CUNDALL

Hayes Digital Park Data Centre Campus, Building LON6

Energy and Sustainability Statement

Colt DCS

Job No: 1042145

Doc ref: LONUX-CDL-ZZ-XX-RP-Z-00002

Revision: P01

Revision date: 21 March 2025

Project title	Hayes Digital Park Data Centre Campus, Building LON6	**Job number**
Report title	Energy and Sustainability Statement	1042145

Document revision history

Revision ref	Issue date	Purpose of issue / description of revision
P01.01	28 February 2025	For Planning DRAFT
P01	21 March 2025	For Planning

Document validation (latest issue)

20/03/2025
X Yifei Pei
Principal author
Signed by: Yifei Pei

20/03/2025
X J.Handley
Checked by
Signed by: Jonny Handley

20/03/2025
X K.Shi
Verified by
Signed by: Karen Shi

© Project title ("Cundall") owns the copyright in this report and it has been written for the sole and confidential use of Colt DCS. It must not be reproduced in whole or in part or relied upon by any third party for any use whatsoever without the express written authorisation of Cundall. If any third party whatsoever comes into possession of this report, they rely on it at their own risk and Cundall accepts no duty or responsibility (including in negligence) to any such third party.

Executive summary

This Energy and Sustainability Statement has been prepared on behalf of Colt Data Centre Services (Colt DCS) ("the Applicant") in support of a planning application submitted to the London Borough of Hillingdon for the redevelopment of Hayes Bridge Retail Park and Heathrow Interchange, Hayes. ("the Site").

Hybrid planning application for a four-phased redevelopment to deliver a data centre campus comprising of:

Phase 1 – Full planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) site access and internal roads including a vehicular and pedestrian link between Uxbridge Road and Bullsbrook Road (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development;

Phase 2 – Outline planning permission for (a) an Innovation Hub (b) hard and soft, green and blue, infrastructure and (c) other ancillary and auxiliary forms of development;

Phase 3 - Outline planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) internal roads (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development; and

Phase 4 - Outline planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) internal roads (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development.

This document provides an outline of the whole sustainability proposal for the entire site. Detailed component and outlined components will be reviewed under different sections for their energy and WLC. This statement sets out the proposed strategy and identifies how the scheme is compliant with the policies set out in the local and GLA Plan.

This Energy Statement includes the carbon offsetting calculation for LON07, LON08, and the Innovation Hub, despite these elements being applied for in outline. This is done to demonstrate that developed of these elements in accordance with the parameters and as envisaged at this stage would comply be with the requirements of Policy SI2.

It is envisaged that a planning condition will be used requiring the submission and approval of an updated Energy Statement at reserved matters stage for those elements for which outline planning permission is sought. This can be done because at this stage it is envisaged that the approach to energy usage is the same between LON07 and LON08. Outline component figures are indicative and subject to change based on further design work and the reserved matters applications.

Reflecting this, the Section 106 will include a formula for the calculation of the carbon offsetting contribution for the outline elements which will be applied based on the Energy Statement that is submitted at reserved matters stage. This is important as it allows for the recording of improvements between the grant of outline planning permission and the submission of reserved matters.

The Statement demonstrates that the 35% reduction beyond Building Regulations can be achieved for all buildings with a financial contribution to be secured through a S106 agreement required to offset the remainder.

Proposed Energy Strategy

Similar design measures and strategies in the campus development were applied for each building block, and a proposed centralized waste heat energy system was outlined to showcase its potential contribution to campus development.

The energy strategy follows the energy hierarchy set out in the GLA's Guidance on Preparing Energy Assessments (June 2022) document. The project team targeted to further reduce the carbon emission while continue developing the scheme in the next stage. The saving measures for the Data Centre element of the proposed development are detailed as follows:

Energy hierarchy overview

Baseline notional model was established accordance with Part L 2022 framework for all the blocks and unregulated energy were reviewed in Be Seen reporting and whole life carbon statement.

According to the latest Part L methodology and GLA guidance, cooling energy for data centre is considered in this study.

Be Lean passive and energy efficiency measures contributing to the energy strategy include:

- The building's envelope will be designed to reduce thermal loads on the HVAC systems, performing better than the Building Regulation standards.
- Glazed areas for data hall are minimal so that solar gain is limited, minimising the cooling loads.
- The energy efficiency measures employed in the development include a highly efficient hybrid cooling system using water-cooled chillers, which will meet the substantial cooling loads while consuming a fraction of the energy of conventional cooling systems.
- High efficacy lighting coupled with occupancy sensing to reduce emissions associated with lighting.
- Electrical and mechanical systems will be tightly monitored, metered and controlled with a full Building Management System (BMS). This will enable energy use to be tracked and opportunities for efficiency improvements to be made.

Be Clean step of the energy hierarchy:

- The large amount of waste heat energy from the data halls has the potential to be exported to appropriate usage within the site; or from the site into the local area, acting as an energy provider rather than an energy consumer. The adoption of this strategy also has the potential to accelerate the development of planned heating network in this area, providing a consistent source of low-grade heat throughout the year. The design has allowed the provision of energy exportation for a future connection to an external third-party heat network, but currently there is no available local heat network.
- The limited residual base load heat demand of the site results in insufficient run hours to allow efficient operation of a CHP system. It is therefore not proposed for inclusion.
- CHP was investigated but as limited residual base load heat demand of the site results in insufficient run hours to allow efficient operation, it will not be an effective or viable option.
- No decentralised energy system has been proposed for the development due to the lack of proximity to an existing network. However, the design will enable connection into a DHN in the future.
- Waste heat utilisation was considered for the administration blocks of LON06/07/08 and Innovation Hub. It's reviewed that there is a good opportunity as the data centre blocks will export large amount of heat through operation.

Be Green consideration of Low and Zero Carbon technologies,

- Most systems which targeted heat generation would be unviable as the heating demand is insignificant.
- Data hall cooling is dominant. Utilising effective cooling system to allow overall 35-42% total saving in the regulated carbon emissions.
- PV for LON06, 07, 08 and Innovation Hub was feasible and is capable to cover approximate 1% of total energy consumption.
- Solar PV area on roof has been maximised as part of the energy strategy.

Be Seen

Unregulated energy was estimated and reflected in the GLA calculation spreadsheet and the corresponding emission is reviewed in Whole Life Carbon Assessment Report which accompanies this planning application

EUI reporting and PUE reporting.

Energy Use Intensity (EUI), and the space heating demand of the development using the GLA's carbon emissions reporting spreadsheet. Since datacentre energy pattern is outranged, the effectiveness of design is reported in PUE to demonstrate the design efforts for efficient system design for cooling. It was reviewed that all blocks are providing system design with energy efficiency within the benchmark range.

All the unregulated carbon emission will be reviewed under WLC Statement.

Reduction and Offsetting

Compliance is currently achieved against Part L 2021 Vol 2 both detailed and outlined component.

Detailed Component:

Part L End-uses Breakdown (kWh/m2)		
End-use	Baseline	Actual (BeGreen)
Heating	0.05	0.25
Cooling	268.99	148.36
Auxiliary	57.41	42.2
Lighting	29.73	16.52
DHW	0.15	0.09
Renewables	0	-2.59
Total	356.32	204.83
Carbon Dioxide Emissions (kgCO_2/m^2 per annum)		
Baseline BER (kgCO_2/m^2 per annum)		**48.02**
Be Green BER (kgCO_2/m^2 per annum)		**27.64**
Percentage improvement		**42%**

Table 1-1 Summary of Energy for LON 06

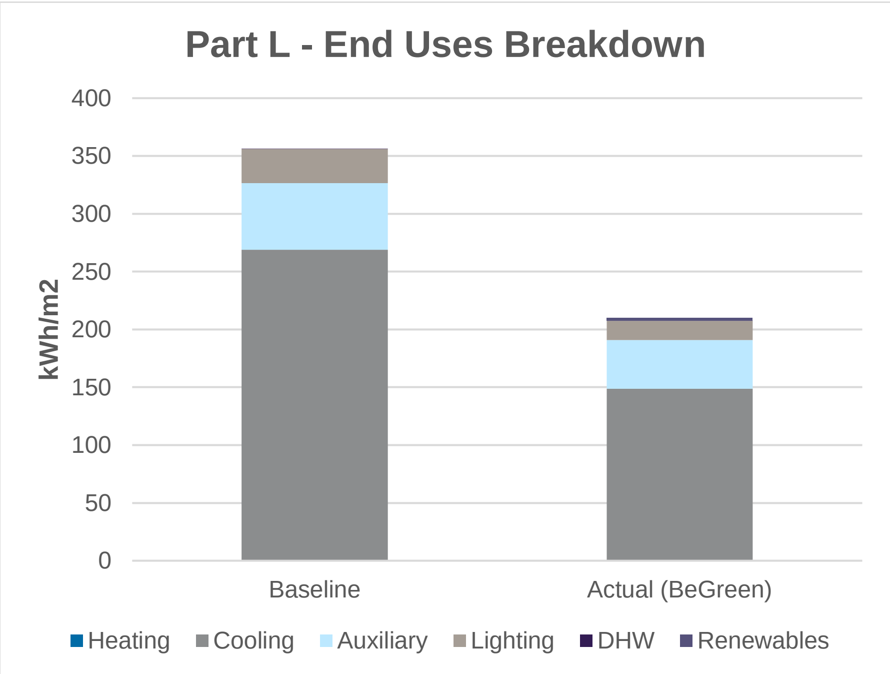


Figure 1-1 Summary of Emission for LON6

Outlined Component:

Data centre building LON07 in outlined component has a different floor size than LON6 but share the same orientation. However, as the data hall energy consumption is dominant and the block design is weather resistant, it shows similar result as that in the detailed component.

Part L End-uses Breakdown (kWh/m2) – LON07		
End-use	Baseline	Actual (BeGreen)
Heating	0.22	0.34
Cooling	274.07	150.28
Auxiliary	59.13	54.54
Lighting	29.41	22.33
DHW	0.14	0.08
Renewables	0	-1.53
Total	362.97	226.04
Carbon Dioxide Emissions ($kgCO_2/m^2$ per annum)		
Baseline BER ($kgCO_2/m^2$ per annum)		**48.95**
Be Green BER ($kgCO_2/m^2$ per annum)		**30.5**
Percentage improvement		**38%**

Table 1-2 Summary of Energy for LON7

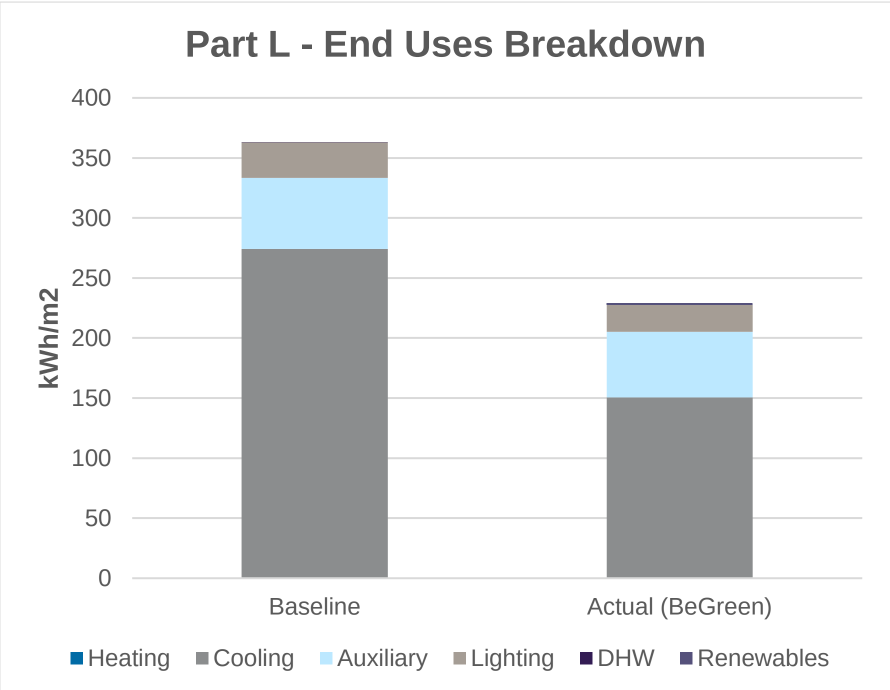


Figure 1-2 Summary of Emission for LON7

Data Centre building LON08 is smaller in size and different in orientation to LON06 and 07. The results of the Part L simulation are listed below:

Part L End-uses Breakdown (kWh/m2) – LON08		
End-use	Baseline	Actual (BeGreen)
Heating	1.7	3.51
Cooling	228.64	125.33
Auxiliary	50.13	51.2
Lighting	20.84	12.2
DHW	0.96	1.06
Renewables	-0.88	-2.32
Total	301.39	191.02
Carbon Dioxide Emissions ($kgCO_2/m^2$ per annum)		
Baseline BER ($kgCO_2/m^2$ per annum)		**40.69**
Be Green BER ($kgCO_2/m^2$ per annum)		**25.84**
Percentage improvement		**36%**

Table 1-3 Summary of Energy for LON8

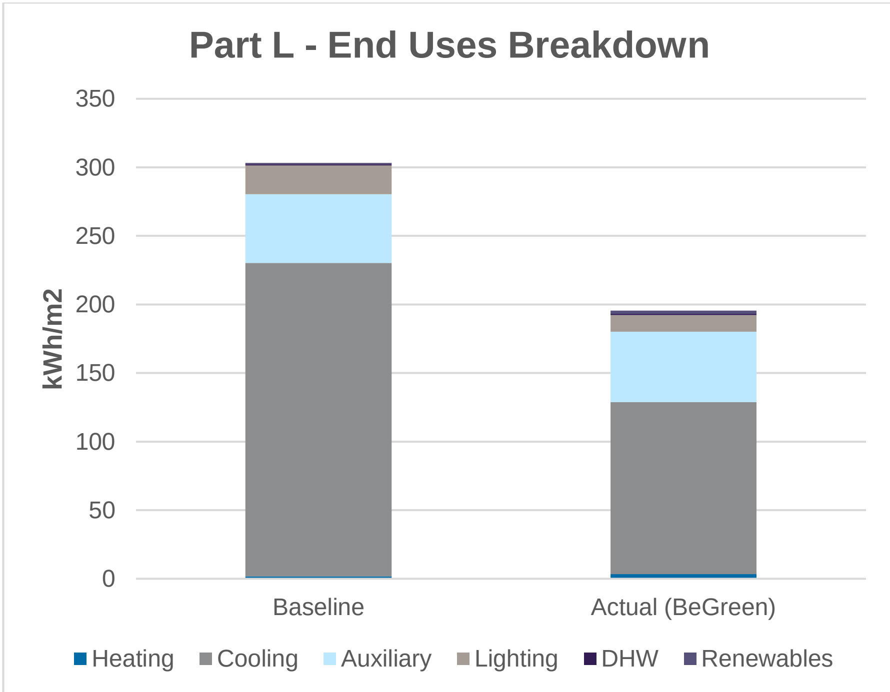


Figure 1-3 Summary of Emission for LON8

Innovation Hub is a small building consisting of a mix of education, research and development, office and community space. It shares the same orientation as LON06 and LON07. The results of the Part L simulation are listed below:

Part L End-uses Breakdown (kWh/m2) – Innovation Hub		
End-use	Baseline	Actual (BeGreen)
Heating	4	3.88
Cooling	3.43	2.33
Auxiliary	7.53	7.55
Lighting	12.27	8
DHW	0.78	0.56
Renewables	0	-7.36
Total	28.01	14.96
Carbon Dioxide Emissions ($kgCO_2/m^2$ per annum)		
Baseline BER ($kgCO_2/m^2$ per annum)		**3.84**
Be Green BER ($kgCO_2/m^2$ per annum)		**2.12**
Percentage improvement		**45%**

Table 1-4 Summary of Energy for LON8

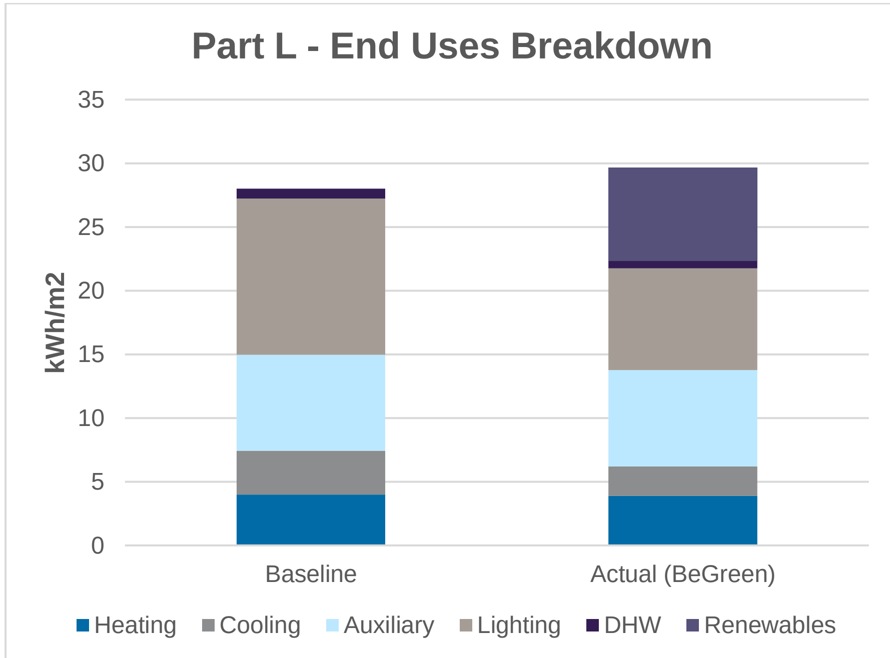


Figure 1-4 Summary of Emission for Innovation Hub

Detailed Component and Overall Reduction Summary:

The CO2 reduction for Data Centre building LON6 is listed below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – LON06			
Scenario	Emissions	Savings	% Saving
TER	**1115.9**		
BER (Be Lean)	651.1	464.8	42%
BER (Be Clean)	651.1	0	0%
BER (Be Green)	642.3	8.8	1%
Cumulative Savings		**473.6**	**42%**

Table 1-5 Summary of Emission for LON6

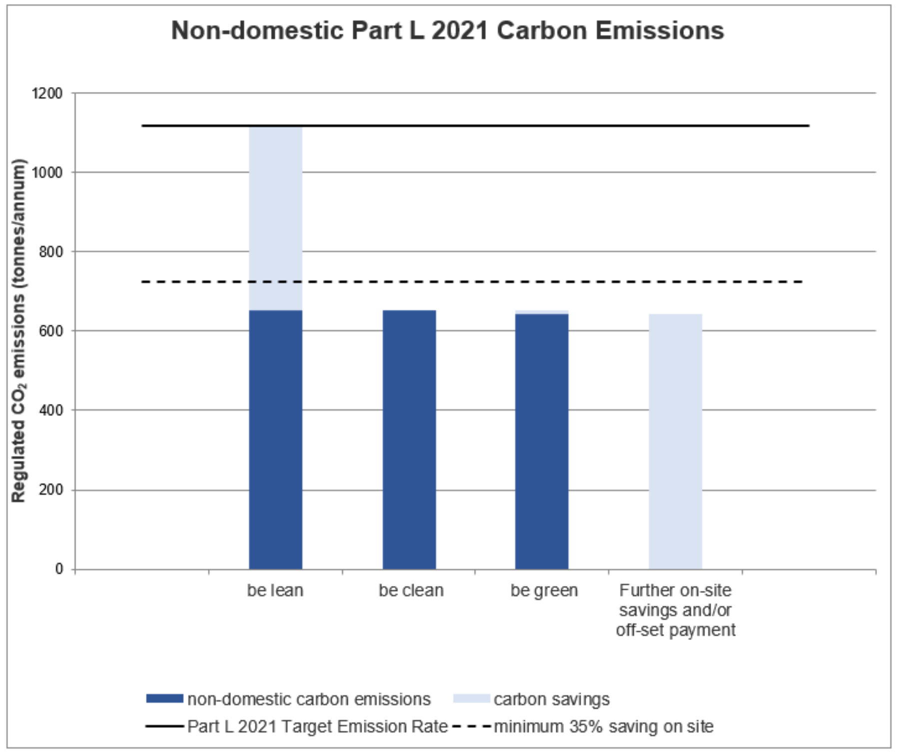


Figure 1-5 Summary of Emission for LON6

Outlined Component and Overall Reduction Summary:

The CO2 reduction for Data Centre building LON07 is listed below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – LON07			
Scenario	**Emissions**	**Savings**	**% Saving**
TER	**1923.5**		
BER (Be Lean)	1208.3	715.2	37%
BER (Be Clean)	1208.3	0.0	0%
BER (Be Green)	1198.5	9.8	1%
Cumulative Savings		**725.0**	**38%**

Table 1-6 Summary of Emission for LON7

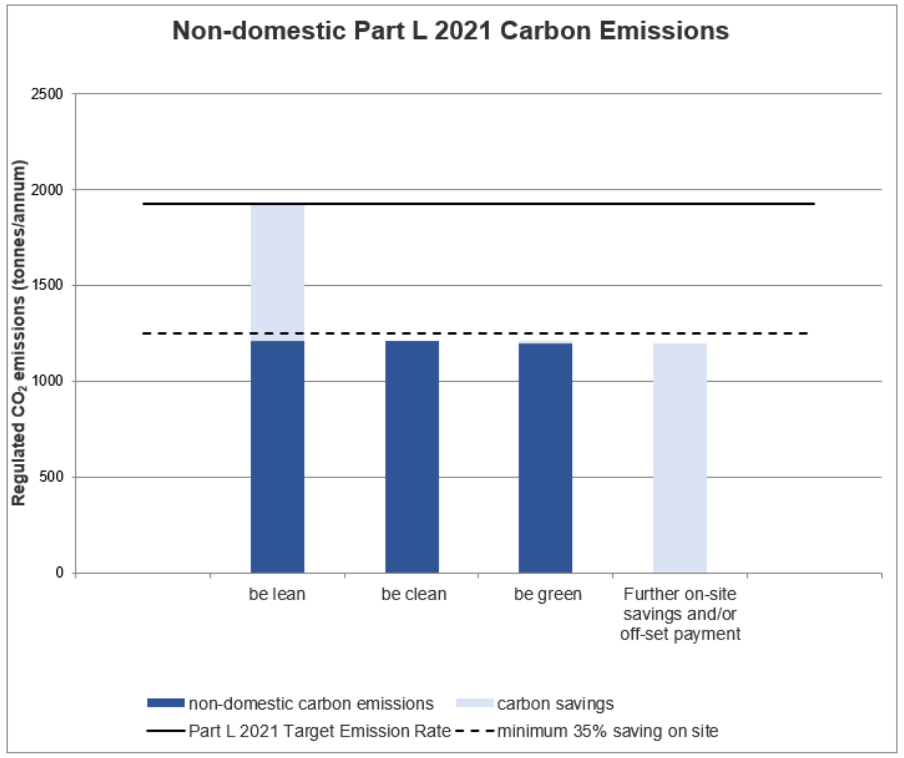


Figure 1-6 Summary of Emission for LON7

The CO2 reduction for Data Centre building LON08 is listed below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – LON08			
Scenario	**Emissions**	**Savings**	**% Saving**
TER	**1,053.2**		
BER (Be Lean)	682.5	370.6	35%
BER (Be Clean)	683.5	0.0	0%
BER (Be Green)	668.8	13.7	1%
Cumulative Savings		**384.4**	**36%**

Table 1-7 Summary of Emission for LON8

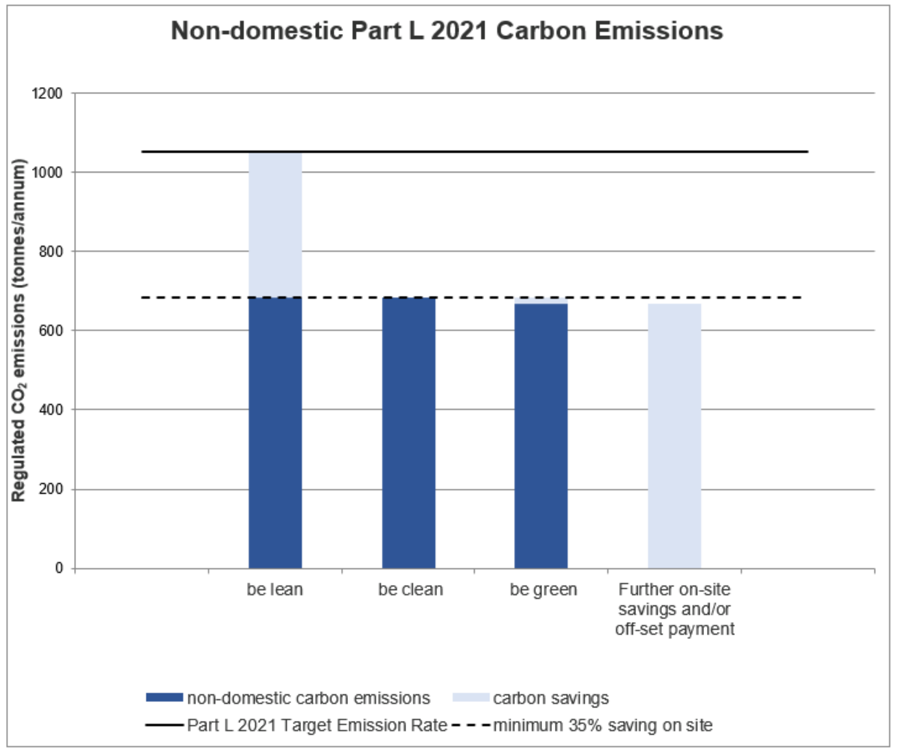


Figure 1-7 Summary of Emission for LON8

The CO2 reduction for Data Centre building Innovation Hub is listed below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – Innovation Hub			
Scenario	**Emissions**	**Savings**	**% Saving**
TER	**7.3**		
BER (Be Lean)	6.9	0.4	5%
BER (Be Clean)	6.9	0.0	0%
BER (Be Green)	4.0	2.9	40%
Cumulative Savings		**3.3**	**45%**

Table 1-8 Summary of Emission for LON8

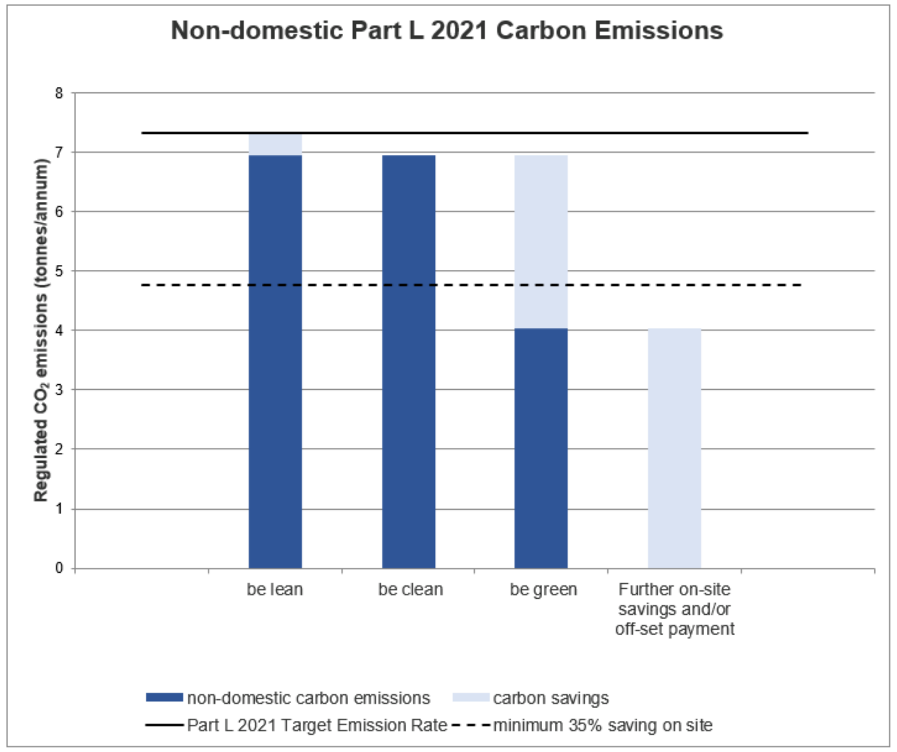


Figure 1-8 Summary of Emission for Innovation Hub

Overall reduction summary for the outlined component is summarized below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO_2 emission output – Overall Outlined Component			
Scenario	**Emissions**	**Savings**	**% Saving**
TER	**2984.0**		
BER (Be Lean)	1897.8	1086.2	36%
BER (Be Clean)	1897.8	0.00	0%
BER (Be Green)	1871.3	26.4	1%
Cumulative Savings		**1112.6**	**37%**

Table 1-9 Summary Emission for Overall Outlined Component

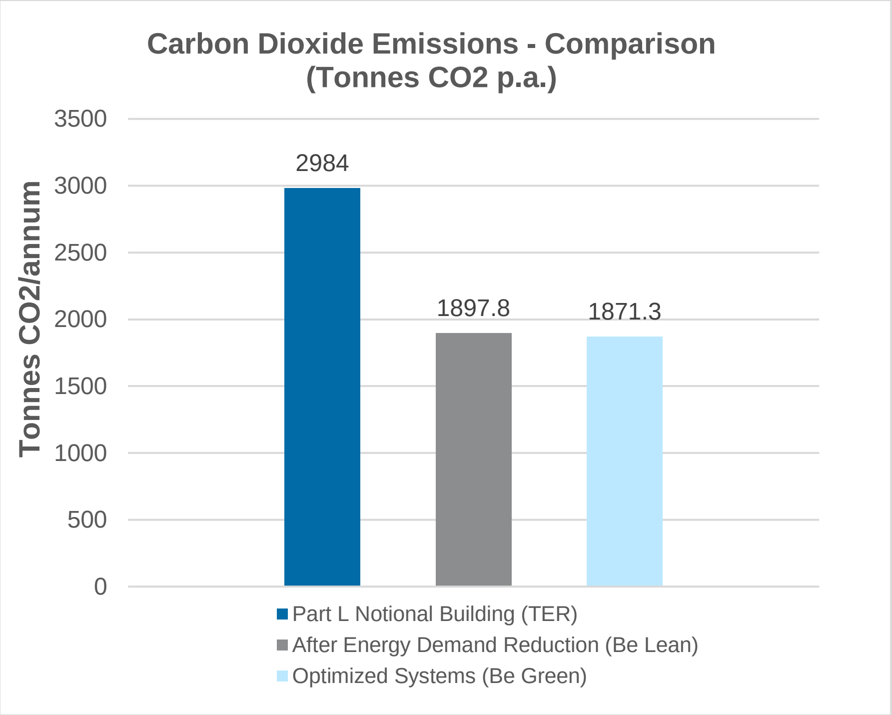


Figure 1-9 Summary of Emission for Overall Outlined Component

The performance levels currently targeted within this report will be reviewed through each design stage to ensure the CO_2 reduction targets are considered in any design, procurement, and construction changes. The individual performances are showcased above in detail for the end use of each building. As per GLA guidelines, the BeGreen case with a saving of 35% over the TER is being met for each building on this site.

Overall reduction summary for the whole site is summarized below:

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – Overall Site			
Scenario	Emissions	Savings	% Saving
TER	4,099.8		
BER (Be Lean)	2,548.9	1,550.9	38%
BER (Be Clean)	2,548.9	0	0%
BER (Be Green)	2,513.6	35.3	1%
Cumulative		**1,586.2**	**39%**

Table 1-10 Summary Emission for Overall Campus

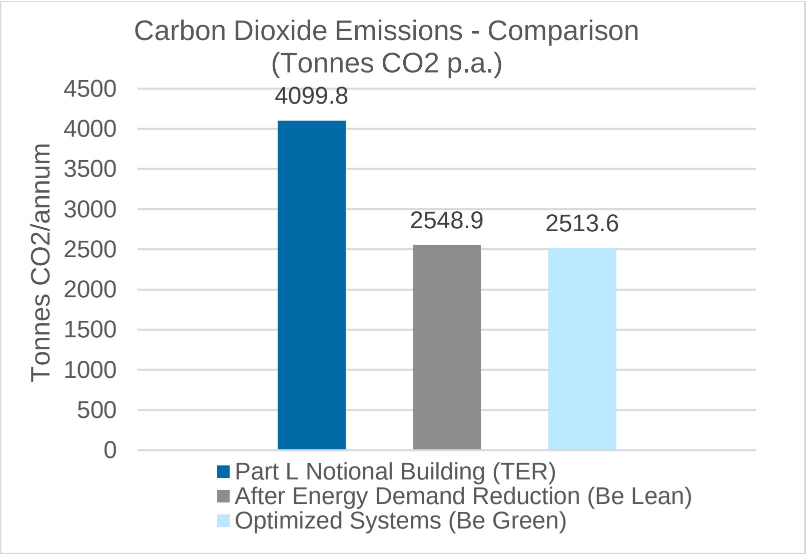


Figure 1-10 Summary of Emission for Overall Campus

The performance levels currently targeted within this report will be reviewed through each design stage to ensure the CO_2 reduction targets are considered in any design, procurement, and construction changes. The individual performances are showcased above in detail for the end use of each building. As per GLA guidelines, the BeGreen case with a saving of 35% over the TER is being met for each building on this site.

