Sainsbury Wellcome Centre

SWC 5th Quad Support Building

Energy Statement

SWC-ARUP-5Q -XX-RP-M-000001

Issue 2 | 24 September 2021

Job number 276600

Ove Arup & Partners Ltd
8 Fitzroy Street
London
W1T 4BJ
United Kingdom
www.arup.com

ARUP

Document verification

ARUP

Job title		SWC 5th Quad Support Building			**Job number** 276600
Document title		Energy Statement			**File reference**
Document ref		SWC-ARUP-5Q -XX-RP-M-000001			
Revision	**Date**	**Filename**	Energy Statement.docx		
Draft 1	23 Jul 2021	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Sophia Rawlins	Darren Barlow	Darren Barlow
		Signature			
Issue 1	30 Jul 2021	Filename	210728 Energy Statement.docx		
		Description	Issue to architect		
			Prepared by	Checked by	Approved by
		Name	Sophia Rawlins	Michael Bradbury	Michael Bradbury
		Signature			
Issue 2	24 Sep 2021	Filename	210924 Energy Statement.docx		
		Description	Planning submission		
			Prepared by	Checked by	Approved by
		Name	Sophia Rawlins	Darren Barlow	Darren Barlow
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document verification with document ✓

Contents

1 Executive Summary

SWC have identified that neuroscience continues to be a fast-evolving field. The importance of large-scale collaboration between labs and external partners is growing, placing increased demand on the core facilities at SWC. In conjunction with this, there has been a shift in the nature of research, with an emphasis placed on data analysis, which requires additional space outside the lab. In order to ensure the facility can keep pace with the changes within the field of neuroscience research, and maintain its ability to attract extramural funding, SWC has identified a critical need to add a set of support facilities to the existing building.

The 5th Quad support building provides 905m² (GIA) of internal accommodation on floors 1-5, each floor level with the existing building. These spaces will be used as workspace, IT support services, meeting space and welfare facilities. Ground level will remain as external, with the 5th Quad providing a sheltered outdoor space. No new vertical circulation or additional heating and cooling plant is proposed as part of the new building.

The 5th Quad will stand separately from the current SWC, located within the south courtyard. A series of bridge links to the north and west provide a vital link for access to stairs, lifts and service connections in the main building. The new 5th Quad Support Building for the Sainsbury Wellcome Centre falls within the medium sized (500-1000sqm GIA) Non-domestic New Building (assessed under L2A) category of the Camden Planning Guidance.
The SWC 5th Quad Support Building proposal is an adaptable and forward-thinking design that is responsive to the future direction of building design in London. Design measures have been implemented to manage overheating and to ensure highly efficient building fabric, based on latest guidance supporting the transition to low and zero carbon buildings.

This document details the specific elements of the deign that address the GLA's 2020 Energy Assessment Guidance and follows the four-tier hierarchy of carbon emissions reduction. These are passive measures (Be Lean), the feasibility and connection to district systems (Be Clean), the introduction of low & zero carbon technologies (Be Green), and the monitoring and reporting of energy performance (Be Seen).

The approach to the energy efficiency measures within the 5th Quad has been holistic. The strategies and technologies selected have been considered for their appropriateness to ensure that it will be as energy efficient as practicable whilst meeting the projects other aspirations.

This report sets out the improvements in carbon reduction using both SAP2012 and SAP10 carbon emissions factors.

The key energy saving measures implemented in the design are:

Be Lean:

- Solar gains are limited through the optimisation of glazing sizes and implementation of high-performance glazing and highly reflective internal blinds. The building takes advantage of shading from surrounding buildings.
- Façade performance criteria has been developed to reduce heating and cooling loads, through low U values and high levels of air tightness.
- For much of the year, all occupied spaces will be naturally ventilated via occupant operated windows.
- When windows are closed, mechanical ventilation will be provided by a modular façade integrated ventilation unit with high efficiency heat recovery.
- Cooling to the workspaces is efficiently delivered via a modular displacement system.
- Demand control ventilation by CO_2 sensors, ensuring the fresh air ventilation to non-occupied spaces can be reduced and even shut off.
- High efficiency lighting used throughout, with intelligent lighting control systems.

Be Clean:

- The 5th Quad will connect to the main building's existing CHP to make use of waste heat.

We have appraised the application of all on-site renewable energy technologies and conclude they are not technically viable on the building. The SWC 5th Quad Support Building does not therefore meet the Camden Council requirement for a 20% reduction in CO2 from on-site renewables.

Submetering of each individual use class is included in the design to help assess energy performance of the building in operation against the as-designed target as part of Be Seen. The project is considering a NABERS rating, whereby the actual energy performance of the building will be assessed annually and a NABERS rating awarded. The NABERS rating of the building would be publicly visible.

The measures listed above and described in this report achieve a cumulative carbon emission saving of **36%** (SAP2012) or **33%** (SAP10) against the TER Baseline, meeting the required 35% improvement set by the GLA. The 'Be Lean' Measures achieve a reduction of 28% (SAP2012) or 34% (SAP10) before the CHP system is added, as required by the GLA. Figure 1 and 2 show the emissions reductions achieved through the stages of the energy hierarchy using SAP2012 and SAP10 respectively. The client is committed to achieving the on-site carbon emissions reduction. The final means of achieving this will be refined in the next stage design of the 5th Quad.

Based on GLA and LBC policy, a carbon offset payment is calculated using £95 per tonne of CO_2 for 30 years. Following the GLA calculation principles, this would result in a total payment of £34,772 (SAP10) or £55,718 (SAP2012). The final value will be agreed between the client and Camden Council.

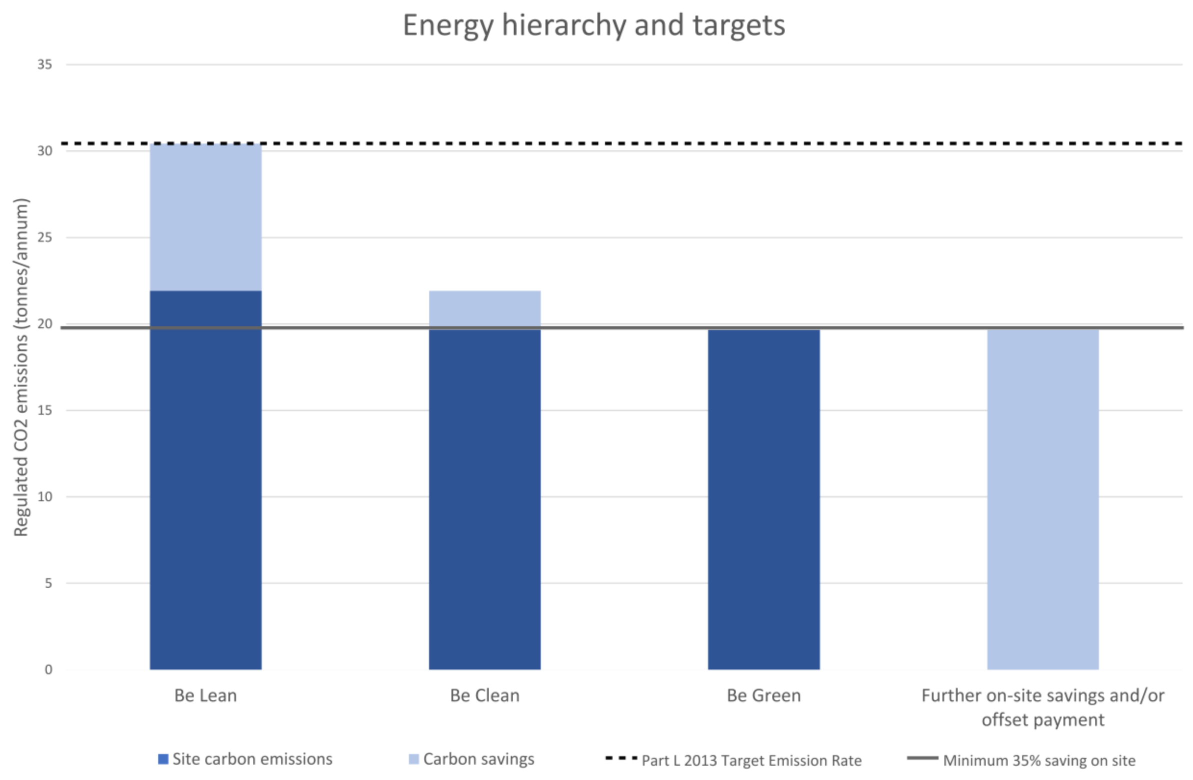

Figure 1 - Carbon reductions achieved through the energy hierarchy – SAP2012

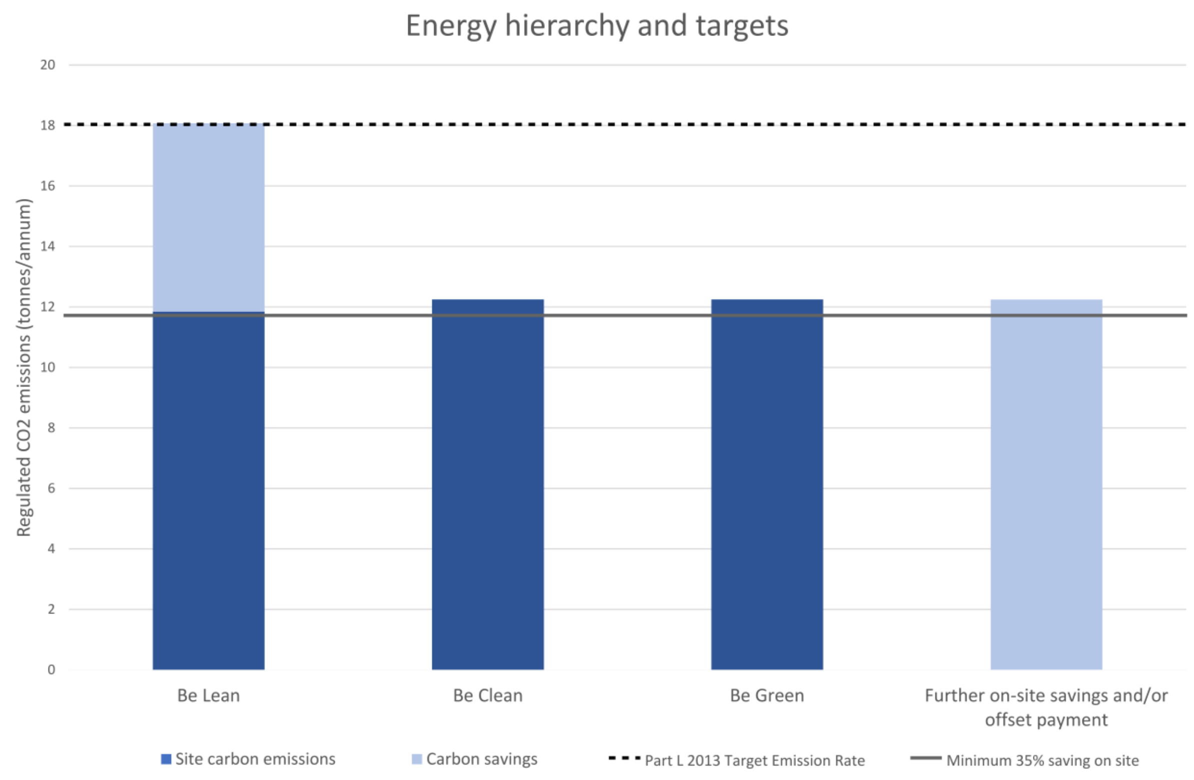

Figure 2 - Carbon reductions achieved through the energy hierarchy – SAP10

In accordance with the London Plan energy master planning guidance and heating network hierarchy provision has been made within the SWC building to connect the future district heat networks anticipated along the Euston Rd. The new building is future proofed to become a net zero carbon building by either connecting to a zero-carbon heat network or transitioning to heat pumps. The buildings heating water temperatures have been selected to enable the building to utilise electric heat pumps with zero carbon electricity source.

