

# Report

Resources and environment

Hall School

Hall School – Life Cycle Carbon Analysis

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## Hall School – Life Cycle Carbon Analysis

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## Executive Summary

Dar Al-Handasah (DAH) London Sustainability Group is providing guidance on a Life Cycle Carbon Analysis (LCCA) Study for Hall School. They are subcontracted by Elementa Consulting for this purpose.

Camden Council has requested an LCCA study to be performed on the proposed and existing buildings. The request is to perform the study on both buildings across their whole life cycle since construction and until demolition. This would include Embodied and Operational Carbon footprint.

The methodology proposed for calculating the Embodied Carbon is based on The Building Research Establishment Environmental Assessment Methodology's (BREEAM) Life Cycle Impacts credit found in the BREEAM New Construction 2014 technical manual. This methodology makes use of the Green Guide to Specification in finding the Embodied Carbon of different materials.

The methodology proposed for calculating the Operational Carbon is based on the calculations done for Part L purposes (regulated energy use only) for the proposed building. Unregulated energy use for the proposed building was obtained through the National Calculation Method (NCM). An estimate for the existing building's annual energy use can be made by looking at its annual electricity and gas bills.

Due to the design still being at early stage, it was necessary to make assumptions for construction materials. All assumptions will be mentioned in this report and will have been reviewed by all relevant sides of the Project Design Team.

**The proposed building's Life Cycle Carbon was found to be 5% lower than that of the existing building.**

# 1 Introduction

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## 1.1 Project Background

Dar Al-Handasah (DAH) London Sustainability Group (referred to as the sustainability team hereafter) is providing Planning and BREEAM assessment services for the redevelopment of Hall School (the Project).

The following companies form the Project Design Team and will be referred to with their profession name hereafter:

- 1) Norr: Architects;
- 2) Elementa: MEP Engineers; and
- 3) Dar Al Handasah: Sustainability.

## 1.2 Planning Requirements

As part of the planning application for the Project, Camden Council has requested an LCCA Study to be performed on the proposed and existing buildings.

## 2 Methodology

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### 2.1 BREEAM

The BREEAM MAT 01 (hereafter referred to as MAT 01) methodology will be used to perform the Embodied Carbon study for the Camden Council requirements. Developed by the BRE, this method was found to be the most suitable for the assessment.

In the case of the Project, the following elements will be assessed;

- 1) External Walls;
- 2) Windows;
- 3) Roof;
- 4) Upper Floor Slab;
- 5) Floor Finishes/Coverings; and
- 6) Internal Walls.

All data used for this study comes from the Green Guide to Specification, also developed by the BRE.

### 2.2 Green Guide to Specification

The Green Guide, developed by the BRE and part of BREEAM, contains more than 1500 specifications used in various types of buildings. The relative environment impact of construction materials is looked at in six different generic types of buildings including commercial, retail and domestic. The guide provides an extensive list of building specifications covering the most common building materials.

This data is set out as an A+ to E ranking system, where A+ represents the best environmental performance / least environmental impact, and E the worst environmental performance / most environmental impact. BRE has provided a summary environmental rating - The Green Guide rating, which is a measure of overall environmental impacts covering the following issues:

- Climate change;
- Water extraction;
- Mineral resource extraction;
- Stratospheric ozone depletion;
- Human toxicity;
- Ecotoxicity to Freshwater;
- Nuclear waste (higher level);
- Ecotoxicity to land;

- Waste disposal;
- Fossil fuel depletion;
- Eutrophication;
- Photochemical ozone creation; and
- Acidification.

The guide also provides an embodied carbon value for each construction material. The value is in kilograms of carbon dioxide equivalent (kgCO<sub>2</sub>eq) over a 60 year period covering a cradle-to-grave scope. As it is CO<sub>2</sub>eq and not just CO<sub>2</sub>, the value considers the impact of other greenhouse gases (such as methane) and normalises their effect in units of CO<sub>2</sub>. The 60 year scope of the study follows the different materials from manufacturing stage to final disposal at demolition.

It should be noted that the Green Guide is continuously updated to reflect industry environmental impact improvements and standard materials used. This places a limitation on assessing old buildings and assumes they have been built with current industry practices.

### 2.3 Assumptions

- Due to the constant updates of the Green Guide (as mentioned in the previous section), the existing building is assumed to have been built at the same time as the proposed building will be. This allows the application of Green Guide data on the existing building;
- Due to the proposed building being in very early design stage when the study was made, a date was chosen in which the design was frozen (in terms of areas) and the embodied carbon study performed on (6<sup>th</sup> of October 2016);
- The most current construction materials were sent by the Architects to the Sustainability Team on the Freeze Date;
- For Operational Energy use, a comparison between Part L calculations and energy bills will be made. Part L estimations are often found to be different from actual energy use;
- No information was provided on the floor finishes for the current building and as a result, this element was only considered for the proposed building;
- The Operational Carbon for the proposed building was found using the NCM method for unregulated energy and Part L calculations for regulated energy. This figure was assumed to be representative of the annual energy and therefore carbon footprint of the building. As the study period for the embodied carbon is 60 years, it is also assumed this number will remain constant. In reality,

depending on the UK's changing energy mix, this value will change as different types of power plants are constructed or decommissioned;

- The Operational Carbon for the existing building was found using gas and electricity bills for the period between 2015 and 2016. That value is assumed to be constant throughout the 60 year study period in this report. In reality, depending on the UK's changing energy mix, this value will change as different types of power plants are constructed or decommissioned.



## 3 Embodied Carbon Study - Proposed Building

### 3.1 Overview

A table of potential materials and their areas provided by the architects was used to calculate the Embodied Carbon. Table 2 gives an overview of the element material specifications, areas and kgCO<sub>2</sub>eq contributions. As can be seen from the table, there is a large variation in the Green Guide rating of the materials picked from D to A+.

