UCL

New Student Centre

Energy Strategy

June 2015

expedition

Revision Schedule

Revision	Date	Comments	By	Checked	Approved
00	01/06/15	Energy Strategy to accompany the planning application for the UCL New Student Centre.	DR	JS	JS

Disclaimer

The analysis contained within this document is applicable to the stage of design at the time of issue. The results outline predicted performance at this stage and may change as the design develops. The report presents an approach for achieving a 35% carbon dioxide improvement against Part L 2013 and may be achieved in alternative ways as the design progresses and technologies develop. For example more efficient lighting may require a smaller contribution from other low energy /renewable technologies i.e. photovoltaic panels (PV), to achieve the same carbon reduction target.

The values generated within this document have been derived for compliance requirements only.

Contents

0.0 Executive Summary

The Energy Strategy has been prepared in accordance with the principles of the energy hierarchy and will deliver a 'Lean', 'Clean' and 'Green' building. The energy assessment contained within this document clearly identifies the carbon emissions of the building after each element of the energy hierarchy.

The New Student Centre has been designed with the following key principles:

- Minimise the demand for energy by enhancing fabric efficiency and promoting passive design.
- Utilise the thermal mass of the building to help control internal heat gains.
- Use of mechanical ventilation with heat recovery to recover ventilation heat loss during the winter.
- Provide heating through a connection to UCL's District Heat Network.
- Prevent spaces from overheating by using natural ventilation or mechanical ventilation (heat recovery element by-passed), with CO2/temperature sensing and optimiser to increase the fresh air rate for comfort purposes.
- Connect the building to a 'free' source of cooling via an open loop ground source borehole system which feeds cooling pipes embedded in the underside of the floor slabs.
- Maximise the use of photovoltaic panels to generate renewable energy.

The New Student Centre will meet Camden Council and the Greater London Authority (GLA) requirement for a 35% carbon dioxide reduction on Part L 2013. Camden Council's renewable target for a 20% reduction in regulated carbon dioxide emissions is also met from on-site renewable energy technologies.

The results from the Part L 2013 calculation in relation to the energy hierarchy are summarised below and have been presented in line with Greater London Authority guidance. The calculations to determine percentage savings from the second and third elements of the energy hierarchy ('Clean' and 'Green') are calculated relative to the Part L 2013 Target Emissions Rate, rather than the residual CO2 emissions after the previous element of the hierarchy.

	Carbon dioxide emissions (Tonnes CO2 per annum)	
	Regulated	**Unregulated**
Baseline: Building Regulations Part L 2013 Compliant Building	99.45	84.97
After energy demand reduction ('Be Lean')	87.23	84.97
After efficient energy supply ('Be Clean')	85.79	84.97
After renewable energy ('Be Green')	64.26	84.97

Table 0.1: Carbon dioxide emissions at each stage of the Energy Hierarchy

	Regulated Carbon dioxide savings	
	(Tonnes CO2 per annum)	**(%)**
Savings from energy demand reduction (‘Be Lean’)	12.22	12%
Savings from efficient energy supply (‘Be Clean’)	1.43	1%
Saving from renewable energy (‘Be Green’)	21.53	22%
Total Cumulative Savings	35.19	35%
Total Target Savings	34.81	35%
Annual Surplus	0.38	-

Table 0.2: Regulated carbon dioxide savings from each stage of the Energy Hierarchy

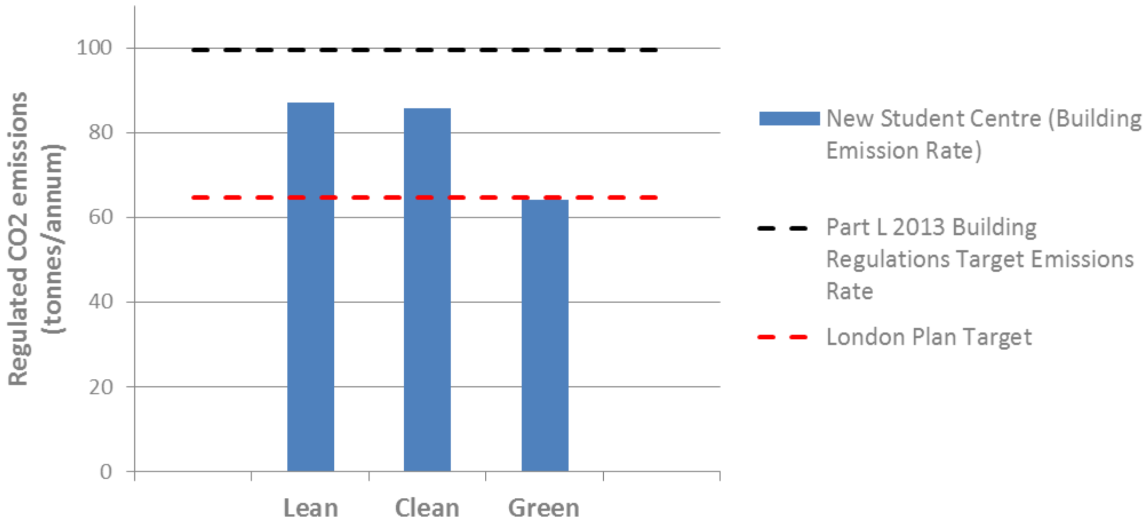


Figure 0.1: The energy hierarchy

1.0 Introduction

This document presents the proposed energy strategy for the New Student Centre and calculates the potential reduction in CO_2 emissions as calculated under Building Regulations Part L 2013.

Key features of the design are discussed along with how have then been represented within the Part L energy model, in accordance with the Notional Calculation Methodology (NCM) modelling guide[1].

1.1 Policy and Guidance

Building Regulations Part L 2013

The development of the New Student Centre will be subject to Approved Document L2A. In accordance with Regulation 26 the actual Building CO_2 Emission rate (BER) must be no greater than the Target CO_2 Emission Rate (TER)".

Greater London Authority (GLA)

On 6 April 2014 the 2013 changes to Part L of the Building Regulations came into effect. Part L 2013 delivers an overall reduction in CO_2 emissions for new residential and new non-domestic buildings, with the targets for individual buildings being differentiated according to building type. This reduction in CO_2 emissions affected the percentage reduction necessary above the Part L 2013 regulations to meet the Mayor's targets in the London Plan.

As outlined in the Sustainable, Design and Construction SPG, since 6 April 2014 the Mayor has applied a 35 per cent carbon reduction target beyond Part L 2013 of the Building Regulations.

Camden

Camden's policy is to follow the recommendation of the GLA. As such the carbon dioxide target for 2013-2016 is 35 per cent beyond Part L 2013 of the Building Regulations.

Camden Planning Guidance on Sustainability (CPG 3) sets out the following additional targets with regards to energy and carbon:

- Where feasible and viable developments will be required to connect to a decentralised energy network or include CHP.
- Developments are to target a 20 per cent reduction in carbon dioxide emissions from on-site renewable energy technologies.

[1] National Calculation Methodology (NCM) modelling guide (for buildings other than dwellings in England), 2013 Edition.

2.0 Environmental Strategy

The approach to conditioning the internal environment is to respond to seasonal weather variations, prioritising the use of passive and low energy measures.

In winter, mechanical ventilation with heat recovery (MVHR) is preferred because it provides much better control and heat recovery. During a midseason scenario, natural ventilation is to be employed, delivering much higher air flows than a MVHR system, providing ‘free cooling’ for this period. Finally, the building will utilise low energy ground source cooling to maintain comfort levels during peak summer months. The environmental strategy is illustrated by Figure 2.1.

As the New Student Centre is provided with cooling, the risk of overheating is mitigated. However the aim is to maximise the ‘mid-season’ and thus natural ventilation operation of the building. By limiting the reliance on energy intensive space conditioning, operational energy consumption can be reduced.

