Heathside Elmbridge School

Department for Education Capital

Energy Strategy Report

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Heathside Elmbridge School

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Project Manager: Ronan Devlin
Author: Tim Rogers
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Jacobs U.K. Limited

Tower Bridge Court
226 Tower Bridge Road
London SE1 2UP
United Kingdom
T +44 (0)20 7403 3330
F +44 (0)20 7939 1418
www.jacobs.com

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Executive Summary

Heathside Elmbridge School is a new three storey block secondary school for 11-16 year old pupils. The site is located in Weybridge and will be part of the part of the ElmWey Learning Trust. The local planning authority is Elmbridge Borough Council (EBC).

This report should be read in conjunction with FS0588-JAC-00-XX-RP-ME-0002 Indoor Environmental Report and and FS0588-JAC-00-XX-RP-A-0100 End of Stage Report and drawings.

The information within this document is based on modelling carried out during the development of the design. The building performance will be subject to amendments following further design development in consultation with stakeholders and the design team, with reference to the internal planning of the building and the specification of the building systems.

EBC requires the production of an Energy Assessment which is structured according to an Energy Hierarchy whereby the following steps are addressed as part of the building design. This Energy Assessment demonstrates how the building has considered these steps and that the basic requirements of Part L are met by demand reduction alone and without the introduction of clean or green technologies.

I. Demand Reduction (Be Lean) - *A passive approach has been implemented to reduce the reliance on active services to condition the building.*

II. Heating Infrastructure including Combined Heat and Power, CHP (Be Clean) – *a district heating system is not currently available for the site, however provision for future connection have been allowed for. A CHP system is not deem to be technically or financially viable for the site.*

III. Renewable Energy (Be Green) – While compliance with the building regulations been met without the use of low to zero carbon technologies a 40kW$_{PEAK}$ photovoltaic system is proposed for the scheme.

The key measures and Carbon Dioxide (CO_2) reductions for each stage of the energy demand reduction are given below. The measures proposed will meet the energy hierarchy and deliver a 25.5% carbon reduction on the 2013 Building Regulations. This report also demonstrates compliance with Approved Document Part L2A Criterion 1 of the Building Regulations and the estimated total annual energy consumption using the CIBSE TM54 methodology.

	Total Regulated Carbon Dioxide Emissions (KgCO$_2$/m^2 per annum)	Reduction in Carbon Dioxide Emissions (KgCO$_2$/m^2 per annum)	Percentage Reduction over TER
Baseline: Part L 2013 of the Building Regulations Compliant Development (TER)	15.7	-	-
With Enhanced Passive design	14.2	1.5	9.5%
With 40kW Solar PV	11.7	2.5	15.9%
TOTAL		4.0	25.5

1. Introduction

Heathside Elmbridge School is a new three storey block secondary school for 11-16 year old pupils. The site is located in Weybridge and will be part of the part of the ElmWey Learning Trust. The local planning authority is Elmbridge Borough Council (EBC).

The ground floor will typically accommodate the practical spaces, school admin and the sports, drama and main hall. The first floor accommodates the teaching and learning spaces and also the library. The second floor accommodates further general teaching and learning spaces and science laboratories.

The information within this document is based on modelling carried out during the development of the design. The building performance will be subject to amendments following further design development in consultation with stakeholders and the design team, with reference to the internal planning of the building and the specification of the building systems.

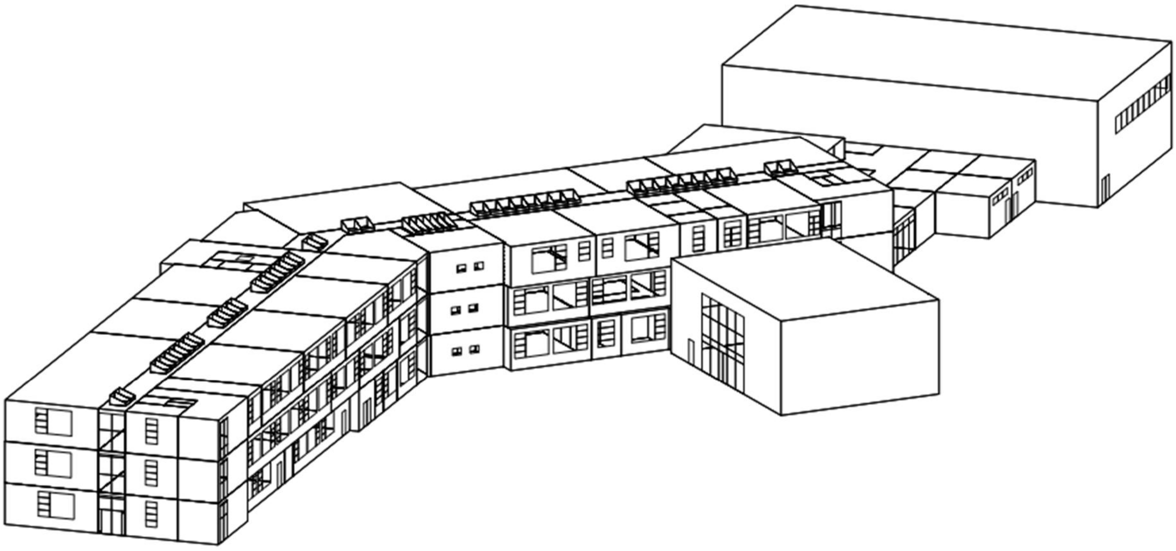

Figure 1 – Rear Elevation of Heathside Elmbridge School 3D Model

2. Planning Policy & Legislative Requirements

The following policies are relevant to this development and supporting energy statement. These include;

- Local Planning requirements
- Building Regulations compliance
- Employer's Requirements

2.1 Elmbridge Borough Council (EBC)

For all major planning applications, EBC requires the submission of a report detailing how the proposed development incorporates energy efficiency best practice measures to the design. The main objectives relevant to EBC is to promote a sustainable scheme, and limit the use of natural resources, reducing the need to travel and maximising the use of renewable energy. Core strategies which are relevant to the energy efficiency requirements for EBC are as follows.

