GOSH CCC
Whole Life-Cycle Assessment

20/05/2022

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NHS
Great Ormond Street Hospital for Children
NHS Foundation Trust

BDP.

A.1.1 Document History

Revision	Date	Author	Checked by	Description of Change
P00	17/01/22	NB	PG	Initial Draft
P01	04/02/22	NB	PG	Draft for Comment
P02	25/03/22	NB	PG	Revised to suit comments
P03	13/05/22	NB	PG	Issue for Planning

Executive Summary

This document serves as the Whole Life Carbon Assessment for the proposed Great Ormond Street Hospital Children's Cancer Centre (GOSHCCC) development, in accordance with GLA guidance. The project involves the replacement of the existing Frontage Building with a new build hospital building as part of the next phase of development at Great Ormond Street Hospital (Phase 4). The activities that support the conclusions of this document were undertaken during RIBA Stages 3 that ran from April 2021 to March 2022, and therefore were informed by the GLA's Whole Life-Cycle Carbon Assessments Guidance consultation draft, October 2020.

This report should be read in conjunction with the GLA Whole Life Carbon Assessment Excel issued alongside.

Table 1. WLC emissions for Assessments 1 and 2.

Building Element	Assessment 1 - SAP 10 emissions factors ($kgCO_2e$)	Assessment 2 - Future emissions factors ($kgCO_2e$)
1. Substructure	847,092.77	847,092.77
2.1-2.4 Superstructure	4,112,172	4,112,172
2.5-2.6 Superstructure	573,898	562,306
2.7-2.9 Superstructure	590,433	590,433
3. Finishes	929,034	929,034
4. FFE	Not modelled	
5. Services (MEP)	2,722,000	2,722,000
6. Prefabricated buildings	Not modelled	Not modelled
7. Work to existing building	Not modelled	Not modelled
8. External Works	6,452	6,452
Other	2,100,000	2,100,000
Operational Energy and water	101,536,311	72,211,710
Total	113,417,269	84,081,075

The proposed building energy strategy has been developed to meet the requirements of the London Plan and the London Borough of Camden's demand for operational net zero carbon emissions.

Passive (Be Lean) measures include the incorporation of high performance building fabric with low U-values within the NHS net zero guidance range, optimised window to wall ratio, and external shading through balconies and windows recess. Details of the fabric envelope have been summarised in Table 2.

Table 2. Fabric Envelope Characteristics

Element	Properties	NHS Net Zero Guide
Ground Floor U-value (W/m^2k)	0.12	0.10-0.12
External Walls (South East Facade) U-value (W/m^2k)	0.13	0.12-0.15
External walls (North Facade) U-value (W/m^2k)	0.15	0.12-0.15
Roof U-value (W/m^2k)	0.12	0.10-0.12
Glazing U-value U-value (W/m^2k)	1.2	1-1.2
Percentage glazing (%)- South-East Facade	35%	25-40%
Percentage glazing (%)- North Facade	25%	25-40%

To address the London Plan Policy SI3, the heat hierarchy was followed and connection to the existing CHP/boiler site system prioritised to provide hot water to the building. There is insufficient capacity to provide primary heating and cooling from the existing site network and its reliance on fossil fuel is penalised by the SAP10 carbon factors. GOSHCCC connects into the existing site network so that it can benefit from the site-wide network when it decarbonises in the future.

Electrically driven heat pumps employing heat recovery between cooling and heating modes are proposed as the primary source of heating and cooling. Through the decarbonisation of the grid, the heating and cooling associated carbon emissions are expected to go down in the future.

Embodied carbon has been optimised through the design of a highly efficient structure and the incorporation of recycled content in the materials selected. The embodied carbon results align with current best practice in hospitals.

Further optimisations to the materials selection have been identified for the project team to explore in the current and later RIBA stages.

The life cycle module that constitutes the greatest proportion of the total Whole Life Carbon emissions of the development is Module B6: Operational Energy use, at 89% of the total Whole Life Carbon emissions using SAP10 carbon factors. The Operational energy B6 decreases by 29,101,040 $kgCO_2$ using the future emissions carbon factors (Assessment 2). This highlights the importance of the decarbonising grid on whole life carbon assessments.

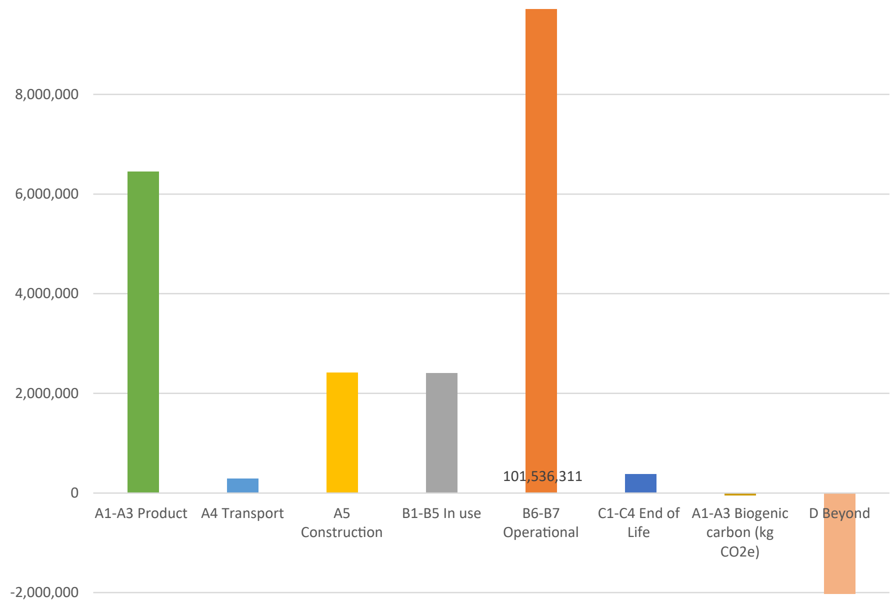

Figure 1. Whole Life Carbon Emissions - SAP10 Emissions Scenario ($kgCO_2e$)

Contents

1 Introduction

1.1 Project Overview

The proposals for GOSHCCC involve the replacement of the existing Frontage Building with a new build hospital building as part of the next phase of development at Great Ormond Street Hospital (Phase 4). This represents an increase of 12,325m² on the existing footprint, as the current building provides significantly less space than required by the Cancer Centre. The Frontage building site is proposed to deliver all of the essential elements and functions of the GOSH Children's Cancer Centre as illustrated in the sketch below, as well as provide a new main entrance to the Hospital.

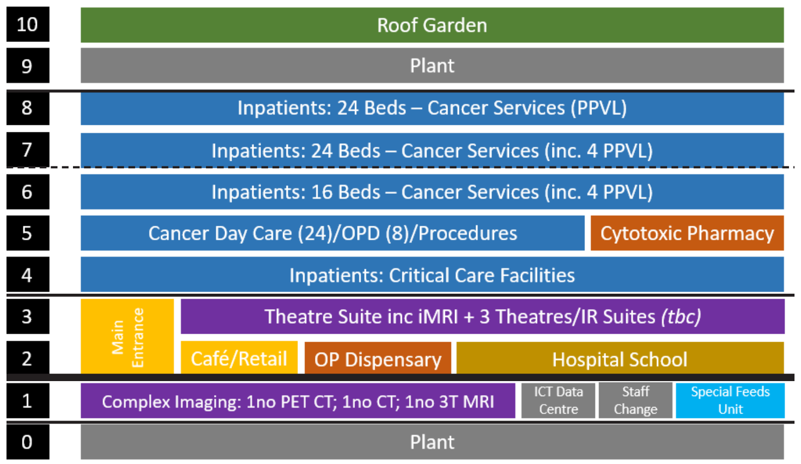

Figure 2. Essential elements and functions of the GOSHCCC

The GOSHCCC includes direct connections into adjacent GOSH buildings, improving efficiency of space use and responding to the need of clinical services, consequently reducing resource consumption.

