Westminster City Council

EMBODIED CARBON EVIDENCE BASE

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CONTENTS

1 EXECUTIVE SUMMARY

This study has evaluated the impact of reducing upfront embodied carbon across four common building archetypes in the City of Westminster. Starting with baseline designs, various decarbonisation strategies were applied and assessed to estimate the magnitude of upfront embodied carbon reductions achievable within current construction practices. Furthermore, the study examined the capital costs associated with each intervention to estimate the financial impact of each carbon reduction measure.

The four archetypes used as reference designs for the analysis are based on a mixture of empirical data from previous WSP projects in London, along with material quantities developed from Structural, Building Services, Façade and Finishes design information for each archetype. The methodology follows the latest industry guidance, specifically the RICS Whole Life Carbon Assessment (WLCA) for the Built Environment Standard, Second Edition (2023), focusing on upfront carbon (A1-A5). Cost analysis has been based on the same material quantity information alongside benchmark industry rates.

This study found that all building archetypes can improve upon the current GLA benchmark for upfront embodied carbon using widely available design practices. Measures assessed included cost and carbon-saving strategies (e.g. reducing grid spans, simplifying finishes and optimising building services systems) and carbon-saving measures with higher costs and/or constraints (e.g. optimising façades and using more timber elements and recycled materials). The maximum achievable carbon reductions for all interventions assessed in combination, are shown in Table 1-1 for each archetype. Overall, this study has shown that carbon savings of between 22-26% can be achieved within a 2-4% cost uplift. However, achieving further reductions will be difficult using decarbonisation measures currently available on the market. Hence, within the limitations of this study, introducing an up-front embodied carbon target below values stated in Table 1-1, may begin to restrict new-build construction rather than acting as a mechanism to reduce embodied carbon of these buildings.

Table 1-1 – Summary of cost and carbon results for each archetype ($kgCO_2e/m^2$).

	A1-A5 'Upfront' Embodied Carbon with all measures applied	A1-A5 excl. Demolition, Facilitating and External Works	Cost Uplift of Interventions [%]	Cost Uplift of Interventions [%] (discounting cost savings)
Large Office	633	579	-1.5%	1.9%
Mixed-use	618	583	-2.4%	1.3%
Residential	720	685	-0.7%	4.1%
Small Office	884*	849	1.7%	3.5%

**Substructure accounts for 391 $kgCO2_e/m^2$ (44%) of the small office final upfront carbon, Table 4-10 shows that removing the basement could save approximately 66% (or 304 $kgCO2_e/m^2$) of the substructure.*

Carbon figures are presented both including and excluding demolition, external works and renewable systems for comparison with both industry benchmarks and the scope of the emerging City of Westminster Retrofit First policy. Additionally, cost uplifts have been presented both including and excluding potential cost savings to present both likely and conservative impacts. This more conservative approach aims to account for cost impacts beyond the limitations of this study, such as the impact of reduced spans on lettable floor area.

The availability of low carbon construction products and solutions is a key constraint, as many solutions are reliant on limited source material. As a result, this study recommends that low carbon designs strategies are prioritised ahead of material specification, such as reduced structural grids, alternative slab optioneering, efficient building massing, and swapping out HVAC systems for lower carbon alternatives.

In relation to this, the impact of basements on overall building embodied carbon has been explored further, demonstrating that the addition of a basement causes a disproportionate increase of embodied carbon compared to the increase in area, most evident in the small office archetype. Consequently, if basements were removed from the small office archetype, which is common for small office buildings then the upfront embodied carbon of the building is likely to be very similar to the large office.

Achieving further reductions across all archetypes is certainly possible but would require more innovative construction methods than those presented in this study. These could include industry wide adoption of more novel cement replacement technologies, higher use of timber and significantly more use of recycled materials not widely adopted or available on the market at scale within current regulatory frameworks. Therefore, the pathway towards net zero is expected to require focus on reuse of structure and other materials from existing buildings, adopting a retrofit first approach by promoting building retention and the circular economy.

This analysis supersedes the previous study prepared for Westminster City Council which was completed in December 2023 and published in March 2024. This revised report, as published in September 2024, has been updated to include revised results aligned to RICS 2.0 (2023), and to scope updates following Westminster City Council's Regulation 19 public consultation for their City Plan Partial Review.

2 INTRODUCTION

In response to rising temperatures and scientific consensus about the impact of rises in greenhouse gas emissions, in 2019 the City of Westminster declared a climate emergency. Since then, the council has pledged to become a net zero council by 2030 and a net zero city by 2040. The City of Westminster Climate Emergency Action Plan states that the built environment contributes up to 86% of the carbon footprint of the city. To reduce the environmental impact of the built environment in the city, the council have set ambitious goals and targets including "*retrofitting of buildings to cut their carbon emissions"* and requiring "*new developments achieve best practice standards".*

To build upon the Council's focus on carbon emissions and ways for the built environment to reduce these emissions, a new policy is proposed as part of the City Plan Partial Review. The emerging Retrofit First policy seeks to introduce a mechanism to encourage planning applications to demonstrate options for retaining a greater proportion of an existing building to reduce embodied carbon. Furthermore, the policy also seeks to introduce upfront embodied carbon targets. The draft policy was published during the Regulation 19 public consultation which took place between March and May 2024.

This report provides an evidence-based embodied carbon study to inform the setting of suitable yet ambitious embodied carbon targets for developments across Westminster. This includes a review of what is possible based on current industry practices, and a number of design interventions. This is complemented by an analysis of associated costs to provide an overview of how prioritising low carbon development could impact construction finances.

The project is framed around the existing report WSP completed as part of the West of England Spatial Development Strategy December 2021: Evidence Base for West of England Net Zero Building Policy: Embodied Carbon[1]. It also builds upon the consultation responses received by the Council during the Regulation 19 engagement.

The original version of this report was first published in March 2024. This current version of the report has been revised and re-published in September 2024. This includes revisions and amendments that respond to feedback received from Westminster City Council's Regulation 19 consultation of their City Plan Partial Review, with this document forming part of the Evidence Base for their emerging Retrofit First planning policy. The most notable change in this version of the report is updates to the calculation methodology used, which now aligns to RICS 2.0 (2023).

[1]Evidence Base for West of England Net Zero Building Policy: Embodied Carbon (2021) https://www.westofengland-ca.gov.uk/wp-content/uploads/2022/01/Spatial-Development-Strategy-Evidence-base-for-Net-Zero-Building-Policy-Embodied-Carbon-Jan-2022.pdf

2.1 POLICY THRESHOLDS

2.1.1 LEGISLATORY FRAMEWORK

On the 20th of April 2021, UK government announced a new law-binding target to reduce emissions by 78% compared to the 1990 levels by 2035[2]. This target comes as an interim target to the target of reducing emissions by 68% by 2030 and the net zero carbon target by 2050.

2.1.2 STANDARDS AND GUIDANCE REVIEW

The standards and guidance for embodied carbon were reviewed in order to understand what embodied carbon targets are recommended for domestic and non-domestic developments on their pathway towards net zero carbon. Upfront embodied carbon (A1-A5) targets are set in the documents below:

- GLA Whole Life-Cycle Carbon Assessments guidance (2022)[3]
- RIBA 2030 Climate Challenge: the scope of these targets covers the whole life of a building (A-B-C), as defined by RICS. In reality, not enough data exists today to address all these stages in a reliable way.
- LETI (Low Energy Transformation Initiative) Climate Emergency Design Guide: the LETI targets are also followed by the work of United Kingdom Green Building Council (UKGBC) in their 'Building the Case for Net Zero' report.

Table 2-1 and Table 2-2 below summarises established industry embodied carbon targets from the GLA, and RIBA.

Table 2-1 – GLA benchmark and aspirational embodied carbon targets.

Upfront Embodied Carbon ($kgCO_2e/m^2$)	***Office***	***Residential***	***Education***	***Retail***
Benchmark	*950*	*850*	*750*	*850*
Aspirational benchmark	*600*	*500*	*500*	*550*
2030 Target (LETI)	*350*	*300*	*300*	*300*

[2] Press release: UK enshrines new target in law to slash emissions by 78% by 2035 (2021) https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035
[3] Greater London Authority, London Plan Guidance – Whole Life-Cycle Carbon Assessment https://www.london.gov.uk/programmes-strategies/planning/implementing-london-plan/london-plan-guidance/whole-life-cycle-carbon-assessments-guidance (March 2022)

Table 2-2– Embodied carbon targets according to the RIBA 2030 Climate Challenge (2021)

Whole Life Embodied Carbon ($kgCO_2e/m^2$)	Current Benchmarks	2025 Target	2030 Target
New Build Office	1,400	970	750
Domestic / Residential	1,200	800	625
New Build School	1,000	675	540

Leading industry bodies working in this area have collaborated to form an established set of embodied carbon targets which align various embodied carbon targets and benchmarks[4]. This work has produced a standardised performance and reporting scope for embodied carbon assessments, aligning of embodied carbon measurement and benchmarking from RICS, RIBA, GLA, Institution of Structural Engineers (IStructE) and UKGBC. This publication introduces a rating system which allowed quick comparison for levels of ambition across various typologies and portfolios and brings together the previous GLA and RIBA targets (mentioned above), as shown by Figure 2-1 and Table 2-2.

- The embodied carbon targets are categorised by letter bandings, rather than a single value target. The industry is already familiar with the letter rating system, as it has been used in the context of Display Energy Certificates.
- Targets are set for four typologies: Residential, Office, School and Retail

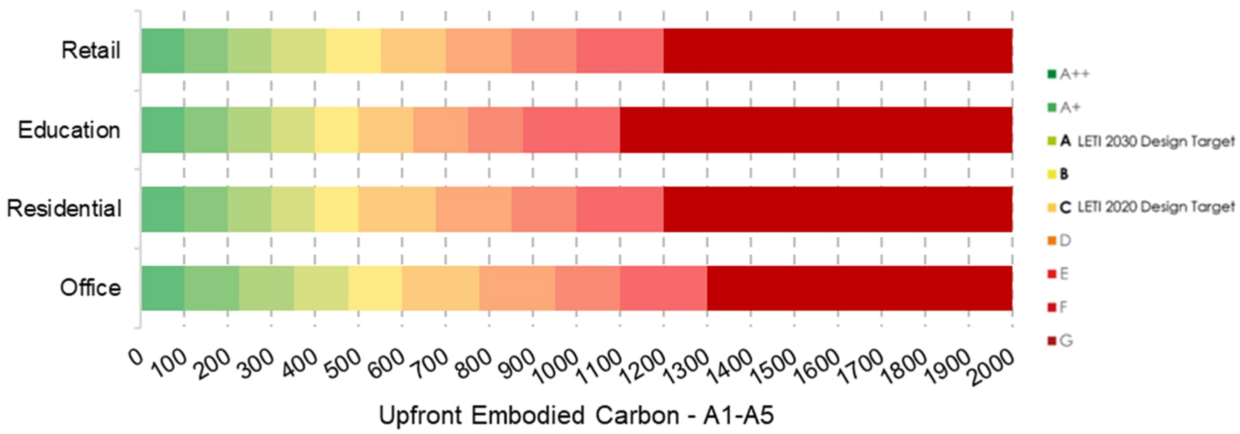


Figure 2-1 – 'Embodied Carbon Target Alignment' - letter bandings.

[4] 'Embodied Carbon Target Alignment' report. Online, available at: https://www.leti.uk/carbonalignment

As part of this work, LETI and RIBA have aligned the new letter banding system with their previous targets. More specifically, the LETI position is that for buildings that are currently in the **design** stage:

- Average design achieves an E
- Good design achieves a C (LETI 2020 target)
- LETI 2030 'Paris Aligned' design target achieves an A

The bandings do not currently differentiate between new build or refurbishment. Part of the rationale for this is that refurbishment projects will find it easier to achieve good performances and this provides an incentive for retrofit. It is expected that as more data is collected for ranges of retrofit, the bandings could be adapted if necessary.

2.1.2.1 Net Zero Carbon Building Standard

Although not issued at the time this study was carried out, WSP is aware of the development of the Net Zero Carbon Building Standard (NZCBS) the draft of which is expected to be released in September 2024. The NZCBS has been formed by a project team of more than 350 voluntary experts from all parts of the built environment industry. The aims of the standard are to provide clear, consistent definitions and trajectories for net zero carbon buildings, drive market transformation through industry and update and align individual projects with the system-level changes required for a net zero UK by 2050.

It is anticipated that there may be differences between the targets provided by the standard and the embodied carbon values provided in this document based on early indicators from NZCBS showing values below GLA and RIBA 2025 targets. This is not unexpected due to the differences in approach between the two projects. It should be noted that the NZCBS uses data aggregated from over 800 projects (in terms of embodied carbon alone) of different sizes, constraints and resources, balanced with top-down analysis using UK carbon budgets and based on RICS Professional Standard for Whole Life Carbon Assessment 1st Edition (2017), hereafter referred to as RICS (2017). In contrast, this study is based on a selection of specific building archetypes that have not been blended with high level budgets but have been assessed using RICS 2.0 (2023) to allow desk based isolated assessment of cost impact of interventions to reduce embodied carbon suitable for these archetypes.

3 METHODOLOGY

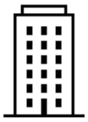
The methodology behind measuring and reporting greenhouse gas emissions from construction projects is evolving as the industry learns and adapts to the challenges of mitigating climate change. The methodology for assessing both carbon and cost information in this report has followed latest available industry guidance at the time of writing from:

- UK Green Building Council (UKGBC)
- Low Energy Transformation Initiative (LETI)
- Royal Institute of British Architects (RIBA)
- Royal Institute of Chartered Surveyors (RICS)
- Institute of Structural Engineers (IStructE)
- Centre for Window and Cladding Technology (CWCT)
- Chartered Institute of Building Services Engineering (CIBSE)

This document has focused on establishing the embodied carbon and cost of four typical building archetypes for the City of Westminster. It is based on a mixture of empirical data from previous WSP projects in London, along with material quantities developed from generated Structural, MEP, Façade and Finishes design information for each archetype.

3.1 BUILDING TYPOLOGIES

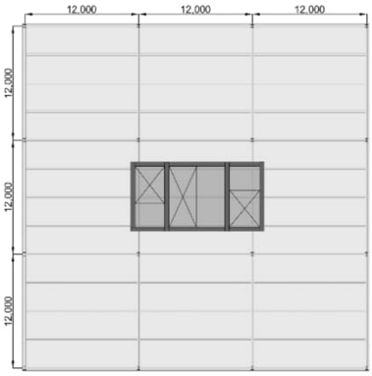
Four building typologies were explored for this exercise, three for non-domestic development and one for domestic, which were developed with Westminster City Council as four representative building typologies for the City of Westminster:



Office

7 Storeys

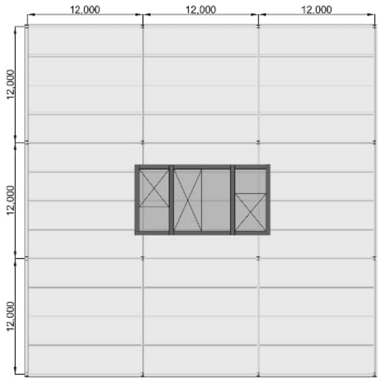
Gross Internal Foor Area = 10,368 m^2



Mixed Use

7 Storeys

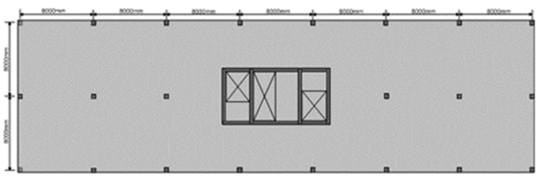
Gross Internal Foor Area = 10,368 m^2



Residential

8 Storeys

Gross Internal Foor Area = 8,064 m^2



Small Office

3 Storeys

Gross Internal Foor Area = 1,440 m^2

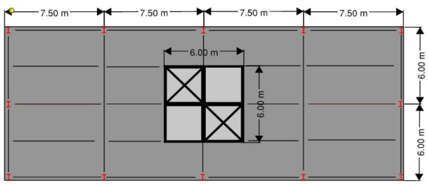


Figure 3-1 – Building archetypes used in study, representative of typical mid-rise building buildings in the City of Westminster. (not to scale)