It should be noted that in some cases, the Green Guide Calculator was used to calculate the Embodied Carbon of materials not found in the Green Guide. The material reports for each of these specifications can be found in the appendix of this report. These materials can be identified by not having a hyperlinked Green Guide Element Number.

### 3.2 Results

The following is a summary table for the Embodied Carbon of the building:

**Table 1: Summary of results for proposed building**

<b>Element</b>	<b>kgCO<sub>2</sub>eq (60 year period)</b>
External Walls	154,762
Windows	18,000
Roof	87,647
Upper Floor Slab	84,504
Internal Walls	67,992
Floor Finishes/Coverings	77,937
<b>Total (kgCO<sub>2</sub>eq)</b>	<b>490,842</b>
<b>Gross Internal Area (m<sup>2</sup>)</b>	<b>3,015</b>
<b>Total Per (kgCO<sub>2</sub>eq/m<sup>2</sup>)</b>	<b>163</b>

163 kgCO<sub>2</sub>eq/m<sup>2</sup> is the embodied carbon of the proposed building for a period of 60 years.

### 3.3 Discussion

As mentioned previously, a large number of the specifications attached to elements were assumed. This coupled with the fact that the building's design will potentially change makes the top figures suitable for this stage only. As will be shown later on in the report, the embodied carbon forms a very small percentage of the total lifecycle carbon making the uncertainties associated with operational carbon more significant.

Table 2: Overview of proposed building data

External Walls	Type 1: Brick Walls - General	Type 2: Vertical Clay Tiles	Type 3: Vertical Standing Seam	Type 4: Bronze Cladding	Curtain wall	Total		
<b>Prescribed Element</b>	Build-up – (from outside) brick 102.5mm, cavity 50mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS thickness TBC by S.E., Vapour control layer, plasterboard 15mm.	Build-up – (from outside) tiles nominal 50mm, battens 42mm, composite panel ridge zone 35mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS/rafter thickness TBC by S.E., Vapour control layer, plasterboard 15mm.	Build-up – (from outside) 25mm standing seam, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS thickness TBC by S.E., Vapour control layer, plasterboard 15mm.	Build-up – (from outside) Aluminium (Powder coated Bronze) 25mm, Insulation zone 100 mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS/rafter thickness TBC by S.E., Vapour control layer, plasterboard 15mm.	U-value = 1.5 W/m <sup>2</sup> K (1.4 including frame) G-value < 0.4 Light transmission > 70% Glazing – inner pane, clear toughened glass. Outer pane, at low level clear laminated glass, at high level clear toughened glass Internal framing – engineered timber, clear matt lacquer finish External cover cap – extruded aluminium, powder coated, colour bronze			
<b>Green Guide Element</b>	Brickwork, external leaf, 102.5 mm, cement lime mortar Cavity (any size) SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, 15 mm, dabs, emulsions pain	Cladding, plan clay tile, battens, building paper SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, 15 mm, dabs, emulsions pain	Aluminium standing seam (single skin) SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, 15 mm, dabs, emulsions pain	Built up, coated aluminium standing seam, aluminium liner, insulation, steel supports SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, 15 mm, dabs, emulsions pain	Laminated timber stick type curtain wall: 1 transom per floor, laminated sealed glass unit, coated aluminium spandrel panel with pentane blown PUR/PIR insulation			
<b>Rating</b>	A	A	A	B	B			

<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	142.05	162.73	131.56	206.66	210.00	<b>154,761.76</b> kgCO <sub>2</sub> eq		
<b>Green Guide Element Number</b>	79903246	79903259	79903261	79903267	<a href="#">1206520004</a>			
<b>Percentage of Total Area</b>	65%	2%	9%	3%	21%	<b>100%</b>		
<b>Area (m<sup>2</sup>)</b>	636	20	92	24	210	<b>982</b>		
<b>Windows</b>	<b>Type 1 – Casement and Side Slider</b>	<b>Type 2 – Single Casement</b>	<b>Type 3 – Vertical Sliders</b>	<b>Type 4 – Roof lights (Combination of Pitched and Flat)</b>	<b>Total</b>			
<b>Prescribed Element</b>	Glass 79% Frame 21% frame material laminated timber clear lacquered finish, capping material aluminium powder coated bronze U-value = 1.5 W/m <sup>2</sup> K (1.4 including frame) G-value < 0.4 Light transmission > 70% Glazing – inner pane, clear toughened glass. Outer pane, at low level clear laminated glass, at high level clear toughened glass	Glass 72% Frame 28% frame material laminated timber clear lacquered finish, capping material aluminium powder coated bronze U-value = 1.5 W/m <sup>2</sup> K (1.4 including frame) G-value < 0.4 Light transmission > 70% Glazing – inner pane, clear toughened glass. Outer pane, at low level clear laminated glass, at high level clear toughened glass	Glass 71% Frame 29% frame material laminated timber clear lacquered finish, capping material aluminium powder coated bronze U-value = 1.5 W/m <sup>2</sup> K (1.4 including frame) G-value < 0.4 Light transmission > 70% Glazing – inner pane, clear toughened glass. Outer pane, at low level clear laminated glass, at high level clear toughened glass	Glass 72% Frame 28% Structural opening – formed in roof secondary framing in either SFS or timber at head, sill and jambs Frame – mild steel, ppc RAL Glazing – 4mm SGG Planitherm Total + (low E) toughened inner, 16mm argon cavity, 4mm SGG Bioclean toughened outer U-value – centre pane = 1.2W/m <sup>2</sup> K				
<b>Green Guide Element</b>	Aluminium window (profile >1.2 kg/m) with redwood timber internal frame, water based stain to timber, double glazed	Aluminium window (profile >1.2 kg/m) with redwood timber internal frame, water based stain to timber, double glazed	Aluminium window (profile >1.2 kg/m) with redwood timber internal frame, water based stain to timber, double glazed	PVC-U window with steel reinforcement, double glazed				
<b>Rating</b>	B	B	B	A+				

