

ENERGY STATEMENT

**RUISLIP HIGH SCHOOL,
28 SIDMOUTH DR, RUISLIP HA4 0BY**

AUGUST 2017

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1 Executive Summary

This report provides a detailed energy assessment to demonstrate how the targets for carbon dioxide emissions reduction are to be met, in line with the Mayor's Climate Change Mitigation and Energy Strategy.

Arcadis have modelled and predicted energy performance and carbon dioxide emissions of the proposed Ruislip High School development situated at 28 Sidmouth Drive, Ruislip, United Kingdom, based on the information provided by the architects.

1.1 Energy Assessment

To conduct our analysis, a model of the development was constructed on the thermal modelling software, IES (Integrated Environmental Solutions) and an SBEM calculation was performed. The methodology used in calculating CO₂ reductions are in accordance with the three-step strategy set of the Energy Hierarchy out in the London Plan (March 2016) Policy 5.2. This includes:

- energy efficient measures to reduce carbon dioxide emissions (Be Lean),
- further reductions in carbon dioxide emissions through potential connections to district heating, cooling or combined heat and power network (Be Clean),
- proposals to further reduce carbon dioxide emissions through the use of on-site renewable energy technologies (Be Green).

As per Hillingdon Council's Development Management Policy (October 2015), the site will aim to minimise regulated CO₂ emissions to the targets suggested in the London Plan Policy 5.2, which sets the Building Regulations as the target TER at 35% below Part L 2013 for commercial development schemes from 2016-2019.

Through the implementation of these energy efficient measures, annual CO₂ emissions from this refurbished development is 35% lower than the emissions of an equivalent new build development built to 2013 building regulations.

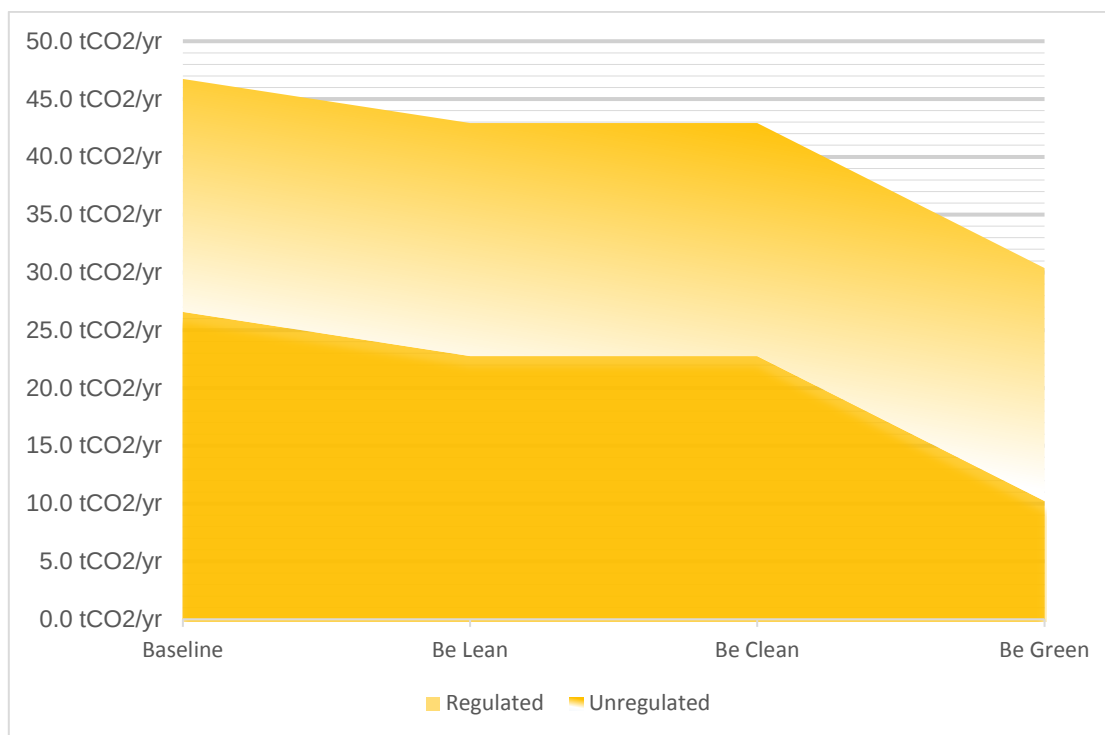
Further reductions were explored:

- Availability of local CHP or district heating systems were investigated, where it was found that there were no local systems in place.
- Initiation of a new CHP or district heating community system were considered, however, due to site constraints and obstructions, lack of new high usage / high-density development in the area, and residential nature of the surroundings area, it was unlikely that such system would be unsuitable.
- Creation of a local small CHP was considered for this project, however, after analysing the annual consumption characteristics of the building, the use of CHP was deemed to be unsuitable.

The most suitable LZC (Low and Zero Carbon) technology for the scheme was found to be photovoltaic cells.

- The use of photovoltaic panels as a renewable energy source was considered to be the most suitable LZC technology for this project. The proposed development will include the installation of 226m² of photovoltaic panels contributing a 61.5% over building regulations savings of the regulated CO₂ emissions per annum for this development.

The table below summarises the CO₂ emissions and savings achievable for this development in line with these three stages.



	Regulated CO2 Summary			Total CO2 Summary		
		<i>saved</i>	<i>% savings</i>		<i>saved</i>	<i>% savings</i>
Building Regulations	26.6 tCO2/yr	-	-	46.7 tCO2/yr	-	-
After energy demand reduction	22.8 tCO2/yr	3.8 tCO2/yr	14.3%	42.9 tCO2/yr	3.8 tCO2/yr	8.2%
After CHP	22.8 tCO2/yr	3.8 tCO2/yr	14.3%	42.9 tCO2/yr	3.8 tCO2/yr	8.2%
After renewables	10.2 tCO2/yr	16.4 tCO2/yr	61.5%	30.4 tCO2/yr	16.4 tCO2/yr	35.0%

1.2 Overheating Analysis

As per the GLA (Greater London Authority) Guidance on preparing Energy Statements 2016, an overheating checklist analysis is to be completed at pre-application and submission stage to assist developers and planning officers identify and address overheating risk from conceptual design stages.

The study indicated that several classroom areas and staff areas will fail the overheating criteria, and as such will require additional forms of low energy ventilation to ensure suitable temperatures during extreme summer periods.

1.3 Conclusion

In total, the development is expected to reduce CO₂ emissions by 61.5% when compared to the benchmarked Part L 2013 baseline emissions taking into account regulated energy use. This equates to a

CO₂ emissions reduction of 35.0% compared to the total Part L 2013 baseline emissions taking into account the unregulated energy use.

Through the use of these LZC technologies, the reductions are capable of contributing to a post-efficiency reduction of approximately 12.6 tonnes of CO₂ beyond the Lean/Clean scenario. 19.0% / 24,169kWh of the buildings annual energy generation will be provided by this zero carbon photovoltaic system.

The total reduction of 16.4 tonnes CO₂ per annum met the target 35% reduction set out by the London Plan.

In conclusion, through adopting the energy strategy detailed in this document, Hillingdon Council is committing to building an energy efficient development which will have low CO₂ emissions, compliant to the local council and the latest London Plan.

2 Introduction

Arcadis (UK) Limited has been commissioned to produce an energy statement for the proposed development of the Ruislip High School, 28 Sidmouth Drive, Ruislip, HA4 0BY, United Kingdom. The report demonstrates compliance with national, regional & local planning policies and the Building Regulations L2A for the new build adjacent to the existing school building.

Through the implementation of these measures in accordance with the three-step strategy set of the Energy Hierarchy out in the London Plan, annual CO₂ emissions are expected to be substantially less than if the development was built to current Part L building regulation.

This document discusses the expected energy performance of the development and explains the inclusions and design features that will reduce the energy use and associated CO₂ emissions of the development.

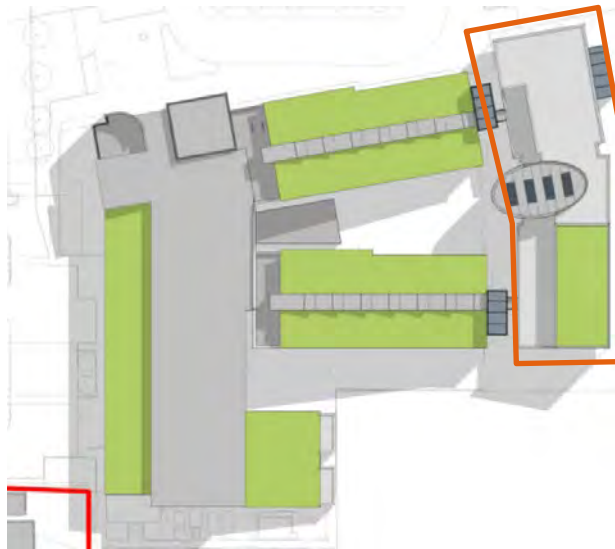
1.4 Site Description

The proposed development is a building located in a residential area of Ruislip, within the London Borough of Hillingdon demise. The new building will provide new classrooms and workspaces, and comprise classrooms, art store, accessible and general toilet facilities, new common hall, 6th form social areas, and SRP therapy rooms across three storeys. In total, the development comprises 2542 m² of floor area.

The development is to be built to the north-east to the existing school building, which will connect to the two large existing building wings and provide access to all storeys with a new external stairwell. The building will be surrounded by residential areas. Beyond the school premises, the site is bounded by Sidmouth Drive to the south, Darthmouth Road to the south and the Yeading Brook to the south and the main road, West End Road to the west. The site will be located approximately 5-7m from existing school development.

The school is located near numerous transport hubs, including bus stops on West End Road, and approximately 0.6 km from Ruislip Gardens Station tube station.

The proposed new building is shown below.



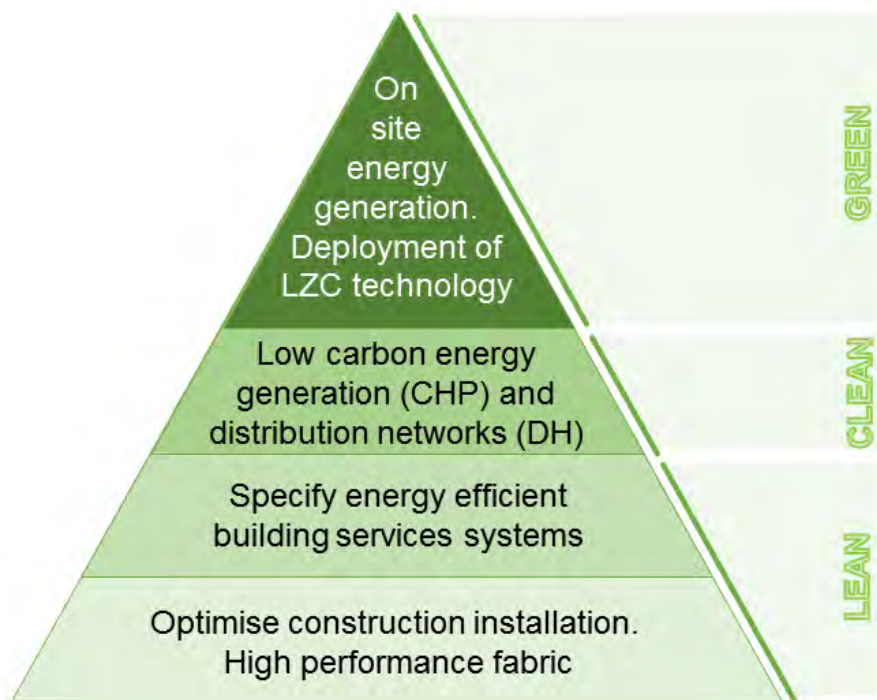
To conduct our analysis, a model of the development was constructed using the thermal modelling software, IES, and an SBEM calculation was performed. The model developed is based on the latest architect's drawings, which are provided in Appendix A of this report. Images and a 3D representation of the model are provided in Appendix B.

