ICE-BERG

BOORD STREET, GREENWICH

PBSA

WHOLE LIFE CYCLE CARBON ASSESSMENT (WLCA)

Document no.: BST-WLCA-001

Project: 26-011

RIBA Stage 4, September 2026

Revision: 0

Issued for planning

ICE-BERG is a trading name of ICE-BERG Building Physics Ltd a company registered in England and Wales.

Company ref.: 12562278

Revisions:

Revision	Status	Description of revision	Date	Prepared:	Checked:	Reviewed:
0	For comment	Technical design stage	Sep 2026	C. Yates	C. Yates	LVM

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EXECUTIVE SUMMARY

The GLA treats WLCA is a live process which evolves as design and construction move through RIBA stages, into the occupancy and operation of a facility. Early stages involve significant levels of uncertainty. Certainty increases as the project progresses, only maturing to full confidence once the project has been complete and has been operating for at least a couple of years. At this stage, we are approaching construction phase and have gained certainty over significant aspects of the supply chain. However, confidence is not yet 100% complete. This report reflects the "live" nature of the process, and it is important that the change record is kept up to date with each issue stage.

The analysis has been undertaken using the One Click LCA software tool using the GLA module by a suitably qualified person with quality and verification oversight.

Embodied Carbon Contribution:

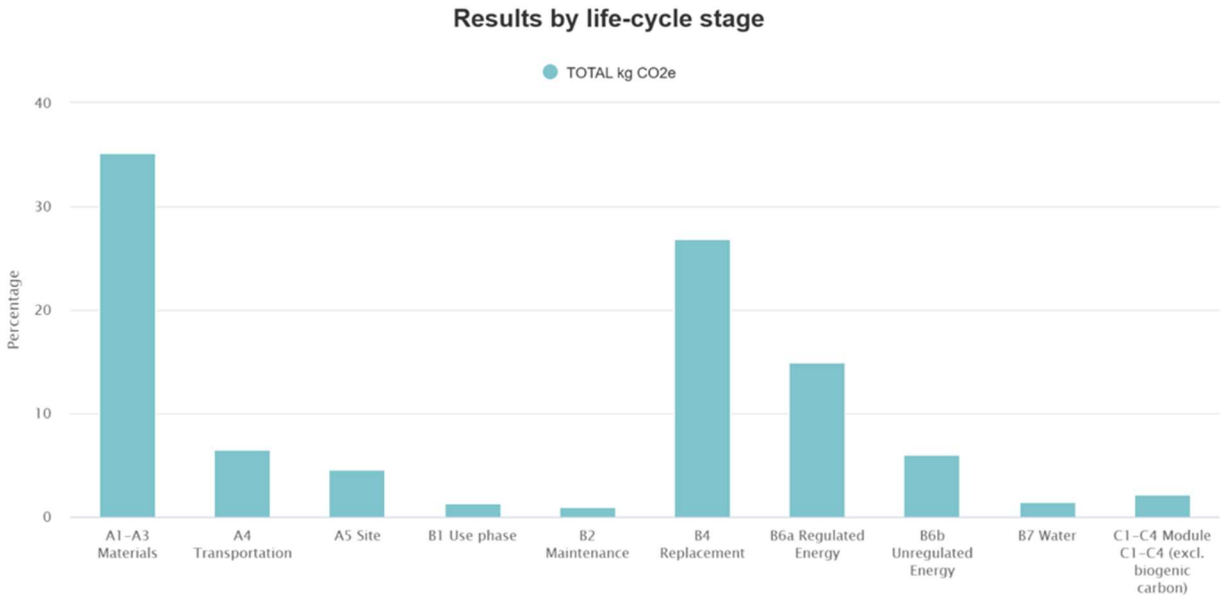


Figure 1: CO_2 contribution through life cycle stages

- The life cycle environmental impact is currently calculated at 13,100 tonnes (including preconstruction demolition and sequestered carbon).

Benchmark comparison:

Comparison of WLC assessment results of the proposed development with GLA WLC Benchmarks :

Table 1: Comparison with GLA benchmarks

($kgCO_{2e}/m^2$ GIA)

	A1-A5 (Excluding sequestration)	B-C (Excluding B6-B7)	A-C (Excluding B6-B7; Including sequestered carbon)
WLC Benchmark	*<850*	*<350*	*<1200*
Aspirational WLC Benchmark	*<500*	*<300*	*<800*
The development – Boord Street PBSA	501	343	829

- Residential benchmark used.
- Scheme GIA: 12,120 m^2
- Note that modules B-C are dependent on operational energy in-use. This can be highly variable.

Stage 2 comparison:

A comparison of projected emissions with the previous stage is required is presented below. It should be noted that significant change has taken place since Stage 2, making it a challenge to make reliable comparisons. This is especially true regarding total emissions.

Table 2: comparison of scheme WLCA, Stage 2 vs. Stage 4

Stage	Metric (kg.CO2e)	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excluding B6-B7; including sequestered carbon)
Stage 2	Total	8,383,664	7,284,506	15,436,737
	kg.CO2e/m^2	725	630	1334
Stage 4	Total	6,070,427	4,156,776	10,046,503
	kg.CO2e/m^2	501	343	829

- Notably, Stage 2 Modules B-C do not comply with the residential benchmark of "<350". This may be attributed to the choice of repair scenarios.

Highest contributions (all WLCA stages):

In terms of total life-cycle impact, the following figure consolidates the most critical categories:

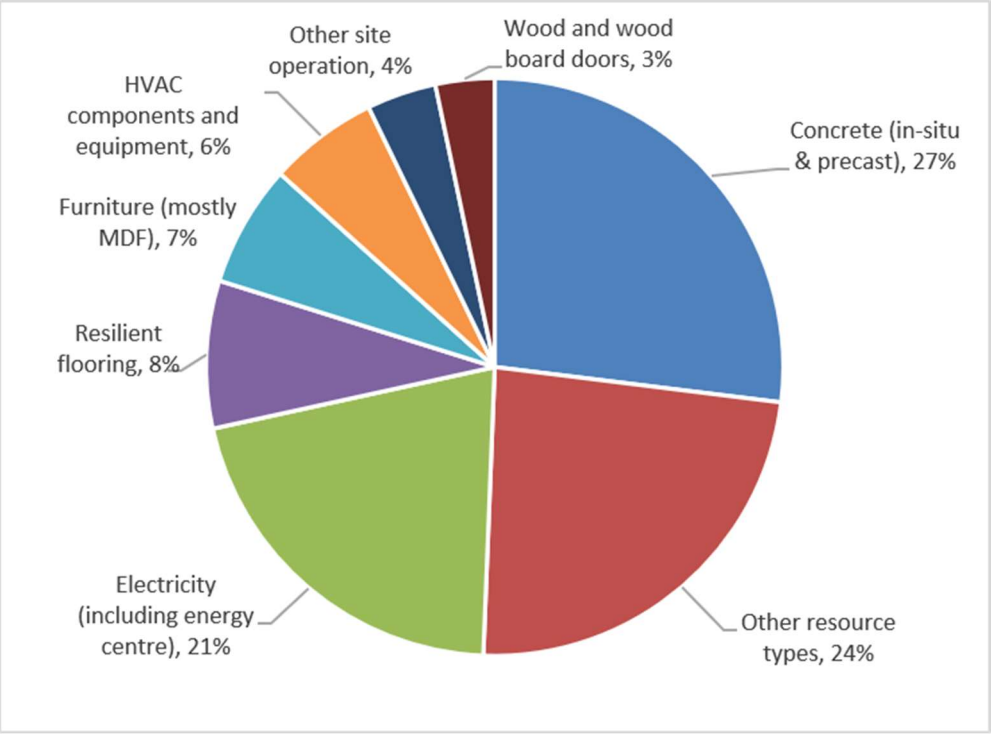


Figure 2: Material type contributions

Highest contributions (construction materials):

The materials with the twelve highest impacts in the building's embodied carbon are shown below:

Table 3: Highest GWP-contributing materials in order of impact (top 12)

Resource	Cradle to gate impacts (A1-A3), (tonnes CO2e)	Of cradle to gate (A1-A3)
1. Ready-mix concrete, RC 40/50 (40/50 MPa), with CEM I	1,372	29.7 %
2. Ready-mix concrete, normal-strength, generic, C30/37 (4350/5365 PSI), XC3, 0% recycled binders in binder (349 kg/m3 binder, CEM I + additions)	902	19.6 %
3. Reinforcement steel (rebar), generic, 90% recycled content, A615 co2	395	8.6 %
4. MDF doorset with wood frame, 66 kg/unit	188	4.1 %
5. Electricity distribution system, cabling and central (switchboards/panelboards), per m2 GFA, for all building types	184	4.0 %
6. Galvanized steel stud, 500 mm centre, 6.5 kg/m co2	179	3.9 %
7. Resins, calculated average for United Kingdom, co2	137	3.0 %
8. Kitchen cabinet, H: 900 mm, D: 600 mm, W: 600 mm, 44 kg/unit co2	136	3.0 %
9. Vinyl flooring with polyamide and fiber glass reinforced backing, 5.3 mm, 4.54 kg/m2 co2	92	2.0 %
10. Extruded aluminium profiles for window and door frames, generic, 30% recycled content, average world aluminium manufacturing technology co2	83	1.8 %
11. Argon gas filled insulating glass unit (IGU) with one laminated and one coated glass panes, double glazed, 4-16-8.76, 31.36 kg/m2 co2	70	1.5 %
12. Clay brick, UK average production, 215 mm x 102.5 mm x 65 mm, 2.13 kg/unit, 1485 kg/m3 co2	56	1.2 %

- It should be noted that the above table is based on raw inputs and the materials represent individual EPDs or "line-items". There is no grouping or categorisation.
- For example, if all the grades of concrete were combined, concrete's contribution would be closer to 50%.

Scenarios/ Improvements

There is currently opportunity to engage with the supply chain to bring about improved outcomes. This is considered in this section alongside persistent uncertainty. Focus shall be maintained on opportunities to improve supply chain outcomes, and iron out uncertainties.

Note: where models are presented as "what if?" the improvement has been taken credit for and the scenario represents omitting this credit.