A particular focus has been to ensure the area below roof level does not result in significant cooling loads. Solar shading has been maximised in this area to help reduce solar gains.

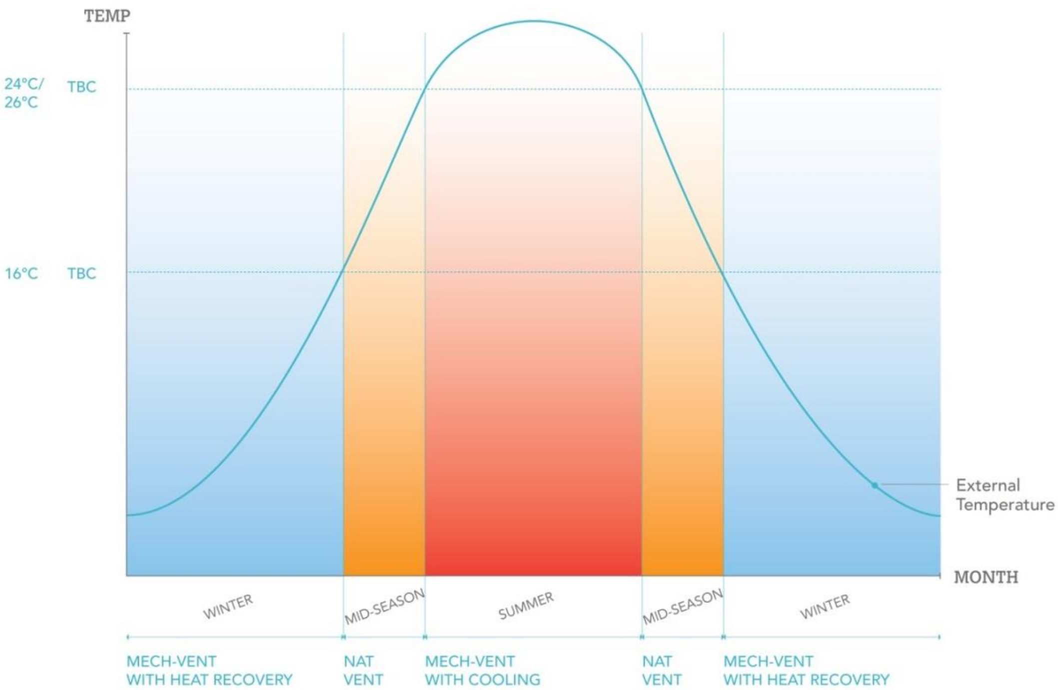


Figure 2.1: Proposed environmental strategy

3.0 Energy and Carbon Profiles

3.1 Dynamic Simulation

Part L compliance calculations were undertaken on IES Virtual Environment Version 2014.2.1.0 using the VE Compliance (UK & Ireland) module version 7.0.2.0.

The standard weather set used is for London which is closest in distance to the site of the proposed building.

The 2013 version of the NCM Activity database has been used to define internal gains and environmental conditions, using the building class of "D1 Non-residential Institutions: Education".

Building geometry, constructions and systems have been inputted in accordance with the Notional Calculation Methodology and represents current architectural and mechanical and electrical design.

For a list of compliance modelling assumptions please refer to Appendix A.

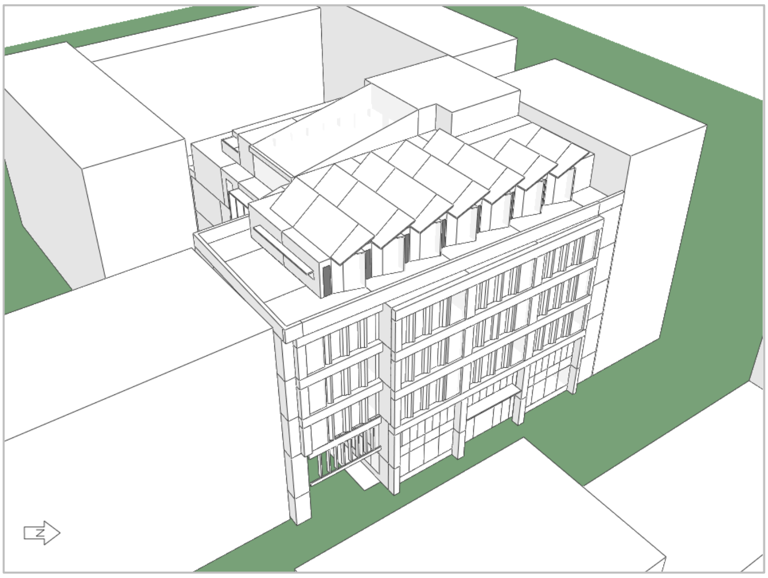


Figure 3.1: IES dynamic model of the New Student Centre for simulation purposes

4.0 Use Less Energy ('Be Lean')

The priority of any energy strategy is to reduce energy demand. Once this is achieved efficient means of supplying energy can then be considered. The following sets out strategies to improve the energy efficiency of the New Student Centre.

Passive measures are prioritised and these are intended to limit the energy demands for space heating, cooling and lighting through the appropriate selection of the following:

- Building fabric;
- Thermal bridging;
- Air tightness;
- Thermal mass;
- Features which affect lighting and solar gain.

Building fabric insulation, airtightness and thermal bridge free standards will be maximised before any renewable energy generation is considered. This will minimise the size of expensive equipment required and ensure significant CO_2 reductions over the buildings life.

4.1 Fabric Efficiency

The building envelope is the primary climatic modifier and its enhancement can significantly reduce the energy demand of the building. The building envelope is likely to be retained throughout the life of the building and it is prudent to focus investment here.

The building envelope will aim to achieve an excellent standard of thermal insulation and air tightness, helping to reduce the amount of energy required for space heating during winter months. An air permeability of 3 m3/(h.m2) at 50Pa is proposed along with building fabric parameters outlined in Table 4.1.

Improved solar control glazing (represented by the g-value) will be specified to limit solar gains, helping to reduce cooling demand during the summer period.

Building Element	U-value (W/m2K)	g-value	Light Transmittance
External wall	0.20	-	-
Glazing	1.50*	0.40	0.60 (minimum)
Ground floor	0.13 (adjusted)**	-	-
Exposed floor	0.20		
Roof	0.15	-	-

*10% glazing frame factor.
**Ground contact floor U-value corrected in line with EN-ISO 13370. Correction is based on the ratio between the buildings footprint and perimeter as calculated by IES.
***Default values for thermal bridging coefficient used by IES.

Table 4.1: Proposed building fabric parameters

4.2 Maximise Thermal Mass

In addition to high thermal performance of the building fabric, the building has significant thermal mass to help control internal heat gains. Concrete slabs will be exposed throughout specific areas in the building, to allow access to this thermal mass; and has been represented within the thermal model.

4.3 Optimise Daylight

All glazing will maximise its light transmittance (while mindful of solar gain) to ensure sufficient levels of natural daylight are achieved, helping to reduce the requirement for electric lighting. A central atrium will also help to bring light deep into the building.

4.4 Limit Solar Gain

Strategies for reducing winter heat losses such as superinsulation and good air tightness also help to reduce summer heat gains, minimising overheating and reducing cooling loads; providing there is adequate solar shading.

Solar analysis studies have helped to inform specific façade treatments for the building. The areas of glazing, depths of reveals and overhangs respond to the sun path, working together to reduce the amount of solar gain entering the building.

Solar Shading

Smaller windows have been used on the west elevation (where solar stresses are greatest), with deeper window reveals to limit unwanted solar gain. Glazing along this façade at Japanese Garden level has also been set back from the building line with the use of a colonnade to provide additional shading. Higher up the façade, fixed solar shading is introduced with larger overhangs on the top floor, to shield these more exposed areas of the building.