1.5 The Energy Hierarchy

An energy hierarchy offers an effective framework to guide energy policy and decision making. This is based on the application of the principles that underpin the waste hierarchy- 'reduce, reuse, recycle and recover' to energy. As commonly devised, an energy hierarchy is primarily driven by carbon intensity and resource use. The key elements of the hierarchy are as outlined below.

The first consideration is to reduce the amount of energy used by minimising demand, then improve the efficiency of all mechanical and electrical services to reduce energy consumption. With all achievable methods of reduction in place and all plants/boilers functioning efficiently, it is then appropriate to consider how to generate energy from renewable sources. This hierarchical approach has been illustrated by the Mayor of London to comprise of three basic steps:

- Using less energy, in particular by adopting sustainable design and construction measures;
- Supplying energy efficiently, in particular by prioritising decentralised energy generation and
- Using renewable energy



The development's Energy Strategy derives from the energy hierarchy, hence has adopted the following ethos:

1.5.1 Be Lean

The first step deals with the reduction in energy use through the adoption of sustainable design and construction measures. The development will strive to reduce CO₂ emissions by incorporating a range of energy efficiency measures. This includes:

- provision for low energy internal and external lighting,
- improved air permeability
- improved levels of insulation within the existing envelope and

- installation of high-performance windows.

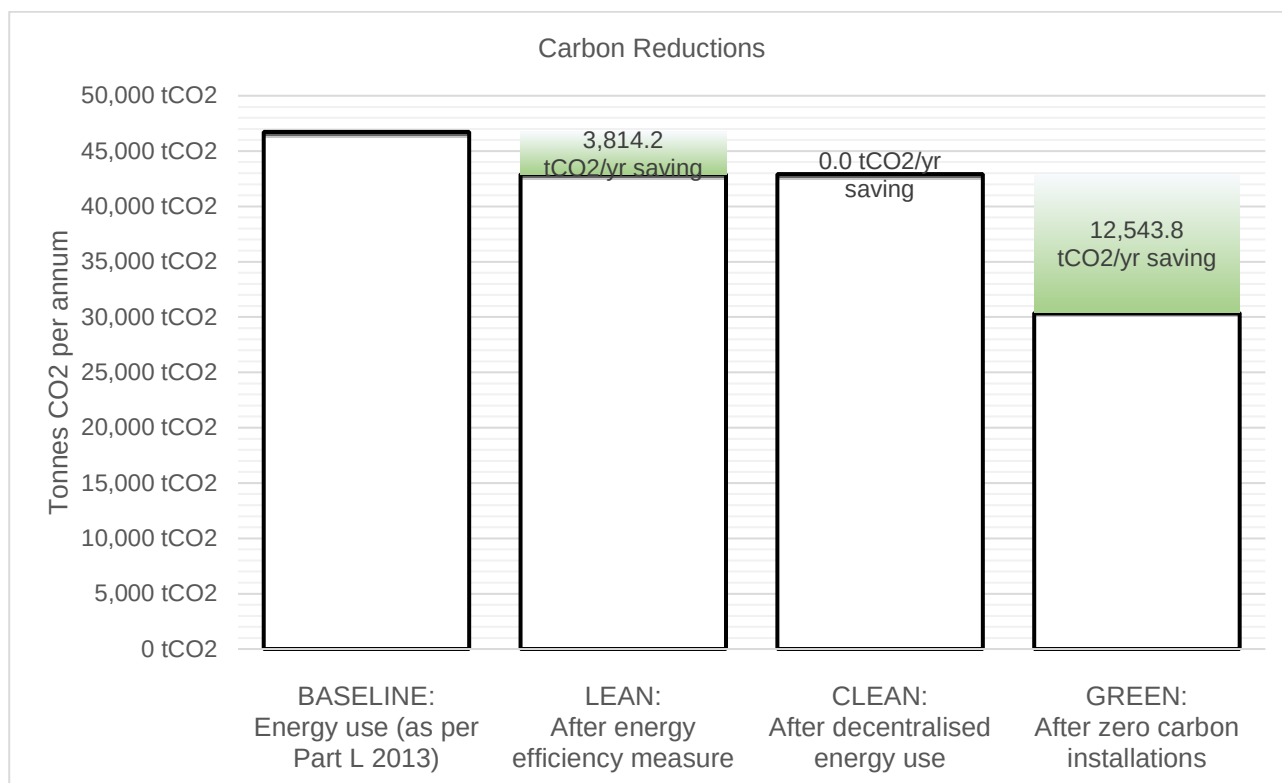
1.5.2 Be Clean

The second strategy takes into account the efficient supply of energy, by prioritising decentralised energy generation. Hot water and space heating will be supplied by high efficiency condensing gas boilers to each dwelling.

1.5.3 Be Green

Once energy demand has been reduced, renewable energy sources will be used to further reduce total building CO₂ emissions. A variety of LZC technologies and systems were analysed including a biomass heating system, solar thermal, ground source heat pumps, air-source heat pumps, photovoltaics and wind turbines.

- **BE LEAN** – By using less energy and taking into account the further energy efficiency measure in comparison to the baseline building.
- **BE CLEAN** – By supplying energy efficiently. The clean building looks at further carbon dioxide emission savings over the lean building by taking into consideration the use of decentralised energy via CHP.
- **BE GREEN** – By integrating renewable energy into the scheme which can further reduce the carbon dioxide emission rate.



1.6 Policy Document

The Mayor seeks to achieve an overall reduction in London's carbon dioxide emissions of 60 per cent (below 1990 levels) by 2025, in line with the Government's established a target to reduce the UK's greenhouse gas emissions by 80 percent by 2050, as per the Climate Change Act 2008.

The report should be used to demonstrate to the Hillingdon Planning Authority how the development fulfils the relevant policies of the new London Plan (March 2016).

The methodology used in calculating CO₂ reductions are in accordance with the three-step strategy set of the Energy Hierarchy out in the London Plan (March 2016) Policy 5.2.

As per Hillingdon Council's Development Management Policy (October 2015), the site will aim to minimise CO₂ emissions to the targets suggested in the London Plan Policy 5.2, which sets the Building Regulations as the target TER at 35% below Part L 2013 for commercial development schemes from 2016-2019, unless it can be demonstrated that such provision is not feasible.

As per the GLA (Greater London Authority) Guidance on preparing Energy Statements 2016, an overheating checklist analysis is to be completed at pre-application and submission stage to assist developers and planning officers identify and address overheating risk from conceptual design stages.

Where CO₂ reductions are explored, this report reflects on the suitability of each proposal, taking account of its physical size, environment and location, accessibility, and usage type of the proposed development.

2 Energy Studies

2.1 Overheating Analysis

Overheating analysis has been carried out to predict summer overheating in the building, and subsequently inform designers, developers, and others responsible for defining the indoor environment in buildings.

To avoid overheating, passive measures such as selecting:

- suitably sized windows have been incorporated in parts of the facade to provide shading to limit solar gains to classroom areas, and
- specification of glazing that will provide a balance of solar control
- the introduction of low energy lighting.

Using the model, an overheating analysis is carried out to identify areas which do not meet the CIBSE Technical Memorandum (TM) 52 -2013 Comfort Analysis adaptive criteria.

Where it is not possible to meet the TM52 criteria (refer to Appendix C), alternative design options such as low energy stack ventilation are incorporated within the design to prevent overheating in classrooms and staff rooms.

Appendix C provides a summary of rooms where low energy mechanical ventilation is required.

2.2 Baseline

The baseline energy consumption of the proposed development is evaluated in this section. This baseline will serve as a starting point for setting energy efficiency improvement goals as well as a comparison point for evaluating efforts aimed at reducing the development's CO₂ emission. The baseline energy use and resulting CO₂ emission rate of the development has been assessed using the IES/SBEM Government approved software. For the purpose of this report, the baseline energy use and CO₂ emissions are calculated based on the minimum requirements specified in the Building Regulations ADL2A 2013.

The baseline annual energy use and CO₂ emissions are presented in the table below.

	Baseline (Part L)		
	Energy	CO2 emissions*	CO2/m2
Hot Water	11,519 kWh/yr	2,488 kgCO2/yr	1.6 kgCO2/m ² /yr
Space Heating	54,576 kWh/yr	11,789 kgCO2/yr	7.8 kgCO2/m ² /yr
Cooling	0 kWh/yr	0 kgCO2/yr	0.0 kgCO2/m ² /yr
Auxiliary	1,366 kWh/yr	709 kgCO2/yr	0.5 kgCO2/m ² /yr
Lighting	22,356 kWh/yr	11,603 kgCO2/yr	7.6 kgCO2/m ² /yr
Equipment (Unregulated)	38,823 kWh/yr	20,149 kgCO2/yr	13.3 kgCO2/m ² /yr
Total Part L	89,817 kWh/yr	26,588 kgCO2/yr	17.5 kgCO2/m ² /yr
Total (including equipment)	128,640 kWh/yr	46,737 kgCO2/yr	30.8 kgCO2/m ² /yr

2.3 Lean

In line with the Mayor's aspiration, as per Policy 5.3 of the London Plan March 2016, the new development will significantly reduce emissions by incorporating a range of energy efficiency measures throughout the site including to achieve the highest standards of sustainable design and construction, and demonstrate sustainable design standards are integral to the proposal during its construction and operational stages.

To quantify the energy and CO₂ reductions expected at the development, the following proposed measures were modelled:

- Improved building fabric and insulations beyond building regulations,
- High-performance windows
- Improved air tightness
- Specification of low-flow taps and showers
- Provision of 100% low energy lighting

2.3.1 Heat Loss

By reducing heat loss through the fabric of the building during the heating season, the energy required for space heating is minimised. The heat loss through the different elements of the building is dependent upon the U-value of that element.

The development will achieve the following U-values by incorporating good levels of insulation, complying with the current Part L2A 2013 Building Regulations with 2016 amendments.

Building Element	Building Regulations	Proposed Specification
Roof U-value	0.25 W/m ² /K	0.25 W/m ² /K
External Walls U-value	0.25 W/m ² /K	0.25 W/m ² /K
Floor U-value	0.25 W/m ² /K	0.25 W/m ² /K
Window units (whole window) U-value	2.2 W/m ² /K	2.0 W/m ² /K double glazing

2.3.2 Air Permeability

Infiltration heat losses occur through small gaps in the construction elements where the heated internal air is able to pass through the envelope of the building. Infiltration losses occur mainly around the edge of apertures (doors and windows) and through construction junctions.

Additional heat loss occurs due to air infiltration and although this cannot be eliminated altogether from the buildings, it will be minimised through ensuring good construction detailing and using best practice construction techniques (e.g. ensuring a constant un-punctured vapour control layer, robust detailing at critical junctions).

Building Element	Building Regulations	Proposed Specification
Air permeability	10 m ³ /(h.m ²) at 50 Pa	5 m ³ /(h.m ²) at 50 Pa

Current Part L building regulations set a maximum air permeability of 10 m³/(h.m²) at 50Pa, by adopting good practice construction techniques, the proposed development will seek to improve upon this to achieve 5 m³/(h.m²) at 50Pa.