2 Introduction

This statement sets out the proposed energy strategy for SWC 5th Quad Support Building. It presents the results of the modelled carbon emissions improvements against their respective baseline and contains information of the energy efficiency measures proposed in the design.

2.1 Background

The 5th Quad support building provides 905m² (GIA) of internal accommodation on floors 1-5, each floor level with the existing building. These spaces will be used as workspace, IT support services, meeting space and welfare facilities. Ground level will remain as external, with the 5th Quad providing a sheltered outdoor space.

The 5th Quad will not have standalone heating and cooling generation equipment, instead connecting to the main building's existing heating and cooling systems. The main building has a 650kW CHP engine that feeds the SWC heating system and in 2020 connections were extended to the Astor College development adjacent to the site.

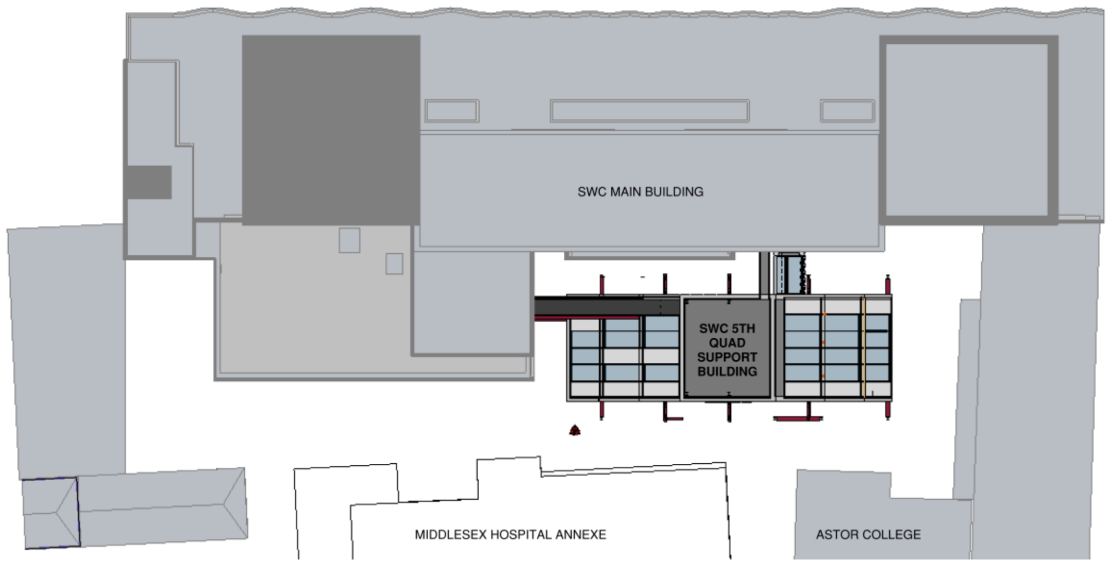

Figure 3 - The SWC site

Sustainability is a key driver for the project and influences all design decisions. The re-use of the existing SWC substructure combined with the light weight CLT slabs has led to significant savings in embodied carbon and the new MEP systems are designed to minimise operational carbon. The building is targeting BREEAM Excellent and seeks to be assessed under the NABERS rating scheme for operational energy performance. This is subject to agreement with SWC and appointment of a NABERS assessor.

The approach taken by the design team to reducing operational carbon emissions aligns with the Greater London Authority's (GLA) energy hierarchy. Reducing energy use through passive measures, such as optimised glazing, high efficiency lighting and efficient system selection, is prioritised. The 5th Quad also follows the London Plan energy master planning guidance and heating network hierarchy prioritising the new building's connection to the existing CHP plant. Previsions (street connections) were also made for future connection to a district heating network running along Euston Road.

3 Review of Regulation, Policy, and Guidance

This section presents the key relevant statutory and planning requirements and guidance which have informed the development of the energy strategy. It also highlights key policy and regulatory issues and sets out how the energy assessment has taken account of these matters.

3.1 Building Regulations

Energy in buildings is regulated by the provisions of Part L of the Building Regulations. The most recent version of Part L is 2013, which incorporates 2016 amendments. Part L covers the energy associated with the operation of buildings and include heating, hot water, cooling, ventilation, and lighting systems. Other energy uses, such as small power, cooking and IT equipment are unregulated.

Part L2A applies to new non-domestic developments and will therefore be considered for this project. There are no residential units in the 5th Quad.

SAP10 has not yet been adopted by the Building Regulations, however, it is stated within the GLA Energy Assessment Guidance (April 2020) that from January 2019 onwards, planning applicants are encouraged to use the SAP10 emission factors for referable applications that are in areas where there are no opportunities to connect to existing or planned district heating networks. As the SWC 5th Quad Support Building will make use of the waste heat from the main building's existing CHP plant, and there is a potential future connection to a district heating network, results will be presented using both SAP2012 and SAP10 factors. Table 1 states the proposed SAP 10 carbon factors in comparison to SAP 2012.

Table 1 - SAP2012 and SAP10

	Carbon Intensity, $kgCO_2/kWh$	
	SAP 2012	**Draft SAP10**
Mains Gas	0.216	0.210
Electricity	0.519	0.233

3.2 Planning Context and Vision

This statement has been prepared in response to the planning requirements and guidelines in the following documents:

- National Planning Policy Framework (June2019) and relevant planning practice guidance
- The London Plan (GLA, March 2021), Chapter 9 Sustainable Infrastructure
- Camden Planning Guidance, Energy Efficiency and Adaptation 2021
- Camden Local Plan 2017

3.2.1 The London Plan

The London Plan policies addressed in this submission include:

- SI2 – Minimising greenhouse gas emissions
- SI3 – Energy Infrastructure
- SI4 – Managing Heat Risk

The overarching principle for the project is to develop a low carbon energy solution in accordance with the Mayor's energy hierarchy, which meets or exceeds the overall carbon emissions targets defined in Policy SI2

Policy SI2 states that all major developments should be net-zero carbon. By following the energy hierarchy, carbon must be cut by a minimum of 35% beyond Building Regulations. Non-Domestic developments should aim to achieve 15% through energy efficiency measures alone.

The Energy Hierarchy is shown in Figure 4.

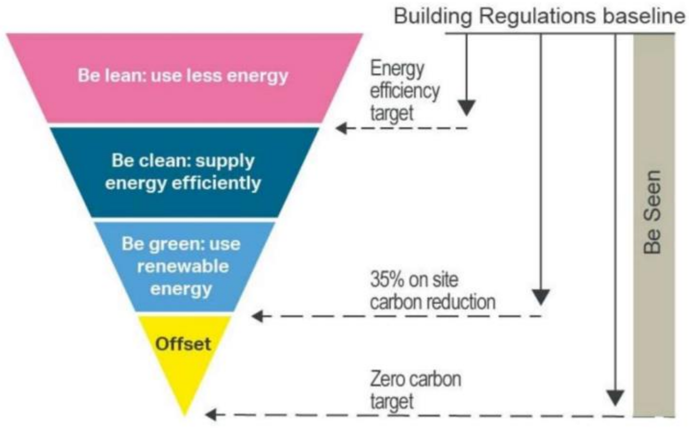

Figure 4 - The GLA Energy Hierarchy

Where it is clearly demonstrated that a zero-carbon target cannot be met on site, any shortfall should be provided through cash in lieu contributions to the relevant borough's carbon offset fund or off-site generation.

Policy SI3 outlines the new heating hierarchy, which will also be considered in the development of this energy assessment:

1. Connect to local existing or planned heat networks
2. Use Zero-emission or local secondary heat sources (in conjunction with heat pump, if required, and a lower temperature heating system)
3. Use low-emission combined heat and power (CHP), only where there is a case for CHP to enable the delivery of an area-wide heat network, meet the development's electricity demand and provide response to the local electricity network.
4. Use ultra-low NOx gas boilers.

Similarly, Policy SI4 of the adopted London Plan sets out the cooling hierarchy, which will also inform this assessment:

1. Reduce the amount of heat entering the building through orientation, shading, high albedo materials, fenestration, insulation, and the provision of green infrastructure
2. Minimise internal heat generation through energy efficient design
3. Manage the heat within the building through exposed thermal mass and high ceilings
4. Provide passive ventilation
5. Provide mechanical ventilation
6. Provide active cooling systems (ensuring they're the lowest carbon options)

3.2.2 Camden Energy Policy

The Camden Planning Guidance recommends the greatest possible reduction below Part L of 2013 Building Regulations (Local Plan CC1) for a the medium sized (500-1000sqm) Non-domestic New Building (assessed under L2A), and a 20% reduction in CO2 from onsite renewables (Local Plan CC1).

4 Energy Assessment Method

This section describes the method applied to the energy assessment. It identifies how relevant guidance was applied and highlights the approach taken in relation to key challenges.

4.1 Modelling Software

4.1.1 Regulated Emissions

To establish the carbon dioxide emission for each of the stages of the energy hierarchy, a government-approved software was used to assess the building's carbon emissions under Part L2A.

The carbon emissions were estimated using dynamic thermal modelling software, Integrated Environmental Solutions' Virtual Environment (IES VE 2021) software. The VE compliance module was used to generate a BRUKL report.

4.1.2 Unregulated Emissions

Unregulated emissions are defined as those resulting from non-regulated energy sources such as small power (computers, audio equipment and other electrical appliances). The additional emissions associated with unregulated elements are established by using individual end use figures from CIBSE Guide F guide baselines.

The unregulated emissions are provided as part of the output of the dynamic thermal model simulation from IES VE 2021.

5 Baseline

The baseline case for the energy hierarchy is the target emissions rate (TER). This is calculated as part of virtual environment (VE) compliance in IES where a notional building is created from the model with heating provided by gas boilers and cooling by electrically powered equipment.

The regulated and unregulated baseline carbon dioxide emissions calculated for the development are shown in Table 2.

Table 2 - Baseline Model Emissions

Baseline: Part L 2013 of the Building Regulations Compliant Development	**Carbon dioxide emissions (tonnes CO_2 per annum)**	
	Regulated	**Unregulated**
SAP2012	30.4	21.0
SAP10	18.1	9.4

6 Be Lean

This section examines the first step of the energy hierarchy for reducing carbon dioxide emissions, which involves reducing energy demand by adopting energy efficiency principles. These are considered on a holistic basis to optimise them for the development.

