

Energy Assessment The Abbey Senior School

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Executive Summary

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About the scheme:

The project consists of an extension and addition of a new storey to the existing Abbey School in Reading. The total gross internal floor area of the proposed scheme is approximately 3,100m².

Planning policy

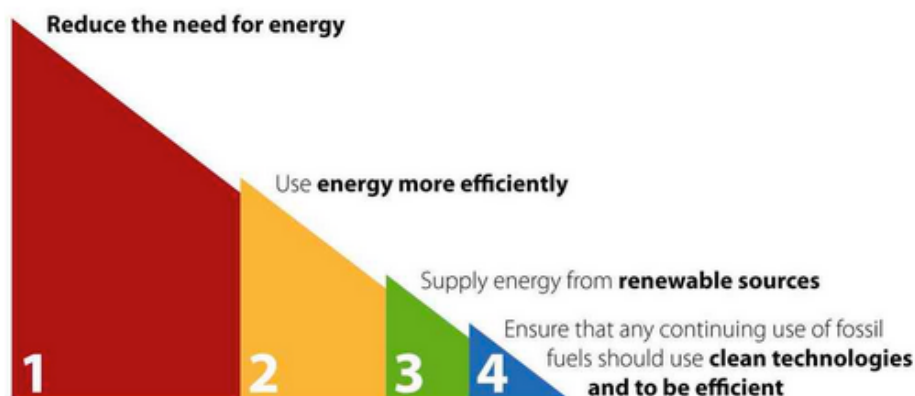
The scheme has targeted to achieve a minimum of 35% reduction in carbon emissions over the existing building.

The scheme complies with the 2013 Building Regulations Part L and the minimum energy efficiency targets in the following documents have been followed:

- Refurbishment (Part L2B) – The actual building CO₂ emissions rate (BER) is no greater than the existing building CO₂ emissions rate.

The Energy Hierarchy

The proposed scheme has followed the energy hierarchy that is illustrated below:



GLA's Energy Hierarchy: Regulated carbon emissions
Calculated using SAP 2012 carbon dioxide emission factors

	Baseline:	Be lean:	Be clean:	Be green:
CO ₂ emissions (tCO ₂ /yr)	66.74	47.10	–	42.08
CO ₂ emissions saving (tCO ₂ /yr)	–	19.65	–	5.01
Saving from each stage (%)	–	29.40	–	7.50
Total CO ₂ emissions saving (tCO ₂ /yr)		24.66		

36.9% total carbon emissions savings over the existing building achieved

Executive Summary

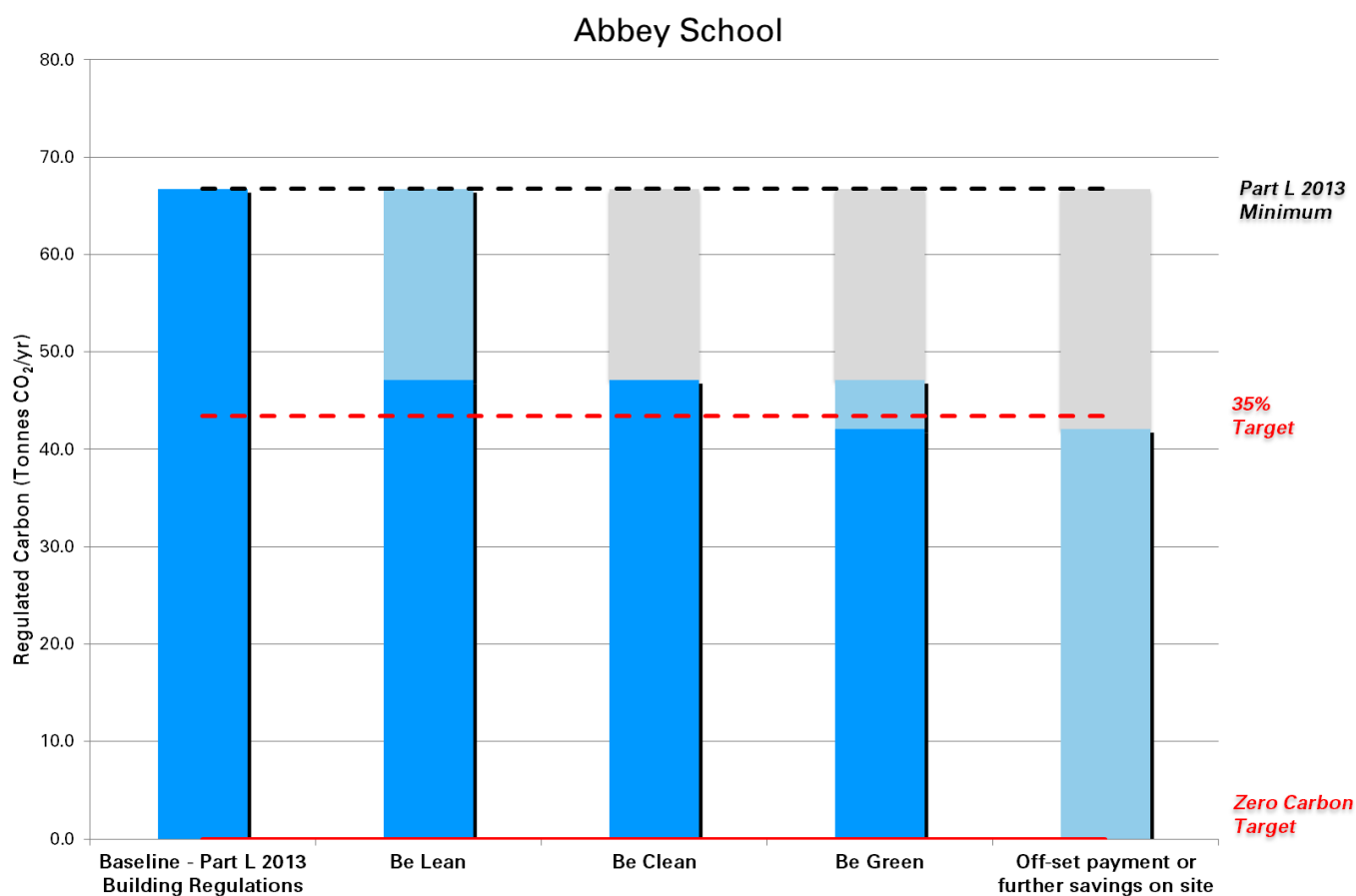
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GLA's Energy Hierarchy – Regulated carbon emissions:

A graphical illustration of how the development performs in relation to Building Regulations and the Energy Hierarchy is shown below. Carbon dioxide emission factors for SAP 2012 have been used for the calculation.

Figure:



Summary

As demonstrated above the development will reduce carbon emissions by 29.4% from the fabric energy efficiency measures described in the 'Be Lean' section and will reduce total carbon emissions by 36.9% over the existing building with the further inclusion of low and zero carbon technologies (solar photovoltaic panels and heat pumps).

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Shortfall in emissions:

The carbon dioxide emissions of the scheme are presented below;

Carbon Dioxide Emissions – Regulated (Tonnes CO ₂ /yr)		
	(Tonnes CO ₂ /yr)	%
Be Lean: Savings from energy demand reduction	19.65	29.4%
Be Clean: Savings from heat networks	0.00	0.0%
Be Green: Savings from renewable energy	5.01	7.5%
Total Savings	24.66	36.9%
Total Target Savings	23.36	35%
Annual Surplus	1.30	1.9%

Total carbon emissions:

Both the regulated and unregulated emissions of the development must be quantified and demonstrated. The total emissions for the scheme are shown below.

Carbon Dioxide Emissions – Regulated and Unregulated (Tonnes CO ₂ /yr)			
	Regulated Emissions	Unregulated Emissions	Total Emissions
Baseline: Existing building	66.74	54.10	120.84
Be Lean: After demand reduction	47.10	54.10	101.19
Be Clean: After CHP	–	–	–
Be Green: After Renewable energy	42.08	54.10	96.18

Introduction

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Aim of this study:

The purpose of an energy assessment is to demonstrate the climate change mitigation measures, including the energy hierarchy. It also ensures energy remains an integral part of the development's design and evolution.

Methodology:

The methodology followed in this report demonstrates how the energy hierarchy has been followed i.e. 'Lean, Clean, Green', including consideration of passive design and decentralised energy options such as CHP/Community CHP.

This report has followed these documents and comprises the following components:

- **BASELINE:** A calculation of the existing building compliant CO₂ emission using approved software. The baseline assumes a gas boiler would provide heating and any active cooling would be electrically powered.
- **LEAN:** A calculation of the impact of demand reduction measures. For example, passive design measures, including optimising orientation and site layout, natural ventilation and lighting, thermal mass and solar shading, and active design measures such as high efficacy lighting and efficient mechanical ventilation with heat recovery.
- **CLEAN:** This report has demonstrated how the scheme has selected heating, cooling and power systems to minimise carbon emissions. This comprises an evaluation of the feasibility of connecting to existing low carbon heat networks, planned networks, site-wide and communal heat networks and CHP.
- **GREEN:** This report has conducted a feasibility assessment of renewable energy technologies. This comprised a site-specific analysis of the technologies and, if applicable, how they would be integrated into the heating and cooling strategy for the scheme.