Generally areas of high thermal stress along the West and South are shielded by the surrounding buildings. All of these features have helped to reduce the annual solar exposure, illustrated by the following images.

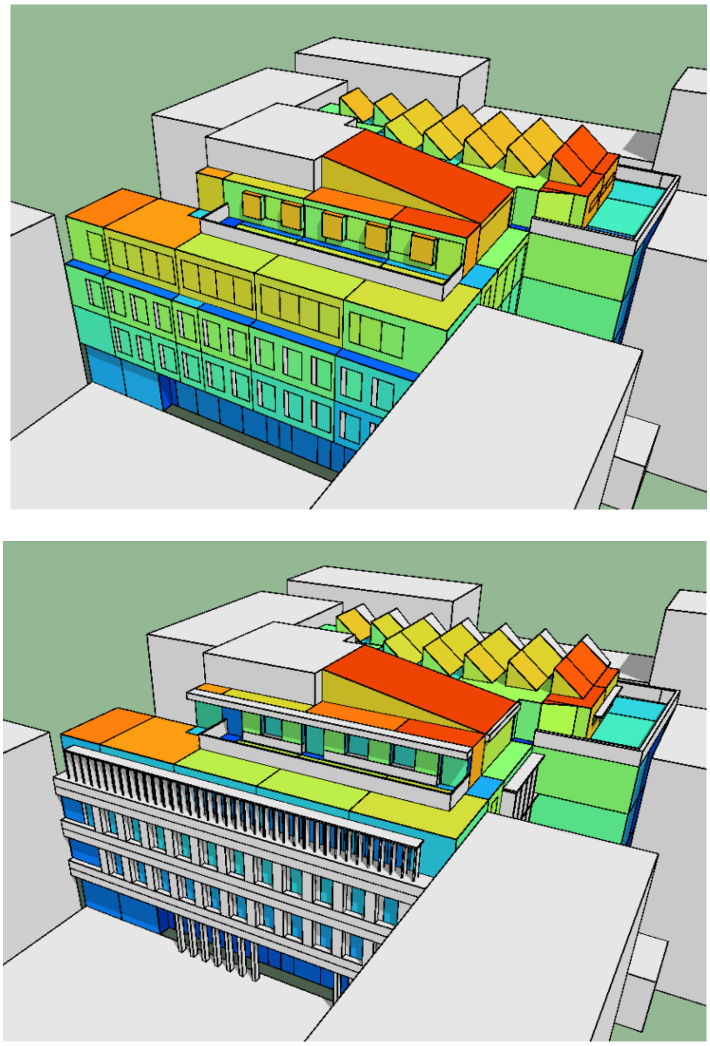


Figure 4.2: Solar exposure studies along West façade, without and with solar shading, top and bottom respectively

Grilles

In line with current architectural plans, grilles are applied in front of a selection of windows along the East façade (please refer to architectural drawings). This type of external shading device has been modelled as a miniature louvre system for the purposes of Part L modelling. The transmission characteristics for the effected windows have been specified as a function of the vertical shadow angle in line with guidance from IES (outlined in Appendix B).

Limiting the Effects of Heat Gains in Summer

The New Student Centre will aim to limit the effects of solar gains during the summer period in accordance with Criterion 3 of Part L2A. This condition aims to reduce the actual amount of solar gain entering a space, whether air conditioned or not, and is in addition to minimising the effects of overheating. By minimising the cause of overheating comfortable space conditions can be achieved, alongside a reduced reliance on mechanical cooling.

Improved g-values, solar shading and reduced glazing areas have all been considered to help the New Student Centre meet these requirements. Appropriate solar gain checks have been undertaken and are illustrated within the Part L Report of Appendix C.

4.5 Low Energy Lighting

Fixed lighting systems are proposed to be energy efficient with control systems to help minimise their use. Current electrical design is targeting a maximum sensible gain of 6W/m2 to all spaces and has been included within the thermal model.

All of the lighting will be controlled by occupancy sensors. In line with NCM modelling guide, areas larger than 30m2 are unable to receive local manual switching and thus for these areas occupancy sensing is in the form of “Auto-on-off”. All other spaces are modelled with occupancy sensing in the form of “Manual-on-Auto-off” i.e. manually switched on and automatically switched off when no movement has been detected for a set time.

All spaces which receive natural daylight directly (via windows) will have their lighting regulated by daylight sensors. In line with NCM modelling guide daylight-linked control applies to a lighting zone up to approximately 6m from the building perimeter. Daylight sensors are to be “Standalone” with “Switching” control type. Back sensors are also included.

Parasitic power associated with the occupancy sensing and photoelectric options is calculated in accordance with the NCM modelling guide at 3% of the installed lighting load. All sensors to have time switch control allowing them to be turned off when spaces are unoccupied so that they do not consume power unnecessarily.

4.6 Mechanical Ventilation with Heat Recovery

Ventilation losses account for a significant component of the total heat losses in a low energy building. Mechanical ventilation with heat recovery (MVHR) is used to recover ventilation heat losses during the winter and will also help prevent spaces from overheating during warmer periods (with the heat recovery element by-passed).

In line with the proposed environmental strategy, the New Student Centre is expected to utilise mechanical ventilation throughout the majority of the year. To counteract the energy use associated with running mechanical ventilation, a key component of the energy strategy will be low specific fan powers (SFP) of 1.8 W/(l/s) and high efficiency heat recovery of 72.9%.

All spaces with mechanical ventilation provision are provided with demand control to regulate flow rates with variable speed control fans via CO2 sensors.

WC and cleaner stores are connected to a central extract system with a SFP of 0.5 (extract at 6ACH).

4.7 Natural Ventilation and Free Cooling

When conditions permit natural ventilation may be used to reduce the energy consumption associated with mechanical ventilation and cooling provision. Natural ventilation will be provided via openable windows, with the central atrium helping to facilitate stack induced ventilation.

In line with the mixed-mode strategy for NSC outside air will be made available for 'free cooling'. As such a "free cooling flow capacity" has been included within the thermal modelling, indicating the maximum intake of outside air that is available for free cooling.

In the case of a naturally ventilated room (i.e. all those with access to openable windows), a typical value of 5 air-changes per hour (ach) is assumed to model ventilation available by window opening. Where the outside air is brought in via a system (i.e. mechanically ventilated spaces in the basement) a lower value of 0.5 l/(s.m2) has been assumed.

The additional air will be brought in, subject to the given maximum, only if appropriate (i.e. outside temperature less than inside) when the room temperature reaches the cooling set point. This applies whether or not there is air conditioning in the room. If there is no air conditioning, the free cooling represents an idealised form of natural ventilation, introducing just enough air to hold the room temperature at the set point. If there is air conditioning, the free cooling represents an idealised from of fresh air optimisation. (Simulation of 'free cooling' in line with, IES guidance[2]).

4.8 Smart Controls

Where applicable, in line with NCM guidance, variable speed pumps with multiple pressure sensors have been included within the thermal model, along with the following management features:

- Power quality control system to have an electric power factor greater than 0.95.
- Lighting systems have provision for metering.
- Lighting systems metering warns of 'out-of-range' values.

[2] Building Regulation – Part L2 (2013), ApacheSim (DSM) User Guide, IES Virtual Environment, April 2014

5.0 Supply Energy Efficiently ('Be Clean')

Community heating and/or cooling provides heat/'coolth' from a central source to one or many buildings via its own distribution network. The heat/'coolth' can be supplied from conventional fossil fuels and/or through low and zero carbon technologies, such as combined heat and power plant (CHP).