The activities that support the conclusions of this document were undertaken during RIBA Stages 3 that ran from April 2021 to March 2022, and therefore were informed by the GLA's Whole Life-Cycle Carbon Assessments Guidance consultation draft, October 2020.

1.2 RICS Methodology

The RICS professional statement: Whole Life Carbon Assessment (WLC) for the Built Environment, released in 2017, seeks to standardise WLC assessment and enhance consistency in outputs by providing guidance on implementing the broad appraisal methodology set out in EN 15978: Sustainability of Construction Works. The Greater London Authority have adopted the RICS WLC methodology in their guidance methodology for Whole Life Carbon assessment of referable planning applications.

As part of the requirement of the RICS methodology, a minimum of 95% of the capital cost allocated to each building element category was accounted for at each stage of the WLC assessment.

The building elements are broken down according to the RICS New Rules of Measurement (NRM) classification system:

1. Substructure
2. Superstructure
3. Finishes
4. Fittings, furnishings and equipment (FF&E)
5. Building services/MEP
6. Prefabricated Buildings and Building Units
7. Work to Existing Building
8. External Works

The breakdown of sub elements included can be seen in section 3.2 of this report.

The operational and embodied carbon estimates from construction and materials for applicable life-cycle stages A1 – C4 are estimated for a life-cycle of 60 years.

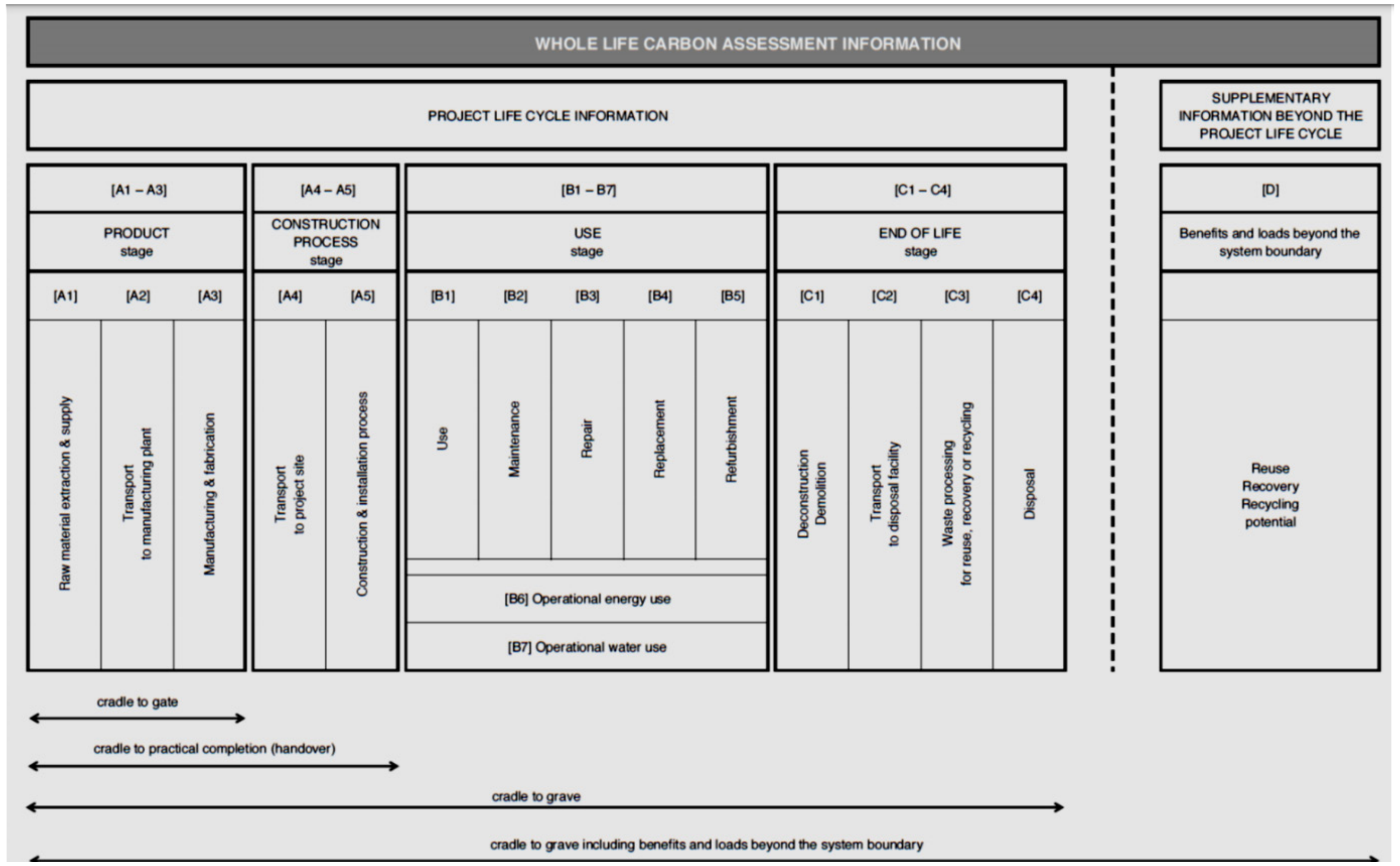

Figure 3. EN 15978 Whole life Carbon Assessment

1.3 UKGBC Net Zero Carbon Definition

As a response to mainstream scientific consensus on the urgent need to reduce carbon emissions, the UK Government has legislated to achieve Net Zero carbon by 2050. As part of the definition of Net Zero, the UK Green Building Council has developed a Framework Definition, which includes embodied carbon emissions and this definition is widely being used to develop a roadmap to the 2050 Net Zero target.

Whilst the UKGBC provides an approach for reducing and offsetting carbon for Modules A and B6, currently the approach has not set out a methodology for the appraisal of Whole Life Carbon, which is still being developed (see figure 4). As per the NHS net zero carbon brief, the project will be aligning to the UKGBC framework.