Through the design measures that are presented below, a carbon emission saving of 29% (SAP2012) or 35% (SAP10) is achieved by energy efficiency measures alone. This meets the Part L2A 2013 target for non-domestic building of 15% savings.

The energy efficiency measures discussed below split into two parts:

- **Passive interventions** – involve performance improvements through the building form and fabric.
- **Building systems interventions** – involve improvements to the efficiency of the building's systems.

Table 3 - Regulated carbon savings after be lean - SAP2012

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	30.4	21.0
After energy demand reduction (be lean)	21.9	21.0

Table 4 - Regulated carbon savings after be lean - SAP10

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	18.1	9.4
After energy demand reduction (be lean)	11.8	9.4

6.1 Passive Interventions

Optimising passive design is the most effect means, both in terms of carbon and financial terms, of ensuring the development is inherently low in energy use. The passive interventions taken in the design are described below.

6.1.1 Site Orientation

The 3D form of the 5th Quad has evolved as a function of floor space demand, connections to the existing SWC building, retaining an acceptable level of sunlight and daylight to the users of in Astor College (student accommodation) and the new residential and business occupants within the Middlesex Hospital Annex and the existing SWC amenity of the south courtyard. The detailed modelling has looked at the optimisation of sunlight and daylight through the east and west ends, initially using a stepped form and subsequently a sloping-sided form. This has informed an approach to the envelope based on a highly insulated north and south façade with small window openings avoiding overlooking of the neighbouring properties to the south and an increased use of glazing to east and west guided by thermal modelling.

6.1.2 Limiting Solar Gains

Limiting heat gains in the building is essential to implementing a more efficient cooling system. Internal gains from occupants and equipment are less easy for designers to control, and therefore the limiting of peaks in solar gain is an area where improvements can be made.

The extent and performance of glazing has been optimised to balance daylight with solar gain and achieve the target set above. Optimising the glazed area is a more cost-effective way of reducing solar gain compared to the use of external shading. External shading also comes with an embodied carbon penalty and can have a significant detrimental effect on internal daylight levels and views out, especially on east and west facades that experience a low sun angle.

The building takes advantage of shading from the surrounding developments, and therefore results in reduced solar irradiation. Internal blinds are proposed on the east and west facades and sloping glazing that limit the peak solar gains. The blinds will be automated deploying whenever the solar irradiance exceeds 250W/m^2 on the façade. The glazing will achieve a G-value of 0.38. The total glazing area as a percentage of total façade area is approximately 22.3%.

Table 5 - Blind type and application

Blind Type	Equivalent G-value	Application Area
Panama Pro 10% openness (white)	0.32	Level 1 E/W Level 1 North Bridge Link Level 2 East only Level 2 North Bridge Link
Panama Chrome 3% openness	0.23	Level 1 West Bridge Link (Southern glazing only) Level 2 West only Level 3 East / West + Bridge Link Level 4 East / West + Bridge Link Level 5 East / West + Bridge Link

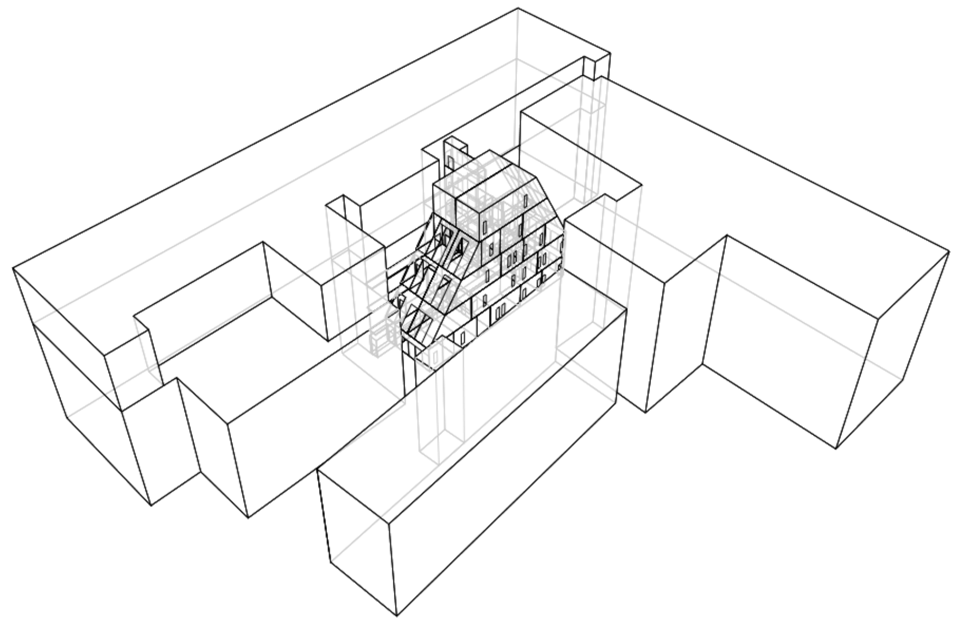

Figure 5 – Buildings surrounding SWC 5th Quad Support Building

6.1.3 Thermal Envelope Performance

The following table shows the minimum Part L2A fabric performance targets as well as the design values proposed for the 5th Quad. The highly efficient fabric performance has been developed using the latest guidance supporting the transition to low and zero carbon buildings such as the London Energy Transformation Initiative (LETI).

Table 6 - Facade U Values

	U Values, W/m^{2}K	
	Part L2A 2013	Proposed Design
Wall	0.35	0.13
Floor	0.25	0.12
Roof	0.25	0.12
Windows	2.2	1.40

Air tightness is important to limit the amount of unwanted air infiltration into the building. When the external temperatures are significantly higher or lower than the internal temperatures, infiltration increases the cooling and heating loads in the building. The façade will be specified to achieve a very good airtightness and careful design of the vertical and horizontal interfaces within the building envelope will be made.

Good practice construction techniques will be combined with airtightness tests at completion to ensure that the finished construction achieves the design values. A minimum airtightness value of 3m^3/m^2/h @50Pa has been targeted.

6.1.4 Thermal Mass

As the SWC 5th Quad Support Building is a lightweight structure of CLT floors and steel frame, there is no opportunity to use thermal mass.

6.1.5 Natural Ventilation

A significant portion of the energy usage of the building comes from cooling and therefore any reduction that can be made to this load will greatly reduce the overall carbon emissions of the building. The shallow floor plate and generous floor to ceiling heights lend this building to natural ventilation.

The ventilation systems will be mixed mode, allowing the occupiers to utilise natural ventilation when the outside conditions allow. Natural ventilation openings will be provided in all façade orientations and in every occupied room. The mixed mode strategy will improve comfort and occupier choice whilst also minimising energy usage, as when the windows are open the mechanical ventilation and cooling system will automatically shut down.

6.2 Energy Efficient Systems

6.2.1 Mechanical Ventilation

Façade integrated ventilation units will provide fresh air, as well as heating and cooling via displacement. Energy is recovered from the return air via a thermal wheel within the unit High efficiency fans will be used in the ventilation units.

The localised units offer a high degree of user control that is much simpler than a centralised solution as each unit will be associated with a room. The fresh air will be controlled on CO2 sensors, reducing the energy wasted by conditioning unoccupied spaces.

As façade integrated ventilation units are proposed, ductwork is minimised. There is no supply ductwork, and the small amount of ductwork extending the height of the return point to the ventilation units is generously sized to keep the pressure drop low.

The units will be interlocked with window contact sensors to minimise energy usage.

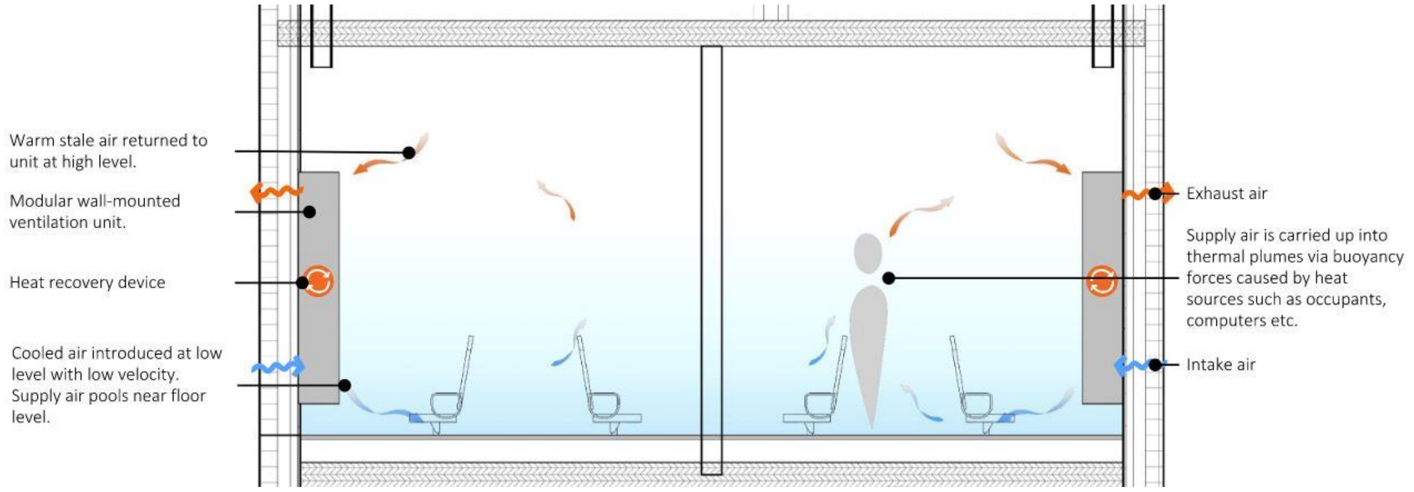

Figure 6 - Facade integrated ventilation units

6.2.2 Cooling

The façade integrated ventilation units will provide cooling to the rooms through displacement. The temperature range in the office has been expanded from BCO guidance of 21-24°C, to 20-26°C to further reduce energy use.

Cooling will be generated by the existing high efficiency air-cooled chillers located in the main building, using the redundant capacity within the system. The SWC 5th Quad Support Building will connect directly to the existing flow and return headers and will not have independent cooling generation equipment.

6.2.3 Heating

The SWC 5th Quad Support Building will connect on to the existing flow and return header of the main building, using the redundant capacity within the system. This is connected to highly efficient gas-fired boilers. The boilers are supplemented by an existing CHP engine which is appraised within the "Be Clean" section of this report.

6.2.4 Lighting

Low energy LED lighting will be used throughout the 5th Quad consistent with the existing building. This will make a significant contribution to carbon emission reduction.

Internal lux levels will be specified to suite the internal tasks within the development. Where possible, lower levels will be used.

Daylight dimming will be present both to optimise the light levels within the space but also to reduce the artificial light required and therefore the energy use. Additionally, the zones within the space will be carefully divided to ensure that the presence detection does not result in the whole floor lighting up, but only the area that's required.

7 Be Clean

This section outlines the second stage of the energy hierarchy set out in The London Plan. The measures that were considered are described below.