Please note that these findings are currently subject to a detailed analysis from a building services design engineer and qualified quantity surveyor.

Establishing Emissions: The Carbon Profile Energy Assessment The Abbey Senior School

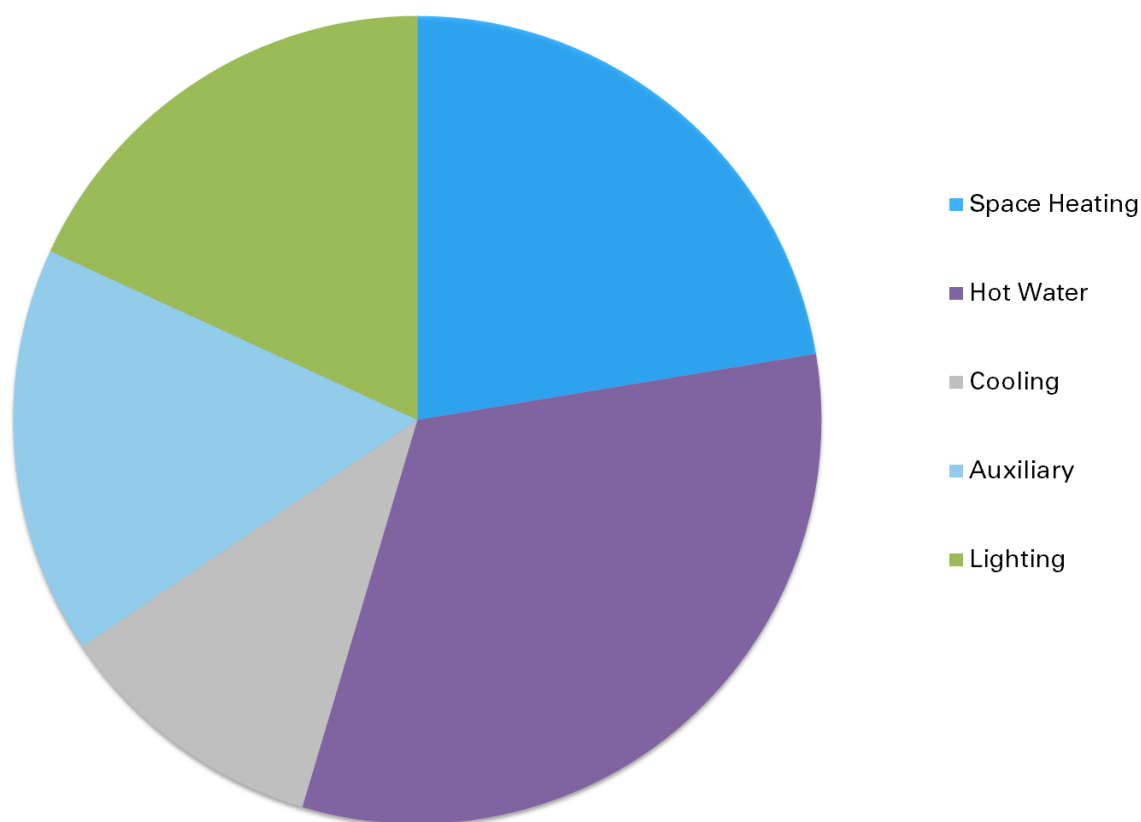
Building regulations Part L 2013 Minimum compliance:

The total baseline carbon emissions for the existing building is 66.74 tonnes CO₂/yr.

The pie chart below provides a breakdown of the specific carbon emissions by system over the course of one year.

Carbon Emissions in tonnes CO ₂ /yr.	Heating	Hot Water	Cooling	Auxiliary	Lighting
66.74	14.94	21.50	7.30	10.90	12.11

Baseline CO₂ Breakdown



Overview:

The chart above shows that hot water is the primary source of carbon dioxide emissions, and space heating is the second largest, across the scheme as a whole.

'Be Lean': Demand Reduction Measures Energy Assessment The Abbey Senior School

Be Lean – summary:

Demand reduction measures have reduced the scheme's carbon emissions by 29.4% over the existing building.

Building fabric Passive design measures:

Proposed U Values for the scheme are shown in the table below:

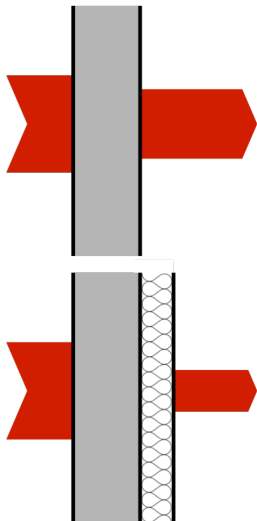
Element	Existing building U-value W/m ² K	Proposed U-value W/m ² K
Exposed and ground Floors	0.45	0.45
Upgraded external walls	0.55	0.30
New external walls	0.28	0.25
New roof	0.18	0.17
Existing roof	0.45	0.17
Windows	3.92 (G-value 0.72)	1.30 (G-value 0.3)
Rooflights	3.92 (G-value 0.72)	1.40 (G-value 0.3)
Door	3.00	1.50
Air Permeability in m ³ /hour/m ² at 50pa.		
Whole scheme	25	5

The air permeability target is 5 m³/hour/m². This will require careful attention to two key areas:

- Structural leakage
- Services leakage

Structural leakage occurs at joints in the building fabric and around window and door openings, loft hatches and access openings. There will also be some diffusion through materials such as cracks in masonry walls typically caused by poor perpends in blockwork inner leafs. Structural leakage is hard to remedy retrospectively therefore good detailing at the design stage is essential.

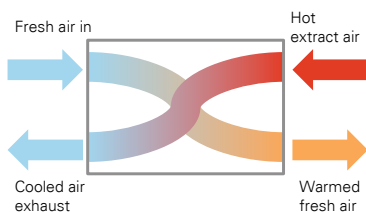
Services leakage occurs at penetrations from pipes and cables entering the building. These can be sewerage pipes, water pipes and heating pipes. As well as electricity cables there may also be telecommunication cables. Attention therefore, needs to be paid to sealing all penetrations during construction.



Graphic illustrations of the heat flow through a wall and how it is minimized with low u-value (consequence of the additional insulation).

'Be Lean': Demand Reduction Measures Energy Assessment The Abbey Senior School

Energy efficient services Active design measures:



Graphic illustration of a heat recovery unit, which exploits the extract hot air of the room to heat the cold supply air.

Heating:

New gas fired gas boilers will be installed in the plantroom with a minimum efficiency of 95%. Heating will be supplied via underfloor heating in the dining hall, and via radiators to classrooms and other areas.

Hot Water:

Hot water will be provided by direct fire water heaters, with the same efficiency as the main heating system.

Ventilation:

Mechanical ventilation with heat recovery has been specified for the development, with a high efficiency heat recovery of 80% and a maximum specific fan power of 1.4 W/l/s. The ventilation system will be demand controlled.

Cooling:

Cooling has been specified for the classrooms, kitchen spaces and main occupied areas. Cooling will be supplied via an air source heat pump using a variable refrigerant flow system (VRF) with a minimum efficiency of 3.2.

Lighting:

High efficiency lighting has been specified for the development with a minimum efficacy of 110 lumens/W. PIR sensors will be used.

Controls:

The proposed scheme sets out to address demand side response to energy efficiency, including smart meters, to provide more consumption data to inform control which will allow the running of some equipment at a lower capacity during times of peak demand. The design team will also explore the possibility of energy storage, smart controls, to optimise heating and power systems at a later stage of the project.

'Be Clean': Site Wide Networks and CHP Energy Assessment The Abbey Senior School

Combined Heat and Power (CHP)

CHP systems are best utilised where there is a consistent and high demand for heat. Because of the small electricity supplies and demand of this scheme, a CHP installed to meet the base heat load would typically require the export of electricity to the grid. The administrative burden of managing CHP electricity sales at a small scale without an active energy service companies (ESCOs) is prohibitive for smaller operators of developments.

The heat demand profile of this scheme is not suitable to CHP. The implemented fabric improvements from the 'Be Lean' scenario have also reduced the energy demand from space heating to hot water. For CHP systems to be economically viable they need to run for at least 5,000 hours per year. Therefore, a CHP system would most likely be oversized, and as a result less efficient and economic.

'Be Clean': Cooling Energy Assessment The Abbey Senior School

Overheating and cooling:

The aim of this section is to reduce the impact of the urban heat island effect and encourage the design of spaces to avoid overheating and excessive heat generation, and to mitigate overheating due to the impact of climate change.