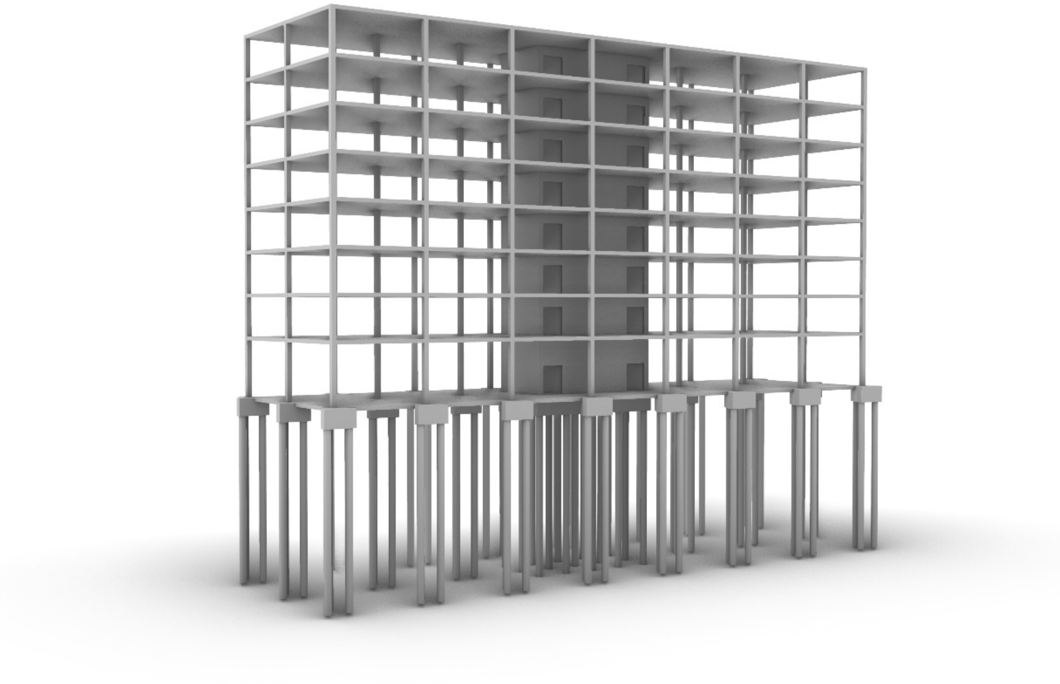


Figure 3-2 – Residential archetype 3D view (structure only)

Figure 3-3 – Office & mixed-use archetype 3D view (structure only)

3.2 BASELINE AND ALTERNATIVE SCENARIOS

Four different baselines were created for the study these are:

Office:

- Steel structural frame with composite concrete-steel deck slabs for floors
- Stick-system curtain walling with Double Glazed Unit and opaque external wall with terracotta finishing
- Heat pumps and chillers, with typical fan coil unit arrangement

Mixed Use:

- Retail on ground floor (14%)
- 3 floors of commercial office space (43%)
- 3 floors of residential (43%)
- Steel structural frame with composite concrete-steel deck slabs for floors
- Stick-system curtain walling with Double Glazed Unit and opaque external wall with terracotta finishing
- Mix of residential and commercial MEP system

Residential:

- Concrete structural frame with concrete flat slabs for floors and roof
- Triple Glazed Unit aluminium window and opaque external wall with terracotta finishing
- Ambient loop system with secondary heat pumps in each apartment

Small Office:

- Steel structural frame with composite concrete-steel deck slabs for floors
- Stick-system curtain walling with Double Glazed Unit and opaque external wall with terracotta finishing
- Heat pumps and chillers, with typical fan coil unit arrangement

Although the initial review contained the structure as shown in Figure 3-1 and Figure 3-2, a single storey basement was added into the baseline option as it was deemed more representative of typical buildings currently in construction.

Then, using the baselines, seven alternative scenarios were developed as summarised in Table 3-1 below:

Table 3-1 – Alternative scenarios.

Building Archetype	S1 - Baseline	S2 – Low Carbon Facade	S3 – Low Carbon Finishes	S4 – Low Carbon MEP	S5 – Reduced Grid Spacing	S6 – Low Carbon Concrete	S7 – Low Carbon Steel & 50% Cement replacement (Residential)	S8 – Hybrid Timber
Large and Small Office	Steel frame and composite concrete-steel deck floor slabs	Increase recycled aluminium content of the curtain walling framing and replace terracotta rainscreen cladding components with timber cladding.	Removal of ceiling tiles and use of reclaimed floor tiles for 50% of net internal area.	Replace traditional 4-pipe fan coil unit system with displacement ventilation system with on floor air handling units.	Reduction in grid spacing from 12m to 9m.	+25% cement replacement included in concrete mixes	Additional +10% steel reuse & + 15% electric arc furnace steel (compared to current UK average)	Steel frame and CLT floors/ roof
Mixed-Use	Steel frame and composite concrete-steel deck floor slabs	Increase recycled aluminium content of the curtain walling framing and review external wall build-up including bricks as finishing.	Removal of ceiling tiles and use of reclaimed floor tiles for 50% of net internal area.	Replace ambient loop system with heat pump in apartments with more typical heating only system. Commercial same as office baseline	Reduction in grid spacing from 12m to 9m.	+25% cement replacement included in concrete mixes	Additional +10% steel reuse & +15% EAF steel (compared to current UK average)	Steel frame and CLT floors/ roof
Residential	Concrete frame and reinforced concrete in-situ flat slabs	Replace window aluminium framing with composite framing and review external wall build-up including bricks as finishing.	Removal of ceiling tiles and use of reclaimed floor tiles for 50% of net internal area.	Replace ambient loop system with heat pump in apartments with more typical heating only system.	Reduction in grid spacing from 8m to 6m.	+25% cement replacement included in concrete mixes	+50% cement replacement included in concrete mixes	

The scenarios described above were applied cumulatively to the baseline, such that the combined impact could be examined. This assessment allowed for the combined impact of these interventions to be explored and the results to be compared against current industry targets with a view to informing any embodied carbon targets to be set by policy.

It should be noted that while the "cement replacement" and "low carbon steel" scenarios noted above are based on GGBS (ground granulated blast furnace slag) and a combination of Electric Arc Furnace (EAF) and reused steel, these are representative of lower carbon material specification and should not be seen as prescriptive measures. Future innovation in cement replacement is expected to rely on diverse alternative approaches to achieve market wide carbon savings, with calcined clay presenting the highest potential availability[5]. Similarly, in the short-term EAF steel is lower carbon than more traditional basic oxygen furnace (BOF) steel but further developments in Direct Reduced Iron (DRI) technology are expected to increase the availability of alternative low carbon steel. Additionally, the change of structural floor type to CLT demonstrates the impact that consideration of different floor types can have on the embodied carbon of the overall building. Further details on these can be found in Appendix B.

3.3 BUILDING ELEMENTS

To assess which building elements should be in-scope or out-of-scope, the guidelines from RICS 2.0 (2023)[6] have been reviewed and followed.

For the purpose of this study, the scope for the detailed analysis includes the Substructure (RICS Category 1), Superstructure (RICS Category 2) calculated following guidance in the IStructE's "How to calculate embodied carbon (Second edition)"[7], CWCT's "How To Calculate The Embodied Carbon Of Facades: A Methodology[8] . Finishes (RICS Category 3) have been calculated by evaluating a reference design using embodied carbon rates from OneClick LCA. Building Services (RICS Category 5) elements following guidance from CIBSE. These were chosen as:

- They are expected to have a high share of embodied carbon emissions
- They are commonly considered during early design stages

An allowance for demolition and construction activities has been added following guidance from RICS 2.0 (2023). For this, demolition activities have been excluded from the calculation. One change in the guidance from RICS is more detail on A4-A5 scope emissions. As part of this, where no site-specific data is available, RICS 2.0 (2023) suggests that a 40 $kgCO_2e/m^2$ so this has been included as a separate line item in the scope of the assessment. RICS 2.0 (2023) also recommends an average of 35 $kgCO_2e/m^2$ to be added per m^2 of demolished building. However, in this generic

[5] IStructE Beyond Portland cement: Low-carbon alternatives https://www.istructe.org/resources/guidance/beyond-portland-cement-low-carbon-alternatives/
[6] RICS, 2023. Whole life carbon assessment (WLCA) for the build environment.2nd Edition. Online Available at: Whole life carbon assessment (WLCA) for the built environment (rics.org)
[7] How to calculate embodied carbon (Second edition) (IStructE, 2022) https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/
[8] How To Calculate The Embodied Carbon Of Facades: A Methodology (CWCT, 2023) https://www.cwct.co.uk/pages/embodied-carbon-methodology-for-facades

case, it is impossible to accurately predict the size of building to be demolished and hence demolition emissions have been excluded from the assessment. leading to a total 40 $kgCO_2e/m^2$ uplift for construction activities. External works (RICS Category 8) have been based on GLA benchmark values, from the GLA's Guidance on Whole Life-Cycle Carbon Assessments. These have been applied as a percentage of the GLA Benchmark Value and then applied consistently to each option, as shown by Table 3-2.

The scope of the assessment has been aligned to shell and core and Cat A fit out for commercial archetypes and landlord and tenant areas for residential buildings

Table 3-2 – Percentage increase per building typology for the FFE (Fittings, Furnishings, Equipment) and the External works (extended scope).

	FFE	External Works
Large Office	2%	2%
Mixed Use	1%	2%
Residential	1%	1%
Small Office	2%	2%

Finally, there are some categories of building elements which were omitted from the scope of this assessment as these will vary considerably depending on the unique nature of each project and would not be feasible to calculate for a generic archetypal building. These categories include the "Prefabricated buildings and building units", the "Works to existing buildings" and "External works outside the project boundary". Table 3-3 summarises the in-scope and out-of-scope elements considered for this study.

Table 3-3 – Building elements in scope of this assessment by RICS category.

Scope A: Scope aligned to RICS 2.0 calculation methodology

Scope B: Reduced scope to align with WCC Retrofit First Policy

RICS 2.0 Category	A	B	Methodology
0.1 Demolition works	✓	✗	RICS 2.0 (2023) guideline
0.2 Construction Activities	✓	✗	RICS 2.0 (2023) guideline
1 Substructure	✓	✓	IStructE methodolgy
2 Superstructure - Structural elements	✓	✓	IStructE methodolgy
2 Superstructure - Building envelope	✓	✓	CWCT methodology
2 Superstructure - Internal elements	✓	✓	Based on WSP LCA data
3 Finishes	✓	✓	reference design calculation using OCLCA
4 Fittings, furnishings and equipment (FF&E)	✓	✓	GLA benchmark value
5 Services (MEP)	✓	✓	CIBSE TM65 methodology
5.1 Renewables	✓	✗	CIBSE TM65 methodology
6 Pre-fabricated buildings and units	✗	✗	not included
7 Works to existing buildings	✗	✗	not included
8 External works associated with the project (within boundary)	✓	✗	GLA benchmark value
8 External works associated with the project (outside of boundary)	✗	✗	not included

3.4 LIFECYCLE STAGES

To determine the lifecycle stages to be included in the scope of this study, the guidelines from RICS 2.0 (2023) have been reviewed. As a result, two lifecycle stages scopes were followed; the 'Product' and 'Construction' stages, A1-A5 modules which are known as “upfront carbon”. Consequently, the results of this study should only be compared to upfront embodied carbon targets.

While there are a range of other lifecycle stages to consider when assessing whole life carbon; upfront emissions, from a regulatory perspective, are the most impactful and are important to limit as they are the emissions emitted by the developer during construction up until practical completion. It is common that at practical completion, a building is handed over to another organisation for the operational phase. By focussing the study on A1-A5 emissions and as a result, setting ambitious upfront embodied targets for new construction, this should have the effect of encouraging more redevelopment of existing buildings. However, it is recommended that the focus is broader than just upfront embodied carbon and that any proposals for development should always be accompanied by a whole life carbon study. In doing so, this prevents short-term decision making which favours only meeting upfront embodied carbon requirements and instead focuses on how informed designs and an emphasis on design for long lifespans and operational carbon considerations can collectively reduce whole life carbon overall.

In the Scope of this Assessment – Upfront Embodied Carbon: This scope focuses only on the upfront carbon (A1-A5), excluding emissions from B, C and D lifecycle stages. Module D of RICS 2.0 (2023) sets out a methodology for carbon sequestration have been excluded from both scopes for the purpose of this assessment. WSP recommend that these carbon 'benefits' are required to be reported separately by the new policy.

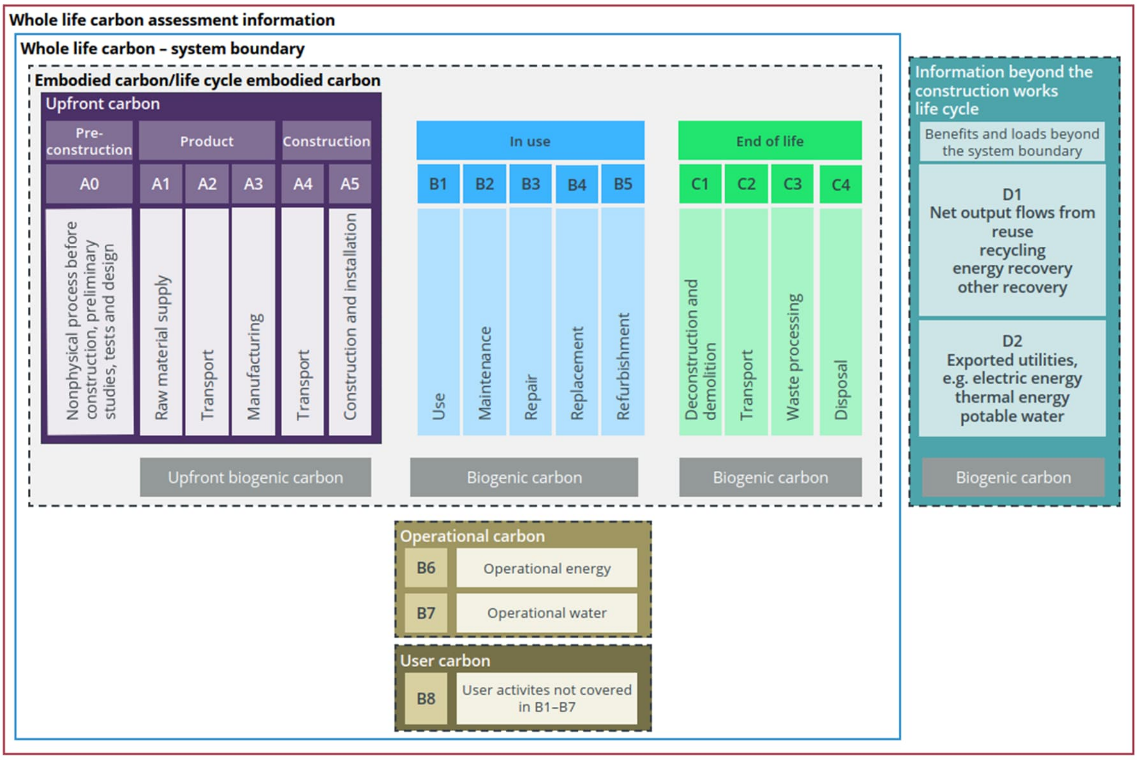


Figure 3-4 – Life cycle stages as defined by BS EN 15978:2011.

3.5 STRUCTURAL METHODOLOGY

The IStructE produced the guide "How to calculate embodied carbon (2nd edition)"[9] for the structural engineering community to follow when calculating embodied carbon. The guide establishes a baseline for calculating embodied carbon such that all designs can be compared between structural schemes. To quantify the structural accurate material quantities embodied carbon as per the IStructE guide, the quantity of each material is multiplied by a carbon factor for the life cycle modules being considered (see Equation 1 below). Each structural element for the study in Westminster has been calculated using the methodology as described above and in the IStructE guide.

Material quantity (kg) x carbon factor ($kgCO_2e$/kg) = embodied carbon ($kgCO_2e$)

In order to derive material quantities for each of the options, full structural schemes were developed which assessed beam & slab sizes/thicknesses, column sizes, outline sizes for stability members and optimal foundation types and sizes (explained further in Section 3.5.1). From this, the material quantities could be estimated, and subsequently embodied carbon, could be calculated. See Appendix B for further detailed assumptions relating to the structural assessment.

3.5.1 GEOTECHNICAL & FOUNDATIONS

Foundations are a large structural contributor of embodied carbon and as such it formed an important area of focus for this study. WSP's geotechnical team were engaged to understand the expected ground conditions within Westminster and therefore likely foundation solutions for the archetype designs.

Whilst the archetypes are of no fixed location, the likely strata to be encountered within the City of Westminster can be loosely divided into two zones. Close to the river in the South, there is an approximate 7m of made ground overlaying alluvium, sand, gravel, then London clay. In the North of the City, the depth of made ground reduces to approximately 3m. The soil data in the North of the site has formed the basis of the foundation design undertaken herein as it represents the largest area within the City itself and is therefore deemed more representative of a typical building.

Based on the assessed foundation loads for each building, pile-load graphs were used to determine the required pile depths & diameters for both piles beneath pile caps and the piled wall where a basement is included

3.5.2 SEQUESTRATION

Sequestration refers to the process of removing carbon from the atmosphere and storing it. Timber naturally sequesters carbon by absorbing it as wood grows and storing it over its lifetime. The carbon is often released at the end of life of the timber product, such as through burning. For this

[9] How to calculate embodied carbon (Second edition) (IStructE, 2022) https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/

reason, it has been presented separately to the upfront/embodied carbon values as the benefit should only be taken with consideration of the end-of-life strategy for the material or element.

In order to account for the benefit of carbon sequestration within a whole-life carbon assessment, it must be ensured the sequestration will happen; the timber must be sustainably sourced, and the felled trees must be replaced in line with current European standards. Therefore, on a typical project, whether or not to include sequestration and how to incorporate the figures within carbon calculations will come down to project specifics relating to how the timber has been procured.

Because these procurement requirements cannot necessarily be guaranteed, for this study the biogenic carbon numbers are not included within the results, and it can be decided on a project-by-project basis whether or not to include them subject to aforementioned procurement requirements. Module D of RICS 2.0 (2023) sets out a methodology for carbon sequestration have been excluded from both scopes for the purpose of this assessment. WSP recommend that these carbon ‘benefits’ are required to be reported separately by the new policy.