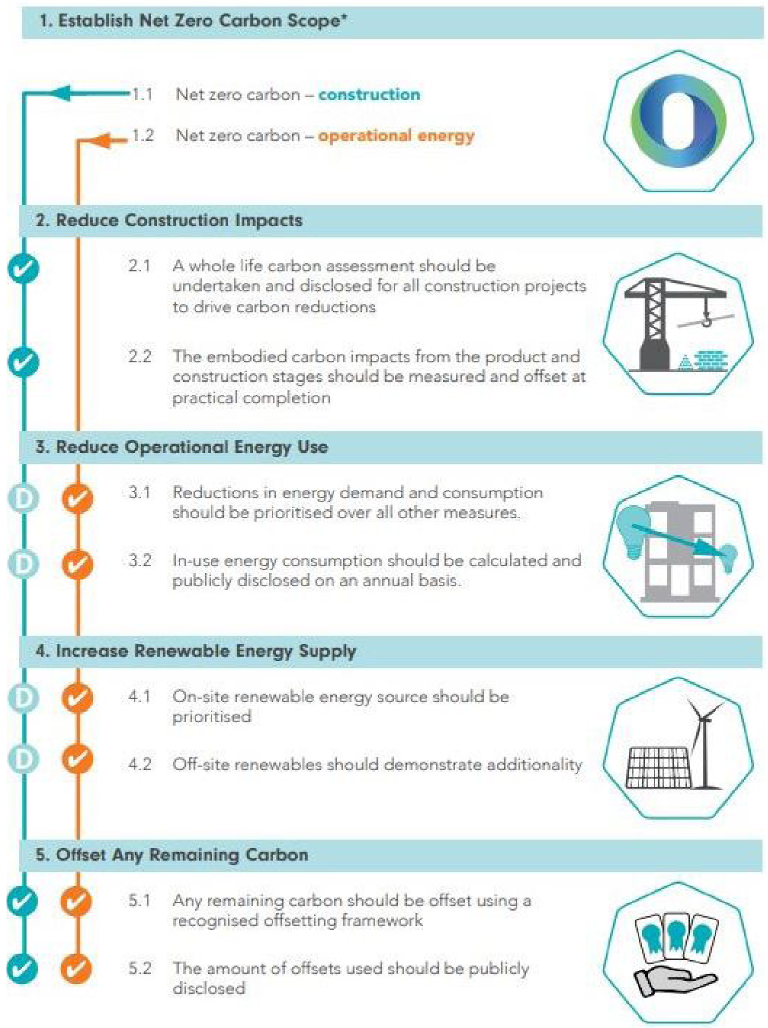

Figure 4. UKGBC Net Zero Carbon Framework

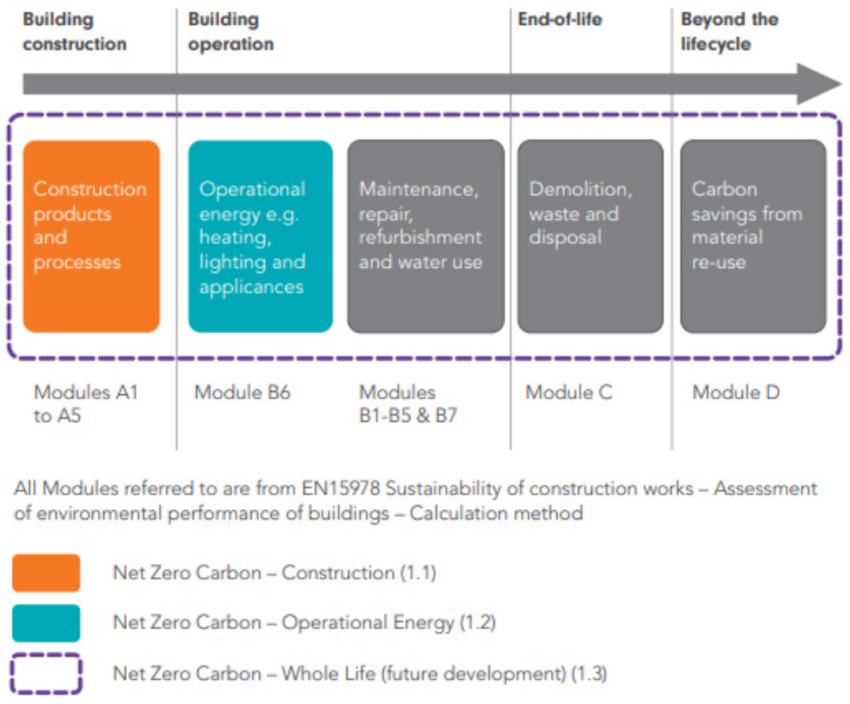

Figure 5. UKGBC Net Zero Carbon Scope

1.4 NHS England Net Zero Carbon Guidance

The NHS is currently preparing a new Net Zero Carbon Hospital Standard, which is due to be formally released in mid-2022.

The requirements and definitions of this document will set the performance standards for new hospitals. The report will outline the performance requirements of new build and refurbishments for new hospital development. The guidance is anticipated to set project-specific performance targets based on a range of contributing factors that are defined by tools and guidance frameworks in the early designs stages. This will permit flexibility in scale, location and function rather than applying standardised targets that do not account for the wide range of healthcare facilities.

1.5 Circular Economy

The construction and operation of the built environment consumes 60% of all materials in the UK. At the end of life, materials are often diverted from landfill, but in reality, down-cycled, reducing their value.

There is growing industry consensus that the way we design, build, operate and dispose of our buildings and associated facilities needs a major overhaul to obviate waste and increase efficiency. This shift will create significant opportunity across the entire supply chain.

Designing for longevity and adaptability and maximizing the use of recycled and renewable materials could reduce greenhouse gas emissions while increasing innovation opportunities and economic growth. Replacing finite and fossil-based materials with responsibly managed renewable materials can decrease carbon emissions whilst reducing dependency on finite resources.

By considering the carbon emissions of a development from a whole life perspective, design decisions can be made to not only minimize embodied carbon in construction, but it can assist to produce a development which reduces resource consumption throughout its use, extending life cycles of products, maximizing re-use of building components and ensuring that all components are considered as a 'product resource', rather than 'product waste'.

2 Methodology

2.1 Assessment Scope

The assessment WLC emissions consists of the following sections: total operational carbon emissions (regulated plus unregulated); embodied carbon emissions; and any future potential carbon emission 'benefits', post end-of-life, including benefits from reuse and recycling of building structure and materials.

This assessment has been undertaken in line with the draft GLA guidance for undertaking WLC Assessments and therefore in line with the RICS Professional Statement: Whole Life Carbon Assessment for the Built Environment.

2.2 Operational Energy

In line with the draft GLA guidance, the operational carbon emissions are calculated based on an early stage TM54 analysis for the Proposed Development. This encompasses carbon emissions related to both regulated and unregulated energy uses, accumulated over a 60-year study period.

The outputs of the Dynamic Simulation analysis include:

- Regulated energy consumption (heating, cooling, auxiliary, lighting and hot water);
- Unregulated energy consumption, not regulated under Building Regulations Part L but estimated using the TM54 methodology (Catering, server rooms, Lifts and Escalators, Small Power, other equipment)

A dynamic simulation model (DSM) using IES, a software approved by DCLG for Part L2A calculations was used:

- Near field shading (local buildings) has been modelled;
- HVAC was modelled with basic 'Apache systems'.

Software used: IES Virtual Environment 2021

The analysis was supervised by a CIBSE accredited Low Carbon Energy Assessor (LCEA).

A more detailed TM54 Analysis will be carried out on the project later in the current design stage. This analysis will provide a better understanding of operational energy consumption and will inform the ongoing design process.

2.3 Embodied Carbon

To assess the embodied carbon for the project, a Life Cycle Assessment (LCA) tool – One Click LCA – has been used to make allocations for the anticipated materials quantities in an inventory analysis. The materials are represented within the model by using materials with associated Environmental Product Declarations (EPDs).

EPDs are produced by manufacturers and identify the carbon emissions of a product. By scheduling the materials proposed for the development, the overall carbon emissions can be approximated.

It should be noted here that the LCA tool has a limited database of materials. In the scenario where a specified material isn't included in the database, the most similar material in terms of material composition is selected instead.