2.3.3 Efficiency

The development incorporates measures and systems to ensure that energy is efficiently generated, distributed and used within the development. Efficiency measures considered include low energy lighting.

Low Energy Lighting and Control

100% of lighting will be specified with low energy light fittings throughout the building, ensuring only LEDs are used. Internal and external areas of infrequent use will be fitted with occupancy sensors, whereas day lit areas will receive daylight sensors.

The light fittings will be the low energy Light Emitting Diode (LED) lighting utilizing 1.2 W/m² LED, 100 Lux

Building Element	Building Regulations	Proposed Specification
Low Energy Lighting	60 lm/circuit watt	1.2 W/m ² LED, 100 Lux

High-efficiency condensing gas boilers

All spaces will be fitted with high-efficiency condensing gas boilers (SEDBUK rating A).

Domestic hot water for the preparation of student's meal and general DHW use will be provided utilizing a separate high efficiency (up to 97%) direct natural gas fired boilers.

Assumed fuel efficiency factors are provided in Appendix D.

2.3.4 Green Roofs

The report should be used to demonstrate to the Hillingdon Planning Authority how the development fulfils the relevant policies of the new London Plan (March 2016).

**As per Hillingdon Council's Development Management Policy (October 2015)
Policy DME1 1, the site will aim to incorporate living roofs and/or walls into the development unless a suitable justification is provided where living walls cannot be provided.**

The existing school has a series of green roofs across the building and in particular, on the two main teaching wings. A green roof was also considered for the new extension building and this has been incorporated into the proposals. The green roof is located on the pitched roof of the Art Studio on the second floor level and covers an approximate area of 300m². This green roof helps to soften the visual impact of the building as well as enhancing the on-site biodiversity.

2.3.5 Passive Design

The development will reduce the need for active cooling systems for the majority of areas and provide artificial lighting and take advantage of winter solar gains through the incorporation of passive design techniques.

Daylighting

The development has been designed to provide good levels of daylight, thereby improving the quality of life for the occupant. Appropriate daylighting will also avoid the need for energy-intensive artificial lighting needed to light the habitable spaces. Particular daylighting initiatives include generous window sizing and interior walls which are painted in light colours to reflect light into rooms.

Natural Ventilation

Since the current development incorporates a number of learning areas, the level of CO₂ is expected to be a key design factor, particularly during the learning hours. Also in the summer, solar heating can constitute substantial temperature rise within the building leading to overheating. Thus, we adopt a strategy that aims at controlling the overall air quality by regulating interior temperatures and CO₂ level. The system will incorporate smart windows which will be controlled by temperature and CO₂ sensors. The threshold temperature and CO₂ level will be those specified in Building Bulletin 101. At temperatures or CO₂ equal to or greater than the threshold value, the sensors will be triggered to open the windows and admit fresh air into the room. It is intended to supply fresh air at a rate of 8 l/s per person such that the carbon dioxide concentration will generally remain below 1000 as recommended in BB 101.

All classrooms feature external glazing, and will be fitted with large openable windows sized to provide natural ventilation at sufficient fresh air rates to enhance internal air quality.

Due to the shallow plan of the development, the majority of the classrooms will be fitted with glazing elements on multiple sides, thereby encouraging cross flow natural ventilation and reduce vulnerability to overheating.

Where the model indicates that it not possible to maintain suitable internal conditions during summer periods through natural ventilation, low energy stack ventilation is to be provided in combination with openable windows. Full details of this are provided in Appendix C.

Daylighting

The development has been designed to provide good levels of daylight whilst also ensuring excessive solar gain does not cause overheating. This will mitigate the requirement of mechanical cooling whilst help to avoid the use of energy-intensive artificial lighting. Particular daylighting initiatives include generous window sizing and the light colouring of interior walls to reflect light into rooms.

2.3.6 Control of Unregulated Energy

Energy efficiency improvement measures for unregulated energy (energy not currently regulated by Part L) use cannot be quantified with SBEM software. However, for the proposed development, measures for reducing energy consumption in the two main areas of office equipment (PC's and printers) are proposed;

- an energy policy & management strategy is recommended to ensure all equipment is switched off when not in use and that the most energy efficient equipment is installed in the first place.
- A time switch on the electrical riser will reduce the energy wasted across the whole building during unoccupied times. For the office levels, this will ensure that energy is not wasted through tenants leaving electrical appliances and items on overnight during 'out of office' times. Where possible, equipment shall be fitted with integral time switches.
- Further savings are achievable where the developer will encourage tenants to adopt Eco-labelled goods recognised under the EU energy efficiency labelling scheme, including A+ and A++ rated appliances.

It is anticipated that if the above strategy is implemented, a reduction of CO₂ emission in the region of 10% could be achieved.

Finally, renewables calculations based on the Renewables Toolkit were used to demonstrate the effect of CLEAN and GREEN renewables.

- Internal blinds will be incorporated into the design to reduce the energy consumed in cooling the building.
- Particular daylighting initiatives include generous window sizing and the light colouring of interior walls to reflect light into rooms.

2.3.7 Savings after BE LEAN Stage

The following table summarises the reduction in building energy consumption and the corresponding reduction in CO₂ emission resulting from the implementation of the measures mentioned above. All calculations have been carried out in IES which is based on SBEM – the government approved calculation engine.

The output BRUKL Document is provided in Appendix E of this report.

	Baseline	Lean	% Improvement
	(Part L 2013)	(After Energy Efficiency Measures)	(Lean over Part L 2013 Baseline)
Regulated Energy	89,817 kWh/yr	88,254 kWh/yr	1.7%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	128,640 kWh/yr	127,077 kWh/yr	1.2%
Regulated CO2	26,588 kgCO2/yr	22,774 kgCO2/yr	14.3%
Unregulated CO2	20,149 kgCO2/yr	20,149 kgCO2/yr	0.0%
Total CO2	46,737 kgCO2/yr	42,923 kgCO2/yr	8.2%

2.4 BE CLEAN – CHP & Decentralised Energy Networks

The energy hierarchy encourages the use of a CHP system and the connection to District Heating system to reduce CO₂ emissions further.

Decentralised Energy

Policies 5.5A of the London Plan March 2016 highlight the Mayor's expectation of 25% of heat and power used in London to be generated through the use of localized decentralized energy systems by 2025. The advantages of decentralised energy systems for heating, cooling and power. In a communal energy system, energy in the form of heat, cooling, and/or electricity is generated from a central source and distributed via a network to surrounding residences and commercial units.

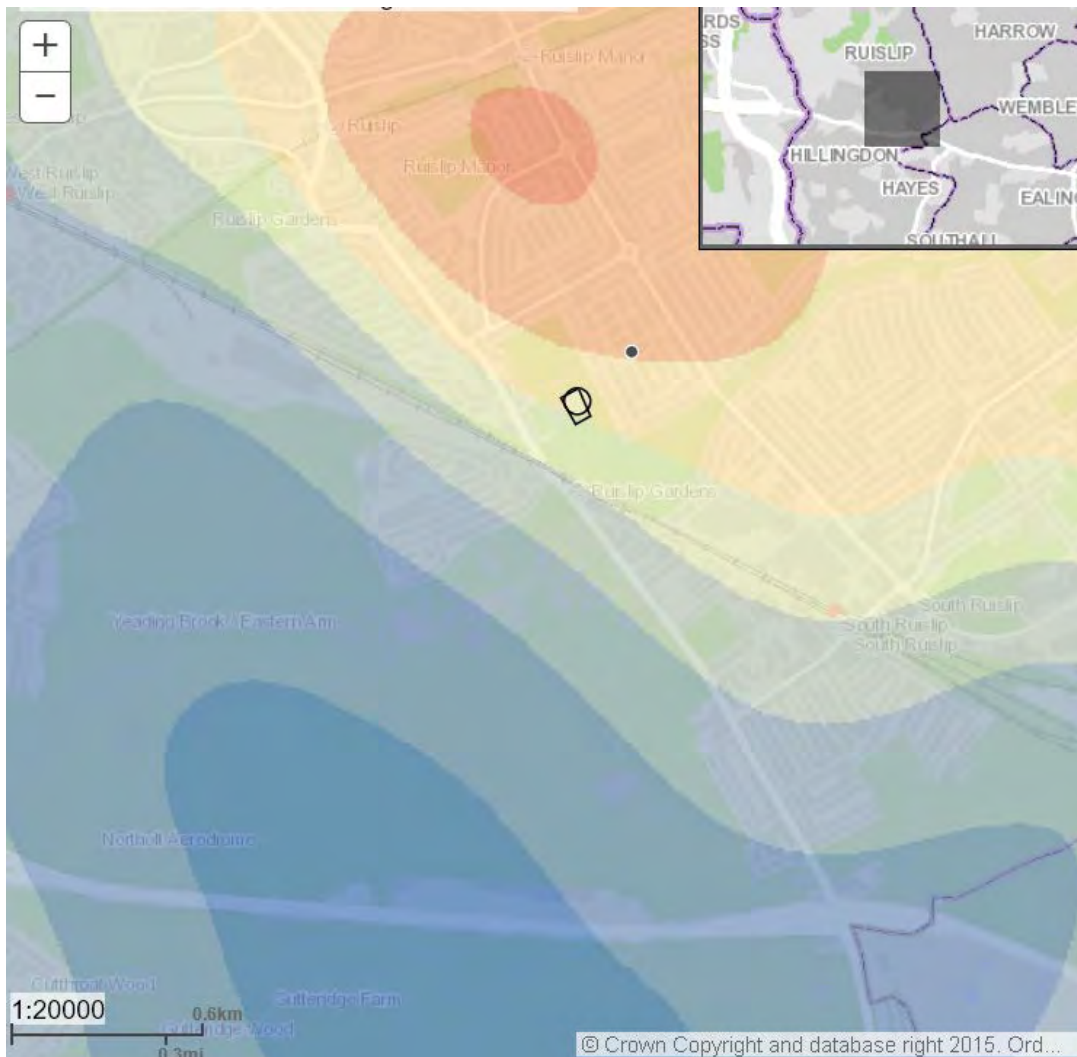
The feasibility of connecting into an existing heating network or providing the building with its own combined heat and power plant has been assessed in Sections Communal Heating and CHP below.

2.4.1 Communal Heating

A communal or district heating system supplies heat to a number of buildings from a common heat source. Typically, these would comprise of a large scale boiler, pump sets and network piping sized to serve multiple buildings. This type of system uses significantly less energy when compared to numerous individual gas fired boilers. Furthermore, various communal heating systems can be combined with other renewable energy sources (biogas, LPG etc), to permit greatly reduced carbon emissions.

Heat, in the form of hot water, can be distributed from a central plant to all units via insulated pipes. The heat will then be distributed to each building via a plate heat exchanger unit which will allow instantaneous water heating. This removes the requirement for individual boilers and a gas supply in the building, and provides each the end user with the same autonomy as if they had their own boiler. Modern communal heating systems tend to include independent meters to ensure each user pay for only the energy they use.

In line with Policy 5.5B, the development will incorporate a communal heating system, which has the potential to increase the efficiency of on-site heating use and generation by evening out load variations.



There are no identifiable communal heating networks in close proximity to the proposed development site. The nearest existing communal heating system is located in Stanmore located approximately 5 miles east of the site. In the absence of any existing local heating networks within 500m from the site, it will not be feasible to connect the site to an existing communal heating scheme.

The London Heat Map indicates the area has a moderate annual heating kWh usage. A higher annual heating demand is observed near Ruislip Manor, to the north. However, given the proximity to high heating demand areas, it would not be feasible to develop and initiate a new district heating scheme as part of the development.