3.6 FAÇADE METHODOLOGY

In September 2022, the CWCT introduced a methodology titled "How to Calculate the Embodied Carbon of Facades"[10]. This method aims to establish consistency in the industry when determining the embodied carbon of facades. The CWCT methodology, part of a suite of guides for various building elements like the primary structure (IStructE guide) and building services (CIBSE TM65), underscores the significance of a meticulous evaluation of individual building facade components. The assessment, tailored to the design stage, involves a conceptual estimation of embodied carbon, considering allowances for uncertainties, variations, and contingencies.

During the early design phases the assessment is conceptual, estimating the embodied carbon and other relevant characteristics of the facade system whilst including allowances for uncertainty. These allowances address variations in the carbon footprint of the construction of a façade system and ensure more realistic estimates. The primary objective is to derive accurate figures for the embodied carbon and other aspects of the facade through a detailed assessment of its components and materials. Once these figures are established, they can be included in project documentation providing clear specifications for sustainability, materials, and other factors to contractors.

The CWCT Methodology follows the framework set out in BS EN 15978 and is aligned with the RICS 2.0 (2023) Professional Statement: “Whole Life Carbon Assessment for the Built Environment”.

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[10] How To Calculate The Embodied Carbon Of Facades: A Methodology (CWCT, 2023) https://www.cwct.co.uk/pages/embodied-carbon-methodology-for-facades

3.6.1 FAÇADE FORM FACTOR

The usual method for calculating the embodied carbon of a facade involves expressing it in units per square meter of Facade Surface Area (FSA). This stands in contrast to typical building carbon targets or assessments, which are often presented in units per square meter of gross internal floor area (GIA). Consequently, the ratio between a building's FSA and GIA, referred to as the 'Facade Form Factor (FFF),' plays a crucial role in determining the facade's impact on the overall embodied carbon of the building.

The FFF greatly influences how much the facade contributes to the overall embodied carbon per square meter of GIA. Buildings with low form factors, meaning more efficient designs, will have facades that contribute less to the building's total embodied carbon.

Table 3-4 – Façade surface area and form factor for each building archetype.

Building Archetype	GIA	FSA	FFF
Mixed Use	10,368	4,248	0.41
Large Office	10,368	4,248	0.41
Residential	8,064	7,168	0.88
Small Office	1,440	882	0.61

3.6.2 WINDOW-TO-WALL RATIO

The Window to Wall Ratio (WWR) is the proportion of a facade's surface area that is occupied by windows, and it is a critical parameter for embodied carbon calculations as it affects the choice of materials, energy use during the building's lifespan, manufacturing processes, transportation emissions, and end-of-life considerations.

Understanding and optimising the WWR is essential for designing facades that align with sustainability goals and minimise the overall environmental impact of a building: a higher window-to-wall ratio increases solar heat gains and consequently cooling demands, but also allows for more natural light, reducing energy required for lighting. Nevertheless, the WWR is a project specific parameter to be optimized also in accordance with climate, building orientation and intended use. It is important to note that reducing glazing areas before taking steps to improve the carbon intensity of materials used for the opaque elements of a façade often has a positive impact, reducing the embodied carbon further. This principle applies to façade in a similar way that reducing grid spacing in structural systems improves the carbon performance independent of material choices.

Different transparent areas have been assigned to the archetypes in accordance with the defined building geometry. For residential, the maximum area of glazing has been defined in accordance with the Building Regulations, Approved Document Part O – Overheating[11]. Windows have been assumed to be on all sides of the building, while true for some buildings others will be terrace or end of terrace buildings with reduced window to wall ratio. It is expected that façade contribution of these buildings will be lower, due to higher façade contribution of glazing units compared with opaque units.

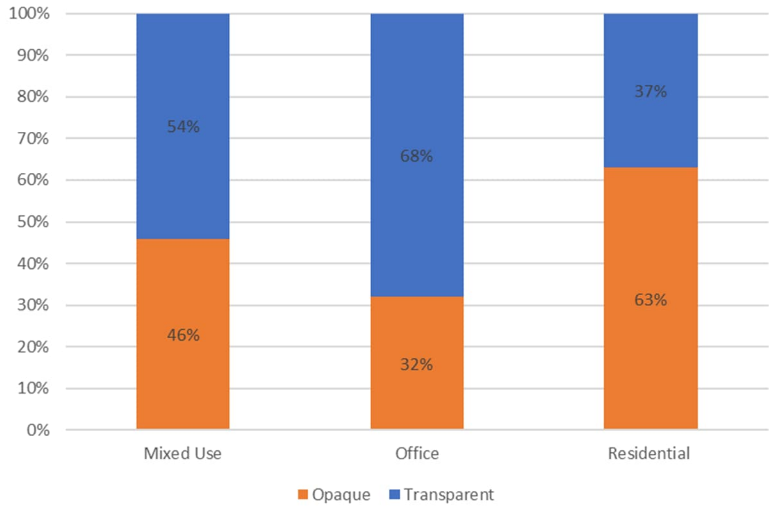

Figure 3-5 – Window to wall ratio of each building archetype (Large office and small office have the same WWR).

[11] GOV.UK (2021) Overheating: Approved Document O. Available online at: https://www.gov.uk/government/publications/overheating-approved-document-o

3.6.3 FAÇADE SYSTEMS

Two different scenarios have been used to define façade systems of each building archetype. A transparent and an opaque build-up are used in the proportions explained above. A baseline has been defined for the typical façade systems and an optimised alternative has been produced to compare carbon reductions of these two scenarios for each building archetype. The scenarios chosen should not been interpreted as prescriptive measures for designers to follow, noting they are defined to allow a comparison of carbon and cost on these standardised archetypes as part of this theoretical study.

Some components have been substituted for lower carbon intensive solutions. Their procurement strategy has been revised to accommodate for materials that are manufactured locally or nationally RICS 2.0 (2023) defines different transport scenarios when components are transported to site under A5 scope emissions. Furthermore, a reduced wastage rate has been applied, based on the standard wastage rates provided by the RICS 2.0 (2023).

Future innovation in façade solutions is expected to be more aligned with sustainable practice, such as designing for disassembly, to promote the circular economy principles of reusing, closed-loop recycling, and upcycling components at the end of their life. Façade solutions must also be climate resilient and designed for extreme climate conditions. These wider sustainability considerations reinforce the importance of following a passive design approach to façade design in line with GLA Energy Assessment Guidance [12].

The upfront carbon focus of this study also presents constraints for holistic façade optimisation, noting elements that require more frequent replacement including glazing and coating systems have a relatively higher impact on whole life carbon results above the figures in an upfront carbon comparison. Building designers are encouraged to focus on the broad whole life carbon assessment including operational energy implications when presenting façade solutions for consideration to Westminster City Council.

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[12] Greater London Authority (2022) Energy Assessment Guidance, available online. https://www.london.gov.uk/programmes-strategies/planning/planning-applications-and-decisions/pre-planning-application-meeting-service/energy-planning-guidance

3.6.4 FURTHER OPTIMISATION

In the hypothesis that the current scenario will evolve, and the timber cladding assembly is not discarded as an option for residential buildings, a further optimisation has been set out to compare the above-mentioned options with a more sustainable façade system.

Following the same approach, and supposing that the content of recycled glass will increase in the production of glass, an alternative for offices has been included. See Appendix C for further details assumption relating to the façade options.

Table 3-5 – Façade embodied carbon reduction measures and materials assessed; mixed-use façade typologies are a combination of the above.

Building Archetypes	**Typical Facade Systems**	**Low Carbon Façade Systems**
Office And Small Office	Aluminium framing curtain walling system + Rainscreen terracotta cladding	Curtain walling with higher recycle content in aluminium framing + Rainscreen timber cladding
Residential	Aluminium framing window + Rainscreen terracotta cladding	Composite framing window + Steel Framing System and brick finishing
Mixed Use	Mixed (43% Office, 43% Residential, 14% Retail)	Mixed (43% Office, 43% Residential, 14% Retail)

3.7 SERVICES METHODOLOGY

3.7.1 INTRODUCTION

In response to growing concern about the amount of embodied carbon in building services products, in January 2021 CIBSE introduced the TM65 methodology to guide professionals in quantifying and understanding the embodied carbon associated with building services equipment[13]. The document outlines an approach to measuring embodied carbon for a building services product lifecycle, from material extraction, manufacturing, and transport to the end-of-life processes, such as waste processing and disposal. Furthermore, TM65 accounts for complexities in product manufacturing and provides recommendations for carbon estimations in the absence of specific data, ensuring a comprehensive yet adaptable methodology for various building services products. The amount of data on embodied carbon of building services equipment (namely Environmental Product Declarations (EPDs) or CIBSE TM65 Forms) is limited and constantly evolving as the industry adapts to this new challenge. TM65 accounts for this by applying a product complexity factor, and conservative buffer factor to account for uncertainty in carbon data and to provide an element of contingency to the calculations.

3.7.2 OVERVIEW

The embodied carbon calculation for RICS category 5 has been undertaken using the WSP MEP Embodied Carbon Calculator. Two scenarios have been assessed for each option: a baseline MEP system, and a low carbon option. The only difference between the options is the heating, ventilation and air conditioning (HVAC) design, with all other services such as power supply, fire suppression, vertical transport and drainage remaining constant between the options. The core part of this analysis has considered the upfront A1-A5 embodied carbon emissions of the system. As building services products are typically replaced 2-3 times throughout a building's lifespan and often contain materials and substances with high global warming potential, such as refrigerants a separate stand-alone calculation has been undertaken for the whole life embodied carbon of each option. The operational energy and carbon emissions of the building have not been considered in this analysis. The 'low carbon' option is therefore a low embodied carbon option, and in some cases, there may be a trade-off against increased operational emissions. The high-level description of MEP services options used in the assessment can be found in

Table *3-6*. The MEP systems include shell and core and Cat A fit out for the office, and shell and landlord and tenant fit out for the residential system.

[13] Chartered Institute of Building Services Engineers (2021) Technical Memorandum 65, "Embodied carbon in building services: A calculation methodology (TM65)", available online at: https://www.cibse.org/tm65

3.7.3 RICS 2.0 (2023) UPDATE

RICS 2.0 (2023) was published in November 2023 and has been in force since July 2024. For MEP systems this represents a significant change in how the embodied carbon of building services is calculated. The main change is that RICS 2.0 (2023) provides much more detail on which items should be included in the scope of an embodied carbon assessment for building services systems. Alongside the guidance, RICS published 'MEP Supplementary Tables' which contain quantity information for typical building services designs to be used where no specific design information is available for the project. These have been used as the basis of this analysis, alongside Stage 2 design information from comparable WSP projects across London. This means that the methodology followed in this study should be comparable to the methodology followed by design teams undertaking building services calculations at the planning stage as RICS 2.0 (2023) has been much clearer in defining both the scope, quantities and methodology of the assessment.

Table 3-6 – MEP services options.

	Large Office/Retail/Small Office		Residential	
	Baseline	Low Carbon	Baseline	Low Carbon
Air Handling Plant	Central air handling unit	On floor air handling units	Mechanical ventilation with heat recovery	Mechanical ventilation with heat recovery
Air Distribution	Ducted supply and extract	Displacement ventilation system	Ducted supply & extract	Ducted supply & extract
Primary Heat Source	4 pipe air source heatpump	4 pipe air source heatpump	4 pipe air source heatpump	2 pipe air source heatpump
Cooling Source	4 pipe air source heatpump	4 pipe air source heatpump	4 pipe air source heatpump	Cooling bolt-on to ventilation unit
Primary Distribution	Traditional central distribution	Traditional central distribution	Ambient loop distribution	Central heating distribution with heat interface units
Emitter	Fan coil units	On floor air + trench heating	fan coil unit	underfloor heating
Refrigerant	R32	Low GWP Refrigerant (R290)	R32	Low GWP refrigerant (R290)

The MEP design information to generate the quantity information for the calculation has been taken from planning stage WSP projects in London which closely match the building archetype. Large office and small office are assumed to have the same system throughout, whereas the mixed-use archetype has been made up of a combination of the residential units and commercial system, assuming the baseline commercial system for the retail and office areas. Information on mechanical and electrical plant items (for example, heat pumps, air handling units, transformers etc.) have been taken from manufacturer selections of equipment for each project, suitable for a RIBA Stage 2 planning submission. See Appendix D for more information.

3.7.4 WSP MEP EMBODIED CARBON CALCULATOR

The WSP MEP Embodied Carbon Calculator has been developed in accordance with guidance from CIBSE (CIBSE TM65). For building services plant, it uses the plant schedule including the number and predicted weight of each component. If EPD data can be found for the product type, then the calculator uses this for the calculation. If no EPD data could be found for the product then the calculation follows the CIBSE TM65 Basic methodology, which involves estimating the material breakdown of the product and then applying the relevant carbon factor based on the Inventory of Carbon and Energy (ICE) materials database, with appropriate scale up factors to account for the complexity of the supply chain of the product. If neither of these data types was available for the product the calculation defaults to the most appropriate generic value from the OneClick LCA database.

3.7.5 WHOLE LIFE CARBON

Whole life embodied carbon (excluding B6 and B7) has also been assessed and reported separately to better understand the impact on whole life carbon.

3.8 INTERNAL FINISHES METHODOLOGY

3.8.1 ASSUMPTIONS

Based on cost plans provided for similar typology projects, assumptions were made in terms of the internal finishes applied to each building scenario. These were compared to the RICS 2.0 (2023) Building element categories in order to ensure that all features were covered. The following assumptions made across these scenarios can be seen in Table 3-7 below.

Table 3-7 – Internal Finishes assumptions applied.

	Assumptions Made
General	• 25% Back of House and 75% Front of House • Stairs in Office typology assumed as 140m^2 of building and in Residential assumed as 32m^2 per floor, in alignment with structural method • Bathroom assumed as 5% of FOH surface area in Office and 7.5% in Residential
Wall Finishes	• Wall to Window Ratio assumed in line with Section 3.6.2
Ceiling Finishes	• 1 ceiling hatch assumed by every 50m^2 GIA, in line with Building Services assumptions
Floor Finishes	• 50% vinyl and 50% carpet assumed on remainer of FOH floor surface area

A full list of all the materials included within the internal finishes carbon analysis can be seen below in Table 3-8.

Table 3-8 – List of Materials applied to each building typology.

	Building Archetypes		**Material Carbon Factors** ($kgCO_2e/m^2$, unless noted otherwise)
	Office	**Residential**	
Wall Finishes	Paint	Paint	0.15
	Fire Resistant Plasterboard	Fire Resistant Plasterboard	1.67
	Insulation	Insulation	0.84
		Wall Tiling (in bathrooms)	2.46
		Tiling adhesive/mortar	2.46
Ceiling Finishes	Paint	Paint	0.15
	Plaster, skim & plasterboard	Plaster, skim & plasterboard	1.67
	Suspended Ceiling System	Suspended Ceiling System	18.7
	Acoustic Ceiling Panel	Acoustic Ceiling Panel	3.54
	Ceiling hatches	Ceiling hatches	155.
	Insulation	Insulation	3.2
Floor Finishes	Raised access floors including pedestals	Raised access floors including pedestals	3.8 $kgCO_2e/kg$
	Raised access floor panels	Raised access floor panels	32.22
	Levelling Screed (BOH & FOH)	Levelling Screed (BOH & FOH)	1.89
	Carpet (FOH 50%)	Carpet (FOH 50%)	4.02
	Vinyl (FOH 50%)	Vinyl (FOH 50%)	8.22
	Stairs robust floor covering	Stairs robust floor covering	3.79
	Floor Tiling (in bathrooms)	Floor Tiling (in bathrooms)	11.5
	Skirting (FOH)	Skirting (FOH)	1.21 $kgCO_2e/m$
	Concrete finish (BOH)	Concrete finish (BOH)	2.46
	Floor Insulation	Floor Insulation	0.84

*For the Mixed-Use Typology, the internal finishes were applied as 57% commercial and 43% residential and prorated based on the overall GIA assumed for each building scenario.

The carbon outputs of the internal finishes analysis for each building archetype can be seen summarised in Table 3-9.

Table 3-9 – Internal Finishes Upfront Carbon for each Building Typology.

Building Typology	Baseline Upfront Carbon ($kgCO_2e/m^2$)	Low Carbon Scenario Exposed Ceiling + Reused RAF ($kgCO_2e/m^2$)
Office and Small Office	93	45
Residential	97	44
Mixed-Use	95	44

3.8.2 LOW CARBON FINISHES

In addition to the typical baselines explored for each building typology, a low carbon scenario was explored to minimise the carbon associated with the internal finishes of the building typologies. In general, internal finishes vastly depend on the architectural decisions implemented as part of the design of the building thus prove difficult to predict on a prorated basis as they are highly project specific. However, some of the major areas for improvement and consideration for building finishes are focused on the circularity of the materials being applied. Thus, some of the main areas for carbon reduction be achieved through the application of the following strategies:

- Material **Carbon Intensity**: identification of areas where material use can be reduced e.g. opting for a raft ceiling over a full suspended ceiling.
- Focusing on **Material Lifespan**, many internal finishes such as paint, gloss finishes only last up to approximately 5 years. The durability of these finishes should be considered to ensure that they can last under everyday use, especially in high foot fall areas.
- **Flexibility And Adaptability** within the finishes should be supported to allow for potential future design changes and maintenance of the site. For example, an exposed ceiling creates reduced material intensity as well as having additional benefits such as increasing the ease of accessibility to services, and therefore reducing the risk and complexity of maintenance and replacement.
- **Prioritise High Recycled/Reused Content:** using recycled or reclaimed materials and components for internal finishes is often perceived to have concerns around building codes and regulation, higher labour costs and problems associated with installation, quality or aesthetics. However, recent years have seen growing market opportunities and increasing breakthroughs in terms of liability being pushed for by these companies. The benefits of reusing and recycling internal finishes can be significant, offering waste, energy, carbon and cost savings.