In line with standard UK practice, the LCA process and results included by this report have been assessed in line with BS 15978:2011 and the RICS Professional Statement: Whole Life Carbon assessment for the built environment. All EPDs used have been produced in line with the requirements of BS EN 15804:2012. Hence, each material has been assessed against the following life cycle stage:

- A1-A3: Product stage
- A4: Material transportation to site
- B4-B5: Replacement and maintenance
- C1-C4: End of life

Both current and future emissions factors were implemented within the One Click LCA tool parameters options, applying SAP10 and future emissions projections for operational carbon and applying the GLA future emissions discount for embodied carbon.

2.4 Emissions Factors

The carbon intensity of grid supplied electricity is reducing as more renewable energy is coming online. The Department of Business, Environment and Industrial Strategy (BEIS) provide grid projections to 2035 (revised annually) that demonstrate this projected fall in carbon intensity.

The current Part L uses outdated SAP 2012 carbon factors that do not reflect recent trends in decarbonisation of 'grid' supplied energy. SAP 10 carbon factors reflect real carbon intensities more accurately. SAP 10 factors have been encouraged by the GLA Energy Assessment Guidance but have not yet been incorporated in UK Building Regulations compliance modelling. Using SAP 2012 carbon conversion factors to inform an approach to design would continue to encourage the uptake of combustion technologies due to the low carbon intensity of gas and comparably high carbon intensity of electricity, which is not the case.

For the purpose of this report and in order to more accurately estimate the annual carbon emissions, carbon emission conversion factor projections from BEIS have been used. The figure below articulates the comparison between SAP 2012, SAP 10 and BEIS emission factors.

Following the GLA's Whole Life-Cycle Carbon Assessment Guidance Consultation Draft, two sets of WLC calculations have been produced. The Assessment 1 has been based on the current status of the electricity grid considering that there will be no future changes in carbon factors. The associated operational carbon emissions have been estimated, applying SAP 10 carbon emissions factors in line with the GLA's Energy Assessment Guidance.

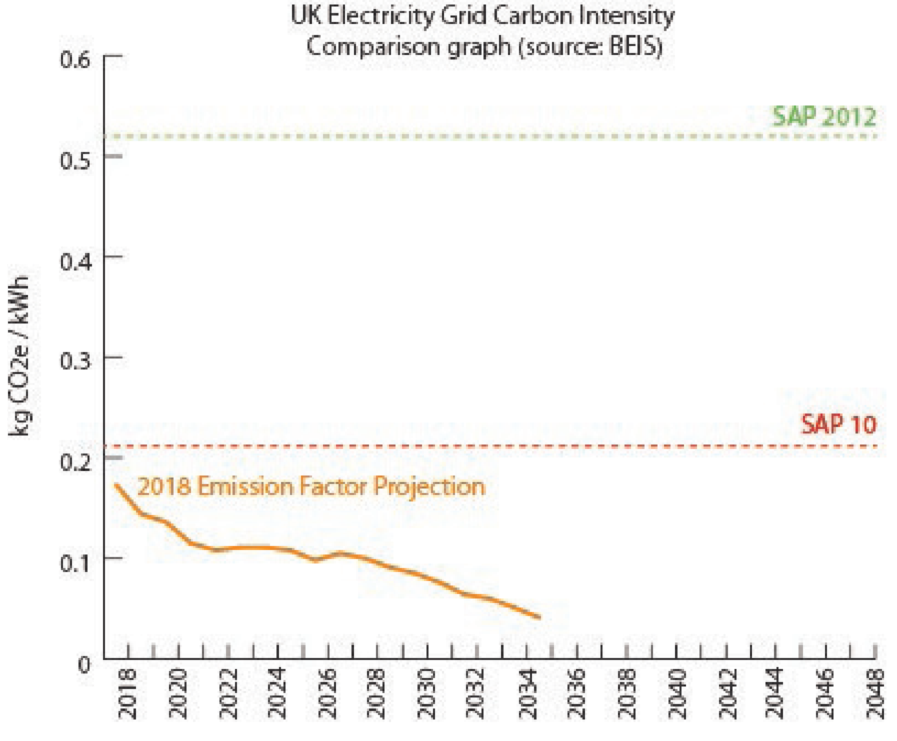

Figure 6. BEIS Emission Factor Projections

3 Data Inputs

Assessment 2 has taken into consideration the decarbonisation of the electricity grid, for the calculation of the associated operational carbon (B6) as well as the embodied carbon in the Use stage (B1-B6) and the beyond building life-cycle stage (D). The estimation of the decarbonisation of the grid for the operational energy is in accordance with the BEIS emissions projections. The embodied carbon decarbonisation factors come from the National Grids Future Energy scenarios.

This report presents and analyses the results from Assessment 1. However, an assessment accounting for future decarbonisation of both material and operational energy has been included in both this report and GLA WLC Assessment template.

3.1 Operational Energy

Weather data

The Test Reference Years are synthetically generated from average months selected from a historical baseline of 1984 to 2004. 2005 weather files are the most current TRY weather data sets for 14 UK locations - this is used in line with CIBSE Guide A and the NCM Modelling Guide 2013.

- Location: London
- CIBSE 2005 Test Reference Year

Geometry

The geometry is consistent across both the overheating and energy strategy simulations. It is based on the BIM models as well as internal discussions with engineers and architects. The orientation is constrained by adjacent buildings, the existing hospital building and Great Ormond Street.

Shading

- The shading from adjacent buildings and external buildings has been modelled

NCM Assignments

Spaces are proportioned by space type to reasonably match the schedule of spaces exported from Revit and translated into the NCM templates.

Fenestration

The percentage glazing complies with the NHS net zero guideline, and was modelled as 35% for the South-East Facade, 25% for the North Facade, as per the architectural latest drawings. The external balconies and external architectural features were also modelled.

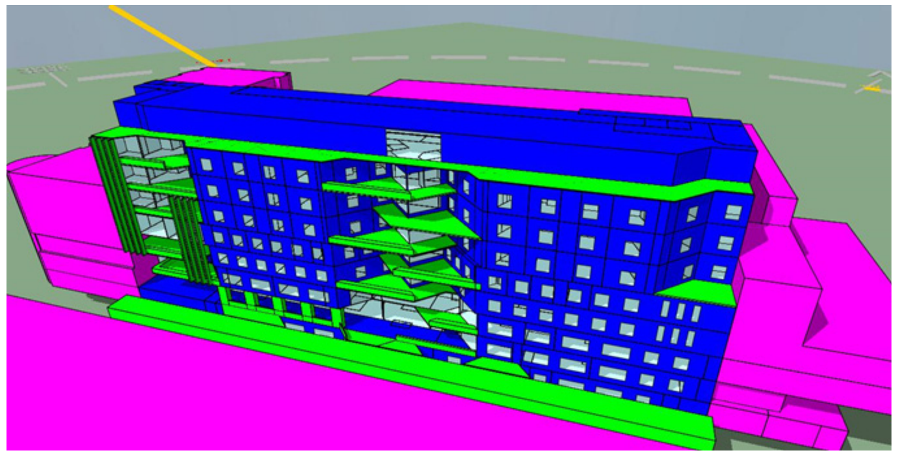

Figure 7. IES Model view

Table 3. Fenestration Model Input Values

U-value (glazing + framing)	g-value
1.2	0.34

Building Fabric

Table 4. Building Fabric Model Input Values

Element	U-value (W/m²k)
Ground Floor	0.12
External Walls (South East Facade)	0.13
External walls (North Facade)	0.15
Roof	0.12

Air Permeability

Air permeability was set at 2m³/h/m² @ 50 Pa.