By generating energy closer to where it is needed, transmission losses can be avoided. The viability of community heating is considered, specifically UCLs existing Bloomsbury Campus district heat scheme.

5.1 District Heating

UCL's district heating system supplies UCL's central campus with heat and is powered by a combination of gas CHP engines, gas boilers and oil boilers (used for back-up only). This produces a combination of medium temperature hot water and steam that feeds into the network.

UCL have installed a comprehensive set of meters on the district heating system to identify the carbon intensity of the heat that is produced by the system. The CO2 emissions per kWh of heat produced by the system are estimated to be 0.205 kgCO2/kWh excluding distribution losses (using 2013 fuel emission factors). Distribution losses are estimated to be approximately 18 per cent, providing an overall system performance of 0.242 kgCO2/kWh.

The current performance is comparable to that of a standard natural gas boiler (assuming a boiler efficiency of 90%). However, a district heating system would be expected to perform with greater efficiencies.

Due to system inefficiencies carbon savings from the inclusion of district heating will not provide the carbon savings expected of such a system. This is also the case in terms of Part L calculation (in line with the National Calculation Methodology) which will attribute no benefit over the Notional building for a district heating system with an emission factor this high. In this scenario the Notional building will have the same emission factor of heat supplied as the Actual building. To gain benefit against the Notional building the emission factor of heat supplied will need to be less than 0.15 kgCO2/kWh.

UCL is currently reviewing the performance of this system, with efficiency improvements planned for the future.

5.2 Space Heating and Domestic Hot Water

In line with planning requirements the New Student Centre will be connected to this existing decentralised energy network. The district heating will serve: the air handling units doing the ventilation heating load; and domestic hot water requirements. The remainder of the space heating, to the perimeter trench heaters (meeting the fabric load) will be met by a ground source heat pump (GSHP) linked to the open loop ground source borehole. For modelling purposes the coefficient of performance (COP) of the GSHP is estimated to be 3.6.

5.3 District Cooling

An open loop system will abstract cool water from the ground (at around 12degC) and provide this directly to the building for 'free cooling'. Compared with conventional chillers, the energy savings associated with the use of ground water cooling are significant. The only energy requirement is for circulating water (pump power), whereas the majority of energy associated with conventional cooling is for compressors within the chiller plant. Therefore the coefficient of performance (COP) is very high when compared to traditional cooling systems. Initial investigations have been undertaken by Ground Source Consult Ltd and based on data from them; the COP has been estimated at 20 for modelling purposes.

5.4 Cooling

During periods of peak summer temperatures, when natural ventilation can no longer maintain comfort conditions, cooling is needed to ensure the building remains comfortable.

Cooling will be provided for 'free' via an open loop ground source borehole. The cool water will be used to cool ventilation air directly and will then be circulated through pipework embedded in the underside of the concrete floor slab; cooling the structure and providing radiant cooling to occupants.

Initial studies suggest the capacity of the open loop system is sufficient to cope with the cooling loads of the building. A 90% saving in cooling energy consumption has been calculated for the ground water cooling system, compared with the cooling consumption of the Notional building (based on results from the Part L Compliance modelling).

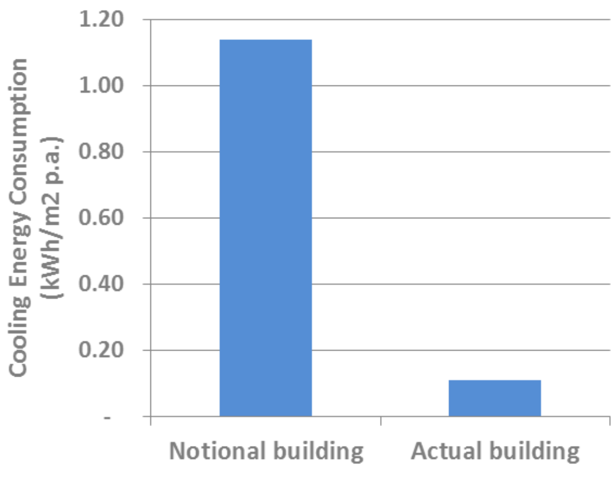


Figure 5.1: Cooling energy consumption saving

The cooling strategy has been developed in line with the 'Cooling Hierarchy' with passive measures prioritised to help reduce the installed capacity of the cooling systems:

1. Minimise internal heat generation using energy efficient lighting and control systems.
2. Reduce the amount of heat entering the building in summer through reduced glazing areas along the West and South, improved solar control glazing and shading devices.
3. Manage heat within the building through exposed internal thermal mass.
4. Utilise passive ventilation when external conditions permit.
5. Highly efficient mechanical ventilation and 'free-cooling' to maintain comfort conditions.
6. Cooling systems making use of the open loop borehole.

6.0 Use Renewable Energy ('Be Green')

Having maximised energy savings from fabric efficiencies and low energy measures, low to zero carbon technologies (LZC) are reviewed as part of a holistic energy strategy. LZC technologies will be necessary to help the New Student Centre meet the challenging carbon targets, especially considering the current poor performance of UCL's existing District Heating system.

An initial analysis has been undertaken to determine the most appropriate local LZC technologies for the New Student Centre, based on their suitability for the site and building. Consideration was given to: available local systems; how technologies could be integrated with the proposed mechanical and electrical strategy; and if they would provide reasonable energy, carbon and cost savings. Please refer to Appendix C for the feasibility study.

Renewable technologies are relied upon to meet carbon targets for the project. In addition to a connection to UCLs District Heating network and the proposed ground source cooling, photovoltaic panels (PV) are to be used.

6.1 Photovoltaic Panels (PV)

The energy strategy has aimed to maximise the PV installation with three areas proposed for PV provision:

- Building integrated photovoltaics (BIPV) for the atrium roof
- Pitched roof lights
- Bloomsbury Theatre roof.

Adequate area has been identified following discussions with the architect and a number of PV suppliers. Initial investigations undertaken by these PV suppliers have suggested there is sufficient area to generate the energy required to reach the carbon reduction and renewable energy targets for the project.

Current Part L modelling suggests the PV panels will need to generate approximately 41,410 kWh of electricity. This output has been included within the Part L model, saving approximately 21.5 tonnes of CO2 per annum.

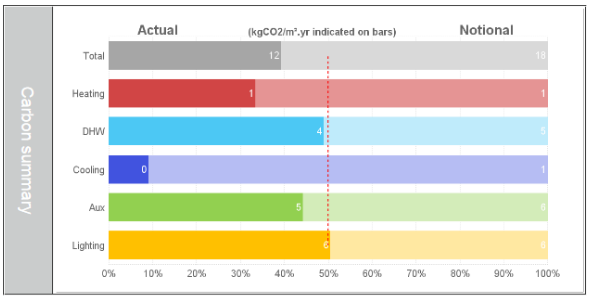
7.0 Results

7.1 Building Regulations Part L 2013

A 35 per cent carbon dioxide reduction on 2013 Building Regulations is anticipated for the New Student Centre. The BRUKL Output Document is contained within Appendix C. Carbon and energy summaries are detailed in Figures 7.1 and 7.2.

Target Emission Rate (TER)	18.1 kgCO2/m2.annum
Building Emission Rate (BER)	11.7 kgCO2/m2.annum
Percentage Improvement	35%

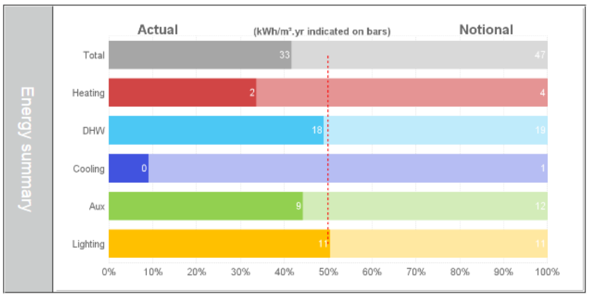
Table 7.1: Part L 2013 results



$kgCO_2/m^2.yr$	Actual	Notional
Heating	0.66	1.31
DHW	4.46	4.63
Cooling	0.06	0.58
Aux	4.79	6.03
Lighting	5.61	5.51
Renewables	(-3.91)	(0.00)
Total	**11.68**	**18.07**

Results represent total CO_2 output. BER rating includes applicable adjustment factors.