BER (BeGreen) of each component showing the amount of carbon that needs to be offset below:

Building Component	BER (BeGreen) – (Tonnes CO_2 p.a.)
LON06	642.3
LON07	1198.5
LON08	668.8
Innovation Hub	4.0

Table 1-11 Summary of carbon emissions to be offset for Overall Campus

Thermal Comfort

Overheating assessment was undertaken for the admin areas of LON06 and Innovation Hub. Heat has been limited from entering the building through careful consideration of glazing. This must be balanced with a need for good daylight and solar heat in winter, so the use of solar control glass has been considered. All assessed spaces comply with the thermal comfort requirement and pass the overheating risk assessment.

Circular Economy

A circular economy statement has been produced, setting out the development's circular economy strategy, in response to the GLA's energy and sustainability planning policies. Specifically, the focus' for this scheme is to 'design for adaptability & replaceability', then 'design for flexibility & longevity'.

Whole Life-Cycle Assessment

A full embodied carbon assessment was undertaken for the data centres and Innovation Hub for the purposes of reporting the developments embodied carbon against the GLA's Upfront Carbon (A1-A5) and whole-life carbon (A-C) benchmarking targets.

Detailed Component

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	790
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1740

Table 1-12. Whole Life-cycle Carbon breakdown LON06

Outlined Component

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	792
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1742

Table 1-13. Whole Life-cycle Carbon breakdown LON07

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	792
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1742

Table 1-14. Whole Life-cycle Carbon breakdown LON08

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	952
Modules B-C (excluding B6 & B7)	<450	<370	827
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1778

Table 1-15. Whole Life-cycle Carbon breakdown Innovation Hub

CUNDALL

Contents

1.0

Introduction

1.0 Introduction

This Energy and Sustainability Statement has been prepared in supporting of the planning application for the Hayes Digital Park Data Centre Campus development at Hayes Bridge Retail Park and Heathrow Interchange in the London Borough of Hillingdon. It aims to meet the energy and climate change requirements of the Hillingdon Local Plan and the Greater London Authority (GLA).

This statement incorporated both detailed and outlined component's performance to provide an overview carbon reduction effort from the site, by minimising the emissions of CO2 through renewable / sustainable means.

The format of this report is based on GLA's Energy Assessment Guidance, June 2022 document.

1.1 Existing Site

The proposed development site is located off Uxbridge Road, Hayes, at the Hayes Bridge Retail Park and Heathrow Interchange Site. The site is part of the London Borough of Hillingdon.

Figure 1-1 Wider context of Bridge Retail Park Site in Hayes, West London.

1.2 Description of Proposed Development

The planning application seeks planning permission for the following description of development:

Hybrid planning application for a four-phased redevelopment to deliver a data centre campus comprising of:

Phase 1 – Full planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) site access and internal roads including a vehicular and pedestrian link between Uxbridge Road and Bullsbrook Road (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development;

Phase 2 – Outline planning permission for (a) an Innovation Hub (b) hard and soft, green and blue, infrastructure and (c) other ancillary and auxiliary forms of development;

Phase 3 - Outline planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) internal roads (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development; and

Phase 4 - Outline planning permission for (a) a data centre building (b) energy, power, and water infrastructure (c) internal roads (d) site security arrangements and security fencing (e) hard and soft, green and blue, infrastructure and (f) other ancillary and auxiliary forms of development.

LON06, LON07, and the Innovation Hub are to be located on the site of Hayes Bridge Retail Park with LON08 (and the substation for which there is a separate application for full planning permission for) to be located on the site of Heathrow Interchange. The Metro Bank building and use in the northeast corner of the site will be retained.

Outline component will be discussed in Section 3 - 4; while Detailed component will be discussed in Section 5 - 6.

All the unregulated carbon emission will be reviewed under WLC Statement.

1.3 Area Schedule and Visualisations

<u>Outline Component</u>

Use Class	GEA	GIA
LON07 Data Centre	53,415 sqm	-
LON08 Data Centre	29,656 sqm	-
Innovation Hub	2,000 sqm	-
Outline Component Total	**85,071 sqm**	-

Table 1-1 Area summary of Outlined Component

<u>Detailed Component</u>

Use Class	GEA	GIA
LON06 Date Centre	25,235 sqm	24,114 sqm
Detailed Component Total	**25,235 sqm**	**24,114 sqm**

Table 1-2 Area summary of Detailed Component

1.4 Site Allocation of all components

Site Arrangement overview

Figure 1-2 Overall Site Plan

Outlined Component

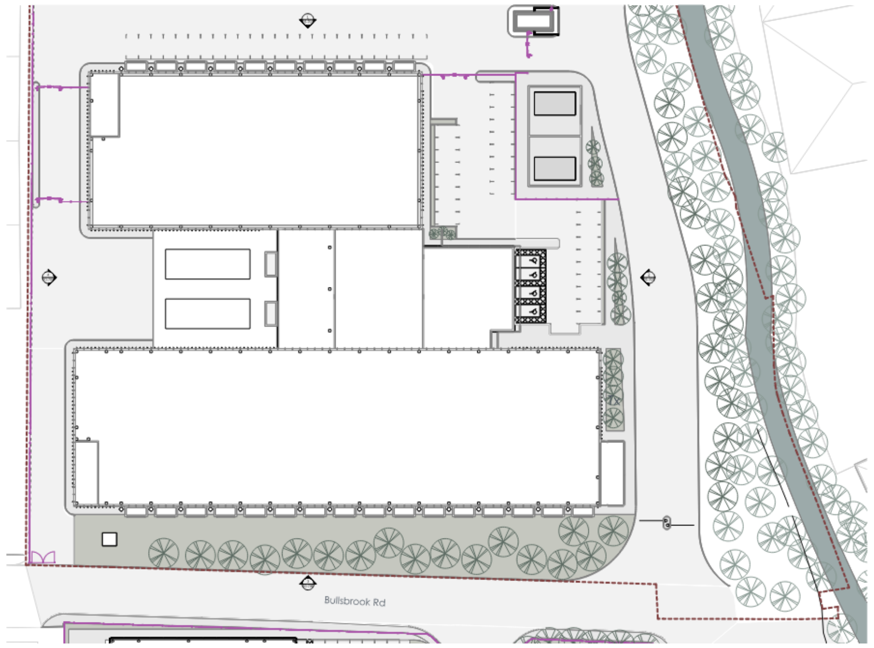


Figure 1-3 LON 7 Site Plan

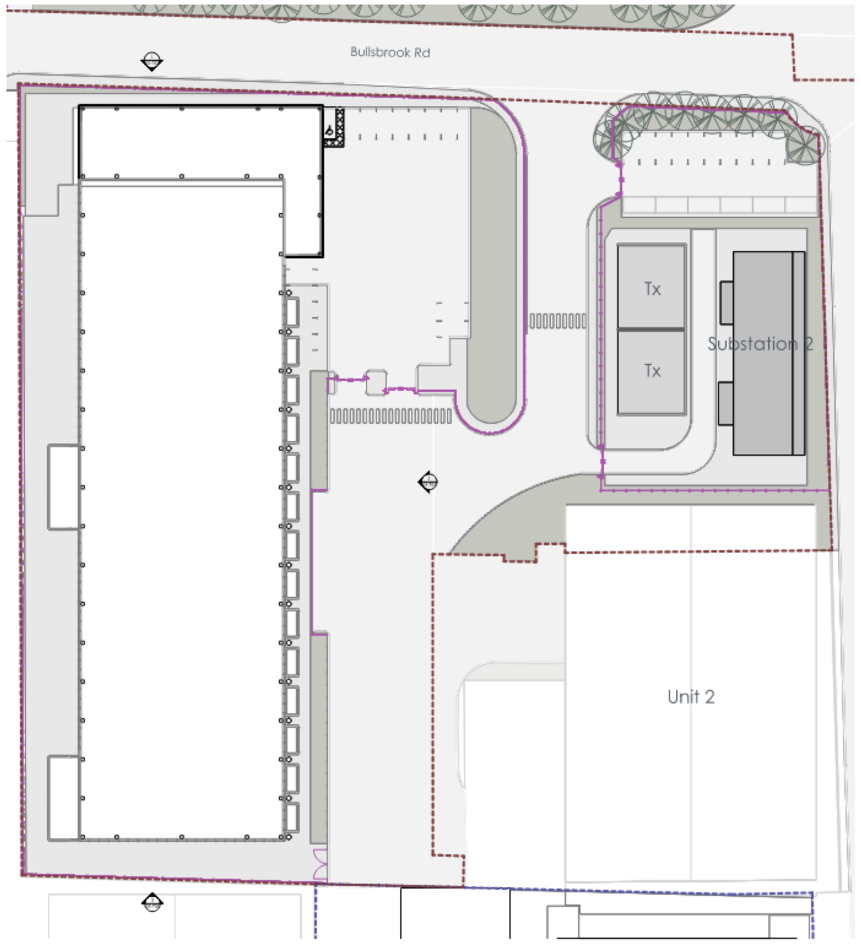


Figure 1-4 LON 8 Site Plan

Detailed Component

Figure 1-5 LON 6 Site Plan

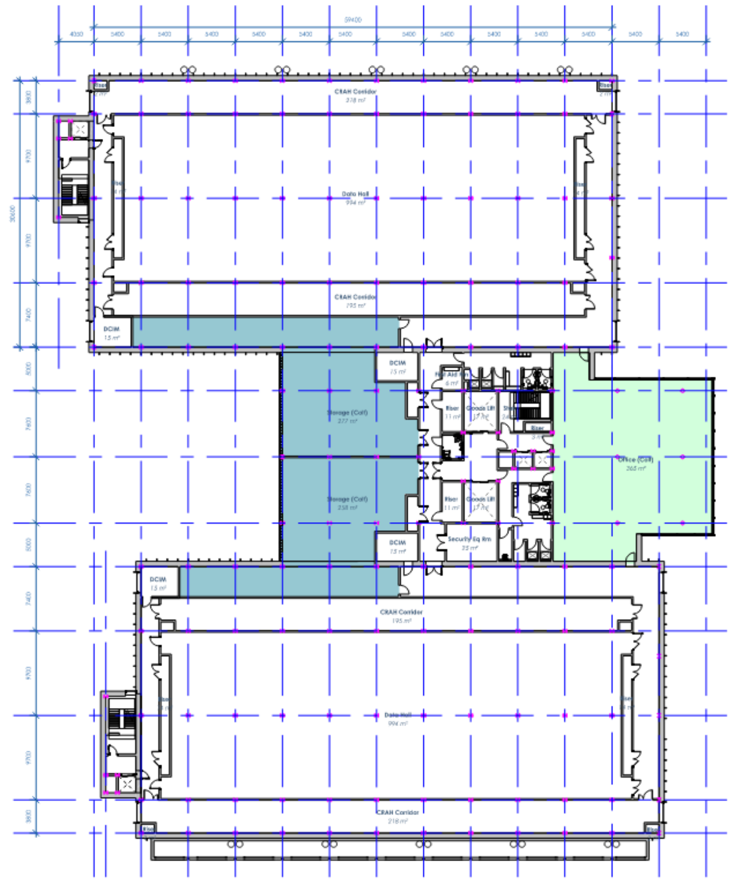


Figure 1-6 LON 6 Typical Floor Plan

2.0

Planning Policy

2.0 Planning Policy

2.1 National Policy

The revised National Planning Policy Framework (NPPF) was published in December 2024 and sets out the government's planning policies for England and states a clear presumption in favour of sustainable development. The revised Framework replaces the previous NPPF published in July 2021.

The NPPF supports the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change, and encourages the reuse of existing resources, including conversion of existing buildings, and encourages the use of renewable resources.

The NPPF, Section 14 outlines its energy and climate change policies. New development should be planned for in ways that:

- Avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and
- Help to reduce greenhouse gas emissions, such as through its location, orientation, and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards.

To help increase the use and supply of renewable and low carbon energy and heat, plans should:

- Provide a positive strategy for energy from these sources, that maximises the potential for suitable development, while ensuring that adverse impacts are addressed satisfactorily (including cumulative landscape and visual impacts);
- Consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure their development; and
- Identify opportunities for development to draw its energy supply from decentralised, renewable, or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

Local planning authorities should support community-led initiatives for renewable and low carbon energy, including developments outside areas identified in local plans or other strategic policies that are being taken forward through neighbourhood planning.

The NPPF states that in determining planning applications, local planning authorities should expect new development to:

- Comply with any development plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and
- Take account of landform, layout, building orientation, massing, and landscaping to minimise energy consumption.

When determining planning applications for renewable and low carbon development, local planning authorities should:

- Not require applicants to demonstrate the overall need for renewable or low carbon energy, and recognise that even small-scale and community-led projects provide a valuable contribution to cutting greenhouse gas emissions; and
- Approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas.

The key focus of the NPPF is to support local and regional planning authorities.

2.2 The London Plan (GLA)

The GLA London Plan and GLA Energy Strategy are the benchmark for local planning regulation. Together they provide a useful tool against which to undertake energy and sustainability assessments. The key requirements of the London Plan (March 2021 version) for new developments are:

Policy SI 2 - requires that major non-residential developments, achieve a 35% improvement over the 2021 Building Regulation CO_2 Emission Target, 15% out of which is achieved through energy efficiency measures. Major development proposals are required to calculate and minimise carbon unregulated emissions.

Policy SI 2 Minimising greenhouse gas emissions

A Major development should be net zero-carbon.[151] This means reducing greenhouse gas emissions in operation and minimising both annual and peak energy demand in accordance with the following energy hierarchy:

1) be lean: use less energy and manage demand during operation
2) be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly
3) be green: maximise opportunities for renewable energy by producing, storing and using renewable energy on-site
4) be seen: monitor, verify and report on energy performance.

B Major development proposals should include a detailed energy strategy to demonstrate how the zero-carbon target will be met within the framework of the energy hierarchy.

C A minimum on-site reduction of at least 35 per cent beyond Building Regulations[152] is required for major development. Residential development should achieve 10 per cent, and non-residential development should achieve 15 per cent through energy efficiency measures. Where it is clearly demonstrated that the zero-carbon target cannot be fully achieved on-site, any shortfall should be provided, in agreement with the borough, either:

1) through a cash in lieu contribution to the borough's carbon offset fund, or
2) off-site provided that an alternative proposal is identified and delivery is certain.

D Boroughs must establish and administer a carbon offset fund. Offset fund payments must be ring-fenced to implement projects that deliver carbon reductions. The operation of offset funds should be monitored and reported on annually.

E Major development proposals should calculate and minimise carbon emissions from any other part of the development, including plant or equipment, that are not covered by Building Regulations, i.e. unregulated emissions.

F Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.

2.3 Energy Assessment Guidance (June 2022)

The energy assessment is prepared according to the assessment guidance to achieve the zero-carbon by the follow energy hierarchy for the policies SI2 to SI4

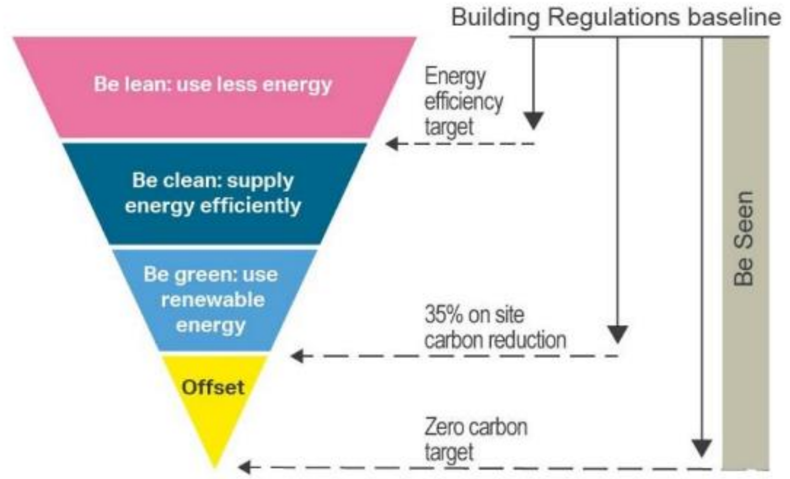


Figure 2-1 The London Plan energy hierarchy

To demonstrate:

1. 35% on-site carbon reduction beyond Part L 2021
2. Provide energy efficiency measures to reduce regulated CO2 emissions by 15%
3. Demonstrated the cooling hierarchy has been reviewed and mitigated measures through passive design.
4. Commit to communal heat network to allow connection to heat network.

The carbon footprint of the development after each stage of the energy hierarchy will be reported:

1. Baseline: Part L 2021 of the Building Regulations Compliant Development
2. After energy demand reduction (be lean)
3. After heat network connection (be clean)
4. After renewable energy (be green).

2.3.1 Carbon Payment

The cumulative shortfall is multiplied by the carbon dioxide offset price to determine the required cash-in-lieu contribution. Boroughs are expected to use the GLA's recommended carbon offset price (currently £95 per tonne of carbon dioxide), or to set their own based on local viability evidence.

Policy SI 3 - requires major developments to evaluate the feasibility of connecting to existing or proposed district heating networks, and where none exists, to consider a site wide Combined Heat and Power (CHP) system.

Policy SI 4 – requires developments to reduce potential overheating and reliance on conditioning systems via a range of measures.

Policy SI 5 – to ensure London's future water security, the prudent use of water will be essential: all new development will need to be water efficient-minimising use of mains water, leakage levels and energy required for pumping.

2.4 Local Policy – London Borough of Hillingdon

The London Borough of Hillingdon Local Development Scheme (adopted July 2024), together with the adopted Hillingdon Local Plan, sets out the vision and key policies for planning in the Borough. The Council proposes to update the Local Plan. The review of the Local Plan will combine the Strategic Policies and the Development Management Policies documents of the Local Plan into a single document and will produce a new Site Allocations document. All Local Plan document will be updated to reflect the most recent National Planning Policy Framework and the London Plan (2021). The review commenced in 2023 and is programmed to complete by mid-2026, with the existing Local Plan Part 1 (2012) and Part 2 (Adopted Version 2020) continuing to carry full weight in any planning application assessments.

These outline several Policies which developments must comply with. The Policies relevant to the energy and sustainability strategy are listed here:

Local Plan Part 1: Climate Change Adaptation and Mitigation

Policy SO11 - Address the impacts of climate change and minimise emissions of carbon and local air quality pollutants from new development and transport.

Environmental Protection and Enhancement:

Local Plan Part 2:

Policy DMEI 2 - Reducing Carbon Emissions

A) All developments are required to make the fullest contribution to minimising carbon dioxide emissions in accordance with London Plan targets.

B) All major development proposals must be accompanied by an energy assessment showing how these reductions will be achieved.

C) Proposals that fail to take reasonable steps to achieve the required savings will be resisted. However, where it is clearly demonstrated that the targets for carbon emissions cannot be met onsite, the Council may approve the application and seek an off-site contribution to make up for the shortfall.

POLICY DMEI 3 - Decentralised Energy

A) All major developments are required to be designed to be able to connect to a Decentralised Energy Network (DEN).

B) Major developments located within 500 metres of an existing DEN, and minor new-build developments located within 100 metres, will be required to connect to that network, including provision of the means to connect to that network and a reasonable financial contribution to the connection charge, unless a feasibility assessment demonstrates that connection is not reasonably possible.

C) Major developments located within 500 metres of a planned future DEN, which is considered by the Council likely to be operational within 3 years of a grant of planning permission, will be required to provide a means to connect to that network and developers shall provide a reasonable financial contribution for the future cost of connection and a commitment to connect via a legal agreement or contract, unless a feasibility assessment demonstrates that connection is not reasonably possible.

D) The Council will support the development of DENs and energy centres in principle, subject to meeting the wider policy requirements of this plan and in particular on design and air quality.

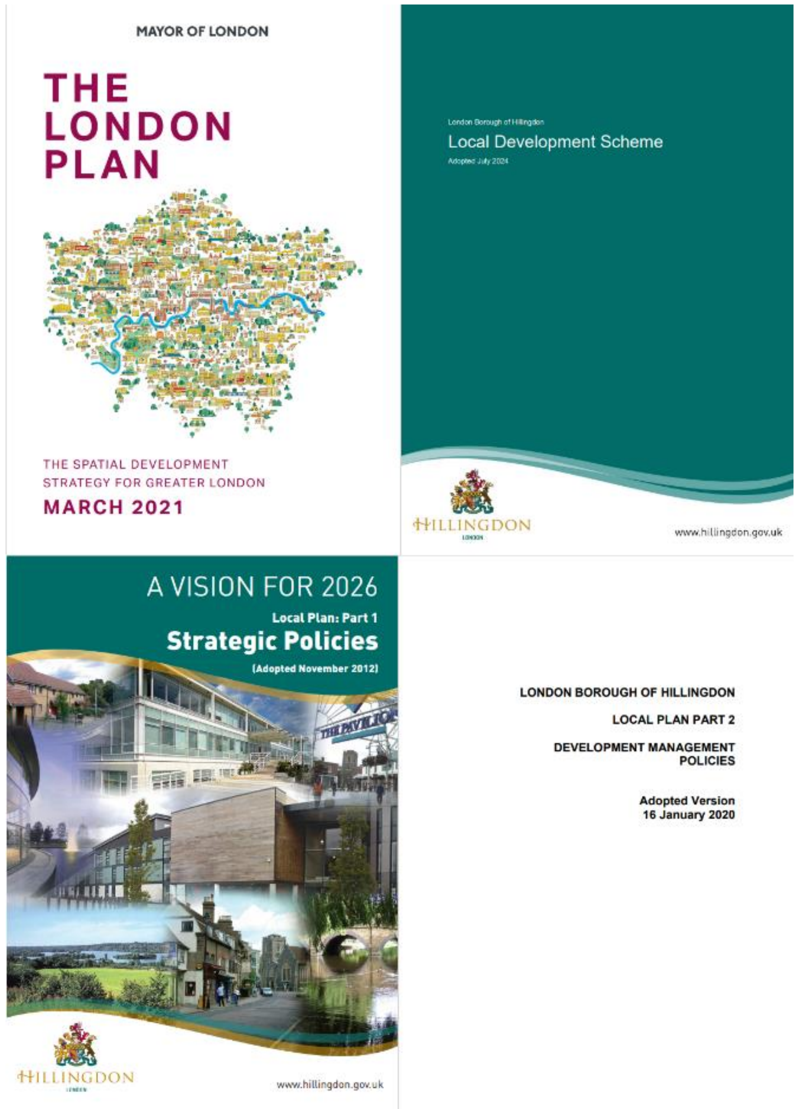


Figure 2-2 Planning Policy

3.0

Detailed Component – Baseline

3.0 Detailed Component – Baseline

This section of the report will estimate the baseline energy consumption and associated CO_2 emissions for the detailed component. The baseline emission refers to Part L 2021 compliant development.

All the blocks in detailed component are non-residential. Part L model is developed to review LON06.

3.1 Estimation of LON6

3.1.1 Outlined setting

LON06 locates in between the Innovation Hub and LON07 with the same orientation and similar build-up area to LON07. The rendered image Figure 5-1 is shown for the reference. Design elements are provided and coordinated with the project team which will be implemented at the time of construction. The optimization on building fabrics is done on the wall, roof and glazing's which results the thermal transmittance is on the lower side for walls and the roof. The glazing window to wall ratio is maximised on the east façade of the building with 54%. The glazing is on the admin section of the building and minimum fenestration was designed for the data hall circulation spaces to limit the solar gains.

The lamp efficacy is 104 lm/W for office area, the data halls have 175 lm/W lamp efficacy for the optimum result. Other spaces have a lamp efficacy range from 140-164 lm/W. Equipment and the occupant density are considered same as the notional.

The predominant cooling system is free cooling air cooled chillers which provide chilled water to CRAH units serving the data halls. There are CRAH units serving the various electrical rooms as well. The admin will utilise waste heat from the data halls for heating via a water-to-water source heat pump and FCUs. A water-cooled chiller will provide cooling to the admin via FCUs. DHW associated with the centralised based heating system is modelled as well for the hot water use in the building.

The efficiencies consider for the systems are as per the notional guidelines, so no saving has been claimed under the HVAC system.

The Target CO_2 emission rate (TER) in $kgCO_2/m^2$. annum for LON06 is 48.02.

3.1.2 Building Targeted Emission Rate (TER)

The Baseline for the LON6 is estimated as below:

Part L2 2021 End-uses Breakdown [kWh/m2]	
End-use	**LON6**
Heating	0.05
Cooling	268.99
Auxiliary	57.41
Lighting	29.73
DHW	0.15
Total	**356.32**

Table 5-1 Baseline End Use Breakdown (TER) for LON06

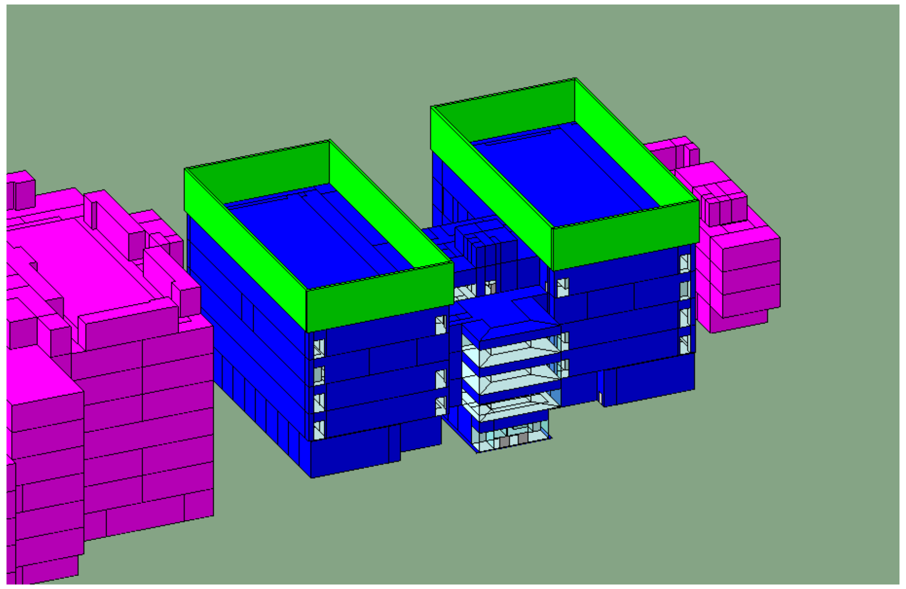


Figure 5-1 Model for LON06

4.0

Detailed Component – Be Lean, Be Clean, Be Green

4.0 Detailed Component – Be Lean, Be Clean, Be Green

4.1 Be Lean

The design of the proposed buildings has been developed to reduce its annual energy consumption, provide energy in an environmentally friendly way, and to minimize its annual CO_2 footprint. In order to achieve this, a "Steps to low carbon" methodology has been applied.

4.1.1 Passive Design

Substantial reductions in energy usage for the scheme, together with improved occupancy comfort, will be achieved largely through consideration of the passive elements of the design. The design team have looked to implement passive design measures through optimising the passive solar design and building envelope performance as described in the following sections.

4.1.1.1 Passive Solar Design

As the development is primarily for the use of data storage, occupant comfort and enjoyment are not paramount for most spaces. Data halls are predominantly cooling led demand spaces, which are not consistently occupied. To this end, the use of windows has been limited, especially in Data Halls, to minimise thermal energy conduction between indoors and outdoors, as well as solar gains. These passive measures will help to reduce cooling loads and resulting energy consumption.

4.1.1.2 Building Fabric

Improving the thermal insulation standards beyond the Building Regulation standards will help to reduce the annual CO_2 emissions associated with the building's heating and cooling systems, by limiting the heat loss, and gain, through the building's fabric. For the data halls, exceptionally high-performance external walls will be specified to minimise cooling loads associated with building typology. The following improvements over the Building Regulation minimum standards are being sought for the development:

4.1.1.3 Air Permeability

An improved air leakage rate of 3.0 $m^3/(hr.m^2)$ is being targeted for the proposed development, in comparison with the Building Regulation minimum standards of 8 $m^3/(hr.m^2)$ at 50Pa. This equates to an infiltration rate of 0.10 ACH. Good air tightness could be achieved by the prefabrication of a number of key building components under factory conditions, robust detailing of junctions and good building practices on site.

Fabric Detail	Design LON06
Ground Floor area weighted thermal conductivity, U-value ($W/m^2.K$)	0.15
Roof area weighted thermal conductivity, U-value ($W/m^2.K$)	0.15
External Walls area weighted thermal conductivity, U-value ($W/m^2.K$)	0.18
External Personnel Doors area weighted thermal conductivity, U-value ($W/m^2.K$)	1.60
Windows area weighted thermal conductivity, U-value ($W/m^2.K$)	1.40
Windows total solar transmission, effective G-value (%)	30
Windows framing factor (%)	20
Air permeability ($m^3/(hr.m^2)$ @50Pa)	3.0

Table 6-1 Fabric details

4.1.2 Energy Efficient Systems

After assessing the contribution of the passive elements to the overall energy balance, the aim is to further reduce CO_2 emissions by selecting efficient mechanical, electrical demand, with effective load demand design by recovery and control systems to manage the energy use during operation.

4.1.2.1 System Demand Reduction

4.1.2.1.1. Low-energy Lighting

Installing efficient low energy light fittings internally and externally can significantly reduce a building's overall lighting load hence lowering its annual CO_2 emissions. The development will reduce the energy consumption by the specification of low energy luminaires in all office and data hall areas.

4.1.2.1.2. Daylighting and Occupancy sensors control

Ancillary spaces throughout the development will use luminaires at a lower efficacy, additionally stairs, storages, server rooms and WCs will be equipped with PIR presence detection.

4.1.2.1.3. Variable System design

All fans and pumps will be specified with variable-speed drives, which will reduce their energy consumption by more than two-thirds compared with equivalent constant speed alternatives, by only supplying the required flow rate to meet the demand.

4.1.2.1.4. Heat demand reduction

As there are large waste heat exported from the data hall space, all other space could be benefit from the waste heat recovery and heat demand is reduced.

4.1.2.1.5. Wate heat recovery and usage

Waste heat recovery and usage is a unique benefit for this campus development. Data hall waste heat is used to provide some heating to the admin block of the data centre via water-to-water heat pumps. The waste heat is also used to temper the air in the Make-up Air (MUA) units that serve to pressurise the technical spaces and provide them with fresh air.

4.1.2.1.6. Controls

The heating/cooling systems shall be appropriately zoned, with local fast responding controls. Appropriate lighting controls, including occupancy sensors shall be specified where applicable for all internal and external lighting.

4.1.2.1.7. Building Energy Management System (BEMS)

Where appropriate Building Energy Management System (BEMS) using information technology (IT) will be used to promote and facilitate a system that supports the energy demand management for commercial buildings (e.g. a system that recognises real-time room conditions in buildings by temperature sensors and/or the optimal operation of lighting and air-conditioning responding to the room condition). A combination of energy saving control techniques, such as optimum start with communication and information systems will allow active management of the building services and the capability to achieve and maintain a high level of energy efficiency.

A full BEMS system will be installed for the development and linked to central control systems. The systems will be easily accessible by the onsite team with automatic monitoring, targeting and automatic alarms for out-of-range values.

4.1.2.2 Energy Metering

Separate metering systems of the energy uses within the development will help the building users and tenants identify areas of excessive consumption and highlight potential energy-saving measures for the future. This will enable on-going reduction of annual CO_2 emissions from these systems.

4.1.3 Fixed Building Services

Several improvements over the Building Regulation's 'notional' building have been incorporated in order to reduce the CO_2 emissions of the development and hence comply with the Building Regulations. The table below provides a summary of the inputs for the model.

System Detail	Design LON06
Ventilation:	
Admin areas system fans' specific fan power (SFP) (W/l/s)	1.0
Mechanical Ventilation Heat Recovery (MVHR) efficiency (%) – Offices/meeting areas (Thermal Wheel)	76.0%
Space Heating:	

System Detail	Design LON06
Admin area WSHP SEER	5.79
Space Cooling:	
Critical cooing system seasonal energy efficiency ratio (SEER)	9.96
Admin area –SEER	9.96
Auxiliary Energy:	
Admin areas system fans' (SFP) (W/L/s)	1.0
Data hall areas system fans' (SFP) (W/L/s)	1.0
Domestic Hot Water (DHW):	
Direct electric point of use source	electricity
Direct electric point of use source efficiency (%)	100%
Lighting:	
Lighting Type 1 efficacy Luminaire Lumens per circuit Watt, lm/W) – Data halls	175
Lighting Type 2 efficacy Luminaire Lumens per circuit Watt, lm/W) – Offices	104
Lighting Type 3 efficacy Luminaire Lumens per circuit Watt, lm/W) – WC	140
Lighting Type 4 efficacy Luminaire Lumens per circuit Watt, lm/W) – Stairs	143
Lighting Type 5 efficacy Luminaire Lumens per circuit Watt, lm/W) – Other spaces	164
Daylight sensors	Yes
Occupancy Sensors (Auto ON/OFF)	Yes
Other:	
HVAC systems with full energy metering and monitoring	Yes
HVAC systems warns of 'out of range' values'	Yes
All fans and pumps fitted with variable speed drives	Yes
Lighting systems with full energy metering and monitoring	Yes
Lighting systems warns of 'out of range' values'	Yes

System Detail	Design LON06
Electrical Power Factor Correction	>0.95

Table 6-1. System detail

4.1.4 Be Lean Part L Performance Results

Calculations results in this report is estimated as below**.**

In accordance with the London Borough of Hillingdon and the Mayor's Energy Hierarchy the estimated energy consumption for the development has been based on the National Calculation Methodology (NCM).