Building Services

Table 5. Building Services Model Inputs

	Parameters
Heating	ASHP SCOP =3.88
Cooling	ASHP SEER = 4.55
DHW	Existing Site Network (CHP/ Boilers system)
Ventilation	Mechanical (Air Sealed Building)

Air Handling Units

Table 6. Air Handling Units Inputs

	Mechanical Ventilation (AHU)
Central SFP (Before adding HEPA filter)	2.0 W/l/s
Central SFP (With HEPA filter)	2.9 W/l/s
Heat Recovery (Level 7-8 run around coils)	68%
Heat Recovery (All other floors- Plate Heat Exchanger)	75%

Lighting

Table 7. Electrical Model Inputs

Electrical	
Power Factor Correction	>0.95
Average Lighting Efficacy	90 lm/w

3.2 Embodied Carbon

The table below lists the building elements covered by the assessment, in line with the Royal Institute of Chartered Surveyors (RICS) Professional Statement: Whole Life Carbon assessment for the built environment.

Table 8. RICS NRM Sub Level 2 Embodied Carbon Calculation Inputs

Building Element Group	Building Element (NRM level 2)	Basis of Information
Demolition	0.1 Toxic/hazardous/contaminated material treatment	An allowance for contaminated land removal and treatment has not been included for the Proposed Development at this stage of the design
	0.2 Major demolition works	Pre Demolition audit
0 Facilitating works	0.3 & 0.5 Temporary/enabling works	Due to the early stage of the design (mid RIBA Stage 3) this information is not yet available and as such has not been included in the assessment
	0.4 Specialist groundworks	No specialist ground works were included; individual ground works accounted for in the relevant substructure / external landscaping sections
1 Substructure	1.1 Substructure	OCLCA, using EPDs was used to model the substructure. BIM model and drawings used to determine quantities of materials
2 Superstructure	2.1 Frame	OCLCA, using EPDs was used to model the structural steel and concrete frames. BIM model and drawings used to determine quantities of materials
	2.2 Upper Floors	OCLCA, using EPDs was used to model the precast and insitu concrete upper floors. BIM model and drawings used to determine quantities of materials
	2.3 Roof	OCLCA, using EPDs was used to model the precast concrete and green roofs. BIM model and drawings used to determine quantities of materials
	2.4 Stairs and Ramps	OCLCA, using EPDs was used to model the insitu concrete stairs. Material quantities were estimated from drawings and BIM model
	2.5 External Walls	OCLCA, using EPDs was used to model the precast concrete facade. BIM model and drawings used to determine quantities of materials
	2.6 Windows and external doors	This was included in the Facade calculation. External doors were included in the glazing component
	2.7 Internal walls and partitions	OCLCA, using EPDs was used to model the internal partitions. BIM model and drawings used to determine quantities of materials
	2.8 Internal doors	OCLCA, using EPDs was used to model the internal partitions. Estimations on the area doors was made from the BIM model and drawings
3 Finishes	3.1 Wall finishes	Wall finishes were included in the preset internal wall build-ups from the EPDs in OCLCA
	3.2 Floor finishes	OCLCA, using EPDs was used to model the vinyl flooring. BIM model and drawings used to determine quantities of materials
	3.3 Ceiling finishes	OCLCA, using EPDs was used to model the general and theatre ceilings. BIM model and drawings used to determine quantities of materials
4 FF&E	4.1 Fittings, furnishings & equipment	Due to a lack of data and EPDs at this stage FFE was excluded from the assessment
5 Building services/MEP	5.1–5.14 Services incl. building-related and non-building-related	Building services data uses data provided from the Energy strategy, which align with the proposed services strategy for the project. The lengths of duct's, electrical distribution and water distribution were calculated on a m^2 GIA basis using in-built EPD within OCLCA
6 Prefabricated Buildings and Building Units	6.1 Prefabricated buildings and building units	Not applicable
7 Work to Existing Building	7.1 Minor demolition/alteration works	OCLCA tool used to estimate embodied carbon associated with demolition works.
8 External works	8.1 Site preparation works	Due to the early stage of the design (mid RIBA Stage 3) this information is not yet available and as such has not been included in the assessment
	8.2 Roads, paths, paving and surfacing	Modelled in OCLCA using best estimated EPDs. Data for roads, paths, paving and surfacing is based on architectural drawings and cost plans
	8.3 Soft landscaping, planting and irrigation systems	Modelled in OCLCA using best estimated EPDs. Data is based on architectural drawings and cost plans
	8.4 Fencing, railings and walls	*Excluded from the assessment due to lack of available data*
	8.5 External fixtures	*Excluded from the assessment due to lack of available data*
	8.6 External drainage	*Excluded from the assessment due to lack of available data*
	8.7 External services	*Excluded from the assessment due to lack of available data*
	8.8 Minor building works and ancillary buildings	No allowance was considered for minor building works and ancillary buildings

4. Results

4.1 Assessment 1

This section details the whole life carbon impact for Assessment 1, using current SAP 10 emissions factors for the operational energy and embodied carbon modelling detailed in sections 4 and 5 of the report.

Table 9. Operational Energy Consumption for Assessment 1

Operational Energy Consumption (kWh/m²)	
Regulated Energy	397.6
Unregulated Energy	198.4
Total	596

Table 10. 60 Year Absolute Carbon Emissions for Assessment 1

Assessment 1 - Current Emissions (SAP 10)	60 Year Carbon Emissions ($kgCO_2e$)
Operational Energy and Water (B6-B7)	101,536,311
Embodied Carbon (A1-A5)	9,103,899
Embodied Carbon (A-C)	11,880,958
Whole Life Carbon	**113,417,269**

Table 11. 60 Year Carbon Emissions Intensities for Assessment 1

Assessment 1 - Current Emissions (SAP 10)	60 Year Carbon Emissions ($kgCO_2e/m^2$)
Operational Energy and Water (B6-B7)	5,604
Embodied Carbon (A1-A5)	505
Embodied Carbon (A-C)	655
Whole Life Carbon	6,260

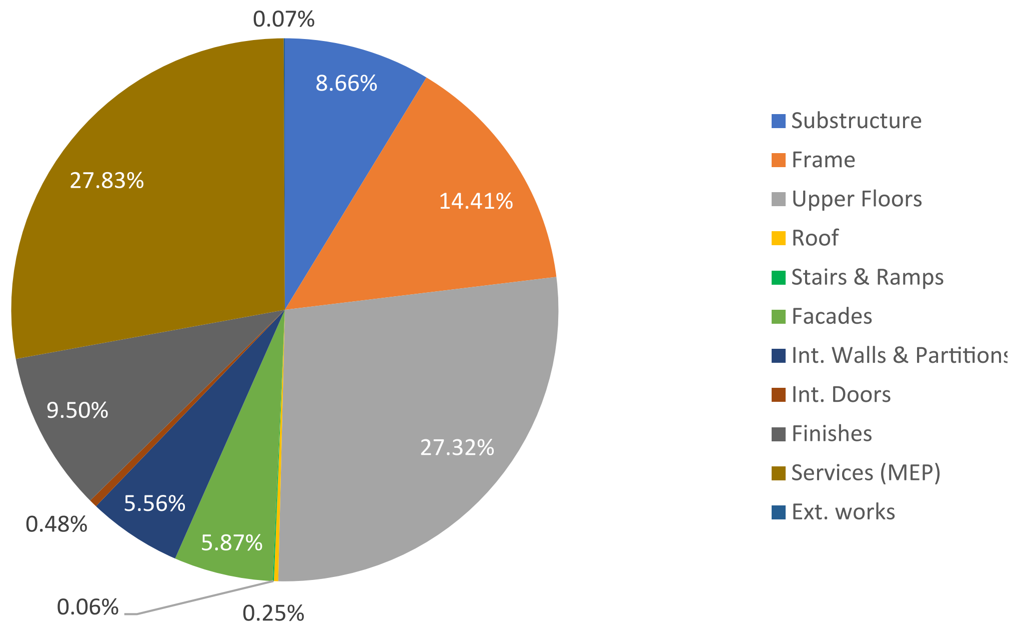

Figure 8. Embodied Carbon Emissions by RICS Category - Current Emissions ($KgCO_2e$)