Figure 7.1: Part L carbon summary



$kWh/m^2.yr$	Actual	Notional
Heating	1.78	3.51
DHW	18.43	19.13
Cooling	0.11	1.14
Aux	9.47	11.92
Lighting	11.10	10.90
Renewables	(-7.52)	(0.00)
Total	**33.36**	**46.60**

Figure 7.2 Part L energy summary

The energy strategy maximises passive and low energy measures, working hard to push every element of the building, ensuring the lowest energy use possible. The poor performance of UCL's existing District Heat system, which is utilised under the 'Clean' element of the Energy Hierarchy, means a more substantial amount of renewable energy generation is required to meet the 35% improvement on current 2013 Building Regulations.

7.2 Energy Demand and Carbon Dioxide Emissions

The baseline energy demand and carbon dioxide emissions have been calculated for the New Student Centre in accordance with Camden Planning Guidance. Modelling using the Standard Assessment Procedure has been undertaken and an analysis of both regulated and unregulated energy has been included.

Energy demand and carbon dioxide emissions have been identified for the following scenarios:

1. Baseline/Notional building – Part L 2013 compliant building.
2. 'Lean' – Reduce energy demand i.e. inclusion of passive and low energy measures.
3. 'Clean' – Supply energy efficiently i.e. inclusion of UCL's District Heating and ground source cooling.
4. 'Green' – Use renewable energy i.e. inclusion of PV panels.

	Baseline/Notional		'Lean'		'Clean'		'Green'	
	kWh	kgCO2	kWh	kgCO2	kWh	kgCO2	kWh	kgCO2
Regulated								
Heating	19,329	7,214	9,802	3,634	9,802	3,634	9,802	3,634
DHW	105,343	25,496	101,488	24,560	101,488	24,560	101,488	24,560
Cooling	6,278	3,194	3,469*	1,762	606	330	606	330
Aux	63,988	33,205	52,148	26,377	52,148	26,377	52,148	26,377
Lighting	60,023	30,342	61,124	30,893	61,124	30,893	61,124	30,893
Unregulated								
Equipment	163,714	84,968	163,714	84,968	163,714	84,968	163,714	84,968
Generated								
PV	-	-	-	-	-	-	-41,410	-21,531
Total								
Reg	254,960	99,451	228,032	87,226	225,169	85,794	183,759	64,263
Reg + Unreg	418,674	184,419	391,747	172,194	388,883	170,762	347,473	149,231
% Improvement Over Baseline								
Reg	-	-	11%	12%	12%	14%	28%	35%
Reg + Unreg	-	-	6%	7%	7%	7%	17%	19%

*Cooling COP assumed to be in line with NCM modelling guide and notional building specification with a cooling SSEER of 3.6 (SEER of 4.5).

Table 7.2: Energy demand and carbon dioxide emissions

As illustrated in Table 7.2 a 35% improvement on the current 2013 Building Regulations is achieved. A 25% reduction in regulated CO2 emissions is achieved from the use of PV when calculated relative to the residual CO2 emissions after the clean element of the hierarchy or 22% calculated relative to the Part L 2013 Target Emissions Rate.

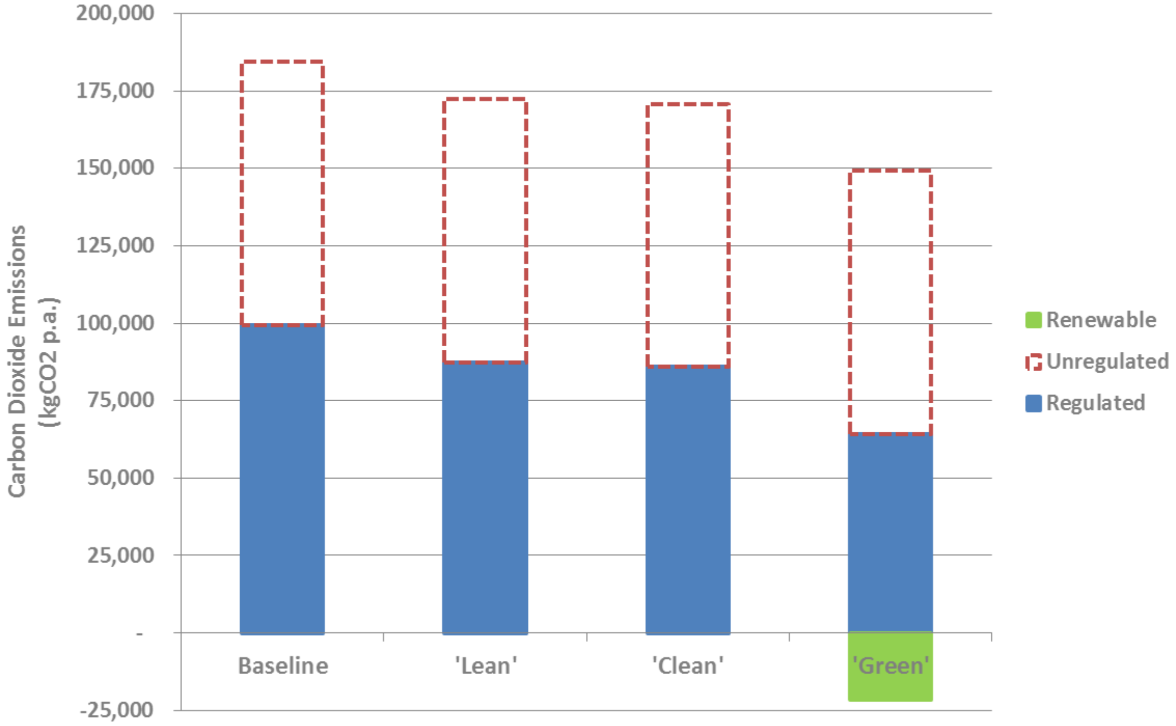


Figure 7.3: Carbon dioxide emissions savings

Appendices

Appendix A Modelling Assumptions

A.1 External Miniature Louvres

Vertical Shadow Angle (degree)	Transmission
0	0.65
15	0.4
30	0.2
45	0
60	0
75	0
90	0

A.2 Systems

In line with National Calculation Methodology (NCM) modelling guide only one system can be applied per zone. In the case of the New Student Centre the open plan zones from the first floor up are served by two systems: perimeter trench heaters supplied by a ground source heat pump (GSHP); and an air handling unit (AHU) with heating coils fed from UCL's District Heat network (DH).

To include both systems within the Compliance model and best represent the intended operation and consumption of the building the following approach has been taken. It has been assumed that the trench heaters predominantly serve one part of the zone (the perimeter) and the AHU serves the other part (interior space). As such the zones in the thermal model have been divided to reflect this with the appropriate system applied to each zone.

The GSHP has been assigned to a perimeter zone extending approximately 6m from the edge of the building. The District Heating has been assigned to the other, interior part of the zone.