It is recommended that the SWC 5th Quad Support Building increases the utilisation and uses the waste heat energy from the existing CHP of the main building. A future connection to a heat network has already been allowed for and will be retained.

Through the connection to the CHP plant, a carbon emission saving of 7% (SAP2012) or -2% (SAP10) is achieved.

Table 7 - Heating Hierarchy

Heating Hierarchy	Technology	Recommendation	Notes
1	District Heating Network	Not feasible	Allowance made for future development.
2	Zero-Emission or local secondary heat source	Not recommended	Spare capacity in existing equipment favoured over new technology.
3	Combined Heat and Power (CHP)	Recommended	Proposal to connect to existing CHP engine heating.
4	Ultra-low NOx gas boilers	Not recommended	Spare capacity in existing equipment favoured over new technology.

Table 8 - Regulated carbon savings after be clean - SAP2012

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	30.4	21.0
After energy demand reduction (be lean)	21.9	21.0
After heat network connection (be clean)	19.7	21.0

Table 9 - Regulated carbon savings after be clean - SAP10

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	18.1	9.4
After energy demand reduction (be lean)	11.8	9.4
After heat network connection (be clean)	12.2	9.4

7.1 Combined Heat and Power

CHP is a low carbon technology, rather than a renewable, as the fuel source is natural gas. CHP uses gas to generate heat and electricity and for every hour that the CHP plant is running, it is generating lower cost electricity than could be purchased from the grid. The electricity generated mitigates against the transmission losses across the electricity grid which is currently reflected in the "Primary Energy Factor" in the UK of 1.5.

An existing 650kW thermal output Jenbacher CHP engine is located in the main Sainsbury Wellcome Trust building. It is connected to the SWC heating system and in 2020 extended to the Astor College development adjacent to the site.

We anticipate that our building will increase the heating demand by 90kW. This will increase the utilisation of the CHP by extending the operating hours throughout the year.

The team are seeking to explore the option for enhancing the control of the CHP engine to synchronise operation with the forecast carbon intensity of the London electricity grid. This will take data from the Electricity System Operator and operate the plant when the grid carbon intensity is high and provide data to the operations team on the overall carbon intensity though out the year.

7.2 Decentralised Heating, Cooling and Power

In accordance with the new heating hierarchy, primary consideration should be given to connect to an existing or planned heat network. This was considered during the design of the main building, and an allowance was made for connections into the LTHW system from a district heating network should one be available, which will be retained. The figure below shows all the current (red) and planned (orange) heat networks around the SWC 5th Quad Support Building site.

There are no existing or planned cooling networks in the vicinity of the SWC 5th Quad Support Building site, and therefore this measure cannot be considered in the energy strategy for this development.

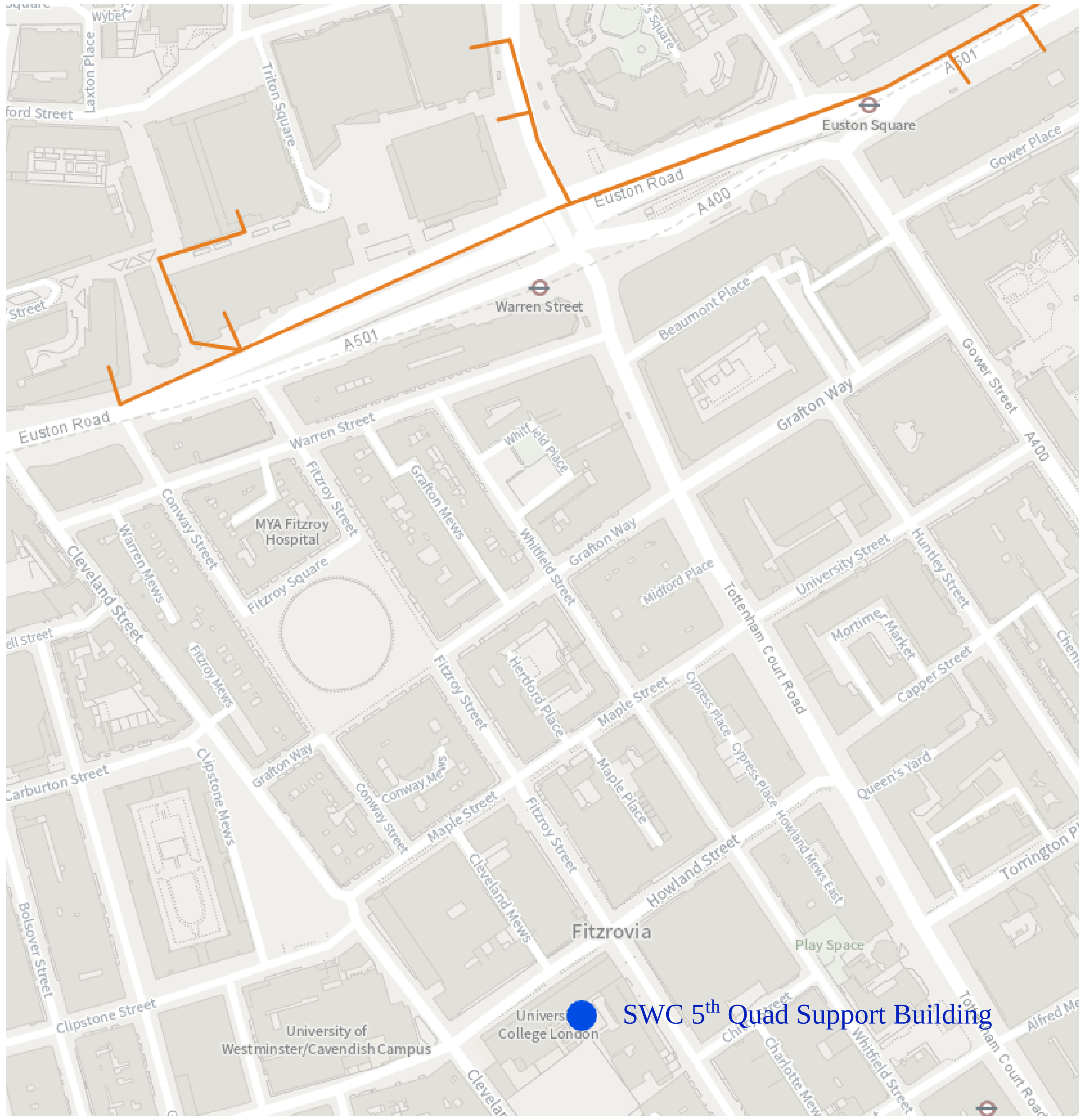

Figure 7 - Heat networks in the vicinity

8 Be Green

The third step in the energy hierarchy for reducing carbon dioxide emissions is to 'be green', where a portion of the development's energy needs should be offset with onsite renewables.

Following GLA and BREEAM guidance an initial review of Low and Zero Carbon technologies was undertaken, which is further explained in the following sections. A summary of the findings is included in the table below.

Table 10 - Renewable technology appraisal

Technology	Feasible?	Key issues/ risks	Adopted?
Solar Thermal	✓	Very low DHW demand. Conflicts with green roof aspirations.	✗
Solar PV	✓	Potential to allocate roof space to PV but would generate very little power due to small roof area. PV conflicts with green roof aspirations.	✗
Ground Source Heat Pumps	✗	Existing substructure is to be retained, incorporating ground source is therefore not feasible	✗
Air Source Heat Pumps	✓	Considered feasible in the future, when the lives of the existing boilers and chillers end.	✗ See 8.2
Water Source Heat Pumps	✓	Can be used to recover heat from the cooling system to the heating system, and to generate DHW. No new cooling proposed and existing cooling equipment within its economic life.	✗ See 8.2
Biomass heating	✗	Site restrictions for fuel delivery and local air quality concerns with this technology	✗
Wind	✗	Site restrictions and turbulent airflow mean wind turbines are not practical	✗

The opportunity to add photovoltaics to the roof was considered, but due to the limited area, the conflict with the green roof aspirations, and the challenging plant replacement strategy, was considered unfeasible.

Whilst ASHP and WSHPs are not currently proposed for the 5th Quad due to structural limitations and the spare capacity in the existing building's systems, the heating system will be future proofed to accommodate the optimum water temperatures of an air source heat pump system.

The building does not currently have opportunities to implement renewable technologies, so no measures are taken in 'Be Green'. The SWC 5th Quad Support Building does not therefore meet the LBC requirement for a 20% reduction in CO_2 from on-site renewables.

As no renewable technologies are considered feasible for this project, there is no change to the carbon emissions.

8.1 Solar Technologies

8.1.1 Solar Thermal

Solar thermal technology has not been proposed on this development due to the low domestic hot water demand and the incompatibility with the green roof.

8.1.2 Solar PV

Photovoltaic panels are semiconductors which convert incident sunlight into electricity. They work well in an urban context if unshaded space can be identified.

In order to meet a 20% reduction in carbon dioxide emissions from on-site renewable energy generation, 111m² of collector array, not including area for access that must be provided. This was calculated using SAP10 carbon factors.

The area of the SWC 5th Quad Support Building's roof is 59m². Allowing for access between panel arrays, a total collector array area of 24m² could be accommodated (no shading applied at this stage). The roof of the main building is congested with MEP plant and would not support the additional PV needed to meet the 20% reduction.

Whilst a small amount of PV could be accommodated on the roof, it would have a low inclination angle and would be incompatible with the green roof. Future panel replacement would also be challenging, as they would need to be moved across a narrow gantry. The provision of solar PV on the roof of the 5th Quad is not included in the design.

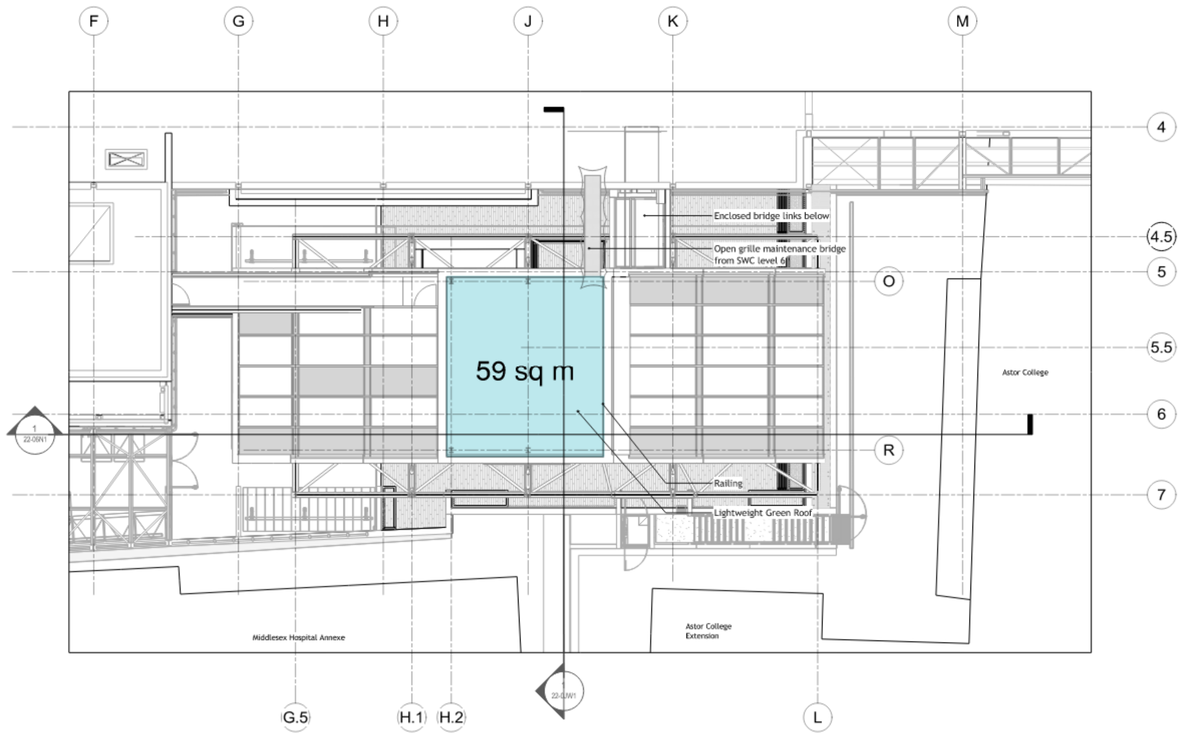

Figure 8 - Available roof area

8.2 Heat Pumps

The use of ground source heat pumps is considered to be unfeasible due to the planned retention of the existing building's substructure.