<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	110.00	110.00	110.00	120.00	<b>18,000.00</b> kgCO <sub>2</sub> eq			
<b>Green Guide Element Number</b>	<a href="#">1231500005</a>	<a href="#">1231500005</a>	<a href="#">1231500005</a>	<a href="#">831500001</a>				
<b>Percentage of Total Area</b>	75%	10%	4%	11%	<b>100%</b>			
<b>Area (m<sup>2</sup>)</b>	121	16	7	18	<b>162</b>			
<b>Roof</b>	<b>Type 1 – Pitched Clay Tiles</b>	<b>Type 2 – Metal Standing Seam</b>	<b>Type 3 - Bituminous Felt Flat Roof</b>	<b>Type 4 – Glass roof</b>	<b>Total</b>			
<b>Prescribed Element</b>	Build-up – (from outside) tiles nominal 50mm, battens 42mm, composite panel ridge zone 35mm, composite panel core 150mm, SFS/rafter thickness TBC by S.E., Vapour Control Layer, 15mm Knauf Comfortboard Lining	Build-up – (from outside) standing seam nominal 5mm (exclude seams), membrane layer (breather), composite panel core 150mm, SFS/rafter thickness TBC by S.E., Vapour Control Layer, 15mm Knauf Comfortboard Lining	Build-up – (from outside) two layers felt nominal 10mm, insulation 180mm, membrane layer (vapour barrier), structural build up separate, Vapour Control Layer, 15mm Knauf Comfortboard Lining	U-value = 1.5 W/m <sup>2</sup> K (1.4 including frame) G-value < 0.4 Light transmission > 70% Glazing – inner pane, clear toughened glass. Outer pane, at low level clear laminated glass, at high level clear toughened glass Internal framing – engineered timber, clear matt lacquer finish External cover cap – extruded aluminium, powder coated, colour bronze				

<b>Green Guide Element</b>	Cladding, plan clay tile, battens, building paper SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, high density, 15mm	Aluminium standing seam roofing (single skin) Breather Membrane SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, high density, 15mm	Asphalt roofing, 20mm, sheating felt foamed glass, 200mm SIP, cement bonded particleboard, pentane PU insulation Steel Studwork, 100 mm Vapour Control Layer (contains aluminium foil for low emissivity) Plasterboard, high density, 15mm	Aluminium window (profile >1.2 kg/m) with redwood timber internal frame, water based stain to timber, double glazed				
<b>Rating</b>	B	A	B	B				
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	162.49	132.13	111.69	110.00	<b>87,647.38</b> kgCO <sub>2</sub> eq			
<b>Green Guide Element Number</b>	79903294	79903296	79903299	<a href="#">1231500005</a>				
<b>Percentage of Total Area</b>	14%	25%	55%	6%	<b>100%</b>			
<b>Area (m<sup>2</sup>)</b>	102	175	385	45	<b>707</b>			
<b>Upper Floor Slab</b>	<b>Type 1 - Upper Ground Floor</b>	<b>Type 2 - First Floor</b>	<b>Type 3 - Second Floor</b>	<b>Total</b>				
<b>Prescribed Element</b>	Concrete on metal deck. 150 concrete, beam size 265 UC's	Concrete on metal deck. 150 concrete, beam size 265 UC's	Concrete on metal deck. 150 concrete, beam size 265 UC's					
<b>Green Guide Element</b>	Powerfloated in situ reinforced concrete slab on "deep" profiled metal decking	Powerfloated in situ reinforced concrete slab on "deep" profiled metal decking	Powerfloated in situ reinforced concrete slab on "deep" profiled metal decking					
<b>Rating</b>	A+	A+	A+					
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	84.00	84.00	84.00	<b>84,504.00</b> kgCO <sub>2</sub> eq				
<b>Green Guide Element Number</b>	<a href="#">807280015</a>	<a href="#">807280015</a>	<a href="#">807280015</a>					
<b>Percentage of Total Area</b>	31%	36%	33%	<b>100%</b>				

Area (m <sup>2</sup> )	318	355	333	1006				
<b>Internal Walls</b>	<b>Type 1 – 40db</b>	<b>Type 2 – 45db</b>	<b>Type 3 – 50db</b>	<b>Type 4 – 55db</b>	<b>Type 5 – Boxing out</b>	<b>Type 6 – Curtain wall</b>	<b>Total</b>	
<b>Prescribed Element</b>	1 x 12.5mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm 'C'	1 x 12.5mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm 'C' stud, with 25mm insulation in the cavity 97mm overall width	1 x 15mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 92mm 'C' stud,	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm 'C' stud,	1 x 12.5mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm 'C' stud, with 25mm insulation in the cavity 97mm overall width	Glass spec varies depending on wall type.		
<b>Green Guide Element</b>	Plasterboard, 12.5mm Light steel structure for external loadbearing wall Plasterboard, 12.5mm	Steel C studs (75mm) with 60mm mineral wool insulation within cavity, 12.5mm gypsum fibreboard and paint to each side	Plasterboard, 12.5mm Light steel structure for external loadbearing wall Plasterboard, 12.5mm	Plasterboard, 12.5mm Plasterboard, 12.5mm Light steel structure for external loadbearing wall Plasterboard, 12.5mm Plasterboard, 12.5mm	Steel C studs (75mm) with 60mm mineral wool insulation within cavity, 12.5mm gypsum fibreboard and paint to each side	Aluminium curtain walling system		
<b>Rating</b>	A+	A+	A+	A	A+	<u>D</u>		
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	24.02	39.00	24.02	33.38	39.00	<u>170.00</u>	<b>67,991.88 kgCO<sub>2</sub>eq</b>	
<b>Green Guide Element Number</b>	79903305	<a href="#">816110026</a>	79903305	79903306	<a href="#">816110026</a>	<a href="#">831500016</a>		
<b>Percentage of Total Area</b>	37%	3%	18%	8%	21%	<u>13%</u>	<b>100</b>	
<b>Area (m<sup>2</sup>)</b>	539	49	265	110	303	<u>184</u>	<b>1450</b>	
<b>Floor Finishes</b>	<b>Type 1: Carpet Tiles</b>	<b>Type 2: Epoxy Resin Floor</b>	<b>Type 3: Non-Slip Ceramic Tiles</b>	<b>Type 4: Non-Slip Flooring</b>	<b>Type 5: Timber Sprung Floor</b>	<b>Type 6: Vinyl Flooring</b>	<b>Type 7: Wooden Block Floor</b>	<b>Total</b>