Where design measures and the use of natural and/or mechanical ventilation are not enough to guarantee the occupant's comfort, in line with the cooling hierarchy the development's cooling strategy must include details of the active cooling plant being proposed, including efficiencies, and the ability to take advantage of free cooling and/or renewable cooling sources.

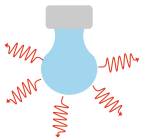
Where appropriate, the cooling strategy should investigate the opportunities to improve cooling efficiencies through the use of locally available sources such as ground cooling and river/dock water-cooling.

The cooling hierarchy:

Major developments should reduce potential overheating and reliance on air conditioning systems and demonstrate this with the Cooling Hierarchy:

- 1) Minimise internal heat generation through energy efficient design
- 2) Reduce the amount of heat entering the building in summer (e.g. shading and fenestration)
- 3) Manage the heat within the building through thermal mass, room height and green roofs
- 4) Passive ventilation
- 5) Mechanical ventilation
- 6) Active cooling systems (ensuring the lowest carbon option)

Avoiding overheating Measures taken:



LED bulbs can emit 80% less heat compared to an incandescent bulb and their life span is up to 41 times more.

The following measures have been taken in accordance with the cooling hierarchy to reduce overheating and the need for cooling:

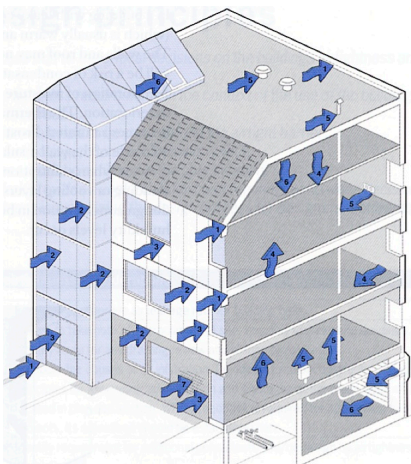
- 1) Minimise internal heat generation through energy efficient design

Internal heat gains have been minimised where possible. Energy efficient appliances will help reduce internal heat gain and reduce the cooling requirement.

Energy efficient lighting will also be specified with an average lumen efficacy of more than 110 lumens per circuit watt. PIR sensors will be used.

'Be Clean': Cooling Energy Assessment The Abbey Senior School

Avoiding overheating Measures taken:



Examples of possible air leakage points in a building



Examples of how the thermal mass absorbs heat during day and emits it during night.

- 2) Reduce the amount of heat entering the building in summer (e.g. shading and fenestration)

Direct solar gains will be controlled in the following ways:

- Solar control – all methods controlling solar gain to within tolerable limits have been considered. The location, size, design and type of window openings and glazing have been optimised and reduced solar gain factors from low emissivity windows with a g-value of 0.3 have been specified for the development.

Heat transfer and infiltration of the new build envelope has been controlled in the following ways:

- Insulation levels have been maximised and the resulting U-values are lower than required by Building Regulations. The build-ups therefore prevent the penetration of heat as much as practically possible. See the 'Be Lean' section of this report for target U-values.
- A reduced air permeability rate of $5 \text{ m}^3/(\text{hr.m}^2) @ 50 \text{ pa}$ has been targeted for the development to minimise uncontrolled air infiltration. This will require attention to detailing and sealing. See 'Be Lean' section of this report for details of how this will be achieved.

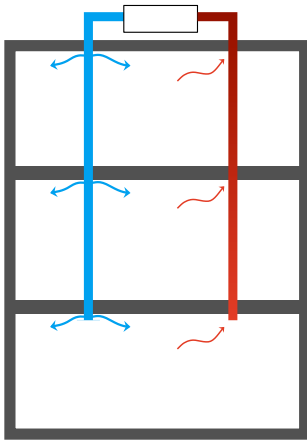
- 3) Manage the heat within the building through thermal mass, room height and green roofs.

The following measures have been specified to manage heat accumulation within the building:

- Room heights –The proposed building has floor to ceiling heights of approximately 2.45m or higher. As the roof will be well insulated to achieve a U-value of $0.17 \text{ W/m}^2\text{K}$, there will be minimal penetration of heat through the roof.

'Be Clean': Cooling Energy Assessment The Abbey Senior School

Avoiding overheating Measures taken:



Typical building section demonstrating a simple method of supply and extract ventilation system.

- 4) Passive ventilation: Ventilation that does not use fans or mechanical system has been specified to reduce the cooling load.
 - Openable windows are specified for the building. Cross ventilation will be achieved to class areas by opening windows on two facades and ensuring there is a clear path for airflow.
 - Night time cooling will also be utilised. This will work in tandem with high thermal mass materials specified. The larger temperature differential that exists between internal and external temperatures at night will allow effective stack ventilation and purging of heat accumulated within the structure during the day.
- 5) Mechanical ventilation: Passive ventilation will not be adequate to cool the building to the required temperature; therefore, mechanical ventilation will be utilised in the scheme.
 - The scheme will be mechanically ventilated with a maximum SFP of 1.4 W/l/s and a heat recovery efficiency of 80%. The ventilation will be demand controlled, based on the occupants inside the building.

'Be Clean': Cooling Energy Assessment The Abbey Senior School

Overheating risk:

The overheating risk considering all the above described passive measures have been assessed for the scheme:

Areas	Overheating risk from SBEM
00 – Floor – Dining Hall	YES (+78.5%)
00 – Floor – Group rooms	NO (-63.9%)
00 – Floor – Form classrooms	NO (-58.9%)
00 – Floor – Office Kitchen	NO (-49.2%)
01 – Floor – Sixth Form classrooms	NO (-53.8%)
02 – Floor – Staff Office	YES (+7.4%)
02 – Floor – Sixth Form Study	YES (+2.4%)
02 – Floor – Sixth Common Room	NO (-23.4%)

An overheating analysis was undertaken by E3 consulting engineers LLP. The overheating results showed that natural ventilation failed the CIBSE TM52 criteria, therefore mechanical cooling has been specified for the scheme.

'Be Green': Renewable Energy Energy Assessment The Abbey Senior School

Renewable energy feasibility:

The feasibility of renewable energy technologies has been considered. A detailed site-specific analysis and associated carbon saving calculations has also been provided for renewable energy technologies considered feasible.

Renewable energy technology Comparison:

Each technology has been assessed under 5 broader categories. There are key criteria for each category on which the technology is evaluated. The key criteria have been given a weighting based on a tick-system, a graphical representation of this is shown below:

✓✓✓✓✓ = 1 scored out of a possible 5

The weighting of each of the criteria within the categories is shown below:

- Local, site-specific impact: (Maximum score of 4)
 - Local planning criteria = ✓✓
 - Land used by all components = ✓
 - Noise impact from operation = ✓
- Suitability and design impact: (Maximum score of 4)
 - Interaction on the current building design = ✓✓
 - Building orientation suitability = ✓
 - Buildability of installation = ✓
- Economic viability: (Maximum score of 5)
 - Capital cost of all components = ✓✓
 - Grants and funding available = ✓
 - Payback periods (years) 3–5, 5–10, 10–15 = ✓✓✓
- Operation and maintenance: (Maximum score of 3)
 - Servicing requirements (low or high) = ✓
 - Maintenance costs (low or high) = ✓
 - Resource use from future maintenance (low or high) = ✓
- CO₂ and sustainability: (Maximum score of 10)
 - Carbon saving per year = ✓✓✓✓
 - Impact of future grid decarbonisation (gas vs. electric) = ✓✓
 - Local air quality/pollution = ✓✓
 - Resource use of installation = ✓✓

Key comments on each of the criteria and the corresponding score will be provided in a table (example below) for each of the technologies. The score for each of the criteria will be summed and each of the technologies will then be ranked. The assessment of each technology is undertaken on the following pages.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓

'Be Green': Renewable Energy

Energy Assessment

The Abbey Senior School

Biomass & Biofuel:

Rejected



Biomass is normally considered a carbon 'neutral' fuel, as the carbon dioxide emitted on burning has been recently absorbed from the atmosphere by photosynthesis. Although some form of fossil fuel derived inputs are required in the production and transportation of the fuel.

Wood is seen as a by-product of other industries and the small quantity of energy for drying, sawing, pelleting and delivery are typically discounted. Biomass from coppicing is likely to have external energy inputs from fertiliser, cutting, drying etc. and these may need to be considered. In this toolkit, all biomass fuels are considered to have zero net carbon emissions.

Biomass can be burnt directly to provide heat in buildings. Wood from forests, urban tree pruning, farmed coppices or farm and factory waste, is the most common fuel and is used commercially in the form of wood chips or pellets. Biomass boilers can also be designed to burn smokeless to comply with the Clean Air Acts.

Boilers can be fed automatically by screw drives from fuel hoppers. This typically involves daily addition of bagged fuels.

A biomass boiler could be installed on site for supplementary LTHW heating; however, a major factor influencing the suitability of a biomass boiler is the availability of the biomass fuel. A local and reliable fuel source would be essential for the biomass boiler to be an efficient replacement for a conventional boiler system. Therefore, a very comprehensive feasibility assessment needs to be undertaken to understand the practicalities of such a system.