An energy assessment has been carried out for the entire development, including the data hall spaces, with the passive design and energy efficiency measures. The preliminary energy assessment is based on the requirements of Part L Volume 2 (2021) and uses approved dynamic simulation software IES Virtual Environment 2022.

The analysis indicates that the proposed baseline development is performing significantly better than the minimum requirements of Part L Volume 2 2021 of the Building Regulations and achieves an improvement of **42%** over the target emissions rate an of **42**% over the primary energy rate as highlighted below.

LON06

LON6 - Part L 2021 End-uses Breakdown – Be Lean				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m^2.annum	
Total	48.02	28.02	524.95	306.1
Improvement	**41.65%**		**41.69%**	
Part L Status	**Pass**		**Pass**	

Table 6-2 Part L 2021 End-uses Breakdown – Be Lean

Regulated Emissions Summary (Tonnes CO_2 p.a.)			
Scenario	Emissions	Savings	% Saving
TER	1115.9		
BER (Be Lean)	651.1	464.8	**42%**

Table 6-3 Regulated Emissions Summary - Be Lean

4.2 Be Clean

4.2.1 District Heating Networks

A heating network can be utilised to provide low carbon heat to both water-based systems: space heating and domestic hot water supplies. In a development with high heating and DHW loads – such as residential or leisure centre developments – a heating network can deliver significant CO_2 savings potential. In an office or data centre-based development, where heating requirements are relatively minimal, the heating network carbon savings potential is not as significant.

The feasibility of connecting to an existing district network has been investigated for the site in accordance with Policy SI 3 of the London Plan. An analysis of the London Heat Map has shown there is no existing or proposed heat network in the vicinity.

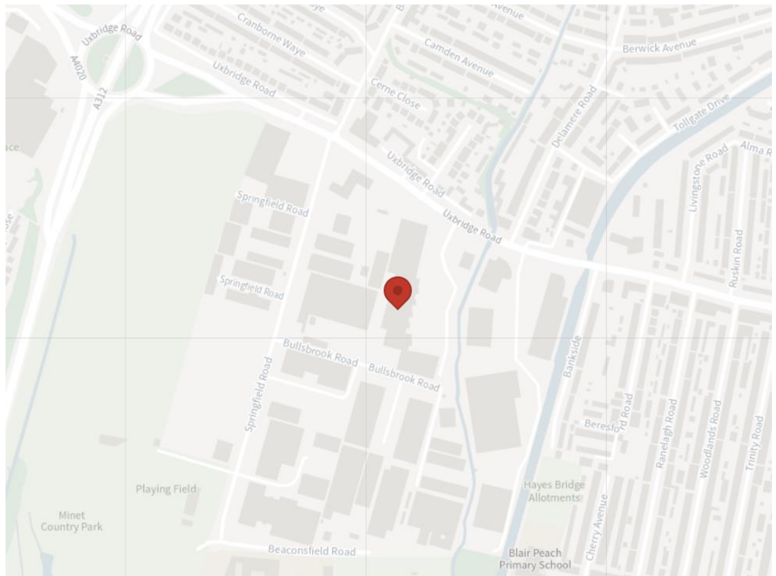


Figure 6-1 London Heat Map showing no available networks around the site.

However, for a datacentre it generates excess heat during its function and intended to export heat and is a self-sustain heat source to the occupied space.

4.2.2 Heat reuse strategy

As mentioned, the demand of hot water consumption is minimal for data centre. There is a higher opportunity considering effectiveness of WSHP if used for the DHW supply. Space heating demands for the development have been minimised with a high-performance thermal fabric. The remaining space heat load is maintained by FCU system and reusing waste heat that generated from the data halls. The space for the supporting equipment will be allocated at roof level plant room. The Data Hall waste heat is provisionally be utilised by the admin block, the opportunities for which are described in Appendix.

Plant room space provision is allowed for the heat exchanger and necessary pipe connections to enable a future connection for the building or local services should it be feasible. Please refer to the appendix.

4.2.3 Exporting Energy to a Heat Network

The data centre development is likely to produce large amounts of waste energy in the form of heat from the data halls. This heat energy amount has the potential to be exported to appropriate usage within the site; or from the site into the local area, acting as an energy provider rather than an energy consumer. The adoption of this strategy also has the potential to accelerate the development of planned heating network in this area, providing a consistent source of low-grade heat throughout the year. Further analysis will be required to determine the potential energy available from the data centre as well as the quality and temperature of the heat energy available. The design has allowed the provision of energy exportation for a future connection to an external third-party heat network, but currently there is no available local heat network. The following considerations have been made in the current design:

- The ability to recover waste heat from data halls via water-to-water heat exchangers, located in the roof plant rooms.
- Heat will be collected via connections to the return pipework from data hall cooling system.
- Low grade heat (~30°C water) is pumped to a connection point housed within a kiosk or energy centre on the site boundary, for extension by others.
- Third Party District Heating Provider, ESCo, local residential, local industry etc. may connect to the system via a set of low-loss headers in the interface kiosk.
- Third parties would need to elevate the temperature of the distribution to a more usable level by means of heat pumps, or other plant (industrial process, pyrolysis, etc.), to suit their specific requirements. This equipment would be part of their installation and would be located off-site.
- Capacity and operating characteristics of the plant would depend upon Third Party's specific requirements.
- Agreement would be subject to commercial business case and based upon principle that heat would only be supplied when available and only taken when needed, with neither party under strict obligation to supply or take heat.
- Availability of heat may vary depending upon phasing and installed capacity of IT equipment within operational data halls.

4.2.4 Combined Heat and Power (CHP)

In accordance with Policy SI 3 the feasibility of a site wide CHP network has been investigated.

CHP is the on-site generation of electricity and the recovery of the normally wasted heat produced during this process.

The operation of CHP plant can offer significant CO_2 emission rates when compared to conventional methods of energy generation and use.

- Most large conventional power stations currently generate electricity at 30-50% efficiency.
- 'Good quality' CHP schemes achieve overall efficiencies of 70-85%.
- The use of CHP depends on finding a use for the electricity and heat generated by the process.

As outlined previously the development's heating requirements have been reduced via the use of increased thermal insulation and air tightness levels, supplemented by high efficiency heat supply and recovery systems.

The limited residual base load heat demand of the site results in insufficient run hours to allow efficient operation of a CHP system. It is therefore not proposed for inclusion.

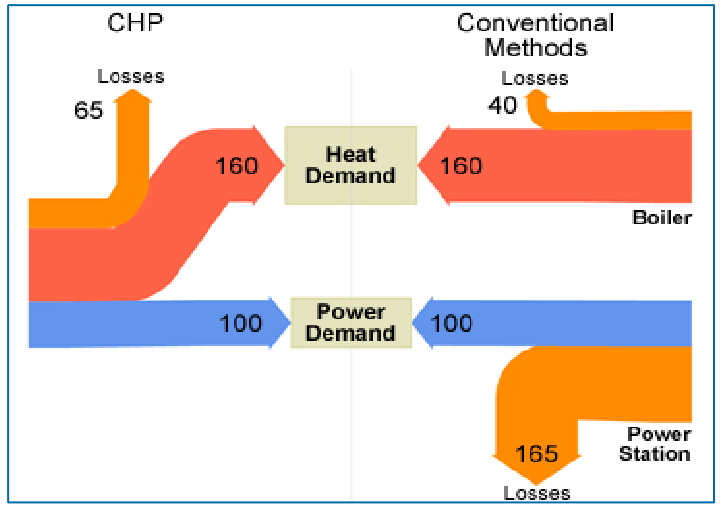


Figure 6-2 Sankey diagram illustrating the energy flows and benefits of CHP vs boiler heating.

4.2.5 Power Agreement

An agreement has been made with National Grid and SSE to provide power to the site.

4.2.6 Be Clean Part L Performance Results

With no decentralised system included in the strategy, the Part L performance results remain the same as they were in the Be Lean scenario.

4.3 Be Green

Policy SI 2 of the London Plan requires that all major developments seek to reduce their CO_2 emissions by at least 35% compared to the notional building, 15% of which should be achieved through energy efficiency measures; remaining 20% improvement can be met through the use of onsite renewable energy generation, wherever feasible.

The following technologies have been considered for supplying a portion of the development's energy demand. The feasibility of each of the energy sources listed has been assessed regarding the potential contribution each could make to supply a proportion of the development's delivered energy requirement, whilst considering the technical, planning, land use and financial issues.

4.3.1 Biomass Heating

Biomass in the form of logs, wood chips and wood pellets are classified as a renewable source of energy because the carbon dioxide emitted when the biomass is burned has been taken out of the atmosphere by the growing plants. Even allowing for emissions of carbon dioxide in planting, harvesting, processing, and transporting the fuel they will typically reduce net CO_2

emissions by over 90%. Biomass boilers are large pieces of plant that require substantial areas and volumes of space for the boiler, the fuel storage, and the waste. A delivery area for trucks frequently supplying and removing fuel and waste would also need to be factored in.

Biomass boilers are ill suited to meeting a fluctuating daily heating demand, especially a relatively low load as is the case in a Data centre. Additionally, the NOx emissions produced by biomass boilers would impact local air quality significantly more than other available technologies.

For these reasons Biomass boilers are not considered to be appropriate for the Hayes Digital Park Data Centre Campus development.

4.3.2 Solar Hot Water Collectors

Solar thermal collectors utilise solar radiation to heat water for use in buildings. The radiation is converted using a solar collector, of which there are two main types: Flat plate, and Evacuated tube collectors. Evacuated type systems occupy a smaller area and are more efficient but also generally more expensive. The optimum orientation for a solar collector in the UK is a south-facing surface, tilted at an angle of 30º from the horizontal.

Solar collectors are typically designed to meet a development's base heat load, associated with its domestic hot water requirements, with a second system meeting the remainder of the load.

There is minimal hot water demand for the building, therefore, solar thermal collectors are not proposed for inclusion in the development.

4.3.3 Air Source Heat Pumps (ASHP)

Air source heat pumps exchange heat between the outside air and a building's internal spaces to provide space heating in winter and cooling in the summer. The efficiency of these systems is inherently linked to the ambient air temperatures. Heat pumps supply more energy than they consume, by extracting heat from their surroundings. Heat pump systems can supply as much as 4kW of heat output for just 1kW of electrical energy input.

Typically, there are two main types of air sourced heat pump systems, one which is refrigerant-based system (VRF) and one which is water-based system (Air to water heat pumps).

VRF systems transfer heat from one location to another using refrigerant. The volume or flow rate of refrigerant is accurately matched to the required heating or cooling loads, thereby saving energy and providing more accurate control of temperatures and energy consumption.

In the case of a data centre, heat pumps can utilise heat that is extracted from the data halls via the cooling system, as opposed to ambient air. This means that there is a relatively constant and warm air supply to extract heat from and transfer to other spaces which require it. However, as the data centre can benefit from reusing waste heat from the chilled water (CHW), WSHP will be employed to provide space heating and cooling to LON06 instead of ASHP.

4.3.4 Water Source Heat Pumps (WSHP)

Water source heat pumps operate in a similar way to ASHP but instead of air, WSHP exchanges heat from water. The water source can be an open source such as a river or lake, or a closed-loop system.

LON06 admin heating and cooling system is designed to comprise 2 water-cooled chillers and 3 water-source heat pumps to serve a 4-pipe FCU system. Both the CHW and the LTHW systems are served from the critical CHW system which cools the data halls. Warm return water is recovered from the critical CHW system to act as a heat source to the water-source heat pump. This water, designed to be at 30°C all year round, provides a highly efficient heating system that is not impacted by cold ambient temperatures. The water-source heat pumps extract heat from the 30°C return water to produce 55°C LTHW to heat the admin building. The admin building cooling also benefits from the critical cooling system that provides 20°C supply water to water-cooled chillers. These chillers produce 8°C CHW to cool the admin building.

4.3.5 Ground Source Heat Pumps (GSHP)

Ground sourced heat pumps differ from air source heat pumps in that they extract heat from the ground and pump it into a building to provide space heating and to pre-heat domestic hot water. In the summer months, this process can be reversed, rejecting heat to the ground, to meet the cooling requirements of a building. GSHPs rely on the stable temperature of the ground of between 10-14ºC. In winter when the ambient air temperatures are below this ground source heat pumps have higher CoPs than air source heat pumps (as there is more thermal energy in the ground).

Due to the groundwork and infrastructure required for a GSHP system, they tend to be more complicated to install and maintain than other heating systems. As there is a minimal heating load in this development as well as the option to recover heat rejected from the cooling systems, the installation of a GSHP is not considered to be feasible.

4.3.6 Wind Turbines

The output from wind turbines is highly sensitive to wind speed. Hence it is essential that turbines should be sited away from obstructions, with a clear exposure, or fetch, for the prevailing wind.

In urban environments, it is difficult to achieve high wind speeds that would make the operation of turbines viable. Turbines would need to be located at a site where wind is channelled and is of a consistently high speed and laminar flow. The most likely option for this in London is on top of a tall building, clear of the urban canopy layer, where obstructions and surrounding buildings would not interfere with the wind flow.

The location of the Hayes Digital Park Data Centre Campus site in a built-up urban environment would result in a turbulent flow regime across the site, which would reduce the potential electrical output from wind turbines. It is also unlikely to be acceptable in townscape terms and as such it is not proposed to include wind turbines as part of the development.

4.3.7 Photovoltaics (PV)

Photovoltaic solar cells convert solar energy directly into electricity. The cells consist of two layers of silicon with a chemical layer between. The incoming solar energy charges the electrons held within the chemical. The energised electrons move through the cell into a wire creating an electrical current.

The advantage of photovoltaic cells is once they are installed, they require minimal maintenance over their operational life and have no primary fuel requirements.

For LON06 Admin block, the rooftop space will be available for 300 m^2 photovoltaic array. Installing it will provide some energy reduction. This is maximised as part of the energy strategy for the data centre.

4.3.8 LZCs Summary

Cooling energy consumption represents the largest share of the regulated energy in the development, therefore implementing the air-source heat-pump based cooling system is the most feasible LZC option.

Accounting for the considerable energy demand of the data centre, the limitations to roof space, other considered LZC technologies can only make a relatively miniscule contribution to emissions savings.

4.4 Overall reduction

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean LON6				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m^2.annum	
Total	48.02	28.02	524.95	306.1
Improvement	**41.65%**		**41.69%**	

Table 6-4 Be Lean LON6 Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate – Be Green LON6				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m^2.annum	
Total	48.02	27.64	524.95	301.84
Improvement	**42.44%**		**42.50%**	

Table 6-5 Be Green LON6 Comparison TER/BER and TPER/BPER

5.0

Outlined Component - Baseline

5.0 Outlined Component – Baseline

This section of the report will estimate the baseline energy consumption and associate CO_2 emission for the outlined component. The baseline emission refers to Part L 2021 compliant development.

All the blocks in outlined component are non-residential. Part L model is developed to estimate LON07, LON08 and Innovation Hub result.

Use Class	GEA
LON07	53,415 sqm
LON08	29,656 sqm
Innovation Hub	2,000 sqm

Table 6-1 Outline GEA

All the blocks in outlined components are intended to follow the same design principal as in the detailed design component, and parameters incorporated in the calculation will form part of the design guidance in the next stage. Outline component figures are indicative and subject to change based on further design work and the reserved matters applications.

5.1 Estimation of LON 07 / 08 / Innovation Hub

5.1.1 Outlined Setting

All outlined components are referenced to the detailed component LON06 setting. Design elements are provided and coordinated with the project team which will be implemented at the time of construction. The optimisation on building fabrics is done on the wall, roof and glazing's which results the thermal transmittance is on the lower side for walls and the roof. The glazing window to wall ratio is maximised on the façades of the admin blocks. Minimum fenestration was designed for the data hall spaces to limit the solar gains.

The lamp efficacy is 104-164 lm/W for all the spaces except the data halls, the data halls have 175-179 lm/W lamp efficacy for the optimum result. Equipment and the occupant density are considered same as the notional.

For LON07 and LON08 The predominant cooling system is free cooling air cooled chillers which provide chilled water to CRAH units serving the data halls. There are CRAH units serving the various electrical rooms as well. The admin will utilise waste heat from the data halls for heating via a water-to-water source heat pump and FCUs. A water-cooled chiller will provide cooling to the admin via FCUs. DHW associated with the centralised based heating system is modelled as well for the hot water use in the building.

The innovation hub will utilise waste heat from the data centre to provide heating.

The efficiencies consider for the systems are as per the notional guidelines, so no saving have been claimed under the HVAC systems.

The Target CO_2 Emission Rate (TER) in $kgCO_2/m^2$. annum for LON07, LON08 and Innovation Hub are 48.95, 40.69 and 3.84 respectively.

Energy Consumption by End Use (kWh/m²)

The Baseline for the LON07 / LON08 / Innovation Hub is estimated as below:

LON07 / 08 / Innovation Hub - Part L2 2021 End-uses Breakdown			
End-use	**LON07**	**LON08**	**Innovation Hub**
Heating	0.34	3.51	3.88
Cooling	150.28	125.33	2.33
Aux	54.54	51.2	7.55
Lighting	22.33	12.2	8
DHW	0.08	1.06	0.56
Renewables	-1.53	-2.32	-7.36
Total	226.04	191.02	14.96

Table 6-2 End-uses Breakdown for LON07 / LON08 / Innovation Hub

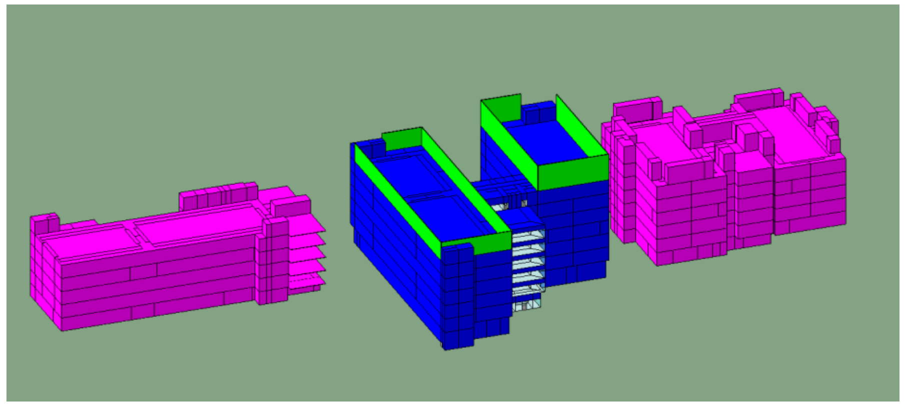


Figure 6-1 Outlined Component LON07 3D image

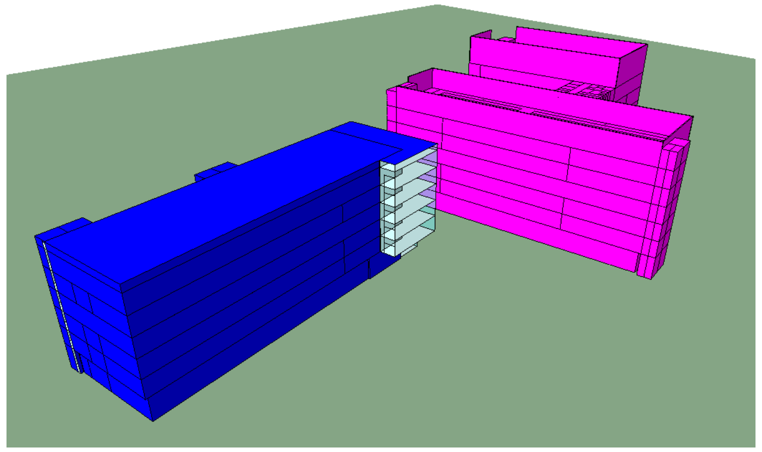


Figure 6-2 Outlined Component LON08 3D image

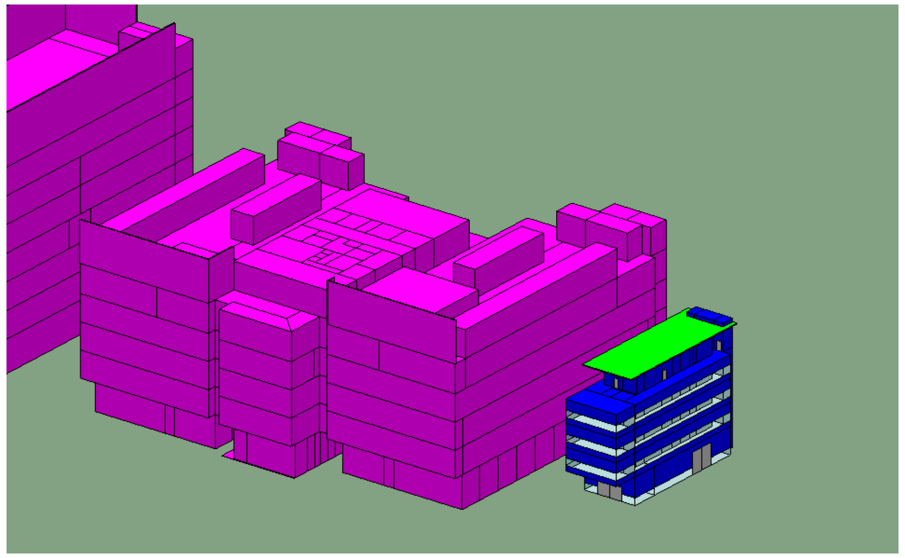


Figure 6-3 Outlined Component Innovation Hub 3D image

6.0

Outlined Component – Be Lean, Be Clean, Be Green

6.0 Outlined Component – Be Lean, Be Clean, Be Green

6.1 Be Lean

The design of the proposed buildings has been developed to reduce its annual energy consumption, provide energy in an environmentally friendly way, and to minimise its annual CO_2 footprint. In order to achieve this, a "Steps to low carbon" methodology has been applied.

6.1.1 Passive Design

Substantial reductions in energy usage for the scheme, together with improved occupancy comfort, will be achieved largely through consideration of the passive elements of the design. The design team have looked to implement passive design measures through optimising solar gains and building envelope performance as described in the following sections.

6.1.1.1 Passive Solar Design

Data halls are predominantly cooling led demand spaces, which are not considered as occupied and should release and export heat for their operation nature. The use of windows has been limited for data hall space to minimise thermal energy conduction, as well as solar gains. This principle is applied to all data hall and industrial space. Considering this passive measure will help to reduce cooling loads and help to release heat load during operation.

For spaces other than the data halls, such as the office areas of the LON07/08 building and the labs of the Innovation Hub, window g-value is limited to balance the occupant's daylighting needs for their well-being, at the same time reducing the potential cooling energy and heating energy for the corresponding thermal space.

Improving the thermal insulation beyond the Building Regulation standards will help to reduce the annual CO_2 emissions associated with the building's heating and cooling systems, by limiting the heat transfer through the building's fabric. This improvement has a significant impact on the overall reduction of the electrical consumption annually.

For the data halls, considering the nature of the equipment operation and the unoccupied condition, external walls will be specified to high performance to minimise cooling loads that associated with operation.

The following improvements over the Building Regulation minimum standards are being sought for the next phase of the project:

6.1.1.2 Air Permeability

An improved air leakage rate of 3.0 $m^3/(hr.m^2)$ is being targeted for the proposed development, in comparison with the Building Regulation minimum standards of 8 $m^3/(hr.m^2)$ at 50Pa for LON07, LON08 and Innovation Hub. This equates to an infiltration rate of 0.10 ACH. Good air tightness could be achieved by prefabrication of several key building components under factory conditions, robust detailing of junctions, reducing the breathability of fabrics, infiltrations, and good building practices on site.

6.1.1.3 Summary of Fabric Design details

Fabric Detail	Design for LON07 / 08 / Innovation Hub
Ground Floor area weighted thermal conductivity, U-value (W/m².K)	0.15
Roof area weighted thermal conductivity, U-value (W/m².K)	0.15
External Walls total solar transmission	0.18
Personnel Doors area weighted thermal conductivity, U-value (W/m².K)	1.60
Windows area weighted thermal conductivity, U-value (W/m².K)	1.40
Windows total solar transmission, effective G-value (%)	30
Air permeability ($m^3/(hr.m^2)$ @50Pa)	3.0

Table 4-1 Fabric details

6.1.2 Energy Efficient Systems

After assessing the contribution of the passive elements to the overall energy balance, the aim is to further reduce CO_2 emissions by selecting efficient mechanical, electrical demand, with effective load demand design by recovery and control systems to manage the energy use during operation. CHW and LTHW with FCU are used as the centralised cooling and heating systems for data halls served through the water source heat pumps. Admin blocks such as office space in LON07 and LON08 have been modelled with the same system design for optimum energy output.

Auxiliary fans are highly efficient in these systems which brings down the overall consumption compared to the notional consumption.

6.1.2.1 System Demand Reduction

6.1.2.1.1. Low-energy Lighting

Installing efficient low energy light fittings internally and externally can significantly reduce a building's overall lighting load hence lowering its annual CO_2 emissions. The development will reduce the energy consumption by the specification of low energy luminaires in all office and data hall areas.

6.1.2.1.2. Daylighting and Occupancy sensors control

Daylight and occupancy sensors are proposed in occupied space such as the the admin area of the data centre buildings. Data Halls have limited or no fenestration hence no daylight controls are required.

6.1.2.1.3. Variable System design

All fans and pumps will be specified with variable-speed drives, which will reduce their energy consumption by more than two-thirds compared with equivalent constant speed alternatives, by only supplying the required flow rate to meet the demand.

6.1.2.1.4. Heat demand reduction

As there are large waste heat exported from the data hall space, all other space could be benefit from the waste heat recovery and heat demand is reduced.

6.1.2.1.5. Waste heat recovery and usage

Waste heat recovery and usage is a unique benefit for this campus development. Data hall waste heat is used to provide some heating to the admin block of the data centre and the Innovation Hub via water-to-water heat pumps. The waste heat is also used to temper the air in the Make-up Air (MUA) units that serve to pressurise the technical spaces and provide them with fresh air.

6.1.2.1.6. Controls

The heating/cooling systems shall be appropriately zoned, with local fast responding controls. Appropriate lighting controls, including occupancy sensors shall be specified where applicable for all internal and external lighting.

Demand control ventilation is proposed in the outlined case, this method is useful to maintain indoor air quality that automatically adjusts the ventilation rate provided to a space in response to changes in conditions such as occupancy fluctuation.

6.1.2.1.7. HVAC Plant Efficiencies

The design team will specify all equipment and plant to exceed the minimum requirements of the non-domestic building services compliance guide. This document provides guidance on the means of complying with the requirements of Part L of the Building Regulations for conventional space heating/cooling systems, hot water systems and ventilation systems.

To address the high cooling loads associated with the data halls, a cooling system of water-cooled or air-cooled chillers will be employed to limit energy used to maintain temperatures in those spaces. This system arrangement allows to utilise free cooling for large proportion of the year.

6.1.2.1.8. Building Energy Management System (BEMS)

Where appropriate Building Energy Management System (BEMS) using information technology (IT) will be used to promote and facilitate a system that supports the energy demand management for commercial buildings (e.g., a system that recognises real-time room conditions in buildings by temperature sensors and/or the optimal operation of lighting and air-conditioning responding to the room condition). A combination of energy saving control techniques, such as optimum start with communication and information systems will allow active management of the building services and the capability to achieve and maintain a high level of energy efficiency.

A full BEMS system will be installed for the development and linked to central control systems. The systems will be easily accessible by the onsite team with automatic monitoring, targeting and automatic alarms for out-of-range values.

6.1.2.1.9. Energy Metering

Separate metering systems of the energy uses within the development will help the building users and tenants identify areas of excessive consumption and highlight potential energy-saving measures for the future. This will enable on-going reduction of annual CO_2 emissions from these systems.

6.1.3 Fixed Building Services Summary

A few improvements over the Building Regulation's 'notional' building have been incorporated in order to reduce the CO_2 emissions of the development and hence comply with the Building Regulations. The table below provides a summary of the inputs for the model.

System Detail	LON07	LON08	Innovation Hub
Admin areas system fans' (SFP) (W/L/s)	1.0	1.262	1.0
Data Hall system fans' (SFP) (W/L/s)	1.0	0.85	n/a
Admin area heating SEER	5.79 (WSHP)	5.79 (ASHP)	5.79 (WSHP)
Electric Radiators	Defrozen only	Defrozen only	Defrozen only
Admin area chiller SEER	9.96	9.96	4.5 (air-cooled)
Circulation areas, WCs – Electric radiators, efficiency (%)	n/a	100%	n/a
Rooftop AHU Heat Recovery efficiency (%)	76.0% (Thermal Wheel)	76% (Plate heat exchanger)	76.0% (Thermal Wheel)
Critical cooling system seasonal energy efficiency ratio (SEER)	9.96	9.96	n/a
Fan	Yes	Yes	Yes
Pump	Yes	Yes	Yes
Direct electric point of use source – Toilet tap water point	electricity	electricity	electricity
Direct electric point of use source efficiency (%)	100%	100%	100%
Lighting Type 1 efficacy Luminaire Lumens per circuit Watt (lm/W) – Data halls	175	179	n/a
Lighting Type 2 efficacy Luminaire Lumens per circuit Watt (lm/W) – Offices	104	140	120 (Labs)
Lighting Type 3 efficacy Luminaire Lumens per circuit Watt (lm/W) – Toilets	140	140	140
Lighting Type 3 efficacy Luminaire Lumens per circuit Watt (lm/W) – All other spaces	164	140	120
Lighting Parasitic Power for presence detection sensors (W/m^2)	0.1	0.1	0.1
Daylight sensors (admin area)	Yes	Yes	Yes
Occupancy Sensors (Auto ON/OFF)	Yes	Yes	Yes
HVAC systems with full energy metering and monitoring	Yes	Yes	Yes
HVAC systems warns of 'out of range' values'	Yes	Yes	Yes
Lighting systems with full energy metering and monitoring	Yes	Yes	Yes
Lighting systems warns of 'out of range' values'	Yes	Yes	Yes
Electrical Power Factor Correction	>0.95	>0.95	>0.95

Table 4-2 System detail

6.1.4 Be Lean Part L Performance Results Summary

Calculations results in this report is estimated as below.

In accordance with the London Borough of Hillingdon and the Mayor's Energy Hierarchy the estimated energy consumption for the development has been based on the National Calculation Methodology (NCM). These improvements are passed based on the NCM requirement, however, in accordance with the GLA guideline, it is required BER to be 15% more efficient than the TER.

BER improvements are 37.18%, 35.19% and 5.21% for LON07, LON08 and Innovation Hub, which indicate they are fulfilling the NCM requirement of minimum 15% more efficient than the TER.

LON07

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean LON07				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m².annum	
Total	48.95	30.75	534.84	335.92
Improvement	**37.18%**		**37.19%**	

Table 4-3 Regulated emissions summary – Be Lean LON07

Part L2 2021 End-uses Breakdown [BeLean (Actual) and Notional] LON07 (kWh/m²)		
End-use	BeLean	Notional
Heating	0.64	0.22
Cooling	150.28	274.07
Aux	54.54	59.13
Lighting	22.33	29.41
DHW	0.15	0.14
Renewables	0	0
Total	**227.94**	**362.97**
Improvement over TER [Target Emission Rate]	**37.18%**	
Part L Status (BER [Building Emission Rate] <TER)	**Pass**	

Table 4-4 Part L 2021 End-uses Breakdown – Be Lean LON07

LON08

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean LON08				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m².annum	
Total	40.69	26.37	444.27	287.46
Improvement	**35.19%**		**35.30%**	

Table 4-5 Regulated emissions summary – Be Lean LON08

Part L2 2021 End-uses Breakdown [BeLean (Actual) and Notional] LON08 (kWh/m²)		
End-use	BeLean	Notional
Heating	5.04	1.7
Cooling	125.37	228.64
Aux	51.2	50.13
Lighting	12.2	20.84
DHW	1.06	0.96
Renewables	0	0.88
Total	**194.87**	**301.39**
Improvement over TER [Target Emission Rate]	**35.19%**	
Part L Status (BER [Building Emission Rate] <TER)	**Pass**	

Table 4-6 Part L 2021 End-uses Breakdown – Be Lean LON08

Innovation Hub

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean Innovation Hub				
	TER	BER	TPER	BPER
	$kgCO_2/m^2$.annum		kWh/m².annum	
Total	3.84	3.64	41.49	38.96
Improvement	**5.21%**		**6.10%**	

Table 4-7 Regulated emissions summary – Be Lean Innovation Hub

Part L2 2021 End-uses Breakdown [BeLean (Actual) and Notional] Innovation Hub (kWh/m²)		
End-use	BeLean	Notional
Heating	7.19	4
Cooling	2.33	3.43
Aux	7.55	7.53
Lighting	8	12.27
DHW	1.08	0.78
Renewables	0	0
Total	**26.15**	**28.01**
Improvement over TER [Target Emission Rate]	**5.21%**	
Part L Status (BER [Building Emission Rate] <TER)	**Pass**	

Table 4-8 Part L 2021 End-uses Breakdown – Be Lean Innovation Hub

6.2 Be Clean

6.2.1 District Heating Networks

A heating network can be utilised to provide low carbon heat to both water-based systems: space heating and domestic hot water supplies. In a development with high heating and DHW loads – such as residential or leisure centre developments – a heating network can deliver significant CO_2 savings potential. In an office or data centre-based development, where heating requirements are relatively minimal, the heating network carbon savings potential is not as significant.