Space will be allowed for within the plant room to allow for a connection to a future suitable district scheme.

2.4.2 CHP

CHP, or Cogeneration, is the production of electricity and useful heat from a single plant, improving the overall energy conversion efficiency of between 25-35% to around 80%.

For a wide range of buildings, installation of a CHP can offer an economical method of providing heat and power which is less environmentally harmful than conventional methods. However, the economic viability of CHP is heavily dependent on the demand for heat and power. For small-scale residential buildings, the use of a CHP engine can prove to be infeasible.

A Carbon Trust 'Good Practice Guide for CHP for Buildings' suggests that a CHP system would be worth investigating for

schemes with a simultaneous demand for heat and power of more than 5,000 hours per year. Since the is a primary school, the occupation will be high from 9am-3pm during weekdays for 40 weeks per year.



Bosch CHP

The implementation of a CHP strategy should be decided according to good practice design. Key factors for efficient implementation of CHP system are:

- Development with a high heating load for the majority of the year.
- CHP operation based on maximum heat load for minimum 10 hours per day.
- CHP operation at a maximum capacity of 90% of its operating period.

For a CHP scheme to be efficient, it is advised that a CHP engine operates at its full power (base energy load) continuously. With this unsteady heat demand profile, this would have a significant effect on the potential CO reduction and payback of the CHP system.

CHP systems can be combined with absorption chillers in summer months, allowing the system to provide heating, electricity, and cooling as required throughout the year, this is known as trigeneration.

The development has been designed to incorporate high-efficiency cooling and therefore trigeneration is not appropriate in this case.

In line with Policy 5.6, Arcadis have produced a feasibility to review the following:

- opportunities to install new CHP network with the potential to extend beyond the site boundary, as per Policy 5.6A
- opportunities to connect to existing CHP networks, as identified using the London Heat Map Tool, as per Policy 5.6A
- opportunities to connect to install a new CHP unit to generate heating and electricity of the proposed building only

Creation of a new CHP system on site to create opportunities to future area

The London Heat Map indicates the area has a moderate annual heating kWh usage. For the same reason as stated with communal heating, given the proximity to high heating demand areas, it would not be feasible to develop and initiate a new district heating scheme as part of the development.

Connect to existing CHP networks

There are no identifiable CHP networks in close proximity to the proposed development site. The nearest existing CHP networks are located in Stanmore and Collingdale (approximately 5-6 miles east of the site). In

the absence of any existing CHP networks within 500m from the site, it will not be feasible to connect the site to an existing CHP scheme.

CHP to serve proposed building only

Due to the nature and function of the school development, a CHP will need to be sized to produce a daily heat load profile for space heating and domestic hot water which are concentrated at peaks when the building is occupied. With this unsteady heat demand profile, the CHP would have to be sized on a very low base load.

This would have a significant effect on the overall size of the CHP selected, and therefore affect the potential CO₂ reduction and payback of the CHP system. If a larger system was selected, the heat load during the summer months would not be sufficient meaning that the engine would not be in use for as many hours and the total CO₂ reduction may be lower.

Combined Heat & Power	
CHP Engine Split (CHP _{heat} /CHP _{elec})	1.67
Efficiency for Heating	50%
Efficiency for Electricity	30%
Backup Heating Efficiency	90%
Hot Water Produced	68,406 kWh/yr
Electricity Produced	51,071 kWh/yr
Total CO₂ Savings	6,237 kgCO₂/yr
Percentage CO₂ reduction due to Gas CHP	14.5%

In conclusion, for the reason of the relatively small development size and subsequent variable peak nature of the annual heat load CHP is not feasible for this development.

A CHP system will not be considered for this development due to the following reasons:

- The heating load of the building is not enough for the CHP system to run efficiently
- Economic viability is heavily dependent on the demand for heat and power, as well as the price of electricity and gas. The heat and power demand of the proposed development is not sufficient for a CHP system to run efficiently.
- Insufficient space available within the development to incorporate the CHP system and potential future connections.

CHP systems can be combined with absorption chillers in summer months, allowing the system to provide heating, electricity, and cooling as required throughout the year, this is known as trigeneration.

- Due to the developments need and high annual cooling demand, trigeneration may prove to be a viable option. However, as the development has been designed to avoid the need for cooling and therefore trigeneration is not appropriate in this case.

In conclusion, assuming that the normal occupancy does not extend into the evenings, the variable nature of the daily heat load CHP is not feasible for this development.

2.4.3 Micro - CHP

Micro combined heat and power (micro-CHP) operates in a similar fashion to its larger CHP counterpart, as discussed above, generating heat and electricity simultaneously at a typical ratio of about 6:1 in individual buildings.

Micro-CHP units are typically similar in size and shape to ordinary domestic boilers, can be wall hung or floor standing and are powered by mains gas or LPG. The key difference between a standard boiler is that micro-CHPs are able to generate electricity whilst generating heating water.



Baxi

Micro CHP has not been considered further for this project for the following reasons:

- Micro - CHP is a relatively new concept (Baxi Ecogen was made available in 2009) and issues are raised in relation to unproven technology
- Inefficiency for shorter run cycles and lack of technical knowledge that can limit the practical application of Micro CHP at present
- Typically only approximately 50% of electricity generated in properties can be supported with this technology
- Very high associated installation cost and estimated low life expectancy have been taken into consideration
- Micro-CHP also has lower FIT tariff rate and period duration and is only applicable for systems under 2kW

Overall, the technology is viewed to be commercially unviable for this development scheme.

2.4.4 Savings after BE CLEAN Stage

The following table summarises the reduction in building energy consumption and the corresponding reduction in CO₂ emission resulting from the implementation of the measures mentioned above.

	Baseline (Part L 2013)	Lean (After Energy Efficiency Measures)	Clean (with Additional Proposed Clean Technology)	% Improvement (Clean over Part L 2013 Baseline)
Regulated Energy	89,817 kWh/yr	88,254 kWh/yr	88,254 kWh/yr	1.7%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	128,640 kWh/yr	127,077 kWh/yr	127,077 kWh/yr	1.2%
Regulated CO ₂	26,588 kgCO ₂ /yr	22,774 kgCO ₂ /yr	22,774 kgCO ₂ /yr	14.3%
Unregulated CO ₂	20,149 kgCO ₂ /yr	20,149 kgCO ₂ /yr	20,149 kgCO ₂ /yr	0.0%
Total CO ₂	46,737 kgCO ₂ /yr	42,923 kgCO ₂ /yr	42,923 kgCO ₂ /yr	8.2%

2.5 BE GREEN – Renewable Energy

Once building energy consumption have been minimised, methods of generating low and zero carbon energy can be assessed. As previously discussed in the introduction, a combination of LZC technologies is required to meet the local authority emissions target.

Due to the nature of the building, spatial and technical limitations of the development, some LZC technologies are unlikely to be suitable for the development. Where this is not possible to meet the reduction in CO₂ requirements the maximum potential CO₂ emissions savings have been calculated.

Technologies that predominantly provide domestic hot water are:

- Biomass
- Communal Heating
- Solar Thermal Collectors

The low carbon technologies that only produce electricity or heat for space heating are:

- Ground Source Heat Pumps
- Wind Turbines
- Photovoltaic Panels

Where possible, each system has been sized to meet the council's planning policy; reducing the total CO₂ emissions of the development by at least 35% from Part L of the 2013 building regulations.

The viability of each of these technologies is discussed in more detail below.

All percentage CO₂ reductions listed for each LCZ relate to an improvement over the Clean scenario unless otherwise stated.

2.5.1 Biomass Heating

Wood-fuelled heating systems, also called biomass systems, burn wood pellets, chips or logs to provide warmth in a single room or to power central heating and hot water boilers.

Pellet boilers also require less maintenance and produce considerably less ash residue. The biomass boiler would provide heat for a community heating scheme supplying the remaining hot water and space heating demand. A biomass system is capable of generating v savings of approximately 32%.

Biomass installations are also qualified to receive payments for heat produced through the UK government's Renewable Heat Incentive. All biomass fuel used by RHI participants must be sourced from a supplier on the Biomass Suppliers List at the time the fuel was purchased.



Treco Biomass Boiler

A system recommended for the school would be fuelled by wood pellets due to their higher energy content. Although pellets are more expensive than chips, they have a greater energy content per unit of weight and require a lower storage volume.

With the integration of a large thermal store, a biomass boiler can provide up to 90% of the annual heat load; however, it will require additional backup during peak load operation. With this sized system, the annual wood pellet usage is expected to be approximately 16 tonnes.

Biomass	
Proportion of heat supplied by biomass	90%
Biomass system efficiency	90%
Carbon Intensity of Biomass	0.028 kgCO ₂ /kWh
Backup system efficiency	92%
Carbon Intensity of Backup System	0.216 kgCO ₂ /kWh
Heating Demand Met	68,406 kWh/yr
Total CO₂ Savings	12,896 kgCO₂/yr
Percentage CO₂ reduction due to Biomass	30.0%

Biomass Fuel Storage Assessment	
Fuel type	Wood pellet
Energy Content of Wood Fuel	4,700 kWh/tonne
Energy Density of Wood Fuel	3,200 kWh/m ³
Annual Fuel Requirements (Mass)	16.2 tonnes
Annual Fuel Requirements (Volume)	24 m ³
Minimum Recommended Fuel Store Level	20%
Deliveries per Year	4 no.
Size of Fuel Store	8 m ³
Dimensions of Fuel Store	2m x 2m x 2m

This would require about 24 m³, so it is proposed that deliveries are distributed throughout the year so that the on-site storage can be reduced. To allow for 4 deliveries per year and assuming a plant room height of 2.0m, a floor area of approximately 4 m² would be required.

There are concerns regarding the use of biomass heating for this development - Biomass boilers is not recommended for this project based on the following reasons:

- As with other types of combustion appliances, Biomass boilers are potentially a source of air pollution. Pollutants associated with biomass combustion include particulate matter (PM₁₀ / P_M^{2.5}) and nitrogen oxides (NO_x) emissions. These pollution emissions can have an impact on local air quality and affect

human health. Although in theory, this can be overcome with the use of flue dilution, however, this LZC technology can be large and expensive and is really only appropriate for much larger systems.

- Biomass has recently been rejected by many London Boroughs as a means of obtaining the on-site renewable contribution (and this will soon send ripples out to other regions). This is because of their associated flue emissions (which can be significantly higher than gas fired boilers) and the difficulty of ensuring the boiler will operate at its optimum efficiency, which is often quoted by designers at the initial design stages. Biomass flue emissions are often difficult to control because the quality of flue can vary significantly between suppliers. Given this is a biofuel, the system may not be acceptable to the Council on planning grounds (e.g. concerns about associated flue emissions/ impact on local 'Air Quality', an increase in road traffic from pellet delivery lorries).
- Biomass fuel requires more onerous and frequent wood fuel silo (site storage issues) replenishing by delivery trucks – which in turn can cause site transportation issues that will need to be considered and addressed along with the impact on the other residents and neighbourhood infrastructure.
- Restrictions on the type of fuel and appliance may apply to the development and according to studies commissioned by DEFRA, the levels of particles emitted by burning of wood chip or waste would be considered to outweigh the benefits of carbon reduction especially in an urban environment such as the proposed development site.
- Dependant on a fuel supply chain contract being confirmed.
- There is no suitable location for the plant and storage of the pellets on site present.

2.5.2 Biofuels

Biofuels can be used to generate heat for use in domestic or small commercial burners.