2.1.1 Core Strategy 1[1]: Spatial Strategy

Spatial strategy promotes the sustainable design and construction, improving energy efficiency and promoting renewable energy can all contribute to saving energy and resources and reduce CO_2 emissions.

2.1.2 Core Strategy 27: Sustainable Buildings

Developments will explore opportunities for decentralised and renewable or low-carbon energy sources. An Energy statement should be submitted with planning applications to demonstrate how these criteria will be met. If not met, robust evidence required will need to be submitted to show why they are not technical or financially achievable having regard to the type of development involved and its design.

2.2 Approved Document Part L2A Compliance

Approved Document Part L2A 2013, consists of five criterions but only three out of the five can be addressed during the design stage.[2]

The building 'as designed' is considered to meet Regulation 17C as follows:

- Criterion 1 – The calculated CO_2 emission rate for the building should not exceed the target emission rate.
- Criterion 2 – The performance of the building fabric and the building services should achieve reasonable overall standards of energy efficiency.
- Criterion 3 – The spaces in the building should have appropriate passive control measures to limit solar gains.

In order to achieve Part L2A compliance, the actual building emission rate (BER) needs to be better than Notional (Target) emission rate (TER).

[1] http://www.elmbridge.gov.uk/planning/local-plan/Core Strategy 2011.
[2] https://www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power/3

2.3 Employers Requirements Deliverables – ESFA Technical Annex 2H – Energy

Schools must be designed to optimise the school energy use in line with the Employer's Requirements Deliverables. Up to the current design stage, the design approach has been in line with the energy efficiency hierarchy.

As final designs are developed and construction begins the Design and Build contactor will be require to consider the following;

2.3.1 Be Lean

- Optimise Daylight
- Control Solar Gain, use of shading where required
- Optimise the Thermal Envelop; including thermal performance, thermal bridging and air tightness
- Use of passive design to reduce the risk of overheating
- Use of natural ventilation and other passive cooling strategies, and
- Optimising the sizing of plant.
- Incorporate other energy efficient and energy saving equipment and system specifications develop.

2.3.2 Be Clean

- Utilising district heating system to supply clean energy

2.3.3 Be Green

- Providing low to zero carbon technologies

2.4 Planning Policy & Legislative Summary

The development is required to meet the following:

1. Implement Building Regulation Part L 2A 2013
2. Produce an Energy Assessment based on Part L 2A.
3. ESFA Employers Requirements Deliverables including a baseline energy model
4. Consider community heating system or district energy systems or any future connection.
5. Using on site renewables to further reduce the buildings annual carbon emissions.

3. Carbon Dioxide (CO_2) emissions

The following section addresses the requirement to identify the energy baseline and associated CO_2 emissions for the Heathside development. The energy modelling benchmark calculates the total regulated energy demand and associated CO_2 emissions from the building split into end use systems. Extracted data from the BRUKL (Building Regulation UK Part L) has been used to prepare the energy statement which enables the calculation of the CO_2 reductions offered by implementing Be Lean, Clean and Green measures.

In order to calculate the CO_2 baseline for the site the energy consumption figures are converted into equivalent CO_2 emissions. This uses CO_2 emission factors for gas and electricity contained within Building Regulations Part L (2013) as shown in Table 1.

Fuel	CO_2 emission factors
Natural Gas	0.216
Grid Supplied Electricity	0.519
Grid Displaced Electricity	0.519

Table 1 - CO_2 factors summary

3.1 Energy Demand Assessment – (Building Regulation Part L 2A)

The estimated regulated emissions for building have been calculated from the IES<VE> dynamic thermal simulation software based on Part L of the Building Regulations 2013. IES is a software tool which simulates the thermal performance of buildings.

The floor area is based on that determined by the energy model software which may differ from floor areas referred to in the planning documentation.

Building Reference	Emission Rate $kgCO_2/m^2$)	Gross Floor Area(m^2)	Total Part L CO_2 Emissions ($kgCO_2$/yr.)
Heathside School - Baseline TER	15.7	6,939	108,942

Table 2 - Overview of energy demand and emission rates.

3.2 Energy Hierarchy

The design approach taken follows the Energy Hierarchy which comprises of the following stages:

- Demand Reduction (Be Lean)
- Connecting to a district Heating Infrastructure (Be Clean)
- Implementing Low to Zero Carbon Technologies (Be Green)

4. Demand Reduction (Be Lean)

This section of this report sets out the demand reduction measures to be considered for this development by implementing passive and energy efficient measures to comply with the Part L2A of the Building Regulations.

4.1 Building Form and Orientation

The building massing and form, including the orientation, has been limited due to the site constraints, however where possible the internal spaces planning, location of windows have been optimised to minimise the impact to the environment.

The key divers for the building positioning, form and orientation have been from consultation with the Design: South East review panel and the planners. In addition, the building has been sited to optimise the provision of external areas (Guidance Document, Building Bulletin 103, Part B: The Site externals) and the Trust's physical education curriculum as well as the existing Gatwick fuel line.

As noted below, the thermal performance has been optimised to balance daylight and unwanted solar gains. The server room has been positioned to minimise solar gains thereby reducing the need to additional cooling. The sports hall glazing is position on the North / East facades to reduce unwanted solar gains.

Roof Lights and voids have been incorporated into the design to provide corridors with natural daylight and a mean of ventilation. These roof light have been orientated to minimise solar gains but benefit from diffused light.

4.2 Building Fabric

4.2.1 Building Fabric Thermal Performance

The design has taken a fabric first approach. The performance of the thermal elements will be optimised to minimise heat loss in the heating season and heat gains in the cooling season. This will lead reduced heating and cooling loads, respectively, thereby reducing the carbon dioxide emissions from the building's energy sources to maintain the indoor environment.

The insulation performance of the actual building exceeds that of the Part L baseline under the Building Regulations 2013.

The following fabric thermal performance values will be utilised within the building model. Each is an improvement on the minimum requirements outlined in Building Regulations Part L2A.