It is necessary to avoid plant areas from the roof / building and minimise the overall building weight due to the foundation reuse strategy required for the project. As a result, heat pumps cannot be accommodated directly on the 5th Quad but would be located on the roof of the main building. Currently, there is no space on the main building's roof to accommodate heat pumps and associated equipment.

Air and water source heat pumps are considered to be feasible in the future. When the lives of the existing boilers, CHP and chillers come to an end, heat pumps will be used for the generation of cooling, heating, and hot water. To future proof the SWC 5th Quad Support Building's systems, the pipework, heating and cooling coils will be sized to the optimum water temperatures of an air source heat pump system.

8.3 Biomass Heating

Biomass heating commonly uses woodchips or wood pellets as a fuel source. These are then combusted to generate heat. The process can be classified as renewable provided that the biomass used as a fuel is replaced with new organic material. Theoretically, carbon which is released during the burning of the biomass fuel is absorbed from the atmosphere when the plant material is growing, offering large potential carbon dioxide reductions when compared to conventional fossil fuels.

However, in reality, the extent of the CO_2 reductions offered by biomass fuels depends on a number of factors, including:

- Carbon emissions involved in growing and harvesting the biomass fuel
- Carbon emissions involved in producing and processing the biomass fuel
- Transportation emissions associated with delivering the biomass fuel to site.

Although biomass fuels have the potential to offer reductions in CO_2 emissions, they tend to produce significantly higher NOx and particulate emissions than conventional fuels.

Significant fuel storage is required and there is a need for frequent deliveries by large goods vehicles.

Whilst solid or liquid biomass fuels have been proven in a number of projects in the UK, they have an adverse impact on air quality (PM10 and PM2.5).

Along with this and the associated fuel delivery and storage requirements, biomass has been discounted and considered not feasible for the project.

8.4 Wind

Wind turbines are generally less suitable in dense urban environments such as the proposed development, since wind speeds are generally lower and more turbulent. In order to get any power from wind turbines, they need to be mounted significantly above all obstacles, which means they have a visual impact not considered appropriate in this environment. For this reason, they were considered not feasible for the design and have been discounted.

9 Be Seen

The successful implementation of the proposed building’s energy strategy will be demonstrated by its actual performance in operation. The London Plan features requirements to ‘Be Seen’, including reporting of energy usage data, which should assist in identifying energy performance gaps between design and operation of the building and will drive optimisation of the proposed systems’ performance.

Advanced modelling simulations will be carried out in the next design stages in order to more accurately predict the energy consumption and to optimise the controls strategies of the systems.

Submetering of each individual use class is included in the design to help assess energy performance of the building in operation against the as-designed target. The project is considering a NABERS rating, whereby the actual energy performance of the building will be assessed annually and a NABERS rating awarded. The NABERS rating of the building would be publicly visible.

10 Results

The tables and graphs below collate the results from each stage of the energy hierarchy. Results are provided using both SAP2012 and SAP10 carbon factors, as the SWC 5th Quad Support Building will benefit from the existing CHP.

The results are presented using the tables in the GLAs Carbon Emission Reporting worksheet v.1.2. A complete copy of the worksheet can be found in the appendix.

10.1 Proposed Scheme

Table 12, 13 and Figure 9, 7 show the results of the carbon saving measures implemented on the project, showing progressive savings through the energy hierarchy.

A 29% (SAP2012) or 35% (SAP10) reduction is achieved through energy efficiency measures discussed in the 'Be Lean' section of this report, meeting the GLA target. A further 7% (SAP2012) or -2% (SAP10) reduction is seen from the connection to the existing CHP plant, taking to total cumulative saving to 36% (SAP2012) or 33% (SAP10).

An offset payment of £55,718 (SAP2012) or £34,772 (SAP10) is required to take the building to Net-Zero, as required by the London Plan. The final value will be agreed between the client and Camden Council.

SAP2012

Table 11 - The London Plan energy hierarchy – SAP2012

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	30.7	21.0
After energy demand reduction (be lean)	21.9	21.0
After heat network connection (be clean)	19.6	21.0
After renewable energy (be green)	19.6	21.0

Table 12 – Regulated carbon dioxide savings from each stage of the energy hierarchy – SAP2012

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	**(%)**
Be Lean: Savings from energy demand reduction	9	29%
Be Clean: Savings from heat network	2	7%
Be Green: Savings from renewable energy	0	0%
Total Cumulative Savings	**11**	**36%**
Carbon shortfall	20	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	587	
Cash in-lieu contribution*	£55,718	

** Based on London Borough of Camden price of £95 per tonne*

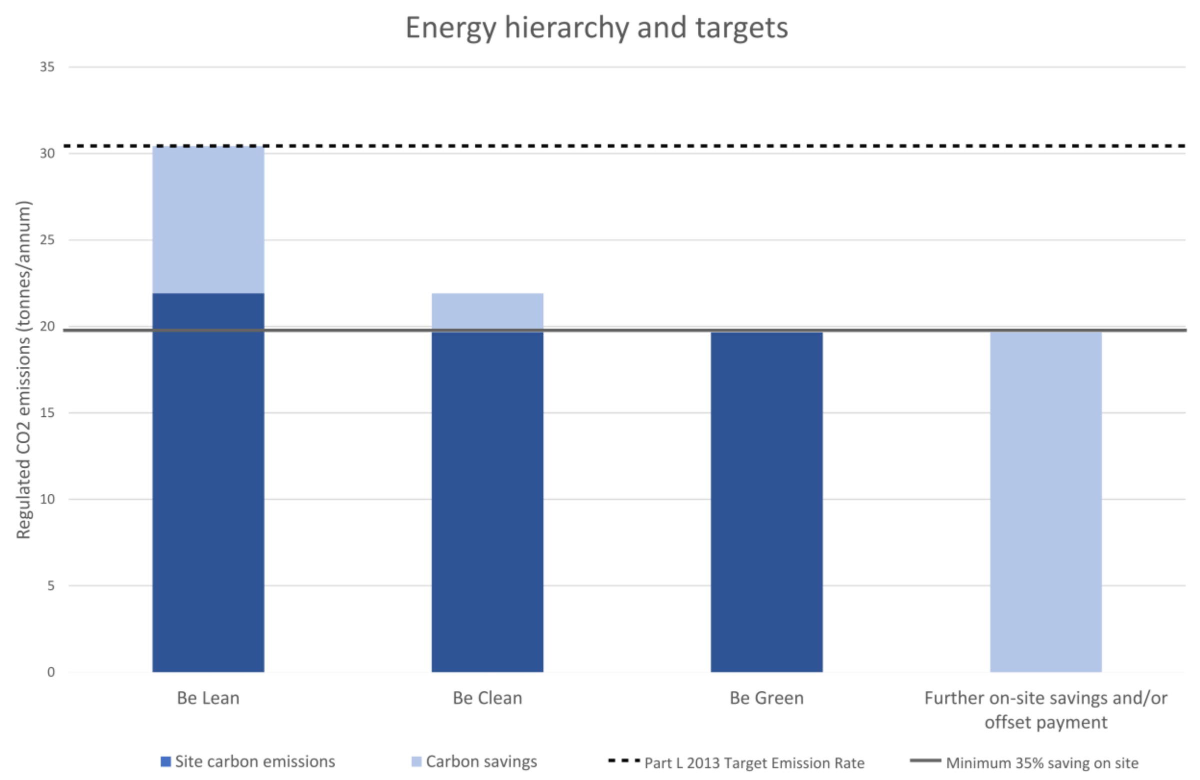

Figure 9 - Carbon savings through the energy hierarchy – SAP2012

SAP10

Table 13 - The London Plan energy hierarchy – SAP10

	Carbon dioxide emissions (tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	18.3	9.4
After energy demand reduction (be lean)	11.8	9.4
After heat network connection (be clean)	12.2	9.4
After renewable energy (be green)	12.2	9.4

Table 14 - Regulated carbon dioxide savings from each stage of the energy hierarchy – SAP10

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be Lean: Savings from energy demand reduction	6	35%
Be Clean: Savings from heat network	0	-2%
Be Green: Savings from renewable energy	0	0%
Total Cumulative Savings	**6**	**33%**
Carbon shortfall	12	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	366	-
Cash in-lieu contribution*	£34,772	-