Biofuels tend to be more environment-friendly when burned in comparison to standard fossil fuel oil, with less carbon monoxide emission, less particulate matter, less unburned hydrocarbons, and does not contain sulphur. In general, biofuel is often thought to be more expensive by fossil fuel oil.

The quality of the biofuel is dependent on the supplier and source, varying significantly in cost and quality, from a good quality biofuel which requires less filtration, to those from a by-product from frying which will contain many particles.

Biofuel also tends to be highly sensitive to low temperatures, and thus an oil tank should not be situated outside where temperatures fall below 5-10°C.

Biofuel, as with biomass, also produces NO_x emissions, and therefore has not been selected as a feasible solution for the development.

2.5.3 Hydrogen Fuel Cells

The BlueGen product is a ceramic fuel cell and has recently entered the UK market. Using ceramic fuel cells, BlueGen electrochemically converts natural gas into electricity at up to 60 percent electrical efficiency. Electricity is consumed locally, with unused power being exported to the grid. When the integrated heat recovery system is connected, the waste heat from BlueGen can be used to produce hot water – which improves the total efficiency to approximately 85 percent.

Not commercially viable yet – as a result, this solution will not be assessed any further.

2.5.4 Small scale hydro

Hydro technology uses running water to generate electricity, whether it's a small stream or a larger river. The technology uses the conversion of potential energy of water at height into kinetic energy in a turbine, which drives a generator to produce electricity. The greater the height and current there is flowing through the turbine, the more electricity can be generated.

Small-scale hydroelectric will not be studied any further because of the location and the spatial limitations of the development. There is no river or lake within the development site boundaries. As a result, this solution will not be assessed any further.

2.5.5 Ground Source Heat Pumps (GSHP)

A ground source heat pump (GSHP) system uses buried pipes to extract heat from the ground. The electrically powered heat pump circulates a water and antifreeze solution around a loop of pipe, to absorb heat from the ground into the fluid and then passes through a heat exchanger into the heat pump.

There are two distinct types of systems: a trench/'slinky' system, where pipes are spread across horizontally in a field, or a borehole system, where pipes route vertically deeper into the ground. Whatever the adopted system is, the longer the pipe system, the more heat that can be drawn from the ground. This heat can then be used to heat radiators, underfloor or warm air heating systems and hot water in your home.

As the ground stays at a fairly constant temperature under the surface, the heat pump can be used throughout the year. Unlike gas and oil boilers, heat pumps operate on electrical current to drive the compressor in the heat pump,

and thus can lower (or eliminate) gas consumption on site. This technology can also be coupled with other zero-carbon electricity generation technologies, contributing to a very low carbon emission building.

The heat pump generally delivers heat at lower temperatures over much longer periods, as such, heaters may need to be on constantly during winter periods to maintain suitable indoor temperatures.



GSHP Compressor Pumpset by Dimplex

Due to the small footprint of the site, a borehole system rather than a trench system would be more realistic.

A system for the site would include boreholes with a closed ground loop (ground-to-water heat exchanger). The system would deliver space heating through a low-temperature efficient distribution network such as underfloor heating. Approximately 90% of the space heating demand can be supplied by the ground source heat pump if it is sized to approximately 50% of the peak load.

If the domestic hot water demand were also to be addressed by the heat pump, higher temperatures would need to be achieved, therefore decreasing the efficiency (coefficient of performance) of the system. If a proportion of the hot water is pre-heated to about 35°C - 40°C there will be no loss in efficiency so theoretically GSHP could meet up to 25% of the hot water demand.

As the peak space heating load is predicted to be approximately 160 kW, the GSHP would be sized to meet 80 kW.

Assuming a ground heat exchanger seasonal COP performance of 8 and borehole performance of 50W/m, the total borehole length would be approximately 200m (or alternatively no. 16 at 100m boreholes).

Ground Source Heat Pump	
COP for Heating	4.0
Carbon Intensity of Electricity	0.519 kgCO ₂ /kWh
Proportion of Domestic Hot Water from GSHP	25%
Proportion of Space Heating from GSHP	90%
Heating Demand met by GSHP	54,826 kWh/yr
Electricity Used by GSHP	13,707 kWh/yr
Total CO₂ Savings	6,045 kgCO₂/yr
Percentage CO₂ reduction due to GSHP	14.1%

Because of the low CO₂ savings possible with the technology, GSHP was not considered further for the Ruislip School. Further reasons for not including GSHP in the study are as follows:

- If an open loop configuration was to be adopted, a test borehole would be needed to assess the available resource. The test resource process is expensive and of course, does not guarantee an acceptable resource in the ground. Additionally, a closed-loop borehole configuration could not be used due to spatial limitations of the site.
- There are likely to be planning issues associated with borehole excavation and drilling
- Running cost and maintenance may be minimal. However, installation is costly. A GSHP solution will represent a relatively expensive option in comparison to other renewable technologies available.
- Additional electric immersion and pumps will be required to heat the GSHP water up to suitable temperature to be used around the building and it likely a centralised plant area will also be required to house the circulation pumps.
- This technology is not recommended due to increased plant energy consumption requirements, in turn, impacting the BER/TER score for the required energy strategy objectives.
- Furthermore, boreholes also destabilise the ground surface and may be considered a minus for environmentally friendly endeavours.

2.5.6 Air Source Heat Pumps (ASHP)

Air source heat pumps employ the same technology as GSHPs; however, instead of using heat exchangers buried in the ground, heat is extracted from the external ambient air.

As air temperature is less stable than ground temperature, ASHPs tend to have a lower COP. This is because heat pumps are more efficient when the temperature difference between the temperature source and the space demand is lower. Like GSHP, it is not recommended that ASHP provides a significant contribution to the domestic hot water demand due to the high-temperature requirements.

As with GSHPs, the heat pump generally delivers heat at lower temperatures over much longer periods, as such, heaters may need to be on constantly during winter periods to maintain suitable indoor temperatures.

Based on the size and topology of the proposed building, a roof mounted ASHP would be the most suitable approach to utilising the LZC technology at the development.



Daikin ASHP

Air Source Heat Pump	
COP for Heating	3.2
Carbon Intensity of Electricity	0.519 kgCO ₂ /kWh
Proportion of Domestic Hot Water from ASHP	25%
Proportion of Space Heating from ASHP	90%
Heating Demand met by ASHP	54,826 kWh/yr
Electricity Used by ASHP	17,133 kWh/yr
Total CO₂ Savings	4,266 kgCO₂/yr
Percentage CO₂ reduction due to ASHP	9.9%

Our feasibility study also highlighted these further constraints on the suitability of ASHP at the development.

- This technology is not recommended due to increased plant energy consumption requirements, in turn, impacting the BER/TER score for the required energy strategy objectives.
- Running cost and maintenance may be minimal. However, installation is costly. An ASHP solution will represent a relatively expensive option for the achieved carbon savings in comparison to other renewable technologies available.
- Additional electric immersion and pumps may be required to heat the ASHP water up to suitable temperature before circulating around the building's local heating units. A centralised plant area will be required to house the circulation pumps.
- One issue regarding ASHPs is that the evaporator has to be located outside. Because of this, it will be likely that there will be a noise issue associated with the units, particularly at night. This may be problematic for the local residents situated approximately 30-60m from the development.

- During cold weather, the coils in the evaporator may freeze. To bring the coils back to operating temperature, the ASHP may have to enter a defrost cycle where the system stops providing heat. Obviously, this can cause issues during particularly cold spells which can be problematic for such a scheme.
- Outdoor plant space is required for this option. If there is a proposed green roof planned, a SUDS strategy will be required.

Due to the low CO₂ reductions, lack of suitable plant space and the potential noise issues, ASHPs are not considered further for the Ruislip School.

2.5.7 Wind Turbines

Wind turbines utilise the power of the wind to generate electricity. Wind turbines use large blades to catch the wind. In windy conditions, the blades are forced round, thereby driving a turbine which generates electricity. The stronger the wind, the more electricity produced.

With approximately 40 percent of all wind energy in Europe passing over the UK, a typical system in an exposed site can easily generate more power than your lights and electrical appliances use.

There are two types of domestic-sized wind turbine:

- Pole/mast mounted units are free standing on firm ground, erected in a suitably exposed position. Systems are often capable of generating 5kW to 6kW peak.
- Building mounted units are smaller than pole mounted systems, and can, therefore, be installed on the roof where there is a suitable wind resource. Often these are around 1kW to 2kW peak.

This technology requires significant maintenance which would generally cost around £100 to £200 per year depending on turbine size. And may require a replacement of the inverter at some stage during its typical 20-year lifespan, costing approximately £1,000 to £2,000.

Wind turbine outputs are based on the NOABL wind map data, which provides an estimation of the average annual wind speed. For the Ruislip School development, the following wind profile is assumed:

Height Above Ground Level	Wind Speed
At 10 meters	4.8 m/s 10.7 mph
At 25 meters	5.5 m/s 12.3 mph
At 45 meters	6 m/s 13.4 mph

Using a typical Wind Yield Estimation Tool and assume a high-density cityscape and a mid-rotor height equal to the hub height of the turbine plus the height of the highest part of the development. The estimated average wind speed at the site is 5 m/s and factors in the surrounding terrain. The power curves used are based on information provided by Proven Energy.

Calculations are shown below for 6 kW wind turbines and 2.5kW turbines mounted at 20 metres above the ground on the roof of the main tower. Since the development is located in a dense residential and commercial area, the wind resource may be restricted due the adjacent large trees and air turbulence generated between them.

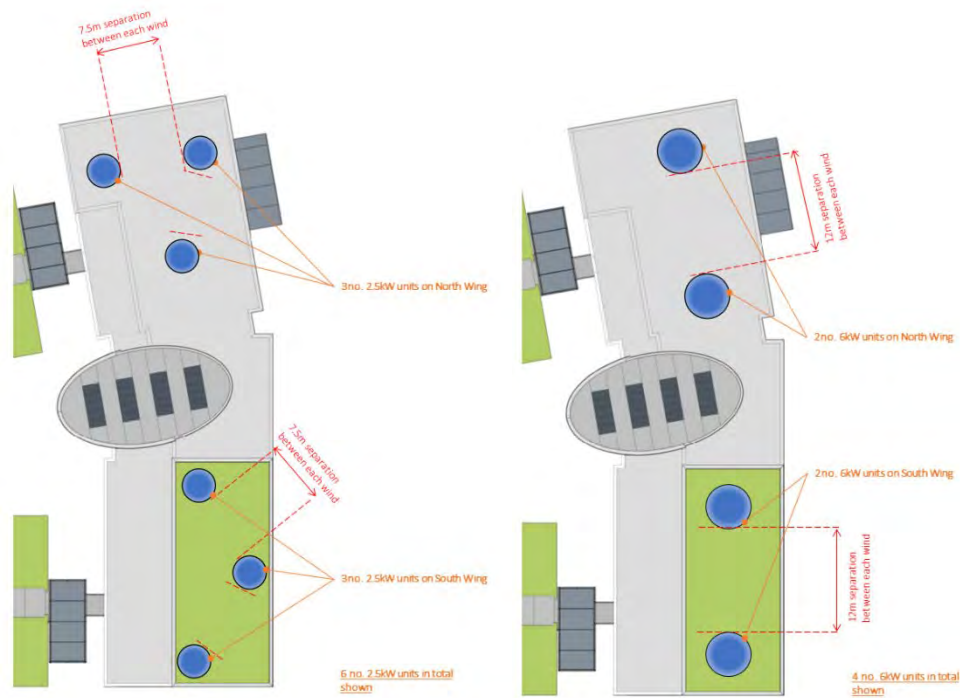


Quiet Revolution Vertical Wind Turbine



Proven Wind Freestanding Wind Turbine

The calculations assume that only 6 no. 2.5kW wind turbines or 4 no. 6 kW wind turbines can be realistically installed on the roof, as shown in the images below:



Wind - 2.5 kW	
Average wind speed for site	5 m/s
Height of installation	10 m
Number of turbines	6 no.
Annual energy output based on weather files and CP curve	1,760 kWh/yr
Annual Energy Output (savings)	9,504 kWh/yr
CO2 emissions factor for electricity	0.529 kgCO2/kWh
Total CO2 Savings	5,028 kgCO2/yr
Percentage CO2 reduction due to Wind Turbines	11.7%

Wind - 6 kW	
Average wind speed for site	5 m/s
Height of installation	10 m
Number of turbines	4 no.