As part of this study, two low carbon options were analysed in terms of the internal finishes of the building archetypes as detailed in Table 3-10.

Table 3-10 – Low Carbon Internal Finishes Optimisations applied for the Low Carbon Internal Finishes Scenario

Low Carbon Internal Finishes Scenario	Detailed Optimisation
Optimisation 1	Use of exposed ceilings*: *Suspended Ceiling System, ceiling panels and hatches all removed from this design option. Acoustic Panelling still included.*
Optimisation 2	50% Reused Raised Access Flooring System. *This decision was made to reflect current possible availability issues in the reuse market.*

*Not included within residential areas

3.9 COST ASSESSMENT METHODOLOGY

WSP quantity surveying team have undertaken a cost analysis of the scenarios presented within this report. The study analyses the capital cost for each building type and embodied carbon scenario and is intended to inform policy by demonstrating where there may be impacts to project finances as a result of introducing upfront embodied carbon targets within the City Plan. The analysis is split into the four building types and multiple different embodied carbon scenarios outlined within this report; please refer to Section 3.1 for details.

The building elements and quantities for each scenario have been produced by WSP based on design information for each building archetype. The material and quantity outputs were then reviewed and advised on their relevance in reference to current practice based on construction experience. Examples include the appropriate rate for a timber-clad façade system. It should be noted that these scenarios are hypothetical only, and on a real-life project they would benefit from a further design assurance, design validity or buildability assessment as part of the next design stage.

Once the final schedule of quantities was agreed, this was then developed into a cost plan format in order to accurately assess the cost of each scenario. The original set of quantities were broken down into individual materials before being grouped together to price composite rates. The building fabric elements were priced in detail based on benchmark rates and in consultation with the industry supply chain for key building elements such as terracotta tiling, structural steel, timber, reinforced concrete, and aluminium framing, costs were regionally specific to London and the City of Westminster.

The cost analysis results are shown within Section 4.1 below as a percentage variance from the baseline for each alternative scenario. This is not cumulative and should be read with reference to the change from the baseline.

The RICS categories costed for follow the same method of inclusion and exclusion as the embodied carbon calculation, as shown by Table 3-3, and therefore costs for demolition, enabling and specialist works have been excluded. Costs that could not be grounded in material quantities, i.e. fixtures, fittings and external works have been based on reference projects within London and/or the City of Westminster for that given archetype and are fixed for each option.

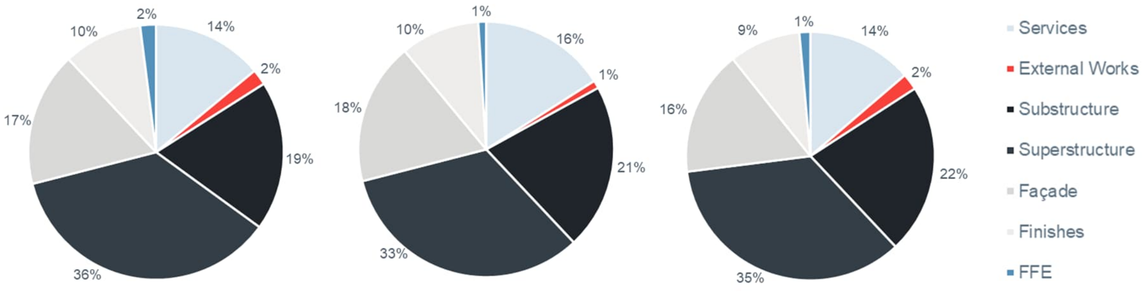
This report provides an analysis of various carbon intervention measures aimed at reducing the embodied carbon of building materials. It is important to note that the cost estimates presented are subject to fluctuations due to a variety of external factors. These include global supply chain disruptions, such as those experienced during the COVID-19 pandemic and the war in Ukraine, which can impact material availability and pricing. The effects of Brexit including changes in trade regulations and customs procedures, has also significantly influenced the cost and availability of construction materials in the UK. The prices of raw materials, which are prone to global market changes, energy costs, and geopolitical events further contribute to cost volatility. Environmental regulations and sustainability trends, aiming to reduce the carbon footprint, can also lead to higher costs for "eco-friendly" materials. The impact of this has been seen in the price of cement replacements such as GGBS, which although cheaper to produce than Portland cement is typically on a cost par for purchasing. Therefore, while this report strives to provide accurate and current data, the dynamic nature of these factors should be considered when interpreting the findings.

4 RESULTS AND DISCUSSION

4.1 COST AND CARBON RESULTS

4.1.1 BASELINE

An initial analysis of the baseline embodied carbon scenario was undertaken to identify “carbon hotspots”. Figure 4-1 shows the distribution of upfront embodied carbon by element based on industry benchmarks. The structure (including substructure) can be seen to be the largest proportion of carbon emissions across all the archetypes at around ~40% of building emissions. Comparatively, Figure 4-2 shows the split upfront carbon share for the baseline building assessed for each typology.



A) Office ***B) Residential*** ***C) Mixed Use***

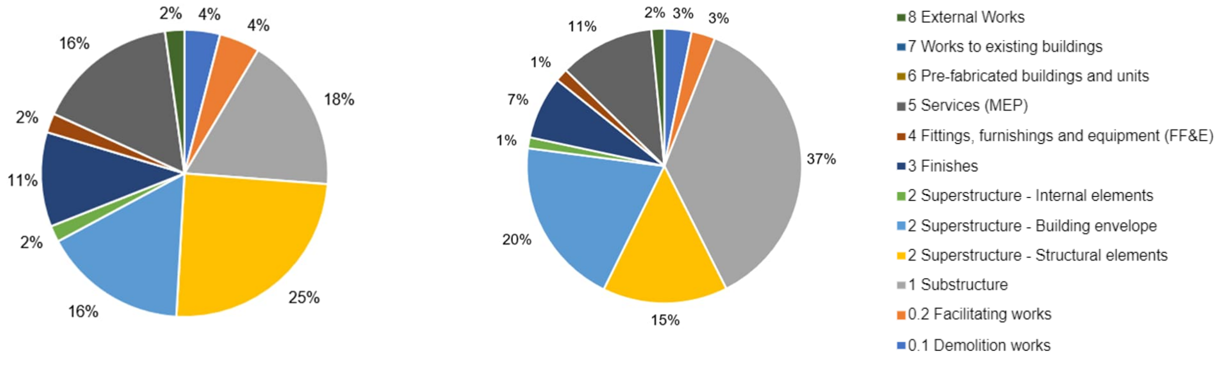
Figure 4-1 – Carbon breakdown based on industry guidance per building archetype.

However, compared to industry benchmarks the embodied carbon for building services components and façade systems is proportionally higher than for example the approximate breakdowns shown by Figure 4-1. This analysis draws on the most recent guidelines from the CWCT and CIBSE regarding the measurement of embodied carbon in façade systems and building services. This research has revealed that the environmental impact of products used in these construction areas is generally greater than previously estimated, reflecting an advancement in our understanding of these products. This is particularly the case for the residential archetype, where the facade can be seen to make up 29% of the baseline emissions. The increase is most pronounced in this archetype due to the high building surface area to volume ratio or form factor, leading to proportionally more façade per square metre of floor area.

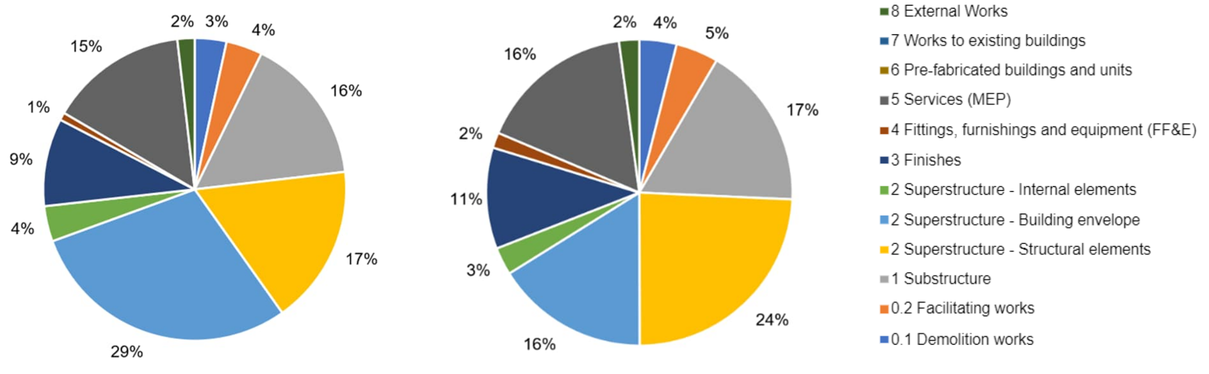
When compared the baseline to benchmarks created by existing work done by the GLA and others, as in Table 4-1, it can be seen that both the office and mixed-use archetypes have lower upfront embodied carbon than the baseline and the residential and small office have a significantly higher upfront embodied carbon than the benchmark solution. This is explained by the efficient form factor of the large office and mixed-use archetype, and the conversely poor form factor for the residential and small office archetype, meaning that the residential archetype is more sensitive to changes in façade embodied carbon.

Table 4-1 – Baseline compared with existing GLA benchmark.

Archetype	A1-A5 Baseline Performance [kgCO_2e/m^2]	A1-A5 GLA Target [kgCO_2e/m^2]	Difference [kgCO_2e/m^2]
Large Office	874	950	-76
Mixed-use	891	950	-59
Residential	1033	850	+183
Small office	1252	950	+302



A) Large Office ~10,000m^2 ***B) Small Office ~1,000m^2***



B) Residential ***C) Mixed Use***

Figure 4-2 – Carbon breakdown of archetype baseline by engineering or architectural discipline.

4.1.2 OFFICE

The upfront embodied carbon reductions for each intervention when applied collectively is displayed in Figure 4-3, with the relative and total decrease in carbon emissions and cost displayed in Table 4-2 & Table 4-3 respectively.

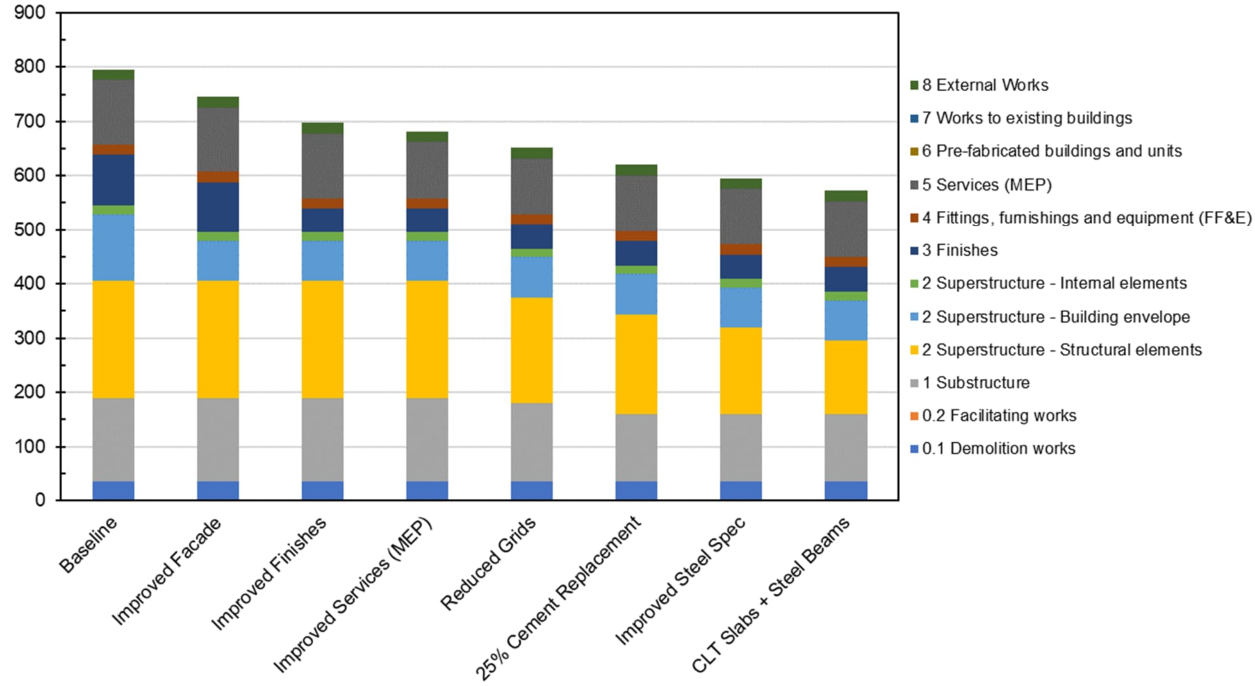


Figure 4-3 – Carbon and cost impact of intervention when considered in combination.

Table 4-2 – Carbon impact of each intervention for office.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replace ment	Improved Steel Spec	CLT Slabs + Steel Beams
Reduction of Each Intervention [%]	6%	6%	2%	4%	4%	4%	4%
Cumulative Reduction from Baseline [%]	6%	11%	13%	17%	20%	23%	26%

Table 4-3 – Cost impact of each intervention for office.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replace ment	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Change from Intervention	1.1%	-1.7%	-0.7%	-1.0%	0.5%	0.0%	0.2%
Percentage Change from Baseline	1.1%	-0.6%	-1.3%	-2.3%	-1.8%	-1.8%	-1.5%
Percentage Change from Baseline (Excluding Cost Savings*)	1.1%	1.1%	1.1%	1.1%	1.6%	1.6%	1.9%

* Any potential cost savings from low carbon interventions have been discounted in this scenario.

4.1.2.1 Structure

The impact of applying each of the structural scenarios in sequence from the baseline are shown in Figure 4-4 below. The embodied carbon values shown are for structure only.

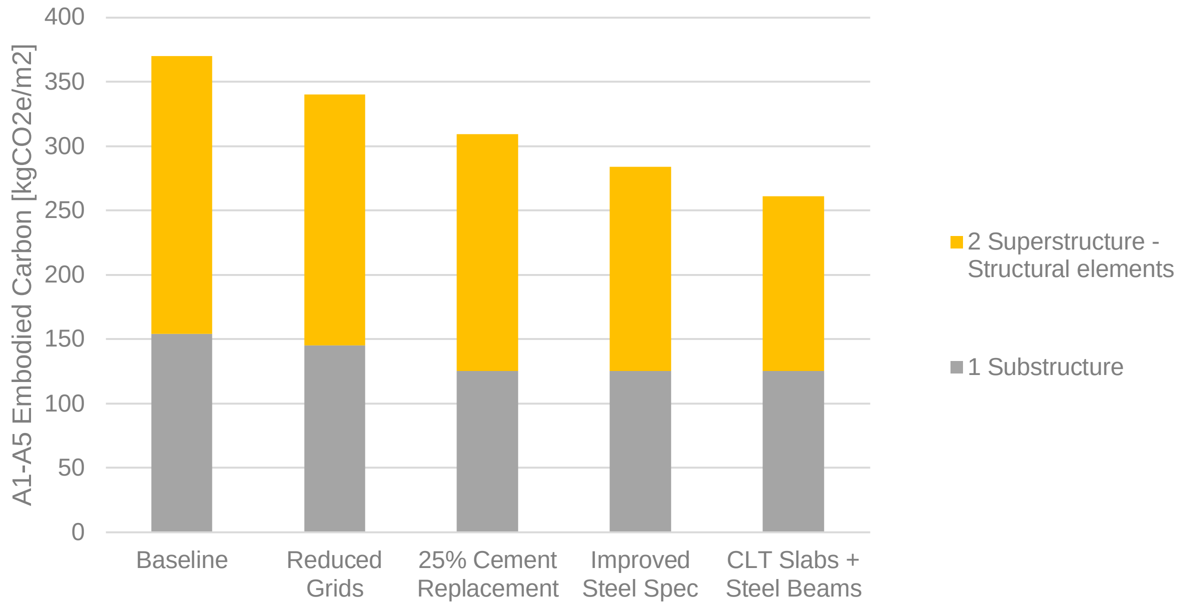


Figure 4-4 – Impact of structure on carbon emissions.

The impact of each scenario can be described as follows, starting from the baseline:

- Reducing the grid spacing from 12m to 9m results in a decrease in embodied carbon of 31 $kgCO_2e/m^2$ (4.0% decrease in total up-front embodied carbon). This is an important step as it is independent of material specifications and can greatly reduce the embodied carbon given its impact on floor plate efficiency. When looking at overall structural contributors to embodied carbon, the floor plates are usually the most carbon intensive, and so targeting the spans can have a significant impact on overall embodied carbon as the slab doesn't have to work as hard over smaller spans and can therefore require less material. This is further evidenced by an example project that demonstrates the impact of even more reduced spans, as shown in the graph below.