Systems	Heating supplied by	Cooling supplied by	UK NCM Type	Notes
Basement AHU	Heating coil served by DH.	Ground source cooling.	Constant volume system (variable fresh air rate).	-
Ground floor underfloor heating	Underfloor heating served by GSHP.	Ground source cooling.	Water loop heat pump.	-
Perimeter trench heating	Trench heating served by GSHP.	Ground source cooling.	Chilled ceilings or passive chilled beams and displacement ventilation.	Zone extends 6m from the perimeter of the building (matching the lighting zone).
Interior space AHU displacement ventilation	AHU heating coil served by DH.	Ground source cooling.	Chilled ceilings or passive chilled beams and displacement ventilation.	-

Cellular spaces	Trench heating served by GSHP.	Ground source cooling.	Chilled ceilings or passive chilled beams and displacement ventilation.	-
Toilet and Cleaner extract	Heating to accessible WC	None.	Central heating using water: radiators.	-

A.3 Domestic Hot Water

- 600 litres storage volume
- Storage tank losses of 0.00630 kWh/l.day, in line with guidance from The Non-domestic Building Services Compliance guide.

Appendix B LZC Feasibility Study

LZC	Suitable for Site	Reason	Preferred Option	Reason
Solar: The suns energy can be converted into useful electricity/heating energy for buildings.				
Solar Thermal: Convert energy from the sun into hot water.	☑	Solar collectors are able to receive both direct (sunlight) and diffuse (daylight) solar energy. Therefore, this system is well suited to the UK, which experiences a high percentage of cloudy days. The orientation and nature of the roof of NSC appears to be favourable to the installation of solar technologies. Educational buildings have a substantial year round demand for hot water which will improve the viability of an installation.	☒	Solar thermal installations are not to be recommended in conjunction with any District Heat or Combined Heat and Power systems, as these two technologies would 'compete' to meet the available heat demand, particularly during summer periods. Space heating and domestic hot water is to be provided by UCL's District Heat system, in line with the 'Be Clean' tier of the energy hierarchy.
Photovoltaic (PV) Panel: Convert solar energy into electricity.	☑	Reasonable solar resource available throughout the UK. Annual total global horizontal irradiation in London appears to be around 900-1000 kWh/m2. Sufficient roof space identified for the installation of PV panels.	☑	Sufficient solar exposure to the New Student Centre and Bloomsbury Theatre roofs identified for PV installation. Appears to be adequate un-shaded roof areas and ability to position panels optimally, for efficient energy generation.
Ground Source Cooling: Accesses 'coolth' stored in the ground, which is suitable for directly cooling many types of buildings				
Open loop system: Water is abstracted from the ground then passed through a heat exchanger to transfer 'coolth' to the building systems.	☑	Typically in the UK ground temperatures 12m below the surface lie between 9 and 12°C. These temperatures are suitable for directly cooling the New Student Centre. Initial investigations undertaken by Ground Source Consult Ltd state an aquifer is present with an accessible source of ground water available for extraction.	☑	A ground water cooling system can provide the New Student Centre with 'free cooling'. Compared with conventional chillers, the energy savings associated with the use of ground water cooling are significant. The only energy requirement is for circulating water (pump power), whereas the majority of energy associated with conventional cooling is for compressors within the chiller plant.

LZC	Suitable for Site	Reason	Preferred Option	Reason
Heat Pumps: Extracts heat from one location (the 'source'), upgrades the heat and moves it to another location (the 'sink').				
Ground /Water /Air Source Heat Pumps: The source of heat can be the ground, water or air.	☑	Open loop ground boreholes are proposed to provide cooling to the site. Ground source heat pumps can make use of the heat stored in the ground and raise it to a more useful output temperature for use in heating buildings.	☑	Source of low grade heat to serve trench heaters that deal with building fabric heat load.
Biomass: Biomass is fuel derived from burning or gasification of trees or plants which have absorbed CO2 during their lifetime.				
Biomass Boiler: Works like a conventional gas boiler, but burns wood instead of gas.	☒	No adequate facilities for biomass storage.	☒	Space heating and domestic hot water is to be provided by UCL's District Heat system, in line with the 'Be Clean' tier of the energy hierarchy.
Wind: Electrical energy generated by wind turbines.				
Wind Turbine: The wind turns blades which drive a turbine to generate electricity.	☑	The average wind speed on site according to the UK Wind Speed Database (Department of Energy & Climate Change) is greater than the 5m/s which is required for generating worthwhile quantities of electricity.	☒	For a wind turbine to work at good capacity, an exposed windy site that is not too close to buildings or obstructions is required. Positioned within a highly built up urban location there are a number of obstructions that may interfere with the wind flow, negatively effecting performance. Wind turbines are also unlikely to be granted planning permission as The New Student Centre is in the Bloomsbury Conservation Area and close to several listed buildings.

Appendix C Part L Results (BRUKL Report)

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

UCL New Student Centre

As designed

Date: Wed May 20 15:45:09 2015

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.2

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.2

BRUKL compliance check version: v5.2.b.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

1.1	CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	18.1
1.2	Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	18.1
1.3	Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	11.7
1.4	Are emissions from the building less than or equal to the target?	BER =< TER
1.5	Are as built details the same as used in the BER calculations?	Separate submission

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

Values which do not meet standards in the 2013 Non-Domestic Building Services Compliance Guide are displayed in red.

2.a Building fabric

Element	$U_{a\text{-Limit}}$	$U_{a\text{-Calc}}$	$U_{i\text{-Calc}}$	Surface where the maximum value occurs*
Wall**	0.35	0.22	1.49	0200004C:Surf[2]
Floor	0.25	0.16	0.2	0M00000A:Surf[0]
Roof	0.25	0.15	0.15	04000006:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.45	1.49	00000003:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

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

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

2.b 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- GSHP

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.6	20	0	1.8	0.73
Standard value	2.5*	3.2	N/A	1.6	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.

2- Nat Vent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
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	YES				

3- Perimeter - GSHP - (Free NV)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.6	20	0	1.8	0.73
Standard value	2.5*	3.2	N/A	1.6	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.

4- Cellular - GSHP - (Free MV)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.6	20	0	1.8	0.73
Standard value	2.5*	3.2	N/A	1.6	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.

5- Inner Space - DH - (Free NV)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	20	0	1.8	0.73
Standard value	N/A	3.2	N/A	1.6	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

6- AHU - DH (and DHW)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	20	0	1.8	0.73
Standard value	N/A	3.2	N/A	1.6	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

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

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
00_reception-1	-	59	15	320
00_circ-1	-	68	-	135
00_acc wc-1	-	127	-	27
00_wc-2	-	167	-	17
00_wc-3	-	167	-	17
00_stairs-1	-	64	-	190
00_first aid	77	-	-	34
00_stairs to B1	-	85	-	66
00_staits to 0M	-	68	-	82
00_circ-2	-	78	-	223
00_circ-5	-	56	-	264
00_informal study-1	40	-	-	333
0M_study-2	65	-	-	56
0M_stairs-1	-	79	-	190
0M_circ-1	-	101	-	236
0M_acc wc-1	-	174	-	27
0M_wc-2	-	174	-	17
0M_wc-3	-	174	-	17
0M_wc-4	-	174	-	17
0M_wc-5	-	174	-	17
B1_stair	-	82	-	139
B1_store	109	-	-	65
B1_circ-2	-	88	-	245
01_consult-2	87	-	-	40
01_hub	77	-	-	49
01_stair-1	-	72	-	190
01_acc wc-1	-	162	-	27
01_wc-2	-	174	-	17
01_wc-3	-	174	-	17
01_wc-4	-	174	-	17
01_wc-5	-	174	-	17
01_void	-	174	-	0
01_circ-4	-	61	-	98
01_study-1	39	-	-	191
01_study-3	39	-	-	186
01_circ-1	-	88	-	236
02_hub	77	-	-	49
02_stair-1	-	72	-	190
02_acc wc-1	-	162	-	27
02_wc-2	-	174	-	17
02_wc-3	-	174	-	17
02_wc-4	-	174	-	17