The feasibility of connecting to an existing district network has been investigated for the site in accordance with Policy SI 3 of the London Plan. An analysis of the London Heat Map has shown there is no existing or proposed heat network in the vicinity.

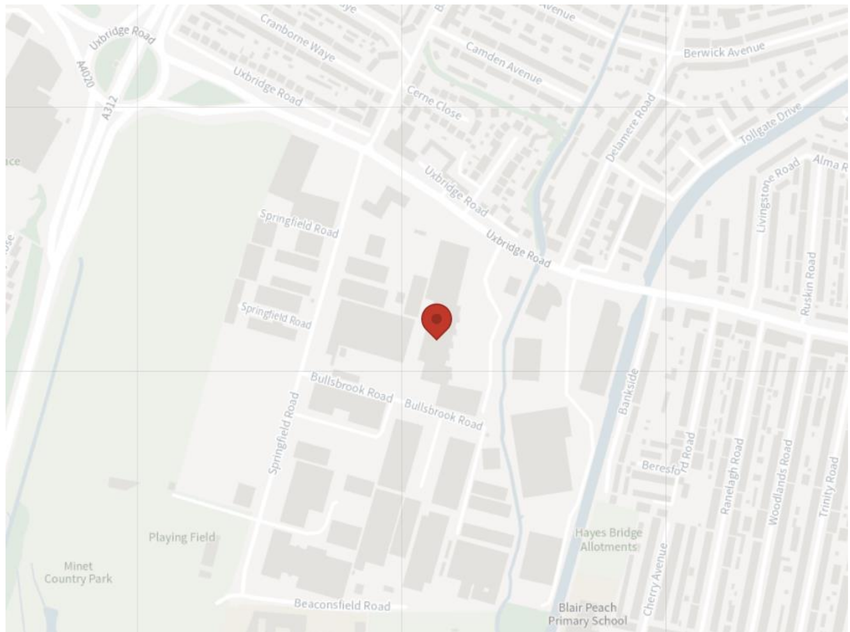


Figure 4-3 London Heat Map showing no available networks around the site.

However, for a datacentre it generates excess heat during its function and intended to export heat and is a self-sustain heat source to the occupied space.

6.2.2 Heat reuse strategy

<u>Domestic hot water (DHW)</u>

Demand of hot water consumption is minimal for data centre considering the nature of industrial usage. After considered system and material effectiveness WSHP will be used for the DHW supply for the admin block of data centre.

<u>Space heating</u>

Space heating demands for the development have been minimised with a high-performance thermal fabric for the admin area and for the Innovation Hub. The remaining space heat load is maintained by FCU system and reusing waste heat that generated from the data halls. The space for the supporting equipment will be allocated at roof level plant room. The Data Hall waste heat is provisionally be utilised outside the building, the opportunities for which are described in Appendix B.

Plant room space provision is allowed for the heat exchanger and necessary pipe connections to enable a future connection for the building or local services should it be feasible and is described in Appendix B for details.

6.2.3 Exporting Energy to occupied space and 3rd party Heat Network

The data centre development is likely to produce large amounts of waste energy in the form of heat from the data halls. This heat energy amount has the potential to be exported to appropriate usage within the site; or from the site into the local area, acting as an energy provider rather than an energy consumer. The adoption of this strategy also has the potential to accelerate the development of planned heating network in this area, providing a consistent source of low-grade heat throughout the year. Further analysis will be required to determine the potential energy available from the data centre as well as the quality and temperature of the heat energy available. The design has allowed the provision of energy exportation for a future connection to an external third-party heat network, but currently there is no available local heat network. Details of the system and the review is described in Appendix B. The following considerations have been made in the current design:

- The ability to recover waste heat from data halls via water-to-water heat exchangers, located in the roof plant rooms.
- Heat will be collected via connections to the return pipework from data hall cooling system.
- Low grade heat (~30°C water) is pumped to a connection point housed within a kiosk or energy centre on the site boundary, for extension by others.
- Third Party District Heating Provider, ESCo, local residential, local industry etc. may connect to the system via a set of low-loss headers in the interface kiosk.
- Third parties would need to elevate the temperature of the distribution to a more usable level by means of heat pumps, or other plant (industrial process, pyrolysis, etc.), to suit their specific requirements. This equipment would be part of their installation and would be located off-site.
- Capacity and operating characteristics of the plant would depend upon Third Party's specific requirements.
- Agreement would be subject to commercial business case and based upon principle that heat would only be supplied when available and only taken when needed, with neither party under strict obligation to supply or take heat.
- Availability of heat may vary depending upon phasing and installed capacity of IT equipment within operational data halls.

6.2.4 Combined Heat and Power (CHP)

In accordance with Policy SI 3 the feasibility of a site wide CHP network has been investigated.

CHP is the on-site generation of electricity and the recovery of the normally wasted heat produced during this process.

The operation of CHP plant can offer significant CO_2 emission rates when compared to conventional methods of energy generation and use.

- Most large conventional power stations currently generate electricity at 30-50% efficiency.
- 'Good quality' CHP schemes achieve overall efficiencies of 70-85%.
- The use of CHP depends on finding a use for the electricity and heat generated by the process.

As outlined previously the development's heating requirements have been reduced via the use of increased thermal insulation, air tightness levels, supplemented by high efficiency heat supply and recovery systems.

The limited residual base load heat demand of the site results in insufficient run hours to allow efficient operation of a CHP system. It is therefore not proposed for inclusion.

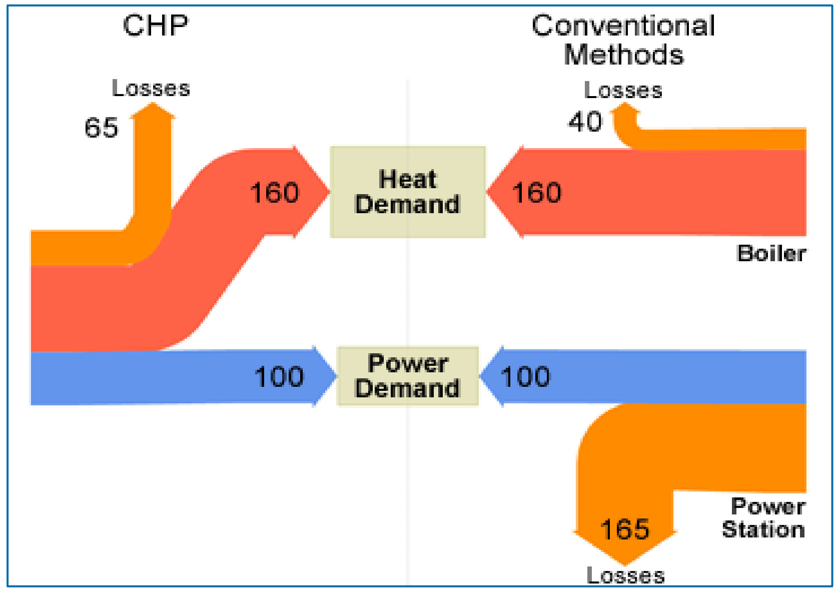


Figure 4-4 Sankey diagram illustrating the energy flows and benefits of CHP vs boiler heating.

6.2.5 Power Agreement

An agreement has been made with National Grid and SSE to provide power to the site.

6.2.6 Be Clean Part L Performance Results

With no decentralised system included in the strategy, the Part L performance results remain the same as they were in the Be Lean scenario.

6.3 Be Green

Policy SI 2 of the London Plan requires that all major developments seek to reduce their CO2 emissions by at least 35% compared to the notional building, 15% of which should be achieved through energy efficiency measures; remaining 20% improvement can be met through the use of onsite renewable energy generation, wherever feasible.

The following technologies have been considered for supplying a portion of the development's energy demand. The feasibility of each of the energy sources listed has been assessed regarding the potential contribution each could make to supply a proportion of the development's delivered energy requirement, whilst considering the technical, planning, land use and financial issues.

6.3.1 Biomass Heating

Biomass in the form of logs, wood chips and wood pellets are classified as a renewable source of energy because the carbon dioxide emitted when the biomass is burned has been taken out of the atmosphere by the growing plants. Even allowing for emissions of carbon dioxide in planting, harvesting, processing, and transporting the fuel they will typically reduce net CO_2 emissions by over 90%. Biomass boilers are large pieces of plant that require substantial areas and volumes of space for the boiler, the fuel storage and the waste. A delivery area for trucks frequently supplying and removing fuel and waste would also need to be factored in.

Biomass boilers are ill suited to meeting a fluctuating daily heating demand, especially a relatively low load as is the case in a Data centre. Additionally, the NOx emissions produced by biomass boilers would impact local air quality significantly more than other available technologies.

For these reasons Biomass boilers are not considered to be appropriate for the Hayes Digital Park Data Centre Campus development.

6.3.2 Solar Hot Water Collectors

Solar thermal collectors utilise solar radiation to heat water for use in buildings. The radiation is converted using a solar collector, of which there are two main types: Flat plate, and Evacuated tube collectors. Evacuated type systems occupy a smaller area and are more efficient but also generally more expensive. The optimum orientation for a solar collector in the UK is a south-facing surface, tilted at an angle of 30º from the horizontal.

Solar collectors are typically designed to meet a development's base heat load, associated with its domestic hot water requirements, with a second system meeting the remainder of the load.

There is minimal hot water demand for the building, therefore, solar thermal collectors are not proposed for inclusion in the development.

6.3.3 Air Source Heat Pumps (ASHP)

Air source heat pumps exchange heat between the outside air and a building's internal spaces to provide space heating in winter and cooling in the summer. The efficiency of these systems is inherently linked to the ambient air temperatures. Heat pumps supply more energy than they consume, by extracting heat from their surroundings. Heat pump systems can supply as much as 4kW of heat output for just 1kW of electrical energy input.

Typically, there are two main types of air sourced heat pump systems, one which is refrigerant-based system (VRF) and one which is water-based system (Air to water heat pumps).

VRF systems transfer heat from one location to another using refrigerant. The volume or flow rate of refrigerant is accurately matched to the required heating or cooling loads, thereby saving energy, and providing more accurate control of temperatures and energy consumption.

In the case of a data centre, heat pumps can utilise heat that is extracted from the data halls via the cooling system, as opposed to ambient air. This means that there is a relatively constant and warm air supply to extract heat from and transfer to other spaces which require it. However, as the data centre can take benefits from reusing waste heat from the chilled water (CHW), WSHP will be employed to provide space heating and cooling to LON06 instead of ASHP.

6.3.4 Water Source Heat Pumps (WSHP)

Water source heat pump operates in a similar way to ASHP but instead of air, WSHP exchanges heat from water. The water source can be an open source such as a river or lake, or a closed-loop system.

The energy efficiency measures employed in the outlined development include a highly efficient cooling system using chillers, which will meet the substantial cooling loads while consuming a fraction of the energy of conventional cooling systems. This is achieved by elevating the chilled water temperatures supplied by the chillers to reduce their energy consumption. WSHP is prioritised in the design consideration due to the use of chilled water.

6.3.5 Ground Source Heat Pumps (GSHP)

Ground sourced heat pumps differ from air source heat pumps in that they extract heat from the ground and pump it into a building to provide space heating and to pre-heat domestic hot water. In the summer months, this process can be reversed, rejecting heat to the ground, to meet the cooling requirements of a building. GSHPs rely on the stable temperature of the ground of between 10-14ºC. In winter when the ambient air temperatures are below this ground source heat pumps have higher CoPs than air source heat pumps (as there is more thermal energy in the ground).

Due to the groundwork and infrastructure required for a GSHP system, they tend to be more complicated to install and maintain than other heating systems. As there is a minimal heating load in this development as well as the option to recover heat rejected from the cooling systems, the installation of a GSHP is not considered to be feasible.

6.3.6 Wind Turbines

The output from wind turbines is highly sensitive to wind speed. Hence it is essential that turbines should be sited away from obstructions, with a clear exposure, or fetch, for the prevailing wind.

In urban environments, it is difficult to achieve high wind speeds that would make the operation of turbines viable. Turbines would need to be located at a site where wind is channelled and is of a consistently high speed and laminar flow. The most likely option for this in London is on top of a tall building, clear of the urban canopy layer, where obstructions and surrounding buildings would not interfere with the wind flow.

The location of the Hayes Digital Park Data Centre Campus site in a built-up urban environment would result in a turbulent flow regime across the site, which would reduce the potential electrical output from wind turbines. It is also unlikely to be acceptable in townscape terms and as such it is not proposed to include wind turbines as part of the development.

6.3.7 Photovoltaics (PV)

Photovoltaic solar cells convert solar energy directly into electricity. The cells consist of two layers of silicon with a chemical layer between. The incoming solar energy charges the electrons held within the chemical. The energised electrons move through the cell into a wire creating an electrical current.

The advantage of photovoltaic cells is once they are installed, they require minimal maintenance over their operational life and have no primary fuel requirements.

LON07 / 08 / Innovation Hub

For the Administration blocks and Innovation Hub, the rooftop space will be available for a photovoltaic array. Installing it will provide some energy reduction.

Following the site development energy strategy, the PV system has been maximised with the available roof space and provides 300 m^2 of PV installation each for LON07 and LON08, and 70 m^2 for Innovation Hub, based on estimation with assumptions.

6.3.8 LZCs Summary

Cooling energy consumption represents the largest share of the regulated energy in the development, therefore implementing the water source heat pump based cooling system is the most feasible LZC option.

Accounting for the considerable energy demand of the data centre, the limitations to roof space, other considered LZC technologies can only make a relatively miniscule contribution to emissions savings.

6.4 Overall Be Lean and Be Green result

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean LON07				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	48.95	30.75	534.84	335.92
Improvement	**37.18%**		**37.19%**	

Table 4-7 Be Lean LON07 Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate – Be Green LON07				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	48.95	30.5	534.84	333.11
Improvement	**37.69%**		**37.72%**	

Table 4-8 Be Green LON07 Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean LON08				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	40.69	26.37	444.27	287.46
Improvement	**35.19%**		**35.30%**	

Table 4-9 Be Lean LON08 Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate –Be Green LON08				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	40.69	25.84	444.27	281.7
Improvement	**36.50%**		**36.59%**	

Table 4-10 Be Green LON08 Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate – Be Lean Innovation Hub				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	3.84	3.64	41.49	38.96
Improvement	**5.21%**		**6.10%**	

Table 4-11 Be Lean Innovation Hub Comparison TER/BER and TPER/BPER

Part L 2021 CO2 emission & Primary Energy Rate – Be Green Innovation Hub				
	TER	BER	TPER	BPER
	kgCO$_2$/m^2 annum		kWh/m^2.annum	
Total	3.84	2.12	41.49	22.29
Improvement	**44.79%**		**46.28%**	

Table 4-12 Be Green Innovation Hub Comparison TER/BER and TPER/BPER

7.0

Overall Summary of Energy Statement

7.0 Overall Summary

In accordance with the London Borough of Hillingdon and the Mayor's Energy Hierarchy, the estimated energy consumption and resulting carbon emissions for the Hayes Digital Park Data Centre Campus development has been based on the National Calculation Methodology (NCM).

Policy SI 2 of the London Plan requires a carbon dioxide reduction target for new development of 35% over the current 2021 Building Regulations target.

An energy assessment has been carried out for the proposed development based on the following energy strategies.

7.1 Be Lean Summary

Passive solar considerations have formed an integral part of the design for the proposed development. Reducing glazing along with high performance U-values are specified in order to minimise solar gains and heat transfer through the fabric so that associated cooling loads are minimised.

The energy efficiency design measures employed in the development include a high efficiency free cooling system, and low energy lighting coupled with PIR controls to significantly reduce the emissions.

The application of passive and active design measures allows building Be Lean BER to achieve a 38% reduction over the Part L Volume 2 (2021) baseline TER.

7.2 Be Clean Summary

The feasibility of connecting to an existing or proposed district heating network has been investigated for the site in accordance with Policy SI 3 of the London Plan. There is currently no district heating network located near to the site. Waste heat generated from data halls can be potentially utilised internally via the use of water-to-water heat exchangers. A space for these, as well as associated pumps and pipework, has been located in a plant room at rooftop level. The system design has capacity of future provision to a district heating network.

CHP is not considered appropriate due to the low heat loads.

7.3 Be Green Summary

The major share of the regulated energy consumption in the development is associated with a cooling system. By replacing the conventional cooling with a high efficiency proposed cooling system results in a 39% reduction in carbon emissions from regulated energy use for building.

The tables opposite give the CO_2 emissions of the site at each stage of the energy hierarchy. The unregulated emissions remain the same throughout each stage of the hierarchy, as savings from energy efficiency measures and the LZCs are applied to the regulated emissions only.

7.4 Proposed Fixed Building Services Strategy

Cooling will be provided to data halls via high efficiency computer room air handlers (CRAHs) fed by a cooling system consisting of water-cooled chillers.

Fresh air ventilation will be the minimum required for data hall processes. The minor office type areas will have supply ventilation with heat recovery. WCs will have extract ventilation to avoid odour build up.

Office areas heating and cooling will be served by a heat recovered FCU system.

Domestic Hot Water (DHW) will be electric point of use for the entire building.

For lighting, high efficacy luminaires will be used throughout all spaces. Data halls, storage, server rooms, stairs and WCs will benefit from occupancy presence/absence detection.

7.5 Approximated PUE

PUE has become a globally recognised metric of measuring data centre efficiency as it fits into the nature of data centre operation and energy consumption. A standard figure seen across the industry is a PUE value of 1.5 for these types of systems. Based on the efficient design of the technical system the proposed development is aiming to achieve a PUE value of 1.55.

7.6 Overall Result

The analysis shows the development is achieving an overall reduction of a 39% over the Part L Volume 2 (2021) baseline TER, which equates to an annual saving of 1586.2 tonnes of CO_2. This satisfies the London Plan 35% reduction target. Overall reduction summary for the outlined component and detailed component were summarized below:

7.6.1 Outlined Component

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – Outlined Component			
Scenario	Emissions	Savings	% Saving
\TER	2,984.0		
BER (Be Lean)	1,897.8	1,086.2	36%
BER (Be Clean)	1,897.8	0.0	0%
BER (Be Green)	1,871.3	26.4	1%
Cumulative		**1,112.6**	**37%**

Table 7-1 Summary of Emission for Outlined Component

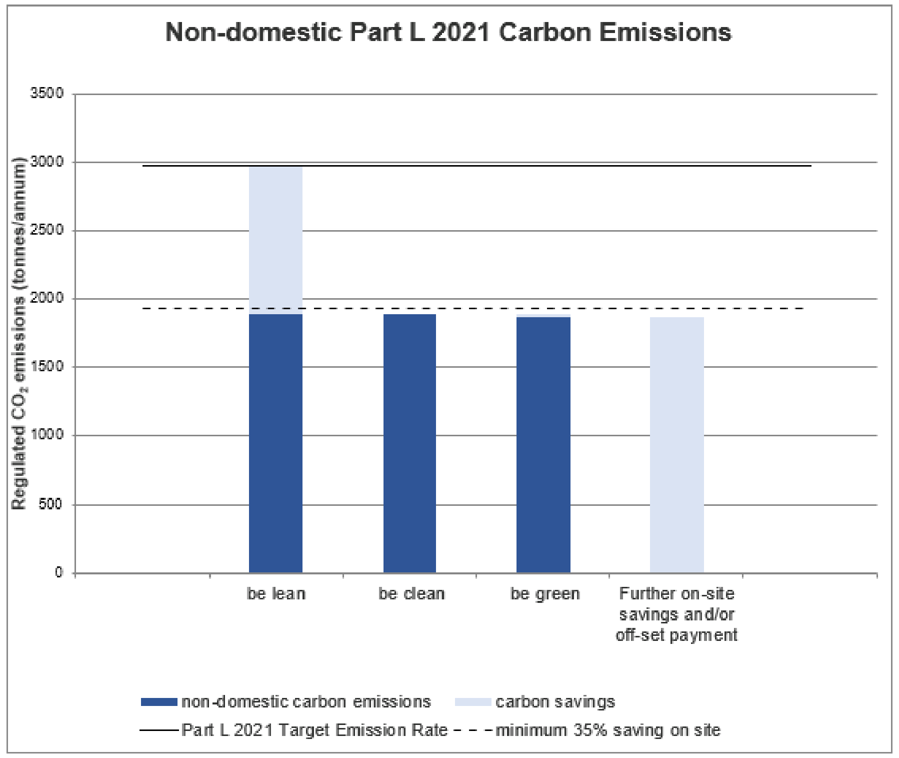


Figure 7-1 Summary of Emission for Outlined Component

The cash in-lieu contribution for the outlined component is approximated as £5.3M.

	(Tonnes CO_2)	
Cumulative savings for off-set payment	**56,140**	-
Cash in-lieu contribution (£)	**5,333,311**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development

Table 7-2 Cash in-lieu contribution from Outlined Component

7.6.2 Detailed Component

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – Detailed Component			
Scenario	Emissions	Savings	% Saving
TER	1,115.9		
BER (Be Lean)	651.1	464.8	42%
BER (Be Clean)	651.1	0	0%
BER (Be Green)	642.3	8.8	1%
Cumulative		**473.6**	**42%**

Table 7-3 Summary of Emission for Detailed Component

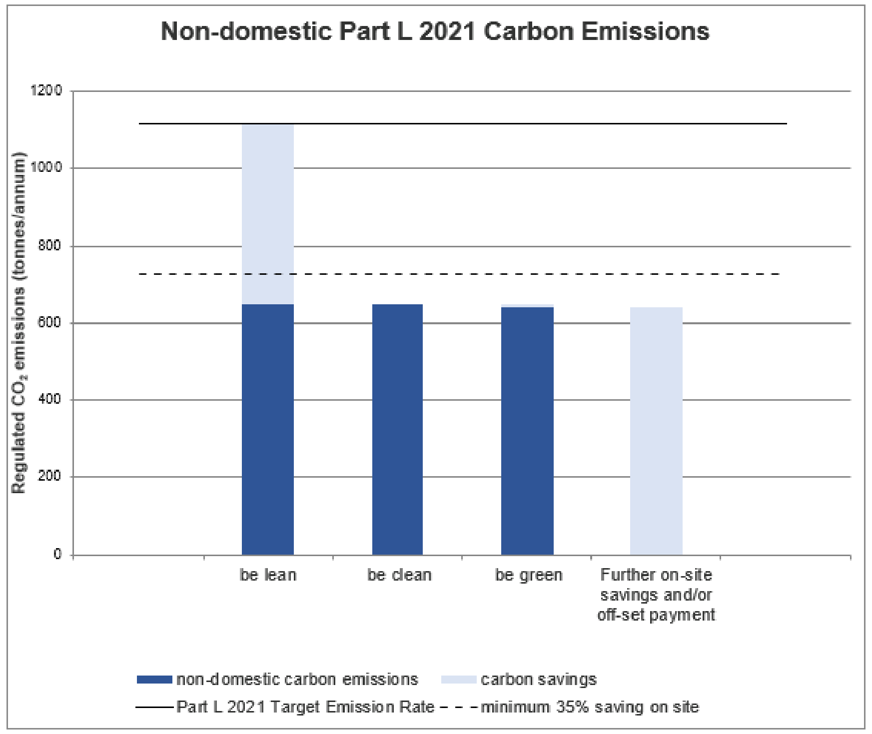


Figure 7-2 Summary of Emission for Detailed Component

The cash in-lieu contribution for the detailed component site is approximated as £1.8M.

	(Tonnes CO_2)	
Cumulative savings for off-set payment	**19,269**	-
Cash in-lieu contribution (£)	**1,830,527**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development

Table 7-4 Cash in-lieu contribution from Outlined Component

7.6.3 Overall Summary

Regulated Emissions Summary (Tonnes CO_2 p.a.) Overall CO2 emission output – Overall Site			
Scenario	Emissions	Savings	% Saving
TER	4,099.8		
BER (Be Lean)	2,548.9	1,550.9	38%
BER (Be Clean)	2,548.9	0	0%
BER (Be Green)	2,513.6	35.3	1%
Cumulative		**1,586.2**	**39%**

Table 7-5 Summary Emission for Overall Campus

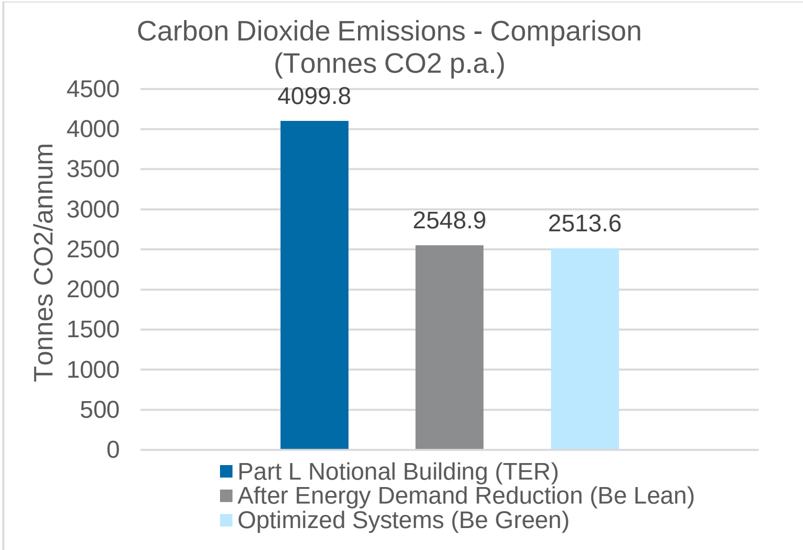


Figure 7-3 Summary of Emission for Overall Campus

The performance levels currently targeted within this report will be reviewed through each design stage to ensure the CO_2 reduction targets are considered in any design, procurement, and construction changes. The individual performances are showcased above in detail for the end use of each building. As per GLA guidelines, the BeGreen case with a saving of 35% over the TER is being met for each building on this site.

The cash in-lieu contribution for the overall site is approximated as £7.2M.

	(Tonnes CO_2)	
Cumulative savings for off-set payment	**75,409**	-
Cash in-lieu contribution (£)	**7,163,837**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development

Table 7-6 Cash in-lieu contribution from Overall Site

7.7 Other energy saving opportunities

There is several opportunities that are considered for further energy consumption reduction. These are being reviewed by the design team and are summarised below.

7.7.1 Waste Heat Recovery

Waste heat generated from data halls can be utilised both internally and exported off-site via the use of water-to-water heat exchangers. A space for these, as well as associated pumps and pipework, has been in a plant room at roof level. Heat can be collected via a connection to the return pipework loop from data hall cooling system. This heat will be low grade heat (~30°C water) and can be pumped to a connection point housed within a kiosk on the site boundary, for extension by others.

The current design has allowed the future provision of energy exportation. The following considerations have been made in the current design:

- The ability to recover waste heat from data halls via water-to-water heat exchangers, located in the roof plant rooms.
- Heat will be collected via connections to the return pipework from data hall cooling system.
- Low grade heat (~30°C water) is pumped to a connection point housed within a kiosk or energy centre on the site boundary, for extension by others.
- Third Party District Heating Provider, ESCo, local residential, local industry etc. may connect to the system via a set of low-loss headers in the interface kiosk.
- Third parties would need to elevate the temperature of the distribution to a more usable level by means of heat pumps, or other plant (industrial process, pyrolysis, etc.), to suit their specific requirements. This equipment would be part of their installation and would be located off-site.
- Capacity and operating characteristics of the plant would depend upon Third Party's specific requirements.
- Agreement would be subject to commercial business case and based upon principle that heat would only be supplied when available and only taken when needed, with neither party under strict obligation to supply or take heat.
- Availability of heat may vary depending upon phasing and installed capacity of IT equipment within operational data halls.

7.7.2 Feasibility of River Cooling

Cooling using the river has been explored. There are two potential uses of the river water, both as a means of heat rejection from the building cooling system and as a supply of water for the cooling system. Overall, the river is not viable either as a means of heat rejection or as a means of water supply.

8.0

Overheating and Cooling

8.0 Overheating and Cooling

8.1 Assessment for different component

Overheating assessment was not undertaken for the data hall blocks as the development is not normally occupied spaces. Dynamic CIBSE TM52 analysis for overheating risk was undertaken for all occupied space of LON06 Admin block and Innovation Hub.

Although it is not required for the data hall wings, the proposed development has been designed to minimise its use of energy intensive cooling systems through passive and energy efficient measures.

All development is following the below hierarchy to review.

8.2 GLA Cooling Hierarchy

To reduce the need for cooling and reduce the risk of overheating, the following measures have been taken in accordance with Policy SI 4 of the GLA's Cooling Hierarchy:

8.2.1 Reducing the amount of heat entering the building

The development's external envelope has minimised glazing in the data hall areas. Glazing benefits largely revolve around occupant comfort, but as the data centre will not house occupants frequently there is little need for windows. By limiting glazed areas to core spaces, the building is largely protected from solar gains, which would unnecessarily increase the cooling loads. Furthermore, the fabric will include low u-values in order to minimise the amount of thermal energy transfer via conduction between indoor spaces and outdoors. This measure will also help to reduce both cooling and heating loads.

By contrast, areas of glazing are larger in areas that will be occupied more frequently such as the office and other occupied servicing spaces.

	Cooling Demand Reduced	MJ/m2 Actual	MJ/m2 Notional
Outlined Component			
LON07	Yes	249.2	310.8
LON08	Yes	92.8	149.6
Innovation Hub	Yes	62.8	92.4
Detailed Component			
LON06	Yes	324.6	327.9

Table 8-1 Outlined and detailed component cooling reduction

8.2.2 Minimising internal heat generation

Plug-loads and occupant densities associated with office activities cannot be altered beyond the client's brief. Therefore, the only area that can be targeted is the lighting. Low energy, high efficacy lighting will be used through-out the development to minimize internal heat gains.

8.2.3 Use of thermal mass and high ceiling to manage heat

Due to the 'round the clock' operational nature of data halls, thermal mass has little value, as there is no opportunity to purge the spaces (in periods of disuse) and eject the heat captured in the thermal mass. As such, no consideration has been given to thermal mass in this development.

8.2.4 Passive ventilation

The cooling demand associated with data halls is extremely high, too high for effective cooling via natural ventilation in London's climate. For the glazed occupied space, the cooling demand during the day is high. Constant ventilation with night purge did not effectively remove the heat. Therefore, instead of passive ventilation, the envelope of LON06 and Innovation Hub will be well sealed and cooled via tightly controlled mechanical cooling systems. Little fresh air is required for the space type, so mechanical ventilation will be minimal.

8.2.5 Mechanical ventilation and active cooling systems

As has been highlighted, the cooling loads of the data halls will be substantial. For this reason, a specialist data halls mechanical cooling system will be employed.

Mechanical cooling systems in the few office type spaces will be the FCU. All fresh air will be delivered by AHUs in the offices and other occupied area.

Efficiency values of these systems will exceed the requirements of the 'Non-Domestic Building Services Compliance Guide' and will meet requirements of the more demanding sustainability rating tool BREEAM, which the development is aspiring to achieve an 'Excellent' rating.

8.3 Part L Criterion Limiting Solar Gains

Under Part L of the building regulations, developments must demonstrate solar gains have been reduced to a sufficient level under 'Requirement L1(a) – Limiting heat gains and losses – Limiting the effects of heat gains in summer'. The assessment has shown that all spaces comply with the Requirement L1(a). Results can be found in the Be Lean BRUKL document in Appendix.

8.4 Overheating Risk Analysis

Cooling demand is reviewed for all occupied space, and they are lower than the notional case. MJ/m2 for each block is reported. There is no non-domestic space undertaking natural ventilation.

Dynamic CIBSE TM52 analysis for overheating risk was undertaken for all occupied space in the admin area of LON06 and Innovation Hub. Heat has been limited from entering the building through careful consideration of glazing. This must be balanced with a need for good daylight and solar heat in winter, so the use of solar control glass has been considered.