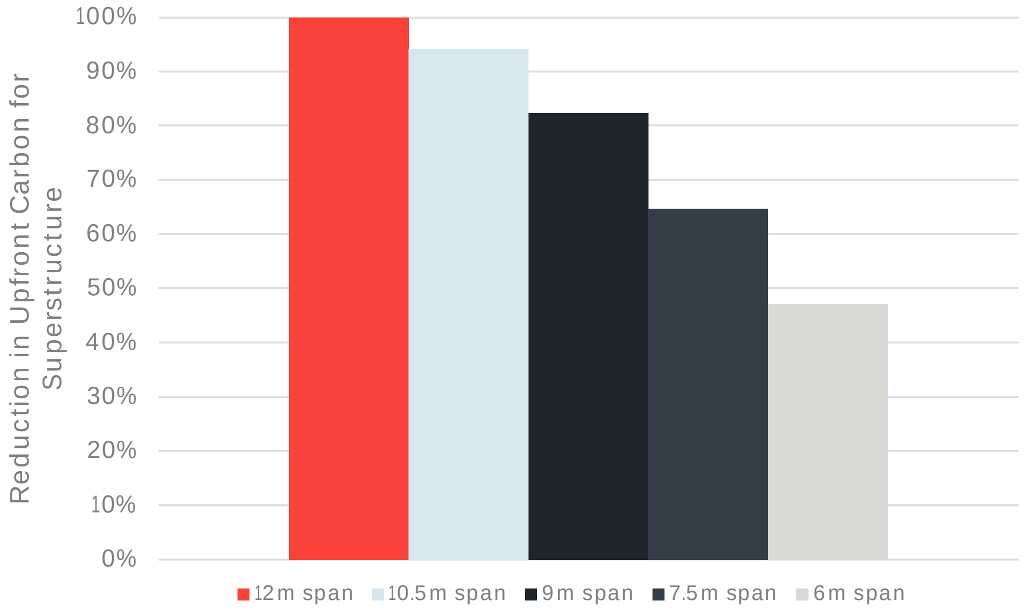


Figure 4-5 – Comparison of upfront carbon in different slab spans on example project

- Introducing 25% cement replacement results in a further reduction of 31 $kgCO_2e/m^2$ (4.4% decrease in total up-front embodied carbon) in embodied carbon. It should be noted that the baseline contained 0% cement replacement, as it is suggested that measures to reduce carbon which are not reliant upon material specifications (e.g. reducing grid spacings) should be explored first. This is because any subsequent specification changes will have an overall greater impact without reliance upon specific material procurement routes.
- Adopting low carbon steel provides a further reduction of 25 $kgCO_2e/m^2$ (3.7% decrease in total up-front embodied carbon) against the previous option. In this context, an additional 15% EAF steel and 10% steel reuse has been considered relative to the previous steel specification - this is deemed to be a reasonable and realistic assumption based on available procurement in the current market. However, it must be noted that the supply remains constrained with significant investment required for the industry to achieve large scale decarbonisation of steel production (and large volumes of low carbon steel) and adoption of higher percentages of steel reuse, hence why small percentages of these have been considered in this study.
- Replacing the composite decking with CLT flooring has a large reduction from the previous scenario of 23 $kgCO_2e/m^2$ (3.5% decrease in total up-front embodied carbon). As previously stated, the floor plates are typically the largest structural contributor to embodied carbon and this is exemplified by the significant change here. Should certain timber procurement routes be met (as described in Section 3.5.2) then further benefit to the whole life carbon could be obtained through sequestration as set out in RICS 2.0 (2023) Module D.

4.1.2.2 Façade

The façade embodied carbon reduction for offices is related to the substitution of some components within the façade build-up which are commonly used for rainscreen but are heavy contributors in embodied carbon.

For this exercise, the terracotta rainscreen panel (and its metal substructure) has been included in the baseline to allow for common finishings, while the optimised system includes low-carbon materials such as timber rainscreen cladding.

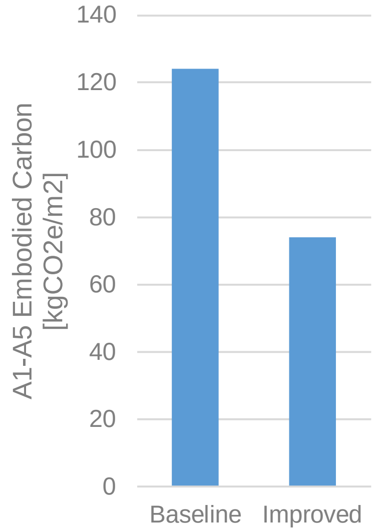


Figure 4-6 – Impact of facade on carbon emissions.

The transparent façade is made of a curtain walling system where aluminium components are responsible for almost 60% of the embodied carbon of the facade system. In the optimised option the content of recycled aluminium has been increased from around 30% to 75% to represent a level of recycled content that can be purchased from the market. It is important to note that scrap aluminium is a constrained resource and therefore cannot be expected scale to meeting the entire market at this level of recycled content. Designers are encouraged to consider best integrated façade solutions considering passive design, operational energy and importantly whole life carbon impacts when presenting solutions to Westminster City Council.

Even though the cost associated to opaque rainscreen is reduced due to the inclusion of low-carbon components, the low carbon façade sees an overall cost increase due to the cost associated with recycled aluminium in the glazing system.

- Adopting a greater proportion of recycled aluminium into the framing system and using a timber rainscreen cladding could lead to a total reduction of building embodied carbon of up to 50 $kgCO_2e/m^2$ (5.8% decrease in total up-front embodied carbon).
- Incorporating more recycled glass (up to 60% pre consumer cullet) could lead to a further reduction noting that recycled glazing units are not currently widely available from the market.

4.1.2.3 Services

For the low carbon scenario for the office MEP, the HVAC system was changed from a typical fan-coil unit system to a displacement ventilation system with underfloor air distribution. This reduced the overall embodied carbon of the system by removing much of the on-floor distribution, including fan-coil units, pipework and ductwork.

- Optimising the HVAC system and shifting towards an underfloor air distribution system can save up to 16 $kgCO_2e/m^2$ (2.1% decrease in total up-front embodied carbon).

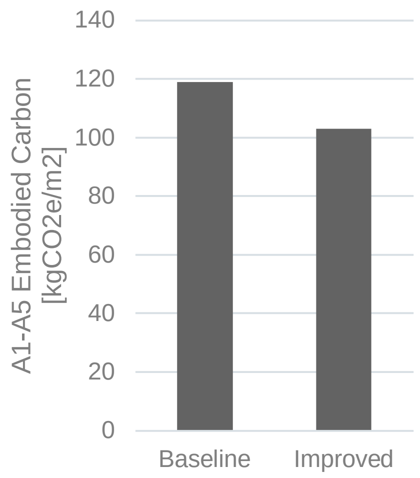


Figure 4-7 – Impact of services on carbon emissions.

4.1.2.4 Internal Finishes

For the low carbon optimisation of the internal finishes within the mixed-use archetype, two scenarios were modelled: an exposed ceiling and 50% reused raised access flooring system. Each of which have significant impact through the reduction in use of new raw materials, in turn impacting through a reduced carbon intensity of the material elements applied to the ceiling and floor finishes.

- Optimising the ceiling finishes and implementation of reused elements within the proposed raised access flooring in the office showed a 48 $kgCO_2e/m^2$ reduction (6% decrease in total up-front embodied carbon).

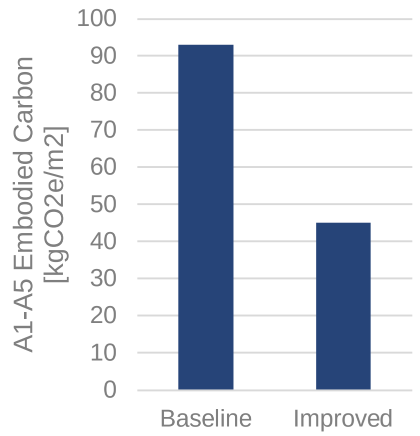


Figure 4-8 – Low Carbon Internal Finishes Optimisations.

4.1.3 MIXED-USE

The upfront embodied carbon reductions for each intervention when applied collectively is displayed in Figure 4-9, with the relative and total decrease in carbon emissions and cost displayed in Table 4-4 & Table 4-5 respectively.

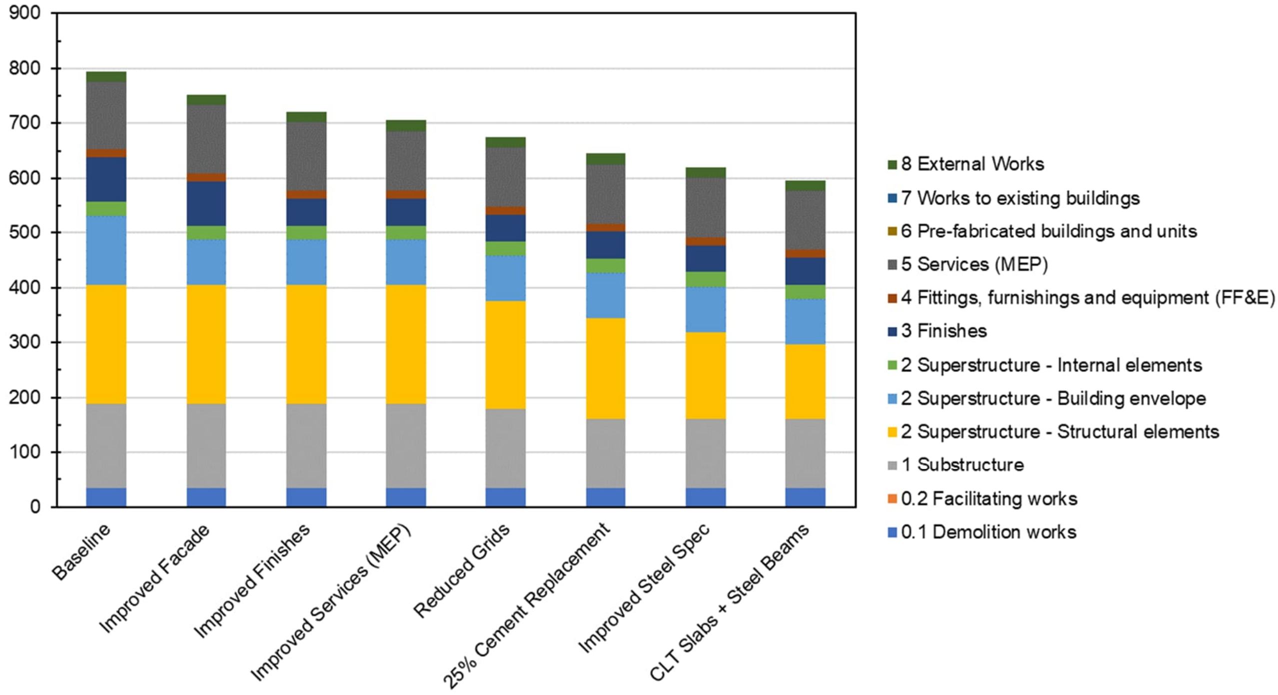


Figure 4-9 – Carbon and cost impact of intervention when considered in combination for mixed-use archetype.

Table 4-4 – Carbon Impact of each intervention for mixed-use.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Reduction of Each Intervention [%]	5%	4%	2%	4%	4%	4%	4%
Percentage Reduction from Baseline [%]	5%	9%	11%	15%	18%	21%	24%

Table 4-5 – Cost Impact of each intervention for mixed-use.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Change from Intervention	0.5%	-1.3%	-1.4%	-0.9%	0.5%	0.0%	0.2%
Percentage Change from Baseline	0.5%	-0.8%	-2.2%	-3.1%	-2.6%	-2.6%	-2.4%
Percentage Change from Baseline (Excluding Cost Savings*)	0.5%	0.5%	0.5%	0.5%	1.0%	1.0%	1.3%

* Any potential cost savings from low carbon interventions have been discounted in this scenario.

4.1.3.1 Structure

Due to the near identical structural results between the office & mixed-use archetypes, please refer to the discussion in Section 4.1.2 for a discussion around the implications of the structural results.

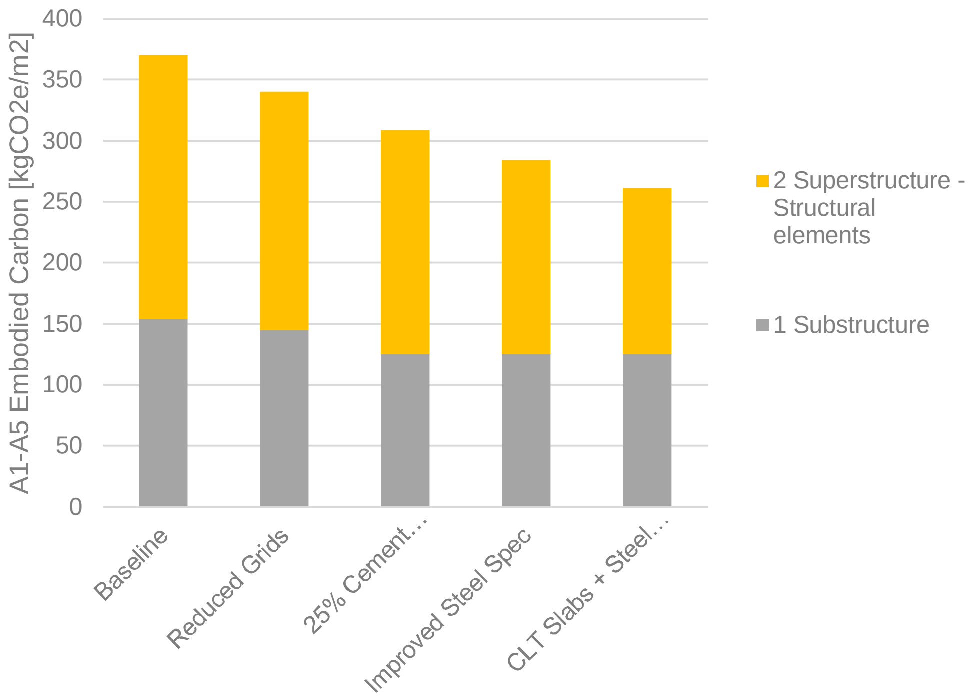


Figure 4-10 – Impact of structure on carbon emissions for mixed-use archetype.

It should be noted that mixed-use structures are more likely to be subject to varying spatial and therefore span requirements in different areas or levels of the buildings which may lead to the inclusion of transfer structures within the design. The use of transfer structures can lead to efficient structures in different areas of the building, but this must be balanced with the material and carbon of the transfer itself. Care must be taken to ensure that the need for transfer structure is interrogated and evaluated from carbon intensity, structural efficiency, social and spatial perspectives before being incorporated into the design.

4.1.3.2 Façade

The baseline total facade cost is around £500 per square metre including different façade systems distributed across the façade surface area of the selected building archetype.

The low carbon façade sees a cost reduction due to change from high-cost, high carbon materials such as terracotta rainscreen panels to brickworks for the opaque element, with the additional cost associated with recycled aluminium in the curtain walling system offset by this saving as per the office archetype. As with the office archetype, it is important to note that scrap aluminium is a constrained resource and therefore the total available supply cannot be expected to scale to meet the entire market demand at this level of recycled content. Designers are encouraged to consider best integrated façade solutions considering passive design, operational energy and importantly whole life carbon impacts when presenting solutions to the Westminster City Council.

- Adopting a greater proportion of recycled aluminium into the framing system and brickwork cladding could lead to a reduction of façade embodied carbon of up to 43 $kgCO_2e/m^2$ (5.3% decrease in total up-front embodied carbon).
- Incorporating timber rain screen could lead to a further reduction noting that using timber for residential buildings over 18m in this way is not currently feasible.

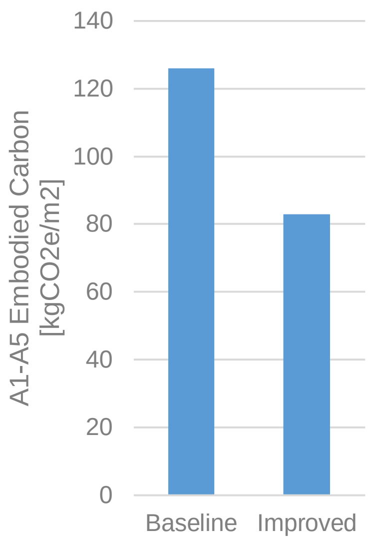


Figure 4-11 – Impact of facade on carbon emissions for mixed-use archetype.

4.1.3.3 Services

The low carbon scenario for building services was a centralised heating system with underfloor heating and heat interface units in each apartment. Figure 4-12 shows that optimising the HVAC system by moving away from an ambient loop system to a more traditional central hot water and heating system can save 15 $kgCO_2e/m^2$ (2.0% decrease in total up-front embodied carbon). This is a direct result of removing secondary heat pumps and fan-coil units in the apartments. The savings are less pronounced here than in the office as the commercial HVAC system remains consistent with the baseline.

- Optimising the HVAC system, and shifting towards an underfloor air distribution system can save up to 15 $kgCO_2e/m^2$ (2.0% decrease in total up-front embodied carbon).