<b>Prescribed Element</b>	a) Manufacturer: InterfaceFlor, or acceptable equivalent. b) Range: Entropy. c) Colour: To be confirmed d) Adhesive: Tackifier.	Epoxy resin floor paint mixed with aggregate to provide a non-slip finish- SIKA or similar - plant area	Ceramic floor tiling. a) Manufacturer/ Supplier: Domus Tiles, or acceptable equivalent. b) Reference: Flow. d) Finish: Rock finish e) Size: 596mm x 98mm x 9.7mm. f) Joint width: To be confirmed by the Architect. g) Grout: Colour's shall be confirmed by the Architect. h) Floor tiling shall include matching skirting	3.5.1.1. Linoleum Flooring 2mm linoleum sheet flooring to various substrates indicated on the Tender Drawings. a) Manufacturer: Forbo, or acceptable equivalent. b) Range: Marmoleum Fresco.	a) Manufacturer: Junckers, or acceptable equivalent. b) Reference: Junckers Sports Floor Clip System. c) Boards: Prefinished 22mm Sylva Sport Premium. d) Finish: i) Sports markings shall be sealed with Type FL-05a Lacquer to timber surfaces. ii) System shall include PT-10 Line marking paint. iii) Final coat: HP Sport lacquer shall be applied after line marking paint. f) Underlay: 10mm thick Profoam.	2mm vinyl sheet flooring a) Manufacturer: Altro Ltd., or acceptable equivalent. b) Range: Altro Suprema. c) Colour: Orpheus SU 2008.	Industrial oak parquet flooring in atrium and main entrance strip oak on ply base a) Blocks: 160mm x 8mm x 10mm thick loose strips held together with tape in blocks. b) Finish: Sanded after installation and sealed to receive a satin top coat finish c) Colours: Oak Striped and Rustic Oak chosen from the suppliers	
<b>Green Guide Element</b>	Carpet Tile - polyamide loop tufted, 500 g/m <sup>2</sup> , PVC backing. FCSS 23/32	Resin based terrazzo/agglomerated stone/composite tiles (10% resin content)	Ceramic floor tiles	Plain and decorative linoleum (EN 548). FCSS 23/32	Timber veneered laminate flooring (8mm) on acoustic underlay	Homogeneous polyvinyl chloride floor coverings (EN649). FCSS 23/32.	14mm Engineered Oak Flooring, 9.29 kg/m <sup>2</sup> with adhesive	
<b>Rating</b>	B	D	B	A+	A+	A+	A+	
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	130.00	190.00	79.00	28.00	1.60	39.00	-11.00	<b>77,937.40 kgCO<sub>2</sub>eq</b>
<b>Green Guide Element Number</b>	<a href="#">821570028</a>	<a href="#">821580018</a>	<a href="#">821580001</a>	<a href="#">821570017</a>	<a href="#">821580019</a>	<a href="#">821570065</a>	<a href="#">1321580002</a>	
<b>Percentage of Total Area</b>	4%	3%	1%	51%	16%	9%	16%	<b>100%</b>
<b>Area (m<sup>2</sup>)</b>	100	86	33	1443	439	253	453	<b>2807</b>

## 4 Embodied Carbon Study - Existing Building

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### 4.1 Overview

A set of architectural drawings were provided for the Sustainability Team by the Architects to be used for estimating the areas of elements in the existing building. The drawings date from the late 80s and are the original drawings for the building. Table 4 gives an overview of the element material specifications, areas and kgCO<sub>2</sub>eq contributions. As noted in the assumptions section (2.3), no information on the floor finishes was available. It was therefore not considered in this section.

It should be noted that in some cases, the Green Guide calculator was used to calculate the Embodied Carbon of materials not found in the Green Guide. The material reports for each of these specifications can be found in the appendix of this report. These materials can be identified by not having a hyperlinked Green Guide Element Number.

### 4.2 Results

The following is a summary table for the Embodied Carbon of the building:

**Table 3: Summary of results for existing building**

Element	kgCO <sub>2</sub> eq (60 year period)
External Walls	23,590
Windows	2,306
Roof	41,311
Upper Floor Slab	13,158
Internal Walls	10,292
Floor Finishes/Coverings	N/A
<b>Total (kgCO<sub>2</sub>eq)</b>	<b>90,657</b>
<b>Gross Internal Area (m<sup>2</sup>)</b>	<b>1,750</b>
<b>Total Per (kgCO<sub>2</sub>eq/m<sup>2</sup>)</b>	<b>52</b>

52 kgCO<sub>2</sub>eq/m<sup>2</sup> is the embodied carbon of the proposed building for a period of 60 years.