The spaces are assessed under the current scenario with the "London-LHR-DSY1-2020High50.epw", representing a 'moderately warm summer.'

To establish the potential for extreme weather years, the spaces were assessed with the "London-LHR-DSY2-2020High50.epw" and the "London-LHR-DSY3-2020High50.epw", dynamic weather files.

The tables in Appendix G summarise the occupancy schedules, the internal gains related to occupancy, lighting and equipment as well as clothing levels, metabolic rates, and air speed assumptions.

All assessed spaces comply with the thermal comfort requirement and pass the overheating risk assessment, results are reported in Appendix G of this report.

Please note that results and recommendations are based on assumptions described in this report. If any of the inputs change, this will have an impact on the results and the recommendations may no longer be appropriate.

9.0

Materials

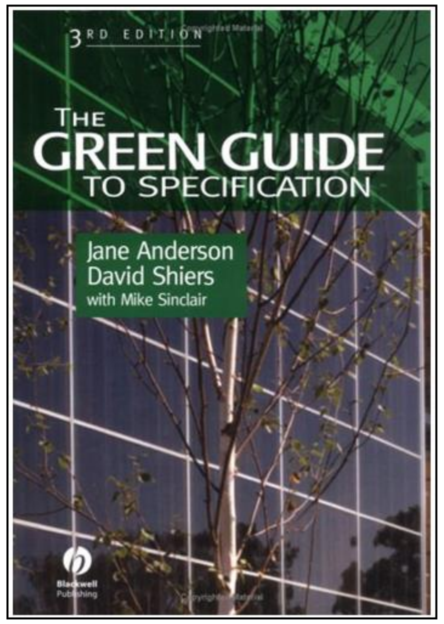
9.0 Materials

Building and construction activities worldwide consume 3 billion tonnes of raw material each year, which account for approximately 50% of total global consumption. Using green/sustainable building materials and products promotes conservation of dwindling non-renewable resources. In addition, integrating sustainable building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these source materials.

The Hayes Digital Park Data Centre Campus development can reduce site-wide embodied carbon emissions through reuse of the existing site materials and careful selection of new building materials. The opportunity to reuse certain elements means that CO_2 emissions associated with the procurement, manufacture and transportation of new materials can be reduced.

9.1 Environmental Impact of Materials

Materials with low overall environmental impact will be chosen and advice from the Green Guide to Specification will be taken into consideration for the selection. The Green Guide rates the environmental impact of different materials and components, considering factors like toxicity, ozone depletion, ease of recycling, and waste disposal (core issues marked with an asterisk under Environmental Issue). Where viable, at least 80% (by area) of the main elements in the building, fabric & building services insulation should be specified to achieve the best performing “A” and “A+” ratings from the Green Guide.



Environmental Issue
Climate Change*
Water extraction
Mineral extraction
Stratospheric ozone depletion*
Human toxicity
Ecotoxicity to freshwater
Higher level nuclear waste
Ecotoxicity to land
Waste disposal
Fossil fuel depletion
Eutrophication*
Photochemical ozone creation*
Acidification*

9.2 Sustainable Timber

All timber used for basic or finishing building elements in the scheme will be sourced from responsibly managed and sustainable forests or plantations. Such timber products are the only truly renewable construction material in common use and the responsible management of forests for timber helps to lock in CO_2. By maximising the use of timber for structural or finishing purposes the embodied carbon impact of the development can be reduced.

9.3 Locally Sourced Materials

A building that is truly sustainable must be constructed using locally sourced, sustainable materials i.e., materials that can be supplied without any adverse effect on the environment. Therefore, where practical, materials should be sourced from local suppliers, reducing the environment impacts and CO_2 emissions associated with transportation to the site.

9.4 Recycled Materials

Scope for increased recycling will be incorporated by specifying recycled materials where possible and ensuring that even where new materials are used, as much as possible can be recycled at the end of the building’s life.

Specifying materials with a high-recycled content is also another method of saving processing or manufacturing energy. The recycled content of a material can be described as either post-consumer or post-industrial to indicate at what point in the life cycle a material is reclaimed.

9.5 Ozone Depletion and Global Warming

CFCs and HCFCs, compounds commonly used in insulation materials and refrigerants, can cause long-term damage to the Earth’s stratospheric ozone layer, exposing living organisms to harmful radiation from the sun. They also significantly increase global warming if they leak into the atmosphere. Following the Montreal Protocol, production and use of CFCs is no longer permitted, and EC regulations required phasing out of HCFCs by 2015. However, products that replaced these gases are often still potent global warming contributors.

All insulation materials specified for the proposed scheme will have zero Ozone Depleting Potential and low Global Warming Potential, (GWP<5) in either manufacture or composition. This will include insulation for building elements (ceiling, internal & external walls, and floor – including foundations) as well as insulation for hot water vessels and pipe or duct work.

9.6 Embodied Carbon

The embodied energy of a building is the energy required to make, deliver, assemble, and dispose of all the materials used in its construction, refurbishment, and demolition. Embodied carbon is the CO_2 emissions released due to the embodied energy plus any process emissions, such as the CO_2 released by the chemical reaction when cement is produced. It is often annotated as ECO_2. The embodied carbon of a building is calculated by measuring the quantity of every material used over the life of the building and multiplying this by an emissions factor for each. To this are added emissions due to delivery of materials to site, construction activities, and waste.

9.7 Whole Life-Carbon

Whole life-cycle carbon emissions are the total greenhouse gas emissions arising from a development over its lifetime, from the emissions associated with raw material extraction, the manufacture and transport of building materials, to installation/construction, operation, maintenance, and eventual material disposal.

Operational carbon emissions will make up a declining proportion of a development’s whole life carbon emissions as operational carbon targets become more stringent. To fully capture a development’s carbon impact, a whole life-cycle approach is needed to capture its unregulated emissions (i.e., those associated with equipment), its embodied emissions (i.e., those associated with raw material extraction, manufacture and transport of building materials, and construction) and emissions associated with maintenance and eventual material disposal.

The design team have undertaken and are addressing a series of sustainable design measures to be applied to the development to reduce its embodied carbon footprint and to achieve the sustainable design aspirations. These have been developed along with a Whole Life Carbon Assessment (WLCA).

Calculating and reducing WLC emissions offers a wealth of benefits including:

- Ensuring that a significant source of emissions from the built environment are accounted for, which is necessary in achieving a net zero-carbon city.
- Achieving resource efficiency and cost savings by encouraging the re-use of existing materials instead of new materials and the retrofit and retention of existing structures and fabric over new construction.
- Identifying the carbon benefits of using recycled material and the benefits of designing for future reuse and recycling to reduce waste and support the circular economy.
- Identifying the impact of maintenance, repair, and replacement over a building’s life cycle, which improves life-time resource efficiency and reduces life-cycle costs, contributing to the future proofing of asset value.
- Encouraging local sourcing of materials and short supply chains, with resulting carbon, social and economic benefits for the local economy.
- Encouraging durable construction and flexible design, both of which contribute to greater longevity, reduced obsolescence of buildings and avoiding carbon emissions associated with demolition and new construction.

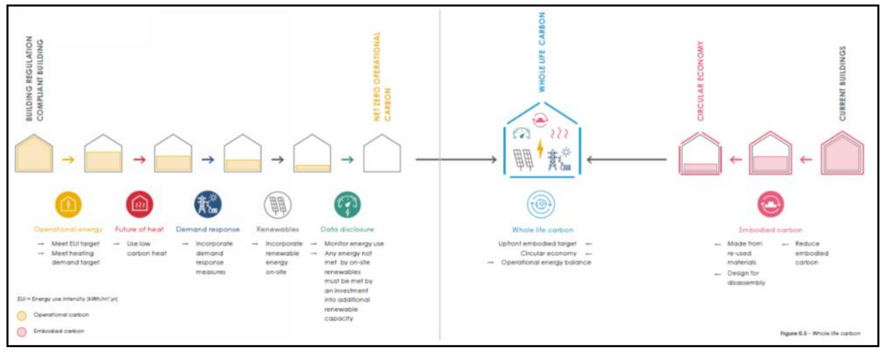


Figure 9-1 LETI whole life carbon blueprint

9.7.1 Life-cycle Modules

The WLC assessment covered all modules A, B and C set out in BS EN 15978 and the RICS Professional Statement: Whole Life Carbon assessment for the built environment (referred to as the RICS PS for the remainder of this document). in the life of a typical project described as life-cycle modules. The reference study period (i.e., the assumed building life expectancy) for the purposes of the assessment is 60 years.

To provide a holistic view of the GWP, the whole life carbon assessment accounts for all components relating to the project during all life stages. Embodied Carbon emissions are attributed to four main categories taken from BS EN 15978. The categories are:

- **Product Stages (module A1 to A3):** The carbon emissions generated at this stage arise from extracting the raw materials from the ground, their transport to a point of manufacture and then the primary energy used (and the associated carbon impacts that arise) from transforming the raw materials into construction products.
- **Construction (module A4 to A5):** These carbon impacts arise from transporting the construction products to site, and their subsequent processing and assembly into the building.
- **In-Use Stages (module B1 to B7):** This covers a wide range of sources from the embodied carbon emissions associated with the operation of the building, including the materials used during maintenance, replacement, and refurbishment.
- **End of Life Stages (module C1 to C4):** The eventual deconstruction and disposal of the existing building at the end of its life takes account of the on-site activities of the demolition contractors. No 'credit' is taken for any future carbon benefit associated with the reuse or recycling of a material into new products.
- **Benefits and loads beyond the system boundary (module D):** Any potential benefit from the reuse, recovery and recycling potential of a building or a building product.

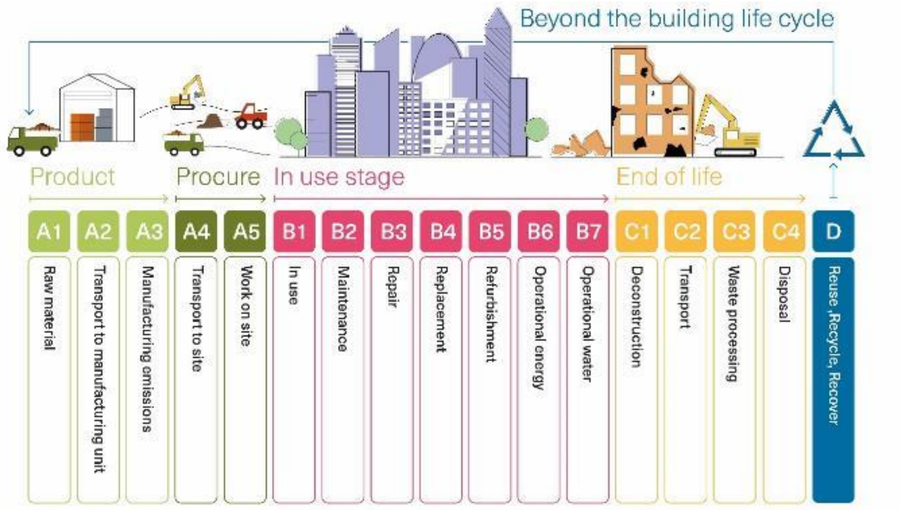


Figure 9-2. Life Cycle Modules as per BS EN 15978

9.7.2 Methodology

The assessment follows a nationally recognised assessment methodology, namely, BS EN 15978: 2011: (Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method).

Underpinning BS EN 15978 is the RICS Professional Statement: Whole Life Carbon assessment for the built environment (RICS PS). The RICS PS serves as a guide to the practical implementation of the BS EN 15978 principles. It sets out technical details and calculation details and so was used as the methodology for the assessment.

This study covers the following,

- Upfront Embodied Carbon (A1-A5).
- Life Cycle Embodied Carbon (B-C).
- Benefits & Loads beyond the system boundary (D).
- Carbon Reduction Opportunities.

9.7.3 Assessment Scope

Below is an outline of the building elements that contribute to whole life carbon content. For all elements, a detailed whole life carbon and cost assessment of the options have been undertaken to inform the design process.

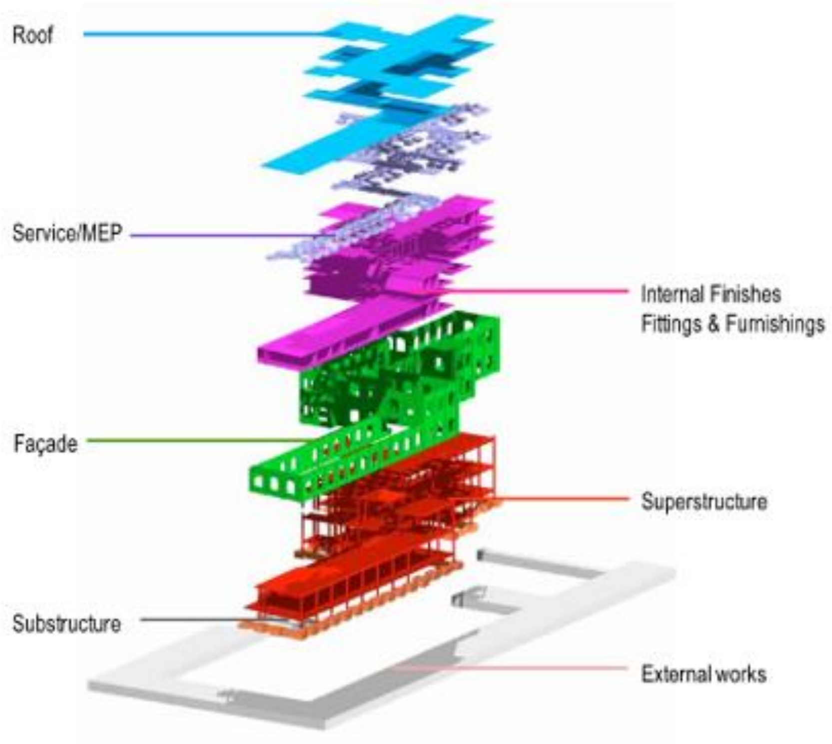


Figure 9-3. Indicative 3D Model of scope of elements analysed for embodied carbon impact

- Durability and flexibility. Consider factors causing degradation, replacement, or obsolescence to occur more rapidly.
- Efficient fabrication. Use of offsite manufacturing and standardisation.
- Minimising waste. Particularly during construction and installation. Produce a site wide waste management plan.
- Maintenance. Specify durable and easy to use materials and systems.
- Finishes. Consider finishes that do not require gluing down to enable easier, cleaner replacement & deconstruction.
- Deconstruction. Design and specify materials and system for end of life utilising the circular economy principles.

An additional Stage 3 Whole Life Carbon Assessment (WLCA) report is enclosed with the application.

Further details of the development's response to embodied carbon can be found in the Whole Life Carbon Assessment Report produced by Savills enclosed with the planning application.

9.7.4 Operational Energy and Carbon

Operational energy is all the energy consumed in the day-to-day operations of a building across its useful lifespan. It includes the ‘regulated’ energy end-uses addressed under Part L, as well as the various ‘unregulated’ uses.

Due to a heavy reliance on Part L, and a lack of effective calculation tools, operational energy is not traditionally well quantified in the UK. Tools such as NABERS UK, PHPP, TM54 or the Design for Performance, would be required to effectively estimate total energy consumption and emissions.

Strict and detailed metering, monitoring, and reporting processes, combined with building systems tuning would also be required as part of the ongoing procedure to ensure buildings are performing to the best of their ability.

The Hayes Digital Park Data Centre Campus operational energy use has been assessed and modelled with TM54 calculations. This data along with calculated total operational water use has then been used to inform and calculate the expected operational carbon emissions for Hayes Digital Park Data Centre Campus (Stages B6 & B7).

9.7.5 Embodied Carbon

The World Green Building Council (WGBC) reports that buildings are responsible for 39% of global energy related carbon emissions of which 11% are from the upfront use of materials and construction. This upfront embodied carbon is defined as carbon footprint of construction materials from its extraction, through manufacture, to installation, and the emissions associated with the construction works.

Early consideration for the upfront embodied carbon has been key to the sustainable design of Hayes Digital Park Data Centre Campus. For all elements a detailed whole life carbon and cost assessment of the options has been conducted to determine the most carbon efficient solution and inform the design process. Major embodied carbon ‘hotspots’ that were targeted for design reduction include Substructure, Superstructure, MEP services, Facades, Internal walls, and Construction activities.

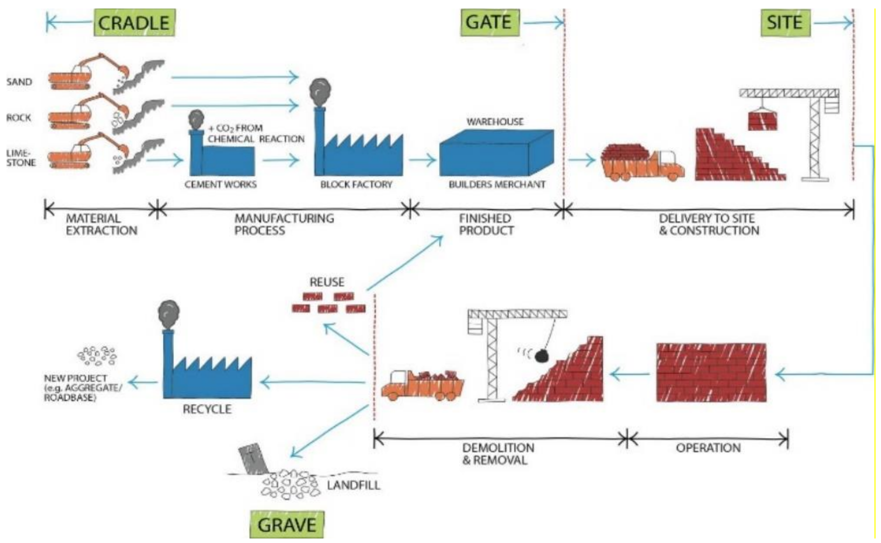


Figure 9-4: Diagram illustrating the 'cradle to grave' cycle that contributes to embodied carbon.

The project’s whole life carbon footprints have been considered at progressive stages of design, and the sustainability requirements have been included as part of detailed design of the scheme. This has enabled sufficient details to be available at an early enough stage in the process to ensure changes can be made that are both impactful, yet achievable considering other design criteria.

9.7.6 Embodied Carbon Design

The Hayes Digital Park Data Centre Campus Design Team have undertaken and are addressing a series of sustainable design measures to be applied to the development to reduce its embodied carbon footprint and to achieve the sustainable design aspirations. These have been developed in accordance with WLCA in the WLCA Report.

Key design actions included or under investigation are:

1. Use of Concrete with GGBS in Substructure
2. Use of Industry Average EPD for Concrete in Frame
3. Use of Industry Average EPD for Reinforcement Steel

9.7.7 Whole Life Carbon & GLA Benchmark

The Greater London Authority (GLA) has benchmarks for certain building types, but not for Data Centres.

The Hayes Digital Park Data Centre Campus development’s carbon emissions are shown, for guidance in comparison to the Greater London Authority (GLA) benchmark emission rate for office developments. The Hayes Digital Park Data Centre Campus development emissions are shown to be significantly greater, in the instances of both upfront and whole life-cycle embodied carbon. The benchmarks include all life-cycle modules excluding B6, B7 (operational energy and operational water) and module D, as well as demolition. It can be seen that the WLC carbon emissions are driven mainly by the operational energy life-cycle emissions, as would be expected from a data centre development.

9.7.7.1 Detailed Component:

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	790
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1740

Table 9-1. Whole Life-cycle Carbon breakdown LON06

9.7.7.2 Outline Component:

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	792
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1742

Table 9-1. Whole Life-cycle Carbon breakdown LON07

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	951
Modules B-C (excluding B6 & B7)	<450	<370	792
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1742

Table 9-2. Whole Life-cycle Carbon breakdown LON08

LCA Module	WLC Benchmark ($kgCO_{2e}/m^2$)	Aspirational WLC Benchmark ($kgCO_{2e}/m^2$)	Proposed Development ($kgCO_{2e}/m^2$)
Modules A1-A5 (excluding sequestered carbon)	<950	<600	952
Modules B-C (excluding B6 & B7)	<450	<370	827
Module A-C (excluding B6 & B7; including sequestered carbon)	<1400	<970	1778

Table 9-2. Whole Life-cycle Carbon breakdown Innovation Hub

10.0

Water Practices

10.0 Water Practices

10.1 Water Conservation

Water consumption in the UK has risen by 70% over the last 30 years. Trying to meet the increasing demand by locating new sources of water supply is both expensive and damaging to the environment. Therefore, the design team have focused on reducing the demand for water and managing the existing resources.

- New build non-residential developments should achieve at least BREEAM 'Excellent' rating. All developments are required to incorporate water efficiency measures to achieve an 'excellent' Wat 01 rating.

10.1.1 Demand Reduction and Water Efficiency

The aim is to minimise internal and external potable water use within the development. Good water management can contribute to reducing the overall level of water consumption maintaining a vital resource and having environmental as well as cost benefits in the life cycle of the building. The following water saving measures are being considered for a range of areas in line with the BREEAM requirements:

Dual Flush Cisterns on WC's - These units can provide a single flush of 4L and/or a full flush of 6L. It is proposed that these are used throughout the development to minimise water consumption.

Flow Restrictors to Taps - Flow restrictors reduce the volume of water discharging from the tap. Spray taps have a similar effect and are recommended to reduce both hot and cold-water consumption. Low flow taps in one of the above forms will be installed in all of areas to comply with the BREEAM mandatory requirements.

Low Flow Showers - The average shower uses 15 litres of water a minute, by restricting the output of the showers in the development to a maximum of 9 litres/ min a 40% water saving can be achieved. Flow rate can be reduced to 6 litres/minute without compromising on water pressure and hence will be considered as the design develops.

Water Meters - In 1995 approximately 33,200 million litres of water a day were extracted in England and Wales, this increased to 44,130 million litres/day in 2001, and much of this was for domestic water supply. To reduce this figure, accurate information on usage is required for management of a building's consumption. Water meters will be specified on the main supply and sub-metering to all secondary bathroom areas in line with the BREEAM requirements.

Further details are referred to the Water Cycle Strategy report (LONUX-CDL-ZZ-XX-RP-Z-00008).

10.2 Sustainable Urban Drainage

The site's drainage strategy will aim to reduce the impact of development on the natural drainage patterns, by retaining water on site through the incorporation of Sustainable Urban Drainage systems (SUDs).

SUDs designs must take account of the City's archaeological heritage, complex underground utilities, transport infrastructure and other underground structures, incorporating suitable SUDs elements for the site.

The Environment Agency's Flood Map indicates that the site is in a Medium-to-Low Flood Risk Zone.

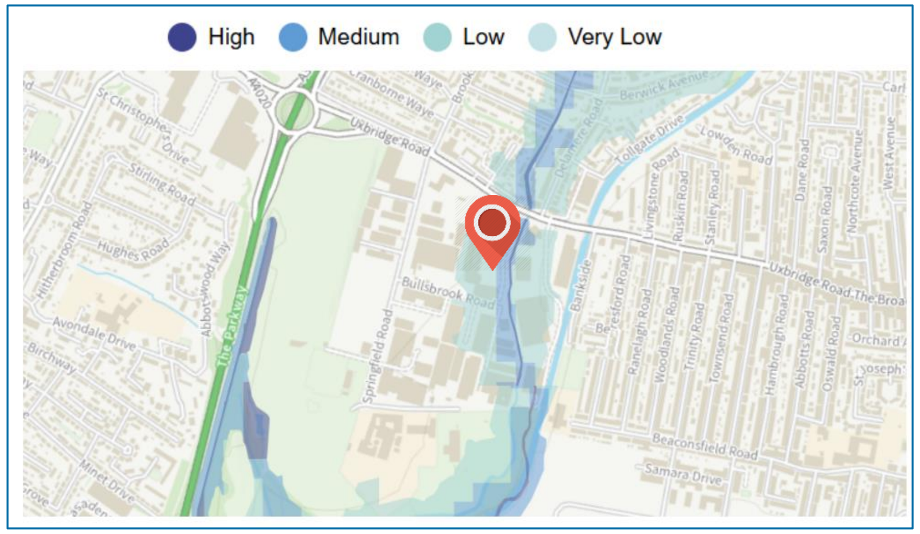


Figure 10-1. Flood Map of London, marking the Hayes Digital Park Data Centre Campus site in a medium-to-low risk zone.

Additionally, the site is in an area that benefits from flood defences. As such, there is little flood risk to the site.

The site is currently mostly impermeable with hard landscaping and building areas. The main aim of the drainage strategy is to maintain surface water runoff rates at no higher than greenfield equivalent runoff up to 1 in 100-year plus climate change allowance, which would meet the London Plan essential standard. SUDs considerations are identified in Flood Risk Assessment and Ground Drainage Strategy (FRA), which is prepared for planning submission. Specific SUDs are identified for the development and details are listed in the Drainage Strategy Report (LONUX-ARUP-SW-LP-RP-C-52001.pdf) in line with the drainage hierarchy.

- Rainwater Harvesting
- Pervious Paving in the light vehicle areas
- Swales, Filter Drains
- Geocellular Storage
- Below Ground Geocellular Attenuation Tank

11.0

Management

11.0 Management

11.1 Waste Management

Buildings and building sites produce a significant amount of waste per year. Most of the waste produced in the UK is disposed of in landfill sites and only a small percentage of it is recycled or reused. A Waste Management Plan (Delivery & Servicing Management Plan) has been prepared by ARUP in support planning application for operational waste and the measures is highlighted in below section.

11.1.1 Waste Management Policy

A waste management plan has been developed according to below legislation, policy and strategy:

1. Resources and Waste Strategy for England 2018;
2. Waste Regulations England and Wales 2011;
3. National Planning Policy for Waste;
4. The London Plan 2021;
   a. Policy S17 Reducing waste and supporting the circular economy
   b. Policy S18 Waste capacity and net waste self sufficiency
   c. Policy S19 Safeguard waste sites
   d. Policy SI10 Aggregates
5. The Mayor's Business Waste Strategy 2011;
6. The Hillingdon Local Plan
   a. EM11 – Sustainable Waste Management
7. The West London Waste Plan

11.1.2 Waste Targets

To achieve BREEAM and the latest policy target several measures are implemented, including landfill tax, aiming to discourage disposal of waste to landfill. Good waste management is a key component of sustainable development and is an important means of:

- Reducing unnecessary expenditure.
- Reducing the number of natural resources for production of new materials.
- Reducing energy for waste disposal.
- Reducing levels of contamination and pollution arising from waste disposal.

11.1.3 Demolition and Construction

During the construction phase a large amount of waste material will be generated through construction, demolition and land clearing procedures. In building construction, the primary waste products in descending percentages are: wood, asphalt/concrete/masonry, drywall, roofing, metals, and paper products.

Prior to commencement on site a Site Waste Management Plan (SWMP) that complies with the requirements of current legislation and BREEAM will be prepared. This plan will identify the local waste haulers and recyclers, determine the local salvage material market, identify, and clearly label site spaces for various waste material storage and require a reporting system that will quantify the results and set targets. As a minimum, the SWMP will contain:

a. The target benchmark for resource efficiency e.g., m^3 of waste per 100 m^2 or tonnes of waste per 100 m^2;
b. Procedures and commitments for minimising non-hazardous waste in line with the benchmark;
c. Procedures for minimising hazardous waste;
d. Procedures for monitoring, measuring and reporting hazardous and non-hazardous site waste;
e. Procedures for sorting/ reusing/ recycling construction waste into defined waste groups either on site or through a licensed external contractor;
f. The name/ job title of the individual responsible for implementing the above.

11.1.4 Operational Waste Management and Reporting

As the proposed Hayes Digital Park Data Centre Campus development is on land that has previously been built upon, there is the potential for using waste materials from the existing buildings and hard paved areas. Bricks and concrete could possibly be reused as hard-core materials etc. Opportunities for introducing more reused or reusable materials/components will be explored during detailed design.

Waste management plans outline the approach for multiple business operations for the site with below principles:

1. Overall waste management services will be facilitated on site by the data centre management/landlord.
2. Data centre management/landlord to arrange for the collection of data centre waste via a commercial waste contractor.
3. Data centre tenants to manage their own waste within the delivery areas arising from the data centre and offices.
4. Data centre tenants will make the necessary arrangements for the segregation of recyclables and food waste in accordance with the waste contractor's collection requirements.
5. Data centre tenants to make their own internal arrangements to promote waste prevention activities and raise general awareness of recycling systems to employees.
6. Data centre tenants to make their own arrangements for environmental awareness raising amongst employees, incorporating waste and carbon reduction aspects.
7. There are no common part areas that require management of waste or from which waste will be generated.
8. The data centre management/landlord, where site maintenance services such as landscaping are required, and waste is generated will arrange for any waste generated to be managed by the contractor and removed from site.

It is assumed that the waste will be split 30:70 between refuse and recycling due to the likely future targets for recycling and packaging waste recycling and the likely requirement for the segregated collection of dry recyclables and food in the future. Of the recycling containers provided, it is proposed that at least one container per building would be made available for the separate collection of food waste.

Waste Storage

All storage areas and containers are to have clear signage and, where beneficial, containers to be colour coded to assist with the segregation of material for recycling.

It is anticipated that waste prevention and recycling arrangements will be promoted to employees at the development as part of their business operations.

The main aim will be to recycle as much waste as possible, this will be achieved by making sure that waste recycling facilities are strategically placed in convenient locations.

The container storage area within each data centre will house wheeled bins of 1,100 litre size for both refuse and segregated recycling prior to movement to a centralised waste management area. Detail estimated storage area could be referenced to the waste management plan.

Waste Collection

The landlord/data centre building management will arrange for a licenced commercial waste contractor to collect their waste, including recycling and residual waste. Waste will be taken by each customer to the waste store throughout the day and the FM team will bring the waste from the waste store to the loading bay at the end of each day prior to collection.

To collect the waste a refuse collection vehicle would enter the site and travel via the road to collect from the loading bay and then exit via the same route. It is intended that one waste contractor will service the data centre complex minimise the number of refuse collection vehicles entering the site.

The requirements for the data centre tenants with regards to waste management would be stipulated within their tenure agreements to ensure that tenants use the designated waste storage areas and that appropriate collection arrangements are put in place that support segregated recycling and waste prevention activity and that duty of care obligations as a 'waste holder' are carried out.

11.2 Environmental Management

Construction sites are responsible for significant impacts, especially at a local level. These arise from noise, potential sources of pollution, waste and other disturbances. Impacts such as increased energy and water use are also significant. Therefore, attention is being given to site-related parameters with the aim to protect and enhance the existing site & its ecology.

The aim is to have a construction site managed in an environmentally sound manner in terms of resource use, storage, waste management, pollution and good neighbourliness.

11.2.1 Considerate Construction Scheme

To achieve this, there will be a commitment to comply with the Considerate Constructors Scheme and achieve formal certification under the scheme in line with the BREEAM requirements. As a minimum, a score of greater than 35 of out 50 will be achieved with an aspiration to exceed 40, with no individual section achieving a score of less than 7.

Areas that can be taken into consideration to minimise the impact of the construction site on its surroundings and the global environment as outlined in the BREEAM methodology:

- Monitor, report and set targets for CO_2 or energy usage from site activities.
- Monitor, report and set targets for CO_2 or energy usage arising from transport to and from site.
- Monitor, report and set targets for water consumption from site activities.
- Monitor construction waste on site, sorting and recycling construction waste where applicable.
- Adopt best practice policies in respect of air and water pollution arising from site activities.
- Operates an Environmental Management System.
- Additionally, all timber used on site will be responsibly sourced.

12.0

Pollution and Land use

12.0 Pollution and Land Use

12.1 Pollution

Global concern for environmental pollution has risen in recent years, as concentrations of harmful pollutants in the atmosphere are increasing. Buildings have the potential to create major pollution both from their construction and operation, largely through pollution to the air (dust emissions, NOx emissions, ozone depletion and global warming) but also through pollution to watercourses and ground water. The proposed development will aim to minimise the above impacts, both at the design stage and onsite.

12.1.1 Ozone Depletion

CFCs and HCFCs, compounds commonly used in insulation materials and refrigerants, can cause long-term damage to the Earth's stratospheric ozone layer, exposing living organisms to harmful radiation from the sun. They also significantly increase global warming if they leak into the atmosphere. Following the Montreal Protocol, production and use of CFCs is no longer permitted, and EC regulations required phasing out of HCFCs by 2015. However, products that replaced these gases are often still potent global warming contributors. Where refrigerants are used for air-conditioning and comfort cooling, they will be CFC and HCFC-free.

12.1.2 Internal pollutants

Volatile organic compounds (VOCs) are emitted as gases (commonly referred to as off-gassing) from certain solids or liquids. VOCs include a variety of chemicals, some of which are known to have short-term and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors.

VOCs are emitted by a wide array of products numbering in the thousands. Examples include paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials, furnishings, adhesives, Urea-formaldehyde foam insulation (UFFI), pressed wood products (hardwood plywood wall panelling, particleboard, fibreboard) and furniture made with these pressed wood products.

'No' or 'low' VOC paints are available from most standard mainstream paint manufacturers. There 'eco-friendly' paints are made from organic plant sources and low solvent-based products.