Table 4: scenarios and improvement options

Scenario/ Potential improvement	Comments	Potential impact
1. Operational energy (District heat and electrical)	Energy assessment indicates that operational energy can vary significantly. Management can play a key role, but there is a dichotomy. Successful buildings tend to be busy buildings, which drives up energy usage.	Can vary the results significantly either way.
2. District heat carbon factor	Related to operational energy is the carbon intensity of the district heat energy centre. What if Hemiko's energy centre doesn't decarbonise at their forecast rate? This test investigates a "worst case" scenario.	Potential missing of operational targets. Shown on separate graph.
3. Test GFRP modular pod supply chain ("what if?" model)	These are defined under "6.1.3.Pods". There are two approaches to define the composite: (1). Using a single EPD, possibly intended for modelling "thin wall" composites; or (2). Recreate the ingredients of the "thick walled" composite including filler materials and additives. The "Current design" uses the latter whilst this model is a counterfactual test of approach (1). A more complete set of material assumptions is available in the appendices.	Nominal when compared to the whole. Nevertheless, it is a significant factor, worthy of attention.
4. Test lighting supply chain	Few LED lighting manufacturers have EPD credentials as LED manufacturing is typically carbon and chemical-intensive. The supply chain needs testing in this regard.	This has not been tested.
5. Insulation "what if?" model	Rockwool has been extensively specified. The manufacturer has extensive EPDs. The main model takes credit for this. These were tested against a counterfactual case using generic EPDs. Extruded Polystyrene (XPS) EPDs have also been taken credit for. These were found to have a nominal effect and are not presented separately herein.	Rockwool EPDs present significant embodied carbon reduction compared to generic EPDs.
6. Precast cladding EPD "what if?" model	The precast cladding supplier has sought to optimise embodied carbon and is currently demonstrating this via a self-declared EPD. However, the EPD was deemed to fall short of the necessary verification requirements, and potentially did not cover bespoke elements of the Boord St scheme. Application of the supplier's EPD was investigated in this model.	Significant. However, it was hard to understand exactly what components the reductions came from.

Key Findings

The scenarios were tested for their impact on the development's embodied carbon. All parameters not pertaining to any of the specific tests remain constant with the "Current Design" scenario. The results are shown below:

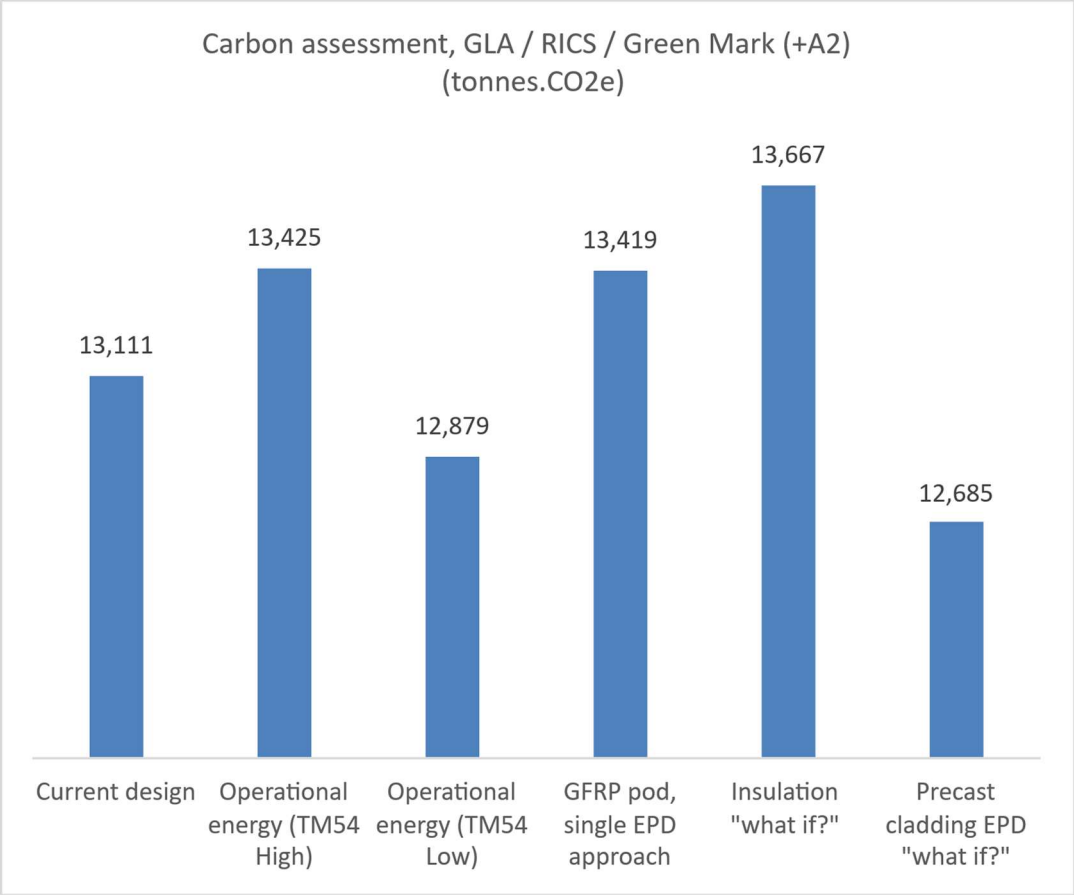


Figure 3: Total tonnes CO_2e for feasible scenarios and improvements

The results above show some small, embodied carbon savings are feasible if materials or products that require large quantities are selected on their environmental credentials or recycled content.

Next steps…

Minimising Whole-Life carbon is exactly what it says… a "lifetime" endeavour. However, steps taken now will set the scheme in good stead for this:

- Compliance with Part L and CIBSE TM39 from the outset will allow oversight of electricity and heat-usage the during operational life.
- Stay updated regarding Hemiko's district heat decarbonisation progress.
- Fully test the precast cladding supplier's EPD, as it pertains to this scheme.
- Source ready-mix concrete that uses as high a recycled content in its manufacturing as possible.
- Investigate more "detailed" aspects such as the MDF / cabinetry supply chain and resin-intensive products such as the GFRP bathroom pods.
- Continue seeking out supplier EPDs, such as lighting and glazing.

District Heat Decarbonisation Risk

The scheme will connect to the nearby Greenwich Energy Centre, operated by Hemiko (formerly Pinnacle Power). The operator is currently following a decarbonisation plan.

In summary:

- The current emissions are a mix including CHP and heat pumps:
  - Carbon intensity: 238 gCO_2/kWh (approx.)
- The future trajectory increases electrification (more heat pumps):
  - Forecast intensity: 77 gCO_2/kWh (up to 2050)
- This report's main "baseline" scenario models the latter, as closely as possible.

What happens if decarbonisation doesn't go to plan?

The following graph presents a "worst case" scenario.

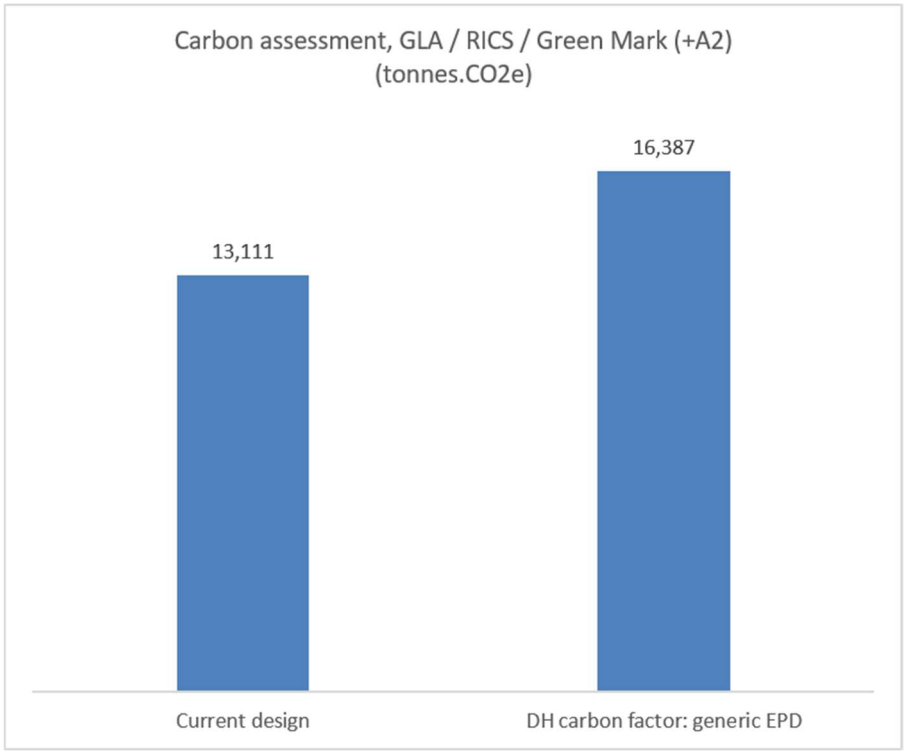


Figure 4: Total tonnes CO_2e for comparison of unrealised DH network decarbonisation

1 INTRODUCTION

ICE-BERG have carried out a Whole Life Cycle Carbon Assessment (WLCA) of the design for the proposed PBSA facility on the development site at Boord Street, Greenwich. This is to continue to act in reducing embodied carbon throughout the design stages.

The proposed development is in Greenwich, London, on the corner of Boord Street and Millenium Way. The site is a former lorry park, which is being redeveloped to deliver a mixed-use development comprising of residential units, commercial spaces, a nursery, a Purpose-Built Student Accommodation (PBSA), self-storage facility and light industrial workspaces.

This report is in relation to the PBSA only which will provide accommodation and amenity space for 353 students over 19 storeys. The building will provide a mixture of individual studios and cluster flats.

The amenity facilities will be provided throughout the ground and intermediate floors.

This document sets out the results of the RIBA stage 4 analysis for planning.

1.1 London Plan 2021

The main policy driver is the current London Plan, published in 2021. It has the following requirements for embodied carbon:

"Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions".

Guidance: Whole Life-Cycle Carbon Assessments March 2022

To assist consultants with producing WLCA assessments the GLA produced guidance in March 2022 showing how compliance with policy SI2 can be achieved. Generally, the guidance requires WLCA's to implement the WLC principles as outlined in Table 2.1 of the guidance:

1. Reuse and retrofit of existing built structures.
2. Use repurposed or recycled materials.
3. Material selection.
4. Minimise operational energy use.
5. Minimise the carbon emissions associated with operational water use.
6. Disassembly and reuse.
7. Building shape and form.
8. Regenerative design.
9. Designing for durability and flexibility.
10. Optimisation of the relationship between operational and embodied carbon.
11. Building life expectancy.
12. Local sourcing.
13. Minimising waste.
14. Efficient construction.
15. Lightweight construction.
16. Circular economy.