** Based on London Borough of Camden price of £95 per tonne*

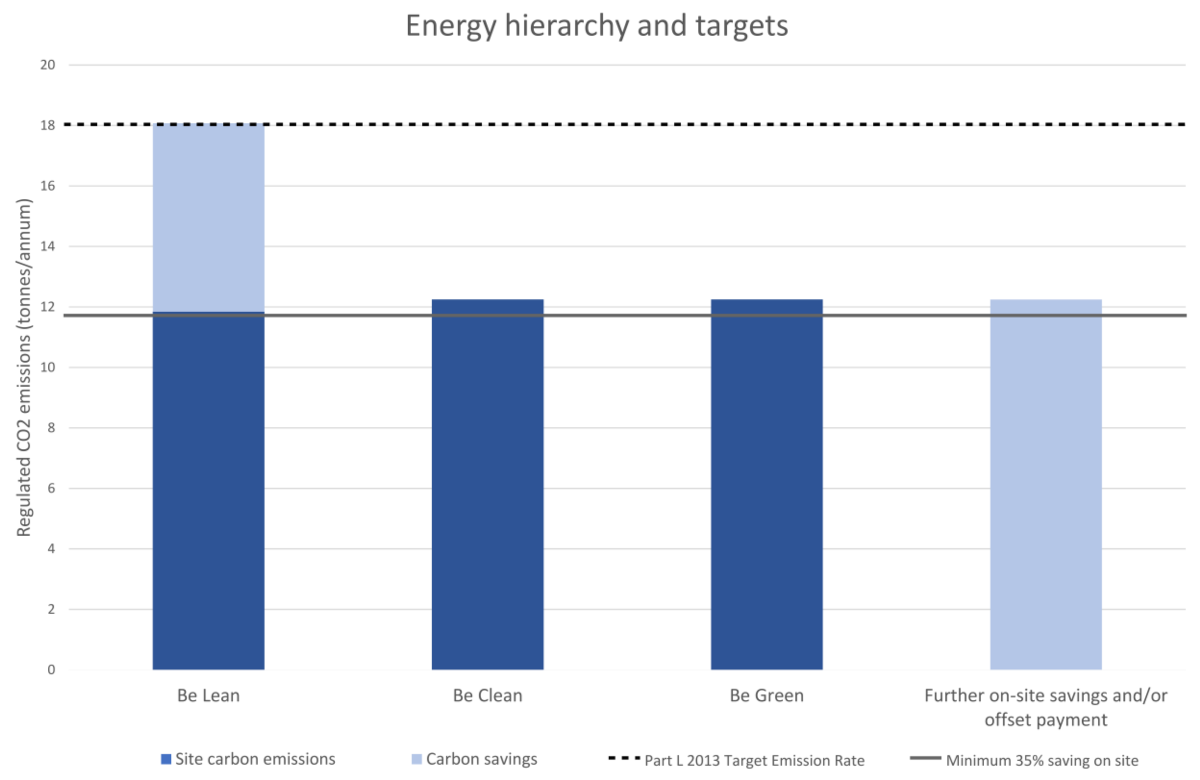

Figure 10 – Carbon savings through the energy hierarchy – SAP10

11 Conclusion

The approach to energy efficiency measures for the proposed SWC 5th Quad Support Building has been holistic. The strategies and technologies have been considered by their appropriateness for the scheme. This is demonstrated in the building's energy and carbon emission performance.

Passive design is at the heart of the design of the SWC 5th Quad Support Building. The 5th Quad has been developed in line with latest net-zero guidance and has followed many of the London Energy Transformation Initiative's (LETI) key principles. This is reflected in the majority of carbon savings reported in the "Be Lean" stage of the energy hierarchy.

The 5th Quad takes advantage of the spare capacity in the existing heating and cooling systems of the main building and does not propose any additional plant. Whilst ASHP and WSHPs are not currently proposed for the 5th Quad due to structural limitations and the spare capacity in the existing building's systems, the heating system will be future proofed to accommodate the optimum water temperatures of an air source heat pump system.

The client is committed to achieving the on-site carbon emissions reduction. The final means of achieving this will be addressed in the next design stage for the SWC 5th Quad Support Building design.

Appendix A

Be Lean BRUKL Report

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

SWC 5th Quad Support Building - Be Lean

As designed

Date: Thu Jul 29 17:50:38 2021

Administrative information

Building Details

Address: Sainsbury Wellcome Centre, 46 Cleveland Street, LONDON, W1T 4JG

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Hans (Ip Ka) Chao

Telephone number: 020 7636 1531

Address: Arup, 8 Fitzroy Street, LONDON, W1T 4BJ

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	30
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	30
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	21.3
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-Limit}}$	$U_{a\text{-Calc}}$	$U_{i\text{-Calc}}$	Surface where the maximum value occurs*
Wall**	0.35	0.13	0.26	04000000:Surf[1]
Floor	0.25	0.12	0.12	01000002:Surf[0]
Roof	0.25	0.13	0.18	04000000:Surf[6]
Windows***, roof windows, and rooflights	2.2	1.32	1.4	04000000:Surf[0]
Personnel doors	2.2	1.2	1.2	0100000A:Surf[1]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

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

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

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

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- Local vent + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	5.59	0	0.86	0.75
Standard value	0.91*	2.55	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

2- Toilet ex + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	5.59	0	0.1	0.75
Standard value	0.91*	2.55	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- MVHR + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.93	-	0.2	0.5	0.75
Standard value	0.91	N/A	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

1- Local vent + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.96	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

2- Toilet ex + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.96	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

3- MVHR + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.93	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

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	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
01.06.03 - Fab Lab Storage	0.3	-	-	-	0.3	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W]			General lighting [W]
	Luminaire	Lamp	Display lamp	
Standard value	60	60	22	
01.06.01 - Fab Lab Rm 1	112	-	-	203
01.06.02 - Fab Lab Rm 2	112	-	-	199
01.06.03 - Fab Lab Storage	112	-	-	150
01.06.05 - IT Workspace	112	-	-	138
01.06.04 - 10p Meeting Rm	112	-	-	173
02.06.02 - 6p Office 1	112	-	-	178
02.06.03 - 6p Office 2	112	-	-	176
01.06.10 - Circulation	112	-	-	196
01.06.08 - IT Help Centre	112	-	-	305
05.06.10S - 24p Meeting Room S	112	-	-	305
05.06.10N - 24p Meeting Room N	112	-	-	304
01.06.06 - IT Admin Rm	112	-	-	192
01.06.07 - Head of IT	112	-	-	122
01.06.12 Link Bridge W	112	-	-	53
04.06.04 Wellbeing 1	112	-	-	121
04.06.03 Wellbeing 2	112	-	-	137
04.06.05 - WC	-	112	-	54
04.06.01 - Kitchenette	112	-	-	92
03.06.06N - Open Plan Workspace N	112	-	-	217
03.06.06S - Open Plan Workspace S	112	-	-	242
03.06.04 - PI Workspace 2	112	-	-	128
03.06.03 - PI Workspace 1	112	-	-	128
03.06.02 - Visiting Scholar Office	112	-	-	153
03.06.05 - Breakout/Circulation	112	-	-	221
03.06.01 - PI Office	112	-	-	128

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
02.06.01N - Open Plan Workspace N	112	-	-	309
02.06.01S - Open Plan Workspace S	112	-	-	307
02.06.05 - 6p Office 3	112	-	-	198
02.06.04 - 5p Office	112	-	-	188
04.06.02SE - Breakout SE	112	-	-	167
04.06.02NE - Breakout NE	112	-	-	166
01.06.11 Bridge Link	112	-	-	127
02.06.07 Bridge Link	112	-	-	127
03.06.07 Bridge Link	112	-	-	127
04.06.07 Bridge Link	112	-	-	137
05.06.02 Link Bridge	112	-	-	107
04.06.02NW - Breakout NW	112	-	-	231

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01.06.01 - Fab Lab Rm 1	NO (-67.4%)	YES
01.06.02 - Fab Lab Rm 2	NO (-94.5%)	NO
01.06.03 - Fab Lab Storage	N/A	N/A
01.06.05 - IT Workspace	NO (-90%)	NO
01.06.04 - 10p Meeting Rm	NO (-92.1%)	NO
02.06.02 - 6p Office 1	NO (-84.7%)	YES
02.06.03 - 6p Office 2	NO (-80.2%)	YES
01.06.10 - Circulation	NO (-97.7%)	NO
01.06.08 - IT Help Centre	NO (-97.9%)	NO
05.06.10S - 24p Meeting Room S	NO (-61.8%)	YES
05.06.10N - 24p Meeting Room N	NO (-60.5%)	YES
01.06.06 - IT Admin Rm	NO (-78%)	YES
01.06.07 - Head of IT	NO (-83.2%)	YES
01.06.12 Link Bridge W	NO (-60.8%)	YES
04.06.04 Wellbeing 1	NO (-85.6%)	NO
04.06.03 Wellbeing 2	NO (-89.2%)	NO
04.06.01 - Kitchenette	NO (-96.7%)	NO
03.06.06N - Open Plan Workspace N	NO (-69.7%)	YES
03.06.06S - Open Plan Workspace S	NO (-74.5%)	YES
03.06.04 - PI Workspace 2	NO (-85.2%)	NO
03.06.03 - PI Workspace 1	NO (-87.8%)	NO
03.06.02 - Visiting Scholar Office	NO (-35.2%)	YES
03.06.05 - Breakout/Circulation	NO (-96.9%)	NO
03.06.01 - PI Office	NO (-85.3%)	YES
02.06.01N - Open Plan Workspace N	NO (-97.2%)	NO
02.06.01S - Open Plan Workspace S	NO (-94.8%)	NO
02.06.05 - 6p Office 3	NO (-66.4%)	YES
02.06.04 - 5p Office	NO (-86.8%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
04.06.02SE - Breakout SE	NO (-43%)	YES
04.06.02NE - Breakout NE	NO (-29.6%)	YES
01.06.11 Bridge Link	NO (-87.6%)	YES
02.06.07 Bridge Link	NO (-86.9%)	YES
03.06.07 Bridge Link	NO (-90%)	YES
04.06.07 Bridge Link	NO (-86.2%)	YES
05.06.02 Link Bridge	NO (-78.6%)	YES
04.06.02NW - Breakout NW	NO (-0.1%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	963.4	963.4
External area [m²]	1891.6	1891.6
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	650.69	1091.38
Average U-value [W/m²K]	0.34	0.58
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 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	18.41	40.54
Cooling	1.64	3.89
Auxiliary	22.6	14.89
Lighting	8.72	21.95
Hot water	3.14	3.14
Equipment*	41.9	41.9
TOTAL**	**54.51**	**84.41**

* 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

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	91.61	165.61
Primary energy* [kWh/m²]	124.94	175.22
Total emissions [kg/m²]	21.3	30

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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] Single-duct VAV, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	61.3	31.7	18.7	1.7	23.1	0.91	5.31	0.96	5.59
	Notional	127.1	40.3	41	3.9	14.9	0.86	2.84	----	----
[ST] Single-duct VAV, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	28.9	31.2	8.8	1.6	8.5	0.91	5.31	0.96	5.59
	Notional	81.6	35.9	26.3	3.5	16.1	0.86	2.84	----	----
[ST] Central heating using air distribution, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	14.5	0	4.5	0	1.5	0.9	0	0.93	0
	Notional	82.6	0	26.6	0	8.6	0.86	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

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	**$U_{i\text{-}Typ}$**	**$U_{i\text{-}Min}$**	**Surface where the minimum value occurs***
Wall	0.23	0.13	01000002:Surf[6]
Floor	0.2	0.12	01000002:Surf[0]
Roof	0.15	0.12	01000000:Surf[1]
Windows, roof windows, and rooflights	1.5	1.2	05000000:Surf[2]
Personnel doors	1.5	1.2	0100000A:Surf[1]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)]

$U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	**Typical value**	**This building**
m³/(h.m²) at 50 Pa	5	3

Appendix B

Be Clean BRUKL Report

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

SWC 5th Quad Support Building - Be Clean

As designed

Date: Thu Jul 29 17:51:59 2021

Administrative information

Building Details

Address: Sainsbury Wellcome Centre, 46 Cleveland Street, LONDON, W1T 4JG

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Hans (Ip Ka) Chao

Telephone number: 020 7636 1531

Address: Arup, 8 Fitzroy Street, LONDON, W1T 4BJ

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	30
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	30
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	18.1
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.13	0.26	04000000:Surf[1]
Floor	0.25	0.12	0.12	01000002:Surf[0]
Roof	0.25	0.13	0.18	04000000:Surf[6]
Windows***, roof windows, and rooflights	2.2	1.32	1.4	04000000:Surf[0]
Personnel doors	2.2	1.2	1.2	0100000A:Surf[1]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