It is estimated that the heating and hot water demand of the site is too small to meet the required CO₂ emissions reduction if a biomass boiler was a standalone system. Therefore, a biomass boiler would need to be combined with energy demand reduction measures and/or CHP. In order to meet the 35% CO₂ emissions reduction a biomass boiler would need to be installed. The likely installed cost would be circa £60,000. The additional cost of providing and storing the bio-fuel also needs to be accounted for. The site is likely to be unsuitable for biomass boilers due to site constraints such as limited transport/access issues, and storage of the biomass fuel. A detailed feasibility study will be required to investigate the suitability.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
Biomass Boiler	✓✓✓✓ Local air quality impacts, increased transport usage on the restricted site, increased plant space.	✓✓✓✓ Increase in plant space required, orientation fine, slightly increased buildability issues.	✓✓✓✓✓ Increased capital costs of installation, typical payback of 8 years	✓✓✓ Increased maintenance relative to gas boiler, resource use not significantly increased if well serviced.	✓✓✓✓✓ Very low carbon intensity of feedstock if properly procured. Decarbonisation impact not applicable, air quality issues.

'Be Green': Renewable Energy

Energy Assessment

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Photovoltaic (PV):

Accepted



Photovoltaic systems convert energy from the sun into electricity through semi-conductor cells. Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn the direct current (DC) output into alternating current (AC) electricity for use in buildings.

Photovoltaic systems can be discreet through being designed as an integral part of the roof. An 'invisible' design using slates or shingles as opposed to an architectural statement could be preferable in a sensitive area.

Photovoltaic panels supply electricity to the building and are attached to electricity gird or to any other electrical load. Excess electricity can be sold to the National Grid when the generated power exceeds the local need. PV systems require only daylight, not sunlight to generate electricity (although more electricity is produced with more sunlight), so energy can still be produced in overcast or cloudy conditions.

The cost of PV cells is heavily dependent on the size of the array. There are significant cost reductions available for larger installations.

The most suitable location for mounting photovoltaic panels is on roofs as they usually have the greatest exposure to the sun. The proposed site has potential useable flat roof area of approximately 600m².

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
Photovoltaic	✓✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer has concerns for part of the site, no noise issues.	✓✓✓✓ Can be added to the roof, good orientation, and slightly increased buildability issues for wiring and metering.	✓✓✓✓✓ Increased capital costs of installation, typical payback of 8 years, Feed in Tariff available.	✓✓✓ Limited servicing and maintenance i.e. 1 visit per year, inverter will require replacement.	✓✓✓✓✓ ✓✓✓✓✓ High carbon saving from electricity, uses minimal grid electricity, no local air impact, high embodied energy of panels.

'Be Green': Renewable Energy

Energy Assessment

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Solar Thermal:

Rejected



Solar water heating systems use the energy from the sun to heat water for non-domestic hot water needs. The systems use a heat collector, generally mounted on the roof in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

Like photovoltaic panels the most suitable location for mounting solar hot water panels is on roofs as they usually have the greatest exposure to the sun. The proposed site has potential useable flat roof area of approximately 600m².

It is estimated that the CO₂ emissions reduction that would be produced by solar hot water as a standalone system would not be adequate to achieve the required CO₂ emissions reduction target. Therefore, a solar hot water system would need to be combined with more energy efficiency strategies, a CHP or additional renewable technologies to achieve the carbon reduction target.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
Solar Thermal	✓✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer has concerns for part of the site, no noise issues.	✓✓✓✓ Can be added to the roof, good orientation, and slightly increased buildability issues for piping and cylinders.	✓✓✓✓✓ Increased capital costs of installation, typical payback of 8 years, Renewable Heat Incentive available.	✓✓✓ Limited servicing and maintenance i.e. 1 visit every two years, heat transfer fluid requires replacing every 10 years.	✓✓✓✓✓ Lower carbon saving as primarily displacing gas, uses minimal grid electricity, no local air impact, medium embodied energy of panels.

'Be Green': Renewable Energy

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Wind Energy:

Rejected



Wind energy is a cost effective method of renewable power generation. Wind turbines can produce electricity without carbon dioxide emissions in ranges from watts to megawatt outputs. The most common design is for three blades mounted on a horizontal axis, which is free to rotate into the wind on a tall tower.

The blades drive a generator either directly or via a gearbox to produce electricity. The electricity can either be linked to the grid or charge batteries. An inverter is required to convert the electricity from direct current (DC) to alternating current (AC) for feeding into the grid.

Modern quiet wind turbines are becoming viable in low density areas where ease of maintenance and immediate connection to the grid or direct use of the electricity in a building, may make them cost effective, despite lower wind speeds than open areas.

Wind turbines are generally less suited to dense urban areas as their output will be affected by potentially lower and more disrupted wind speeds, and their use of much more cost effective machines may be prohibited by their proximity to some building types. Small turbines can be used in inner city areas mounted on buildings, although there are relatively few installations.

Typically a 1.5 kW turbine can provide 4,000 kWh of electrical power annually. To achieve the required CO₂ emissions reduction target approximately 2 turbines would be required as a standalone solution. The indicative cost of a smaller roof mounted turbine is £2,000/kW.

A detailed wind resource evaluation would be required for the site to fully understand the generation potential and payback period. Also, it is likely that planning restrictions and resistance from small groups within the local community could also affect the viability of wind energy for the project.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
Wind Energy	✓✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer will have concerns for the site, minor noise issues.	✓✓✓✓ Can be added to the roof, relatively limited wind speeds in local area, increased buildability issues for wiring and metering.	✓✓✓✓✓ Medium capital costs of installation, typical payback < 5 years, Feed in Tariff available.	✓✓✓ Very limited servicing and maintenance, costs of 2–3% typical.	✓✓✓✓✓ High carbon saving from electricity, output limited from urban installation, consumes little grid electricity, no local air impact, low embodied energy of panels.

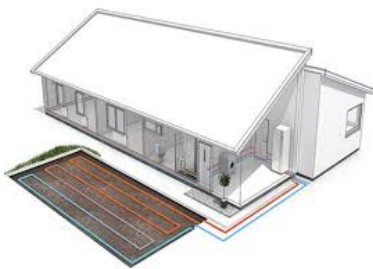
'Be Green': Renewable Energy

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Ground Source Heat Pump (GSHP):

Rejected



Geo-thermal energy is essentially heat collected from the ground. Heat obtained from the ground may be considered it as a source of heating and cooling within the UK by the use of a geo-thermal heat pump or ground source heat pumps.

A ground source heat pump is a device for converting energy in the form of low level heat to heat at a usable temperature. The heat pump consists of five main parts; ground collector loop/or bores, heat exchanger, compressor, condenser heat exchanger and expansion valve.

At approximately 1.2–1.5 metres down below ground level the temperature is a constant 10 to 12°C. Any bores would need to be sunk to an effective depth of 50 – 120m and a ground feasibility report would be required to ascertain if this method of heat source was viable.

From the bores pre-insulated pipework is laid in the ground to the heat exchanger device. The system is filled with water and antifreeze. The cooled water is pumped around the loop / bore gathering energy as it circulates. The water that has been heated to 10–12°C is returned to the ground source heat exchanger where the energy is transferred to the refrigerant gas. For every 1kW of energy used to compress the refrigerant, the process 'gives up' 4 kW of energy for use in the system being used to heat the building.

Typical costs for an installation this are in the region of £80,000, with general installation costs at £1200 /kW of energy produced.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
GSHP	✓✓✓✓ No local air quality impacts, not visible so conservation friendly, no noise issues, however the constrained site may prohibit its installation.	✓✓✓✓ Increased buildability issues for pipework and heating emitters internally.	✓✓✓✓✓ High capital costs of installation, typical payback of 15 years where gas is displaced, Renewable Heat Incentive available.	✓✓✓ Limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓✓ Limited carbon saving from gas displacement, consumes some electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

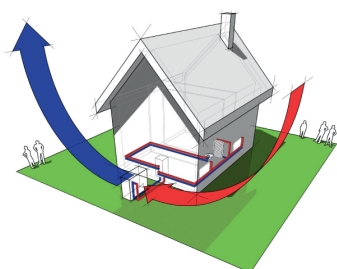
'Be Green': Renewable Energy

Energy Assessment

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Air Source Heat Pump (ASHP):

Accepted



Air source heat pump systems work on the same principle as a ground source heat pump although they use the outside air as the heat source.

The coefficients of performance given by air source heat pump systems are inferior to that of ground source systems due to varying air temperatures. In the depth of winter the energy efficiency of an air source system will be lower than that of a ground source system, and it is likely that more back-up heat will be required if an air source unit is fitted. This back-up heat often comes from a direct electric heater. They operate over a varying temperatures range of -15°C to $+25^{\circ}\text{C}$, however, the performance will reduce to below the required 3 to 1 carbon saving ratio in winter, and they also require a defrosting mechanism to melt ice that forms on the air heat exchanger.