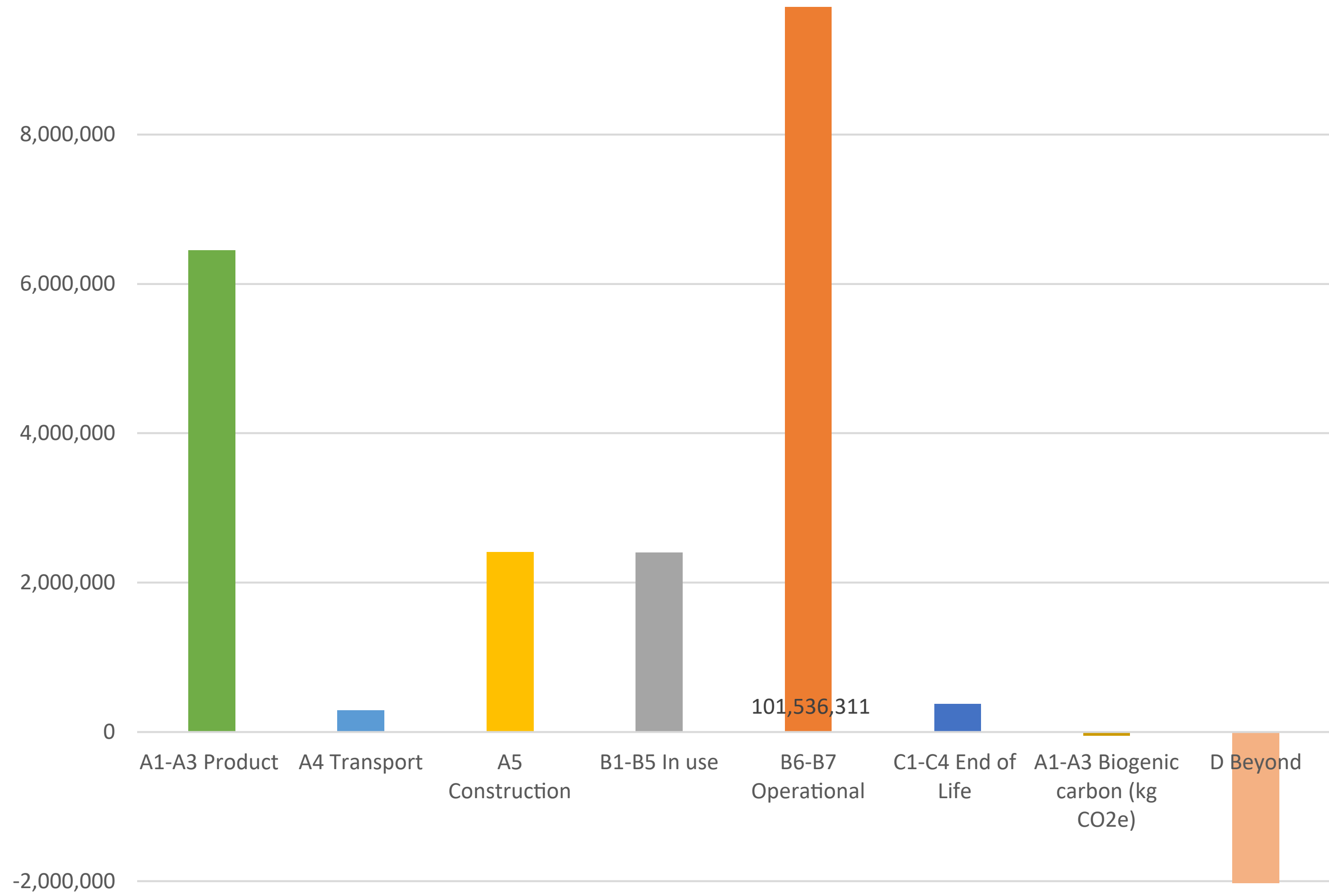

Figure 9. Whole Life Carbon Emissions - SAP10 Emissions ($KgCO_2e$)

4.2 Assessment 2

This section details the whole life carbon impact for Assessment 2, using future emissions scenarios for the operational energy and embodied carbon modelling detailed in sections 4 and 5 of the report.

Table 12. Operational Energy Consumption for Assessment 2

Operational Energy Consumption (kWh/m²)	
Regulated Energy	397.6
Unregulated Energy	198.4
Total	596

Table 13. 60 Year Absolute Carbon Emissions for Assessment 2

Assessment 2 - Future Emissions	60 Year Carbon Emissions ($kgCO_2e$)
Operational Energy and Water (B6-B7)	72,211,710
Embodied Carbon (A1-A5)	9,092,306
Embodied Carbon (A-C)	11,869,366
Whole Life Carbon	**84,081,075**

Table 14. 60 Year Carbon Emissions Intensities for Assessment 2

Assessment 2 - Future Emissions	60 Year Carbon Emissions ($kgCO_2e/m^2$)
Operational Energy and Water (B6-B7)	3,985
Embodied Carbon (A1-A5)	504
Embodied Carbon (A-C)	655
Whole Life Carbon	4,640

Assessment 2, forms the basis for the design teams approach to whole life carbon.

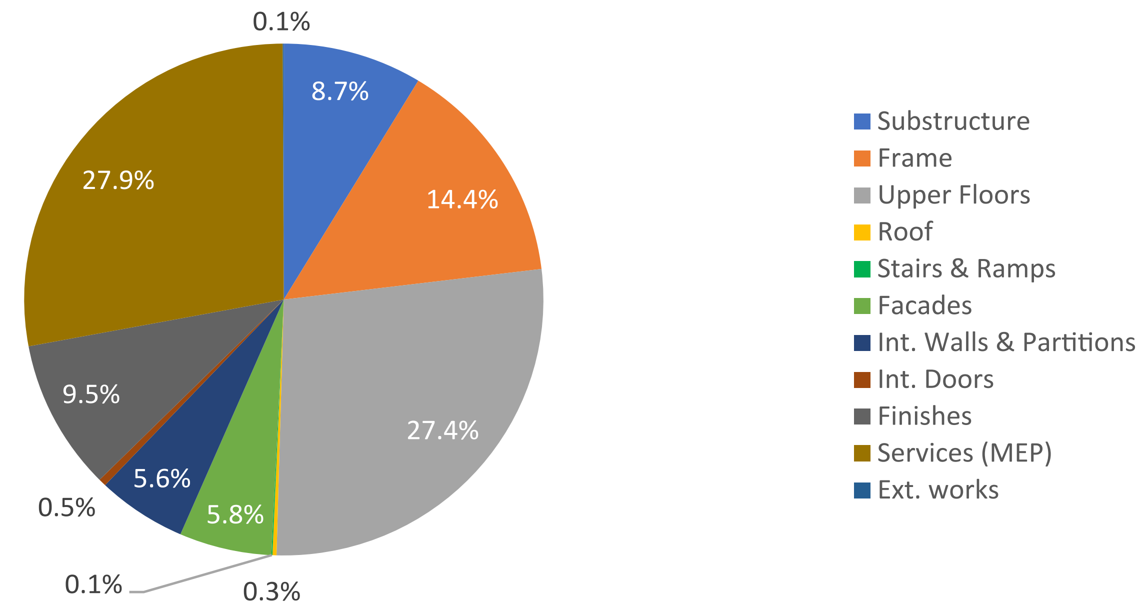

Figure 10. Embodied Carbon Emissions by RICS Category - Future Emissions (KgCO₂e)