Annual energy output based on weather files and CP curve	4,507 kWh/yr
Annual Energy Output (savings)	16,225 kWh/yr
CO2 emissions factor for electricity	0.529 kgCO2/kWh
Total CO2 Savings	8,583 kgCO2/yr
Percentage CO2 reduction due to Wind Turbines	20.0%

To achieve a significant reduction in energy demand, the development can incorporate no more than 6 no. 2.5kW turbines, or 4 no. 6kW turbines.

There is little appropriate space for a stand-alone turbine on the site. Therefore, building-integrated turbines were considered to ensure that wind speeds would be as high as possible. In terms of available space, it is not recommend installing more than 3 turbines on the roof of the building.

Due to the quantity of wind turbines, combined with the high maintenance costs and uncertainty of the wind speeds, the technology is not feasible and would need to be combined with another renewable technology.

Wind turbine(s) have been discounted for this development scheme for the following reasons:

- A large mast horizontal axis wind turbine will not be able to generate electricity at the optimal operating range since it requires higher average wind speeds. Furthermore, the installation of small scale wind turbine won't be feasible due to low average wind speed at 10 meters height, 25m, and 45m height.
- Due to the close proximity of neighbouring commercial and residential properties and trees.
- In addition, the low-frequency noise generated by wind turbines might cause inconvenience to the neighbouring residents. However, the level a person can be affected by low-frequency noise varies from individual to individual.
- Due to the size and required the height of a potential wind turbine scheme, there is also an issue with the propellers' impacting bird traffic, obstructiveness, shadow flicker which means that generally large wind turbines need to be located at least 300m from any residential properties, which would not be possible on this site.
- Generally not favourable in close proximity to airports and landing runways (Heathrow airport and Northolt Airstrip), due to the potential and unfavourable light flickering caused by incoming pilots.
- Roof mounted units are limited in size due to wind induced stresses which are transmitted to the building structure. Most roofs mounted turbines currently on the market are approximately 2 m diameter and capable of producing 1-1.5kW each. However, the output is dependent on the surrounding obstructions and local wind speed. Thus small-scale wind turbines would not make any meaningful impact on a site such as this.
- Because of the above investment case with regards to this technology, the solution is not viable compared to other solutions with a more attractive ROI.
- Finally, the installation of wind turbines on the development requires planning permission (and is likely to instigate neighbourhood committee interest regarding its aesthetics and acoustic issues).

If this option is pursued, it is recommended that wind speeds are measured for one year before installation and that issues of noise and vibration are assessed in detail. Wind turbines should be mounted above building cores to minimise those issues. Alternatively, vibration isolation pads may need to be considered.

The same guidance applies to this technology in terms of acoustics which makes it unfavourable so close to the residential dwellings.

2.5.8 Photovoltaic Panels

PV (Photovoltaic) cells are made from layers of semi-conducting material, usually silicon, which creates an electric field across the layers when exposed to light. The stronger the sunshine, the more electricity is produced, and without needing direct sunlight to work – they can still generate some electricity on a cloudy day. Groups of cells are mounted together in panels or modules that can either be mounted on your roof or on the ground. The power of a PV cell is measured in kilowatts peak (kWp). That's the rate at which it generates energy at peak performance in full direct sunlight during the summer.



Antaris Solar PVs

PV cells come in a variety of shapes and sizes. Most PV systems are made up of panels that fit on top on flat or pitched roofs, or alternatively as solar tiles.

Currently, there are four types of solar cells available: mono-crystalline, poly-crystalline, thin film, and hybrid. Mono-crystalline and hybrid cells are the most expensive to produce but are the most efficient (12-20%), poly-crystalline cells are cheaper but their efficiency is lower (9-15%) and thin film cells are only 5-8% efficient but can be produced as thin flexible sheets.

Photovoltaic panels are best orientated to the south and inclined between 30 and 40 degrees. 30° Incline PV

A high-efficiency mono-crystalline panel system sized can cover about 226 m² of PV area and would be rated at about 33.9 kWp (assuming 15.0% efficient PV modules mounted at 10°).

Photovoltaic Panels	
Module Efficiency (before losses)	15.0%
Collector Orientation	SE/SW
Tilt of Collector	10°
Overshadowing	None or Little (<20%)
Predicted Site Solar Energy	0,890 kWh/m2/yr
System Losses	20%
Installation Peak Output Power	33.9 kWp
Array Area	226 m ²
Primary Electricity Offset by PV Array	24,169 kWh/yr
Total CO2 Savings	12,544 kgCO2/yr

Due to space for maintenance and roof plant equipment, it is not possible to install a larger PV area on the proposed flat roof area available. An overall roof area available in the development will allow for a maximum of 226 m² of PV area mounted at southeast facing, 10° incline. This would provide the 33.9 kWp, which has the potential of saving up to 29.2% of CO₂ emissions from Clean.

Our feasibility raised the following points regarding PV:

- The proposed site is not in close proximity to the surrounding residential and commercial buildings. In addition, all the surrounding buildings are of heights which are comparable or lower than the proposed development. There are a few trees, but they have located some distance away and therefore not expected to constitute a major overshadowing challenge. Considering these factors, a <20% overshadowing has been used in the calculations even though it is expected to be practically below this level.
- As with every renewable energy system, Photovoltaic (PV) system is limited by the amount of visual impact it creates. But for the system proposed for the current development, the high efficiency coupled with high power panels would substantially reduce the visual impact. More power per panel means fewer panel per install. This reduces the total area of panel arrays and hence the visual impact compared to conventional panels.

Due to the calculated achievable savings and site suitability, photovoltaics is a recommended LZC technology for the proposed development at Ruislip School. Full details about the associated design requirements are provided in Appendix F.

2.5.9 Solar Thermal Water Heating

Solar thermal panels act in a similar way to PV array in terms of orientation and inclination, uses free heat from the sun to warm domestic hot water. A conventional boiler or immersion heater can be used to make the water hotter or to provide hot water when solar energy is unavailable.

There are two types of solar thermal water heaters: Evacuated tube and at plate collectors are both commercially available. Although evacuated tube collectors are more expensive than flat plate collectors, the higher efficiency and higher temperatures of evacuated tube collectors make them a better choice for the UK climate.

The best performance would come from a south-facing array with an optimum inclination of about 35°.



Baxi SolarFlo

The proposed system would be used for domestic hot water only, not space heating since this is not required during the season when solar thermal is the most effective. Therefore solar thermal does not partner well with community heating as they are both ideally set up to supply hot water.

As discussed in the PV section suitable roof space is limited, and therefore a 226 m² of panel area is possible. It is not possible, as mentioned with PV, to mount more than 227 m² of panel area on the available flat roof area available after allowances for overshadowing and maintenance space are considered.

A suitable solar thermal system would supply approximately 50% of the annual hot water consumption (the maximum feasible due to seasonal variations), and would be topped up with an additional heat source. A system sized to meet 50% of hot water demand would potentially save 13.3 % of CO₂ emissions.

Solar Thermal Water Heating	
Collector Type	Evacuated Tube
System Efficiency	30%
Collector Orientation	SE/SW
Tilt of Collector	10°
Overshadowing	None or Little (<20%)
Predicted Site Solar Energy	0,890 kWh/m ² /yr
Collector Area	226 m ²
Total output	60,423 kWh/yr
Primary Gas Offset by Solar Thermal Array	67,137 kWh/yr
Total CO₂ Savings	13,293 kgCO₂/yr
Percentage CO₂ reduction due to STHW	31.0%

Solar thermal would have to be combined with further renewables to provide significant CO₂ reductions.

SWH will not be considered any further for the following reasons:

- Solar thermal arrangements can appear obstructive on the building fabric, and have a significantly negative visual impact of the building.
- Although solar water heating could be utilized for this specific project to assist with domestic hot water generation only, recent cost reductions and funding incentives in other LZC technologies such as PV and ASHP (subject to confirmation of the RHI qualifying criteria) makes the solar thermal option a less attractive proposition.
- Evidence also indicates that PV installations are becoming more cost effective to install than solar thermal hot water systems, especially against the current FIT scheme.
- Solar thermal technology is also a seasonal technology and will not operate as well in winter compared to summer periods. As a result, a secondary heating system sized to the full heating and hot water load will require plant space and installation to serve the building's demand in the winter season.

2.5.10 Savings after BE GREEN Stage

The following table summarises the reduction in building energy consumption and the corresponding reduction in CO₂ emission resulting from the implementation of the measures mentioned above.

	Baseline (Part L 2013)	Lean (After Energy Efficiency Measures)	Clean (with Additional Proposed Clean Technology)	Green (with Additional Proposed Green Technology)	% Improvement (Green over Part L 2013 Baseline)
Regulated Energy	89,817 kWh/yr	88,254 kWh/yr	88,254 kWh/yr	88,254 kWh/yr	1.7%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	128,640 kWh/yr	127,077 kWh/yr	127,077 kWh/yr	127,077 kWh/yr	1.2%
Regulated CO ₂	26,588 kgCO ₂ /yr	22,774 kgCO ₂ /yr	22,774 kgCO ₂ /yr	10,230 kgCO ₂ /yr	61.5%
Unregulated CO ₂	20,149 kgCO ₂ /yr	20,149 kgCO ₂ /yr	20,149 kgCO ₂ /yr	20,149 kgCO ₂ /yr	0.0%
Total CO ₂	46,737 kgCO ₂ /yr	42,923 kgCO ₂ /yr	42,923 kgCO ₂ /yr	30,379 kgCO ₂ /yr	35.0%

8 Conclusion

This preliminary energy statement has been developed to analyse the energy strategies proposed for the Ruislip High School development. The aim is to minimise the development's energy consumption and consequently its carbon footprint by implementing different energy saving measures as well as through the utilization of Low or Zero Carbon technology. In particular, an energy and sustainability analysis has been undertaken to satisfy the following requirements:

- To demonstrate how the development will meet the BRUK-L2A requirement of 35% CO₂ savings, and
- To show how it is intended to generate on-site total energy demand from LZC.

In order to meet these requirements, a wide range of energy saving measures has been considered. Those measures identified as both relevant and with the potential to provide substantial savings are intended to be implemented to achieve the maximum CO₂ emission savings. In addition, a photovoltaic system has been adopted following the extensive analysis of different renewable options in order to further reduce the development's carbon footprint.

To quantify the levels of energy and CO₂ savings associated with the different strategies considered. The below table summarises the renewable systems analysed and the different aspects taken into consideration, including estimated capital cost, simplified payback, and lifetime, the level of maintenance and level of impact on external appearance. The column relating to site feasibility indicates how feasible the technology is for the development (10 being the most feasible and 0 being the least feasible).