ASHPs are cheaper to install than ground source heat pumps but are only available on a relatively small scale. If applied across a larger site a number of plant zones would be required for generation of heat, leading to increased plant space requirements. Typical costs for an installation of this scale are in the region of £30,000.

Carbon dioxide emissions savings will typically be less than that of the ground source heat pump. Air source heat pumps may be more suitable as an HVAC solution.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability
ASHP	✓✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer may have minor concerns over visual impact, no noise issues.	✓✓✓✓ Can be added to the roof, good air-flow on roof, increased buildability issues for pipework and heating emitters internally.	✓✓✓✓✓ Medium– high capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available.	✓✓✓ Limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓ Limited carbon saving from gas displacement, less efficient in winter, consumes electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

‘Be Green’: Summary of Renewable Technologies Energy Assessment

The Abbey Senior School

Summary comparison matrix:

An assessment of the feasibility of each of the technologies is shown below.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO ₂ and sustainability	Total Score
Biomass Boiler	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	15 out of 26
Photovoltaic	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	17 out of 26
Solar Thermal	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	16 out of 26
Wind Energy	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	17 out of 26
GSHP	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	15 out of 26
ASHP	✓✓✓✓	✓✓✓✓	✓✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓✓✓✓✓	16 out of 26

Renewable technology Conclusion & specification:

Photovoltaic panels and wind energy have scored the best. It is assumed that wind energy would be considered unsuitable for the area and that the local residents would raise concerns over potential noise and turbulence.

Therefore, photovoltaic panels have been considered to be the optimum balance of sustainable and economic objectives. Heat pumps will be used to supply cooling demand, using a hybrid VRF system.

'Be Green': Photovoltaic Energy Assessment The Abbey Senior School

Summary:

A photovoltaic panel system of 13.2 kWp has been specified for the development and detailed summary of the lifecycle cost, revenue and payback for the photovoltaic panels is presented in this section.

Location:

The site has potential useable flat roof area of approximately 600m² that could be used to install photovoltaic modules.

40 PV panels (330W each) will be specified for the development, roof mounted facing south with 30° tilt.

Lifecycle Cost

The lifecycle of the proposed high efficiency panels is 25 years. To calculate the lifecycle cost of the panels, the maintenance of the system and replacement cost will be included.

The total costs for the proposed system's lifetime is:

- Capital Cost = £20,000
- Maintenance Cost = £2,500
- Operation Cost = £1,000 (replacement inverters etc.)
- Total Costs = £23,500

Revenue and Payback Parameters

- The cost of electricity to be displaced is 14p/kWh.
- The 13.2 kWp system is estimated to generate approximately 9,600 kWh/yr. Based on the assumption that 50% of the electricity will be used on site, an offset saving of £670/yr will be achieved.
- With the current Feed in Tariff, a tariff of 5.38p/kWh will be received for export, which gives an additional saving of £260.

Summary Performance Calculations

The following tables summarise the reduction in carbon emissions and the life cycle cost of the photovoltaic system.

Energy and Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	9,600
Annual Carbon Emissions Reductions (kg CO ₂ /year)	5,000
CO ₂ Emissions Reduction (%)	7.5
Cost Performance Criteria	Value
Total Cost Over Life Cycle (£)	23,500
Predicted Annual Savings (£)	930
Payback Period (years)	25.3

Conclusion

Energy Assessment

The Abbey Senior School

Summary

The baseline carbon emissions for the scheme are 66.74 tonnes CO₂/yr.

As demonstrated, the development will reduce carbon emissions by 36.9% over the existing building, with the further inclusion of the proposed solar photovoltaic panels.

GLA's Energy Hierarchy: regulated carbon emissions Calculated using SAP 2012 carbon dioxide emission factors				
	Baseline:	Be lean:	Be clean:	Be green:
CO ₂ emissions (tCO ₂ /yr)	66.74	47.10	–	42.08
CO ₂ emissions saving (tCO ₂ /yr)	–	19.65	–	5.01
Saving from each stage (%)	–	29.40	–	7.5
Total CO ₂ emissions saving (tCO ₂ /yr)		24.66		
36.9% total carbon emissions savings over the existing building achieved				

Appendix A – Input Sheet

Energy Assessment

The Abbey Senior School

Input	Be Lean	Be Clean	Be Green
Exposed and ground Floors		0.45 W/m ² K	
Upgraded external walls		0.30 W/m ² K	
New external walls		0.25 W/m ² K	
New roof		0.17 W/m ² K	
Existing roof		0.17 W/m ² K	
Windows		1.30 W/m ² K (G-value 0.3)	
Rooflights		1.40 W/m ² K (G-value 0.3)	
Door		1.50 W/m ² K	
Mechanical ventilation	Mechanical ventilation with heat recovery has been specified for the development, with a high efficiency heat recovery with a minimum efficiency of 80% and a maximum specific fan power of 1.4 W/l/s. The ventilation system will be demand controlled.		
Space Heating	New gas fired gas boilers will be installed in the plantroom with a minimum efficiency of 95%. Heating will be supplied via underfloor heating in the dining hall, and via radiators to classrooms and other areas.		
Cooling	Cooling has been specified for the classrooms, kitchen spaces and main occupied areas. Cooling will be supplied via a variable refrigerant flow system (VRF) with a minimum efficiency of 3.2.		
Hot water	Hot water will be provided by direct fire water heaters, with the same efficiency as the main heating system.		
Lighting	High efficiency lighting has been specified for the development with a minimum efficacy of 110 lumens/W. PIR sensors will be used.		
Photovoltaic system	–	–	13.2 kWp (40 PV panels of 0.33 kWp each) south facing roof mounted with 30° tilt.

Appendix B – SBEM Energy Assessment The Abbey Senior School

Further Information:

The emission figures and details of the calculations and methodology used to determine the figures provided within the report can be found in the following pages:

Baseline – BER from the Existing BRUKL

Be Lean – BER from the Be Lean scenario BRUKL

Be Green– BER from the Be Green scenario BRUKL

Appendix B – SBEM

Energy Assessment

The Abbey Senior School

Baseline

Project name

The Abbey School**As designed****Date:** Wed Dec 18 09:49:04 2019**Administrative information****Building Details****Address:** The Abbey School, 17 Kendrick Rd, Reading, , RG1 5DZ**Certification tool****Calculation engine:** SBEM**Calculation engine version:** v5.6.a.1**Interface to calculation engine:** DesignBuilder SBEM**Interface to calculation engine version:** v6.0.1**BRUKL compliance check version:** v5.6.a.1**Owner Details****Name:****Telephone number:****Address:** , ,**Certifier details****Name:****Telephone number:****Address:** , ,**Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target****The building does not comply with England Building Regulations Part L 2013**

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	15
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	15
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	21.5
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and 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 -Limit	U _a -Calc	U _i -Calc	Surface where the maximum value occurs*
Wall**	0.35	0.46	0.55	01-Floor - Sixth Form Classroom SF10_W_5
Floor	0.25	0.15	0.45	00-Floor - Group room SF16_S_3
Roof	0.25	0.21	0.45	00-Floor - Dining Hall_R_35
Windows***, roof windows, and rooflights	2.2	3.92	3.92	00-Floor - Group room SF15_G_6
Personnel doors	2.2	3	3	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"
U _a -Limit = Limiting area-weighted average U-values [W/(m ² K)] U _a -Calc = Calculated area-weighted average U-values [W/(m ² K)] U _i -Calc = Calculated maximum individual element U-values [W/(m ² K)] * 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	25

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	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- Project HVAC + Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	3.2	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

2- Project HVAC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	-
Standard value	N/A	N/A

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	
00-Floor - Group room SF16	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - Group room SF15	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - Sixth Form Classroom SF13-	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - Sixth Form Classroom SF14-	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF10-	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Small Group room SF2	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF4	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF3	-	-	-	1.9	-	-	-	-	-	0.5	0.5	

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-Floor - Sixth Form Classroom SF5	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF6	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF7	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF9	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF11	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF8	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
01-Floor - Sixth Form Classroom SF12	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
02-Floor - Sixth Form Common Room	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
02-Floor - Sixth Form Study SF1	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - Dining Hall	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - WC-1	-	-	0.5	-	-	-	-	-	-	-	N/A	
00-Floor - Cleaners cupboard	-	-	0.5	-	-	-	-	-	-	-	N/A	
00-Floor - WC Dis	-	-	0.5	-	-	-	-	-	-	-	N/A	
00-Floor - WC-2	-	-	0.5	-	-	-	-	-	-	-	N/A	
00-Floor - Kitchen Prep Area	-	-	-	-	-	-	-	-	1	-	N/A	
00-Floor - WC-kitchen	-	-	0.5	-	-	-	-	-	-	-	N/A	
00-Floor - Office-Kitchen	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
00-Floor - Kitchen small	-	-	-	-	-	-	-	-	1	-	N/A	
01-Floor - WC Dis	-	-	0.5	-	-	-	-	-	-	-	N/A	
01-Floor - WC-1	-	-	0.5	-	-	-	-	-	-	-	N/A	
01-Floor - Cleaners Cupboard	-	-	0.5	-	-	-	-	-	-	-	N/A	
01-Floor - Head of Sixth Form	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
02-Floor - Cafe	-	-	-	1.9	-	-	-	-	-	0.5	0.5	
02-Floor - WC Staff	-	-	0.5	-	-	-	-	-	-	-	N/A	
02-Floor - WC	-	-	0.5	-	-	-	-	-	-	-	N/A	
02-Floor - Staff Office	-	-	-	1.9	-	-	-	-	-	0.5	0.5	