Fabric U-values (W/m^2.K)	Part L 2013 Minimum	Heathside Target
Walls	0.35	0.25
Ground Floor	0.25	0.21
Roof	0.25	0.19

Table 3 - Fabric U-values

4.2.2 Thermal Mass

The proposed structure (ceiling soffit) shall consist of thermal mass. The mass will be exposed in high occupancy density teaching and learning spaces. The primary use of thermal mass is to limit the risk of overheating during the summer period. Thermal mass is used as a heat sink in spaces of high heat gains; it absorbs the room's heat gains during the day and when coupled with night time cooling it releases the heat from the mass to allow the gains to be absorbed again the following occupied day, reducing peak daytime temperature. Conversely, in winter, when the internal room's temperature falls, the stored daytime heat is used to maintain the temperature above the room set point.

Figure 2 - Thermal Mass Properties

4.2.3 Glazing

The glazing performance, properties and ratios, have been optimised to balance heat loss, natural daylight, risk of overheating and acoustics. A standard glazing system selected achieves a balanced solution. The associated light transmittance and G-value will allow for a good balance between achieving reasonable daylighting whilst avoiding the risk of overheating.

Fabric U-values ($W/m^2.K$)	Part L 2013 Minimum	Heathside Target
Glazing (incl. frame) North | South	2.2	1.74 | 1.46
Doors	3.5	1.45

4.2.4 Air Tightness

The building is targeting an air permeability rate of $3m^3/(h.m^2)$ @ 50Pa. Part L of the Building Regulations 2013 sets the limit to $10m^3/(h.m^2)$ @ 50Pa, with the notional building adopting an air permeability rate of $5m^3/(h.m^2)$ @ 50Pa. While a rate of 3 $m^3/(h.m^2)$ is low, it is an achievable target with modern construction techniques.

4.3 Building Systems

4.3.1 Lighting

Energy efficiency of the artificial lighting systems has been maximized by using LED and low energy luminaires operating under the dictates of occupancy and daylight sensors. Optimum glazing ratios and roof lights will be used to provide useful natural daylight to reduce the reliance on artificial lighting during daytime hours.

4.3.2 Ventilation

The occupied spaces will be served primarily with local or zonal MVHRs (Mechanical Ventilation with Heat Recovery). While local occupancy controlled to natural ventilation is possible, due to the site noise constraints this may be limited use to 200 hours of the hottest day (refer to Building Bulletin 93). Mechanical ventilation will operate based on room CO_2 and room temperature. In the summer, to boost the ventilation the user will have local control to open the windows, subject to external noise levels.

4.3.3 Controls

The controls solution should allow operation of the plant to minimise the delivered energy to maintain the internal environment. All heating and ventilation services will be locally controlled to ensure that only the correct amount of fresh air or heat energy is provided in each individual space or cluster of spaces.

The Part L Regulation stipulates that the new building will require commissioning of all controlled services (heating, hot water, electrical and mechanical) to be carried out in accordance with Chartered Institute of Building Services Engineers (CIBSE) Code M8 by a commissioning specialist (individual or organisation) from the Commissioning Specialists Association or the commissioning group of the HVCA. An operating and maintenance manual (logbook) is also required to be provided.

4.3.4 Plant Efficiency

Auxiliary plant, such as fans and pumps, will be variable speed. During the detailed design stage, delivery systems, such as duct work and pipes, will be sized to balance operational efficiency and capital expenditure.

High efficiency gas fired boiler will be installed and the heating system will be sized on return temperature that permit energy efficiency condensing to occur.

4.3.5 Metering and Demand Controls

A comprehensive controls and metering package will be implemented and connected to a central building energy management system (BEMS). Using occupancy and environmental quality sensors, and variable speed fans and pumps, the building systems will be controlled to match the energy demand to the energy consumption.

The BEMS will also record the energy consumption of the end use systems so the school can validate their bills and use the data for educational purposes. This data will be uploaded to iServ so that the systems can be benched marked such that issues or improvements can be recognised.

The BEMS shall be developed further at the next stage in line with Technical Annex 2H.

4.3.6 Power Factor Correction

The electrical system will incorporate power factor correction to achieve a whole building power factor of greater than 0.95.

4.4 'Be Lean' Summary

The carbon emissions reduction over Part L 2013 is 9.5% from the 'be lean' measures.

Building Reference	Carbon Emissions (Total $KgCO_2/m^2$ per annum)	Reduction %
Target Emission Rate (TER)	15.7	n/a
Building Emission Rate (BER)	14.2	9.5%

Table 4 - Part L CO2 emissions from demand reductions

5. Heating and Cooling Infrastructure (Be Clean)

5.1 Heating Infrastructure

The potential to serve the scheme from a district heat network has been evaluated. According to the Association for Decentralised Energy (https://www.theade.co.uk/resources/publications/district-heating-installation-map) there are no existing, future or potential extensions in the vicinity to connect to.

Figure 3 - Map of Existing District Heat Network Availability

5.2 'Be Clean' Summary

As there are no district heating systems for the scheme to connect to. A combined heat and power system (CHP) has been considered as a clean measure, however the typical school usage profiles would not make a CHP unit technically or financially viable due to the limited operating hours.

The scheme will allow for possible future connection to a network should one be made available. A pair of ducts shall be allowed for in the design from the ground floor to the main plant room with a spare flow and return connection on the header.

6. Renewable Energy (Be Green)

6.1 Introduction to Be Green

EBC does not state any numerical targets for incorporating renewables however based on CS27, the council will seek to utilise the low carbon technologies to become more energy efficient.

Table 5 gives the potential viability of various low carbon and renewable technologies which has been considered for Heathside School.