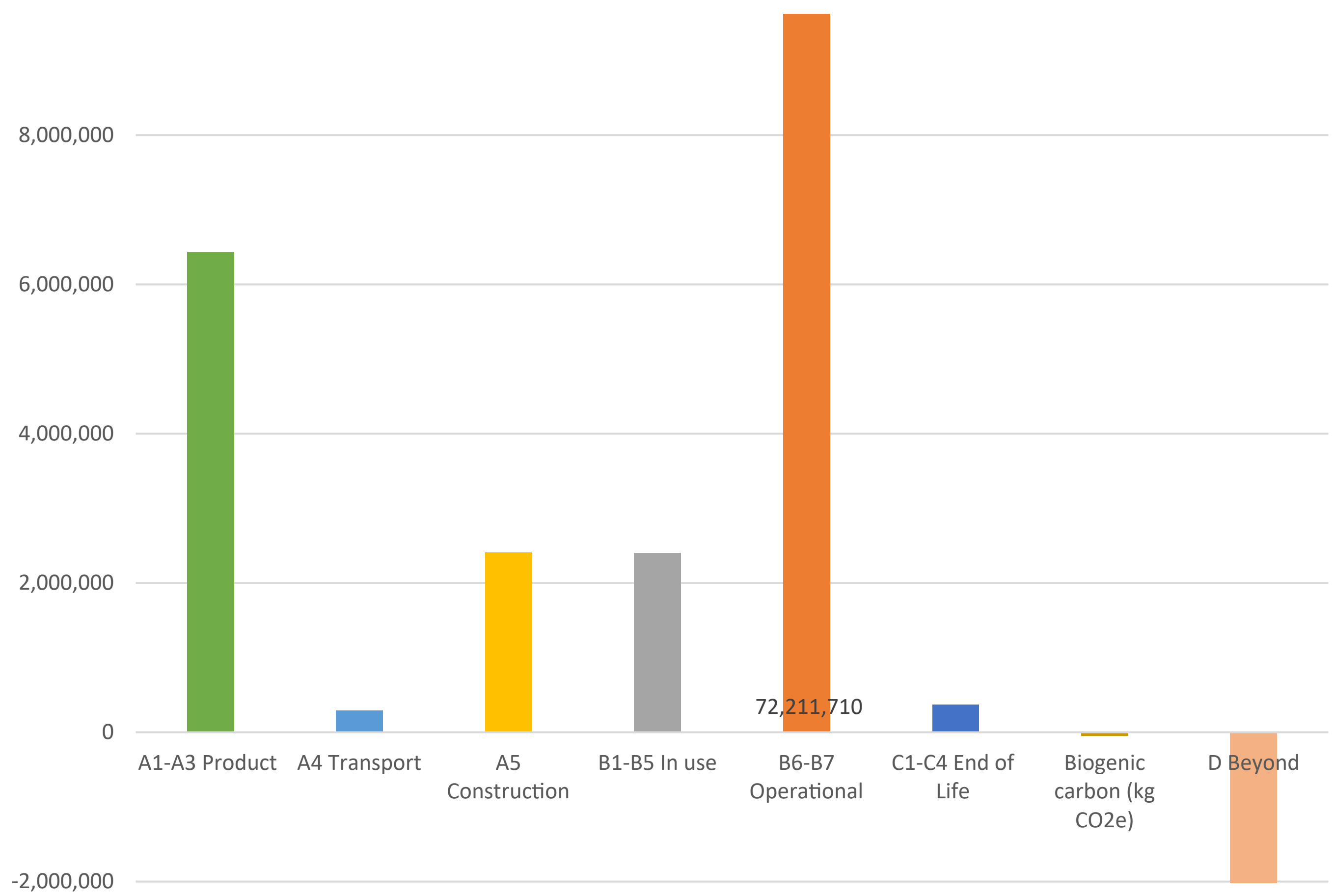

Figure 11. Whole Life Carbon Emissions - Future Emissions Scenario ($KgCO_2e$)

5. Benchmarking

5.1 Benchmarking

The NHS Net Zero Guide refers to the LETI Guidance A1-A5 benchmark: *"Useful reference documents on operational and embodied carbon have been produced recently from the London Energy Transformation Initiative (LETI) and the UK Green Building Council (UKGBC).*

Research by LETI suggests an embodied carbon target of 600kgCO2/m2 GIA (gross internal area) for non-residential buildings, although this target may be additionally challenging for healthcare projects. This is due to the requirement for many small rooms to provide patient privacy in consulting rooms, clinics and treatment rooms etc. Smaller rooms require the construction of more internal walls, and therefore an increased embodied carbon of material, but the target of 600kgCO2/m² GIA is still a target that could be adopted."

Table 15. Net zero performance targets for embodied carbon for Hospitals and Commercial Buildings

	2020	2025	2030
NHS Brief	Refers to the LETI targets		
LETI (Modules A1-A5)	600 $kgCO_2e/m^2$	-	350 $kgCO_2e/m^2$

Currently, the building appears to be performing in line with current benchmarks and future targets for Net Zero Carbon hospitals.

The building's performance was also compared to the GLA Whole Life-Cycle Carbon Assessment Guidance benchmark for offices using the One Click methodology shown on Page 32 which is based on the One Click average of 56 office buildings.

Table 16. Net zero performance targets based on One Click GLA Office benchmark

	Carbon at Completion (A1-A5)	Carbon Over Life Cycle
OneClick Office average	437	102

The GOSHCCC building is currently achieving 505.1 $kgCO_2/m^2$ (SAP10 Carbon Factors) for modules A1-A5, and Carbon over Life Cycle (B-C excluding operational energy) of 165.61 $kgCO_2/m^2$. This is slightly higher than the One Click average for offices, though is expected as a Hospital has more stringent material requirements for clinical vibration control (hence the use of concrete) and infection control which limits the choice of material.