Technology	CO ₂ Reduction Achievable	% CO ₂ Reduction over Part L Achievable	Capital Cost	Simple Payback	Lifetime	Maintenance Requirement	Impact on External Appearance	Site Feasibility Score
CHP	6237 kgCO ₂ /yr	14.5%	£ 80k	10-15 years	20 years	High	Low	1
Biomass Heating	12896 kgCO ₂ /yr	30.0%	£ 40k	25-35 years	15 years	Medium	Medium	4
Ground Source Heat Pump	6045 kgCO ₂ /yr	14.1%	£ 45k	20-25 years	20 years	Low	Low	4
Air Source Heat Pump	4266 kgCO ₂ /yr	9.9%	£ 25k	20-25 years	25 years	Medium	Low	3
Wind	8583 kgCO ₂ /yr	20.0%	£ 40k	20 years	20 years	Medium	High	2
Solar Thermal	13293 kgCO ₂ /yr	31.0%	£ 40k	5-10 years	20 years	Medium	Medium	5
Photovoltaics	12544 kgCO ₂ /yr	29.2%	£ 36k	5-10 years	15 years	Low	Medium	7

The energy demand for the development has been evaluated through SBEM calculations using IES. The full energy calculation results are documented in the Appendix G and are summarised in the table below.

	Baseline (Part L 2013)	Green (after Additional Proposed Lean, Clean and Green Technologies)	% Improvement (Post green over Part L 2013 Baseline)
Regulated Energy	89,817 kWh/yr	88,254 kWh/yr	1.7%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	128,640 kWh/yr	127,077 kWh/yr	1.2%
Regulated CO2	26,588 kgCO2/yr	10,230 kgCO2/yr	61.5%
Unregulated CO2	20,149 kgCO2/yr	20,149 kgCO2/yr	0.0%
Total CO2	46,737 kgCO2/yr	30,379 kgCO2/yr	35.0%

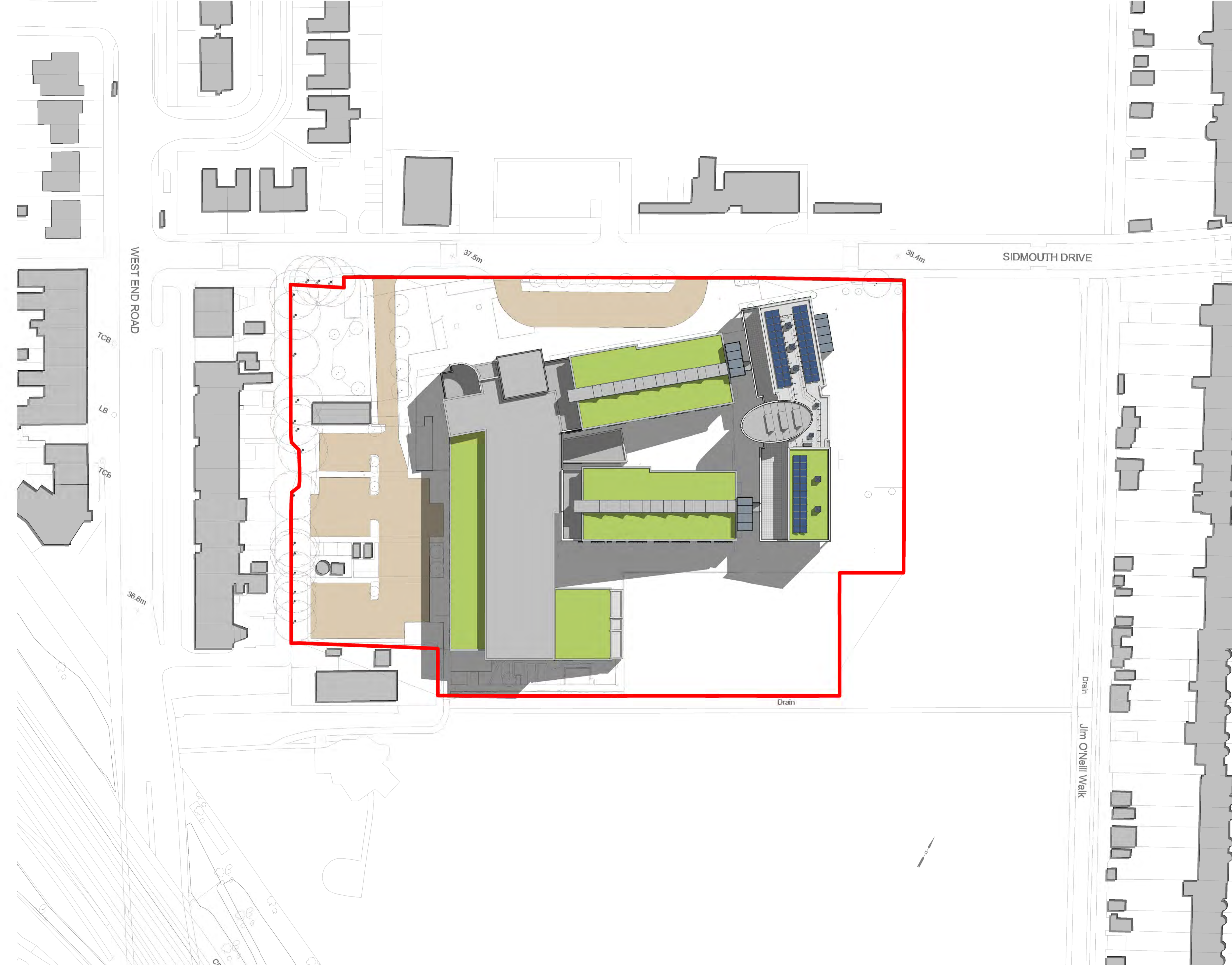
The proposed renewable energy strategy for the site is a Photovoltaic system. **This system will provide zero-carbon electricity for the development throughout the year reducing CO₂ emissions by approximately 22.9% over the energy efficient design, and over Part L 2013 by 35.0%.**

The following LZC technologies are not being considered for use for the site for the reasons below:

- CHP - Due to the inconsistent peak nature of the heating demand, and small baseload required for efficient CHP operation, CHP was rejected for the site. Lack of other existing or proposed CHPs and District Heating systems were noted.
- Biomass (and Biofuels) - rejected due to NO_x emissions on combustion.
- Ground Source Heat Pumps - the quantity of boreholes required and low CO₂ savings mean that GSHP will not be included in the development.
- Air Source Heat Pumps - ASHPs provide a lower CO₂ saving than GSHPs and there are also issues regarding noise. Space for the outdoor plant is limited on such a small site.
- Wind - the aesthetics of installing wind turbines on the roof of the development as well as the noise implications and low outputs mean the wind is not suitable at this urban site.
- Solar Thermal - limited roof space available does not allow for solar thermal technology to be used in photovoltaics. It is preferred to use photovoltaics over solar thermal, where photovoltaics will provide a greater contribution to CO₂ savings than solar thermal.

It is, therefore, evident from the results obtained that **19.0% of the development's energy demand is generated via a PV system, a zero-carbon technology.**

Appendix A – Architectural Plans



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C	31/08/2017	Planning Submission
B	04/08/2017	Draft Planning Issue 2
A	14/07/2017	Draft Planning Issue 1
REV NO.	DATE	DESCRIPTION

KEY PLAN

PROJECT

Ruislip High School

CLIENT

London Borough of Hillingdon



CallisonRTKL 25 Farringdon Street, 10th Floor, London, EC4A 4AB,
T: +44(0)20 7306 0404

SHEET IDENTIFICATION

TITLE

PROPOSED SITE BLOCK PLAN

STATUS

Planning

PROJECT NUMBER	DATE DRAWN	12/07/17
050-160089	SCALE @ A1:	1:500
	DRAWN BY:	WA
	CHECKED BY:	RD

DRAWING NUMBER	REVISION
R-A-10001	C

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30/08/2017 18:06:05

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REV NO.	DATE	DESCRIPTION

KEY PLAN

PROJECT

Ruislip High School

CLIENT

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T: +44 (0)20 7306 0404

SHEET IDENTIFICATION

TITLE

PROPOSED GROUND FLOOR PLAN

STATUS

Planning

PROJECT NUMBER	DATE DRAWN	12/07/17
050-160089	SCALE @ A1	1 : 200
	DRAWN BY:	WA
	CHECKED BY:	AR

DRAWING NUMBER

R-A-12001

REVISION

C

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24/Aug/2017 10:57:06



Scale 1:200



1 Ground Floor Plan
1 : 200



1 First Floor Plan
1 : 200

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REV NO.	DATE	DESCRIPTION

KEY PLAN

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Ruislip High School

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SHEET IDENTIFICATION

TITLE

PROPOSED FIRST FLOOR PLAN

STATUS

Planning

PROJECT NUMBER 050-160089	DATE DRAWN 12/07/17
DRAWN BY: WA	SCALE @ A1: 1 : 200
CHECKED BY: RD	REVISION C

DRAWING NUMBER
R-A-12002

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Scale 1:200

24/Aug/2017 10:57:09



1 Second Floor Plan
1:200

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A	14/07/2017	Draft Planning Issue 1

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SHEET IDENTIFICATION

TITLE

PROPOSED SECOND
FLOOR PLAN

STATUS

Planning

PROJECT NUMBER 050-160089	DATE DRAWN 12/07/17	SCALE @ A1 1:200
DRAWN BY: WA	CHECKED BY: RD	REVISION C

DRAWING NUMBER
R-A-12003

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Scale 1:200



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REV NO.	DATE	DESCRIPTION

KEY PLAN

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TITLE

**AXONOMETRIC - ROOF
FLOOR LEVEL**

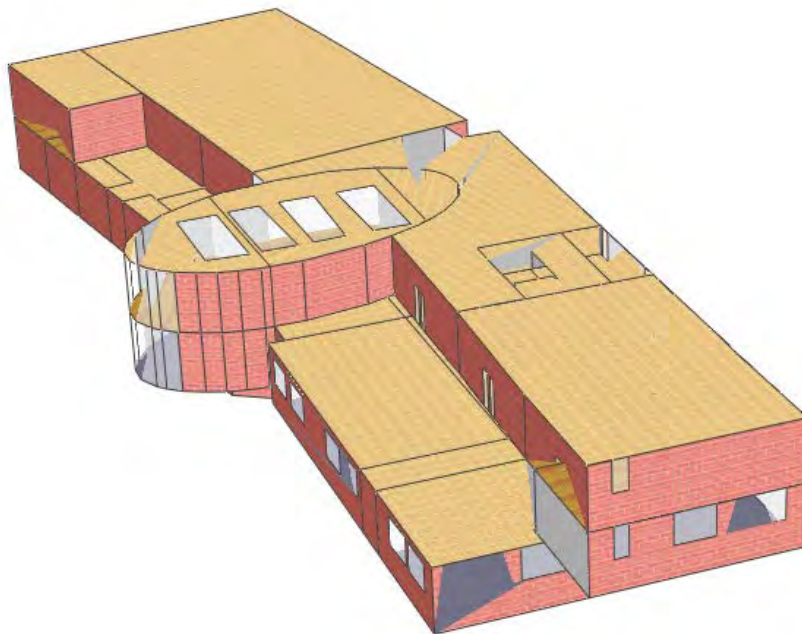
STATUS

Planning

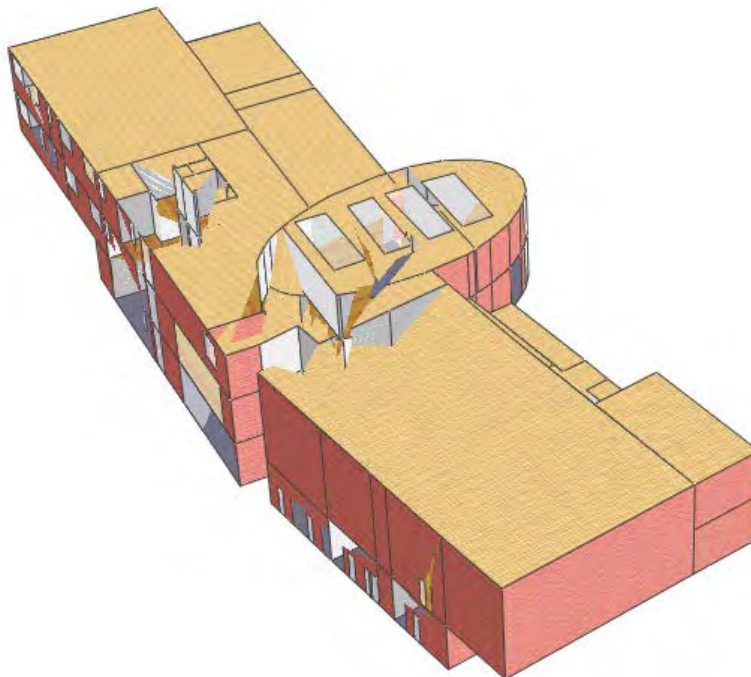
PROJECT NUMBER 050-160089	DATE DRAWN SCALE @ A1: DRAWN BY: CHECKED BY:	12/07/17 NTS WA RD
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DRAWING NUMBER R-A-90004	REVISION C
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Appendix B – Thermodynamic Model