Generation of electrical energy	Generation of thermal energy	Potential viability for Heathside Elmbridge School
Photovoltaic (PV)		Viable and could be taken forward, *it consists of flat roof that could be suitable for a PV array.*
	Solar hot water	Viable but discounted, *the buildings hot water demand is a small proportion of the overall usage and roof space is better served using Solar PV*
	Biomass boilers	Not viable, *as is likely to cost more than gas and site arrangements and layouts would need to alter considerably to accommodate fuel deliveries.*
Wind generation		Not viable, *the site is urban and overall annual wind harvest from small scale turbines is likely to be low. Large turbines are not viable.*
	Ground source heat pump	Not viable, *the site is contaminated and therefore the financial benefit of installing the system is low. In addition, the low temperature does not suit the proposed heating strategy.*
	Air source heat pump	Viable *Where there are high heat loads and cooling is likely to be required. This will be provided by a reversible ASHP.*
Combined heat and power (CHP)		Not viable, *due to limited operating hours.*

Table 5 - Low carbon and renewable technology viability

Following this assessment, gas boilers coupled with solar photovoltaic system is deemed to be the most appropriate solution for this scheme.

6.2 Solar PV (40kWp)

The building incorporates a roof mounted photovoltaic array which will be mounted on angled frames. The current proposal is for an array of 122 panels (indicative dimensions of 1600mm by 1100mm) with a capacity of approximately 330 W_{peak}, providing a total panel area around 203m^2 at an installed capacity of 40kW$_{PEAK}$. These are located on the school roof facing south on a 30º inclination. Sufficient clearance has been allowed to avoid overshadowing by the roof enclosure and/or parapet.

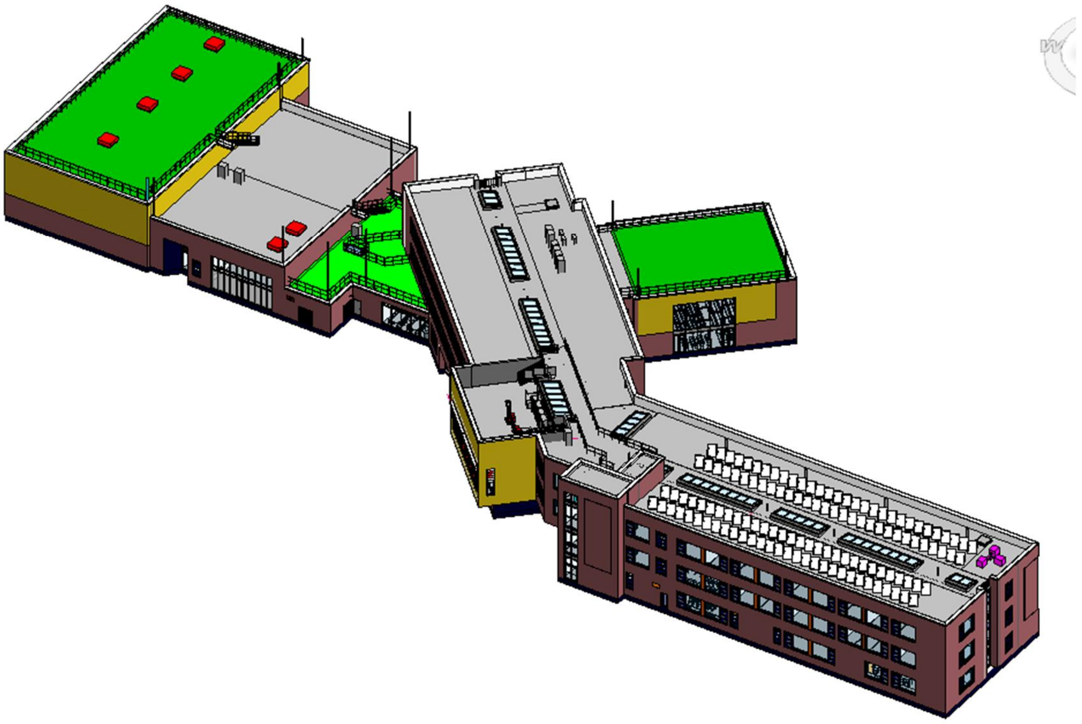

Figure 4 – Indicative location for PV panels

The proposed system utilises photovoltaic system with an efficiency of approximately 19.7%. It is likely that all the generated energy will be consumed on site, however, during the detailed design stage if sufficient energy may be exported than an export arrangement will be considered.

6.3 Be Green' Summary

Table 6 provides the carbon savings from the PV installation.

Photovoltaic Summary	Regulated Carbon dioxide savings	
	(Total $KgCO_2/m^2$ per annum)	(%)
Savings from PV (40kW)	2.5	15.9%

Table 6 – 40kW PV Summary

7. Energy Benchmarks

7.1 Design Benchmarks

Based on the current design stage, in line with ESFA requirements, an assessment has been carried out to predict the total energy consumption of the proposed school buildings which is separate from standard Part L calculations. This stage 3 design has been developed to limit energy demand and consumption in line with the end use energy targets. Through the utilisation of CIBSE TM54 modelling methodology, and applying several professional assumptions, a concept energy model has been developed to demonstrate the potential energy in use for each end use system. Moving forward, the Contractor will need to prove that the final design can meet the energy targets through energy modelling and as detailed in the Employer's Requirements Deliverables. The contractor will also have a greater opportunity to influence energy in use through the specification of certain equipment.

7.2 Benchmark Analysis

The ESFA has produced the following set of energy benchmarks which are based on the following:

- energy modelling of a baseline design,
- operational data from Primary, Secondary and Special Schools,
- analysis of Display Energy Certificates (DECs), and
- analysis of the performance of a selection of recently built schools

System	Range	Notes
External lighting	Up to 12 kWh/m2/year	Depending on the extent of external sports and security lighting
Internal lighting	Up to 13 kWh/m2/year	Including emergency lighting
Space heating	45 – 55 kWh/m2/year	
Domestic hot water	3 – 10 kWh/m2/year	
Fans and pumps	6 – 15 kWh/m2/year	
Server rooms	4 – 8 kWh/m2/year	
IT	8 – 10 kWh/m2/year	Depends on pupil to PC/laptop ratio and charging method
Catering	6 - 12 kWh/m2/year	Including hot water energy use
Miscellaneous & small power	5 – 10 kWh/m2/year	
The range is based on the energy end use for the school per square metre of gross internal floor area excluding any unheated areas. All figures are normalised across total floor area.		