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

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

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

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- Local vent + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	5.59	0	0.86	0.75
Standard value	0.91*	2.55	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

2- Toilet ex + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	5.59	0	0.1	0.75
Standard value	0.91*	2.55	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- MVHR + boilers + chillers

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.93	-	0.2	0.5	0.75
Standard value	0.91	N/A	N/A	1.1^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

1- Local vent + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.96	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

2- Toilet ex + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.96	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

3- MVHR + boilers + chillers

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.93	-
Standard value	0.9*	N/A

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

1- CHECK2-CHP

	CHPQA quality index	CHP electrical efficiency
This building	105	0.38
Standard value	105	0.2

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

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	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
01.06.03 - Fab Lab Storage	0.3	-	-	-	0.3	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W] Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
01.06.01 - Fab Lab Rm 1	112	-	-	203
01.06.02 - Fab Lab Rm 2	112	-	-	199
01.06.03 - Fab Lab Storage	112	-	-	150
01.06.05 - IT Workspace	112	-	-	138
01.06.04 - 10p Meeting Rm	112	-	-	173
02.06.02 - 6p Office 1	112	-	-	178
02.06.03 - 6p Office 2	112	-	-	176
01.06.10 - Circulation	112	-	-	196
01.06.08 - IT Help Centre	112	-	-	305
05.06.10S - 24p Meeting Room S	112	-	-	305
05.06.10N - 24p Meeting Room N	112	-	-	304
01.06.06 - IT Admin Rm	112	-	-	192
01.06.07 - Head of IT	112	-	-	122
01.06.12 Link Bridge W	112	-	-	53
04.06.04 Wellbeing 1	112	-	-	121
04.06.03 Wellbeing 2	112	-	-	137
04.06.05 - WC	-	112	-	54
04.06.01 - Kitchenette	112	-	-	92
03.06.06N - Open Plan Workspace N	112	-	-	217
03.06.06S - Open Plan Workspace S	112	-	-	242
03.06.04 - PI Workspace 2	112	-	-	128
03.06.03 - PI Workspace 1	112	-	-	128

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
03.06.02 - Visiting Scholar Office	112	-	-	153
03.06.05 - Breakout/Circulation	112	-	-	221
03.06.01 - PI Office	112	-	-	128
02.06.01N - Open Plan Workspace N	112	-	-	309
02.06.01S - Open Plan Workspace S	112	-	-	307
02.06.05 - 6p Office 3	112	-	-	198
02.06.04 - 5p Office	112	-	-	188
04.06.02SE - Breakout SE	112	-	-	167
04.06.02NE - Breakout NE	112	-	-	166
01.06.11 Bridge Link	112	-	-	127
02.06.07 Bridge Link	112	-	-	127
03.06.07 Bridge Link	112	-	-	127
04.06.07 Bridge Link	112	-	-	137
05.06.02 Link Bridge	112	-	-	107
04.06.02NW - Breakout NW	112	-	-	231

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01.06.01 - Fab Lab Rm 1	NO (-67.4%)	YES
01.06.02 - Fab Lab Rm 2	NO (-94.5%)	NO
01.06.03 - Fab Lab Storage	N/A	N/A
01.06.05 - IT Workspace	NO (-90%)	NO
01.06.04 - 10p Meeting Rm	NO (-92.1%)	NO
02.06.02 - 6p Office 1	NO (-84.7%)	YES
02.06.03 - 6p Office 2	NO (-80.2%)	YES
01.06.10 - Circulation	NO (-97.7%)	NO
01.06.08 - IT Help Centre	NO (-97.9%)	NO
05.06.10S - 24p Meeting Room S	NO (-61.8%)	YES
05.06.10N - 24p Meeting Room N	NO (-60.5%)	YES
01.06.06 - IT Admin Rm	NO (-78%)	YES
01.06.07 - Head of IT	NO (-83.2%)	YES
01.06.12 Link Bridge W	NO (-60.8%)	YES
04.06.04 Wellbeing 1	NO (-85.6%)	NO
04.06.03 Wellbeing 2	NO (-89.2%)	NO
04.06.01 - Kitchenette	NO (-96.7%)	NO
03.06.06N - Open Plan Workspace N	NO (-69.7%)	YES
03.06.06S - Open Plan Workspace S	NO (-74.5%)	YES
03.06.04 - PI Workspace 2	NO (-85.2%)	NO
03.06.03 - PI Workspace 1	NO (-87.8%)	NO
03.06.02 - Visiting Scholar Office	NO (-35.2%)	YES
03.06.05 - Breakout/Circulation	NO (-96.9%)	NO
03.06.01 - PI Office	NO (-85.3%)	YES
02.06.01N - Open Plan Workspace N	NO (-97.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
02.06.01S - Open Plan Workspace S	NO (-94.8%)	NO
02.06.05 - 6p Office 3	NO (-66.4%)	YES
02.06.04 - 5p Office	NO (-86.8%)	YES
04.06.02SE - Breakout SE	NO (-43%)	YES
04.06.02NE - Breakout NE	NO (-29.6%)	YES
01.06.11 Bridge Link	NO (-87.6%)	YES
02.06.07 Bridge Link	NO (-86.9%)	YES
03.06.07 Bridge Link	NO (-90%)	YES
04.06.07 Bridge Link	NO (-86.2%)	YES
05.06.02 Link Bridge	NO (-78.6%)	YES
04.06.02NW - Breakout NW	NO (-0.1%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	963.4	963.4
External area [m²]	1891.6	1891.6
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	650.69	0
Average U-value [W/m²K]	0.34	0
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 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	31.45	40.54
Cooling	1.64	3.89
Auxiliary	22.6	14.89
Lighting	8.72	21.95
Hot water	6.16	3.14
Equipment*	41.9	41.9
TOTAL**	**57.59**	**84.41**

* 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	12.97	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	91.61	165.61
Primary energy* [kWh/m²]	104.71	175.22
Total emissions [kg/m²]	18.1	30

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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] Single-duct VAV, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	61.3	31.7	4.8	1.7	23.1	0.91	5.31	0.96	5.59
	Notional	127.1	40.3	41	3.9	14.9	0.86	2.84	----	----
[ST] Single-duct VAV, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	28.9	31.2	4.1	1.6	8.5	0.91	5.31	0.96	5.59
	Notional	81.6	35.9	26.3	3.5	16.1	0.86	2.84	----	----
[ST] Central heating using air distribution, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	14.5	0	4.5	0	1.5	0.9	0	0.93	0
	Notional	82.6	0	26.6	0	8.6	0.86	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

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	$U_{i\text{-}Typ}$	$U_{i\text{-}Min}$	Surface where the minimum value occurs*
Wall	0.23	0.13	01000002:Surf[6]
Floor	0.2	0.12	01000002:Surf[0]
Roof	0.15	0.12	01000000:Surf[1]
Windows, roof windows, and rooflights	1.5	1.2	05000000:Surf[2]
Personnel doors	1.5	1.2	0100000A:Surf[1]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)] $U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	3

Appendix C

GLA Carbon Emission Reporting Worksheet v.1.2

-

Table 1. CARBON (CO_2) FACTORS			Notes
Fuel type	Fuel Carbon Factor (kgCO2/kWh)		
	SAP 2012	SAP 10	
Natural Gas	0.216	0.210	SAP 2012 and SAP 10 carbon emission factors (Table 12).
Grid Electricity	0.519	0.233	
Enter Carbon Factor 1			These factors should be used where alternative fuel is used to grid gas and electricity. Carbon emission factors used here must be taken from Table 12 within the SAP 2012 and SAP 10 documents. Fuel type should be updated and referenced in Column A when additional carbon factor values have been added.
Enter Carbon Factor 2			
Enter Carbon Factor 3			
Enter Carbon Factor 4			
Bespoke DH Factor			This should only be used for non-domestic buildings that are connecting to District Heating (DH) networks. The network carbon factor should be calculated in line with Part L requirements and a seperate factors should be provided using SAP 2012 and SAP 10 fuel factors. Assumptions and workings should be shown below in Table 4.

Table 2. BESPOKE DH CARBON FACTOR CALCULATION METHODOLOGY
Please provide below details of the calculation methodology followed to establish the bespoke carbon factor, if applicable.

NON-DOMESTIC ENERGY CONSUMPTION AND CO_2 ANALYSIS

Building Use	Area per unit (m²)	Number of units	Total area represented by model (m²)	VALIDATION CHECK: Calculated TER 2012 (kgCO2 / m2)	BRUKL TER 2012 (kgCO2 / m2)	REGULATED ENERGY CONSUMPTION BY END USE (kWh/m² p.a.) TER - SOURCE: BRUKL OUTPUT: Space Heating	Fuel type Space Heating	Domestic Hot Water	Fuel type Domestic Hot Water	Lighting	Auxiliary	Cooling	REGULATED ENERGY CONSUMPTION BY FUEL TYPE (kWh/m² p.a.) TER - SOURCE: BRUKL.INP or *SIM.CSV FILE: Natural Gas ##############	Grid Electricity ##############				2012 CO2 emissions (kgCO2 p.a.)	REGULATED ENERGY CONSUMPTION BY FUEL TYPE (kWh/m² p.a.) - TER BRUKL: Natural Gas ##############	Grid Electricity ##############				REGULATED CO2 EMISSIONS: SAP10 CO2 emissions (kgCO2 p.a.)	BRUKL TER SAP10 (kgCO2 / m2)
Office	*963.4*	*1*	*963.4*	**31.8**		*41.9*	*Natural Gas*	*3.14*	*Grid Electricity*	*21.95*	*14.89*	*3.9*	**42**	**44**				**30,659**	**42**	**44**				**18,327**	**19.0**
Sum	963	1	963	31.8	-	40,366	40,366	0	0	0	0	0	42	44	N/A	N/A	N/A	*30,659*	42	44	N/A	N/A	N/A	*18,327*	19.0

SITE-WIDE ENERGY CONSUMPTION AND CO_2 ANALYSIS

Use	Total Area (m²)	Calculated TER 2012 (kgCO2 / m2)	-	REGULATED ENERGY CONSUMPTION: Space Heating (kWh p.a.)	N/A	Domestic Hot Water (kWh p.a.)	N/A	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)		REGULATED CO2 EMISSIONS: 2012 CO2 emissions (kgCO2 p.a.)		REGULATED CO2 EMISSIONS PER UNIT: SAP10 CO2 emissions (kgCO2 p.a.)	Calculated TER SAP10 (kgCO2 / m2)
Sum	963	31.8	-	40,366		0		0	0	0		*30,659*		*18,327*	19.0