1.2 Whole Life Cycle Assessment

Whole Life Cycle Assessment (WLCA) considers the impact of the construction industry on non-renewable resources, global warming, and greenhouses gases emissions for a building's life. Managing the environmental impacts that arise from the construction and operation of building is of key importance in mitigating the damage caused directly and indirectly on the biosphere. LCA is the leading industry standard in clearly identifying optimum strategies for reducing environmental impacts.

- This report presents the results for the LCA assessment undertaken during RIBA Stage 4.
- OneClick LCA software has been used to model the infrastructure's environmental and cost impacts.

This study has been conducted in accordance with the following standards:

- European Standard EN 15978: Sustainability of Construction Works – Assessment of Environmental Performance of Buildings – Calculation Method.
- International Standards 14040:2006 (en).

1.3 Assessor Details

The report has been written by Chris Yates C Eng MCIBSE LCEA of ICE-BERG Building Physics. They have been a building physicist for 20+ years and undertaken Life Cycle Assessments from 2015 ranging from BREEAM UK projects to BREEAM Infrastructure (CEEQUAL) in accordance with PAS 2080. They are the director of ICE-BERG, Building Physics speciality company established in 2020 (CV can be found in Appendix 1).

Chris has received training in performing Life Cycle Assessments for buildings and infrastructure. The training was delivered by Oneclick, who is a training partner for BRE Academy, various Green Building Councils and organisations, and delivers GBCI approved continued education trainings.

Other training includes partaking in the original IMPACT course training provided in partnership with Integrated Environmental Solutions and the BRE in 2015. A summary of relevant training is provided in the appendices.

1.4 Aims of the LCA Study

The aim of the study is to profile and improve the environmental performance of the development as an embodied approach, rather than just running costs, as per the diagram below:

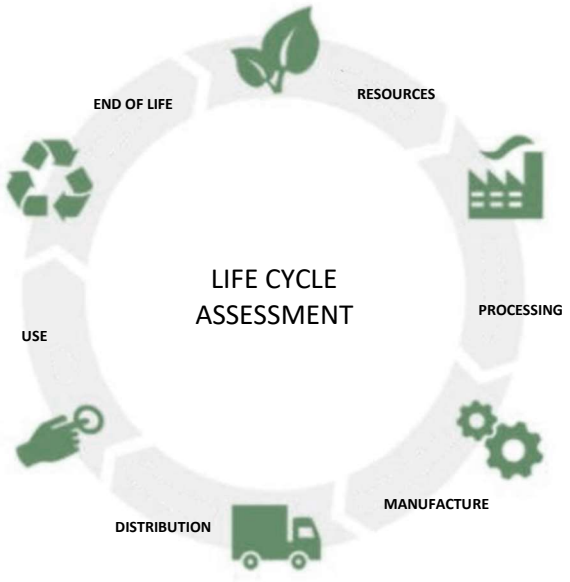


Figure 5: Life-cycle assessment stages

1.5 Report Assumptions

The function of the building must reflect the core purpose of the asset such that it can be compared accurately to different designs to get most viable design options.

The assumed design life is 60 years which has been adopted for the LCA study period. This takes into consideration the structural service life limit (30 years) as well as redevelopment pressure on the asset such as surrounding density, asset ownership structures and the architectural design quality.

The object of the assessment is the structure itself. The assessment includes all the upstream and downstream processes needed to provide the primary function of the structure from construction, maintenance, operation and finally demolition and disposal. The inventory includes the extraction of raw materials or energy and the release of substances back to the environment or to the point where the inventory items exit the system boundary either during or at the end of the project life cycle.

1.6 Source Data & Scopes

WLCA incorporates data in various formats from multiple design team members.

List of design team members:

- RG-Group (RG) – Main Contractor / project management
- Hadfield Cawkwell Davidson (HCD) – Architect
- Apex Consulting Engineers (Apex) – Civil & Structural Engineer
- Creagh Concreate (Creagh) – Precast concrete façade designer & manufacturer
- HG Consulting Engineers (HGCE) – MEP consultants
- Exterior Architecture (EXA) – Landscape architect
- RG Real Estate (RGRE) – Client / developer

Data sources:

- BIM & drawings
- Direct consultation during verification meetings.
- Confirmations by email (QS and architects).

Table 5: source data and scopes

Team member	Main Scope	Principal sources	Scope duplication/ crossover
Apex	Civil and structural	BIM sources	Floor slabs duplicated in HCD BIM
HCD	Architectural	BIM, drawings, meetings and EPDs	The architectural data has several crossovers. For example, the exterior walls share scope with Creagh. Structural elements have been derived from Apex's scope with some exceptions (e.g., stairways).
Creagh	Exterior cladding and insulation.	BIM sources	Crosses over with, and supersedes, architectural scope in terms of exterior shell. However, there is a scope line between exterior and interior layers of insulation.
HGCE	MEP	BIM & modelling reports	Some trivial crossovers such as service penetrations and small façade "Airbrick" louvres.
EXA	Landscaping, mainly exterior ground level – asphalt, block paving, and planting.	2D drawings	Roof terraces comprise of block paving mainly. Quantities have been derived from the architectural sources rather than EXA.

1.7 Method statements

The basic requirements for a Life Cycle Carbon Assessment are built based on standards such as ISO 14040 and ISO 14044. In the construction sector the relevant scope is defined by the LCA standard EN15978, RICS methodology and relevant issues are highlighted below.

The EN15978 cut-off criteria were used to ensure that all relevant potential environmental impacts were appropriately represented:

- Mass – if a flow is less than 1% of the mass at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not of concern.
- Energy – if a flow is less than 1% of the energy at either a product-level or individual-process level, then it has been excluded, provided its environmental relevance is not a concern.
- Neglected Mass – The total of neglected input flows per module as defined in CEN/TC 350 EN Standards, e.g., per module A1-A3, A4-A5, B1-B5, B6-B7, C1-C4 and module D shall be a maximum of 5% of energy usage and mass.
- Environmental relevance – if a flow meets the above criteria for exclusion but is considered to potentially have a significant environmental impact, it has been included. All material flows which leave the system (emissions) and whose environmental impact is higher than 1% of an impact category, have been included.

The RICS professional statement (PS) indicated component lifespans which has been used for replacement cycles in this assessment.

The Operational Guidance for Life Cycle Assessment Studies (Wittstock et al. 2012) states:

“The apparent paradox is that one must know the result of the LCA (so one can show that the omission of a certain process is insignificant for the overall results) to be able to know which processes, elementary flows etc. can be left out. The approach taken in this study is to continue modelling smaller inputs until confidence is gained that the criteria is safely met”.

Allocation rules follow those of EN15804 as given below:

- Allocation will respect the main purpose of the studied processes. If the main purpose of combined processes cannot be defined (e.g., combined mining and extraction of nickel and precious metals), economic allocation may be used to divide resources and emissions between the products.
- The principle of modularity is maintained. Where processes influence the product’s environmental performance during its life cycle, they will be assigned to the module where they occur.
- The sum of the allocated inputs and outputs of a unit process are equal to the inputs and outputs of the unit process before allocation. This means no double counting of inputs or outputs is permissible.

1.7.1 RICS contingency factor

RICS guidance, “Whole life carbon assessment for thebuilt environment” (2023) outlines advice regarding uncertainty in section 4.10.1 “The contingency factor”. It recommends applying contingencies based on the uncertainty at the time of the assessment. Uncertainty is tied to the maturity of the design, or project completion, via RIBA stage.

- Contingency: 6% (RIBA Stage 4)
- This project: 6% applied to all concrete (in-situ and precast) to allow for RC-detailing.
- No other contingencies have been applied, but the section “Scenarios/ improvements” offers insight regarding both sensitivity and uncertainty.

1.8 Energy Calculations

1.8.1 Dwellings

For dwellings, residential operational energy calculations are taken from the approved SAP 10 software. The software used will be Elmhurst Energy's Design SAP software. All versions of Elmhurst's Design SAP software are tested and Government approved for the building regulations/standards of England (Part L1).

- Whilst the PBSA scheme is of a residential nature, its function is defined within the remit of non-dwellings according to the building regulations, Part L2.
- Therefore, SAP is not used.

1.8.2 Non-dwellings

All non-dwellings are simulated using detailed TM54 calculations and referenced against benchmarks. Dynamic Simulation Modelling (DSM) method are used. Unlike the calculations used to produce BRUKL documents for the energy strategy, which use pre-set National Calculation Method (NCM) inputs, TM54 modelling uses specific inputs, gains, and internal temperatures in line with how the building is predicted to operate. This is backed up with any available benchmark data.

- Available TM 54 data is used.
- Benchmark data from comparable sites is used.

2 QUALITY ASSURANCE

2.1 Review Process

The inputs used for this analysis have been provided by the project management team, with inputs from the architect, M&E & cost consultancy. The materials used should represent over 95% of the predicted building elements to be utilised in the building.

2.2 Third Party Verification

Third party verification has been undertaken via extensive consultation with the project team. The review process will also be used for third party verification once the analysis is complete. This team is intended at the time of writing to oversee the entire project from design stage to project completion.

- Documented review / meetings with cost and commercial managers.
- Consultancy with architectural and project management teams.
- Email exchanges and queries to suppliers.

Responses to comments and a comprehensive rerun of all models resulted in the following refinements:

- Decisions regarding one supplier-provided EPD. The cladding supplier had done substantial work in developing an EPD. However, upon testing it was decided that it was not fully verifiable. Therefore, it was decided not to include this in the main model. Instead, it was presented as a potential scenario.
- Confirmations and corrections of quantities erroneously extracted from BIM sources. For example, metal stud quantities were corrected.
- Inclusion of RICS 6% uplift advice. It was felt appropriate to apply this to the RC concrete to provide some leeway for RC-detailing.
- Decision that the generic MDF kitchen cabinet EPD was over-stated at an average cabinet mass of 44kg. This was adjusted down to an average mass of approximately 27kg/ unit, including for a mixture of types, worktops, and other MDF fittings.
- Dishwashers removed.
- Module D omission fixed: PV generation.
- Clarifications regarding inputted materials. For example, a membrane was presented as “Cladding” in a table. Also clarified was that prescribed supplier EPDs had been used for flooring.
- Energy-usage: The kWh-based ***District Heat Generic EPD*** was deemed to incorporate elements of CHP and therefore unfairly inflated in-use carbon. This was changed to an ***Electric Source EPD*** supplying heat via a heat pump with a SCOP of approximately 3.0.