Table 7 – EFA Energy Benchmarks

The CIBSE TM54 energy assessment results will be compared against these energy benchmark targets.

7.3 CIBSE TM54 Methodology

The aim of TM54 is to help engineers, designers and, most importantly stakeholders, consider likely energy impacts of new buildings and to provide a methodology to undertake better informed calculation of energy use in operation. The outputs of this assessment can be used to monitor the performance of the new buildings once completed and in operation while also providing useful data that can contribute to energy forecasting activities.

Figure 4 below is shows the general approach adopted for the various components. Steps which are calculated outside of a 'DSM' (Dynamic Simulation Model) follow different calculation methodologies but are generally driven by CIBSE guides or similar. Calculations within a DSM are produced in thermal simulation software such as EDSL Tas or IES.

It should be noted that the DSM loads should not be taken from the compliance modelling.

Certain components such as catering are excluded and assumptions around these exclusions are stated below.

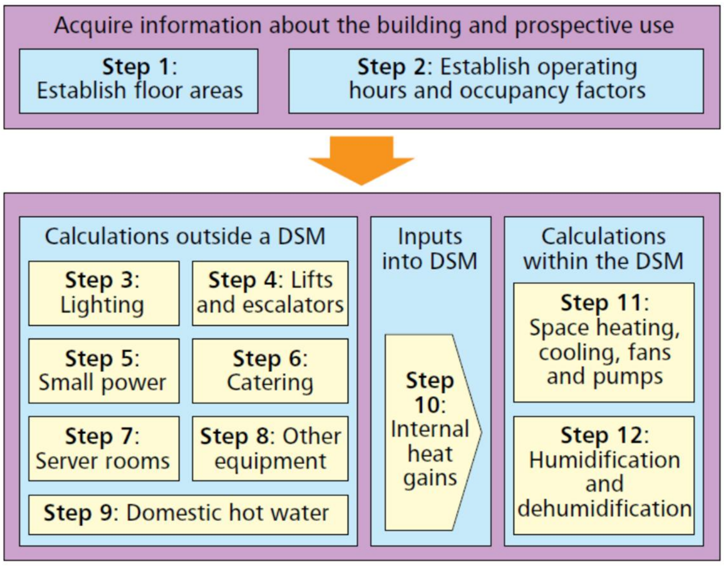

Figure 5 : Extract from CIBSE TM54 'Methodology for evaluating operational energy use at the design' (Figure 5, page 4).

7.3.1 Lighting

This step is based on Section 4 of BS EN 15193: 2007 (BSI, 2007) for calculating the energy used for lighting. This document has been replaced with BS EN 15193:2017 Energy Requirements for Lighting, although the equation is the same.

This methodology is referenced in the SLL Code for Lighting (SLL, 2010) and is referred to as LENI (lighting energy numeric indicator).

The main variables are:

1. Installed power
2. Occupancy dependency
3. Daylight dependency
4. Usage hours

7.3.2 Lifting Equipment

This step is based on CIBSE Guide D for calculating the energy used for by lifts. Only the lift consumption has been considered for this scheme.

The main variables are:

1. Motor rating
2. Number of starts per year
3. Time taken to travel to the highest floor

7.3.3 Small Power

This step is based on simple manual calculations but utilizes data from CIBSE Guide F (2012).

This step has been used to calculate the following reasonable small power elements;

1. IT work stations and screens
2. Photocopiers
3. Projectors
4. Fridges
5. Dishwasher
6. Vending machines
7. Hand Dryers

7.3.4 Server Rooms

This is manual calculation based on a typical server rack power load, annual operations hours and a ratio of rated to operational power demand.

7.3.5 Catering

Estimates can be made using environmental and operational energy usage benchmarks per meal served

7.3.6 Domestic Hot Water

This can be taken from the dynamic simulation model produced for the scheme or via manual calculation based on usage person, temperature rise and number of occupants. The manual calculation is based on data from CIBSE Guide G.

7.3.7 Space Heating, Cooling, Fans and Pumps

These components were calculated using the dynamic simulation model produced for the scheme using actual predicted gains and occupancy profiles.

7.4 Results

The energy performance results are broken down based on the different end use systems. It is important to consider these results have been based on professional assumptions and may change as the design develops.

Figures 6 & Table 8 below provide the energy breakdown for the various end use systems assessed. Electricity consumption is responsible for 46% of the overall annual energy consumption.