### 4.3 Discussion

The Embodied Carbon of the existing building was found to be lower than the proposed buildings. There are several reasons for why this is case which will be presented in the conclusions section. The roofs found in the existing building have the relative worst Green Guide ratings and contribute the most to the overall Embodied Carbon.



Table 4: Overview of existing building data

External Walls	Type 1-Hall surrounding walls	Type 2-Level 1 external walls	Type 3-Level 1 southern external wall	Type 4-Level 2 External Walls	Type 5-Level 3 External Walls	Type 6-Wall above large glazing	Total
Prescribed Element	Reinforced Concrete, 375 mm	140 Block Walls (mm): 15 mm cavity ties 900% horz, 450% Vert, 21 N/mm2 Blocks with external bricks	140 Block Walls (mm): 15 mm cavity ties 900% horz, 450% Vert, 21 N/mm2 Blocks with external bricks	Blockwork, 292mm, 21 N/mm2 w/cavity with external bricks	Blockwork, 292mm, 21 N/mm2 w/cavity with external bricks	Blockwork, 292mm, 21 N/mm2 w/cavity with external bricks	
Green Guide Element	Fair face solid blockwork outer leaf, insulation, aircrete blockwork inner leaf, cement mortar, plaster, paint	Brickwork outer leaf, insulation, aircrete blockwork inner leaf, cement mortar, plaster, paint	Brickwork outer leaf, insulation, aircrete blockwork inner leaf, cement mortar, plaster, paint	Blockwork, aircrete, external leaf, 140mm, cement mortar Cavity (any size) Blockwork, aircrete, external leaf, 140mm, cement mortar	Blockwork, aircrete, external leaf, 140mm, cement mortar Cavity (any size) Blockwork, aircrete, external leaf, 140mm, cement mortar	Blockwork, aircrete, external leaf, 140mm, cement mortar Cavity (any size) Blockwork, aircrete, external leaf, 140mm, cement mortar	
Rating	A+	A+	A+	A+	A+	A+	
kgCO2/m <sup>2</sup>	60.00	73.00	73.00	62.17	62.17	62.17	<b>23,589.62 kgCO<sub>2</sub>eq</b>
Green Guide Element Number	<a href="#">806180232</a>	<a href="#">806170028</a>	<a href="#">806170028</a>	79903483	79903483	79903483	
Percentage of Total Area	46%	1%	6%	23%	23%	0%	
Area (m <sup>2</sup> )	312.88	5.88	43.71	159.88	158.09	3.23	<b>683.67</b>
<b>Windows</b>	<b>Type 1-Normal front and back windows</b>	<b>Type 2-Large glazed area</b>					<b>Total</b>
Prescribed Element	Simple, double glazed, aluminium frame	Probably same as to the left					
Green Guide Element	Aluminium window, (profile mass >1.75kg/m), double glazed	Aluminium window, (profile mass >1.75kg/m), double glazed					
Rating	C	C					
kgCO2/m <sup>2</sup>	130.00	130.00					<b>2,306.05 kgCO<sub>2</sub>eq</b>
Green Guide Element Number	<a href="#">1231500004</a>	<a href="#">1231500004</a>			-	-	
Percentage of Total Area	71%	29%	0%	0%	0%	0%	

Area (m <sup>2</sup> )	44.10	17.74					62
<b>Roof</b>	<b>Type 1-Hall roof</b>	<b>Type 2-Groundfloor Roof</b>	<b>Type 3-Normal Roof</b>	<b>Type 4-Normal Roof</b>	<b>Type 5-Plant Room</b>		<b>Total</b>
<b>Prescribed Element</b>	Metal Deck fixed with steel beams and Asphalt	Timber Joists	PC Concrete Slab 150 mm	PC Concrete Slab 200 mm	Timber rafters with concrete cover		
<b>Green Guide Element</b>	Profiled metal "deep" decking with in situ concrete, vapour control layer, insulation, felt isolating layer, mastic asphalt roofing	Timber joists, OSB/3 decking, vapour control layer, insulation, Polyester cold applied liquid waterproofing membrane system.	In situ reinforced concrete slab, vapour control layer, insulation, EPDM single ply roofing membrane	In situ reinforced concrete slab, vapour control layer, insulation, EPDM single ply roofing membrane	Timber joists, OSB/3 decking, vapour control layer, insulation, Polyester cold applied liquid waterproofing membrane system.		
<b>Rating</b>	C	A+	C	C	A+		
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	180.00	55.00	190.00	190.00	55.00		<b>41,311.16 kgCO<sub>2</sub>eq</b>
<b>Green Guide Element Number</b>	<a href="#">1212540025</a>	<a href="#">1212540078</a>	<a href="#">1212540016</a>	<a href="#">1212540016</a>	<a href="#">1212540078</a>	-	
<b>Percentage of Total Area</b>	48%	13%	9%	12%	18%	0%	
<b>Area (m<sup>2</sup>)</b>	346.98	97.35	66.52	85.21	129.57		<b>726</b>
<b>Upper Floor Slab</b>	<b>Type 1-Level 1 and 2 south</b>	<b>Type 2-Level 1 and 2 mid</b>	<b>Type 3-Level 1 North</b>	<b>Type 4-Level 2 North</b>	<b>Type 5-Mezanine Floor</b>		<b>Total</b>
<b>Prescribed Element</b>	200 mm precast concrete	150 reinforced concrete units	200X50 Joists	150 precast concrete	Concrete 150-300 mm		
<b>Green Guide Element</b>	Lattice girder precast concrete floor with in situ concrete topping	Power floated in situ reinforced concrete floor slab	Chipboard decking on metal web joists	Lattice girder precast concrete floor with in situ concrete topping	Power floated in situ reinforced concrete floor slab		
<b>Rating</b>	B	D	A+	B	D		
<b>kgCO<sub>2</sub>/m<sup>2</sup></b>	100.00	120.00	3.80	100.00	120.00		<b>13,157.84 kgCO<sub>2</sub>eq</b>
<b>Green Guide Element Number</b>	<a href="#">807280012</a>	<a href="#">807280054</a>	<a href="#">807280005</a>	<a href="#">807280012</a>	<a href="#">807280054</a>	-	
<b>Percentage of Total Area</b>	52%	5%	13%	13%	17%	0%	
<b>Area (m<sup>2</sup>)</b>	170.43	15.48	43.88	43.88	56.21		<b>330</b>

