of 8

Domestic

SAP Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mr Greg Jones	Assessor number	7740
Client		Last modified	10/11/2017
Address	01 02 01, London		

1. Overall dwelling dimensions

		Area (m^2)			Average storey height (m)			Volume (m^3)	
Lowest occupied		104.00	(1a)	x	2.95	(2a)	=	306.80	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	104.00	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			306.80	(5)

2. Ventilation rate

			m^3 per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)

				Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.15	(18)
Number of sides on which the dwelling is sheltered		2	(19)
Shelter factor	1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.13	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(24a)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	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)

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3. Heat losses and heat loss parameter

Element	Gross area, m^2	Openings m^2	Net area A, m^2		U-value W/m^2K		A x U W/K	κ-value, $kJ/m^2.K$	A x κ, kJ/K	
Window			37.72	x	1.33	=	50.01			(27)
Door			2.30	x	2.00	=	4.60			(26)
External wall			55.79	x	0.12	=	6.69			(29a)
Party wall			44.84	x	0.00	=	0.00			(32)
External wall			10.44	x	0.20	=	2.09			(29a)
Total area of external elements ∑A, m^2			106.25							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	63.39	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m^2K		100.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		10.44	(36)
Total fabric heat loss	(33) + (36) =	73.83	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	28.35	28.03	27.71	26.10	25.77	24.16	24.16	23.84	24.80	25.77	26.42	27.06	(38)
Heat transfer coefficient, W/K (37)m + (38)m	102.18	101.86	101.54	99.93	99.60	97.99	97.99	97.67	98.63	99.60	100.25	100.89	
Average = ∑(39)1...12/12 =												99.84	(39)
Heat loss parameter (HLP), W/m^2K (39)m ÷ (4)	0.98	0.98	0.98	0.96	0.96	0.94	0.94	0.94	0.95	0.96	0.96	0.97	
Average = ∑(40)1...12/12 =												0.96	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.77	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	100.07	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)	110.08	106.08	102.07	98.07	94.07	90.07	90.07	94.07	98.07	102.07	106.08	110.08	
∑(44)1...12 =												1200.88	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	163.25	142.78	147.33	128.45	123.25	106.35	98.55	113.09	114.44	133.37	145.58	158.09	
∑(45)1...12 =												1574.54	(45)
Distribution loss 0.15 x (45)m	24.49	21.42	22.10	19.27	18.49	15.95	14.78	16.96	17.17	20.01	21.84	23.71	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	1.00	(47)

Water storage loss:

b) Manufacturer's declared loss factor is not known

Hot water storage loss factor from Table 2 (kWh/litre/day)	0.02	(51)
Volume factor from Table 2a	4.93	(52)
Temperature factor from Table 2b	1.00	(53)
Energy lost from water storage (kWh/day) (47) x (51) x (52) x (53)	0.10	(54)
Enter (50) or (54) in (55)	0.10	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	3.24	2.92	3.24	3.13	3.24	3.13	3.24	3.24	3.13	3.24	3.13	3.24	(56)

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If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
If the vessel contains dedicated solar storage...	3.24	2.92	3.24	3.13	3.24	3.13	3.24	3.24	3.13	3.24	3.13	3.24	(57)
Primary circuit loss for each month from Table 3	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)
Combi loss for each month from Table 3a, 3b or 3c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)
Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m	189.75	166.71	173.83	154.09	149.75	132.00	125.05	139.59	140.09	159.87	171.23	184.60	(62)
Solar DHW input calculated using Appendix G or Appendix H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)
Output from water heater for each month (kWh/month) (62)m + (63)m	189.75	166.71	173.83	154.09	149.75	132.00	125.05	139.59	140.09	159.87	171.23	184.60	