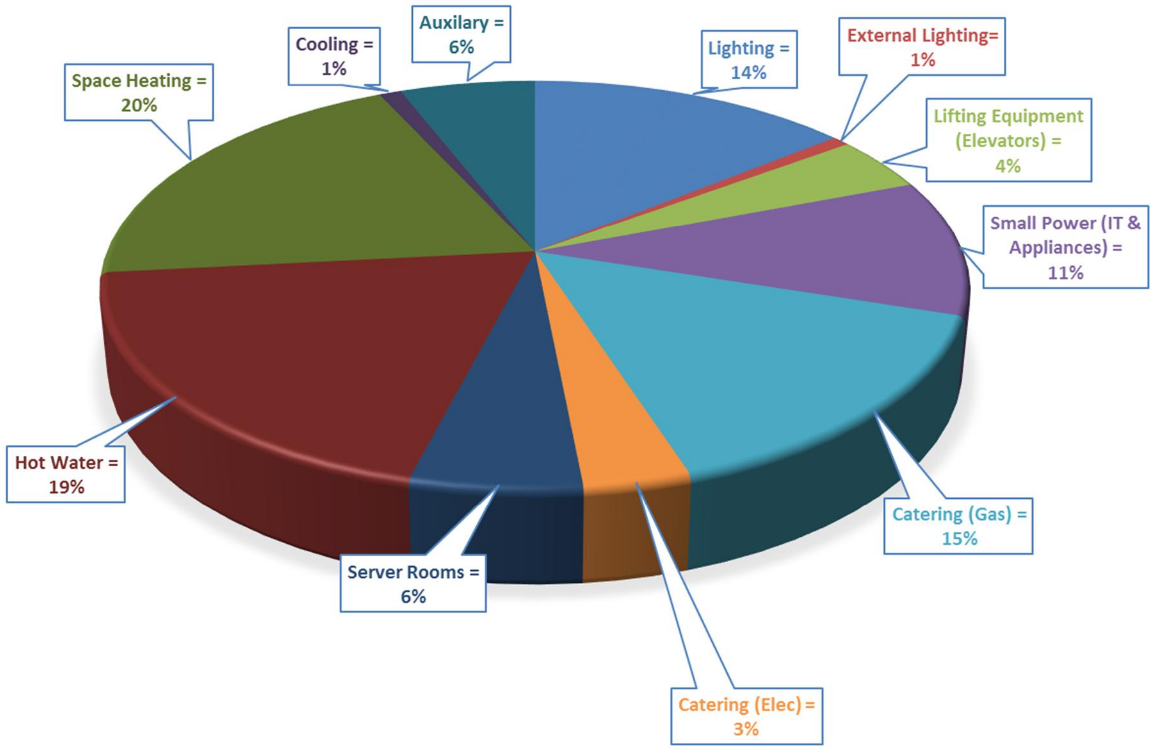

Figure 6 : Heathside Energy Breakdown Split

Lighting =	53,570	kWh/year	8.14	kW.h/m2	14.1%
External Lighting=	2,935	kWh/year	0.45	kW.h/m2	0.8%
Lifting Equipment (Elevators) =	16,300	kWh/year	2.48	kW.h/m2	4.3%
Small Power (IT & Appliances) =	41,225	kWh/year	6.27	kW.h/m2	10.8%
Catering (Gas) =	57,038	kWh/year	8.67	kW.h/m2	15.0%
Catering (Elec) =	13,163	kWh/year	2.00	kW.h/m2	3.5%
Server Rooms =	21,024	kWh/year	3.20	kW.h/m2	5.5%
Hot Water =	73,482	kWh/year	11.17	kW.h/m2	19.3%
Space Heating =	75,149	kWh/year	11.42	kW.h/m2	19.8%
Cooling =	3,678	kWh/year	0.56	kW.h/m2	1.0%
Auxilary =	22,482	kWh/year	3.42	kW.h/m2	5.9%
PV Generation =	- 33,168	kWh/year	- 5.04	kW.h/m2	n/a
Total Energy Usage =	380,046	kWh/year	57.76	kW.h/m2	

Table 8 : Heathside Energy Breakdown per component

The total electrical estimated load for Heathside is 26.50 kWh/m^2.

The total gas estimated load for Heathside is 31.26 kWh/m^2.

**Please note that the PV generation figures are not included in the total energy usage figure, the kWh/m^2 estimates for electricity or the total kWh/m^2 estimate.*

7.5 Benchmark Comparison

Whilst the data presented above is calculated through the concept energy model, and is subject to further design and development, it has been compared to the ESFA's benchmark range (taken from Technical Annex 2H: Energy). The table below provides a comparison against these different sources.

System	ESFA Benchmark Range (kWh/m²/year)	Concept Energy Model CIBSE TM54 and DSM (kWh/m²/year)
External lighting	Up to 12	0.45
Internal lighting	Up to 13	8.14
Lifting Equipment	Up to 1	2.48
Space heating	45 – 55	11.42
Domestic hot water	3 – 10	11.17
Cooling	Up to 1	0.56
Fans and pumps	6 – 15	3.42
Server rooms	4 – 8	3.2
Catering	6 - 12	10.67 (elec and gas)
IT, Miscellaneous & small power	13 – 20	6.27

Table 9 : Comparison of Heathside Energy Breakdown to CIBSE TM54 & DSM

When compared to the Concept Energy Model breakdown as shown in Figure 8, this provides a greater contrast in certain areas. Electrically it is not too dissimilar although lighting assumed in the Concept Energy Model is more linked to complying with Part L rather than the expected fittings and wattages used in the TM54 calculation. Concept Energy Model estimate for hot water is much higher than the TM54 calculation and EFA benchmark suggests. This is more an issue with the assumption of hot water usage utilised under the Concept Energy Model.

The TM54 estimate for heat of 11.42 kWh/m^2 is based on the Concept Energy Model output. Compared to the actual EFA target benchmark, the TM54 estimate is potentially between 400 – 500% different from reality. This further reinforces the limitations of using Concept Energy Model for predicting thermal consumption and the actual thermal consumption for Heathside Elmbridge School is more likely to be in the range of 40-50 kWh/m^2.

Some of the reasons for this limitation are listed below:

- Air Leakage maybe higher on current buildings
- Room set points are likely to differ from the model to reality
- Heat recovery efficiencies will vary
- Thermal bridging is approximated in the model and may differ when actually constructed
- Actual usage & controls can be different the modelling assumptions
- User behaviour issues – i.e. overriding controls and set points.

7.5.1 ESFA weighted energy benchmarks

Whilst the data has been compared to the ESFA's benchmark range, it then needs to be expressed as energy targets. Energy targets required by the EFSA are expressed as electricity equivalent (kWhe), which is calculated by multiplying the different fuel kWh consumptions by the relevant energy weighting factor. The table below provides energy targets after multiplying relevant energy weighting factor. A weighting factor of 1 is used for electricity usage and 0.4 is used for fuel usage such as natural gas. This can then be compared to the EFSA Design Energy Targets for Secondary Schools (taken from Table 4 of the Technical Annex 2H: Energy).