NON-DOMESTIC ENERGY CONSUMPTION AND CO_2 ANALYSIS

Building Use	Area per unit (m²)	Number of units	Total area represented by model (m²)	VALIDATION CHECK Calculated BER 2012 (kgCO2 / m2)	VALIDATION CHECK BRUKL BER 2012 (kgCO2 / m2)	REGULATED ENERGY CONSUMPTION BY END USE (kWh/m² p.a.) 'BE LEAN' BER - SOURCE: BRUKL OUTPUT Space Heating (kWh/m² p.a.)	Fuel type Space Heating	Domestic Hot Water (kWh/m² p.a.)	Fuel type Domestic Hot Water	Lighting (kWh/m² p.a.)	Auxiliary (kWh/m² p.a.)	Cooling (kWh/m² p.a.)
Office	*963.4*	*1*	*963.4*	**22.7**		*18.41*	*Natural Gas*	*3.14*	*Grid Electricity*	*8.72*	*22.6*	*1.64*
Sum	963	1	963	22.7	-	17,736	N/A	3,025	N/A	8,401	21,773	1,580

Building Use	LATED ENERGY CONSUMPTION BY FUEL TYPE (kWh/m² p.a.) 'BE LEAN' BER - SOURCE: BRUKL.INP or *SIM.CSV Natural Gas ##############	Grid Electricity ##############				2012 CO2 emissions (kgCO2 p.a.)	REGULATED CO2 EMISSIONS PER UNIT Natural Gas ##############	Grid Electricity ##############	SAP10 CO2 emissions (kgCO2 p.a.)	BRUKL BER SAP10 (kgCO2 / m2)	
Office	18	36				21,881	18	36	11,828	12.3	N/A
Sum	18	36	N/A	N/A	N/A	*21,881*	18	36	*11,828*	12.3	

NON-DOMESTIC ENERGY DEMAND

Building Use	REGULATED ENERGY DEMAND PER UNIT PER ANNUM (kWh p.a.) Space Heating (kWh p.a.)	Domestic Hot Water (kWh p.a.)	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)
Office	19	3	9	21	1
Sum	19	3	9	21	1

SITE-WIDE ENERGY CONSUMPTION AND CO_2 ANALYSIS

Use	Total Area (m²)	Calculated BER 2012 (kgCO2 / m2)	-	REGULATED ENERGY CONSUMPTION Space Heating (kWh p.a.)	N/A	Domestic Hot Water (kWh p.a.)	N/A	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)
Sum	963	22.7	-	17,736		3,025		8,401	21,773	1,580

Use	REGULATED CO2 EMISSIONS 2012 CO2 emissions (kgCO2 p.a.)	REGULATED CO2 EMISSIONS SAP10 CO2 emissions (kgCO2 p.a.)	Calculated BER SAP10 (kgCO2 / m2)	N/A	REGULATED ENERGY DEMAND PER UNIT PER ANNUM (kWh p.a.) Space Heating (kWh p.a.)	Domestic Hot Water (kWh p.a.)	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)
Sum	*21,881*	*11,828*	12.3		19	3	9	21	1

NON-DOMESTIC ENERGY CONSUMPTION AND CO_2 ANALYSIS

Building Use	Area per unit (m²)	Number of units	Total area represented by model (m²)	VALIDATION CHECK: Calculated BER 2012 (kgCO2 / m2)	VALIDATION CHECK: BRUKL BER 2012 (kgCO2 / m2)	REGULATED ENERGY CONSUMPTION BY END USE (kWh/m² p.a.) 'BE CLEAN' BER - SOURCE: BRUKL OUTPUT: Space Heating	Fuel type Space Heating	Domestic Hot Water	Fuel type Domestic Hot Water			Total Electricity generated by CHP (-) if applicable	Lighting	Auxiliary	Cooling	REGULATED ENERGY CONSUMPTION BY FUEL TYPE (kWh/m² p.a.) 'BE CLEAN' BER - SOURCE: BRUKL.INP or *SIM.CSV FILE: Natural Gas	Grid Electricity	Bespoke DH Factor	Electricity generated by CHP (-) if applicable	2012 CO2 emissions (kgCO2 p.a.)	REGULATED CO2 EMISSIONS PER UNIT: Natural Gas	Grid Electricity	Bespoke DH Factor	Electricity generated by CHP (-) if applicable	SAP 10 CO2 emissions (kgCO2 p.a.)	BRUKL BER SAP10 (kgCO2 / m2)
																##############	##############	##############	##############		##############	##############	##############	##############		
Office	*963.4*	*1*	*963.4*	**20.4**		*31.45*	*Natural Gas*	*6.16*	*Grid Electricity*	N/A	N/A	*-12.97*	*8.72*	*22.6*	*1.64*	**31**	**39**		*-12.97*	**19,620**	**31**	**39**		**-13**	**12,233**	**12.7**
Sum	963	1	963	20.4	-	30,299	N/A	5,935	N/A			-12,495	8,401	21,773	1,580	31	39	0	-13	*19,620*	31	39	0	-13	*12,233*	12.7

SITE-WIDE ENERGY CONSUMPTION AND CO_2 ANALYSIS

Use	Total Area (m²)	Calculated BER 2012 (kgCO2 / m2)	-	REGULATED ENERGY CONSUMPTION: Space Heating (kWh p.a.)	N/A	Domestic Hot Water (kWh p.a.)	N/A	Space and Domestic Hot Water from CHP (kWh p.a.)	N/A	Electricity generated by CHP (kWh p.a.) *if applicable*	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)	REGULATED CO2 EMISSIONS: 2012 CO2 emissions (kgCO2 p.a.)	REGULATED CO2 EMISSIONS PER UNIT: SAP 10 CO2 emissions (kgCO2 p.a.)	Calculated BER SAP10 (kgCO2 / m2)
Sum	963	20.4	-	30,299		5,935		0		-12,495	8,401	21,773	1,580	*19,620*	*12,233*	12.7

NON-DOMESTIC ENERGY CONSUMPTION AND CO_2 ANALYSIS

Use	Area per unit (m²)	Number of units	Total area represented by model (m²)	VALIDATION CHECK: Calculated BER 2012 (kgCO2 / m2)	VALIDATION CHECK: BRUKL BER 2012 (kgCO2 / m2)
Office	*963.4*	*1*	*963.4*	**20.3**	
Sum	963	1	963	20.3	-

Use	REGULATED ENERGY CONSUMPTION BY END USE (kWh/m² p.a.) 'BE GREEN' BER - SOURCE: BRUKL OUTPUT: Space Heating	Fuel type Space Heating	Domestic Hot Water	Fuel type Domestic Hot Water							Electricity generated by CHP (-) if applicable	Electricity generated by renewable technology (-) if applicable	Lighting	Auxiliary	Cooling
Office	*31.45*	*Grid Electricity*	*6.16*	*Grid Electricity*	N/A	N/A	N/A	N/A	N/A	N/A	*-13.17*		*8.72*	*22.66*	*1.64*
Sum	30,299	N/A	5,935	N/A							-12,688	0	8,401	21,831	1,580

Use	REGULATED ENERGY CONSUMPTION BY FUEL TYPE (kWh/m² p.a.) 'BE GREEN' BER - SOURCE: BRUKL.INP or *SIM.CSV FILE: Natural Gas	Grid Electricity	Bespoke DH Factor	Electricity generated by CHP (-) *if applicable*	Electricity generated by renewable technology (-) if applicable	Enter Carbon Factor 1	Enter Carbon Factor 2	Enter Carbon Factor 3	2012 CO2 emissions (kgCO2 p.a.)
	##############	##############	##############	##############	##############	##############	##############	##############	
Office	31	39		*-13.17*					19,550
Sum	31	39	0	-13	0	0	0	0	*19,550*

Use	REGULATED CO2 EMISSIONS PER UNIT: Natural Gas	Grid Electricity	Bespoke DH Factor	Electricity generated by CHP (-) if applicable	Electricity generated by renewable technology (-) if applicable	Enter Carbon Factor 1	Enter Carbon Factor 2	Enter Carbon Factor 3	SAP10 CO2 emissions	BRUKL BER SAP10 (kgCO2 / m2)
	##############	##############	##############	##############	##############	##############	##############	##############		
Office	31	39		-13					12,201	12.7
Sum	31	39	0	-13	0	0	0	0	*12,201*	12.7

SITE-WIDE ENERGY CONSUMPTION AND CO_2 ANALYSIS

Use	Total Area (m²)	Calculated BER 2012 (kgCO2 / m2)	-
Sum	963	0.0	-

Use	REGULATED CO2 EMISSIONS: Space Heating (kWh p.a.)	N/A	Domestic Hot Water (kWh p.a.)	N/A	Space Heating (kWh p.a.)	N/A	Domestic Hot Water (kWh p.a.)	N/A	Space and Domestic Hot Water from CHP (kWh p.a.)	N/A	Electricity generated by CHP (kWh p.a.) *if applicable*	Electricity generated by renewable (kWh p.a.) *if applicable*	Lighting (kWh p.a.)	Auxiliary (kWh p.a.)	Cooling (kWh p.a.)
Sum	30,299		5,935		0		0		0		-12,688	0	8,401	21,831	1,580

Use	REGULATED CO2 EMISSIONS: Space Heating CO2 emissions	Domestic Hot Water CO2 emissions	Space Heating and DHW from CHP CO2 emissions if applicable	Electricity generated by CHP CO2 savings if applicable	Electricity generated by renewable CO2 savings if applicable	Lighting CO2 emissions	Auxiliary CO2 emissions	Cooling CO2 emissions	2012 CO2 emissions
Sum	31	39	0	-13	0	0	0	0	*19,550*

Use	REGULATED CO2 EMISSIONS PER UNIT: Space Heating CO2 emissions	Domestic Hot Water CO2 emissions	Space Heating and DHW from CHP CO2 emissions if applicable	Electricity generated by CHP CO2 savings if applicable	Electricity generated by renewable CO2 savings if applicable	Lighting CO2 emissions	Auxiliary CO2 emissions	Cooling CO2 emissions	SAP10 CO2 emissions	Calculated BER SAP10 (kgCO2 / m2)
Sum	31	39	0	-13	0	0	0	0	*12,201*	12.7

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	31	21
After energy demand reduction	22	21
After heat network / CHP	20	21
After renewable energy	20	21

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	9	29%
Savings from heat network / CHP	2	7%
Savings from renewable energy	0	0%
Total Cumulative Savings	**11**	**36%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	**11**	-
Shortfall	0	-11
Cash in-lieu contribution (£)	**-682**	-

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	18	9
After energy demand reduction	12	9
After heat network / CHP	12	9
After renewable energy	12	9

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	6	35%
Savings from heat network / CHP	0	-2%
Savings from renewable energy	0	0%
Total Cumulative Savings	**6**	**33%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	6	-
Shortfall	0	9
Cash in-lieu contribution (£)	**520**	-

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	31		
Be lean	22	9	29%
Be clean	20	2	7%
Be green	20	0	0%
	-	**CO2 savings off-set (Tonnes CO2)**	-
Off-set	-	**-11**	-

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	18		
Be lean	12	6	35%
Be clean	12	0	-2%
Be green	12	0	0%
	-	**CO2 savings off-set (Tonnes CO2)**	-
Off-set	-	**9**	-