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
Standard value		60	60	22	
00-Floor - Group room SF16		60	-	-	307
00-Floor - Group room SF15		60	-	-	239
00-Floor - Sixth Form Classroom SF13		60	-	-	470
00-Floor - Sixth Form Classroom SF14		60	-	-	356
01-Floor - Sixth Form Classroom SF10		60	-	-	429
01-Floor - Small Group room SF2		60	-	-	179
01-Floor - Sixth Form Classroom SF4		60	-	-	362
01-Floor - Sixth Form Classroom SF3		60	-	-	476
01-Floor - Sixth Form Classroom SF5		60	-	-	251
01-Floor - Sixth Form Classroom SF6		60	-	-	401
01-Floor - Sixth Form Classroom SF7		60	-	-	214
01-Floor - Sixth Form Classroom SF9		60	-	-	199
01-Floor - Sixth Form Classroom SF11		60	-	-	189

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
	Standard value	60	60	22	
01-Floor - Sixth Form Classroom SF8		60	-	-	210
01-Floor - Sixth Form Classroom SF12		60	-	-	323
02-Floor - Sixth Form Common Room		-	60	-	1294
02-Floor - Sixth Form Study SF1		60	-	-	556
00-Floor - Dining Hall		-	60	-	3011
00-Floor - Circulation-4		-	60	-	282
00-Floor - WC-1		-	60	-	150
00-Floor - Circulation-3		-	60	-	85
00-Floor - Circulation-5		-	60	-	146
00-Floor - Cleaners cupboard		60	-	-	15
00-Floor - Circulation-6		-	60	-	215
00-Floor - WC Dis		-	60	-	50
00-Floor - WC-2		-	60	-	189
00-Floor - Storage-5		60	-	-	22
00-Floor - Kitchen Prep Area		-	60	-	2108
00-Floor - Storage-1		60	-	-	18
00-Floor - Plant-2		60	-	-	94
00-Floor - Chair and Table Store		60	-	-	65
00-Floor - Circulation-1		-	60	-	204
00-Floor - Storage-2		60	-	-	19
00-Floor - Storage-3		60	-	-	22
00-Floor - Storage-4		60	-	-	15
00-Floor - Waste area		60	-	-	17
00-Floor - WC-kitchen		-	60	-	78
00-Floor - Office-Kitchen		60	-	-	113
00-Floor - Kitchen small		-	60	-	207
00-Floor - Circulation-2		-	60	-	149
00-Floor - Plant-1		60	-	-	87
01-Floor - Circulation-5		-	60	-	110
01-Floor - Circulation-2		-	60	-	135
01-Floor - Circulation-1		-	60	-	138
01-Floor - WC Dis		-	60	-	53
01-Floor - WC-1		-	60	-	194
01-Floor - Cleaners Cupboard		60	-	-	13
01-Floor - Circulation-6		-	60	-	168
01-Floor - Circulation-3		-	60	-	97
01-Floor - Server room		60	-	-	16
01-Floor - Head of Sixth Form		60	-	-	157
01-Floor - Circulation-4		-	60	-	281
02-Floor - Circulation-3		-	60	-	56
02-Floor - Cafe		-	60	-	453
02-Floor - Circulation-1		-	60	-	66
02-Floor - WC Staff		-	60	-	35

General lighting and display lighting		Luminous efficacy [lm/W]		
Zone name		Luminaire	Lamp	Display lamp
	Standard value	60	60	22
02-Floor - WC		-	60	-
02-Floor - Staff Office		60	-	-
02-Floor - Circulation-2		-	60	-
				General lighting [W]
				120
				314
				98

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-Floor - Group room SF16	N/A	N/A
00-Floor - Group room SF15	NO (-13.4%)	NO
00-Floor - Sixth Form Classroom SF13	NO (-31.8%)	NO
00-Floor - Sixth Form Classroom SF14	NO (-1.3%)	NO
01-Floor - Sixth Form Classroom SF10	NO (-62.9%)	NO
01-Floor - Small Group room SF2	YES (+3.9%)	NO
01-Floor - Sixth Form Classroom SF4	NO (-1.3%)	NO
01-Floor - Sixth Form Classroom SF3	NO (-22%)	NO
01-Floor - Sixth Form Classroom SF5	YES (+10.8%)	NO
01-Floor - Sixth Form Classroom SF6	N/A	N/A
01-Floor - Sixth Form Classroom SF7	NO (-3.5%)	NO
01-Floor - Sixth Form Classroom SF9	YES (+4.7%)	NO
01-Floor - Sixth Form Classroom SF11	N/A	N/A
01-Floor - Sixth Form Classroom SF8	YES (+0.4%)	NO
01-Floor - Sixth Form Classroom SF12	N/A	N/A
02-Floor - Sixth Form Common Room	YES (+84.3%)	NO
02-Floor - Sixth Form Study SF1	YES (+145.9%)	NO
00-Floor - Dining Hall	YES (+328.4%)	NO
00-Floor - Office-Kitchen	YES (+22%)	NO
01-Floor - Head of Sixth Form	N/A	N/A
02-Floor - Staff Office	YES (+157.9%)	NO

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?	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]	3105.8	3105.8
External area [m ²]	4043.1	4043.1
Weather	LON	LON
Infiltration [m ³ /hm ² @ 50Pa]	25	3
Average conductance [W/K]	3158.26	1248.01
Average U-value [W/m ² K]	0.78	0.31
Alpha value* [%]	5.87	12.93

* 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 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
100 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	22.27	5.13
Cooling	4.53	2.48
Auxiliary	6.76	2.9
Lighting	7.51	8.41
Hot water	32.05	32.05
Equipment*	33.56	33.56
TOTAL **	73.13	50.96

* 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 & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	150.86	88.23
Primary energy* [kWh/m ²]	124	86.62
Total emissions [kg/m ²]	21.5	15

* 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 SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER	
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	93.3	114.5	30.6	14	10.7	0.85	2.27	0.91	3.2
	Notional	13.6	99	4.6	7.6	3.4	0.82	3.6	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	53.5	70.1	18.3	0	4.9	0.81	0	0.91	0
	Notional	15.8	60.7	5.4	0	2.6	0.82	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-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.28	00-Floor - Group room SF15_W_5
Floor	0.2	0.05	00-Floor - Circulation-1_S_3
Roof	0.15	0.18	00-Floor - Dining Hall_R_35
Windows, roof windows, and rooflights	1.5	3.92	00-Floor - Group room SF15_G_6
Personnel doors	1.5	3	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"
U _{i-Typ} = Typical individual element U-values [W/(m²K)]		U _{i-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	25

Appendix B – SBEM Energy Assessment The Abbey Senior School

Project name

The Abbey School**As designed****Date:** Tue Dec 17 16:39:43 2019**Administrative information****Building Details****Address:** The Abbey School, 17 Kendrick Rd, Reading, , RG1 5DZ**Certification tool****Calculation engine:** SBEM**Calculation engine version:** v5.6.a.1**Interface to calculation engine:** DesignBuilder SBEM**Interface to calculation engine version:** v6.0.1**BRUKL compliance check version:** v5.6.a.1**Owner Details****Name:****Telephone number:****Address:** , ,**Certifier details****Name:****Telephone number:****Address:** , ,**Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target****The building does not comply with England Building Regulations Part L 2013**

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	15
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	15
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	15.2
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and 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 -Limit	U _a -Calc	U _i -Calc	Surface where the maximum value occurs*
Wall**	0.35	0.3	0.32	00-Floor - Dining Hall_W_10
Floor	0.25	0.15	0.45	00-Floor - Group room SF16_S_3
Roof	0.25	0.17	0.21	00-Floor - Dining Hall_R_35
Windows***, roof windows, and rooflights	2.2	1.32	1.4	00-Floor - Dining Hall_G_19
Personnel doors	2.2	1.5	1.5	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"
U _a -Limit = Limiting area-weighted average U-values [W/(m ² K)] U _a -Calc = Calculated area-weighted average U-values [W/(m ² K)] U _i -Calc = Calculated maximum individual element U-values [W/(m ² K)]				
* 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	5

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	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- HVAC - Dining Hall Underfloor Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

2- Project HVAC + Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	3.2	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