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
02_wc-5	-	174	-	17
02_void	-	174	-	0
02_circ-5	-	61	-	98
02_resource-1	-	81	-	56
02_circ-1	-	88	-	236
02_circ-4	-	73	-	105
02_group-2	71	-	-	60
03_hub	77	-	-	49
03_stair-1	-	72	-	190
03_acc wc-1	-	162	-	27
03_wc-2	-	174	-	17
03_wc-3	-	174	-	17
03_wc-4	-	174	-	17
03_wc-5	-	174	-	17
03_resource-1	-	81	-	56
03_void	-	174	-	0
03_circ-3	-	61	-	98
03_study-3	48	-	-	77
02_study-18	39	-	-	191
02_study-16	39	-	-	186
02_study-10	53	-	-	40
02_study-3	48	-	-	77
02_study-5	45	-	-	120
02_study-7	47	-	-	124
02_group-1	76	-	-	53
02_circ-3	-	59	-	341
03_study-5	47	-	-	122
03_study-7	46	-	-	98
03_cafe-5	-	56	-	143
03_cafe-7	-	56	-	147
04_stair-1	-	67	-	190
04_wc-1	-	164	-	17
04_wc-2	-	164	-	17
B2_cl	120	-	-	15
B1_cl	120	-	-	15
00_cl	120	-	-	15
00_circ-3	-	72	-	220
0M_cl	120	-	-	15
01_cl	120	-	-	15
02_cl	120	-	-	15
03_cl	120	-	-	15
04_cl	120	-	-	15
04_circ-0	-	61	-	124

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
04_store	95	-	-	23
02_study-6	41	-	-	271
02_study-4	39	-	-	264
02_study-2	40	-	-	261
02_group-3	62	-	-	81
02_circ-4	-	157	-	35
02_study-19	41	-	-	266
02_group-5	80	-	-	45
02_study-12	59	-	-	51
02_study-17	39	-	-	259
02_study-11	42	-	-	151
02_group-7	91	-	-	36
02_study-13	41	-	-	256
02_study-15	42	-	-	187
02_study-14	42	-	-	151
02_group-6	91	-	-	36
01_study-2	41	-	-	266
01_study-4	39	-	-	259
02_group-4	61	-	-	86
02_stair-2	-	76	-	160
01_stair-2	-	76	-	160
02_study-8	45	-	-	329
01_sefl service 2	47	-	-	194
01_consult-7	82	-	-	44
01_consult-5	81	-	-	45
01_consult-9	76	-	-	53
01_circ-5	-	174	-	19
01_consult-8	89	-	-	37
01_self service 3	51	-	-	105
01_consult-6	95	-	-	33
01_student enquiries	39	-	-	723
01_circ-3	-	64	-	135
01_consult-4	78	-	-	48
01_consult-3	77	-	-	50
01_wc-6	-	83	-	124
01_cl	120	-	-	23
01_staff admin	68	-	-	72
01_study-5	42	-	-	151
01_study-6	42	-	-	187
01_staff base	57	-	-	151
01_stair-3	-	74	-	246
01_self service 1	51	-	-	245
01_store	120	-	-	19

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
01_student services office	44	-	-	517
03_study-2	40	-	-	261
03_study-4	41	-	-	264
03_study-6	41	-	-	271
03_cafe-4	-	57	-	259
03_cafe-6	-	58	-	266
03_stair-3	-	76	-	160
03_study-8	41	-	-	222
03_study-9	44	-	-	220
03_circ-2	-	60	-	368
03_group-1	77	-	-	51
03_group-2	74	-	-	56
03_stair-2	-	73	-	197
03_cafe-3	-	67	-	87
03_wc-6	-	129	-	38
03_cafe prep	-	74	-	162
03_cafe-2	-	57	-	252
03_cafe-1	-	63	-	261
03_circ-4	-	87	-	279
04_study-1	48	-	-	68
04_study-10	41	-	-	123
04_study-11	43	-	-	94
04_circ-3	-	60	-	90
04_wc-3	-	164	-	17
04_wc-3	-	164	-	17
04_acc wc-5	-	125	-	27
04_circ-1	-	77	-	236
04_study-9	54	-	-	91
04_study-8	45	-	-	115
04_stairs-2	-	64	-	113
04_study-6	41	-	-	243
04_study-7	39	-	-	286
04_study-4	41	-	-	237
04_study-5	39	-	-	285
04_study-2	46	-	-	191
04_study-3	44	-	-	79
04_void	-	174	-	0
04_void top	-	174	-	0
00_circ-4	-	56	-	307
0M_study-1	56	-	-	79
00_circ-8	-	63	-	364
00_informal study-2	39	-	-	355
00_circ-7	-	73	-	128

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
00_circ-6	-	72	-	113
0M_circ-2	-	64	-	220
0M_study-5	41	-	-	333
0M_study-4	39	-	-	307
0M_study-3	40	-	-	320
0M_void	-	57	-	307
0M_circ-3	-	63	-	98
0M_study-9	41	-	-	266
0M_study-8	39	-	-	115
0M_circ-5	-	57	-	259
0M_circ-4	-	56	-	112
0M_study-7	41	-	-	364
0M_study-6	49	-	-	104
0M_stairs-2	-	82	-	210
0M_circ-6	-	89	-	148
B1_plant	43	-	-	731
B1_circ-4	-	116	-	72
B1_media-3	72	-	-	58
B1_media-4	76	-	-	53
B1_media-5	82	-	-	47
B1_media-1	72	-	-	58
B1_media-2	76	-	-	53
B1_resource	82	-	-	47
B1_circ-3	-	72	-	242
B1_study-4	41	-	-	415
B1_study-3	41	-	-	371
B1_study-2	42	-	-	302
B1_study-1	42	-	-	294
B1_staff	69	-	-	156
B1_wc-3	-	174	-	18
B1_wc-2	-	174	-	17
B1_acc wc-1	-	174	-	41
B1_circ-1	-	97	-	289
B2_store	82	-	-	52
B2_plant	42	-	-	956
B2_store	54	-	-	71
B2_shower	-	67	-	249
B2_server	63	-	-	96
B2_wc-1	-	174	-	20
B2_wc-2	-	174	-	17
B2_stairs-1	-	73	-	245
B2_ablution-2	-	93	-	77
B2_lockers	-	97	-	98

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
B2_circ-3	-	98	-	117
B2_ablution-1	-	89	-	97
B2_circ-1	-	75	-	375
B2_circ-2	-	62	-	229
B2_qcr	40	-	-	840
B2_stairs-2	-	71	-	197
01_consult-1	79	-	-	47
02_study-1	50	-	-	86
03_study-1	50	-	-	86
0M_stair-detached	-	152	-	119
00_stair-detached	-	103	-	119
01_circ-0	-	61	-	124
01_circ-2	-	67	-	90
02_circ-0	-	61	-	124
02_circ-2	-	68	-	96
03_circ-1	-	68	-	96
03_circ-0	-	64	-	124