3 CALCULATION INPUT DATA

As the building is at planning stage the full inventory of materials, energy consumption, construction site activities and demolition are based on design estimates, building regulations calculations (SAP 10 and Part L 2021, where relevant) and benchmarking from other similar projects that have completed.

3.1 Building Summary

The design details and analysis parameters are set out below for reference as they stand at the time of writing:

Table 6: summary of WLCA parameters

Design Details	
Design purpose	Residential-units for educational purposes
Number of floors	19 storeys incl. ground
Primary function	PBSA & amenity space
Structural service life limited	60 years
Predicted design life	60 years
Functional Characteristics	
Occupants	Students (353 units)
Total Floor Area	
Site GIA	12,120 m^2
Building footprint	1395 m^2
Site curtilage	0.158 Hectares

3.2 Building Materials

The following elements forming the building were identified by the design team and can confirm accounts for at least 95% of quantities allocated to each building element. These were imported into the LCA software.

Table 7: Building materials quantities

RICS category	Comment	Sum of Mass of raw materials, kg	Sum of User input Unit
Substructure			
1.1.1.Standard foundations	DP CORE BASE	394,560	164 m3
	DP CORE BASE re-bar	18,840	2 m3
	EPS insulation - Lowest floor	2,657	76 m3
	Ground Beam	78,480	33 m3
	Ground Beam re-bar	9,420	1 m3
	PILECAP	218,640	91 m3
	PILECAP re-bar	11,775	2 m3
	Plinth	3,120	1 m3
	Plinth re-bar	157	m3
	Precast Concrete (PILES)	321,360	134 m3
	Precast Concrete (PILES) re-bar	43,175	6 m3
1.1.2.Specialist foundations	Zero value		
1.1.3.Lowest floor construction	Foundation Slab	310,800	130 m3
	Foundation Slab re-bar	13,345	2 m3
1.1.4.Basement excavation	Zero value		
1.1.5.Basement retaining walls	Zero value		
Superstructure: Frame			
2.1. Frame	Downstand Beam	9,720	4 m3
	Downstand Beam re-bar	1,225	m3
	Downstand Wall	37,392	16 m3
	Downstand Wall re-bar	4,710	1 m3
2.1.1.Steel frames	Metal - Steel Structural	21,274	3 m3
2.1.2.Space decks	Zero value		
2.1.3.Concrete casings to steel frames	Zero value		
2.1.4.Concrete frames	Concrete - Cast-in-Place Concrete	995,760	415 m3
	Concrete - Cast-in-Place Concrete re-bar	133,450	17 m3
	RC UPSTAND	177,120	74 m3
	RC UPSTAND re-bar	10,205	1 m3
	RC WALL	2,352,000	980 m3
	RC WALL re-bar	84,780	11 m3
2.1.5.Timber frames	Zero value		
2.1.6.Other frame systems	Zero value		
Superstructure: Upper Floors			
2.2.1.Floors	RC HALF LANDING	64,817	27 m3
	RC HALF LANDING re-bar	2,787	m3
	RC SLAB	7,812,288	3,288 m3
	RC SLAB re-bar	337,550	43 m3
2.2.2.Balconies	Balcony - zero value		
Superstructure: Roof			
2.3.2.Roof coverings	Balcony - zero value	148,713	551 m2
	Roof: Blue Roof Attenuation Crate	315	1,000 m2
	Roof: Concrete Pavers	37,135	323 m2
	Roof: Gravel	80,038	1,000 m2
	Roof: Standing Seam	417	167 m2
2.3.Roofs	Roof: Insulation_Rigid	8,075	1,042 m2

BOORD STREET WLCA

RICS category	Comment	Sum of Mass of raw materials, kg	Sum of User input Unit
Superstructure: Stairs and Ramps			
2.4.1.Stair and ramp structures	Stairs in core	180,000	75 m3
	Stairs in core re-bar	11,461	1 m3
2.4.2.Stair and ramp finishes	Stairs, ramps, and plant areas	364	1,300 m2
Superstructure: External Walls			
2.5.1.External enclosing walls above ground level	CRE_CladScope: Brick Slip	146,956	99 m3
	CRE_CladScope: Corbel	3,659	2 m3
	CRE_CladScope: Corbel	19,488	8 m3
	CRE_CladScope: Insulation	17,579	5,140 m2
	CRE_CladScope: PANEL	2,538,672	1,058 m3
	CRE_CladScope: PANEL - OTHER	143,280	60 m3
	CRE_CladScope: PANEL - OTHER re-bar	5,157	1 m3
	CRE_CladScope: PANEL re-bar	91,374	12 m3
	CRE_CladScope: PARAPET	112,056	47 m3
	CRE_CladScope: PARAPET re-bar	5,495	1 m3
	CRE_CladScope: SLAB	31,102	13 m3
	CRE_CladScope: SLAB	16,152	7 m3
	CRE_CladScope: SLAB re-bar	2,025	m3
	CRE_CladScope: Steel Connectors	3	3 kg
	Fire Cavity Barrier	4,784	8 m3
	HCD_CladScope: Insulation_MineralWool	16,692	4,437 m2
	Interior lining of exterior walls (HCD)	112,052	5,140 m2
	Interior lining of exterior walls: MF for insulation fill	33,410	5,140 m
	LVL 0-2: outer brickwork	107,005	703 m2
	Breather membrane or VCL	1,148	5,140 m2
	LVL: 0-2 Inner block leaf	198,325	98 m3
	LVL: 0-2 insulation_MineralWool	2,284	703 m2
2.5.2.External enclosing walls below ground level	Below ground wall - zero value		
Superstructure: Windows and External Doors			
2.6.1.External Windows	Louvres Lvl 0-2	1,134	56 m2
	Louvres Lvl 3+	900	60 m2
	Louvres Shading	825	55 m2
	(blank)	60,744	2,146 m2
	(blank)	14,797	1,897 m2
	"Airbricks" Level 3+ MVHR louvres	6,850	45 m2
2.6.2.External doors	Metal doors	259	4 unit
2.6.Windows and external doors	Fire detection components	105	122 unit
Superstructure: Internal Walls and Partitions			
2.7.1.Walls and Partitions	Acoustic insulation	2,002	3,512 m2
	IntWall: Concrete	55,032	23 m3
	IntWall: Concrete Block	309,245	153 m3
	IntWall: Concrete re-bar	2,700	m3
	IntWall: Plasterboard	27,745	3,512 m2
	IntWall: metal studs normalised to 600mm ctrs	38,045	5,853 m
2.7.2.Balustrades and handrails	Exterior railings	3,320	83 m
Superstructure: Internal Doors			
2.8.Internal doors	Doorsets as a pro-rate count of single + double	64,482	977 unit
	Iron mongery for total door count	1,070	892 unit
	Metal glazed interior doors	1,969	11 unit

BOORD STREET WLCA

RICS category	Comment	Sum of Mass of raw materials, kg	Sum of User input Unit
Finishes			
3.2.Floor finishes	Finishes: floor levelling	36,000	8,000 m2
	Vinyl flooring - Forbo	36,320	8,000 m2
	Carpet tiles - Forbo	3,618	890 m2
3.3.2.False ceilings	Ceiling: Insulation_MineralWool	2,443	543 m2
	Ceiling: Metal Ceiling Tiles	7,562	394 m2
	Ceiling: Plasterboard	7,639	967 m2
	Ceiling: Void with MF	13,173	2,027 m
Fittings, furnishings & equipment (FFE)			
4.Fittings, furnishings and equipment	Kitchen cabinets, Accesible units, Level 3+	26,765	26,765 kg
	Kitchen cabinets, Common kitchens, Level 3+	23,002	23,002 kg
	Kitchen cabinets, Level 0-2	822	822 kg
Services (MEP)			
5.1.Sanitary installations	En-suite pods + other	14,703	674 unit
	Kitchen sink, Accesible units, Level 3+	563	101 unit
	Kitchen sink, Common kitchens, Level 3+	312	56 unit
	Kitchen sink, Level 0-2	39	7 unit
5.10.Lift and conveyor installations/systems	Lifts	15,000	3 unit
5.4.Water installations	Fire detection components	1,519	1,519 kg
	Public health drainage	2,241	12,154 m2
	Public health water supply	3,160	12,154 m2
	Heating: valves	154	866 unit
	Heating: pipes	8,877	1,320 m
5.6.Space heating and Airconditioning	14 large amenity space MVHR units	1,559	4 unit
	All terminals (2055 total)	6,161	6,161 kg
	ATTENUATOR, various sizes. 5kg/unit assumed	1,517	1,517 kg
	Vent Axia units. No manufacturer EPD available.	1,806	129 unit
	Fire detection components	48,130	12,154 m2
	Fire detection components	18	12 unit
	VCD from BIM	392	280 unit
	VCD rectangular from BIM	691	128 unit
	Heating: door air curtain	98	1 unit
	Mitsubishi split or VRF	42	3 unit
5.8.3.Lighting installations	No BIM data available. Generic luminaire and quantity.	920	1,000 unit
5.8.Electrical installations	Average extractor is Vent Axia 150 DIA, 3kg each. 402 units, pro-rated.	1,200	71 unit
	Communal laundry equipment: dryer	1,351	8 unit
	Communal laundry equipment: washer	1,684	8 unit
	HIU from BIM	4,050	27 unit
	Oven & Hob, Accesible units, Level 3+	4,037	202 unit
	Oven & Hob, Common kitchens, Level 3+	2,238	112 unit
	Oven & Hob, Level 0-2	120	6 unit
	Fire detection components	471	912 unit
	Heating: valves	693	361 unit
	Heating: tanks	960	9 unit
	Heating: pumps	161	7 unit
	DH substation PHX	17	2 unit
	Heating: Radiators	3,449	363 unit
5.Services	Ductwork from BIM	3,570	3,570 kg
	Fire detection components	2,246	10,209 m