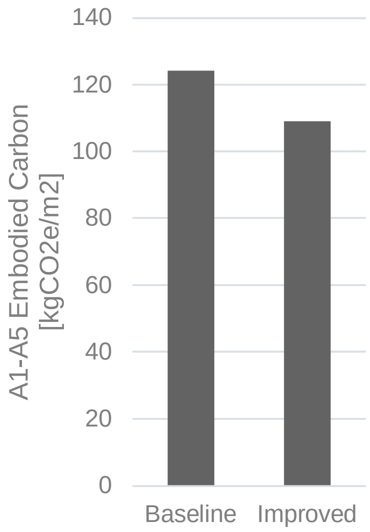


Figure 4-12 – Impact of services carbon emissions for mixed-use archetype.

4.1.3.4 Internal Finishes

For the low carbon optimisation of the internal finishes within the residential archetype, two scenarios were modelled: an exposed ceiling and 50% reused raised access flooring system. Each of which have significant impact through the reduction in use of new raw materials and therefore a reduced carbon intensity of the material elements applied to the ceiling and floor finishes.

- Optimising the ceiling finishes and implementing reused elements within the raised access flooring in the mixed-use typology showed a 31 $kgCO_2e/m^2$ (4.0% decrease in total up-front embodied carbon) reduction from the baseline of the embodied carbon of the internal finishes.

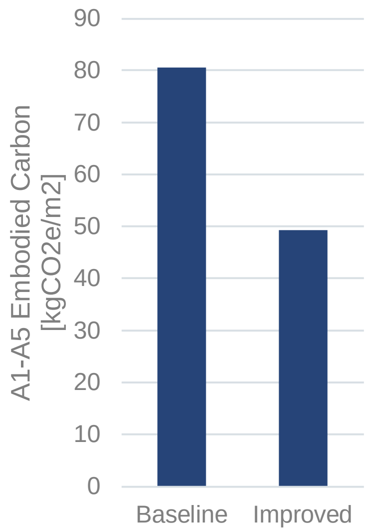


Figure 4-13 – Low Carbon Internal Finishes Optimisations.

4.1.4 RESIDENTIAL

The upfront embodied carbon reductions for each intervention when applied collectively is displayed in Figure 4-14, with the relative and total decrease in carbon emissions and cost displayed in Table 4-6 & Table 4-7 respectively.

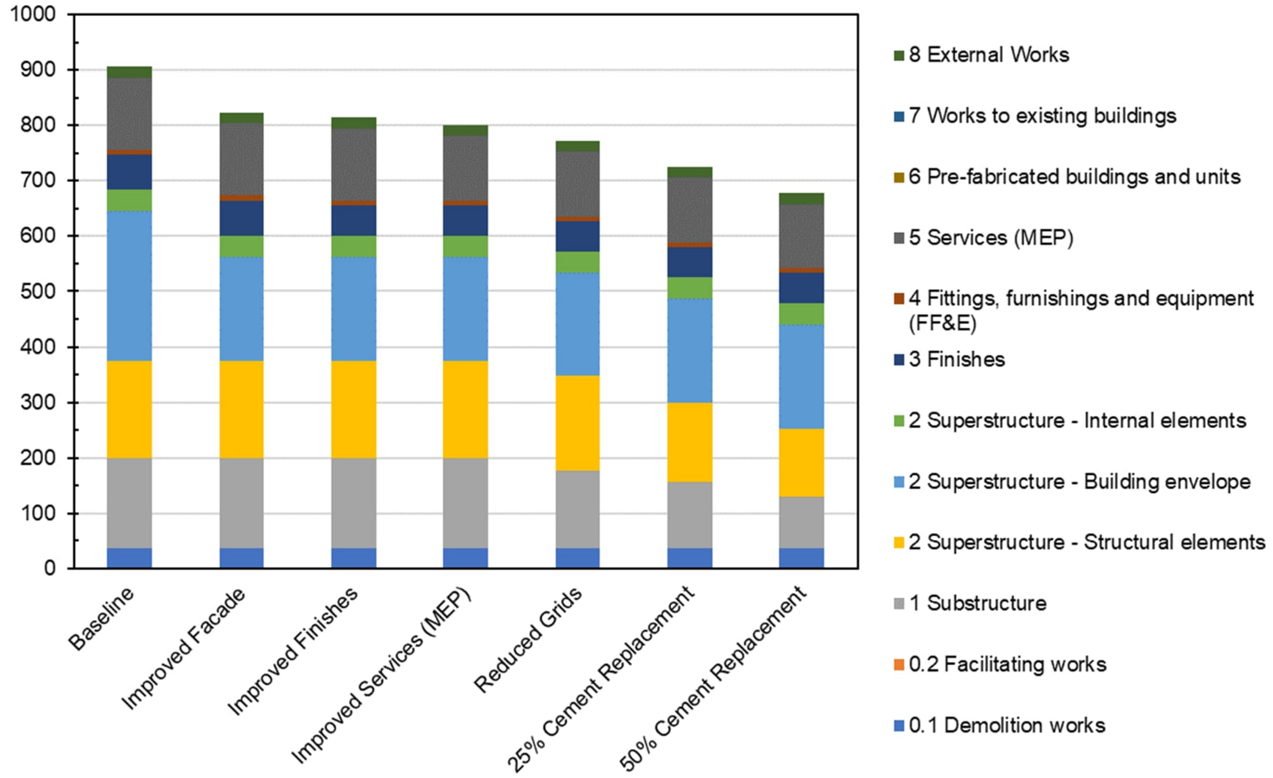


Figure 4-14 – Carbon and cost impact of intervention when considered in combination for residential archetype.

Table 4-6 – Carbon Impact of each intervention for the residential archetype.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
Percentage Reduction of Each Intervention [%]	9%	1%	2%	3%	6%	4%
Percentage Reduction from Baseline [%]	9%	10%	11%	14%	20%	22%

Table 4-7 – Cost Impact of each intervention for the residential archetype.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
Percentage Change from Intervention	0.8%	-0.8%	-1.4%	-2.5%	1.5%	1.8%
Percentage Change from Baseline	0.8%	-0.1%	-1.5%	-4.0%	-2.5%	-0.7%
Percentage Change from Baseline (Excluding Cost Savings)	0.8%	0.8%	0.8%	0.8%	2.3%	4.1%

* Any potential cost savings from low carbon interventions have been discounted in this scenario.

4.1.4.1 Structure

The impact of applying each of the structural scenarios in sequence from the baseline are shown in Figure 4-15 below. The embodied carbon values shown are for structure only.

The impact of each scenario can be described as follows:

- Starting from the baseline, reducing the grid spacing from 7.5m to 6m results in a decrease in embodied carbon of 28 $kgCO_2e/m^2$ (3.4% decrease in total up-front embodied carbon). This is an important step as it is independent of material specifications and can greatly reduce the embodied carbon given its impact on floor plate efficiency. When looking at overall structural contributors to embodied carbon, the floor plates are usually the most carbon intensive, and so targeting the spans can have a great impact on overall embodied carbon.
- An increase in cement replacement from 0% (baseline) to 25% has a significant reduction of 47 $kgCO_2e/m^2$ (5.9% decrease in total up-front embodied carbon).
- A further reduction of 27 $kgCO_2e/m^2$ (3.6% decrease in total up-front embodied carbon) is seen when increasing the cement replacement by a further 25%.

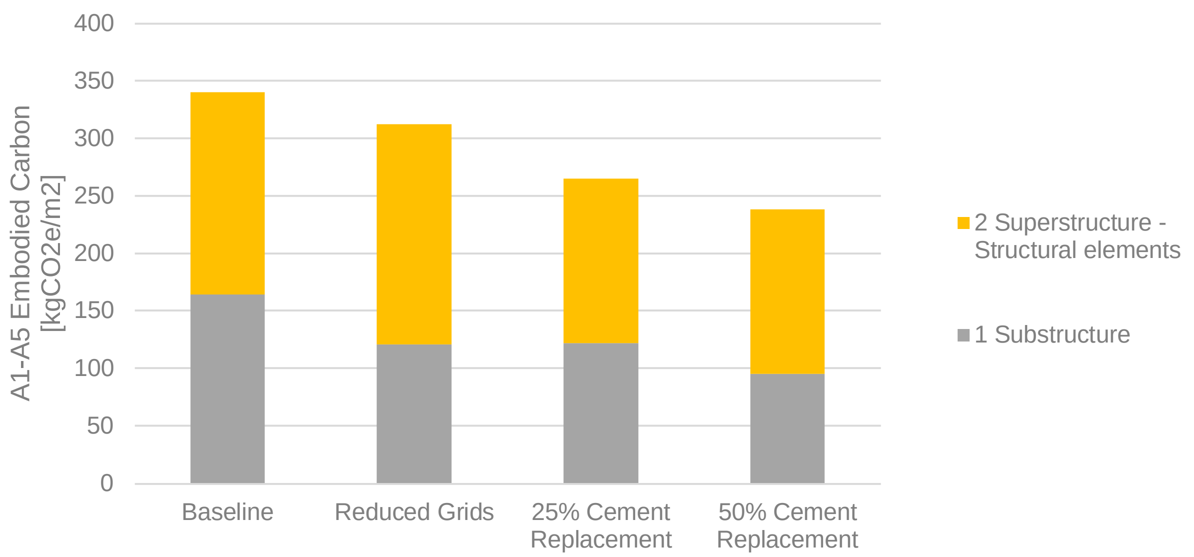


Figure 4-15 – Impact of structure on carbon emissions for residential archetype.

4.1.4.2 Façade

The baseline total façade cost is around £800 per square metre. As for the mixed-use archetype, the terracotta rainscreen included in the baseline are substituted with brickworks to optimise the embodied carbon of the overall build-up. The windows, composed of an aluminium framing, have been substituted by a composite framing, less impactful in terms of embodied carbon content but more expensive.

The low carbon façade sees a cost reduction due to change from high-cost high carbon material such as terracotta panels to brickworks for the opaque element (constituting more than 60% of the façade surface area of the building archetype analysed).

An additional option is reported if a further optimisation is possible, and timber components are accepted by Building Control and are aligned with safety requirements. If limited combustibility components made of timber are accepted, the façade sees a slight increase in price justified by a decrease in embodied carbon.

- Adopting a greater proportion of recycled aluminium into the framing system and brickwork cladding could lead to a reduction of building embodied carbon of up to 83 $kgCO_2e/m^2$ (8.9%).
- Incorporating timber rain screen could lead to a further reduction noting that using timber for residential buildings over 18m in this way is not currently feasible.

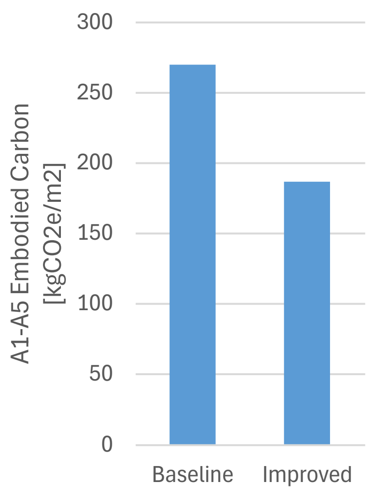


Figure 4-16 – Impact of facade on carbon emissions for residential archetype.

4.1.4.3 Services

The low carbon scenario for building services was a centralised heating system with underfloor heating and heat interface units in each apartment. Figure 4-17 Shows that optimising the HVAC system by moving away from an ambient loop system to a more traditional central hot water and heating system can save 14 $kgCO_2e/m^2$ (1.7% decrease in total up-front embodied carbon). This is a direct result of removing secondary heat pumps and fan-coil units in the apartments. The savings are less pronounced here than in the office as the commercial HVAC system remains consistent with the baseline.

- Optimising the HVAC system, and shifting towards an underfloor air distribution system can save up to 14 $kgCO_2e/m^2$ (1.7% decrease in total up-front embodied carbon).

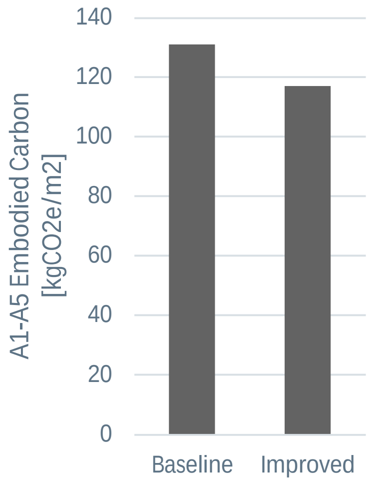


Figure 4-17 – Impact of services carbon emissions for residential archetype.

4.1.4.4 Internal Finishes

The low-carbon finishes scenario for the commercial office archetype removal of ceiling grid in office areas and use of reclaimed/recycled raised access flooring across 50% of the floor area. Each of which having a significant impact through the reduction in use of new raw materials.

- Optimising the ceiling finishes and implementing reused elements in the floor build-up of the in the residential typology showed a 9 $kgCO_2e/m^2$ (1.1% decrease in total up-front embodied carbon) reduction from the baseline of the embodied carbon of the internal finishes.

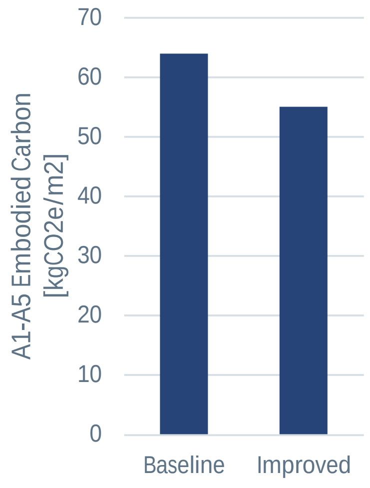


Figure 4-18 – Low Carbon Internal Finishes Optimisations.

The Building Regulations require that any residential building with a height to the last occupied floor from ground level greater than 18m should not have combustible material in the external façade construction. Therefore, in line with current Building Regulations, load bearing cross laminated timber framed residential buildings above 18m are not feasible at this current time unless they can be fully separated from the external walls. The implications on this report are that the residential archetype, which has 8 storeys and is over 30m tall, does not include any timber within any scenarios, limiting the possible carbon reductions relative to the office & mixed-use archetypes as a result. When using the results within this report, it should be noted that inclusion of timber would be possible for residential buildings with a height from ground to the last occupied floor of less than 18m, bringing with it additional carbon benefits. However additional slab types also have the potential to reduce embodied carbon and weight of the structure (reducing embodied carbon in foundations) and options should be reviewed at early stage of design. See Appendix B for further examples.

Given the inability to use timber on the residential archetype, there are fewer structural interventions available relative to the mixed-use & office archetypes. The introduction of cement replacement has a significant reduction of 9% for this archetype from the baseline to 50% cement replacement. A key issue with GGBS is it is a finite resource which is nearly fully utilised across the globe. Specifying high quantities on one project is therefore likely to result in a reduction of use in another location thus balancing each other out and being unlikely to reduce global emissions.[14] If such residential schemes are serious about carbon targets, then it is even more important to consider measures which encourage an efficient structural design first and foremost (e.g. appropriate spans, efficient floorplates, reducing quantity of transfer structures required). In future however, it is possible that alternative low-carbon cement replacements may become both more available and viable and so their inclusion within this report is relevant. See *IStructE Beyond Portland cement: Low-carbon alternatives*[15] for an update list of options under consideration by the wider industry.

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[14] The efficient use of GGBS in reducing global emissions (IStructE, 2023) https://www.istructe.org/resources/guidance/efficient-use-of-ggbs-in-reducing-global-emissions/
[15]Beyond Portland Cement: Low Carbon Alternatives (IStructE) https://www.istructe.org/resources/guidance/beyond-portland-cement-low-carbon-alternatives/Beyond Portland Cement: Low Carbon Alternatives (IStructE) https://www.istructe.org/resources/guidance/beyond-portland-cement-low-carbon-alternatives/

4.1.5 SMALL OFFICE

The upfront embodied carbon reductions for each intervention when applied collectively is displayed in Figure 4-19, with the relative and total decrease in carbon emissions and cost displayed in Table 4-8 & Table 4-9 respectively.

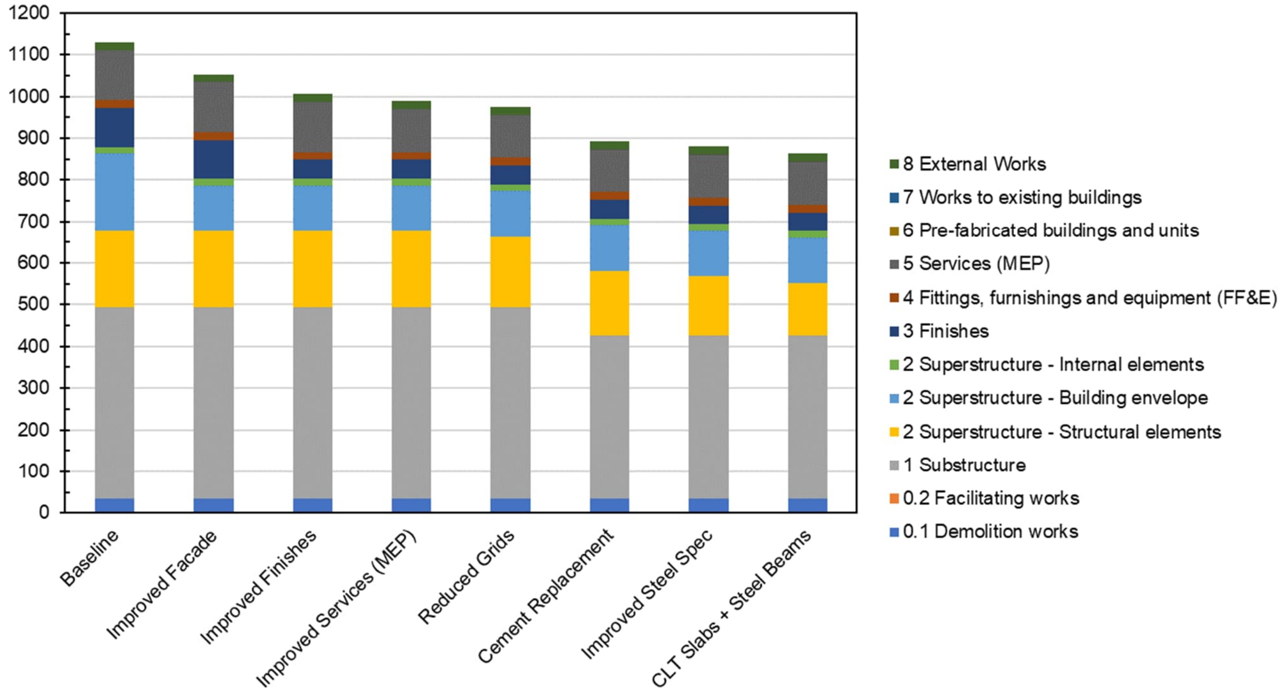

Figure 4-19 – Carbon and cost impact of intervention when considered in combination.