Internal Walls	Type 1-Hall walls	Type 2-Wall Type 1 Level 1	Type 3-Wall Type 2 Level 1	Type 4-Wall Type 3 Level 1	Type 5-wall in floors 4&5	Total
Prescribed Element	Concrete (block), 140 to 190 mm	140 Block Walls (mm): 15 mm cavity ties 900% horz, 450% Vert, 21 N/mm2 Blocks No Cavity	190 block wall 21 n/mm2	Simple Partition	Blockwork	
Green Guide Element	140mm solid blockwork (density 1450 kg/m <sup>3</sup> ) with cement mortar, paint to each side	140mm solid blockwork (density 1450 kg/m <sup>3</sup> ) with cement mortar, paint to each side	Dense solid blockwork 210mm with cement mortar, paint to each side	Timber stud, plasterboard, paint	140mm solid blockwork (density 1450 kg/m <sup>3</sup> ) with cement mortar, paint to each side	
Rating	A+	A+	C	A+	A+	
kgCO <sub>2</sub> /m <sup>2</sup>	46.00	46.00	49	15	46.00	10,292.27 kgCO <sub>2</sub> eq
Green Guide Element Number	<a href="#">816110010</a>	<a href="#">816110010</a>	<a href="#">816110011</a>	<a href="#">809760003</a>	<a href="#">816110010</a>	-
Percentage of Total Area	29%	16%	20%	13%	23%	0%
Area (m <sup>2</sup> )	99	54.82	70	44	80	348

## 5 Operational Energy - Proposed Building

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### 5.1 Overview

The regulated Energy for the building was assumed to equal the Building Emission Rate (BER) calculated as part of the Part L calculations. Unregulated energy was estimated using the NCM method. Both figures were obtained from Elementa Consulting.

### 5.2 Results

The following Table 5 gives the values for regulated and unregulated energy in the building:

**Table 5: Proposed Building Operational Use**

Type of Energy Use	Value kgCO <sub>2</sub> eq/year
Regulated Energy	39,497
Unregulated Energy	65,546
<b>Total (kgCO<sub>2</sub>eq)</b>	<b>105,043</b>
<b>Gross Internal Area (m<sup>2</sup>)</b>	<b>3015</b>
<b>Total (kgCO<sub>2</sub>eq/m<sup>2</sup>.yr)</b>	<b>34.84</b>
<b>Total (kgCO<sub>2</sub>eq/m<sup>2</sup>)</b>	<b>2,090</b>

### 5.3 Discussion

Energy calculations done for Part L purposes are generally only used for regulation purposes. They are not representative of actual energy use and there exists a gap between modelled energy use and actual energy use. When viewing these results, it should be important to consider the final energy use will probably be higher.

## 6 Operational Energy - Existing Building

### 6.1 Overview

The Operational Energy for the existing building was estimated using the energy bills for gas and electricity for a one year period from 2015-2016. Due to the limited availability of old bills, some of the recent ones used (3 out of 12 months) were based on the electricity company's estimates. A conversion factor, obtained from Department of Energy & Climate Change was used to convert gas and electricity in kWh into operational carbon in kgCO<sub>2</sub>eq. The factors are different for energy measured in 2015 and 2016 and in the case of electricity, cover the carbon generated as a result of losses through transmission and distribution also.

### 6.2 Results

The following Table 6 summarises the results for the Operational Energy for the existing building:

**Table 6: Existing Building Operational Energy**

Type of Energy Use	Value kWh/year
Electricity	85,943
Gas	146,894
<b>Electricity (kgCO<sub>2</sub>eq/year)</b>	<b>40,767</b>
<b>Gas (kgCO<sub>2</sub>eq/year)</b>	<b>27,050</b>
<b>Total (kgCO<sub>2</sub>eq/year)</b>	<b>67,818</b>
<b>Total (kgCO<sub>2</sub>eq)</b>	<b>4,069,112</b>
<b>Gross Internal Area (m<sup>2</sup>)</b>	<b>1750</b>
<b>Total (kgCO<sub>2</sub>eq/m<sup>2</sup>)</b>	<b>2,325</b>

### 6.3 Discussion

The data used in the table above corresponds to only a period of one year. It should be noted that one year is not representative enough to make a full estimate for 60 years and that the energy use will vary. As is the case with section 5, conversion factors used to convert energy use into equivalent carbon are also varied on annual basis and will have an effect on the final Operational Carbon figures.

## 7 Conclusions and Summary

Table 7 shows a summary for all the results

**Table 7: Life Cycle Carbon Analysis Summary Table**

	<b>Embodied Carbon</b>	<b>Operational Carbon</b>	<b>Lifecycle Carbon</b>
<b>Total Values</b>			
Existing Building	90,657	4,069,112	4,159,769
Proposed Building	490,842	6,302,556	6,793,398
Difference	400,185	2,233,444	2,633,629
<b>Per m<sup>2</sup> Values</b>			
Existing Building	52	2,325	2,377
Proposed Building	163	2,090	2,253
Difference	111	-235	-124
% Difference	214%	-10%	<b>-5%</b>

**The proposed Life Cycle Carbon was found to be 5% lower than that of the existing building.** It should be noted that the proposed building will have a gross internal area around 72% higher than the existing.