RICS category	Comment	Sum of Mass of raw materials, kg	Sum of User input Unit
	Fire detection components	108	97 unit
	Mitsubishi split or VRF	1,281	20 unit
	PV modules	1,500	100 m2
Prefabricated Buildings and Building Units			
6.1.3.Pods	En-suite pod wall-lining	7,940	1,005 m2
	En-suite pod wall-lining and floor, wet-side (regional EPD)	15,400	11 m3
	En-suite pod. Chopped glass fibres for filler.	3,728	3,728 kg
	En-suite pod. GFRP filler compound	29,821	29,821 kg
	En-suite pod. Proxy for Alumina Trihydrate. Augments GFRP curing	13,254	13,254 kg
	En-suite pod. Resin for filler	33,135	33,135 kg
	Sgl leaf doorsets to en-suite pods	22,110	335 unit
External works			
8.2.1.Roads, paths and pavings	Asphalt layers: Binder and HRA surface courses	140	1 m2
	base buildup for pavers	485	3 m2
	Concrete pavers	66,930	485 m2
	Drainage layer for soft landscape	25,800	86 m2
	Drainage layers for soft landscape	206	172 m2
	Dwarf wall to planting	4,144	10 m2
	Gravel capping / base buildup (50% re-use)	120,000	300 m2

3.3 Energy Use

Following the methods described in the section "Energy calculations", energy categorised by end-use was quantified and imported into the LCA software:

Table 8: Energy and water consumption

Energy Use/ Export, Annual	.per annum
Grid Electricity – Regulated	
Electricity use	96,017 kWh
Grid Electricity – Unregulated	
Electricity use	179,879 kWh
District Heat – Regulated	
Electricity use	346,267 kWh (See note: "District heat")
Water consumption	
Water consumption	11,643,000 kg
Exported electricity (22kWp PV system)	18,200 kWh (module D benefit)

Carbon factors

For all electricity usage, the following carbon factor template is used:

- EPD: Average future electricity, UK (2022-2082, for 60 years' service life) based on Non-2050 compliant - Steady Progression 2050 scenario
- LCA parameters: SAP 10.1 & 10.2 factors
- Carbon intensity: 73.6 gCO_2/kWh (approx.)

District heat

The scheme will connect to the nearby Greenwich Energy Centre, operated by Hemiko (formerly Pinnacle Power). The energy strategy (by HGCE) references the heat network supplier's decarbonisation plan. The builds on previous correspondence between Hemiko and Atelier 10 at Stage 2.

In summary:

- The current emissions are a mix including CHP and heat pumps:
  - Carbon intensity: 238 gCO_2/kWh (approx.)
- The future trajectory increases electrification (more heat pumps):
  - Forecast intensity: 77 gCO_2/kWh (up to 2050)

How is this modelled?

A generic EPD is available for modelling district heat consumption. However, the carbon emissions of this were significantly higher than the future, and even the current scheme operated by Hemiko.

- Generic: District Heat, United Kingdom, 2023 (One Click LCA)
  - Carbon intensity: 278 gCO_2/kWh (approx.)
  - This was deemed to unfairly inflate in-use carbon, so it was not used.
- The electric-source EPD was therefore used to model District heat with 10% losses applied to bring it in line with Hemiko's 2050 forecast.
  - Electric-source intensity: 81 gCO_2/kWh (including 10% losses)

Maintenance scenarios

Energy and water usage during maintenance is covered using the following method:

- Average maintenance per m^2 GIA, dataset version from 2022 (Oneclick).
- Separately input energy and water use attributed to maintenance has not been input.

3.4 Results

Based on the inputs outlined in this report the following result were achieved:

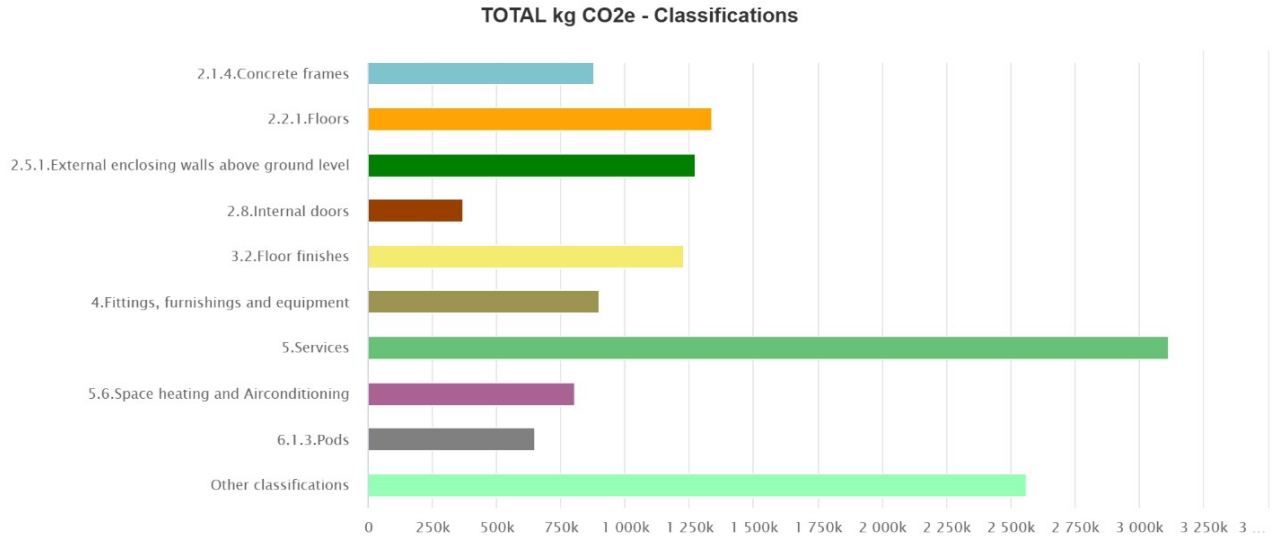


Figure 6: Category impacts

- The above graph presents impacts according to RICS classification. Services and their life-time energy use are the highest individual contributor.

Highest contributions (all WLCA stages):

In terms of total life-cycle impact, the following table consolidates the most critical categories:

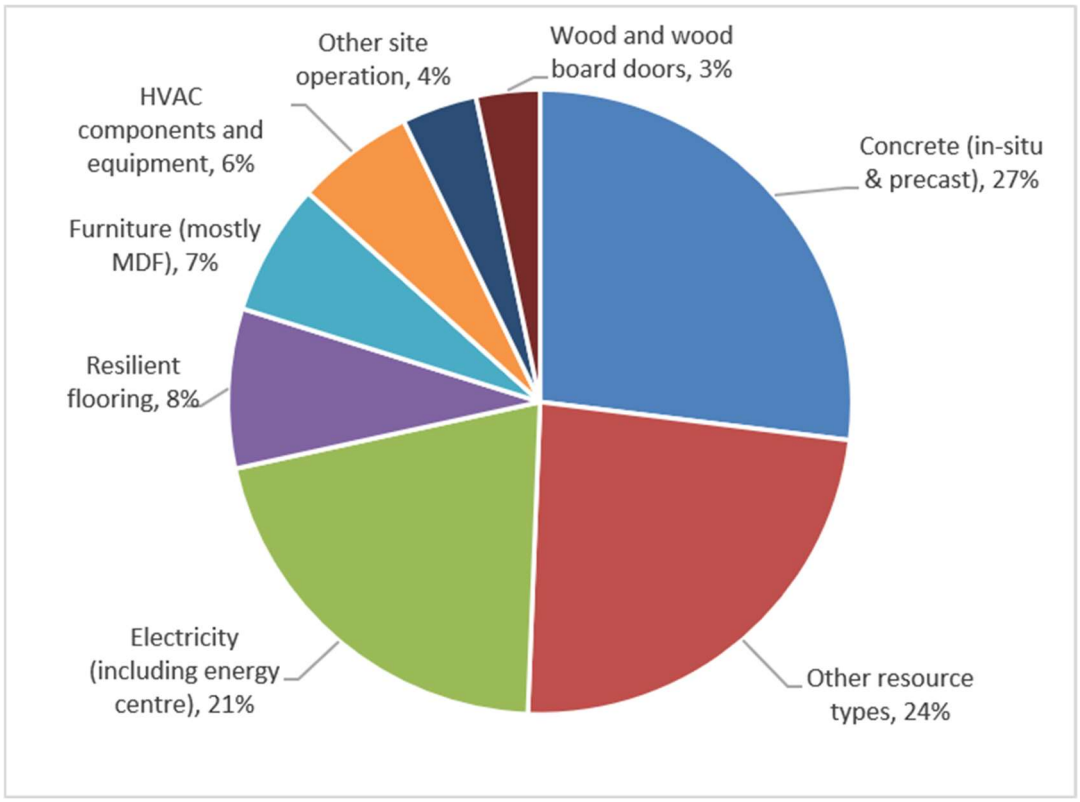


Figure 7: Material type contributions

Table 9: LCA results according to EN 15978 (to 3 significant figures)

Result category	Biogenic carbon (kg CO2e)	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations	B1 Use Phase	B2 Maintenance	B3 Repair	B4 Material replacement - materials	B5 Material refurbishment	B6 perational Energy use - Regulated	B6 perational Energy use - Unregulated	B7 Operational Water use	C1 Deconstruction / demolition	C2 Waste transportation	C3 Waste processing	C4 Waste disposal	TOTAL kg CO2e	D External impacts (not included in totals)
0.1 Toxic Mat.				5.2													5.2	
0.2 Demolition				0.8									41.1				42.0	
0.3 Supports																		
0.4 Groundworks																		
0.5 Diversion																		
1 Substructure	0	285	37.5	17.1			0							7.6	6.2		354	-71
2.1 Frame	0	767	99.4	44.4			0							20.2	1.8		933	-223
2.2 Upper Floors	0	1,070	166.0	63.7			0							36.1	3.5		1,340	-268
2.3 Roof	0	50	13.4	6.1			0	1.6	0					0.6	17.4		89	-17
2.4 Stairs & Ramps	0	38	4.8	2.2			0	4.2	0					1.0	0.1	0	50	-9
2.5 Ext. Walls	0	766	371.0	66.1			0	49.3	0					17.6	3.9	0	1,270	-192
2.6 Windows & Ext. Doors	0	204	8.2	2.6			0	111.0	0					3.0	0.1	0	329	-102
2.7. Int. Walls & Partitions	0	138	35.8	2.7			0	9.2	0					3.4	0.2	0	189	-87
2.8 Int. Doors	-87	162	21.5	0.0			0	185.0	0					0.4	87.4	0	370	-4
3 Finishes	0	178	20.4	13.9			0	1,040.0	0					1.2	82.5	0	1,340	-186
4 Fittings, furnishings & equipments	-64	136	12.2	0.0			0	747.0	0					0.2	64.9	0	896	0
5 Services (MEP)	0	551	33.2	0.7	167		0	1,060.0	0	1,950	794	189		4.6	0.4	0	4,760	-782
6 Prefabricated	-30	259	26.0	19.1			0	313.0	0					0.5	61.8	0	649	-44
7 Existing bldg																		
8 Ext. works	0	9.15	6.16	0.48			0	0.95	0					0.21	0.45		17	-3.67
Other or overall site construction				363													363	
Unclassified / Other						121	0										121	
TOTAL t. CO2e	-181	4,613	855	608	167	121	0	3,521	0	1,950	794	189	41	97	331	0	13,118	-1,988

Highest contributions (construction materials):

The highest-contributing materials in terms of Global Warming Potential (GWP) are presented below. These are areas worthy of further design team focus as the material supply chains are firmed up.