The design team will seek to select internal finishes and fittings with low or no emissions of VOCs and comply with European best practice levels as a minimum.

12.1.3 NOx emissions from boilers

Nitrous oxides (NOx) are emitted from the burning of fossil fuels and contribute to both acid rain and to global warming in the upper atmosphere. At ground level, they react to form ozone, a serious pollutant and irritant at low level. Burners in heating systems are a significant source of low-level NOx, while power stations (and therefore electric heating) are a significant source of NOx in the upper atmosphere.

The amount of NOx emissions varies between products. Therefore, where applicable, low NOx products will be selected.

12.1.4 Night Sky Pollution

External lighting encompasses vehicle and pedestrian access lighting, security lighting, facility illumination and general feature lighting. In summary the lighting will be designed on a site wide basis to meet the mandatory requirements and aesthetic considerations. The strategy is to provide a balance between adequate external lighting for safe and secure operation of the site without unnecessary illumination or power consumption.

The intention is to be a good neighbour and not to introduce nuisance glare or light pollution of the night sky from miss directed or unnecessary lighting. Feature lighting, where required, will be focussed to the task/subject. Where necessary luminaires will be further screened in cases where there may be an issue of proximity and light spill to the adjacent neighbouring residential areas, although the intention is to avoid this situation arising wherever possible from the outset. The external lighting design will take into consideration the relevant guidance from the British Standards and other recommended documents including the following Standards and Design Guides:

- CIBSE Lighting Guide for the Outdoor Environment
- CIBSE Lighting Design Guides
- BS5489 Code of Practice for the Design of Road Lighting
- BS EN 13201-1 Road Lighting, Selection of Lighting Classes
- BSEN 13201-2 Road Lighting, Performance requirements
- Institute of Lighting Engineers Guidance Notes for the Reduction of Obtrusive Light

12.1.5 Surface Water Run-off

Steps must be taken for any development to ensure that the rate of surface water run-off is not increased by the proposed works. Where applicable, this can be achieved using sustainable urban drainage systems (SuDS), which is a comprehensive design approach to the management of water on a site, to delay run-off and encourage filtration using porous surfaces, detention ponds, and swales in ways which enhance amenity and biodiversity and avoid pollution effects. Where ground SuDS cannot be provided for practical reasons, then building design must be appropriate to manage heavy rainfall (e.g., green roofs).

In accordance with the London Sustainable Drainage Action Plan the site will seek to reduce pollution of London's tributary rivers and streams, accounting for potential climate changes wherever possible.

12.2 Land Use Ecology

The site currently comprises of a business park development predominantly utilised for storage. The land has been in use for commercial applications for a long time and the existing site ecology is limited, with little diversity or habitats suitable for wildlife.

Increasing the biodiversity and enhancing the ecology of the site has is a target of the proposed development.

New planted area will be included where possible, to increase the ecological value of the site and help protect local plant and animal species.

Plants can have several ecological as well as economic benefits:

- Visually attractive with a range of flower and foliage effects.
- Low maintenance with little or no artificial irrigation requirement.
- Improvement of air quality by removal of carbon dioxide, release of oxygen and water vapour, deposition of particulate pollutants, and absorption of organic volatiles.
- Reduction of the 'urban heat island effect'.

Recommended enhancement measures include the implementation of protection and mitigation measures during the construction phase. Existing hedgerow as the priority habitat will be removed under the proposals and new hedgerow planting is proposed to compensate the loss. Within the development, majority of the trees are to be removed, and new planting is proposed to retain opportunities for wildlife, with achievable offsetting measure. Retained trees will be safeguarded through mitigation measures.

Through implementation of the ecological enhancement, the opportunity exists to deliver a number of biodiversity net gains at the site:

Habitat Creation

- New Planting of trees and shrubs appropriate to the local area
- Wildflower Grassland creation

Yeading Brook

- Removal of invasive species
- Removal of litter
- Bat boxes and bird boxes
- Reduction of the 'urban heat island effect'.

The proposed development will result in >10% BNG for habitats, hedgerows, and the watercourse. Detail information is included in the Ecological Appraisal report (6890-01 Masterplan EcoAp vf.pdf).

13.0

Transport

13.0 Transport

The transport of people between buildings is the second largest source of CO_2 emissions in the UK after energy use in buildings and remains the main source of many local pollutants. Energy use and emissions from transport are growing at 4% per year, and at the same time, the effects of climate change are becoming more severe; there will be greater pressure to control CO_2 emissions from transport and sites without good access to public transport will be at much greater risk from these controls.

A transport assessment (TA) and a travel plan (TP) are prepared by ARUP to support the planning submission for the site and below is the consideration for sustainable transport.

13.1 Site Locations

The London Public Transport Accessibility Level (PTAL) for the site is 0-1b (southern part of the site) to 2 (northern part of the site). The poor PTAL is due to the surrounding natural features including Minet Country park to the west and Yeading Brook and Grand Union Canal to the east affecting the permeability of the area. Once beyond these barriers the network has good permeability and available routes to local facilities and public transport stations.

Hayes Digital Park Data Centre Campus connects with railway and bus transport links. Hayes and Harlington Station is located to the west of the site, and Southhall Station to the east. Both stations are served by Great Western Railway and TfL Rail connecting to Paddington, Reading, Dicot and Heathrow Airport. The Elizabeth Line also serves both stations connecting to central London. There are two major bus corridors around the site on the Uxbridge Road and Coldharbour/Yeading Lane.

Description	Approx. walking/cycling distance from site	Local Services
Bus Tops	0.3 miles (6-min walk)	207 (Hayes By-Pass – White City)
		427 (Uxbridge – Acton)
	1 mile (23-min walk)	90 (Northolt – Feltham City)
		140 (Hayes – Long Elmes)
		E6 (Bulls Bridge – Greenford)
		SL8 (Uxbridge – White City)
		SL9 (Heathrow Central – Harrow Superloop)

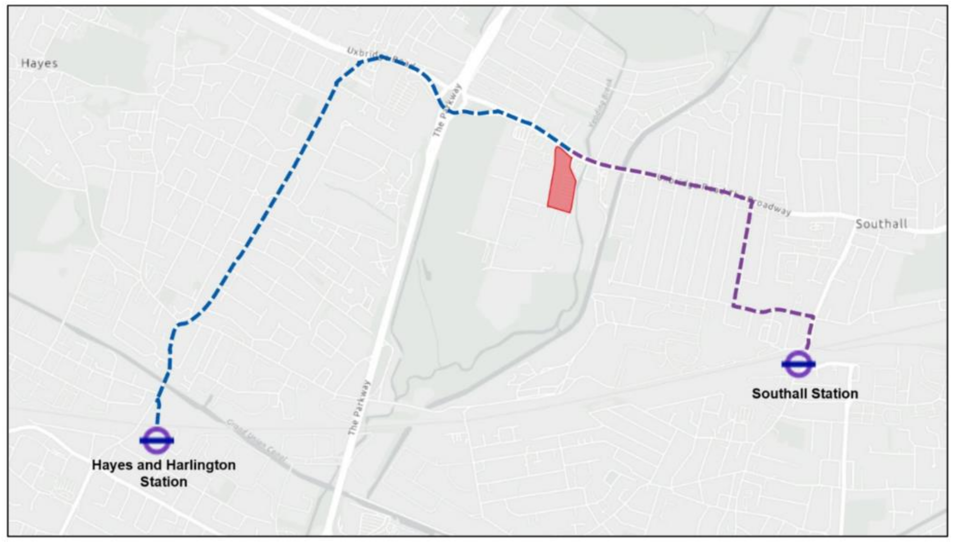


Figure 13-1. Google map's view of the rail network options surrounding the site.

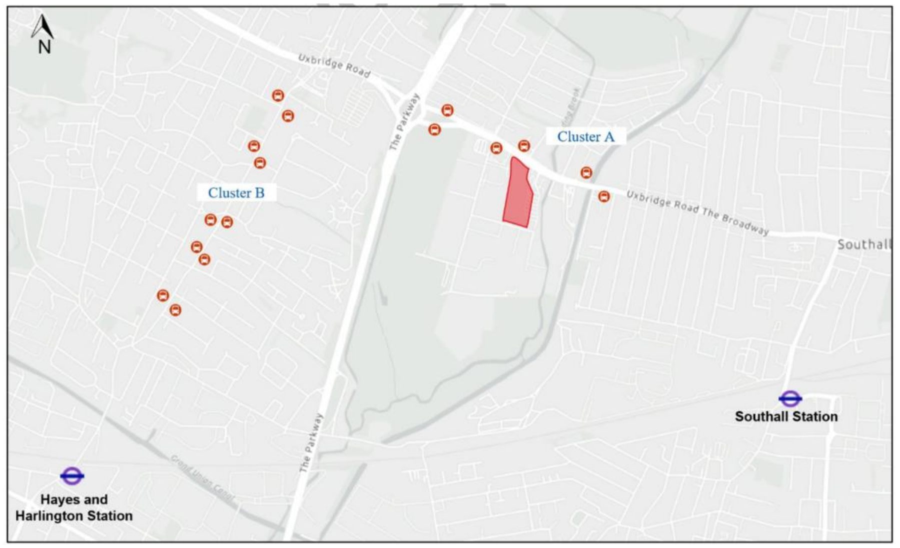


Figure 13-2. Google map's view of the bus options surrounding the site.

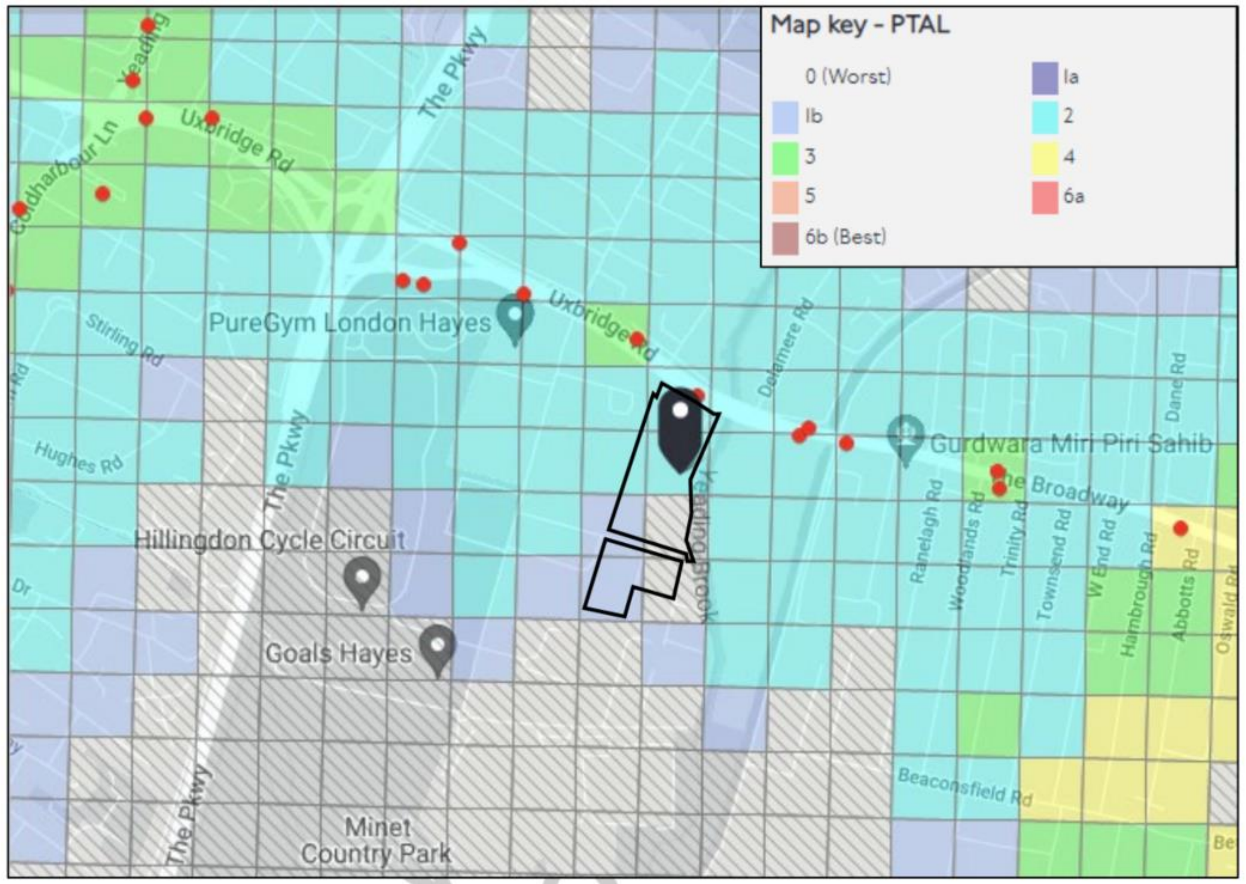


Figure 13-3. London PTAL map showing level of public transport at the Hayes Digital Park Data Centre Campus site.

13.2 Cycling Facilities

Secure cycle facilities will be provided to all the data centre buildings within the campus. Secure measures for both employees and visitors are provided on site (Drawing No. LONUX-NWA-PL-00-DR-A-12200). Reference to travel plan, facilities planned for the building enable occupants to cycle to work and securely lock their bike, encouraging the use of this carbon-free mode of transport. Below highlighted the contribution to the Mayor's Transport Strategy (MTS) sustainably:

- Provision of a highly sustainable and modern Data Centre campus which coincides with the increased number of new jobs identified for London and supports LBN's digital economy aspirations;
- providing a sustainable, car-lite development (except for 'operational' car parking in accordance with London Plan standards for B2-B8 Uses), thus limiting car usage;
- provision of an efficient servicing strategy through means of a dedicated loading bay within the curtilage of each Data Centre Building, while ensuring that the ability for internal pedestrian and cyclist permeability are not compromised;
- improving the site's internal and external pedestrian and cycle environment and public realm in the vicinity of the site, which includes footways on both sides of Uxbridge Road with a segregated two-way cycleway on the southern side of the carriageway and 1.5m wide footway on the southern side of Bullsbrook Road with dropped kerbs at vehicle cross overs;
- providing good quality, secure long and short-stay cycle parking provision.
- For the Detailed Component LON06 10 long stay spaces and 10 short stay spaces are proposed.

13.3 Other Design Measures

The following hard measures will be introduced to support the TP, where such measures relate to the physical infrastructure that is proposed as part of the development.

- secure cycle parking facilities;
- shower and changing facilities for use by staff, within each demise;
- provision of a "Bicycle first-aid kit" on-site including bike pump, puncture repair kit, spare light, batteries and tools.
- future provision of electric vehicle charging points and infrastructure to facilitate and encourage the use of electric vehicles (staff cars and operational vehicles);
- promotion of E-bike advantages for those with a longer commute/ carrying loads
- provision of information on all public transport connections and taxi services.

13.4 Package of measures for sustainable travel

The Sustainable Travel Information Packs will be provided and contain the following information:

- travel information on notice boards/websites/promotional material
- walking maps and connections to the other destinations
- cycling-to-site leaflets
- information on all public transport connections
- information on taxi services and local car clubs

The above information will need to be reviewed and updated on a regular basis by the TPC.

13.5 EV Charging

The assessment and plan encourage a reduction in single occupancy car trips, encouraging the use of electric vehicles will help to make the Development more sustainable and environmentally friendly, by reducing the levels of CO_2 emissions and other particulates.

All the parking spaces will have provision to be equipped with charging facilities in the future.

Measures to management and monitoring for the proposed sustainable travel proposal are outlined in the detail travel plan (LONUX-ARUP-PL-XX-RP-Z-00004_FTP.pdf).

14.0

BREEAM

14.0 BREEAM

BREEAM (Building Research Establishment's Environmental Assessment Method) is the world's leading and most widely used environmental assessment method for buildings. It sets the standard for best practice in sustainable design and has become the de facto measure used to describe building's environmental performance.

The objectives of BREEAM are to visibly promote low environmental impact buildings, to set criteria and standards surpassing those by regulations and thus challenging the market to provide innovative solutions to achieving this criterion and raise the awareness of owners, occupiers, designers and operators of the benefits of buildings with a reduced environmental impact.

14.1 BREEAM Pre-Assessment

A pre-assessment has been carried out using the BREEAM UK Data Centre 2010 methodology for LON06 (Detailed component) and Innovation Hub (Outlined Component). LON07 and LON08 are outlined and will be access and design with latest BREEAM New construction scheme in the next stage targeting at Excellent rating.

14.1.1 BREEAM UK Data Centre

The results of the assessment indicate that the current design for the data centre buildings is likely to achieve a BREEAM 'Excellent' rating, with a score of 78%.

The threshold for an 'Excellent' rating is 70% and for 'Outstanding' rating is 85%. It is recommending a 4-5% additional buffer to mitigate against any unforeseen credit loss throughout the design stages.

BREEAM groups its sustainability rating under the following nine headings:

- Management - Commissioning and construction site management
- Health & Wellbeing - Indoor and external issues
- Energy Use - Operational energy and CO_2 issues
- Transport - Transport related CO_2 and location related factors
- Water - Consumption and water efficiency
- Materials - Environmental implication of building materials
- Waste – Operational and construction waste resource efficiency
- Land Use & Ecology - Ecological value of the site
- Pollution - Air & Water pollution

The overall rating of the building is constructed by achieving 'credits', which represent particular management, design or performance aspects of the building, as stipulated by BREEAM. The building must achieve the relevant mandatory credits, as well as other credits which contribute towards an overall target score. This score is used to determine what BREEAM rating the building achieves.

The following tables summarise the initial strategy to achieve BREEAM 'Excellent' rating for LON06 and Innovation Hub.

Environmental Section	Available	Weighting	Targeted (Excellent)
Management	12	12%	12
Health & Wellbeing	13	10%	11
Energy	25	37%	14
Transport	10	5%	5
Water	8	8.5%	8
Materials	15	7%	12
Waste	7	4.5%	5
Land Use & Ecology	10	6%	8
Pollution	11	10%	8
Exemplary/Innovation	13		5
Total	**124**	**78.06%**	**88**
Excellent	★★★★★		

Table 14-1: BREEAM 'Excellent' Strategy LON06

Environmental Section	Available	Weighting	Targeted (Excellent)
Management	18	11%	18
Health & Wellbeing	18	14%	16
Energy	21	16%	15
Transport	12	10%	7
Water	9	7%	7
Materials	14	15%	9
Waste	10	6%	8
Land Use & Ecology	13	13%	10
Pollution	12	8%	8
Exemplary/Innovation	10		1
Total	**137**	**76.92%**	99
Excellent	★★★★★		

Table 14-2: BREEAM 'Excellent' Strategy Innovation Hub

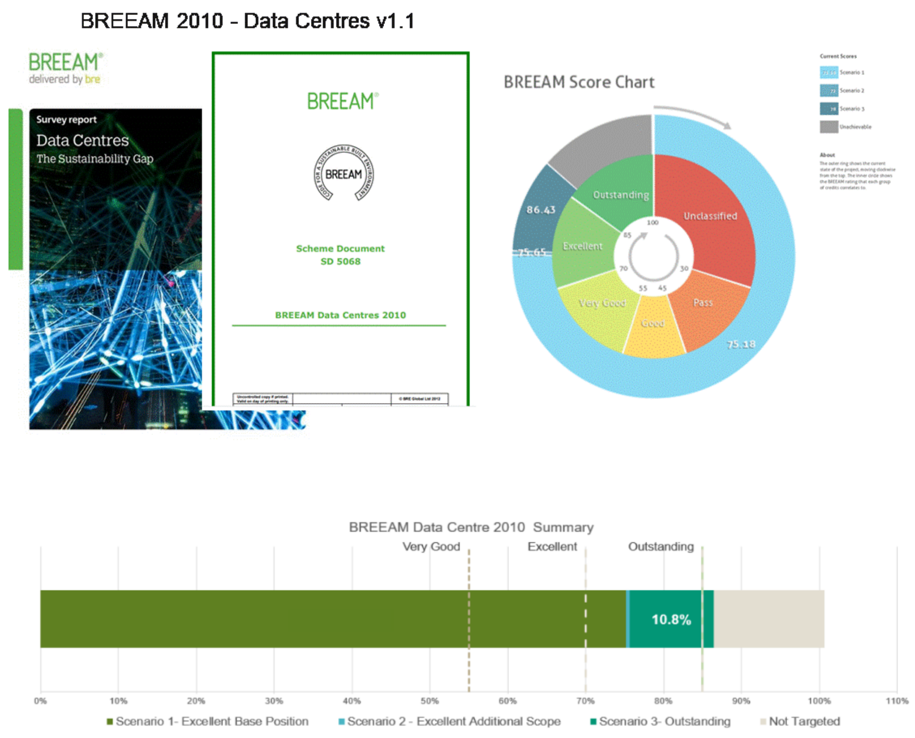


Figure 14-1: Pre-assessment for Data Centre

The minimum standards for 'Excellent' and 'Outstanding' for BREEAM UK Data Centre 2010, non-domestic buildings are shown below:

	Minimum standards by BREEAM rating level				
BREEAM issue	**Pass**	**Good**	**Very Good**	**Excellent**	**Outstanding**
Man 1 Commissioning	1	1	1	1	2
Man 2 Considerate Constructors	-	-	-	1	2
Man 4 Building user guide	-	-	-	1	1
Hea 4 High frequency lighting	1	1	1	1	1
Hea 12 Microbial contamination	1	1	1	1	1
Ene 1 Reduction of CO2 emissions	-	-	-	6	10
Ene 2 Sub-metering of substantial energy uses	-	-	1	1	1
Ene 5 Low or zero carbon technologies	-	-	-	1	1
Wat 1 Water consumption	-	1	1	1	2
Wat 2 Water monitoring	-	1	1	1	1
Wst 3 Storage of recyclable waste	-	-	-	1	1
LE 4 Mitigating ecological impact	-	-	1	1	1

Table 14-3: BREEAM UK Data Centre 2010 minimum standards

The BREEAM strategy includes several actions undertaken at the earliest opportunity to ensure the project is able to achieve the ratings targeted. The assessment is targeting:

- The mandatory credits for 'Excellent' and 'Outstanding' ratings
- Prerequisite credits requirements are incorporated
- The Early-Stage credits required to inform the design in the most cost-efficient way
- Targeting the higher scoring credits

Early Consideration credits considered and has been carried out during design stage:

- Ecology credits
- Construction waste management – Pre-demolition audit
- BREEAM AP
- Transport assessment and Travel Plan
- Low or zero carbon technologies
- Flood risk assessment
- Security assessment

14.1.2 BREEAM New Building

The outlined LON07 and LON08 will be reviewed under the latest BREEAM New building construction and the Excellent rating target, and the corresponding credit requirement will be set as the framework for design in the next stage.

Appendices

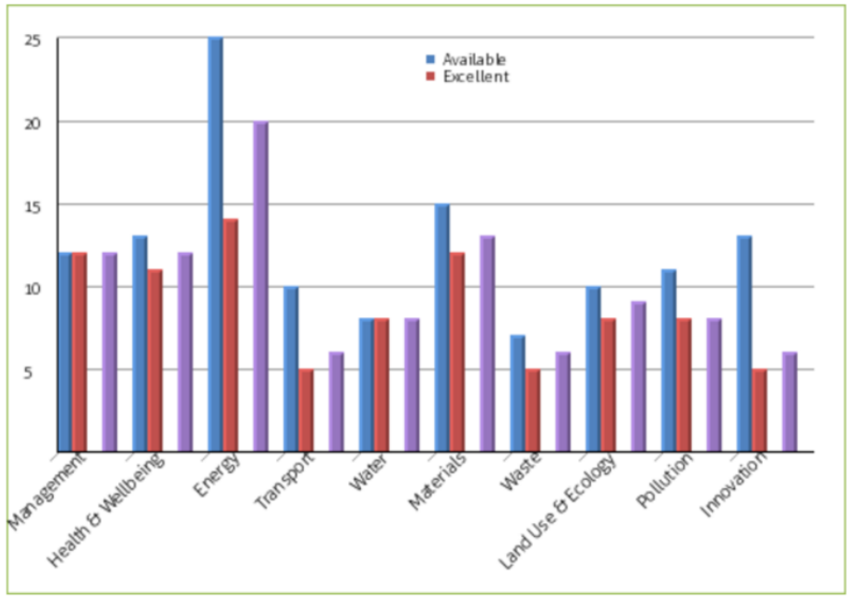
Appendices A – BREEAM Pre-Assessment

Appendix A BREEAM Pre-Assessment

LON06

	No of credits	BREEAM Weighting	Targeted credits
Management	12	12%	12
Health & Wellbeing	13	10%	11
Energy	25	37%	14
Transport	10	5%	5
Water	8	8.5%	8
Materials	15	7%	12
Waste	7	4.5%	5
Land Use & Ecology	10	6%	8
Pollution	11	10%	8
Exemplary/Innovation	13		5
Total:	**124**		**78.06%**

BREEAM summary Excellent Strategy for LON 6 assessment

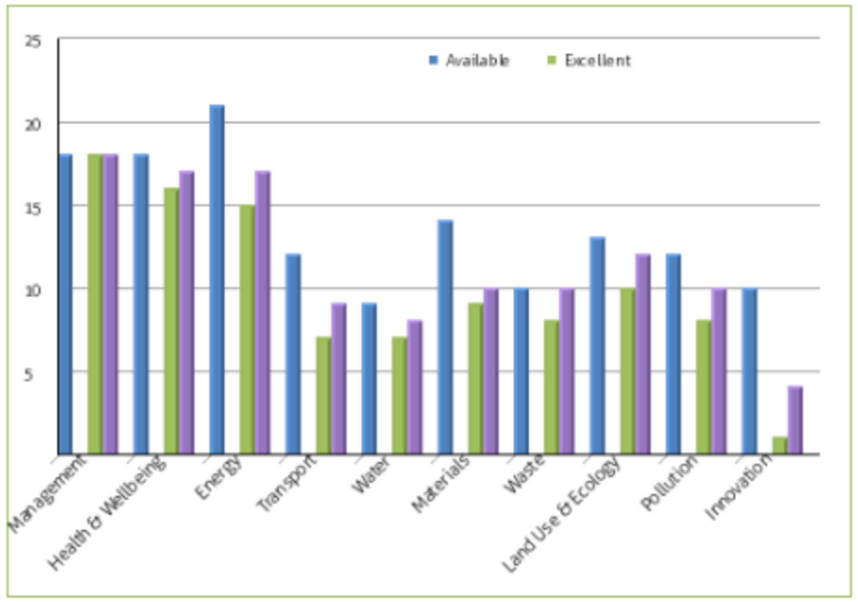


BREEAM Summary Excellent Strategy

Innovation Hub

	No of credits	BREEAM Weighting	Targeted credits
Management	18	11%	18
Health & Wellbeing	18	14%	16
Energy	21	16%	15
Transport	12	10%	7
Water	9	7%	7
Materials	14	15%	9
Waste	10	6%	8
Land Use & Ecology	13	13%	10
Pollution	12	8%	8
Exemplary/Innovation	10		1
Total:	**137**		**76.92%**

BREEAM summary Excellent Strategy for Innovation Hub assessment



BREEAM Summary Excellent Strategy

Management
Man01 - Commissioning
Man02 - Considerate Constructors
Man03 - Construction Site Impacts
Man04 - Building User Guide
Man08 - Man 8 - Security
Man12 - Man 12 - Life Cycle Costing

Health & Wellbeing
Hea01 - Daylighting
Hea02 - View Out
Hea03 - Glare Control
Hea04 - High Frequency Lighting
Hea05 - Internal and External Lighting Levels
Hea06 - Lighting Zones and Controls
Hea07 - Potential for Natural Ventilation
Hea08 - Indoor Air Quality
Hea09 - Volatile Organic Compounds
Hea10 - Thermal Comfort
Hea11 - Thermal Zoning
Hea12 - Microbial Contamination
Hea13 - Acoustic Performance

Energy -
Ene01 - Reduction of CO2 Emissions
Ene02 - Sub-metering of Substantial Energy Uses
Ene04 - External Lighting
Ene05 - Low or Zero Carbon Technologies
Ene08 - Lifts
Ene22 - Procurement of Sustainable IT Equipment

Transport -
Tra01 - Provision of Public Transport
Tra02 - Proximity to Amenities
Tra03 - Cyclist Facilities
Tra04 - Pedestrian and Cyclist Safety
Tra05 - Travel Plan
Tra06 - Maximum Car Parking Capacity

Water -
Wat01 - Water Consumption
Wat02 - Water Meter
Wat03 - Major Leak Detection
Wat04 - Sanitary Supply Shut Off
Wat05 - Water Recycling
Wat06 - Irrigation Systems

Materials -
Mat01 - Materials Specification
Mat02 - Hard Landscaping and Boundary Protection
Mat03 - Reuse of Building Facade
Mat04 - Reuse of Building Structure
Mat05 - Responsible Sourcing of Materials
Mat06 - Insulation
Mat07 - Designing for Robustness

Waste -
Wst01 - Construction Site Waste Management
Wst02 - Recycled Aggregates
Wst03 - Recyclable Waste Storage
Wst04 - Compactor / Baler

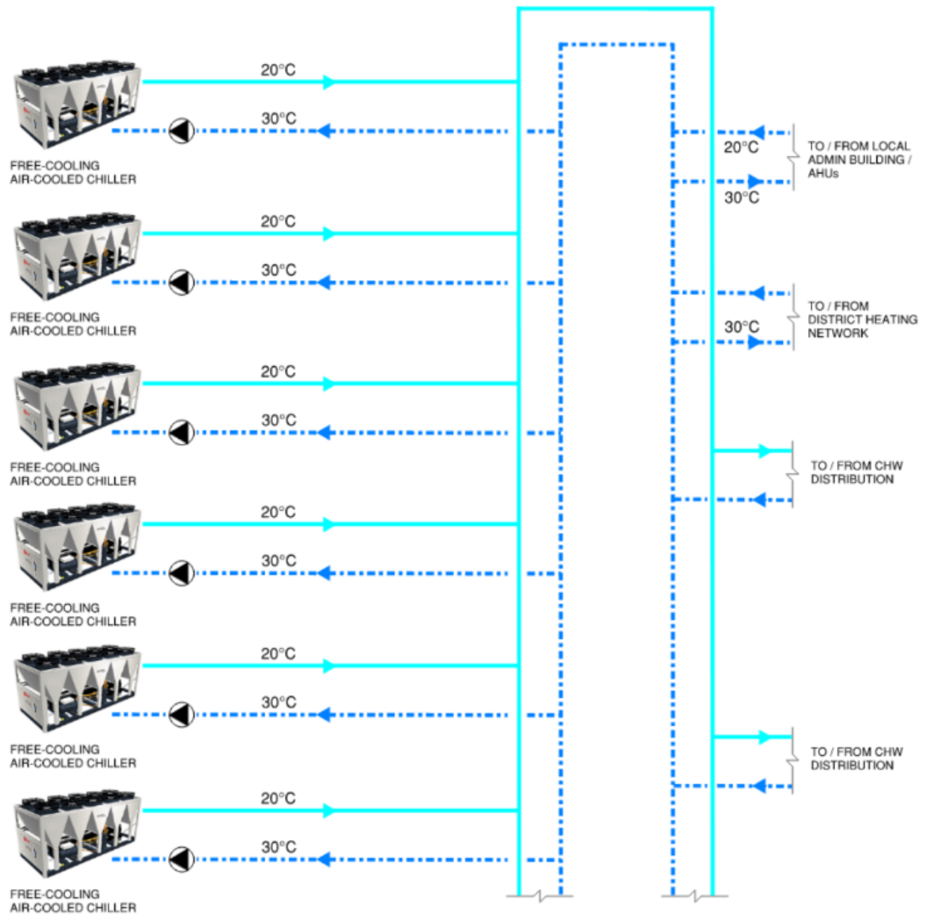
Land Use & Ecology -
LE01 - Reuse of Land
LE02 - Contaminated Land
LE03 - Ecological Value of Site and Protection of Ecological Features
LE04 - Mitigating Ecological Impact
LE05 - Enhancing Site Ecology
LE06 - Long Term Impact on Biodiversity

Pollution -
Pol01 - Refrigerant GWP Building Services
Pol02 - Preventing Refrigerant Leaks
Pol04 - NOx Emissions from Heating Source
Pol05 - Flood Risk
Pol06 - Minimising Watercourse Pollution
Pol07 - Reduction of Night Time Light Pollution
Pol08 - Noise Attenuation