∑(64)1...12 = 1886.56 (64)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]	75.48	66.62	70.19	63.23	62.18	55.88	53.97	58.80	58.57	65.55	68.92	73.77	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	166.42	166.42	166.42	166.42	166.42	166.42	166.42	166.42	166.42	166.42	166.42	166.42	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	58.54	51.99	42.28	32.01	23.93	20.20	21.83	28.37	38.08	48.35	56.44	60.16	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	392.00	396.06	385.81	363.99	336.44	310.55	293.26	289.19	299.44	321.26	348.81	374.70	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	54.42	54.42	54.42	54.42	54.42	54.42	54.42	54.42	54.42	54.42	54.42	54.42	(69)
Pump and fan gains (Table 5a)	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 (Table 5)	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	-110.94	(71)
Water heating gains (Table 5)	101.45	99.14	94.34	87.81	83.58	77.61	72.54	79.04	81.34	88.10	95.73	99.15	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	661.87	657.08	632.32	593.70	553.84	518.25	497.51	506.49	528.75	567.60	610.86	643.90	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
West	1.00	x	15.07	x	19.64	x 0.9 x	0.35	x	0.80	=	74.59	(80)
West	0.54	x	5.26	x	19.64	x 0.9 x	0.35	x	0.80	=	14.06	(80)
North	0.77	x	3.63	x	10.63	x 0.9 x	0.35	x	0.80	=	7.49	(74)
South	0.30	x	3.63	x	46.75	x 0.9 x	0.35	x	0.80	=	12.83	(78)
North	1.00	x	7.56	x	10.63	x 0.9 x	0.35	x	0.80	=	20.26	(74)
East	1.00	x	2.57	x	19.64	x 0.9 x	0.35	x	0.80	=	12.72	(76)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	141.94	272.33	443.43	651.25	810.17	836.56	793.35	672.02	516.10	321.07	175.83	117.58	(83)
Total gains - internal and solar (73)m + (83)m	803.81	929.41	1075.75	1244.95	1364.01	1354.81	1290.86	1178.50	1044.85	888.68	786.69	761.47	(84)

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7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(°C) 21.00 (85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area η1,m (see Table 9a)	0.94	0.91	0.85	0.73	0.59	0.44	0.33	0.37	0.57	0.80	0.91	0.94	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	19.26	19.54	19.97	20.46	20.78	20.93	20.98	20.97	20.85	20.40	19.75	19.21	(87)
Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)	20.10	20.10	20.10	20.12	20.12	20.13	20.13	20.13	20.13	20.12	20.11	20.11	(88)
Utilisation factor for gains for rest of dwelling η2,m	0.93	0.89	0.83	0.71	0.55	0.38	0.26	0.30	0.52	0.77	0.89	0.94	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)	17.78	18.18	18.79	19.46	19.87	20.07	20.12	20.11	19.98	19.41	18.50	17.71	(90)

Living area fraction — Living area ÷ (4) = 0.36 (91)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2	18.31	18.67	19.21	19.82	20.20	20.38	20.43	20.42	20.29	19.76	18.95	18.25	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate	18.31	18.67	19.21	19.82	20.20	20.38	20.43	20.42	20.29	19.76	18.95	18.25	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.91	0.87	0.81	0.69	0.55	0.40	0.29	0.32	0.53	0.76	0.87	0.92	(94)
Useful gains, ηmGm, W (94)m x (84)m	729.20	809.89	867.87	864.42	752.81	540.82	368.12	382.55	551.63	671.51	687.18	698.09	(95)
Monthly average external temperature from Table U1	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, Lm, W [(39)m x [(93)m - (96)m]	1431.59	1402.63	1290.92	1091.07	846.31	566.45	374.97	392.66	610.67	912.67	1187.78	1417.71	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	522.58	398.32	314.75	163.19	69.56	0.00	0.00	0.00	0.00	179.42	360.43	535.39	

∑(98)1...5, 10...12 = 2543.65 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 24.46 (99)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none	0.00	(301)
Fraction of space heat from community system	1 - (301) =	1.00	(302)
Fraction of community heat from boilers		1.00	(303a)
Fraction of total space heat from community boilers	(302) x (303a) =	1.00	(304a)
Factor for control and charging method (Table 4c(3)) for community space heating		1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating		1.00	(305a)
Distribution loss factor (Table 12c) for community heating system		1.05	(306)

Space heating

Annual space heating requirement	2543.65		(98)
Space heat from boilers	(98) x (304a) x (305) x (306) =	2670.83	(307a)

Water heating

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Annual water heating requirement		1886.56			(64)
Water heat from boilers			(64) x (303a) x (305a) x (306) =	1980.89	(310a)
Electricity used for heat distribution			0.01 × [(307a)...(307e) + (310a)...(310e)] =	46.52	(313)
Electricity for pumps, fans and electric keep-hot (Table 4f)					
mechanical ventilation fans - balanced, extract or positive input from outside		294.76			(330a)
Total electricity for the above, kWh/year				294.76	(331)
Electricity for lighting (Appendix L)				413.50	(332)
Total delivered energy for all uses			(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	5359.98	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from boilers	2670.83	x	4.24	x 0.01 =	113.24	(340a)
Water heating from boilers	1980.89	x	4.24	x 0.01 =	83.99	(342a)
Pumps and fans	294.76	x	13.19	x 0.01 =	38.88	(349)
Electricity for lighting	413.50	x	13.19	x 0.01 =	54.54	(350)
Additional standing charges					120.00	(351)
Total energy cost				(340a)...(342e) + (345)...(354) =	410.65	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.16	(357)
SAP value	83.85	
SAP rating (section 13)	84	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

		Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from other sources (space heating)							
Efficiency of boilers		90.00					(367a)
CO2 emissions from boilers	[(307a)+(310a)] x 100 ÷ (367a) =	5168.57	x	0.216	=	1116.41	(367)
Electrical energy for community heat distribution		46.52	x	0.519	=	24.14	(372)
Total CO2 associated with community systems						1140.55	(373)
Total CO2 associated with space and water heating						1140.55	(376)
Pumps and fans		294.76	x	0.519	=	152.98	(378)
Electricity for lighting		413.50	x	0.519	=	214.61	(379)
Total CO_2, kg/year					(376)..(382) =	1508.14	(383)
Dwelling CO_2 emission rate					(383) ÷ (4) =	14.50	(384)
EI value						86.44	
EI rating (section 14)						86	(385)
EI band						B	

13b. Primary energy - community heating scheme

		Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary energy from other sources (space heating)							
Efficiency of boilers		90.00					(367a)
Primary energy from boilers	[(307a)+(310a)] x 100 ÷ (367a) =	5168.57	x	1.22	=	6305.66	(367)

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Electrical energy for community heat distribution	46.52	x	3.07	=	142.81	(372)
Total primary energy associated with community systems					6448.46	(373)
Total primary energy associated with space and water heating					6448.46	(376)
Pumps and fans	294.76	x	3.07	=	904.91	(378)
Electricity for lighting	413.50	x	3.07	=	1269.46	(379)
Primary energy kWh/year					8622.83	(383)
Dwelling primary energy rate kWh/m2/year					82.91	(384)

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9. Appendix D – Available Roof Space for PV

Figure D1: Roof Layout for PV/Green/Brown Roof on Development Area 1 (shown in Green)

10. Appendix E – Indicative Energy Centre Layouts

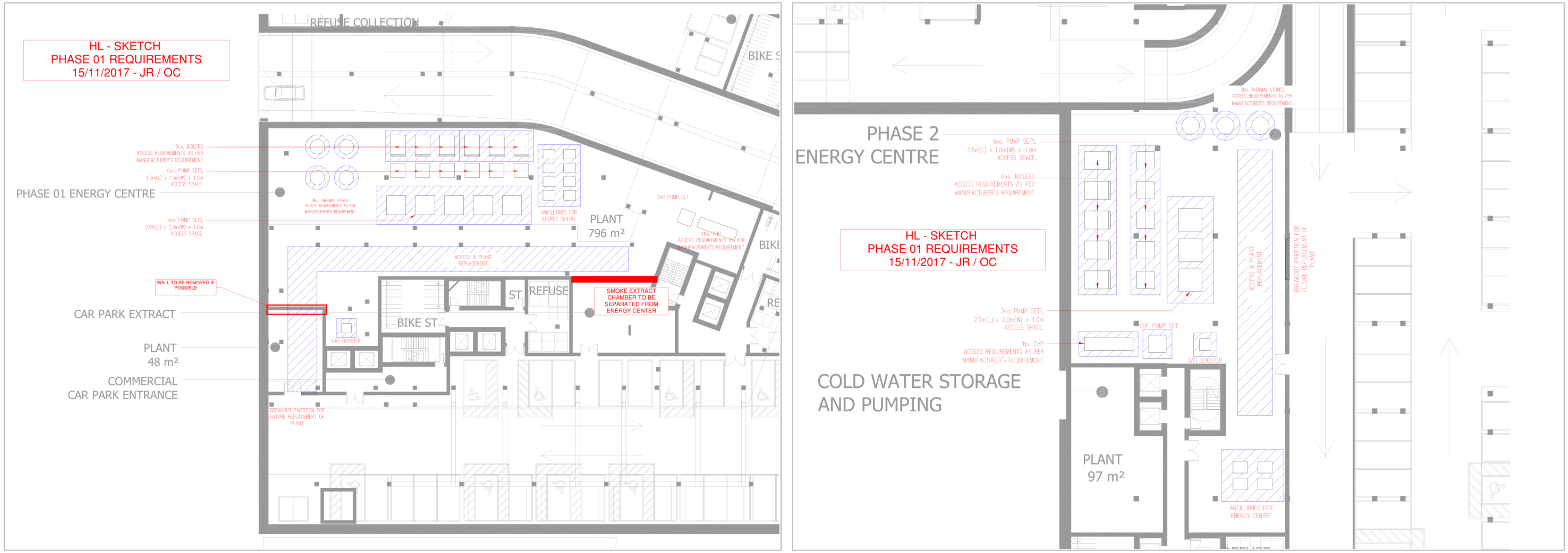

Figure E1: Indicative Energy Centre Layouts Development Area 1 (left) & Development Area 2 (right).

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