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?
00_reception-1	NO (-57.3%)	NO
00_first aid	N/A	N/A
00_staits to 0M	NO (-66.3%)	NO
00_circ-5	NO (-83.2%)	NO
00_informal study-1	NO (-68.7%)	NO
0M_study-2	NO (-89.9%)	NO
01_consult-2	N/A	N/A
01_study-1	NO (-60.6%)	NO
01_study-3	NO (-81.1%)	NO
02_resource-1	NO (-90.7%)	NO
02_circ-4	NO (-65.5%)	NO
02_group-2	N/A	N/A
03_resource-1	NO (-82.8%)	NO
03_study-3	NO (-50.7%)	NO
02_study-18	NO (-50.5%)	NO
02_study-16	NO (-72.8%)	NO
02_study-10	NO (-97.2%)	NO
02_study-3	NO (-55.1%)	NO
02_study-5	NO (-70%)	NO
02_study-7	NO (-75.3%)	NO
02_group-1	N/A	N/A
02_circ-3	NO (-63.8%)	NO
03_study-5	NO (-68.7%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
03_study-7	NO (-63%)	NO
03_cafe-5	NO (-40%)	NO
03_cafe-7	NO (-24.2%)	NO
02_study-6	NO (-72.6%)	NO
02_study-4	NO (-65.1%)	NO
02_study-2	NO (-65.9%)	NO
02_group-3	N/A	N/A
02_study-19	NO (-80.3%)	NO
02_group-5	N/A	N/A
02_study-12	NO (-91.5%)	NO
02_study-17	NO (-61.8%)	NO
02_study-11	NO (-92%)	NO
02_group-7	NO (-58.9%)	NO
02_study-13	NO (-68.4%)	NO
02_study-15	NO (-59.9%)	NO
02_study-14	NO (-72.9%)	NO
02_group-6	N/A	N/A
01_study-2	NO (-83.1%)	NO
01_study-4	NO (-66.6%)	NO
02_group-4	N/A	N/A
02_study-8	NO (-78.1%)	NO
01_sefl service 2	NO (-79%)	NO
01_consult-7	N/A	N/A
01_consult-5	N/A	N/A
01_consult-9	N/A	N/A
01_consult-8	N/A	N/A
01_self service 3	NO (-79%)	NO
01_consult-6	N/A	N/A
01_student enquiries	NO (-89.5%)	NO
01_circ-3	NO (-79.8%)	NO
01_consult-4	N/A	N/A
01_consult-3	N/A	N/A
01_staff admin	NO (-63.9%)	NO
01_study-5	NO (-80.8%)	NO
01_study-6	NO (-64.6%)	NO
01_staff base	NO (-79.9%)	NO
01_self service 1	NO (-62.7%)	NO
01_student services office	NO (-68.8%)	NO
03_study-2	NO (-62.9%)	NO
03_study-4	NO (-59.5%)	NO
03_study-6	NO (-64.7%)	NO
03_cafe-4	NO (-50.6%)	NO
03_cafe-6	NO (-75.7%)	NO
03_study-8	NO (-78.8%)	NO
03_study-9	NO (-85.4%)	NO
03_circ-2	NO (-18.7%)	NO
03_group-1	N/A	N/A
03_group-2	N/A	N/A
03_cafe-3	NO (-41.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
03_cafe prep	NO (-94.2%)	NO
03_cafe-2	NO (-53.7%)	NO
03_cafe-1	NO (-68%)	NO
04_study-1	NO (-88.2%)	NO
04_study-10	NO (-39.3%)	NO
04_study-11	NO (-42.2%)	NO
04_study-9	NO (-60.6%)	NO
04_study-8	NO (-70.7%)	NO
04_stairs-2	NO (-65.6%)	NO
04_study-6	NO (-67.7%)	NO
04_study-7	NO (-53.4%)	NO
04_study-4	NO (-68.2%)	NO
04_study-5	NO (-48.1%)	NO
04_study-2	NO (-73.8%)	NO
04_study-3	NO (-35.8%)	NO
00_circ-4	NO (-58.3%)	NO
0M_study-1	NO (-93.6%)	NO
00_circ-8	NO (-41.8%)	NO
00_informal study-2	NO (-70.8%)	NO
0M_study-5	NO (-67.9%)	NO
0M_study-4	NO (-64.1%)	NO
0M_study-3	NO (-62.3%)	NO
0M_study-9	NO (-41.4%)	NO
0M_study-8	NO (-24.4%)	NO
0M_circ-5	NO (-34.7%)	NO
0M_circ-4	NO (-65.6%)	NO
0M_study-7	NO (-47.3%)	NO
0M_study-6	NO (-14.4%)	NO
B1_media-3	N/A	N/A
B1_media-4	N/A	N/A
B1_media-5	N/A	N/A
B1_media-1	N/A	N/A
B1_media-2	N/A	N/A
B1_resource	N/A	N/A
B1_study-4	N/A	N/A
B1_study-3	N/A	N/A
B1_study-2	N/A	N/A
B1_study-1	N/A	N/A
B1_staff	N/A	N/A
B2_ablution-2	N/A	N/A
B2_lockers	N/A	N/A
B2_ablution-1	N/A	N/A
B2_circ-2	N/A	N/A
B2_qcr	N/A	N/A
01_consult-1	N/A	N/A
02_study-1	NO (-91.6%)	NO
03_study-1	NO (-90.8%)	NO
01_circ-2	NO (-81.7%)	NO
02_circ-2	NO (-74.1%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
03_circ-1	NO (-55.8%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the 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?	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
Area [m^2]	5506.7	5506.7
External area [m^2]	6785.6	6785.6
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	2641.46	0
Average U-value [W/m^2K]	0.39	0
Alpha value* [%]	10.13	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
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
100	**D1 Non-residential Inst.: Education**
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: 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/m^2]

	Actual	Notional
Heating	1.78	3.51
Cooling	0.11	1.14
Auxiliary	9.47	11.92
Lighting	11.1	10.9
Hot water	18.43	19.13
Equipment*	29.73	29.73
TOTAL**	**40.89**	**46.6**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	7.52	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/m^2]	22.76	34.18
Primary energy* [kWh/m^2]	86.46	103.14
Total emissions [kg/m^2]	11.7	18.1

* 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] Chilled ceilings or passive chilled beams and displacement ventilation, [HS] Heat pump (electric): ground or water sourc										
	Actual	28.7	6.6	2.2	0.1	8.7	3.6	20	3.6	20
	Notional	40.2	17.9	4.4	1.7	19.3	2.56	2.84	----	----
[ST] Constant volume system (variable fresh air rate), [HS] District heating, [HFT] Natural Gas, [CFT] Electricity										
	Actual	2.6	36.8	0.7	0.5	21.4	1	20	1	20
	Notional	6.1	25	1.7	2.4	15.6	1	2.84	----	----
[ST] Central heating using water: radiators, [HS] District heating, [HFT] Natural Gas, [CFT] Electricity										
	Actual	70.2	0	19.5	0	14.3	1	0	1	0
	Notional	151.4	0	42	0	16.9	1	0	----	----
[ST] Water loop heat pump, [HS] Heat pump (electric): ground or water source, [HFT] Electricity, [CFT] Electricity										
	Actual	10.7	14.9	0.8	0.2	45.4	3.6	20	3.6	20
	Notional	15.1	9.5	1.6	0.9	16.8	2.56	2.84	----	----
[ST] Chilled ceilings or passive chilled beams and displacement ventilation, [HS] District heating, [HFT] Natural Gas, [CFT] El										
	Actual	12	8.1	3.3	0.1	8.4	1	20	1	20
	Notional	21	16.6	5.8	1.6	17.1	1	2.84	----	----
[ST] Chilled ceilings or passive chilled beams and displacement ventilation, [HS] Heat pump (electric): ground or water sourc										
	Actual	71.8	11.6	5.5	0.2	4.8	3.6	20	3.6	20
	Notional	111.6	21.5	12.1	2.1	10.7	2.56	2.84	----	----

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 BCO can give particular attention to items with specifications that 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	0.2	00000003:Surf[5]
Floor	0.2	0.13	B2000006:Surf[1]
Roof	0.15	0.15	B1000018:Surf[0]
Windows, roof windows, and rooflights	1.5	1	04000016:Surf[3]
Personnel doors	1.5	-	No Personnel doors in building
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 [$W/(m^2K)$]

$U_{i\text{-}Min}$ = Minimum individual element U-values [$W/(m^2K)$]

* 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