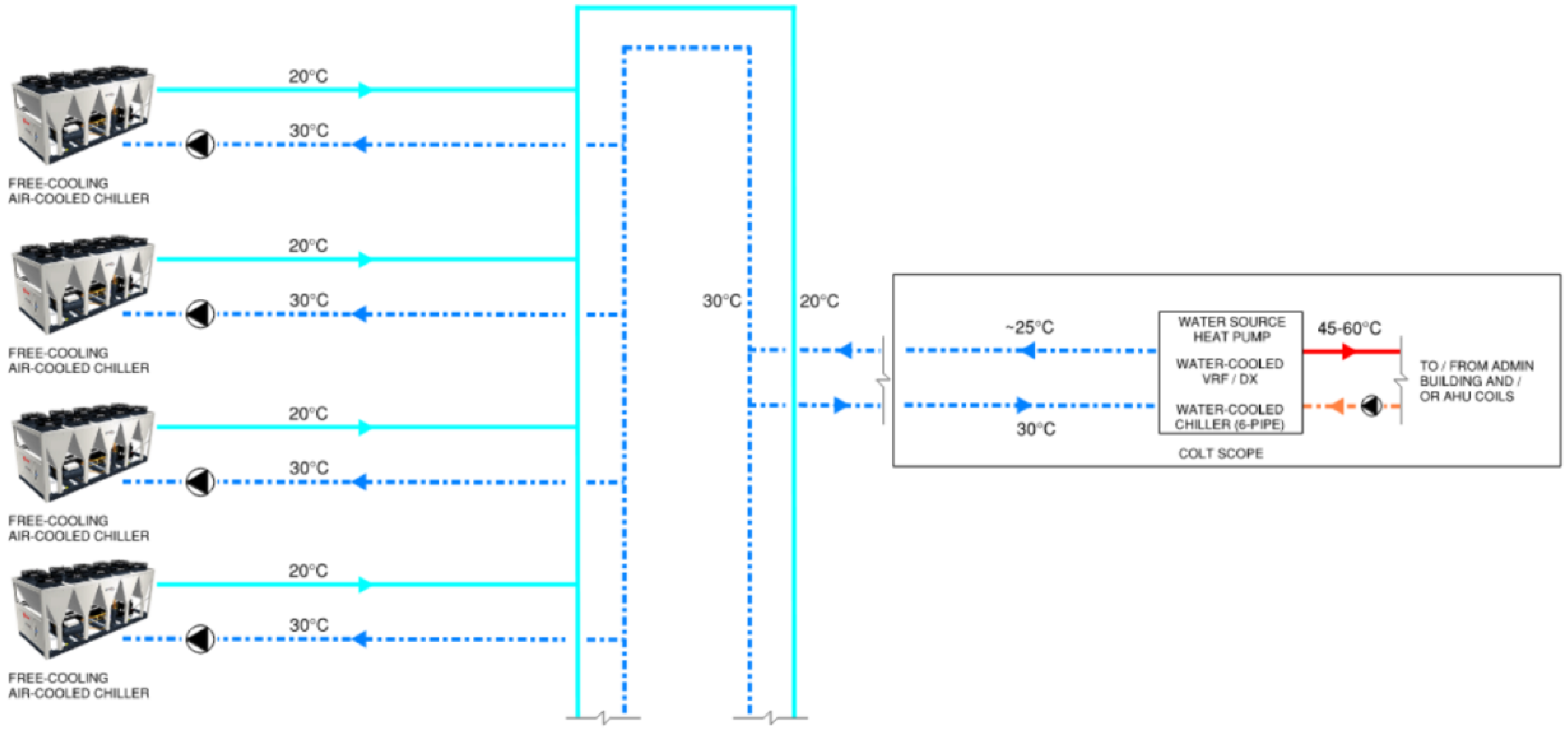
Innovation -
Bap1 - BREEAM AP
Man2 - Considerate Constructors
Hea1 - Daylighting
Ene1 - Reduction of CO2 Emissions
Ene5 - Low or Zero Carbon Technologies
Wat2 - Water Meter
Mat1 - Materials Specification
Mat5 - Responsible Sourcing of Materials
Wst1 - Construction Site Waste Management
Wsat1 - Water Consumption

Appendices B – Heat Recovery, Waste Heat Recovery

Heat Source – CHW Return



Heat Recovery from CHW Return to Colt Admin / AHUs



Appendices C – Outlined Component BRUKL – Be Lean

Outlined Component BRUKL – Be Lean (LON07)

Address: One Carter Ln, London, EC4V 5EY

Foundation area [m²]: 4362.81

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	48.95	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	30.75	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	534.84	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	335.92	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.19	0.26	LN000261:Surf[1]
Floors	0.18	0.17	0.22	LN000261:Surf[4]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.18	LN0001F2:Surf[1]
Windows** and roof windows	1.6	1.42	1.6	LN0001CE:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.4	1.6	LN000156:Surf[2]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW (Data Hall) BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

2- CHW Admin Block BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
LON 07_00_Data_Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
LON 07_00_Data_Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON 07_04_Store 03	164	-	-
LON 07_04_Store 04	164	-	-
LON 07_04_Toilets 02	140	-	-
LON 07_04_Toilets 01	140	-	-
LON 07_04_ACC WC 01	140	-	-
LON 07_04_Circulation 05	164	-	-
LON 07_04_Security Eqp Room 01	164	-	-
LON 07_04_DCIM 02	164	-	-
LON 07_04_DCIM 01	164	-	-
LON 07_05_Cooling unit 01	164	-	-
LON 07_05_Cooling unit 02	164	-	-
LON 07_05_Cooling unit 03	164	-	-
LON 07_05_Cooling unit 04	164	-	-
LON 07_05_Cooling unit 05	164	-	-
LON 07_05_Cooling unit 06	164	-	-
LON 07_05_Corridor 01	164	-	-
LON 07_05_Corridor 02	164	-	-
LON 07_05_Corridor 03	164	-	-
LON 07_05_Corridor 04	164	-	-
LON 07_05_Data Hall 01	175	-	-
LON 07_05_Data Hall 02	175	-	-
LON 07_05_Data Hall 03	175	-	-
LON 07_05_DH Circulation 01	164	-	-
LON 07_05_DH Circulation 02	164	-	-
LON 07_05_DH Circulation 03	164	-	-
LON 07_05_DH Circulation 04	164	-	-
LON 07_05_DH Circulation 05	164	-	-
LON 07_05_DH Circulation 06	164	-	-
LON 07_05_DH Circulation 07	164	-	-
LON 07_05_DH Circulation 08	164	-	-
LON 07_05_DH Circulation 09	164	-	-
LON 07_05_DH Circulation 10	164	-	-
LON 07_05_Lobby 01	164	-	-
LON 07_05_Office 01	104	-	-
LON 07_05_Office 01 Perimeter 01	104	-	-
LON 07_05_Office 01 Perimeter 02	104	-	-
LON 07_05_Stairs 01	164	-	-
LON 07_05_Stairs 02	164	-	-
LON 07_05_Stairs 03	164	-	-
LON 07_05_Stairs 04	164	-	-
LON 07_05_Store 01	164	-	-
LON 07_05_Store 02	164	-	-
LON 07_05_Store 03	164	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Entrance Lobby 01	YES (+52%)	NO
LON 07_00_Manager Office 01	N/A	N/A
LON 07_00_Meeting Rm 01	NO (-23.7%)	NO
LON 07_00_Security Eqp Room 01	N/A	N/A
LON 07_00_Security Office 01	N/A	N/A
LON 07_00_Stairs 01	N/A	N/A
LON 07_00_Stairs 02	N/A	N/A
LON 07_01_Cooling unit 01	N/A	N/A
LON 07_01_Cooling unit 02	N/A	N/A

Page 13 of 19

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 07_01_Cooling unit 03	N/A	N/A
LON 07_01_Cooling unit 04	N/A	N/A
LON 07_01_Cooling unit 05	N/A	N/A
LON 07_01_Cooling unit 06	N/A	N/A
LON 07_01_Data Hall 01	N/A	N/A
LON 07_01_Data Hall 02	N/A	N/A
LON 07_01_Data Hall 03	N/A	N/A
LON 07_01_DH Circulation 01	N/A	N/A
LON 07_01_DH Circulation 02	N/A	N/A
LON 07_01_DH Circulation 03	N/A	N/A
LON 07_01_DH Circulation 04	N/A	N/A
LON 07_01_DH Circulation 05	N/A	N/A
LON 07_01_DH Circulation 06	N/A	N/A
LON 07_01_DH Circulation 07	N/A	N/A
LON 07_01_DH Circulation 08	N/A	N/A
LON 07_01_DH Circulation 09	N/A	N/A
LON 07_01_DH Circulation 10	N/A	N/A
LON 07_01_Office 01	YES (+275.8%)	NO
LON 07_01_Office 01 Perimeter 01	NO (-13%)	NO
LON 07_01_Office 01 Perimeter 02	NO (-4.1%)	NO
LON 07_01_Stairs 01	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	39294.6	39294.6
External area [m²]	34820.2	34820.2
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	8313.38	10423.3
Average U-value [W/m²K]	0.24	0.3
Alpha value* [%]	25.32	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
5	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
95	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	0.64	0.22
Cooling	150.28	274.07
Auxiliary	54.54	59.13
Lighting	22.33	29.41
Hot water	0.15	0.14
Equipment*	1298.36	1298.36
TOTAL**	**227.94**	**362.97**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	4495.72	4572.11
Primary energy [kWh_{PE}/m^2]	335.92	534.85
Total emissions [kg/m²]	30.75	48.95

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	100.7	249.2	10.1	8.3	32.4	2.78	8.3	3.09	9.96
	Notional	7.8	310.8	0.8	18.6	26	2.78	4.63	----	----
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	0.7	5386.7	0.1	180.3	63.4	2.78	8.3	3.09	9.96
	Notional	2.1	5479.4	0.2	328.6	69.4	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Outlined Component BRUKL – Be Lean (LON08)

Address: Street Address, London, Postcode

Foundation area [m²]: 3697.53

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	40.69	
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	26.37	
Target primary energy rate (TPER), kWh_{PE}/m^2.annum	444.27	
Building primary energy rate (BPER), kWh_{PE}/m^2.annum	287.46	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.18	0.18	L0000002:Surf[0]
Floors	0.18	0.15	0.15	L0000002:Surf[3]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	L000000F:Surf[6]
Windows** and roof windows	1.6	1.4	1.4	L0000002:Surf[1]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Electric Heaters

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0.2	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

2- CHW (Data Hall) BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	0.85	0.76
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

3- CHW (Admin Block) BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	1.26	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
LON8_L00_MMR_Room	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON8_L01_Stairecore_01	140	-	-
LON8_L01_Lobby_01	140	-	-
LON8_L01_Circulation_04	140	-	-
LON8_L01_Staircore_02	140	-	-
LON8_L01_Lobby_02	140	-	-
LON8_L03_Office_01	140	-	-
LON8_L03_Staircore_01	140	-	-
LON8_L03_Lobby_01	140	-	-
LON8_L03_Staircore_02	140	-	-
LON8_L03_Lobby_02	140	-	-
LON8_L03_PlantRoom_01	140	-	-
LON8_L05_Office_01	140	-	-
LON8_L05_Staircore_01	140	-	-
LON8_L05_Lobby_01	140	-	-
LON8_L05_Staircore_02	140	-	-
LON8_L05_Lobby_02	140	-	-
LON8_L05_PlantRoom_01	140	-	-
LON8_L06_Office_01	140	-	-
LON8_L06_Staircore_01	140	-	-
LON8_L06_Lobby_01	140	-	-
LON8_L06_Staircore_02	140	-	-
LON8_L06_Lobby_02	140	-	-
LON8_L06_Plant/Switch	140	-	-
LON8_L00_Office_Lobby	140	-	-
LON8_L00_Plant_Room	140	-	-
LON8_L01_DataHall_01	179	-	-
LON8_L01_DataHall_02	179	-	-
LON8_L04_Office_01	140	-	-
LON8_L04_Circulation_ 01	140	-	-
LON8_L04_Circulation_ 02	140	-	-
LON8_L04_Circulation_ 03	140	-	-
LON8_L04_CoolingUnits_ 01	140	-	-
LON8_L04_CoolingUnits_ 02	140	-	-
LON8_L04_CoolingUnits_ 03	140	-	-
LON8_L04_CoolingUnits_ 04	140	-	-
LON8_L04_Staircore_ 01	140	-	-
LON8_L04_Lobby_ 01	140	-	-
LON8_L04_Circulation_ 04	140	-	-
LON8_L04_Staircore_ 02	140	-	-
LON8_L04_Lobby_ 02	140	-	-
LON8_L04_DataHall_ 01	179	-	-
LON8_L04_DataHall_02	179	-	-
LON8_L02_Office_01	140	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON8_L00_MMR_Room	N/A	N/A
LON8_L00_POE	N/A	N/A
LON8_L00_Office_01	YES (+60.1%)	YES
LON8_L00_Office_02	N/A	N/A
LON8_L01_Office_01	YES (+35.1%)	YES
LON8_L01_CoolingUnits_01	N/A	N/A
LON8_L01_CoolingUnits_02	N/A	N/A
LON8_L01_CoolingUnits_03	N/A	N/A
LON8_L01_CoolingUnits_04	N/A	N/A
LON8_L03_Office_01	YES (+35.1%)	YES
LON8_L03_PlantRoom_01	N/A	N/A
LON8_L05_Office_01	YES (+35.1%)	YES
LON8_L05_PlantRoom_01	N/A	N/A
LON8_L06_Office_01	NO (-48.2%)	YES
LON8_L06_Plant/Switch	N/A	N/A
LON8_L00_Office_Lobby	YES (+79.8%)	YES
LON8_L00_Plant_Room	N/A	N/A
LON8_L01_DataHall_01	N/A	N/A
LON8_L01_DataHall_02	N/A	N/A
LON8_L04_Office_01	YES (+35.1%)	YES
LON8_L04_CoolingUnits_ 01	N/A	N/A
LON8_L04_CoolingUnits_ 02	N/A	N/A
LON8_L04_CoolingUnits_ 03	N/A	N/A
LON8_L04_CoolingUnits_ 04	N/A	N/A
LON8_L04_DataHall_ 01	N/A	N/A
LON8_L04_DataHall_02	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON8_L02_Office_01	YES (+35.1%)	YES
LON8_L02_CoolingUnits_ 01	N/A	N/A
LON8_L02_CoolingUnits_ 02	N/A	N/A
LON8_L02_CoolingUnits_ 03	N/A	N/A
LON8_L02_CoolingUnits_ 04	N/A	N/A
LON8_L02_DataHall_ 01	N/A	N/A
LON8_L02_DataHall_02	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	25882.7	25882.7
External area [m²]	20467.3	20467.3
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	7247.78	5987.37
Average U-value [W/m²K]	0.35	0.29
Alpha value* [%]	25	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
4	**General Industrial and Special Industrial Groups**
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
96	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	5.04	1.7
Cooling	125.37	228.64
Auxiliary	51.2	50.13
Lighting	12.2	20.84
Hot water	1.06	0.96
Equipment*	1093.64	1093.64
TOTAL**	**194.87**	**302.27**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0.88
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0.88*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	3802.03	3821.11
Primary energy [kWh_{PE}/m^2]	287.46	444.27
Total emissions [kg/m²]	26.37	40.69

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity									
Actual	47.3	0	14.7	0	5	0.89	0	1	0
Notional	59.6	0	11.7	0	2.4	1.41	0	----	----
[ST] Variable refrigerant flow, [HS] ASHP, [HFT] Electricity, [CFT] Electricity									
Actual	231.5	92.8	23.1	3.7	10	2.78	6.92	3.09	9.96
Notional	2.1	149.6	0.2	9	15.6	2.78	4.63	----	----
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity									
Actual	0	5141.1	0	171	67.4	2.78	8.35	3.09	9.96
Notional	0	5194.9	0	311.6	65.5	2.78	4.63	----	----

Outlined Component BRUKL – Be Lean (Innovation Hub)

Administrative information

Building Details

Address:

Certifier details

Name: Cundall

Telephone number: 020 7438 1600

Address: One Carter Ln, London, EC4V 5EY

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.26

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.26

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 235.8

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	3.84	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	3.64	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	41.49	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	38.96	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.18	0.18	NN000000:Surf[0]
Floors	0.18	0.15	0.15	NN000000:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	NN00001E:Surf[2]
Windows** and roof windows	1.6	1.46	1.6	NN000013:Surf[2]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.6	1.6	NN000013:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW Admin Block with Chiller BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	5.79	0	1	0.76
Standard value	2.5*	4.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
** Standard shown is for air-cooled chillers >=400 kW. For chillers <400 kW, limiting SEER is 4.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
Inn Hub_00_Water Tanks	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_BOH	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_Cafe	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_Life Safety Electrical Room		-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_Main Electrical Room	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_Reception	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_TBC	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_Lab 1	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_Lab 2	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_Lab 3	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_Lab 4	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_WC	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_01_WC	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_02_Lab 1	-	-	-	-	-	-	-	0.3	-	-	N/A

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Inn Hub_00_Water Tanks	N/A	N/A
Inn Hub_00_BOH	N/A	N/A
Inn Hub_00_Cafe	NO (-44.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Inn Hub_00_Life Safety Electrical Room	N/A	N/A
Inn Hub_00_Main Electrical Room	N/A	N/A
Inn Hub_00_Reception	NO (-64.9%)	NO
Inn Hub_00_TBC	N/A	N/A
Inn Hub_01_Lab 1	NO (-70.6%)	NO
Inn Hub_01_Lab 2	NO (-65.6%)	NO
Inn Hub_01_Lab 3	NO (-67.4%)	NO
Inn Hub_01_Lab 4	NO (-40.1%)	NO
Inn Hub_01_WC	N/A	N/A
Inn Hub_01_WC	N/A	N/A
Inn Hub_02_Lab 1	NO (-67%)	NO
Inn Hub_02_Lab 2	NO (-62.2%)	NO
Inn Hub_02_Lab 3	NO (-64.7%)	NO
Inn Hub_02_Lab 4	NO (-34.1%)	NO
Inn Hub_02_WC	N/A	N/A
Inn Hub_02_WC	N/A	N/A
Inn Hub_03_Lab 1	NO (-59.2%)	NO
Inn Hub_03_Lab 2	NO (-52%)	NO
Inn Hub_03_Lab 3	NO (-55%)	NO
Inn Hub_03_Lab 4	NO (-32.1%)	NO
Inn Hub_03_WC	N/A	N/A
Inn Hub_03_WC	N/A	N/A
Inn Hub_04_Acc WC	N/A	N/A
Inn Hub_04_Lecture Hall 1	NO (-60.4%)	NO
Inn Hub_04_WC	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	1907	1907
External area [m²]	3703.8	3703.8
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	1394.38	1452.02
Average U-value [W/m²K]	0.38	0.39
Alpha value* [%]	26.42	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
53	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
47	**Residential Institutions: Universities and Colleges**
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	7.19	4
Cooling	2.33	3.43
Auxiliary	7.55	7.53
Lighting	8	12.27
Hot water	1.08	0.78
Equipment*	30.38	30.38
TOTAL**	**26.15**	**28.01**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	110.74	97.18
Primary energy [kWh_{PE}/m^2]	38.96	41.49
Total emissions [kg/m²]	3.64	3.84

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	116.4	62.8	11.6	3.8	12.2	2.78	4.63	3.09	5.79
	Notional	64.8	92.4	6.5	5.5	12.2	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Appendices D – Outlined Component BRUKL – Be Green

Outlined Component BRUKL – Be Green (LON07)

Administrative information

Building Details
Address:

Certifier details
Name: Cundall
Telephone number: 020 7438 1600
Address: One Carter Ln, London, EC4V 5EY

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.26
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.26
BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 4362.81

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	48.95	
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	30.5	
Target primary energy rate (TPER), $kWh_{PE}/m^2.annum$	534.84	
Building primary energy rate (BPER), $kWh_{PE}/m^2.annum$	333.11	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.19	0.26	LN000261:Surf[1]
Floors	0.18	0.17	0.22	LN000261:Surf[4]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.18	LN0001F2:Surf[1]
Windows** and roof windows	1.6	1.42	1.6	LN0001CE:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.4	1.6	LN000156:Surf[2]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW (Data Hall) BeGreen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

2- CHW Admin Block BeGreen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
LON 07_00_Data_Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
LON 07_00_Data_Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON 07_04_Store 03	164	-	-
LON 07_04_Store 04	164	-	-
LON 07_04_Toilets 02	140	-	-
LON 07_04_Toilets 01	140	-	-
LON 07_04_ACC WC 01	140	-	-
LON 07_04_Circulation 05	164	-	-
LON 07_04_Security Eqp Room 01	164	-	-
LON 07_04_DCIM 02	164	-	-
LON 07_04_DCIM 01	164	-	-
LON 07_05_Cooling unit 01	164	-	-
LON 07_05_Cooling unit 02	164	-	-
LON 07_05_Cooling unit 03	164	-	-
LON 07_05_Cooling unit 04	164	-	-
LON 07_05_Cooling unit 05	164	-	-
LON 07_05_Cooling unit 06	164	-	-
LON 07_05_Corridor 01	164	-	-
LON 07_05_Corridor 02	164	-	-
LON 07_05_Corridor 03	164	-	-
LON 07_05_Corridor 04	164	-	-
LON 07_05_Data Hall 01	175	-	-
LON 07_05_Data Hall 02	175	-	-
LON 07_05_Data Hall 03	175	-	-
LON 07_05_DH Circulation 01	164	-	-
LON 07_05_DH Circulation 02	164	-	-
LON 07_05_DH Circulation 03	164	-	-
LON 07_05_DH Circulation 04	164	-	-
LON 07_05_DH Circulation 05	164	-	-
LON 07_05_DH Circulation 06	164	-	-
LON 07_05_DH Circulation 07	164	-	-
LON 07_05_DH Circulation 08	164	-	-
LON 07_05_DH Circulation 09	164	-	-
LON 07_05_DH Circulation 10	164	-	-
LON 07_05_Lobby 01	164	-	-
LON 07_05_Office 01	104	-	-
LON 07_05_Office 01 Perimeter 01	104	-	-
LON 07_05_Office 01 Perimeter 02	104	-	-
LON 07_05_Stairs 01	164	-	-
LON 07_05_Stairs 02	164	-	-
LON 07_05_Stairs 03	164	-	-
LON 07_05_Stairs 04	164	-	-
LON 07_05_Store 01	164	-	-
LON 07_05_Store 02	164	-	-
LON 07_05_Store 03	164	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Data_Circulation 01	N/A	N/A
LON 07_00_Entrance Lobby 01	YES (+52%)	NO
LON 07_00_Manager Office 01	N/A	N/A
LON 07_00_Meeting Rm 01	NO (-23.7%)	NO
LON 07_00_Security Eqp Room 01	N/A	N/A
LON 07_00_Security Office 01	N/A	N/A
LON 07_00_Stairs 01	N/A	N/A
LON 07_00_Stairs 02	N/A	N/A
LON 07_01_Cooling unit 01	N/A	N/A
LON 07_01_Cooling unit 02	N/A	N/A

Page 13 of 19

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 07_01_Cooling unit 03	N/A	N/A
LON 07_01_Cooling unit 04	N/A	N/A
LON 07_01_Cooling unit 05	N/A	N/A
LON 07_01_Cooling unit 06	N/A	N/A
LON 07_01_Data Hall 01	N/A	N/A
LON 07_01_Data Hall 02	N/A	N/A
LON 07_01_Data Hall 03	N/A	N/A
LON 07_01_DH Circulation 01	N/A	N/A
LON 07_01_DH Circulation 02	N/A	N/A
LON 07_01_DH Circulation 03	N/A	N/A
LON 07_01_DH Circulation 04	N/A	N/A
LON 07_01_DH Circulation 05	N/A	N/A
LON 07_01_DH Circulation 06	N/A	N/A
LON 07_01_DH Circulation 07	N/A	N/A
LON 07_01_DH Circulation 08	N/A	N/A
LON 07_01_DH Circulation 09	N/A	N/A
LON 07_01_DH Circulation 10	N/A	N/A
LON 07_01_Office 01	YES (+275.8%)	NO
LON 07_01_Office 01 Perimeter 01	NO (-13%)	NO
LON 07_01_Office 01 Perimeter 02	NO (-4.1%)	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	39294.6	39294.6
External area [m²]	34820.2	34820.2
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	8313.38	10423.3
Average U-value [W/m²K]	0.24	0.3
Alpha value* [%]	25.32	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
5	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
95	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	0.34	0.22
Cooling	150.28	274.07
Auxiliary	54.54	59.13
Lighting	22.33	29.41
Hot water	0.08	0.14
Equipment*	1298.36	1298.36
TOTAL**	**227.57**	**362.97**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	1.53	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*1.53*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	4495.72	4572.11
Primary energy [kWh_{PE}/m^2]	333.11	534.85
Total emissions [kg/m²]	30.5	48.95

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity									
Actual	100.7	249.2	5.4	8.3	32.4	5.15	8.3	5.79	9.96
Notional	7.8	310.8	0.8	18.6	26	2.78	4.63	----	----
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity									
Actual	0.7	5386.7	0	180.3	63.4	5.15	8.3	5.79	9.96
Notional	2.1	5479.4	0.2	328.6	69.4	2.78	4.63	----	----
[ST] No Heating or Cooling									
Actual	0	0	0	0	0	0	0	0	0
Notional	0	0	0	0	0	0	0	----	----

Outlined Component BRUKL – Be Green (LON08)

Administrative information

Building Details
Address: LON8 Colt4a,

Certifier details
Name: Cundall
Telephone number: Phone
Address: Street Address, London, Postcode

Certification tool
Calculation engine: Apache
Calculation engine version: 7.0.26
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.26
BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 3697.53

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	40.69	
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	25.84	
Target primary energy rate (TPER), kWh_{PE}/m^2.annum	444.27	
Building primary energy rate (BPER), kWh_{PE}/m^2.annum	281.7	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.18	0.18	L0000002:Surf[0]
Floors	0.18	0.15	0.15	L0000002:Surf[3]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	L000000F:Surf[6]
Windows** and roof windows	1.6	1.4	1.4	L0000002:Surf[1]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	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)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Electric Heaters

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0.2	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

2- CHW (Data Hall)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	0.85	0.76
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

3- CHW (Admin Block)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	1.26	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
LON8_L00_MMR_Room	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON8_L01_Stairecore_01	140	-	-
LON8_L01_Lobby_01	140	-	-
LON8_L01_Circulation_04	140	-	-
LON8_L01_Staircore_02	140	-	-
LON8_L01_Lobby_02	140	-	-
LON8_L03_Office_01	140	-	-
LON8_L03_Staircore_01	140	-	-
LON8_L03_Lobby_01	140	-	-
LON8_L03_Staircore_02	140	-	-
LON8_L03_Lobby_02	140	-	-
LON8_L03_PlantRoom_01	140	-	-
LON8_L05_Office_01	140	-	-
LON8_L05_Staircore_01	140	-	-
LON8_L05_Lobby_01	140	-	-
LON8_L05_Staircore_02	140	-	-
LON8_L05_Lobby_02	140	-	-
LON8_L05_PlantRoom_01	140	-	-
LON8_L06_Office_01	140	-	-
LON8_L06_Staircore_01	140	-	-
LON8_L06_Lobby_01	140	-	-
LON8_L06_Staircore_02	140	-	-
LON8_L06_Lobby_02	140	-	-
LON8_L06_Plant/Switch	140	-	-
LON8_L00_Office_Lobby	140	-	-
LON8_L00_Plant_Room	140	-	-
LON8_L01_DataHall_01	179	-	-
LON8_L01_DataHall_02	179	-	-
LON8_L04_Office_01	140	-	-
LON8_L04_Circulation_ 01	140	-	-
LON8_L04_Circulation_ 02	140	-	-
LON8_L04_Circulation_ 03	140	-	-
LON8_L04_CoolingUnits_ 01	140	-	-
LON8_L04_CoolingUnits_ 02	140	-	-
LON8_L04_CoolingUnits_ 03	140	-	-
LON8_L04_CoolingUnits_ 04	140	-	-
LON8_L04_Staircore_ 01	140	-	-
LON8_L04_Lobby_ 01	140	-	-
LON8_L04_Circulation_ 04	140	-	-
LON8_L04_Staircore_ 02	140	-	-
LON8_L04_Lobby_ 02	140	-	-
LON8_L04_DataHall_ 01	179	-	-
LON8_L04_DataHall_02	179	-	-
LON8_L02_Office_01	140	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON8_L00_MMR_Room	N/A	N/A
LON8_L00_POE	N/A	N/A
LON8_L00_Office_01	YES (+60.1%)	YES
LON8_L00_Office_02	N/A	N/A
LON8_L01_Office_01	YES (+35.1%)	YES
LON8_L01_CoolingUnits_01	N/A	N/A
LON8_L01_CoolingUnits_02	N/A	N/A
LON8_L01_CoolingUnits_03	N/A	N/A
LON8_L01_CoolingUnits_04	N/A	N/A
LON8_L03_Office_01	YES (+35.1%)	YES
LON8_L03_PlantRoom_01	N/A	N/A
LON8_L05_Office_01	YES (+35.1%)	YES
LON8_L05_PlantRoom_01	N/A	N/A
LON8_L06_Office_01	NO (-48.2%)	YES
LON8_L06_Plant/Switch	N/A	N/A
LON8_L00_Office_Lobby	YES (+79.8%)	YES
LON8_L00_Plant_Room	N/A	N/A
LON8_L01_DataHall_01	N/A	N/A
LON8_L01_DataHall_02	N/A	N/A
LON8_L04_Office_01	YES (+35.1%)	YES
LON8_L04_CoolingUnits_ 01	N/A	N/A
LON8_L04_CoolingUnits_ 02	N/A	N/A
LON8_L04_CoolingUnits_ 03	N/A	N/A
LON8_L04_CoolingUnits_ 04	N/A	N/A
LON8_L04_DataHall_ 01	N/A	N/A
LON8_L04_DataHall_02	N/A	N/A

Page 5 of 8

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON8_L02_Office_01	YES (+35.1%)	YES
LON8_L02_CoolingUnits_ 01	N/A	N/A
LON8_L02_CoolingUnits_ 02	N/A	N/A
LON8_L02_CoolingUnits_ 03	N/A	N/A
LON8_L02_CoolingUnits_ 04	N/A	N/A
LON8_L02_DataHall_ 01	N/A	N/A
LON8_L02_DataHall_02	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	25882.7	25882.7
External area [m²]	20467.3	20467.3
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	7247.78	5987.37
Average U-value [W/m²K]	0.35	0.29
Alpha value* [%]	25	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
4	**General Industrial and Special Industrial Groups**
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
96	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	3.51	1.7
Cooling	125.37	228.64
Auxiliary	51.2	50.13
Lighting	12.2	20.84
Hot water	1.06	0.96
Equipment*	1093.64	1093.64
TOTAL**	**193.33**	**302.27**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	2.32	0.88
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*2.32*	*0.88*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	3802.03	3821.11
Primary energy [kWh_{PE}/m^2]	281.7	444.27
Total emissions [kg/m²]	25.84	40.69

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Variable refrigerant flow, [HS] ASHP, [HFT] Electricity, [CFT] Electricity									
Actual	231.5	92.8	11.1	3.7	10	5.8	6.92	5.79	9.96
Notional	2.1	149.6	0.2	9	15.6	2.78	4.63	----	----
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity									
Actual	0	5141.1	0	171	67.4	5.07	8.35	5.79	9.96
Notional	0	5194.9	0	311.6	65.5	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity									
Actual	47.3	0	14.7	0	5	0.89	0	1	0
Notional	59.6	0	11.7	0	2.4	1.41	0	----	----

Outlined Component BRUKL – Be Green (Innovation Hub)

Administrative information

Building Details

Address:

Certifier details

Name: Cundall

Telephone number: 020 7438 1600

Address: One Carter Ln, London, EC4V 5EY

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.26

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.26

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 235.8

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	3.84	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	2.12	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	41.49	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	22.29	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.18	0.18	NN000000:Surf[0]
Floors	0.18	0.15	0.15	NN000000:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	NN00001E:Surf[2]
Windows** and roof windows	1.6	1.46	1.6	NN000013:Surf[2]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.6	1.6	NN000013:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW Admin Block with Chiller BeGreen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	5.79	0	1	0.76
Standard value	2.5*	4.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for air-cooled chillers >=400 kW. For chillers <400 kW, limiting SEER is 4.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
Inn Hub_00_Water Tanks	-	-	-	-	-	-	-	0.3	-	-	N/A
Inn Hub_00_BOH	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Inn Hub_00_Water Tanks	120	-	-
Inn Hub_00_BOH	120	-	-
Inn Hub_00_Cafe	120	-	-
Inn Hub_00_Life Safety Electrical Room	120	-	-
Inn Hub_00_Lobby 1	120	-	-
Inn Hub_00_Lobby 2	120	-	-
Inn Hub_00_Lobby 3	120	-	-
Inn Hub_00_Main Electrical Room	120	-	-
Inn Hub_00_Reception	120	90	1.5
Inn Hub_00_Stairs 1	120	-	-
Inn Hub_00_Stairs 2	120	-	-
Inn Hub_00_TBC	120	-	-
Inn Hub_01_BOH	120	-	-
Inn Hub_01_Lab 1	120	-	-
Inn Hub_01_Lab 2	120	-	-
Inn Hub_01_Lab 3	120	-	-
Inn Hub_01_Lab 4	120	-	-
Inn Hub_01_Corridor	120	-	-
Inn Hub_01_Lobby 2	120	-	-
Inn Hub_01_Lobby 1	120	-	-
Inn Hub_01_Lobby 3	120	-	-
Inn Hub_01_Stairs 1	120	-	-
Inn Hub_01_Stairs 2	120	-	-
Inn Hub_01_WC	140	-	-
Inn Hub_01_WC	140	-	-