System	Heathside Concept Energy Model CIBSE TM54 and DSM (kWh/m^2/year)	Energy Weighting factor	Heathside Energy Targets (kWh/m^2/year)	EFSA Annual Design Energy Targets – Secondary Schools (kWh/m^2/year)
External lighting	0.32	1.0	0.32	13
Internal lighting	8.14	1.0	8.14	
Lifting Equipment	2.48	1.0	2.48	1
Space heating	11.42	0.4	4.57	20
Domestic hot water	11.17	0.4	4.47	4
Fans and pumps	3.42	1.0	3.42	7
Cooling	0.56	1.0	0.56	1
Catering	10.67 (elec & gas)	1.0 & 0.4	5.47	n/a
IT, Miscellaneous & small power, server rooms	9.47	1.0	9.47	25

Table 10 : Heathside EFSA Weighted Energy Targets

7.6 In Use and Continuous Monitoring

A well designed and commissioned and fully functioning metering and monitoring system will enable the contractor and the school to compare actual energy usage against some of the benchmarks shown in the previous sections. In addition, the contractor will develop a solution that allow the upload of energy data to iServ. It will help flag any plant or control commissioning issues and even potential behavioural issues with energy use that need addressing.

7.6.1 Monitoring and targeting strategy

Data reliability and analysis are critical to the success of any monitoring and targeting process. Based on the energy estimation from DSM and TM54 for Heathside, contractor will be required to establish feedback mechanisms from metering in order to measure the energy and water consumption. The information collected from the energy meters will allow continuous monitoring of energy status, comparison of consumption to benchmark end use loads and also discrepancy in energy consumption. Sub meters will be placed in various locations to obtain more correct and accurate interpretation of results. The first year's annual operational energy consumption data will need to be uploaded on to Carbon Buzz.

The iSERV methodology will be used to automatically monitor and report on the energy and water use of the school for continuous monitoring. K2n services or any similar system approved by the employer will be used to report consumption and performance in use of buildings and it will be important that the energy uses identified in this report are suitable metered and reported on.

7.6.2 Building Performance Evaluations Review and Monitoring plan

Heathside will need to be provided with an initial 15-month subscription and setup and also provide support during the 12-month commissioning period. 15-minute interval continuous monitoring and benchmarking data to the K2n national benchmarking databases on monthly basis or daily basis shall be provided by contractor to compare EFA targets during 12-month defect period. Reports obtained from K2n will help the school to identify and manage their energy consumption monthly basis.

8. Building Performance Evaluations (BPE)

Building Performance Evaluations is developed by Education and Skills Funding Agency (ESFA) to identify the performance gap between the Contractor's design intent and the in-use performance of the building for newly completed and occupied school buildings.

The aim for the evaluations, as part of the normal procurement process, is to:

- indicate the factors impacting on the operational performance of the building in use.
- identify the root cause of performance issues.
- inform action to improve performance.

BPE focus is on providing a structured and auditable procedure to uncover the poor performance of buildings but not to define the solution of any problems. Contractors and their designers are key players in unlocking good building performance. Therefore, the BPE methodology has been specifically designed to be used within the first year of operation of the school building whilst there is still a contractor responsibility with the school through the defects liability period.

The ESFA's Output Specification contains a requirement for the contractor to ensure that BPE's are provided and is a specific contract deliverable.

8.1.1 Scope of BPE

a. To provide an objective understanding of what is successful and what are areas for improvement.

b. To monitor the result of fine tuning the building performance through seasonal adjustments to the building controls.

c. To establish across the range of schools where there are common issues in order to learn lessons for future school building projects.

d. BPE processes consists of various interrelated aspects which focuses on areas which could be improved and then suggest actions. It comprises

  - Desk-top analysis of specific design and construction information before school visit.
  - School visit to gather information.
  - Review of BMS.
  - Second school visit on benefits of BPE which includes completion of two questionnaires i.e. Teaching staff and technical site staff.
  - Two BPE reviews will be carried out by contractor. Initial Review at 3-6 months and Final Review at 9-12 months after handover in accordance with the Employer's Requirements Deliverables.
  - Compilation of a report on all findings, energy trends and observations from each school – issued to ESFA and clear actions by Contractor provided using the ESFA templates for Initial and Final BPE reports.
  - Compilation of short summary report for the school.

e. The BPE process will give meaningful output when suitable data monitoring and collection systems are effectively placed. Once the building is in-use these monitoring systems will be vital in providing the hard technical data used in the assessment of the building's performance.

f. There will be two stages of post-handover. The first stage will ensure the building is set up correctly to obtain accurate reporting for its ongoing performance. The second stage is more detail assessment of the overall building performance based on recorded actual figures.

8.1.2 BPE stages and requirements

Stage	When undertaken	Activities	Information to be provided/Employers Requirements Deliverables
Stage 1 -Data collection setup	Commissioning	· Ensure data monitoring and sub-metering systems are correctly collecting data and automatically reporting	· Results of 7-day monitoring during soak test (forms part of H&S file)
Stage 2 - Initial performance review	3-6 months post occupancy	· Site visit and walk round with school management team and contractors · Collect and review initial building performance iSERV data and BMS energy consumption data (electricity, gas, water, temperature, CO2) and compare against design prediction · Conduct structured interview of facilities staff/questionnaire · Complete teaching staff questionnaires · Collate all information into the initial report template and provide commentary on the findings · Develop action plan to address any issues identified, e.g. further training, seasonal adjustments and fine tuning · Report findings back to the school	· Initial BPE performance report showing top 5 issues and initial energy and water performance. · Action plan to resolve issues before the end of defect liabilities period and final BPE review
Stage 3 - Final performance review	9-12 months post occupancy	· Collect and review longer term building performance iSERV data and BMS energy consumption data (electricity, gas, water, temperature, CO2 in classrooms). · Conduct structured analysis of data collected accounting for any unexpected results · Collate all information into the final report template and provide commentary on the findings · Develop any further action plan · Report findings back to the school	· Final BPE report showing: confirmed performance and actual annual energy and water consumption figures achieved with a comparison against the design prediction and ESFA benchmarks Any further actions to improve performance

9. Conclusion

By following the energy hierarchy, the proposed scheme has demonstrated compliance with Approved Document Part L2A of the Building Regulations. This has been achieved without the inclusion of Low to Zero Carbon technologies.

The key measures and CO_2 reductions for each stage of the energy demand reduction are given below. The measures proposed will meet the energy hierarchy and deliver a 25% carbon reduction on the 2013 Building Regulations.