Overall, the Operational Energy has the highest impact on the LCCA; as can be seen in Figure 1, the Embodied Energy in both cases makes up less than 10% of the total Life Cycle Carbon. This places high uncertainty on the final figure due to the existing uncertainty in Operational Carbon estimations.

Figure 1 also shows that 2% of the existing building's Life Cycle Carbon is embodied compared to the proposed building's figure of 7%. This shows that investing in improved energy efficiency materials at the start of the project causes a long term saving in total carbon. Although the existing building has lower Embodied Carbon, it has a higher Total Carbon due to the high carbon footprint during operation.

### *Sensitivity Analysis*

Through conducting a sensitivity analysis on some of the assumptions of the design, the following was observed:

- A 50% increase in the proposed building's Operational Energy causes its total life cycle to become 40% higher than that of the existing building instead of 5% lower.

- Similarly, increasing the existing building's Operational Energy causes its total life cycle to become 36% higher than that of the proposed building instead of 5% higher.

This sensitivity analysis is based on two extreme changes but shows significant effects in the final value based on the assumptions inputted. As the design develops and more information becomes concrete, another similar study can be done to assess which building has a Life Cycle Carbon.



Figure 1: Operational vs Embodied Carbon

## 8 Appendix

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# Green Guide Calculator Result

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Project reference			
Address	London		
<b>BREEAM assessment Reference</b>			
<b>EcoHomes reference</b>			
<b>CSH reference</b>		<b>Code level</b>	

SPECIFICATION			
Scheme	Schools		
Element type	External Wall Construction : Brick, Stone & Block Cavity Wall	ID	79903246
Element description	Build-up ? (from outside) brick 102.5mm, cavity 50mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS thickness TBC by S.E., Vapour control layer, plasterboard 15mm.		

Type	Component	Description
Wall Structure - Brick	Brickwork, external leaf, 102.5mm, cement lime mortar	brick 102.5mm
Cavity - Airspace	Cavity (any size)	cavity 50mm
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	composite panel core 100mm, part stud thickness as insulation 50mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	remainder SFS thickness TBC by S.E.

Type	Component	Description
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour control layer
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 15mm, dabs, emulsion paint	plasterboard 15mm

**CALCULATED GREEN GUIDE RATING:****A**kg CO<sub>2</sub>/m<sup>2</sup>

142.05

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SPECIFICATION			
Scheme	Schools		
Element type	External Wall Construction : Cladding on Structurally Insulated Panels	ID	79903259
Element description	Build-up ? (from outside) tiles nominal 50mm, battens 42mm, composite panel ridge zone 35mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS/rafter thickness TBC by S.E., Vapour control layer, plasterboard 15mm.		

Type	Component	Description
Cladding & Roof Covering - Clay tile	Cladding, plain clay tile, battens, building paper	tiles nominal 50mm, battens 42mm,
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	composite panel ridge zone 35mm, composite panel core 100mm, part stud thickness as insulation 50mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	remainder SFS/rafter thickness TBC by S.E

Type	Component	Description
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour control layer
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 15mm, dabs, emulsion paint	plasterboard 15mm

**CALCULATED GREEN GUIDE RATING:****A**kg CO<sub>2</sub>/m<sup>2</sup>

162.73

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SPECIFICATION			
Scheme	Schools		
Element type	External Wall Construction : Render on Structurally Insulated Panels	ID	79903261
Element description	Build-up ? (from outside) 25mm standing seam, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS thickness TBC by S.E., Vapour control layer, plasterboard 15mm.		

Type	Component	Description
Cladding & Roof Covering - Aluminium	Aluminium standing seam (single skin)	25mm standing seam
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	composite panel core 100mm, part stud thickness as insulation 50mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	Remainder SFS/rafter thickness TBC by S.E.
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour control layer

Type	Component	Description
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 15mm, dabs, emulsion paint	plasterboard 15mm

**CALCULATED GREEN GUIDE RATING:****A**kg CO<sub>2</sub>/m<sup>2</sup>

131.56

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SPECIFICATION			
Scheme	Schools		
Element type	External Wall Construction : Cladding on Structurally Insulated Panels	ID	79903267
Element description	Build-up ? (from outside) Aluminium (Powder coated Bronze) 25mm, Insulation zone 100 mm, composite panel core 100mm, part stud thickness as insulation 50mm, remainder SFS/rafter thickness TBC by S.E., Vapour control layer, plasterboard 15mm.		

Type	Component	Description
Cladding & Roof Covering - Aluminium	Built up, coated aluminium standing seam, aluminium liner, insulation, steel supports *	Aluminium (Powder coated Bronze) 25mm
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	Insulation zone 100 mm, composite panel core 100mm, part stud thickness as insulation 50mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	remainder SFS/rafter thickness TBC by S.E.