3- Project HVAC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	-
Standard value	N/A	N/A

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
00-Floor - Dining Hall		-	-	-	1.4	-	-	-	-	-	0.8	0.5

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	
00-Floor - Group room SF16	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Group room SF15	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Sixth Form Classroom SF13	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Sixth Form Classroom SF14	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF10	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Small Group room SF2	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF4	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF3	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF5	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF6	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF7	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF9	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF11	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF8	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF12	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Sixth Form Common Room	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Sixth Form Study SF1	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - WC-1	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Cleaners cupboard	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - WC Dis	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - WC-2	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Kitchen Prep Area	-	-	-	-	-	-	-	-	1	-	N/A	
00-Floor - WC-kitchen	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Office-Kitchen	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Kitchen small	-	-	-	-	-	-	-	-	1	-	N/A	
01-Floor - WC Dis	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - WC-1	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - Cleaners Cupboard	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - Head of Sixth Form	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Cafe	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - WC Staff	-	-	0.3	-	-	-	-	-	-	-	N/A	
02-Floor - WC	-	-	0.3	-	-	-	-	-	-	-	N/A	
02-Floor - Staff Office	-	-	-	1.4	-	-	-	-	-	0.8	0.5	

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
Standard value		60	60	22	
00-Floor - Dining Hall		-	110	-	1643
00-Floor - Group room SF16		110	-	-	168
00-Floor - Group room SF15		110	-	-	131
00-Floor - Sixth Form Classroom SF13		110	-	-	257
00-Floor - Sixth Form Classroom SF14		110	-	-	194
01-Floor - Sixth Form Classroom SF10		110	-	-	234

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
	Standard value	60	60	22	
01-Floor - Small Group room SF2		110	-	-	98
01-Floor - Sixth Form Classroom SF4		110	-	-	197
01-Floor - Sixth Form Classroom SF3		110	-	-	260
01-Floor - Sixth Form Classroom SF5		110	-	-	137
01-Floor - Sixth Form Classroom SF6		110	-	-	219
01-Floor - Sixth Form Classroom SF7		110	-	-	117
01-Floor - Sixth Form Classroom SF9		110	-	-	108
01-Floor - Sixth Form Classroom SF11		110	-	-	103
01-Floor - Sixth Form Classroom SF8		110	-	-	114
01-Floor - Sixth Form Classroom SF12		110	-	-	176
02-Floor - Sixth Form Common Room		-	110	-	706
02-Floor - Sixth Form Study SF1		110	-	-	303
00-Floor - Circulation-4		-	110	-	154
00-Floor - WC-1		-	110	-	82
00-Floor - Circulation-3		-	110	-	47
00-Floor - Circulation-5		-	110	-	80
00-Floor - Cleaners cupboard		110	-	-	8
00-Floor - Circulation-6		-	110	-	117
00-Floor - WC Dis		-	110	-	27
00-Floor - WC-2		-	110	-	103
00-Floor - Storage-5		110	-	-	12
00-Floor - Kitchen Prep Area		-	110	-	1150
00-Floor - Storage-1		110	-	-	10
00-Floor - Plant-2		110	-	-	51
00-Floor - Chair and Table Store		110	-	-	36
00-Floor - Circulation-1		-	110	-	112
00-Floor - Storage-2		110	-	-	10
00-Floor - Storage-3		110	-	-	12
00-Floor - Storage-4		110	-	-	8
00-Floor - Waste area		110	-	-	9
00-Floor - WC-kitchen		-	110	-	43
00-Floor - Office-Kitchen		110	-	-	62
00-Floor - Kitchen small		-	110	-	113
00-Floor - Circulation-2		-	110	-	81
00-Floor - Plant-1		110	-	-	48
01-Floor - Circulation-5		-	110	-	60
01-Floor - Circulation-2		-	110	-	74
01-Floor - Circulation-1		-	110	-	75
01-Floor - WC Dis		-	110	-	29
01-Floor - WC-1		-	110	-	106
01-Floor - Cleaners Cupboard		110	-	-	7
01-Floor - Circulation-6		-	110	-	92
01-Floor - Circulation-3		-	110	-	53

General lighting and display lighting		Luminous efficacy [lm/W]		
Zone name		Luminaire	Lamp	Display lamp
	Standard value	60	60	22
01-Floor - Server room		110	-	-
01-Floor - Head of Sixth Form		110	-	-
01-Floor - Circulation-4		-	110	-
02-Floor - Circulation-3		-	110	-
02-Floor - Cafe		-	110	-
02-Floor - Circulation-1		-	110	-
02-Floor - WC Staff		-	110	-
02-Floor - WC		-	110	-
02-Floor - Staff Office		110	-	-
02-Floor - Circulation-2		-	110	-

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-Floor - Dining Hall	YES (+78.5%)	NO
00-Floor - Group room SF16	N/A	N/A
00-Floor - Group room SF15	NO (-63.9%)	NO
00-Floor - Sixth Form Classroom SF13	NO (-71.6%)	NO
00-Floor - Sixth Form Classroom SF14	NO (-58.9%)	NO
01-Floor - Sixth Form Classroom SF10	NO (-84.5%)	NO
01-Floor - Small Group room SF2	NO (-56.7%)	NO
01-Floor - Sixth Form Classroom SF4	NO (-58.9%)	NO
01-Floor - Sixth Form Classroom SF3	NO (-67.5%)	NO
01-Floor - Sixth Form Classroom SF5	NO (-53.8%)	NO
01-Floor - Sixth Form Classroom SF6	N/A	N/A
01-Floor - Sixth Form Classroom SF7	NO (-59.8%)	NO
01-Floor - Sixth Form Classroom SF9	NO (-56.4%)	NO
01-Floor - Sixth Form Classroom SF11	N/A	N/A
01-Floor - Sixth Form Classroom SF8	NO (-58.2%)	NO
01-Floor - Sixth Form Classroom SF12	N/A	N/A
02-Floor - Sixth Form Common Room	NO (-23.2%)	NO
02-Floor - Sixth Form Study SF1	YES (+2.4%)	NO
00-Floor - Office-Kitchen	NO (-49.2%)	NO
01-Floor - Head of Sixth Form	N/A	N/A
02-Floor - Staff Office	YES (+7.4%)	NO

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?	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]	3105.8	3105.8
External area [m ²]	4043.1	4043.1
Weather	LON	LON
Infiltration [m ³ /hm ² @ 50Pa]	5	3
Average conductance [W/K]	1453.35	1248.01
Average U-value [W/m ² K]	0.36	0.31
Alpha value* [%]	12.75	12.94

* 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 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
100 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	8.58	5.13
Cooling	3.63	2.48
Auxiliary	4.34	2.9
Lighting	4.91	8.41
Hot water	30.7	32.05
Equipment*	33.56	33.56
TOTAL **	52.15	50.96

* 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 & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	90.77	88.23
Primary energy* [kWh/m ²]	87.43	86.62
Total emissions [kg/m ²]	15.2	15

* 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 SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER	
[ST] Central heating using water: floor heating, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
Actual	13.1	68.5	4.3	0	3.2	0.85	0	0.95	0	
Notional	5.5	65.7	1.9	0	1.9	0.82	0	----	----	
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	28.9	91.5	9.1	11.2	5.6	0.89	2.27	0.95	3.2	
Notional	13.6	99	4.6	7.6	3.4	0.82	3.6	----	----	
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	33.3	40.2	10.9	0	4.1	0.85	0	0.95	0	
Notional	22.3	57.5	7.6	0	3.1	0.82	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-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.25	00-Floor - Group room SF15_W_5
Floor	0.2	0.05	00-Floor - Circulation-1_S_3
Roof	0.15	0.15	00-Floor - Dining Hall_R_35
Windows, roof windows, and rooflights	1.5	1.3	00-Floor - Dining Hall_G_11
Personnel doors	1.5	1.5	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"
U _{i-Typ} = Typical individual element U-values [W/(m²K)]		U _{i-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	5

Appendix B – SBEM Energy Assessment The Abbey Senior School

Project name

The Abbey School**As designed****Date:** Tue Dec 17 16:28:09 2019**Administrative information****Building Details****Address:** The Abbey School, 17 Kendrick Rd, Reading, , RG1 5DZ**Certification tool****Calculation engine:** SBEM**Calculation engine version:** v5.6.a.1**Interface to calculation engine:** DesignBuilder SBEM**Interface to calculation engine version:** v6.0.1**BRUKL compliance check version:** v5.6.a.1**Owner Details****Name:****Telephone number:****Address:** , ,**Certifier details****Name:****Telephone number:****Address:** , ,**Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target**

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	15
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	15
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	13.5
Are emissions from the building less than or equal to the target?	BER ≤ TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and 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 -Limit	U _a -Calc	U _i -Calc	Surface where the maximum value occurs*
Wall**	0.35	0.3	0.32	00-Floor - Dining Hall_W_10
Floor	0.25	0.15	0.45	00-Floor - Group room SF16_S_3
Roof	0.25	0.17	0.21	00-Floor - Dining Hall_R_35
Windows***, roof windows, and rooflights	2.2	1.32	1.4	00-Floor - Dining Hall_G_19
Personnel doors	2.2	1.5	1.5	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"
U _a -Limit = Limiting area-weighted average U-values [W/(m ² K)] U _a -Calc = Calculated area-weighted average U-values [W/(m ² K)] U _i -Calc = Calculated maximum individual element U-values [W/(m ² K)]				
* 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	5

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	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- Dining Hall HVAC - Underfloor Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

2- Project HVAC + Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	3.2	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

3- Project HVAC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* 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.					