South View



North View

Appendix C – Overheating Analysis Details

Appendix D – Fuel Emissions Factors

The assessment has assumed the following fuel carbon emissions factors:

Carbon Emission Factor	SBEM kgCO ₂ /KWh
Grid electricity	0.496
Grid displaced electricity	0.496
Manufactured smokeless fuel	0.433
Coal (traditional British Coal)	0.345
Heating oil	0.319
LPG	0.241
Dual fuel (mineral + wood)	0.226
Natural Gas	0.184
Waste heat	0.058
Biomass	0.028

Appendix E – BRUKL Document

Appendix F – Photovoltaic Design Suitability and Considerations Appraisal

A detailed analysis is provided in this Appendix to summarise the applicable financial support available, and design & maintenance requirements for the deployment of PV onto Ruislip School.

Feed-In Tariffs

The key advantages of a PV system is that cost can be offset through Government's incentives. This is coupled with the fact that the system benefits from the Feed-in Tariff (FIT) scheme. Solar PV is eligible for Feed-in Tariffs and you will earn a tariff for each kWh of electricity generated by your system. The client will also receive another tariff for each kWh of electricity you export.

The Feed-in Tariffs (FITs) scheme is a UK Government scheme designed to encourage uptake of a range of small-scale renewable and low-carbon electricity generation technologies and receive payments for the electricity you generate if you install or have installed an eligible system like solar PV. The energy regulator Ofgem currently administers the scheme.

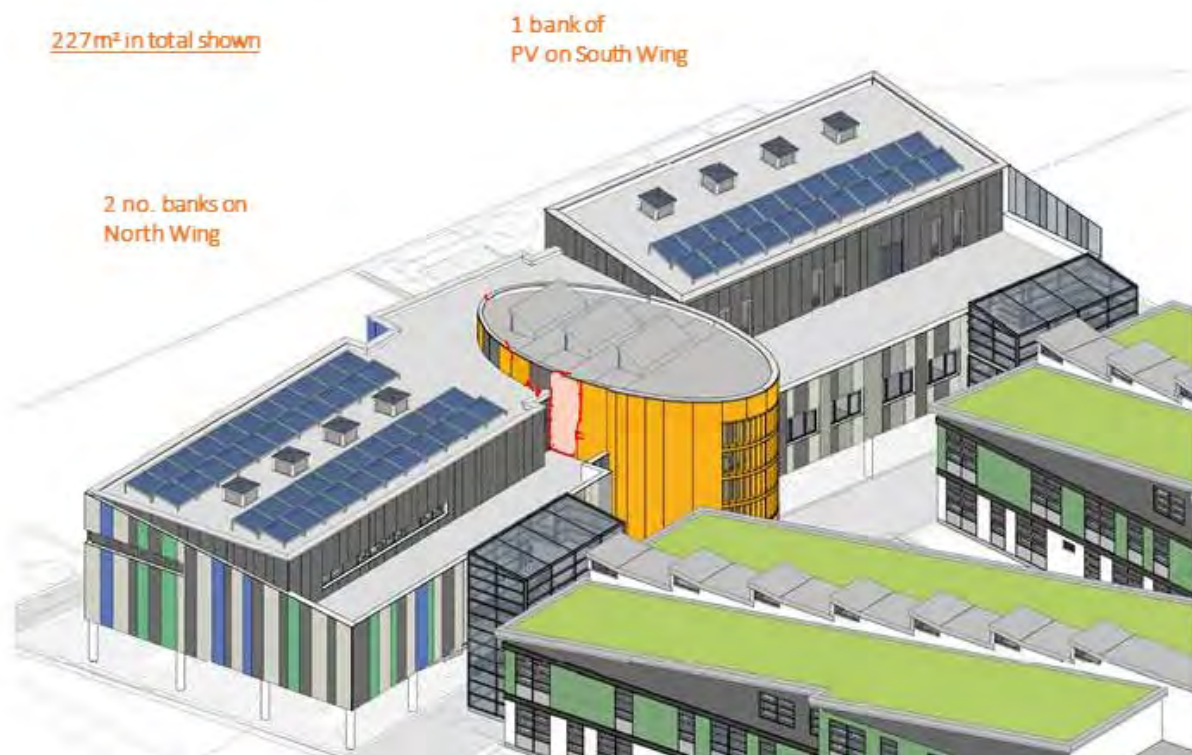
Ruislip School can benefit from three types of FITs payments:

- **Generation tariff:** your energy supplier will pay you a set rate for each unit (or kWh) of electricity you generate. Once your system has been registered, the tariff levels are guaranteed for the period of the tariff (up to 20 years) and are index-linked.
- **Energy bill savings:** the site will be making savings on electricity bills due to generating electricity on site.
- **Export tariff:** your energy supplier will pay you a further rate for each unit you export back to the electricity grid. Systems above 30 kWp will require a meter. However, it is unlikely that the site will benefit from export tariffs.

Design Guidance

Several manufacturers were contacted to provide realistic advice on the expected annual electricity generation to design guidance to install safely.

- Guidelines on roof area to panel area requirements advises a maximum utilisation factor (the ratio of panel area to roof area) of 0.33 to be considered for a typical development. This good practice should allow for sufficient space between rows to prevent overshadowing and provide adequate access space for future maintenance.
- To maximise the annual CO₂ savings, it is recommended to install the PV at a tilt of 10° in the southeast. Mounting the PV in such an orientation will also minimise the wind loadings, thereby reducing stresses onto the building's roof structure.
- For the new build construction, 16 backs of PV at 2m wide can be realistically installed on the flat roof available, as shown in the figure below. The PVs can be arranged onto an aluminum frame.



- Further consideration should be made for ballast masses required to anchor the PV module arrays frame onto the building's roof. A detailed load analysis should be undertaken to size an appropriate ballast mass, and should be located in a position acceptable to the structural engineer.

Our feasibility raised the following points regarding PV:

- The proposed site is not in close proximity to the surrounding residential and commercial buildings. In addition, all the surrounding buildings are of heights which are comparable or lower than the proposed development. There are a few trees, but they have located some distance away and therefore not expected to constitute a major overshadowing challenge. Considering these factors, a <20% overshadowing has been used in the calculations even though it is expected to be practically below this level.
- As with every renewable energy system, Photovoltaic (PV) system is limited by the amount of visual impact it creates. But for the system proposed for the current development, the high efficiency coupled with high power panels would substantially reduce the visual impact. More power per panel means fewer panel per install. This reduces the total area of panel arrays and hence the visual impact compared to conventional panels.

Maintenance Requirements

Minimal maintenance is generally required for PV technologies. A suitably designed PV installation, as per design guidance above, should ensure suitable drainage of rainfall, shall have self-cleaning film to reduce light staining, and the whole assembly is constructed of UV-protected materials.

To ensure a high electrical generation output, the panels should be accessible to ensure 6 monthly cleaning, and landscaping is managed to ensure no tree overshadowing. As it is recommended to install the panels at a tilt of 10°, the panels may not be able to be cleaned by rainfall, as such, debris accumulated should be removed.

A 6 monthly maintenance check should also include checks of the main inverter fault signals and key troubleshooting guidance.

The panels are estimated to last 25 years or more (usually covered by warranty for 25 years from most manufacturers). The inverter is likely to need replacing sometime during this period (estimated the lifespan of 10-15 years) at a cost of about £800.

Appendix G – Full Energy Analysis

	Baseline	Lean	Clean	Green	% Improvement
	(Part L 2013)	(After Energy Efficiency Measures)	(with Additional Proposed Clean Technology)	(with Additional Proposed Green Technology)	(Green over Part L 2013 Baseline)
Regulated Energy	89,817 kWh/yr	88,254 kWh/yr	88,254 kWh/yr	88,254 kWh/yr	1.7%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	128,640 kWh/yr	127,077 kWh/yr	127,077 kWh/yr	127,077 kWh/yr	1.2%
Regulated CO2	26,588 kgCO2/yr	22,774 kgCO2/yr	22,774 kgCO2/yr	10,230 kgCO2/yr	61.5%
Unregulated CO2	20,149 kgCO2/yr	20,149 kgCO2/yr	20,149 kgCO2/yr	20,149 kgCO2/yr	0.0%
Total CO2	46,737 kgCO2/yr	42,923 kgCO2/yr	42,923 kgCO2/yr	30,379 kgCO2/yr	35.0%

Energy calculations below summarises the energy consumption for the building with/without a PV system.

	Without PV (Clean) (without Proposed Green Technology)	With PV (Green) (after Proposed Green Technology contribution)	% Improvement (Zero-carbon green contribution to site)
Regulated Energy	88,254 kWh/yr	88,254 kWh/yr	0.0%
Unregulated Energy	38,823 kWh/yr	38,823 kWh/yr	0.0%
Total Energy	127,077 kWh/yr	127,077 kWh/yr	0.0%
Regulated CO2	22,774 kgCO2/yr	10,230 kgCO2/yr	55.1%
Unregulated CO2	20,149 kgCO2/yr	20,149 kgCO2/yr	0.0%
Total CO2	42,923 kgCO2/yr	30,379 kgCO2/yr	29.2%

		Regulated	Unregulated
(A)	Baseline: Part L 2013 of the Building Regulations Compliant Development	26.6 tCO2/yr	20.1 tCO2/yr
(B)	After renewable energy	22.8 tCO2/yr	20.1 tCO2/yr
(C)	After CHP	22.8 tCO2/yr	20.1 tCO2/yr
(D)	After renewable energy	10.2 tCO2/yr	20.1 tCO2/yr

		Carbon dioxide emissions (Tonnes CO2 per annum)	Percentage savings
(A-B)	Savings from energy demand reduction	3.8 tCO2/yr	14.3%
(B-C)	Savings from CHP	0.0 tCO2/yr	0.0%
(C-D)	Savings from renewables	12.5 tCO2/yr	47.2%
(E=A-D)	Total cumulative savings	16.4 tCO2/yr	61.5%
(F=(A*0.35))	Total Target Savings	9.3 tCO2/yr	35.0%

(G=E-F)	Annual Surplus	7.1 tCO ₂ /yr	
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