Type	Component	Description
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour control layer
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 15mm, dabs, emulsion paint	plasterboard 15mm

**CALCULATED GREEN GUIDE RATING:****B**kg CO<sub>2</sub>/m<sup>2</sup>

206.66

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CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	Roofing : Pitched Roof Steel Construction	ID	79903294
Element description	Build-up ? (from outside) tiles nominal 50mm, battens 42mm, composite panel ridge zone 35mm, composite panel core 150mm, SFS/rafter thickness TBC by S.E., Vapour Control Layer, 15mm Knauf Comfortboard Lining		

Type	Component	Description
Cladding & Roof Covering - Clay tile	Cladding, plain clay tile, battens, building paper	tiles nominal 50mm, battens 42mm
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	composite panel ridge zone 35mm, composite panel core 150mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	SFS/rafter thickness TBC by S.E.
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour Control Layer

Type	Component	Description
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, high density, 15mm	15mm Knauf Comfortboard Lining

**CALCULATED GREEN GUIDE RATING:****B**kg CO<sub>2</sub>/m<sup>2</sup>

162.49

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EcoHomes reference			
CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	Roofing : Pitched Roof Steel Construction	ID	79903296
Element description	Build-up ? (from outside) standing seam nominal 5mm (exclude seams), membrane layer (breather), composite panel core 150mm, SFS/rafter thickness TBC by S.E., Vapour Control Layer, 15mm Knauf Comfortboard Lining		

Type	Component	Description
Cladding & Roof Covering - Aluminium	Aluminium standing seam roofing (single skin)	standing seam nominal 5mm (exclude seams)
Membrane - All Types	Breather membrane	membrane layer (breather)
Structurally Insulated Panels - CBPB	SIP, cement bonded particleboard, pentane PU insulation	composite panel core 150mm
Battens/Joists/Studs - Steel	Steel studwork, 100mm	SFS/rafter thickness TBC by S.E.

Type	Component	Description
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour Control Layer
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, high density, 15mm	15mm Knauf Comfortboard Lining

**CALCULATED GREEN GUIDE RATING:****A**kg CO<sub>2</sub>/m<sup>2</sup>

132.13

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CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	Roofing : Flat Roof: Warm Deck	ID	79903299
Element description	Build-up ? (from outside) two layers felt nominal 10mm, insulation 180mm, membrane layer (vapour barrier), structural build up separate, Vapour Control Layer, 15mm Knauf Comfortboard Lining		

Type	Component	Description
Cladding & Roof Covering - Asphalt	Asphalt roofing, 20mm, sheathing felt	two layers felt nominal 10mm
Insulation - Structural	Foamed glass, 200mm	insulation 180mm
Membrane - All Types	Vapour control membrane, aluminium foil	membrane layer (vapour barrier)
Roof Structure - Steel	Steel profiled metal deck for built-up roof system	structural build up separate
Membrane - All Types	Vapour Control Layer (contains aluminium foil for low emissivity)	Vapour Control Layer

Type	Component	Description
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, high density, 15mm	15mm Knauf Comfortboard Lining

**CALCULATED GREEN GUIDE RATING:****B**kg CO<sub>2</sub>/m<sup>2</sup>

111.69

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PROJECT			
Project name	Hall School		
Project reference			
Address	London		
BREEAM assessment Reference			
EcoHomes reference			
CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	Internal Wall : Proprietary and Demountable Partitions	ID	79903305
Element description	1 x 12.5mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm ?C?		

Type	Component	Description
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	12.5mm dense plasterboard
Wall Structure - Steel	Light steel structure for external loadbearing wall	70mm ?C?
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	12.5mm dense plasterboard

**CALCULATED GREEN GUIDE RATING:**

**A+**

kg CO<sub>2</sub>/m<sup>2</sup>

24.02

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Project name	Hall School		
Project reference			
Address	London		
BREEAM assessment Reference			
EcoHomes reference			
CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	Internal Wall : Framed Partitions	ID	79903306
Element description	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> ) either side of a 70mm 'C' stud,		

Type	Component	Description
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> )
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> )
Wall Structure - Steel	Light steel structure for external loadbearing wall	70mm 'C' stud
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> )
Sheeting/Decking/Finishes - Plasterboard	Plasterboard, 12.5mm	2 x 15mm dense plasterboard (>800kg/m <sup>3</sup> )

## CALCULATED GREEN GUIDE RATING:

**A**kg CO<sub>2</sub>/m<sup>2</sup>

33.38

Date printed: 14/10/2016

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Green Guide Assessment does not imply that BRE Global have assessed the technical performance of this specification



# Green Guide Calculator Result

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Telephone	020 7962 1333	Email	ben.pratt@dargroup.com

PROJECT			
Project name	Hall School		
Project reference			
Address	London		
<b>BREEAM assessment Reference</b>			
<b>EcoHomes reference</b>			
<b>CSH reference</b>		<b>Code level</b>	

SPECIFICATION			
Scheme	Schools		
Element type	Internal Wall : Proprietary and Demountable Partitions	ID	79903307
Element description	Glass spec varies depending on wall type.		

Type	Component	Description
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**CALCULATED GREEN GUIDE RATING:** -

kg CO<sub>2</sub>/m<sup>2</sup> 0.00

Date printed: 14/10/2016

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# Green Guide Calculator Result

ASSESSOR			
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Telephone	020 7962 1333	Email	ben.pratt@dargroup.com

PROJECT			
Project name	Hall School Existing		
Project reference			
Address	London		
BREEAM assessment Reference			
EcoHomes reference			
CSH reference		Code level	

SPECIFICATION			
Scheme	Schools		
Element type	External Wall Construction : Brick, Stone & Block Cavity Wall	ID	79903483
Element description	Blockwork, 292mm, 21 N/mm <sup>2</sup> w/cavity with external bricks		

Type	Component	Description
Wall Structure - Block	Blockwork, aircrete, external leaf, 140mm, cement mortar	
Cavity - Airspace	Cavity (any size)	
Wall Structure - Block	Blockwork, aircrete, external leaf, 140mm, cement mortar	

**CALCULATED GREEN GUIDE RATING:**

**A+**

kg CO<sub>2</sub>/m<sup>2</sup>

62.17

Date printed: 28/10/2016

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Green Guide Assessment does not imply that BRE Global have assessed the technical performance of this specification