Table 10: Highest GWP-contributing materials in order of impact

Resource	Cradle to gate impacts (A1-A3), (tonnes CO2e)	Of cradle to gate (A1-A3)
1. Ready-mix concrete, RC 40/50 (40/50 MPa), with CEM I	1,372	29.7 %
2. Ready-mix concrete, normal-strength, generic, C30/37 (4350/5365 PSI), XC3, 0% recycled binders in binder (349 kg/m3 binder, CEM I + additions)	902	19.6 %
3. Reinforcement steel (rebar), generic, 90% recycled content, A615 co2	395	8.6 %
4. MDF doorset with wood frame, 66 kg/unit	188	4.1 %
5. Electricity distribution system, cabling and central (switchboards/panelboards), per m2 GFA, for all building types	184	4.0 %
6. Galvanized steel stud, 500 mm centre, 6.5 kg/m co2	179	3.9 %
7. Resins, calculated average for United Kingdom, co2	137	3.0 %
8. Kitchen cabinet, H: 900 mm, D: 600 mm, W: 600 mm, 44 kg/unit co2	136	3.0 %
9. Vinyl flooring with polyamide and fiber glass reinforced backing, 5.3 mm, 4.54 kg/m2 co2	92	2.0 %
10. Extruded aluminium profiles for window and door frames, generic, 30% recycled content, average world aluminium manufacturing technology co2	83	1.8 %
11. Argon gas filled insulating glass unit (IGU) with one laminated and one coated glass panes, double glazed, 4-16-8.76, 31.36 kg/m2 co2	70	1.5 %
12. Clay brick, UK average production, 215 mm x 102.5 mm x 65 mm, 2.13 kg/unit, 1485 kg/m3 co2	56	1.2 %
13. Passenger elevators, calculated average for United Kingdom, 5000 kg/unit co2	52	1.1 %
14. Polyester resin laminated part (GFRP, 30% glass fibres), 1400 kg/m3, EN15804+A1, ref. year 2018 co2	51	1.1 %
15. Exhaust grille, 1450 m3/h	46	1.0 %
16. Solid concrete block wall with high density solid blocks, including mortar, 215 mm thickness wall, 435.1 kg/m2	46	1.0 %
17. Stone wool insulation panel, R= 1 m2K/W, thickness: 100 mm, 1.14 kg/m2 co2	45	1.0 %
18. Steel - Mild (sections),	35	0.8 %
19. Metal ceiling tiles and panels without acoustic infill, 0.6 mm, 5.76 kg/m2 co2	30	0.6 %
20. XPS insulation board, 0.033 W/mK, 31 kg/m3 co2	29	0.6 %
21. Gypsum plasterboard, sound resistant, width=1200 mm, 12.5-15 mm, 10.9 kg/m2, 872 kg/m3 co2	26	0.6 %
22. Photo voltaic module (PV), Monocrystalline,	24	0.5 %
23. Single glass pane, excluding frame, 8 mm/m2, 20 kg/m2	17	0.4 %
24. Ceramic toilet set, 26.93 kg/unit co2	16	0.4 %
25. Street slab, from stone, Finnish average, 2700 kg/m3 co2	16	0.3 %

- It should be noted that the above table is based on raw inputs and the materials represent individual EPDs or “line-items”. There is no grouping or categorisation.
- For example, if all the grades of concrete were combined, concrete’s contribution would be closer to 50%.

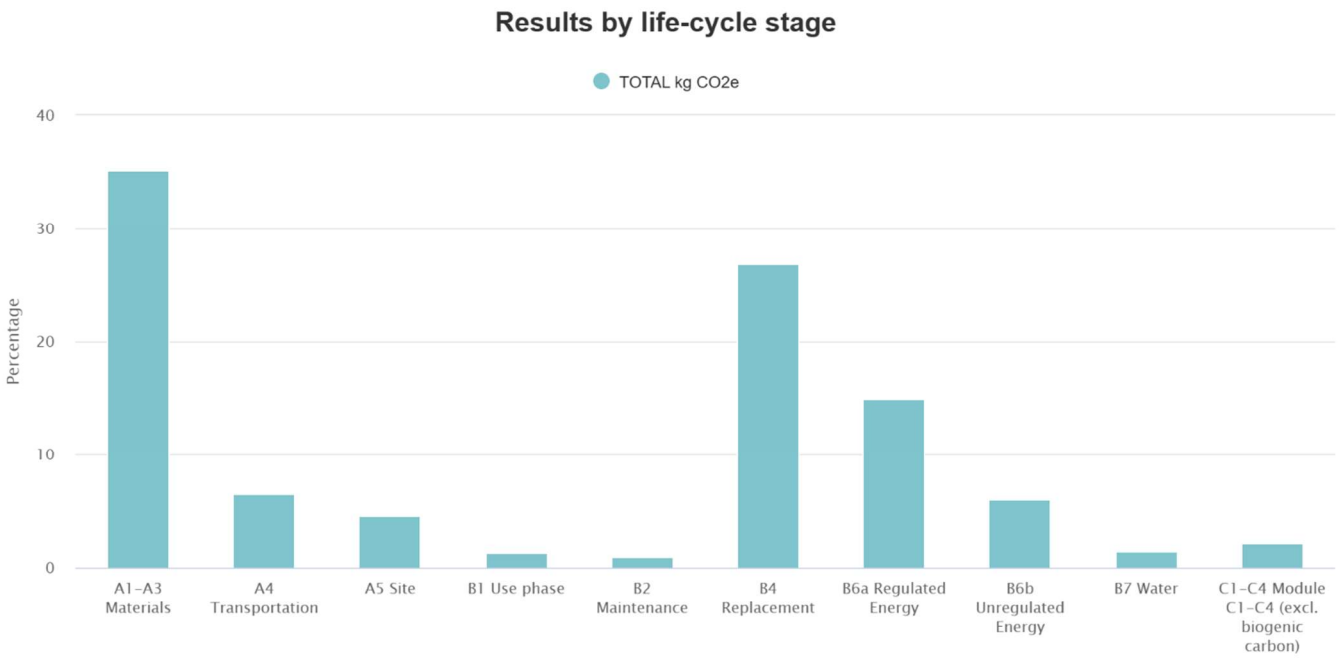


Figure 8: CO_2 through life cycle stages (as percentage)

Demolition Impact

The demolition of the existing site structures, comprising mainly of hardstanding concrete pavement, is predicted to produce 6,060 kg CO_2e. Significant material removal is also required to establish sub-base layers for hard and soft landscaping. It's assumed, conservatively, that 50% of the material from the demolition will be reused.

Construction Site Impact

The construction site processes, resulting from on-site energy usage (e.g., electricity, generator fuel), is predicted to produce 348,000 kg CO_2e.

4 SCENARIOS/ IMPROVEMENTS

There is currently opportunity to engage with the supply chain to bring about improved outcomes. This is considered in this section alongside persistent uncertainty. Focus shall be maintained on opportunities to improve supply chain outcomes, and iron out uncertainties.

- All scenarios below are for comparison with the main, baseline scenario.

Table 11: scenarios and improvement options

Scenario/ Potential improvement	Comments	Potential impact
1. Operational energy (District heat and electrical)	Energy assessment indicates that operational energy can vary significantly. Management can play a key role, but there is a dichotomy. Successful buildings tend to be busy buildings, which drives up energy usage.	Can vary the results significantly either way.
2. District heat carbon factor	Related to operational energy is the carbon intensity of the district heat energy centre. What if Hemiko's energy centre doesn't decarbonise at their forecast rate? This test investigates a "worst case" scenario.	Potential missing of operational targets. Shown on separate graph.
3. Test GFRP modular pod supply chain ("what if?" model)	These are defined under "6.1.3.Pods". There are two approaches to define the composite: (1). Using a single EPD, possibly intended for modelling "thin wall" composites; or (2). Recreate the ingredients of the "thick walled" composite including filler materials and additives. The "Current design" uses the latter whilst this model is a counterfactual test of approach (1). A more complete set of material assumptions is available in the appendices.	Nominal when compared to the whole. Nevertheless, it is a significant factor, worthy of attention.
4. Test lighting supply chain	Few LED lighting manufacturers have EPD credentials as LED manufacturing is typically carbon and chemical-intensive. The supply chain needs testing in this regard.	This has not been tested.
5. Insulation "what if?" model	Rockwool has been extensively specified. The manufacturer has extensive EPDs. The main model takes credit for this. These were tested against a counterfactual case using generic EPDs. Extruded Polystyrene (XPS) EPDs have also been taken credit for. These were found to have a nominal effect and are not presented separately herein.	Rockwool EPDs present significant embodied carbon reduction compared to generic EPDs.
6. Precast cladding EPD "what if?" model	The precast cladding supplier has sought to optimise embodied carbon and is currently demonstrating this via a self-declared EPD. However, the EPD was deemed to fall short of the necessary verification requirements, and potentially did not cover bespoke elements of the Boord St scheme. Application of the supplier's EPD was investigated in this model.	Significant. However, it was hard to understand exactly what components the reductions came from.