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	-
Standard value	N/A	N/A

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	Zone	Standard
00-Floor - Dining Hall		-	-	-	1.4	-	-	-	-	-	0.8	0.5

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	
00-Floor - Group room SF16	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Group room SF15	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Sixth Form Classroom SF13-	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - Sixth Form Classroom SF14-	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF10-	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Small Group room SF2	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF4	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF3	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF5	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF6	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF7	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF9	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF11-	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF8	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
01-Floor - Sixth Form Classroom SF12-	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Sixth Form Common Room	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Sixth Form Study SF1	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
00-Floor - WC-1	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Cleaners cupboard	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - WC Dis	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - WC-2	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Kitchen Prep Area	-	-	-	-	-	-	-	-	1	-	N/A	
00-Floor - WC-kitchen	-	-	0.3	-	-	-	-	-	-	-	N/A	
00-Floor - Office-Kitchen	-	-	-	1.4	-	-	-	-	-	0.8	0.65	
00-Floor - Kitchen small	-	-	-	-	-	-	-	-	1	-	N/A	
01-Floor - WC Dis	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - WC-1	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - Cleaners Cupboard	-	-	0.3	-	-	-	-	-	-	-	N/A	
01-Floor - Head of Sixth Form	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - Cafe	-	-	-	1.4	-	-	-	-	-	0.8	0.5	
02-Floor - WC Staff	-	-	0.3	-	-	-	-	-	-	-	N/A	
02-Floor - WC	-	-	0.3	-	-	-	-	-	-	-	N/A	
02-Floor - Staff Office	-	-	-	1.4	-	-	-	-	-	0.8	0.5	

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
Standard value		60	60	22	
00-Floor - Dining Hall		-	110	-	1643
00-Floor - Group room SF16		110	-	-	168
00-Floor - Group room SF15		110	-	-	131
00-Floor - Sixth Form Classroom SF13		110	-	-	257
00-Floor - Sixth Form Classroom SF14		110	-	-	194
01-Floor - Sixth Form Classroom SF10		110	-	-	234

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
	Standard value	60	60	22	
01-Floor - Small Group room SF2		110	-	-	98
01-Floor - Sixth Form Classroom SF4		110	-	-	197
01-Floor - Sixth Form Classroom SF3		110	-	-	260
01-Floor - Sixth Form Classroom SF5		110	-	-	137
01-Floor - Sixth Form Classroom SF6		110	-	-	219
01-Floor - Sixth Form Classroom SF7		110	-	-	117
01-Floor - Sixth Form Classroom SF9		110	-	-	108
01-Floor - Sixth Form Classroom SF11		110	-	-	103
01-Floor - Sixth Form Classroom SF8		110	-	-	114
01-Floor - Sixth Form Classroom SF12		110	-	-	176
02-Floor - Sixth Form Common Room		-	110	-	706
02-Floor - Sixth Form Study SF1		110	-	-	303
00-Floor - Circulation-4		-	110	-	154
00-Floor - WC-1		-	110	-	82
00-Floor - Circulation-3		-	110	-	47
00-Floor - Circulation-5		-	110	-	80
00-Floor - Cleaners cupboard		110	-	-	8
00-Floor - Circulation-6		-	110	-	117
00-Floor - WC Dis		-	110	-	27
00-Floor - WC-2		-	110	-	103
00-Floor - Storage-5		110	-	-	12
00-Floor - Kitchen Prep Area		-	110	-	1150
00-Floor - Storage-1		110	-	-	10
00-Floor - Plant-2		110	-	-	51
00-Floor - Chair and Table Store		110	-	-	36
00-Floor - Circulation-1		-	110	-	112
00-Floor - Storage-2		110	-	-	10
00-Floor - Storage-3		110	-	-	12
00-Floor - Storage-4		110	-	-	8
00-Floor - Waste area		110	-	-	9
00-Floor - WC-kitchen		-	110	-	43
00-Floor - Office-Kitchen		110	-	-	62
00-Floor - Kitchen small		-	110	-	113
00-Floor - Circulation-2		-	110	-	81
00-Floor - Plant-1		110	-	-	48
01-Floor - Circulation-5		-	110	-	60
01-Floor - Circulation-2		-	110	-	74
01-Floor - Circulation-1		-	110	-	75
01-Floor - WC Dis		-	110	-	29
01-Floor - WC-1		-	110	-	106
01-Floor - Cleaners Cupboard		110	-	-	7
01-Floor - Circulation-6		-	110	-	92
01-Floor - Circulation-3		-	110	-	53

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
01-Floor - Server room	110	-	-	9
01-Floor - Head of Sixth Form	110	-	-	86
01-Floor - Circulation-4	-	110	-	154
02-Floor - Circulation-3	-	110	-	31
02-Floor - Cafe	-	110	-	247
02-Floor - Circulation-1	-	110	-	36
02-Floor - WC Staff	-	110	-	19
02-Floor - WC	-	110	-	65
02-Floor - Staff Office	110	-	-	171
02-Floor - Circulation-2	-	110	-	53

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-Floor - Dining Hall	YES (+78.5%)	NO
00-Floor - Group room SF16	N/A	N/A
00-Floor - Group room SF15	NO (-63.9%)	NO
00-Floor - Sixth Form Classroom SF13	NO (-71.6%)	NO
00-Floor - Sixth Form Classroom SF14	NO (-58.9%)	NO
01-Floor - Sixth Form Classroom SF10	NO (-84.5%)	NO
01-Floor - Small Group room SF2	NO (-56.7%)	NO
01-Floor - Sixth Form Classroom SF4	NO (-58.9%)	NO
01-Floor - Sixth Form Classroom SF3	NO (-67.5%)	NO
01-Floor - Sixth Form Classroom SF5	NO (-53.8%)	NO
01-Floor - Sixth Form Classroom SF6	N/A	N/A
01-Floor - Sixth Form Classroom SF7	NO (-59.8%)	NO
01-Floor - Sixth Form Classroom SF9	NO (-56.4%)	NO
01-Floor - Sixth Form Classroom SF11	N/A	N/A
01-Floor - Sixth Form Classroom SF8	NO (-58.2%)	NO
01-Floor - Sixth Form Classroom SF12	N/A	N/A
02-Floor - Sixth Form Common Room	NO (-23.2%)	NO
02-Floor - Sixth Form Study SF1	YES (+2.4%)	NO
00-Floor - Office-Kitchen	NO (-49.2%)	NO
01-Floor - Head of Sixth Form	N/A	N/A
02-Floor - Staff Office	YES (+7.4%)	NO

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?	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]	3105.8	3105.8
External area [m ²]	4043.1	4043.1
Weather	LON	LON
Infiltration [m ³ /hm ² @ 50Pa]	5	3
Average conductance [W/K]	1453.35	1248.01
Average U-value [W/m ² K]	0.36	0.31
Alpha value* [%]	12.75	12.94

* 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 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
100 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	8.58	5.13
Cooling	3.63	2.48
Auxiliary	4.34	2.9
Lighting	4.91	8.41
Hot water	30.7	32.05
Equipment*	33.56	33.56
TOTAL**	52.15	50.96

* 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	3.11	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	90.77	88.23
Primary energy* [kWh/m ²]	87.43	86.62
Total emissions [kg/m ²]	13.5	15

* 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 SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER	
[ST] Central heating using water: floor heating, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
Actual	13.1	68.5	4.3	0	3.2	0.85	0	0.95	0	
Notional	5.5	65.7	1.9	0	1.9	0.82	0	----	----	
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	28.9	91.5	9.1	11.2	5.6	0.89	2.27	0.95	3.2	
Notional	13.6	99	4.6	7.6	3.4	0.82	3.6	----	----	
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	33.3	40.2	10.9	0	4.1	0.85	0	0.95	0	
Notional	22.3	57.5	7.6	0	3.1	0.82	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-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.25	00-Floor - Group room SF15_W_5
Floor	0.2	0.05	00-Floor - Circulation-1_S_3
Roof	0.15	0.15	00-Floor - Dining Hall_R_35
Windows, roof windows, and rooflights	1.5	1.3	00-Floor - Dining Hall_G_11
Personnel doors	1.5	1.5	00-Floor - Waste area_D_7
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"
U _{i-Typ} = Typical individual element U-values [W/(m²K)]		U _{i-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	5