	Total Regulated Carbon Dioxide Emissions ($KgCO_2/m^2$ per annum)	Reduction in Carbon Dioxide Emissions ($KgCO_2/m^2$ per annum)	Percentage Reduction over TER
Baseline: Part L 2013 of the Building Regulations Compliant Development (TER)	15.7	-	-
With Enhanced Passive design	14.2	1.5	9.5%
With 40kW Solar PV	11.7	2.5	15.9%
TOTAL		4.0	25.5

Table 11 - Carbon Dioxide Emissions after each stage of the Energy Demand Reduction

Table 11 show the CO_2 emissions and reductions associated with each stage of the energy hierarchy and energy demand reduction according to Part L 2013 is reached. Figures in these tables have been rounded to the nearest 0.1 tonne of CO_2.

EBC does not have any numerical target to reduce carbon emissions. The proposed design has demonstrated it has met EBC's core strategies and has exceeded the TER by over 25%.

	Target Reduction on Part L 2013 Building Regulations	Reductions of Heathside School
EBC	No numerical targets	25.5% (Savings from be lean measures and PV system)

Table 12 - Emission Reductions of Heathside School Compared to Relevant Policy Target Reductions

The information within this document is based on modelling carried out during the development of the design. The building performance will be subject to amendments following further design development in consultation with stakeholders and the design team, with reference to the internal planning of the building and the specification of the building systems. Numbers presented in tables are taken directly from the Part L modelling results in the form of BRUKL documents. The percentages are shown to one decimal place to ensure consistency between the report and the BRUKL reports contained in Appendix A.

Appendix A. Energy Model Outputs

This section contains the BRUKL documents which are output from the approved modelling tool. It should be noted that the building areas reported here and elsewhere within this report are taken from the thermal model and may not exactly align with the actual areas defined by the architect.

BRUKL Documents for each stage of the energy demand reduction are appended.

1 - Baseline Building BRUKL Report, with Gas Fired Boiler Serving the Space Heating and Hot Water

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Heathisde_Rev03

As designed

Date: Mon Aug 06 16:43:27 2018

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.10

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.10

BRUKL compliance check version: v5.4.b.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	15.7
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	15.7
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	14.2
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

JACOBS

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	6939.2	6939.2
External area [m²]	11833.7	11833.7
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	4494.44	4491.91
Average U-value [W/m²K]	0.38	0.38
Alpha value* [%]	9.76	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential 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	10.83	19.47
Cooling	0.53	0.38
Auxiliary	3.24	2.24
Lighting	11.29	12.24
Hot water	19.35	18.33
Equipment*	18.6	18.6
TOTAL**	**45.25**	**52.66**

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

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	38.21	65.95
Primary energy* [kWh/m²]	82.57	90.66
Total emissions [kg/m²]	14.2	15.7

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

2 – BRUKL, As 1 with 40kW of PV

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Heathisde_Rev03

As designed

Date: Mon Aug 06 17:07:33 2018

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.10

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.10

BRUKL compliance check version: v5.4.b.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	15.7
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	15.7
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	11.7
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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	6939.2	6939.2
External area [m²]	11833.7	11833.7
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	4494.44	4491.91
Average U-value [W/m²K]	0.38	0.38
Alpha value* [%]	9.76	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential 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	10.83	19.47
Cooling	0.53	0.38
Auxiliary	3.24	2.24
Lighting	11.29	12.24
Hot water	19.35	18.33
Equipment*	18.6	18.6
TOTAL**	**45.25**	**52.66**

* 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	4.78	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	38.21	65.95
Primary energy* [kWh/m²]	82.57	90.66
Total emissions [kg/m²]	11.7	15.7

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

Appendix B. TM54 Assumptions

This section sets out the various assumptions and data sources where applicable.

Floor Areas

- Floor areas were taken from architectural drawings are and based on Gross Internal Floor Area (GIFA).
- FS0588-JAC-00-GF-M2-A-0200
- FS0588-JAC-00-01-M2-A-0201
- FS0588-JAC-00-02-M2-A-0202

Occupancy

- It has been assumed that the main operating period for Heathside is 7am to 6 pm 5 days a week.
- There is also an allowance of 4 hours either side of this period for support staff, cleaning access and for extracurricular activities/community use.

Lighting

Lighting layouts and loads have been taken from the following Thorlux Lighting drawings.

- 511563 00
- 511563 01
- 511563 02
- It has been assumed that lighting controls will be provided with areas such as toilets and store rooms having absence detection.
- Other assumptions relating to maintenance factors, absence factors and daylight dependency factors are taken from Section 4 of BS EN 15193: 2007 (BSI, 2007) for calculating the energy used for lighting. This document has been replaced with BS EN 15193:2017 Energy Requirements for Lighting, although the equation is the same.
- Judgements regarding the various factors have been made for each zone based on our best understanding.

Lifting Equipment

The assumptions made are:

- Elevator load is calculated based on the number of starts per year, rating of driver motor, time to travel entrance to highest served floor and standby energy used by a single lift in a year.
- Main assumption is based on 10 starts a day, 5 days a week;
- 5kW lift motor load;
- 5 seconds to travel from ground to second floor.

Small Power

- Small power energy load is calculated by considering work stations, photocopiers, projectors, fridges, dishwashers, vending, hand dryers and ring circuits/lab equipment.
- Rated power demand for the small power equipment have been obtained from CIBSE TM54 to calculate the energy consumption. Workstations, photocopiers, projectors, fridges and vending energy consumptions are obtained based on the numbers, average power demand during operation, operating hours and sleep mode power demand.
- Dishwashers and hand dryer energy consumption is based on average energy use per cycle and no. of cycles per year.

Server Room

The assumptions made are:

- There is one small server room with an assumed power rating of 4kW and rated power demand and 60% ratio of operational power demand running 24 hours a day.

Catering

The assumptions made are:

- 450 meal covers each day over 39 weeks. Benchmark used is good practice for a secondary school.

Space Heating, Cooling, Auxiliary & PV Generation

- Space heating, cooling and auxiliary base data for the end use kWh/m^2 obtained from the Building Regulations Part L and energy consumption have been obtained multiplying with the area.