Key Findings

The scenarios were tested for their impact on the development's embodied carbon. All parameters not pertaining to any of the specific tests remain constant with the "Current Design" scenario. The results are shown below:

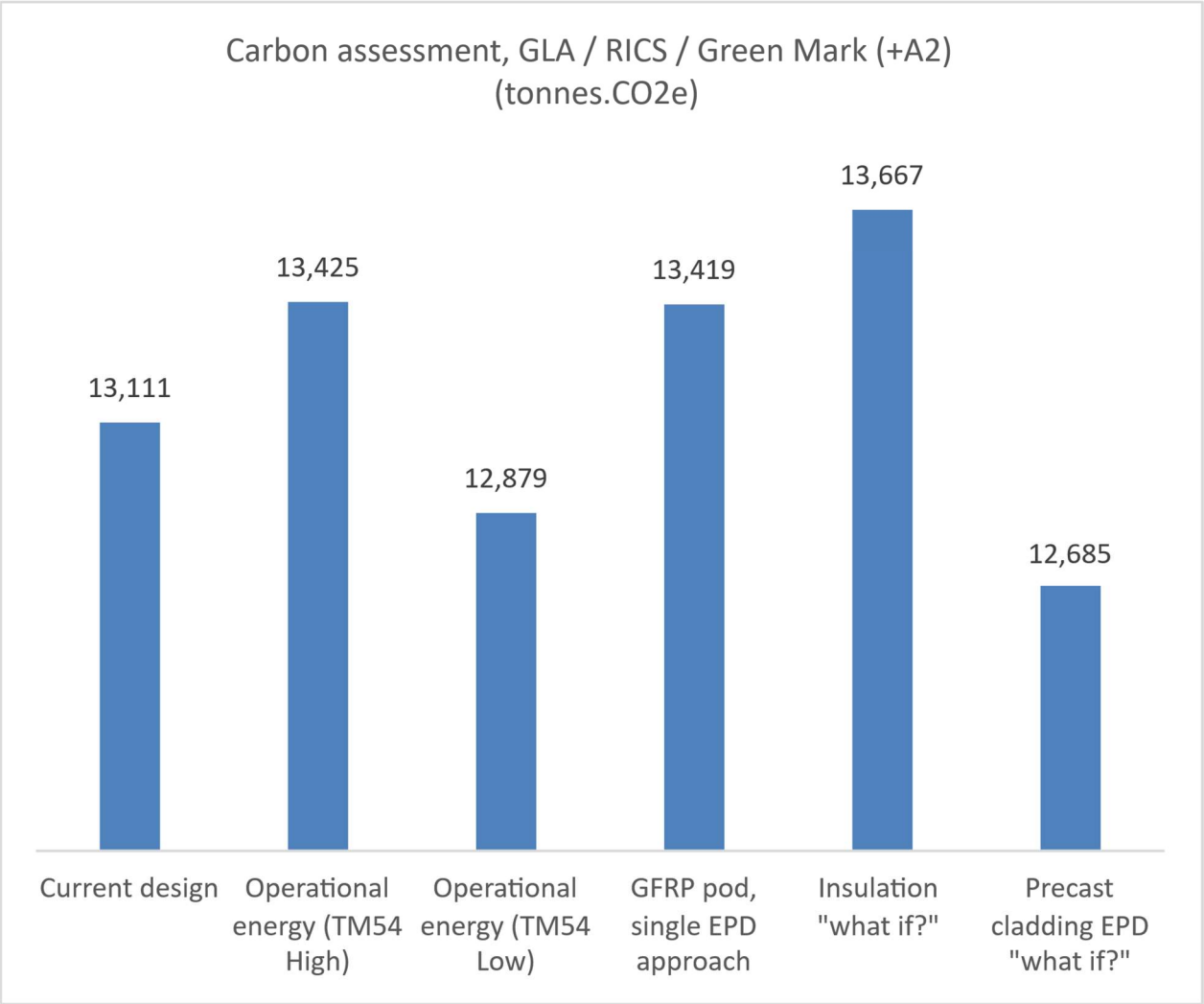


Figure 9: Total tonnes CO_2e for potential "what if?" scenarios and improvements

- Note: non-zero axis crosses at 12,000 tonnes.

District Heat Decarbonisation

The following graph investigates the impact of unrealised decarbonisation in the district heat network.

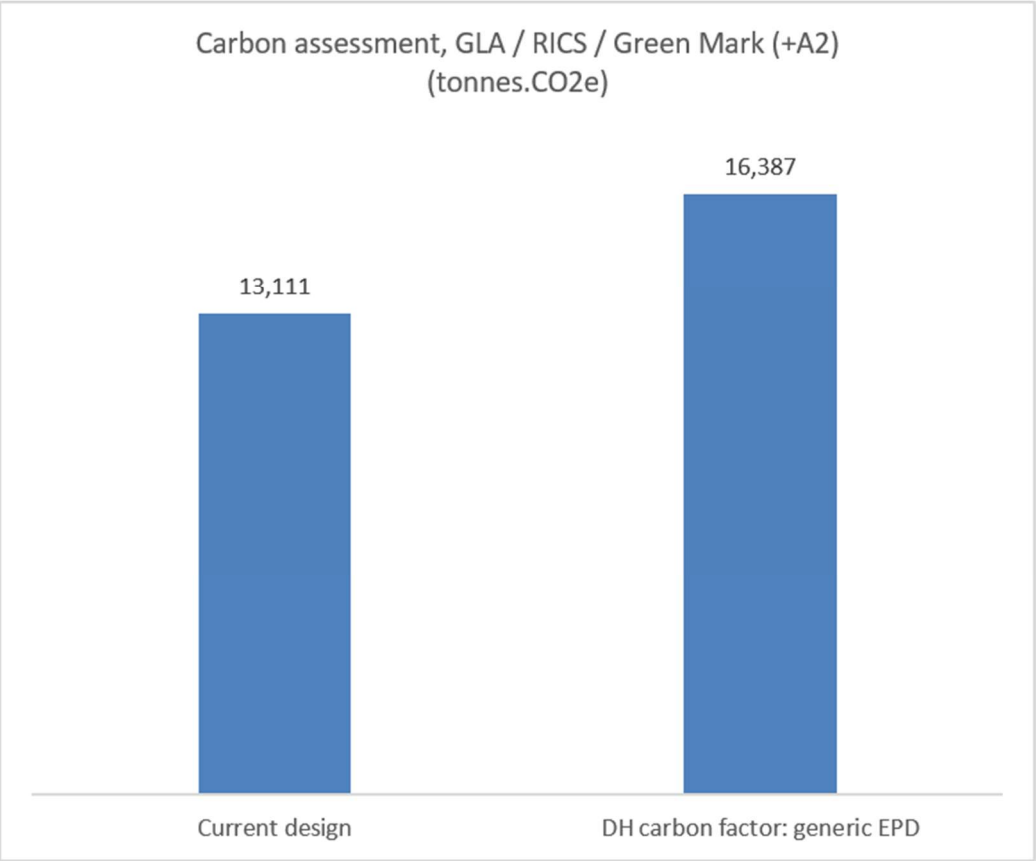


Figure 10: Total tonnes CO_2e for comparison of unrealised DH network decarbonisation

- To make this comparison the generic EPD for modelling district heat consumption was used. This results in significantly higher carbon emissions.
    - The carbon emission factor of this approach exceeds that of Hemiko's current scheme, and far exceeds its 2050-forecast emission factors.
- The "Current design" models the forecast scheme operating to 2050 as provided by the operator, Hemiko.
- See section "Energy consumption" for comparisons of carbon factors and modelling approach.

5 CONCLUSIONS

The proposed development will produce approximately 13,100 tonnes (including pre-construction demolition and sequestered carbon) tonnes of CO_2 over its 60-year life cycle.

Comparison of the proposed development with GLA WLC Benchmarks is shown below:

Table 12: Comparison with GLA benchmarks

		($kgCO_{2e}/m^2$ GIA)	
	A1-A5 (Excluding sequestration)	B-C (Excluding B6-B7)	A-C (Excluding B6-B7; Including sequestered carbon)
WLC Benchmark	*<850*	*<350*	*<1200*
Aspirational WLC Benchmark	*<500*	*<300*	*<800*
The development – Boord Street PBSA	501	343	829

- Residential benchmark used.
- Note that modules B-C are dependent on operational energy in-use. This can be highly variable.

5.1 Stage 2 comparison

A comparison of projected emissions with the previous stage is required. This is presented below. First, the overall building parameters are compared in the following table:

Table 13: comparison of scheme input parameters, Stage 2 vs. Stage 4

Stage	**Concept (Stage 2)**	**Detailed (Stage 4)**
Notes	Previous stage.	Current stage
Consultant	Atelier 10	ICE-BERG/ RG-Group
Date	March 2024	September 2026
GIFA (m^2)	11,569	12,120

- Substantial change has taken place since Stage 2 (e.g., GIFA).
- However, WLCA normalised in terms of GIFA helps comparison.

Table 14: comparison of scheme WLCA, Stage 2 vs. Stage 4

Stage	Metric **(kg.CO2e)**	**Module A1-A5 (excluding sequestered carbon)**	**Modules B-C (excl B6 & B7)**	**Modules A-C (excluding B6-B7; including sequestered carbon)**
Stage 2	Total	8,383,664	7,284,506	15,436,737
	kg.CO2e/m^2	725	630	1334
Stage 4	Total	6,070,427	4,156,776	10,046,503
	kg.CO2e/m^2	501	343	829

- Notably, Stage 2 Modules B-C do not comply with the residential benchmark of "<350". This may be attributed to the choice of repair scenarios.

6 NEXT STEPS

From the above conclusions the following targets will be pursued on the developments design going forward:

- Maintain oversight of heat-usage during operational life. This can be achieved through an effective sub-metering and management strategy. This should be baked in via compliance with Part L and CIBSE TM39 from the outset.
- Keep updated regarding Hemiko's district heat decarbonisation progress.
- Fully test the precast cladding supplier's EPD, as it pertains to this scheme.
- Source ready-mix concrete that uses as high a recycled content in its manufacturing as possible.
- The modular en-suite pods have proven difficult to fully quantify. Resin and glass fibre use is carbon-intensive, but shall probably be mitigated via the use of filler materials.
- Investigate other "detailed" aspects such as the MDF / cabinetry supply chain.
- Few LED lighting manufacturers have EPD credentials as LED manufacturing is typically carbon and chemical-intensive. The supply chain needs testing in this regard.
- At the time of writing, EPDs from the glazing supply chain were not available. It is recommended that this is addressed as procurement continues.

7 APPENDICES

7.1 Appendix A – Glossary of terms

GWP - Global Warming Potential: Anthropogenic global warming is caused by an increase of greenhouse gasses (GHG) in the earth's atmosphere. These gasses reflect some of the heat radiated from the earth's surface that would normally escape into space back to the surface of the earth. Overtime this warms the earth. Common GHGs include CO_2, N2O, CH4 and volatile organic compounds (VOCs). Global Warming Potential (GWP) is expressed in equivalent GHGs released, usually in $kgCO_2e$.