Table 4-8 – Carbon impact of each intervention for office.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replace ment	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Reduction of Each Intervention [%]	7%	4%	2%	1%	8%	1%	2%
Percentage Reduction from Baseline [%]	7%	11%	12%	13%	21%	22%	23%

Table 4-9 – Cost impact of each intervention for office.

	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replace ment	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Change from Intervention	1.3%	-1.3%	-0.5%	0.3%	1.0%	0.0%	0.9%
Percentage Change from Baseline	1.3%	0.0%	-0.6%	-0.2%	0.7%	0.7%	1.7%
Percentage Change from Baseline (Excluding Cost Savings*)	1.3%	1.3%	1.3%	1.6%	2.5%	2.5%	3.5%

* Any potential cost savings from low carbon interventions have been discounted in this scenario.

4.1.5.1 Structure

The impact of applying each of the structural scenarios in sequence from the baseline are shown in Figure 4-20 below. The embodied carbon values shown are for structure only.

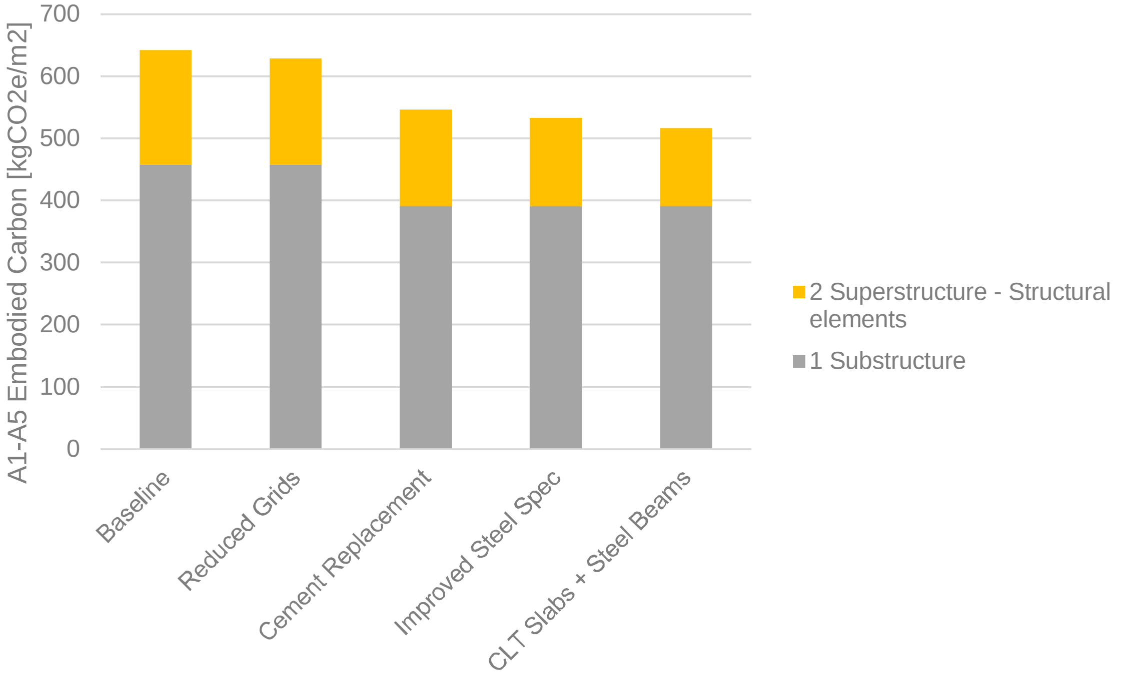

Figure 4-20 – Impact of structure on carbon emissions.

The impact of each scenario can be described as follows:

- Starting from the baseline, reducing the grid spacing from 7.5m to 6m results in a decrease in embodied carbon of 14 $kgCO_2e/m^2$ (1.4% decrease in total up-front embodied carbon). As 7.5m is a relatively efficient grid, and a large portion of the structural carbon is substructure from the basement, this has a relatively small impact on the embodied carbon. However, further analysis of slab types that are even more efficient at lower spans could increase this impact – see Appendix B for further details.

- Introducing 25% cement replacement results in a further reduction of 82 $kgCO_2e/m^2$ (8.2% decrease in total up-front embodied carbon). It should be noted that the baseline contained 0% cement replacement, as it is suggested that measures to reduce carbon which are not reliant upon material specifications (e.g. reducing grid spacings) should be explored first. In this typology, the cement replacement has a bigger impact as concrete is the main material for the basement substructure as well as some of the superstructure, and therefore is a large contributor to the overall embodied carbon.
- Adopting low carbon steel provides a further reduction of 13 $kgCO_2e/m^2$ (1.4% decrease in total up-front embodied carbon) against the previous option. In this context, an additional 15% EAF steel and 10% steel reuse has been considered relative to the previous steel specification - this is deemed to be a reasonable and realistic assumption based on available procurement in the current market. However, it must be noted that the supply remains constrained with significant investment required for the industry to achieve scaled decarbonisation of steel production and adoption of high percentages of steel reuse. Again, as such a large portion of the structural carbon is from the single storey basement on this smaller building, this has a relatively small impact on the embodied carbon.
- Replacing the composite decking with CLT flooring has a reduction from the previous scenario of 17 $kgCO_2e/m^2$ (1.9% decrease in total up-front embodied carbon).
- Overall, the basement, although only one storey, has a much larger impact on the embodied carbon than any other elements and therefore changes such as improvement of concrete specification have a much larger impact on the overall embodied carbon than changes that only affect the superstructure. This shows the importance of optimising below ground structures in smaller, lighter weight structures and especially the avoidance of basements.

4.1.5.2 Façade

Façade was assumed to be the same as the large office archetype, so please refer to Section 4.1.2, for results and discussion for this section.

4.1.5.3 Services

Building services design was assumed to be the same as the large office archetype, so please refer to Section 4.1.2, for results and discussion for this section.

4.1.5.4 Internal Finishes

Internal finishes design was assumed to be the same as the large office archetype, so please refer to Section 4.1.2, for results and discussion for this section.

4.1.6 IMPACT OF BASEMENT

The addition of a basement has been included for all typologies. However, its significance on the embodied carbon, particularly on the structural aspects, should not be taken lightly, as can be seen in the table below (note for the **structure only**).

Table 4-10 – Structural upfront carbon ($kgCO_2e/m^2$, A1-A5)

	Baseline	Baseline with Basement	Uplift (Absolute)	Uplift (%)
Mixed-Use / Office	296	370	74	25%
Residential	243	340	97	40%
Small Office	338	642	304	90%

Including a single storey of basement has a marked increase in carbon for all options, with a 25% increase for the mixed-use & office and a 40% increase for the residential. This is disproportionate compared to including an additional above ground level due to the carbon intense retaining walls that are required, and the deeper foundation slab.

Moreover, with the smaller GIA of the Small Office typology, the effects of the additional embodied carbon are grossly increased leading to a 90% increase. This shows the adverse impact of basements on small sizes of structures, and it is recommended that basements are discouraged for this size of building on the grounds of high embodied carbon.

It should be noted that carbon measurement systems (e.g. RICS/ SCORS) make no differentiation between structures with and without basements, meaning it is likely a carbon penalty will be incurred for schemes which choose to incorporate basement space, especially when demolition, excavation and groundworks are considered. Deep basements may involve significant site activity and have a disproportionate carbon impact as a result.

4.1.7 IMPACT OF REFRIGERANTS ON WHOLE LIFE CARBON ON BUILDING SERVICES

When assessing the embodied carbon of a building services system, it is important to consider the whole life cycle and the impact of the building services design on the whole life carbon of the project. This is due to the fact, building services components need to be replaced 2-3 times throughout a buildings lifespan and are often made from high carbon materials such as metals, electronic components and refrigerants. Refrigerants, in particular, can have extremely high global warming potential (GWP) and can lead to much higher overall carbon emissions if not considered in the design. One study in the Embodied Carbon primer[16], showed that both a heatpump or circulating refrigerant system with a high-GWP refrigerant can have a higher whole life embodied carbon impact than an equivalent gas boiler (1.3x and 2.4x respectively), as shown in Figure 4-21. New policy should aim to provide a mechanism to restrict the use of Type 3 variable refrigerant flow systems (VRF) and high-GWP refrigerants, as these could prove a popular method of achieving low upfront emissions at the expense of a damaging impact on whole life emissions.

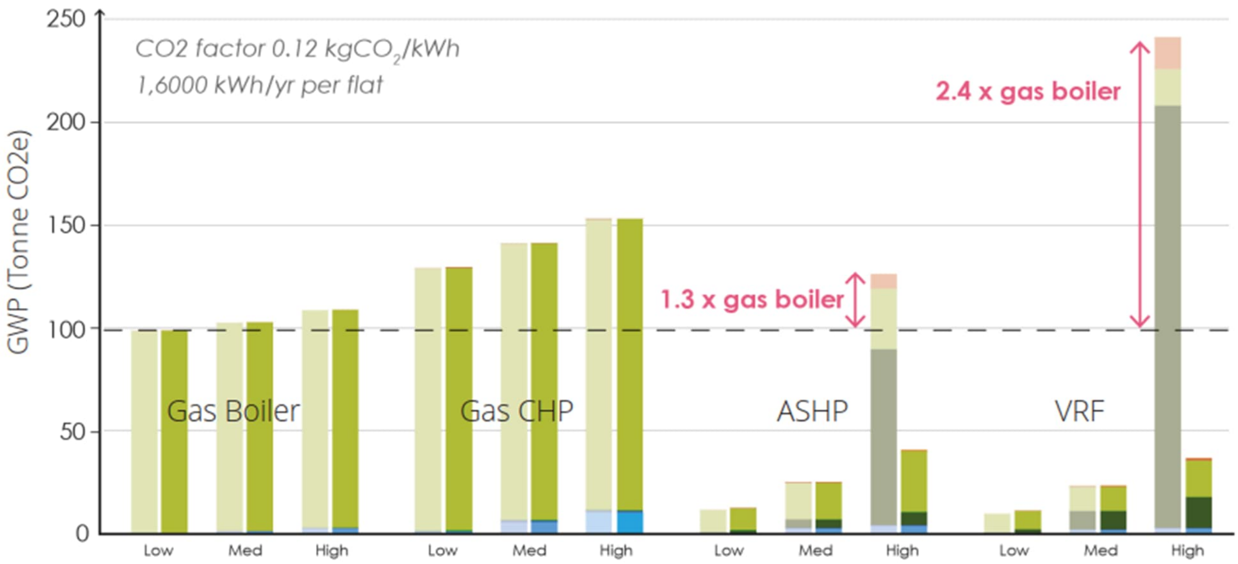

Figure 4-21 – Impact of refrigerant selection on whole life embodied carbon.

[16] LETI (2020) Embodied Carbon Primer, available online at: https://www.leti.uk/ecp

This study looked to assess the impact of the 'low carbon' solution assessed to make sure there was not an adverse impact on whole life embodied carbon and to evaluate the impact of selecting lower-GWP refrigerants. Table 4-11 below shows that switching to R290 for the commercial office system contributed towards a 29% reduction in whole life embodied carbon compared with a 12% reduction in upfront embodied carbon. Conversely, in the residential system switching from R32 on the primary heatpumps, and R410a on the secondary heatpumps to R290 on the primary heat-pump and R32 on the mechanical ventilation with heat recovery (MVHR) boosted cooling unit led to a 11% reduction in WLC compared with a 9% reduction in upfront carbon. The savings are less pronounced in the residential system as the MVHR cooling units are still required to have a refrigerant system to deliver cooling, if the cooling system can be designed out then this would leave to a larger drop in upfront and whole life carbon.

Table 4-11 – Impact of low carbon building services on whole life embodied carbon

	Office Baseline	Office Low Carbon	Residential Baseline	Residential Low Carbon
A1-A5 Upfront Embodied Carbon [kgCO2e/m2]	139	123	152	138
A-C Whole Life Embodied Carbon (excl. B6, B7, and D Emissions) [kgCO2e/m2]	469	334	454	406
Refrigerant Type	R32	R290	R32/R410A	R290/R32
Saving in Upfront Embodied Carbon [%]	12%		9%	
Saving in Whole Life Embodied Carbon [%]	29%		11%	

4.1.8 COMBINED RESULTS

Table 4-12 – Carbon savings and cost uplift per typology.

Building Typology	A1-A5 with all measures applied [$kgCO_2e/m^2$]	A1-A5 (excl. Demolition, Facilitating and External Works) [$kgCO_2e/m^2$]	Cost Uplift (All measures)	Cost Uplift (Excluding Savings)
Large Office	633	579	-1.5%	1.9%
Mixed Use	618	583	-2.4%	1.3%
Residential	720	685	-0.7%	4.1%
Small Office	884	849	1.7%	3.5%

This report corroborates with the previous report by WSP for the West of England, finding that all building typologies can improve upon the GLA benchmark embodied carbon target for upfront emissions using typical design practices. The analysis found that a mixture of adopting cost saving carbon reduction measures (such as reducing grid spans and optimising MEP systems) with more expensive carbon measures (such as optimising the façade and introducing a higher percentage of recycled materials, timber and cement replacement) can be adopted to deliver carbon reductions within 2% of traditional construction costs. It is important to note that while carbon savings at near to cost parity can achieved, the end product is likely to be different as the building design will have reduced spans and different internal fit-out. In order to provide a more conservative estimate, a scenario has been included where all of these cost savings have been discounted. For example, even negating the savings that come from reducing grids, this study found that for the large office archetype to achieve a 25% saving in upfront carbon, a 2% uplift in cost to achieve for a commercial office building is required.

This study found that residential buildings could achieve a 25% reduction in upfront embodied carbon with a 4% uplift in cost. This study highlighted that it would be difficult to achieve further savings, in line with the GLA aspirational target, for residential buildings over 18m with current construction practices. Targets may be achievable through using specific low-carbon products or systems (novel cement replacement technologies, recycled metals). However, current market volatility and supply chain issues made these difficult to price, and it is unlikely at this current time that these are deliverable or appropriate solutions at scale.

The mixed-use archetype was found to achieve 25% carbon saving with only 1.3% increase in cost compared to the baseline, even when savings for cost reducing measures are discounted. Similarly to the commercial office archetype this was achieved by adopting cost-saving carbon reduction measures (such as reducing grid spans and optimising MEP systems) with more expensive carbon measures (such as optimising the façade and introducing a higher percentage of recycled materials and cement replacement) to deliver carbon reductions near to cost parity with traditional construction. This analysis has shown that by adopting good practice design and high levels of material substitution each of the archetypes could achieve savings of up to 23-26%. Achieving carbon reductions beyond 26% is possible but would be difficult in practice with current construction methods and may require innovative construction methods, or significant amounts of retention.

4.2 IMPLEMENTATION

4.2.1 SCOPE

This report has focused on upfront (A1-A5) embodied carbon, following the RICS 2.0 (2023) assessment methodology. This follows the available guidance at the time of writing and was reasonable and appropriate within the scope of this assessment. However, methods for evaluating the embodied carbon of construction projects are continually evolving. It is therefore essential that any new policy takes into consideration other regulatory and industry assessments, and that the results of this work are viewed in the context of this evolving calculation process.

4.2.1.1 Greater London Authority Whole Life-Cycle Carbon Assessment Guidance

The Greater London Authority (GLA) Whole Life-Cycle Carbon Assessment guidance is a key component in London's strategy to mitigate climate change. This methodology is by definition a whole life-cycle carbon assessment, including both upfront and whole life embodied carbon emissions and also operational emissions. A critical aspect of this methodology is the requirement for schemes referrable to the Mayor of London (and other major development proposals where encouraged to undertake an assessment) to calculate and report whole life-cycle carbon emissions in a standardised format, forming a mandatory part of the planning application process. The guidance stipulates calculation standards and reporting protocols, ensuring consistency and accuracy across developments. The GLA also periodically updates this guidance to reflect the latest advancements in sustainable building practices and carbon reduction technologies. These regular revisions ensure that the methodology remains at the forefront of addressing climate change, aligning with evolving environmental goals and technological innovations in the construction industry.