Page 3 of 7

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Inn Hub_02_BOH	120	-	-
Inn Hub_02_Lab 1	120	-	-
Inn Hub_02_Lab 2	120	-	-
Inn Hub_02_Lab 3	120	-	-
Inn Hub_02_Lab 4	120	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Inn Hub_00_Water Tanks	N/A	N/A
Inn Hub_00_BOH	N/A	N/A
Inn Hub_00_Cafe	NO (-44.2%)	NO

Page 4 of 7

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Inn Hub_00_Life Safety Electrical Room	N/A	N/A
Inn Hub_00_Main Electrical Room	N/A	N/A
Inn Hub_00_Reception	NO (-64.9%)	NO
Inn Hub_00_TBC	N/A	N/A
Inn Hub_01_Lab 1	NO (-70.6%)	NO
Inn Hub_01_Lab 2	NO (-65.6%)	NO
Inn Hub_01_Lab 3	NO (-67.4%)	NO
Inn Hub_01_Lab 4	NO (-40.1%)	NO
Inn Hub_01_WC	N/A	N/A
Inn Hub_01_WC	N/A	N/A
Inn Hub_02_Lab 1	NO (-67%)	NO
Inn Hub_02_Lab 2	NO (-62.2%)	NO
Inn Hub_02_Lab 3	NO (-64.7%)	NO
Inn Hub_02_Lab 4	NO (-34.1%)	NO
Inn Hub_02_WC	N/A	N/A
Inn Hub_02_WC	N/A	N/A
Inn Hub_03_Lab 1	NO (-59.2%)	NO
Inn Hub_03_Lab 2	NO (-52%)	NO
Inn Hub_03_Lab 3	NO (-55%)	NO
Inn Hub_03_Lab 4	NO (-32.1%)	NO
Inn Hub_03_WC	N/A	N/A
Inn Hub_03_WC	N/A	N/A
Inn Hub_04_Acc WC	N/A	N/A
Inn Hub_04_Lecture Hall 1	NO (-60.4%)	NO
Inn Hub_04_WC	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	1907	1907
External area [m²]	3703.8	3703.8
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	1394.38	1452.02
Average U-value [W/m²K]	0.38	0.39
Alpha value* [%]	26.42	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
53	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
47	**Residential Institutions: Universities and Colleges**
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	3.88	4
Cooling	2.33	3.43
Auxiliary	7.55	7.53
Lighting	8	12.27
Hot water	0.56	0.78
Equipment*	30.38	30.38
TOTAL**	**22.33**	**28.01**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	7.36	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*7.36*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	110.74	97.18
Primary energy [kWh_{PE}/m^2]	22.29	41.49
Total emissions [kg/m²]	2.12	3.84

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	116.4	62.8	6.3	3.8	12.2	5.15	4.63	5.79	5.79
	Notional	64.8	92.4	6.5	5.5	12.2	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Appendices E – Detailed Component BRUKL – Be Lean

Detailed Component BRUKL – Be Lean (LON06)

Administrative information

Building Details

Address:

Certifier details

Name: Cundall

Telephone number: 020 7438 1600

Address: One Carter Ln, London, EC4V 5EY

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.26

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.26

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 3320

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	48.02	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	28.02	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	524.95	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	306.1	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.18	0.18	LN00000D:Surf[0]
Floors	0.18	0.15	0.15	LN00009C:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	LN000016:Surf[6]
Windows** and roof windows	1.6	1.4	1.4	LN000074:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.51	1.6	LN000016:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW Admin Block BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

2- CHW (Data Hall) BeLean

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.09	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
LON 06_00_Asset Office 01	-	-	-	-	-	-	-	0.3	-	-	N/A
LON 06_00_BMS 01	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON 06_01_Data Hall 01	175	-	-
LON 06_01_Data Hall 02	175	-	-
LON 06_01_Data_Circulation 01	164	-	-
LON 06_01_Data_Circulation 02	164	-	-
LON 06_01_Data_Circulation 03	164	-	-
LON 06_01_Data_Circulation 04	164	-	-
LON 06_01_DCIM 01	164	-	-
LON 06_01_DCIM 02	164	-	-
LON 06_01_DCIM 03	164	-	-
LON 06_01_DCIM 04	164	-	-
LON 06_01_First Aid Rm 01	104	-	-
LON 06_01_Lobby 01	164	-	-
LON 06_01_Lobby 02	164	-	-
LON 06_01_Lobby 03	143	-	-
LON 06_01_Lobby 04	143	-	-
LON 06_01_Office 01	104	-	-
LON 06_01_Office 01 Perimeter 01	104	-	-
LON 06_01_Office 01 Perimeter 02	104	-	-
LON 06_01_Office 01 Perimeter 03	104	-	-
LON 06_01_Security Eqp Room 01	164	-	-
LON 06_01_Shower 01	140	-	-
LON 06_01_Shower 02	140	-	-
LON 06_01_Shower 03	140	-	-
LON 06_01_Shower 04	140	-	-
LON 06_01_Shower 05	140	-	-
LON 06_01_Shower 06	140	-	-
LON 06_01_Shower 07	140	-	-
LON 06_01_Shower 08	140	-	-
LON 06_01_Stair 01	143	-	-
LON 06_01_Stair 02	143	-	-
LON 06_01_Stair 03	143	-	-
LON 06_01_Storage 01	164	-	-
LON 06_01_Storage 02	164	-	-
LON 06_01_Toilet 01	140	-	-
LON 06_01_Toilet 02	140	-	-
LON 06_01_Toilet 03	140	-	-
LON 06_01_Toilet 04	140	-	-
LON 06_02_ACC Shower WC 01	140	-	-
LON 06_02_Cleaner 01	140	-	-
LON 06_02_Corridor 01	164	-	-
LON 06_02_Corridor 02	164	-	-
LON 06_02_CRAH Corridor 01	164	-	-
LON 06_02_CRAH Corridor 02	164	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 06_00_Asset Office 01	N/A	N/A
LON 06_00_BMS 01	NO (-100%)	NO
LON 06_00_BMS 02	NO (-99.9%)	NO
LON 06_00_Data_BTU 01	N/A	N/A
LON 06_00_Data_BTU 02	N/A	N/A
LON 06_00_Data_Circulation 01	N/A	N/A
LON 06_00_Data_Circulation 02	N/A	N/A
LON 06_00_Data_Lobby 01	N/A	N/A
LON 06_00_Data_Lobby 02	N/A	N/A
LON 06_00_Data_Lobby 03	N/A	N/A
LON 06_00_Data_Lobby 04	N/A	N/A
LON 06_00_Data_Lobby 05	N/A	N/A
LON 06_00_Data_Lobby 06	N/A	N/A
LON 06_00_Data_Lobby 07	N/A	N/A
LON 06_00_Data_Lobby 08	N/A	N/A
LON 06_00_Data_MMR 01	N/A	N/A
LON 06_00_Data_MMR 02	N/A	N/A
LON 06_00_Data_MMR 03	N/A	N/A
LON 06_00_Data_MMR 04	N/A	N/A

Page 13 of 19

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 06_00_DH MV Switchroom 01	N/A	N/A
LON 06_00_DH MV Switchroom 02	N/A	N/A
LON 06_00_DH MV Switchroom 03	NO (-100%)	NO
LON 06_00_DH MV Switchroom 04	NO (-100%)	NO
LON 06_00_Entrance Lobby 01	YES (+7.1%)	NO
LON 06_00_Fire Control Rm 01	N/A	N/A
LON 06_00_Generator Room 01	NO (-100%)	NO
LON 06_00_Generator Room 02	N/A	N/A
LON 06_00_Generator Room 03	N/A	N/A
LON 06_00_Generator Room 04	NO (-100%)	NO
LON 06_00_Generator Room 05	N/A	N/A
LON 06_00_Generator Room 06	N/A	N/A
LON 06_00_Generator Room 07	N/A	N/A
LON 06_00_Generator Room 08	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	23237.7	23237.7
External area [m²]	25138.4	25138.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	5979.79	6449.61
Average U-value [W/m²K]	0.24	0.26
Alpha value* [%]	25.39	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
6	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
94	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	0.47	0.05
Cooling	148.36	268.99
Auxiliary	42.2	57.41
Lighting	16.52	29.73
Hot water	0.18	0.15
Equipment*	1282.43	1282.43
TOTAL**	**207.72**	**356.32**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	4436.75	4485.53
Primary energy [kWh_{PE}/m²]	306.1	524.95
Total emissions [kg/m²]	28.02	48.02

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	70.3	324.6	7	10.9	31.9	2.78	8.3	3.09	9.96
	Notional	7.3	327.9	0.7	19.7	26.9	2.78	4.63	----	----
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	0	5575.7	0	186.6	50.6	2.78	8.3	3.09	9.96
	Notional	0	5642.4	0	338.4	70.2	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Appendices F – Detailed Component BRUKL – Be Green

Detailed Component BRUKL – Be Green (LON06)

Administrative information

Building Details

Address:

Certifier details

Name: Cundall
Telephone number: 020 7438 1600
Address: One Carter Ln, London, EC4V 5EY

Certification tool

Calculation engine: Apache
Calculation engine version: 7.0.26
Interface to calculation engine: IES Virtual Environment
Interface to calculation engine version: 7.0.26
BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 3320

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	48.02	
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	27.64	
Target primary energy rate (TPER), $kWh_{PE}/m^2.annum$	524.95	
Building primary energy rate (BPER), $kWh_{PE}/m^2.annum$	301.84	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.18	0.18	LN00000D:Surf[0]
Floors	0.18	0.15	0.15	LN00009C:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	LN000016:Surf[6]
Windows** and roof windows	1.6	1.4	1.4	LN000074:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.51	1.6	LN000016:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- CHW Admin Block BeGreen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

2- CHW (Data Hall) BeGreen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.79	9.96	0	1	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.
^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I	Zone	Standard
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1		
LON 06_00_Asset Office 01	-	-	-	-	-	-	-	0.3	-	-	N/A
LON 06_00_BMS 01	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
LON 06_01_Data Hall 01	175	-	-
LON 06_01_Data Hall 02	175	-	-
LON 06_01_Data_Circulation 01	164	-	-
LON 06_01_Data_Circulation 02	164	-	-
LON 06_01_Data_Circulation 03	164	-	-
LON 06_01_Data_Circulation 04	164	-	-
LON 06_01_DCIM 01	164	-	-
LON 06_01_DCIM 02	164	-	-
LON 06_01_DCIM 03	164	-	-
LON 06_01_DCIM 04	164	-	-
LON 06_01_First Aid Rm 01	104	-	-
LON 06_01_Lobby 01	164	-	-
LON 06_01_Lobby 02	164	-	-
LON 06_01_Lobby 03	143	-	-
LON 06_01_Lobby 04	143	-	-
LON 06_01_Office 01	104	-	-
LON 06_01_Office 01 Perimeter 01	104	-	-
LON 06_01_Office 01 Perimeter 02	104	-	-
LON 06_01_Office 01 Perimeter 03	104	-	-
LON 06_01_Security Eqp Room 01	164	-	-
LON 06_01_Shower 01	140	-	-
LON 06_01_Shower 02	140	-	-
LON 06_01_Shower 03	140	-	-
LON 06_01_Shower 04	140	-	-
LON 06_01_Shower 05	140	-	-
LON 06_01_Shower 06	140	-	-
LON 06_01_Shower 07	140	-	-
LON 06_01_Shower 08	140	-	-
LON 06_01_Stair 01	143	-	-
LON 06_01_Stair 02	143	-	-
LON 06_01_Stair 03	143	-	-
LON 06_01_Storage 01	164	-	-
LON 06_01_Storage 02	164	-	-
LON 06_01_Toilet 01	140	-	-
LON 06_01_Toilet 02	140	-	-
LON 06_01_Toilet 03	140	-	-
LON 06_01_Toilet 04	140	-	-
LON 06_02_ACC Shower WC 01	140	-	-
LON 06_02_Cleaner 01	140	-	-
LON 06_02_Corridor 01	164	-	-
LON 06_02_Corridor 02	164	-	-
LON 06_02_CRAH Corridor 01	164	-	-
LON 06_02_CRAH Corridor 02	164	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 06_00_Asset Office 01	N/A	N/A
LON 06_00_BMS 01	NO (-100%)	NO
LON 06_00_BMS 02	NO (-99.9%)	NO
LON 06_00_Data_BTU 01	N/A	N/A
LON 06_00_Data_BTU 02	N/A	N/A
LON 06_00_Data_Circulation 01	N/A	N/A
LON 06_00_Data_Circulation 02	N/A	N/A
LON 06_00_Data_Lobby 01	N/A	N/A
LON 06_00_Data_Lobby 02	N/A	N/A
LON 06_00_Data_Lobby 03	N/A	N/A
LON 06_00_Data_Lobby 04	N/A	N/A
LON 06_00_Data_Lobby 05	N/A	N/A
LON 06_00_Data_Lobby 06	N/A	N/A
LON 06_00_Data_Lobby 07	N/A	N/A
LON 06_00_Data_Lobby 08	N/A	N/A
LON 06_00_Data_MMR 01	N/A	N/A
LON 06_00_Data_MMR 02	N/A	N/A
LON 06_00_Data_MMR 03	N/A	N/A
LON 06_00_Data_MMR 04	N/A	N/A

Page 13 of 19

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
LON 06_00_DH MV Switchroom 01	N/A	N/A
LON 06_00_DH MV Switchroom 02	N/A	N/A
LON 06_00_DH MV Switchroom 03	NO (-100%)	NO
LON 06_00_DH MV Switchroom 04	NO (-100%)	NO
LON 06_00_Entrance Lobby 01	YES (+7.1%)	NO
LON 06_00_Fire Control Rm 01	N/A	N/A
LON 06_00_Generator Room 01	NO (-100%)	NO
LON 06_00_Generator Room 02	N/A	N/A
LON 06_00_Generator Room 03	N/A	N/A
LON 06_00_Generator Room 04	NO (-100%)	NO
LON 06_00_Generator Room 05	N/A	N/A
LON 06_00_Generator Room 06	N/A	N/A
LON 06_00_Generator Room 07	N/A	N/A
LON 06_00_Generator Room 08	N/A	N/A

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	23237.7	23237.7
External area [m²]	25138.4	25138.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	5979.79	6449.61
Average U-value [W/m²K]	0.24	0.26
Alpha value* [%]	25.39	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
6	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
94	**Others: Miscellaneous 24hr Activities**
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	0.25	0.05
Cooling	148.36	268.99
Auxiliary	42.2	57.41
Lighting	16.52	29.73
Hot water	0.09	0.15
Equipment*	1282.43	1282.43
TOTAL**	**207.42**	**356.32**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	2.59	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*2.59*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	4436.75	4485.53
Primary energy [kWh_{PE}/m^2]	301.84	524.95
Total emissions [kg/m²]	27.64	48.02

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity									
Actual	70.3	324.6	3.8	10.9	31.9	5.15	8.3	5.79	9.96
Notional	7.3	327.9	0.7	19.7	26.9	2.78	4.63	----	----
[ST] Fan coil systems, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity									
Actual	0	5575.7	0	186.6	50.6	5.15	8.3	5.79	9.96
Notional	0	5642.4	0	338.4	70.2	2.78	4.63	----	----
[ST] No Heating or Cooling									
Actual	0	0	0	0	0	0	0	0	0
Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Appendices G – Overheating Risk Assessment Inputs and Results

LON06 Operational Profiles

The lighting, occupancy, equipment, heating, cooling, and ventilation plant are assumed to operate between 24 hours, seven days a week.

LON6 Internal Gains Loads

For the overheating assessment, assumptions have been made on internal heat gains. The following tables summarize the gains related to lighting, equipment and occupancy as well as the profiles.

	Lighting		Equipment	
	Gain (W/m²)	Profile	Peak (W/m2)	Profile
Open Office Security Office Manager's Office Asset Office	12	On continuously	15	On continuously
Circulation / Storage / WC	12	On continuously	-	On continuously
Reception	12	On continuously	15	On continuously
Meeting room	12		15	
Security Equipment Room	12	On continuously	15	On continuously

Table G-1: LON6 Internal gains from lighting and equipment

	Occupancy				
	People	Occupancy Rate (m^2/person)	Sensible Gain (W/person)	Latent Gain (W/person)	Profile
Open Office	-	10	90	60	On continuously
Security Office	-	10			
Manager's Office	-	10			
Asset Office	-	10			
Circulation / Storage / WC	-	-	-	-	-
Reception	-	10	90	60	On continuously
Meeting room	6	-	90	60	On continuously
Security Equipment Room	-	10	90	60	On continuously

Table G-2: LON6 Internal gains from occupancy

	Minimum Clothing Level	Maximum Clothing Level	Metabolic rate
Open Office	0.55	1.0	1.2
Security Office	0.55	1.0	1.2
Manager's Office	0.55	1.0	1.2
Meeting Room	0.55	1.0	1.2

Table G-3: LON6 Clothing level and metabolic rate

LON06 Results

Current Weather File (London_LHR_DSY1_2020High50.epw)

London_LHR_DSY1_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
LON 06_00_Asset Office 01	21	24	-0.35	0.35	7.56	Pass
LON 06_00_Manager Office 01	21	24	-0.31	0.15	6.97	Pass
LON 06_00_Security Office 01	21	24	-0.30	0.21	6.89	Pass
LON 06_01_Office 01	21	24	-0.35	0.35	7.56	Pass
LON 06_01_Office 01 Perimeter 01	21	24	-0.37	0.37	7.92	Pass
LON 06_01_Office 01 Perimeter 02	21	24	-0.38	0.43	8.95	Pass
LON 06_01_Office 01 Perimeter 03	21	24	-0.38	0.40	8.27	Pass
LON 06_02_Office 01	21	24	-0.35	0.35	7.55	Pass
LON 06_02_Office 01 Perimeter 01	21	24	-0.37	0.37	7.89	Pass
LON 06_02_Office 01 Perimeter 02	21	24	-0.38	0.43	8.88	Pass
LON 06_02_Office 01 Perimeter 03	21	24	-0.38	0.39	8.21	Pass
LON 06_02_Office 02	21	24	-0.35	0.34	7.49	Pass
LON 06_03_Office 01	21	24	-0.36	0.36	7.63	Pass
LON 06_03_Office 01 Perimeter 03	21	24	-0.38	0.39	8.15	Pass
LON 06_03_Office 01 Perimeter 01	21	24	-0.38	0.38	7.95	Pass
LON 06_03_Office 01 Perimeter 02	21	24	-0.38	0.43	8.84	Pass
LON 06_04_Office 01	21	24	-0.36	0.37	7.81	Pass

Future Weather File (London_LHR_DSY2_2020High50.epw)

London_LHR_DSY2_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
LON 06_00_Asset Office 01	21	24	-0.36	0.35	7.62	Pass
LON 06_00_Manager Office 01	21	24	-0.32	0.16	7.16	Pass
LON 06_00_Security Office 01	21	24	-0.33	0.21	7.23	Pass
LON 06_01_Office 01	21	24	-0.35	0.35	7.62	Pass
LON 06_01_Office 01 Perimeter 01	21	24	-0.37	0.37	7.90	Pass
LON 06_01_Office 01 Perimeter 02	21	24	-0.39	0.43	8.79	Pass
LON 06_01_Office 01 Perimeter 03	21	24	-0.38	0.40	8.42	Pass
LON 06_02_Office 01	21	24	-0.35	0.36	7.63	Pass
LON 06_02_Office 01 Perimeter 01	21	24	-0.37	0.37	7.91	Pass
LON 06_02_Office 01 Perimeter 02	21	24	-0.38	0.43	8.78	Pass
LON 06_02_Office 01 Perimeter 03	21	24	-0.38	0.40	8.36	Pass
LON 06_02_Office 02	21	24	-0.35	0.35	7.52	Pass
LON 06_03_Office 01	21	24	-0.36	0.36	7.68	Pass
LON 06_03_Office 01 Perimeter 03	21	24	-0.38	0.40	8.28	Pass
LON 06_03_Office 01 Perimeter 01	21	24	-0.38	0.38	7.99	Pass
LON 06_03_Office 01 Perimeter 02	21	24	-0.40	0.45	8.65	Pass
LON 06_04_Office 01	21	24	-0.36	0.36	7.76	Pass

Future Weather File (London_LHR_DSY3_2020High50.epw)

London_LHR_DSY3_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
LON 06_00_Asset Office 01	21	24	-0.35	0.36	7.64	Pass
LON 06_00_Manager Office 01	21	24	-0.33	0.18	7.21	Pass
LON 06_00_Security Office 01	21	24	-0.32	0.22	7.19	Pass
LON 06_01_Office 01	21	24	-0.35	0.36	7.62	Pass
LON 06_01_Office 01 Perimeter 01	21	24	-0.37	0.38	7.98	Pass
LON 06_01_Office 01 Perimeter 02	21	24	-0.38	0.48	9.72	Pass
LON 06_01_Office 01 Perimeter 03	21	24	-0.38	0.38	8.07	Pass
LON 06_02_Office 01	21	24	-0.35	0.35	7.62	Pass
LON 06_02_Office 01 Perimeter 01	21	24	-0.37	0.38	7.96	Pass
LON 06_02_Office 01 Perimeter 02	21	24	-0.38	0.47	9.68	Pass
LON 06_02_Office 01 Perimeter 03	21	24	-0.38	0.38	8.02	Pass
LON 06_02_Office 02	21	24	-0.35	0.35	7.53	Pass
LON 06_03_Office 01	21	24	-0.36	0.36	7.69	Pass
LON 06_03_Office 01 Perimeter 03	21	24	-0.38	0.38	8.01	Pass
LON 06_03_Office 01 Perimeter 01	21	24	-0.38	0.37	7.94	Pass
LON 06_03_Office 01 Perimeter 02	21	24	-0.40	0.47	9.57	Pass
LON 06_04_Office 01	21	24	-0.36	0.37	7.79	Pass

Innovation Hub Internal Gains Loads

For the overheating assessment, assumptions have been made on internal heat gains. The following tables summarize the gains related to lighting, equipment and occupancy as well as the profiles.

Table H-1: Internal gains from lighting and equipment

	Lighting		Equipment	
	Gain (W/m²)	Profile	Peak (W/m2)	Profile
Lab	12	Refer to table H-7 on profiles	15	Refer to table H-7 on profiles
Lecture Hall	12		15	
Cafe	12		15	
Reception	12		15	
Circulation / WC / Storage	12		-	
Plant	12		50	

Table G-4: Innovation Hub Internal gains from lighting and equipment

	Occupancy				
	People	Occupancy Rate (m^2/person)	Sensible Gain (W/person)	Latent Gain (W/person)	Profile
Lab	-	10	90	60	Refer to table H-7 on profiles
Lecture Hall	-	3	90	60	
Cafe	-	3	90	60	
Reception	-	10	90	60	
Circulation / WC / Storage	-	-	-	-	
Plant	-	-	-	-	

Table G-5: Innovation Hub Internal gains from occupancy

	Minimum Clothing Level	Maximum Clothing Level	Metabolic rate
Lab	0.6	1.13	1.2
Lecture Hall	0.6	1.10	1.2
Cafe	0.6	1.10	1.2
Reception	0.6	1.11	1.2

Table G-6: Innovation Hub Clothing level and metabolic rate

Internal Gains Profiles (Based on NCM Open Office Weekday profile)

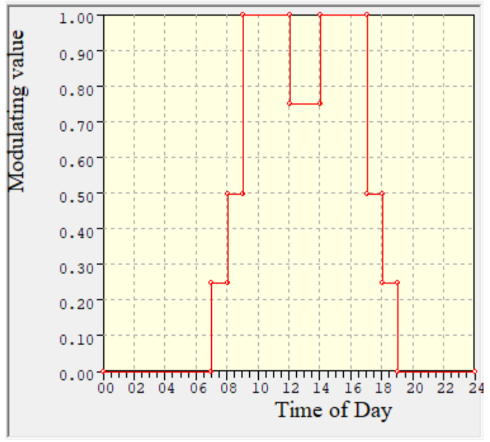
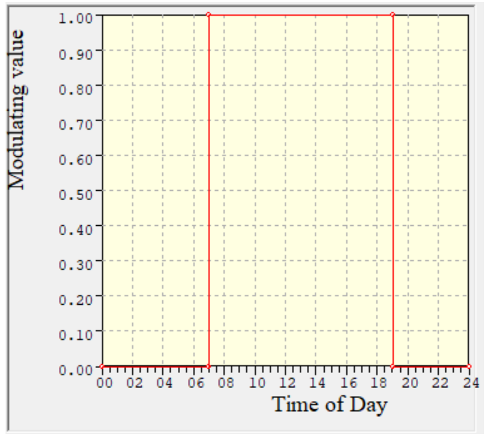
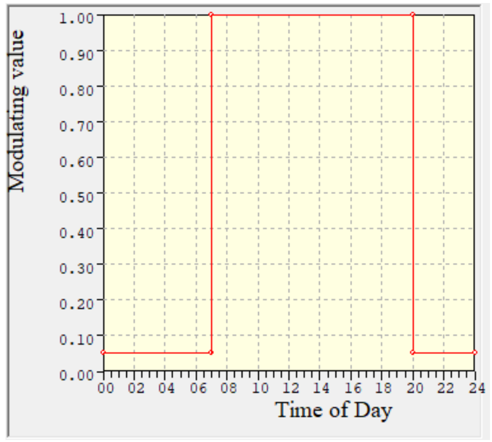
	Profile
Occupancy	
Lighting	
Equipment	

Table G-7: Heating and cooling set-points and profiles for all occupied spaces

Heating and Cooling Set-points Profiles

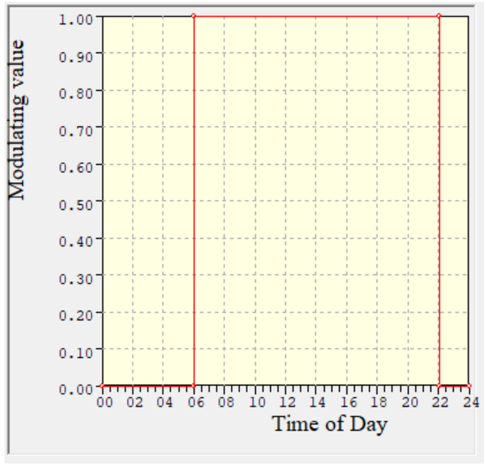
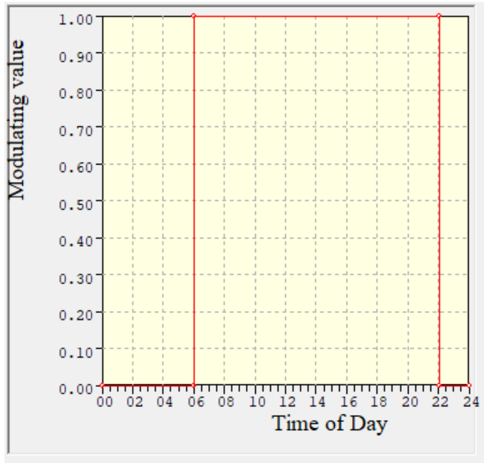
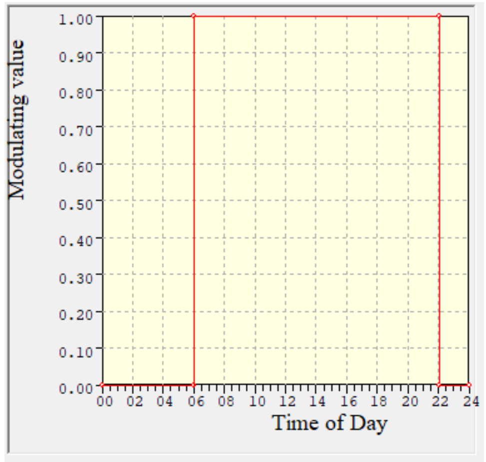
	Profile
Heating	
Cooling	
Mechanical ventilation	

Table G-8: Heating, cooling and mechanical ventilation set-points and profiles for all occupied spaces

Innovation Hub Results

Future Weather File (London_LHR_DSY1_2020High50.epw)

London_LHR_DSY1_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
Inn_Hub_00_Cafe	21	24	-0.39	0.39	8.18	Pass
Inn_Hub_00_Reception	21	24	-0.40	0.40	8.38	Pass
Inn_Hub_01_Lab 1	21	24	-0.40	0.41	8.43	Pass
Inn_Hub_01_Lab 2	21	24	-0.41	0.40	8.47	Pass
Inn_Hub_01_Lab 3	21	24	-0.41	0.40	8.46	Pass
Inn_Hub_01_Lab 4	21	24	-0.41	0.42	8.64	Pass
Inn_Hub_02_Lab 1	21	24	-0.41	0.40	8.44	Pass
Inn_Hub_02_Lab 2	21	24	-0.40	0.41	8.50	Pass
Inn_Hub_02_Lab 3	21	24	-0.41	0.40	8.44	Pass
Inn_Hub_02_Lab 4	21	24	-0.41	0.41	8.54	Pass
Inn_Hub_03_Lab 1	21	24	-0.40	0.41	8.53	Pass
Inn_Hub_03_Lab 2	21	24	-0.40	0.42	8.62	Pass
Inn_Hub_03_Lab 3	21	24	-0.41	0.41	8.49	Pass
Inn_Hub_03_Lab 4	21	24	-0.41	0.41	8.56	Pass
Inn_Hub_04_Lecture Hall 1	21	24	-0.39	0.39	8.25	Pass

Future Weather File (London_LHR_DSY2_2020High50.epw)

London_LHR_DSY2_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
Inn_Hub_00_Cafe	21	24	-0.39	0.40	8.33	Pass
Inn_Hub_00_Reception	21	24	-0.42	0.40	8.69	Pass
Inn_Hub_01_Lab 1	21	24	-0.41	0.40	8.51	Pass
Inn_Hub_01_Lab 2	21	24	-0.40	0.41	8.46	Pass
Inn_Hub_01_Lab 3	21	24	-0.41	0.41	8.47	Pass
Inn_Hub_01_Lab 4	21	24	-0.41	0.41	8.48	Pass
Inn_Hub_02_Lab 1	21	24	-0.40	0.41	8.52	Pass
Inn_Hub_02_Lab 2	21	24	-0.40	0.41	8.45	Pass
Inn_Hub_02_Lab 3	21	24	-0.39	0.41	8.48	Pass
Inn_Hub_02_Lab 4	21	24	-0.41	0.42	8.68	Pass
Inn_Hub_03_Lab 1	21	24	-0.41	0.40	8.44	Pass
Inn_Hub_03_Lab 2	21	24	-0.40	0.41	8.46	Pass
Inn_Hub_03_Lab 3	21	24	-0.40	0.41	8.45	Pass
Inn_Hub_03_Lab 4	21	24	-0.41	0.41	8.53	Pass
Inn_Hub_04_Lecture Hall 1	21	24	-0.38	0.39	8.11	Pass

Future Weather File (London_LHR_DSY3_2020High50.epw)

London_LHR_DSY3_2020High50	Temperature Ranges		PMV (-0.5<PMV<0.5)		PPD (%) (PPD <10%)	Result
	Min	Max	Min	Max	Max	
Inn_Hub_00_Cafe	21	24	-0.41	0.40	8.43	Pass
Inn_Hub_00_Reception	21	24	-0.46	0.41	9.37	Pass
Inn_Hub_01_Lab 1	21	24	-0.40	0.40	8.33	Pass
Inn_Hub_01_Lab 2	21	24	-0.40	0.40	8.38	Pass
Inn_Hub_01_Lab 3	21	24	-0.41	0.40	8.50	Pass
Inn_Hub_01_Lab 4	21	24	-0.42	0.41	8.59	Pass
Inn_Hub_02_Lab 1	21	24	-0.41	0.41	8.44	Pass
Inn_Hub_02_Lab 2	21	24	-0.40	0.41	8.44	Pass
Inn_Hub_02_Lab 3	21	24	-0.41	0.41	8.45	Pass
Inn_Hub_02_Lab 4	21	24	-0.41	0.41	8.58	Pass
Inn_Hub_03_Lab 1	21	24	-0.40	0.41	8.46	Pass
Inn_Hub_03_Lab 2	21	24	-0.41	0.41	8.49	Pass
Inn_Hub_03_Lab 3	21	24	-0.41	0.41	8.55	Pass
Inn_Hub_03_Lab 4	21	24	-0.43	0.41	8.85	Pass
Inn_Hub_04_Lecture Hall 1	21	24	-0.39	0.39	8.25	Pass

Cundall Johnston & Partners LLP
One Carter Lane London EC4V 5ER Tel:+44 (0)20 7438 1600

Asia Australia Europe MENA UK and Ireland
www.cundall.com

ZERO CARBON DESIGN 2030