ODP - Ozone Depletion Potential: Ozone is formed and depleted naturally in the earth's stratosphere (between 15-40 km above the earth's surface). Halocarbon compounds are persistent synthetic halogen containing organic molecules that can reach the stratosphere leading to more rapid depletion of the ozone. As the ozone in the stratosphere is reduced more of the ultraviolet rays in sunlight can reach the earth's surface where they can cause skin cancer and reduced crop yields. Ozone Depletion Potential (ODP) is expressed in equivalent ozone depleting gasses (normally kgCFC11e).

AP - Acidification Potential for Soil and Water: Acidification is a consequence of acids (and other compounds which can be transformed into acids) being emitted to the atmosphere and subsequently deposited in surface soils and water. Increased acidity can result in negative consequences for flora and fauna in addition to increased corrosion of manmade structures (buildings vehicles etc.).

Acidification Potential (AP) is an indicator of such damage and is usually measured in $kgCO_2e$

EP - Eutrophication Potential: Over enrichment of aquatic ecosystems with nutrients leading to increased production of plankton, algae and higher aquatic plants leading to a deterioration of the water quality and a reduction in the value and/or the utilisation of the aquatic ecosystem. Eutrophication is primarily caused by surplus nitrogen and phosphorus. Sources of nutrients include agriculture (fertilisers and manure), aquaculture, municipal wastewater, and nitrogen oxide emissions from fossil fuel combustion.

POCP - Photochemical Ozone Creation Potential: Photochemical Ozone Creation Potential (POCP), commonly known as smog, is toxic to humans in high concentration. Although ozone is protective in the stratosphere at low levels it is problematic from both a health and nuisance perspective. Plant growth is also affected through damaged leaf surfaces and reduced photosynthesis. POCP is formed when sunlight and heat react with Volatile Organic Compounds (VOCs).

ADPM - Abiotic Resource Depletion of energy: This is a measure of the extraction and consumption of primary resources from the earth. Such exploitation reduces resources available to future generations and as such must be managed. "

ARDE - Abiotic Resource Depletion of Energy is a measure of the extraction and consumption of nonrenewable energy sources (primarily fossil fuels, but also inclusive of other energy sources such as uranium). Primary energy content of non-renewable energy sources including the embodied energy to extract, process and deliver the non-renewable fuels, or manufacture, transport and install the renewable generator. Hence there is usually, and non-renewable energy content associated with renewable fuels also.

Use of Renewable Primary Energy Resource: Use of renewable primary energy excluding renewable primary energy resources used as raw materials.

Use of Renewable Primary Energy Resource: Use of renewable primary energy resources used as raw materials.

Total use of Renewable Primary Energy Resources: Total use of renewable primary energy resources.

User of Non-Renewable Primary Energy Resource: Use of non-renewable primary energy excluding nonrenewable primary energy resources used as raw materials.

7.2 GFRP pod material spec

Assumptions have been made regarding the composition of the GFRP en-suite pods.

- It is understood that the fully-serviced pods weigh in at 500kg each. It has been assumed that 300kg of this is accounted for in GFRP and that the GFRP comprises of quantities of glass mat, chopped fibres, resin and fillers in proportion.
- Defining this more simply using the one available generic EPD was shown to increase embodied carbon significantly. However, it was deemed that this approach did not consider filler content. This test looks at the simple/ single EPD approach.

Comparison of quantities:

- GFRP surface area: 17m^2 each
- Average GFRP buildup thickness: 8 mm

1. Single layer/ EPD approach:

	GFRP	
Density	2700	kg/m^3
Mass	367.2	kg per pod
Total volume (all pods)	45.56	m^3

2. Approach accounting for "thick wall" filler content

	2 x Layers	Filler/ core	Core resin	Filler/ core	Curing agent			
	GFRP (2 x layer)	Glass fibres	Resin (generic)	Calcium Carbonate	Aluminate			
Parts		5	100	40	20			Total thickness
"Layer" thickness in proportion to volume	2.0	0.2	3.6	1.5	0.7		mm	8 mm
Volume	11	1	21	8	4		m^3	
Density	2700	2700	1200	2700	2400		kg/m^3	
Total mass	30,753	2,796	24,851	22,366	9,940		kg	Mass per pod
Mass	92	8	74	67	30		kg	271 kg

7.3 Appendix B: Suitably Qualified confirmation

Profile

Chris Yates, BEng (Hons), CEng. MCIBSE, LCEA
Sustainability Engineer

Contact Info
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Spreading the knowledge of building physics and its capabilities in bringing about a sustainable built environment.

Biography

Building physics specialist, with a background in engineering and CAD design. Continues to deliver services for award winning projects in the UK and worldwide. Work interests include measurement, verification and calibrated models; comfort; IAQ; lifecycle; embodied energy and BIM. An excellent communicator, Chris has delivered software training nationally, internationally, and online. He has also shared his knowledge of programming in lunchtime sessions for beginners.

A versatile engineer able to work using his own initiative or as a member of a team. Experience of leading teams of consultants to achieve project deliverables and program dates.

Led BDP's team of energy engineers from 2015 – 2021 in delivering solutions for BREEAM, LEED, bespoke energy strategy and Planning approvals.

Software

- MS Excel and Access.
- All CAD: Revit, AutoCAD, Bentley.
- IES, TAS, Designbuilder, IDA ICE, Energyplus, Energypro, ECAM.
- Coding: VBA, Python and AutoLisp.
- Oneclick – Lifecycle carbon assessment.

Design

- Knowledge of industry standard tools.
- CAD management.
- Lifecycle Carbon Assessment (LCA).
- Green certification schemes: Passivhaus, LEED, BREEAM.

All-round

- Training and leadership.
- Bids, forecasting and planning.
- Writing articles.
- Graphics.

Qualifications

- CIBSE Low Carbon Energy Assessor LCEA (Levels 3, 4 & 5).
- CIBSE DEC assessor.
- OCDEA SAP assessor.
- Oneclick Academy.

Places

Stockholm, Oporto, Cairo, but mostly Stockport

- **From 2021: Director of ICE-BERG, the building physics specialists.**

2015 – December 2020

BDP, Building physics lead

Re-joined BDP and re-established building physics as a core discipline delivered in-house. Training, mentoring, and managing a team that grew from zero to six full-time staff in four years.

Pioneered various forms of bespoke assessment less common in the UK, such as measurement and verification to ASHRAE Guideline 14, thermal bridging and hygrothermal studies.

2013 – 2015

Hilson Moran, Senior sustainability engineer

Great company to work for. It was a pleasure to service their big asks: high quality and diligent client focus.

- EDSL TAS detailed systems modelling
- ASHRAE 90.1 PRM method for LEED
- LCA – Whole Life Cost and Carbon

2007 – 2010

Zero Energy Design, Associate

Inspired by the visions to do something special, I joined an ex-colleague's start-up. With a client base of 50 – mostly UK – based companies, ZED was an exciting and formative period in my career cut unfortunately short by the sub-prime mortgage lending - redundancy.

- Management of TFL EPC framework.
- Computational Fluid Dynamics (CFD).
- Projects from Riyhad to Nova Scotia.

2010 – 2013

Freelance

This was a period of career jetsetting to such exotic places as Stockholm and Bristol. Main contracts:

- EQUA Simulation AB, Stockholm.
- CH2M, Bristol

2005 – 2007

Joined **BDP** for the first time in leading the rollout of IES modelling.

2003

Halcrow: Building physics

I joined Halcrow in a CAD management role. After years of admittance load calculations using Hevacomp and Cymap, an introduction to thermal modelling methods in IES was a revelation to me. I was hooked!

1995 – 2005

- CAD manager: Buildings and infrastructure.
- Building services design.
- Expansion bellows design.
- Engineering sales.
- Electrical heater design.

LCA Projects & Training

Successful outcomes and solutions

2025 29-33 The Hale, Tottenham – MAT01

The Hale is a Mixed-use, primarily multi-residential PBSA new build tower comprising 431 bedrooms in a 25 storey tower with commercial uses at the podium levels. A superstructure options appraisal in accordance with MAT01 was undertaken.

2024 Jubilee House, Stratford – MAT01

Jubilee house is a new build secondary school for the London Academy of Excellence (LAE), with student accommodation (v) for 716 students in a 36-storey tower rising above. A superstructure options appraisal in accordance with MAT01 was undertaken for both the Academy and the PBSA.

2020 – 2024 Viking Link, Lincolnshire

This facility was a “converter station” – one end of Viking Link, a 1.4-Gigawatt, 765 km subsea HVDC (High Voltage Direct Current) interconnector. The other end is in Jutland, Denmark. Sited in a 28-hectare compound including environmentally controlled converter halls with process cooling, a control building, and an AC yard. The wider site includes a 2.8km access road and 2.34km of AC underground cable connecting the facility to a National Grid substation.

ICE-BERG delivered LCA as part of CEEQUAL to the requirements of PAS 2080. This resulted in timely actions to reduce carbon emissions, benchmarking, and useful target setting for future projects. Alternative solutions were investigated in partnership with other value-chain members.

2022 – Portakabin LCA

As an off-site manufacturer, Portakabin is uniquely placed to understand the carbon impact of its products. They are currently embarking upon a program that includes measuring and minimising lifecycle impacts. My involvement so far has been to establish baseline for one of their most popular units, the Ultima.

2015 - One Station Square, CB1 (LCA)

Serving as a new landmark for the city of Cambridge, One Station Square offers 129,000 sq.ft of grade 'A' space greeting arrivals at Cambridge train station. The building was one of the first to comply with the new MAT and MAN "IMPACT" credits in BREEAM. My role was to undertake the LCA analysis using IMPACT compliant software.

2015 – BRE IMPACT training

As part of updates to BREEAM, the BRE and IES partnered to provide training in the use of the new IMPACT tools and dataset. Attendance at two-day session hosted by IES and Flavie Lowres of the BRE. This upgraded attendees’ knowledge with IES Lifecycle, Costplan, and the new BRE database.

Other Training & CPD

- 2020 LCA for BREEAM Infrastructure (CEEQUAL)
- 2021 CIBSE TM 65 launch seminar – embodied carbon in building services.
- 2021 - IStructE – “How to calculate embodied carbon” – seminar and IStructE tool.
- 2024 OneClick EPD training.
- 2026 Cerclos eTool – Basic training to assess software alternative.