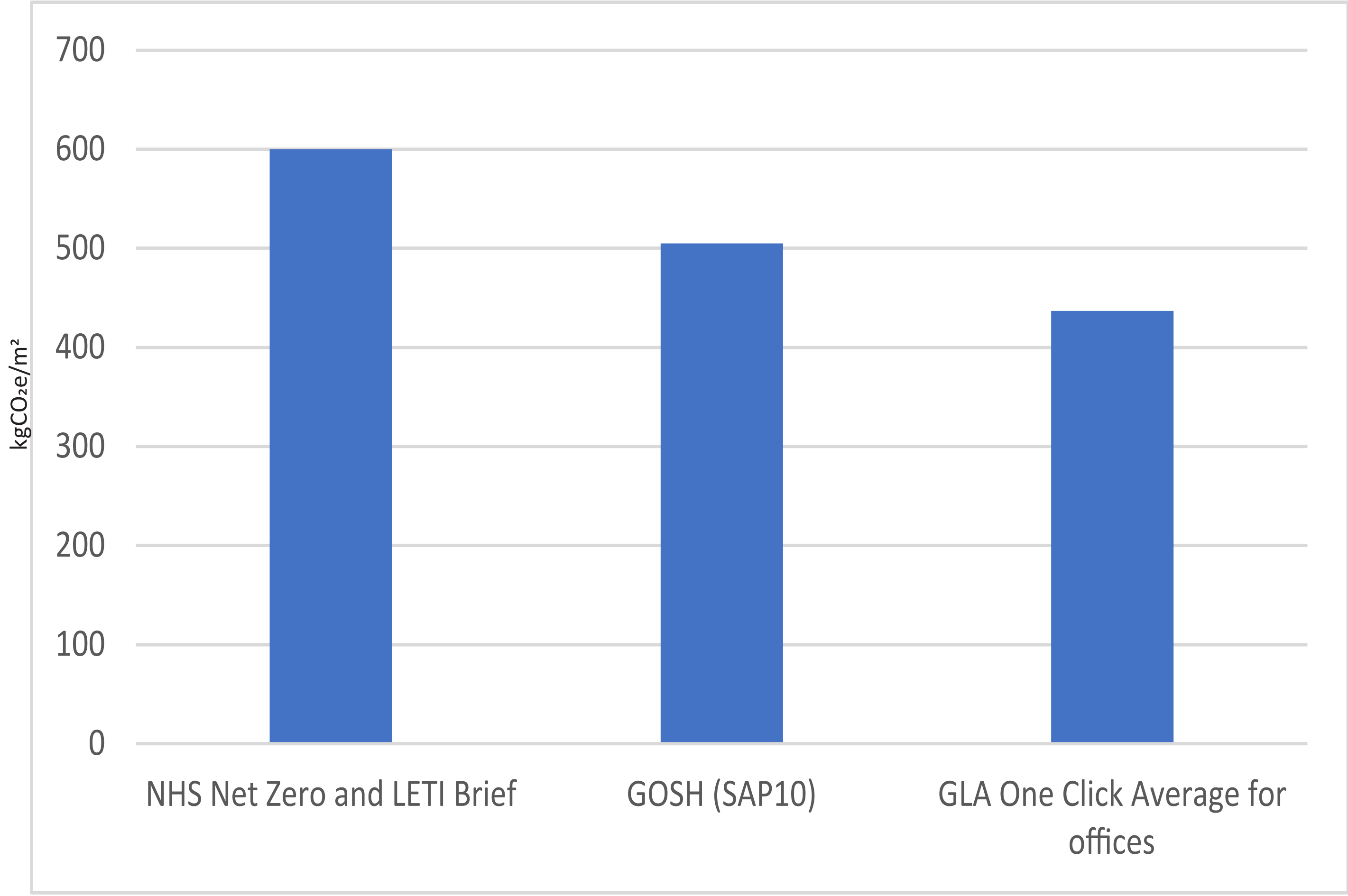

Figure 12. Embodied Carbon Intensity Modules A1-A5 ($kgCO_2e/m^2$) (SAP10 Carbon Factors)

6. Reducing Whole Life Carbon

6.1 Embodied Carbon Opportunities

Recognising the large impact of the structural solution on embodied carbon of the design, early analysis testing various options was undertaken:

- Concrete flat slab solution: adopted, due to its longevity, meeting vibration criteria and ability to be adapted
- CLT and Glulam solution: discounted as it does not meet the strict vibration criteria of a hospital housing sensitive equipment
- Concrete and slimfloor beams: discounted as it reduces potential for adaptability, and nearly doubled the embodied carbon relative to the flat slab concrete option
- CLT and slimfloor beams: discounted due to larger embodied carbon impact relative to flat slab concrete option (heavy concrete screed required in this option), and reduced potential for future adaptation

Further embodied carbon reduction optimisations will be identified and reviewed during the continued RIBA Stage 3 and 4 design development. These optimisations will need to be assessed against cost and feasibility.

The following optimisations will be tested and modelled in One Click LCA when detailed specifications are made, including fermacell plasterboard, alternative window frame solution, alternative finishes. All specifications selected will be interrogated for sustainability credentials, including embodied carbon, responsible sourcing and health impacts (e.g. VOC off-gassing).

6.2 Embodied Carbon Limitations

As part of the review into options to reduce embodied carbon, the following have been considered but discounted as options due to special requirements associated with a healthcare setting and fire regulations:

- More extensive use of timber/CLT frame: Discounted due to vibration and fire concerns
- Increased use of timber for internal finishes: Discounted due to infection control
- Timber cladding: Discounted due to fire and maintenance concerns
- Increasing GGBS beyond 50% aspiration: Discounted due to availability and construction feasibility, however this will be explored with the contractor and suppliers closer to procurement

6.3 Operational Carbon

The energy strategy has been developed in line with the energy hierarchy.

Passive (Be Lean) measures include the incorporation of high performance building fabric with low U-values within the NHS net zero guidance range, optimised window to wall ratio, and external shading through balconies and windows recess. These measures are considered and balanced against the embodied carbon of building materials and any increased material use.

To address the London Plan Policy SI3, the heat hierarchy was followed and connection to the existing CHP/boiler site system prioritised to provide hot water to the building. This efficiency of the system was further improved by lowering the distribution temperature from around 60 degrees celsius, which would be typical for a hospital, to 43 degrees celsius, which drastically reduces the heat loss from the network and is currently only employed in two hospitals in the UK. This is achievable by utilising copper-silver ionisation to mitigate legionella risk. There is insufficient capacity to provide primary heating and cooling from the existing site network and its reliance on fossil fuel is penalised by the SAP10 carbon factors. The proposed development building will be provided with connections to the existing site network so that it is fully integrated within the site-wide network when it decarbonises in the future.

Capitalising on the decarbonisation of the electricity grid, the proposals adopt an all-electric solution using heat pump technology to provide heating and cooling. Energy efficient mechanical and electrical services have been designed into the scheme including low energy light fittings, high efficiency ventilation systems with heat recovery.

The engineering systems chosen have been selected to be highly efficient in operation and include a selection of operating conditions to minimise standing losses and intelligent controls to closely match demand and supply, only delivering the service when needed.

7. Conclusion

7.1 Whole Life Carbon Emissions

This report has set out the Whole Life Carbon emissions estimated for the GOSHCCC building of the Great Ormond Street Hospital development in the London Borough of Camden, completed following the GLA Whole Life-Cycle Carbon Assessment - Pre-consultation draft guidance. Assessment 1 forms the basis of this Whole Life Carbon Assessment.

Table 17. Whole Life Carbon Emissions

Whole Life Carbon Scope	60 Year Whole life Carbon Emissions ($kgCO_2e$)
Assessment 1 Current Emissions (SAP10)	**113,417,269**
Assessment 2 Future Emissions	**84,081,075**

The life cycle module that constitutes the greatest proportion of the total Whole Life Carbon emissions of the development is Module B6: Operational Energy use at 89% of the total Whole Life Carbon emissions using SAP10 carbon factors. The Operational energy B6 decreases by 29,101,040 $kgCO_2$ using the future emissions carbon factors (Assessment 2). This highlights the importance of the decarbonising grid on whole life carbon assessments.