The GLA requirement to undertake WLC assessments for major projects in London has been instrumental in improving industry knowledge and understanding of embodied carbon in construction projects. However, one criticism has been that the embodied carbon target and aspirational targets have not been set low enough to discourage demolition, and developers can proceed with near to business-as-usual practices with limited restrictions. Despite this, the framework and reporting process required to be undertaken by developers is a sound standardised approach that has undertaken rigorous review and has been in action since March 2022, and any new policy should look to align with this existing policy.

4.2.1.2 City of London Optioneering Study

The City of London issued its first Whole Life Carbon Optioneering Planning Advice Note in March 2023 which requires, since the first publication of this report it has also released an update to this policy in the form of Carbon Options Guidance (COG)[17]. This is a good example of an existing planning mechanism to evaluate the whole life carbon implications of newbuild vs retrofit in London.

[17] City of London," Carbon Options Guidance Planning Advice Note", available online at: https://www.cityoflondon.gov.uk/services/planning/planning-application-requirements/sustainable-development-planning-requirements

- WLC Assessment, in line with the GLA's proposed methodology, to be undertaken at pre-application and planning stages, bringing carbon accounting to early stages of design planning.
- Developers to calculate and report the WLC of realistic and feasible options at pre-application where there are existing buildings on site.
- The emissions associated with a minor refurbishment, major refurbishment, significant refurbishment & extension, and new-build options should be compared – compelling clients and design teams to look for opportunities to minimise demolition.
- A WLC reporting dashboard to increase consistency of supporting carbon documents across pre-app and planning application submissions.
- Scope and assumptions across all options to be consistent and presented in a transparent way, without bias.
- An independent third-party verification to be carried out on all optioneering assessments as a quality assurance mechanism.

4.2.1.3 RICS 2017 vs RICS 2.0 (2023)

In November 2023, during the development of this project, The Royal Institute of Chartered Surveyors (RICS) updated their Whole Life Carbon Assessment for the Built Environment. The second edition of the RICS standard represents a significant expansion from its 2017 predecessor, primarily focusing on enhancing consistency in cost and carbon reporting, as well as benchmarking for both new builds and existing assets. This second edition aligns with the International Cost Management Standards (ICMS) 3rd Edition and the Built Environment Carbon Database (BECD), facilitating a uniform output in these areas. Moreover, it integrates guidance from other professional bodies such as CIBSE, IStructE, and CWCT, particularly concerning embodied carbon measurement. This edition sets a comprehensive standard for assessing whole life carbon throughout the entire asset life cycle. It has broadened its scope to include both buildings and infrastructure, making Whole Life Carbon Assessments (WLCA) applicable across all sectors and asset types. The integration with existing software tools has been improved, making the standard more accessible to SMEs, which form a significant portion of RICS members.

The second edition of the RICS framework brings in updated industry-agreed definitions for carbon terminology to ensure clarity and uniformity in approach. It introduces a standardised method for assessing risk in carbon assessment reporting and addresses uncertainties in WLCA reporting by mandating the calculation and reporting of a contingency allowance. This allowance varies based on the stage of WLCA production and the quality of data used. Technically, the new edition delves deeper into carbon data sources, conversion factors, and distinguishes between manufacturer-specific, sector average, and generic data. It also provides additional guidance on grid and material decarbonisation, carbon sequestration, and biogenic carbon. Furthermore, it includes guidance on retrofit and alignment with the circular economy, enabling professionals to work with the most up-to-date standards.

RICS 2.0 (2023) was published in November 2023, and has been in force since July 2024.

4.2.1.4 Industry Best Practice

RICS Guidance 'Whole Life Carbon Assessment for the Built Environment' acts as a reporting framework, but refers specifically to guidance from other institutions such as IStructE, CWCT and

CIBSE for details which is evolving at a separate pace to RICS guidance. As a result, new policy should refer to specific methodologies outlined by Engineering Institutions specifically, IStructE "How to calculate embodied carbon (Second edition)"[18], CWCT "How to Calculate the Embodied Carbon of Facades: a Methodology"[19] and CIBSE "TM65 Embodied Carbon in Building Services"[20].

4.2.1.5 UK Net Zero Carbon Building Standard

Although not issued at the time of publication of this document, WSP is aware of the development of the Net Zero Carbon Building Standard (NZCBS) the draft of which is expected to be released September 2024. The NZBCS brings together net zero carbon requirements for all major building types, based on a 1.5°C trajectory. This standard aims to provide the industry with a clear and robust framework to demonstrate that their built assets are net zero carbon, aligning with the nation's climate goals. To achieve this, the standard will integrate as much as possible with existing net zero initiatives and standards, creating a cohesive approach.

The standard will address both new build and retrofit projects, encompassing a range of typologies such as homes, offices, educational facilities, industrial and retail spaces, hotels, and healthcare buildings.

It is anticipated that there may be differences between the targets provided by the standard and the embodied carbon values provided in this document based on early indicators from NZBCS showing values below GLA and RIBA 2025 targets. This is not unexpected due to the differences in approach between the two projects. It should be noted that the NZCBS uses data aggregated from over 800 projects (in terms of embodied carbon alone) of different sizes, constraints and resources, based on RICS (2017) balanced with top-down analysis using UK carbon budgets. In contrast this study is based on a selection of specific building archetypes that have not been blended with high level budgets but have been assessed using RICS 2.0 (2023) to allow simple isolated assessment of cost impact of particular interventions. For example, in this study low carbon materials such as timber frames were excluded from the residential typology analysis due to the height of the baseline case, whereas in other projects of lower height, this may allow greater embodied carbon reductions.

It is recommended that any policy looking to set embodied carbon targets should be reviewed in light of the NZCBS standard once released with potential for alignment of target values.

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[18] How to calculate embodied carbon (Second edition) (IStructE, 2022) https://www.istructe.org/resources/guidance/how-to-calculate-embodied-carbon/
[19] How To Calculate The Embodied Carbon Of Facades: A Methodology (CWCT, 2023) https://www.cwct.co.uk/pages/embodied-carbon-methodology-for-facades
[20] TM65 Embodied carbon in building services: a calculation methodology (CIBSE, 2021) https://www.cibse.org/knowledge-research/knowledge-portal/embodied-carbon-in-building-services-a-calculation-methodology-tm65

4.2.2 PLANNING CONSIDERATIONS

4.2.2.1 Impact on Energy Consumption

Although it is possible to achieve both low embodied carbon and low operational emissions, one undesirable side-effect of a policy looking to regulate and reduce embodied carbon emissions is the adverse effect of increasing operational emissions by reducing the thermal performance of the building envelope. This reduction in performance may restrict a buildings ability to achieve high operational carbon standards, for example a high NABERS score for commercial buildings or Passivhaus Certification for residential developments. This is particularly the case for residential buildings where the Passivhaus standard requires extremely high performing façade systems, requiring a higher embodied carbon. This is the case, unless extremely low-carbon materials are used to create these high performing facades, which are currently unavailable on the mass market.

This may represent a false trade-off as the UK grid is set to decarbonise, and new developments are required to use all-electric heating systems. As a result, the operational carbon emissions from new developments are expected to be far lower than the embodied carbon emissions of a construction project. Furthermore, these emissions are emitted over the predicted lifespan of the project 30-60 years and subsequently spend less time in the atmosphere contributing towards global climate breakdown. Adopting a whole life carbon approach, such as following the GLA whole life-cycle carbon methodology, will address this issue and ensure that upfront embodied carbon is balanced against, operational carbon emissions.

4.2.2.2 Basements

As discussed in Section 4.1.5 basements are a key source of embodied carbon emissions for new developments. They are also typically the most expensive floor of a building to construct, particularly if there are atypical groundworks required. Therefore, by restricting the construction of new basements in London, it is likely that both a large cost and carbon saving can be achieved. However, basements also provide useful area for parking, bike storage and building services which, if removed, will need to be relocated to the above ground building.

The subsequent reduction in total lettable floor area as a result of removing the basement is significant (12.5% in the case of the office archetype), and this reduction in overall floor area could have a negative financial implication on overall scheme profitability. Therefore, policy looking to discourage the use of basements on the basis of both cost and carbon, could look to provide other financial incentives to developers, by reducing height restrictions on the project to enable an additional floor to create space for amenity and building services plant above ground.

4.2.2.3 Cement Replacements

In terms of embodied carbon, improved specification of concrete through cement replacement across the different archetypes has between a 4 and 8% reduction in embodied carbon with a maximum 1.5% increase in costs. This shows that allowing for slightly increased costs can have a greater impact on embodied carbon, which is a conservative estimation in terms of widely available materials as GGBS currently is typically on a cost par with Portland cement. However, it is anticipated that as the market moves away from the constrained resource of GGBS and looks at novel technologies, there may be a cost increase for these until they reach mass market availability. Considerate specification signals demand in the market and will help accelerate the introduction of more available lower carbon technologies and therefore is to be encouraged.

4.2.2.4 Façade Planning Constraints

Recently published amendments to Approved Document B of the Building Regulations confirm that in buildings with a residential purpose and a storey height of 18m or more, elements such as cladding, balconies, and other external surfaces must achieve class A1 or A2-S1, D0.

However, there is a growing emphasis on sustainability in construction, and there has been an increased interest in exploring alternative, more sustainable materials, including engineered timber products that may have improved fire resistance. Changes in Building Regulations and standards to accommodate sustainable building practices could happen, and some jurisdictions have been revisiting and updating their codes to reflect advancements in materials and construction methods.

4.2.2.5 Higher recycled content of glass and aluminium

The demand for sustainable and recycled façade materials has been growing due to increased awareness of environmental issues and a desire to reduce the carbon footprint of façade systems. Limited supply occurs when there aren't enough sources or manufacturers providing these sustainable materials, which can result in a constrained market. Many construction projects are now aiming to achieve specific environmental certifications and adhere to circular economy principles. This involves using recycled or recyclable materials to minimise waste and environmental impact. The emphasis on meeting these goals contributes to a surge in demand for materials that fulfil these criteria, specifically glass and aluminium as main components from window and curtain walling in facades.

The combination of high demand and limited supply creates a scenario where prices can become volatile. As demand outpaces supply, prices may increase, and the market can experience fluctuations. The price volatility of recycled aluminium and glass presents a risk in project budgeting and cost management: it becomes challenging to estimate and control costs effectively when the prices of these materials are unpredictable and dependence on a single source of supply exacerbates this risk. To mitigate risks associated with a single source of supply, cladding contractors may explore diversifying their supply chain, when manufacturers and suppliers will align their market offer.

4.2.2.6 Demolition and Enabling Works

In line with the RICS 2.0 (2023), an allowance has been made in this study for construction and installation under Module A5. This includes an allowance for both material wastage and site activities generally.

It should also be noted that the embodied carbon of existing structures has been considered as part of this study and that some amount of carbon could be saved by reusing these materials on site. Therefore, improving working practices around disassembly in the demolition phase, and embedding these into construction projects should help to increase the supply of secondary raw material, such as aluminium. This is a key part of circular economy principles and will help to ensure that the supply chain is more robust. Moreover, projects should demonstrate that they have been designed for disassembly throughout the project lifecycle to ensure that these materials can be recovered at the potential demolition phase in future.

4.2.3 OFFSETTING

Due to the current inability to construct in elements and materials that are fully net zero carbon or create high levels of on-site energy production, there are always some remaining emissions to be offset to achieve a net zero carbon building. Therefore, to achieve carbon neutrality, all remaining carbon emissions from a construction project are required to be offset, including both the construction and operational phase. Overall, the embodied carbon emissions of a new development today are expected to be higher than its operational carbon emissions. This is particularly in the case of new all-electric developments which can achieve even lower operational carbon emissions as the electricity grid is decarbonising, the relative significance of embodied carbon emissions is expected to be even higher.

Currently, there is no tax or carbon offset required for embodied carbon emissions. Operational emissions are taxed through Westminster City Council (WCC) carbon offsetting scheme (in line with adopted City Plan policy 36: Energy) with the aim of encouraging the use of on-site renewables to reduce the operational carbon emissions of a new development[21]. It is not known if this would be an appropriate price for offsetting the embodied carbon emissions of new developments. Careful investigation of an appropriate carbon offsetting price specific for providing advantage to low carbon alternatives is recommended, as part of a separate piece of work, and care must be given to avoid creating loopholes or disincentives for comprehensive carbon reduction. For example, if projects such as low-rise timber housing could avoid WCC operational carbon payments as a result of their low embodied carbon, this could diminish the reduction efforts on operational carbon leading to higher overall emissions. A whole life-cycle approach to carbon pricing could offer the most balanced solution, ensuring that all aspects of a building's carbon footprint are addressed.

4.2.4 BREEAM CONSIDERATIONS

A recommendation would be for the policy to instruct a Whole Life Carbon (WLC) assessment to promote carbon literacy and wholistic thinking on reducing emissions. Then this WLC assessment could feed into any BREEAM credits targeted by each design team (i.e. Mat 01, Mat 02, Mat 03, Mat 05 etc.). BREEAM could therefore be considered as a complementary assessment to the requirements for any new policy, which aims to ensure that developments consider sustainability in a holistic way.

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[21] WCC Planning Obligations and Affordable Housing Supplementary Planning Document (2024)

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjyq_y21ceIAxXxwAIHHXeCDfkQFnoECBUQAQ&url=https%3A%2F%2Fwww.westminster.gov.uk%2Fmedia%2Fdocument%2Fplanning-obligations-and-affordable-housing-spd-wcc-adopted-2024&usg=AOvVaw1zv3UZ4cfzUHYbe-q9l4Fl&opi=89978449

5 CONCLUSIONS

Some key conclusions to be considered on how the embodied carbon of new developments could be reduced are:

Structure:

- **Basements:** The inclusion of and/or size of a basement could have significant impact on the ability of a project to meet its carbon targets; a 25% uplift in $kgCO_2e/m^2$ was seen for the office & mixed-use archetypes, with a 40% uplift for the residential. This increased to a 95% uplift in embodied carbon for the small office archetype, emphasising the impact basements have on embodied carbon in small buildings. This is therefore a critical discussion to be had at the start of any project between the client and design team, as not incorporating one can be an easy win with regards to meeting targets. Therefore, policy looking to discourage the use of basements on the basis of both cost and carbon, could look to provide other financial incentives to developers, by reducing height restrictions on the project to enable an additional floor to create space for amenity and building services plant above ground.
- **Grid spacing:** Design decisions which are independent of material type & procurement routes should be explored as a first means when looking for opportunities to reduce carbon emissions. A 4% reduction in $kgCO_2e/m^2$ was seen in the office & mixed-use schemes when reducing the grid spacings, with an equivalent 3% reduction for the residential. When looking at overall structural contributors to embodied carbon the floor plates are usually the most carbon intensive, and so targeting the spans can have a great impact on overall embodied carbon. An efficient and appropriate design reduces the risk that the design team would need to commit to ambitious (and potentially expensive) material specifications early on. A cost saving of 1% for the office & mixed-use was also seen when reducing the grids, although the saving was more pronounced (3%) for the residential due to the enhanced reductions of the concrete frame.
- **Alternative Slab Options:** Given the restrictions around the use of timber within residential schemes above 18m, alternative slab options should be considered that can reduce embodied carbon and weight of the structure (and therefore embodied carbon in foundations), as discussed in Appendix B. Slab options should be considered in regard to the slab span as highlighted above, and combining an efficient slab with a reduced grid could have a large impact on embodied carbon.
- **Material Specification:** Following this, material specification should be considered such as cement replacement (since cement is the constituent of concrete with the highest embodied carbon). The most common cement replacement, GGBS (ground granulated blast furnace slag), is a limited and constrained resource that is nearly fully utilised across the globe. Specifying high quantities on one project is therefore likely to result in a reduction of use in another location thus balancing each other out and being unlikely to reduce global emissions.[22] For such schemes it is

[22]The efficient use of GGBS in reducing global emissions (IStructE, 2023) https://www.istructe.org/resources/guidance/efficient-use-of-ggbs-in-reducing-global-emissions/

therefore important to consider measures which encourage an efficient structural design first and foremost (e.g. sensible spans, restricting or limiting basement space, reducing quantity of transfer structures required). In future however, it is possible that alternative low-carbon cement replacements may become both more available and viable and so their inclusion within this report is deemed relevant. See IStructE Beyond Portland cement: Low-carbon alternatives[23] for current alternative technologies under consideration by the wider industry.

- **Timber:** For the office & mixed-use archetypes, a significant reduction in embodied carbon was seen with the introduction of CLT slabs (4%). As previously stated, the floorplates are typically the largest structural contributor to embodied carbon and this is exemplified by the significant change here. Should certain timber procurement routes be met (as described in Section 3.5.2) and the end-of-life scenario considered then further benefit to the whole life carbon could be obtained through sequestration. As stated above, these procurement routes are not available to residential schemes above 18m, however below this height these benefits could be obtained. To benefit from the introduction of timber, only a minor cost penalty is incurred; an uplift of around 0.2% is seen when introducing hybrid timber CLT flooring.

Façade:

- Predicting the embodied carbon contribution of a facade system is challenging due to the multitude of variables involved in the design and construction process. The specific combination of materials, components, and finishes selected for a particular project greatly influences its overall carbon footprint. Assumptions made in different design stages, such as transportation distances and wastage rates, can significantly impact the accuracy of embodied carbon predictions. Transportation emissions depend on the distance materials travel from manufacturing sites to the construction site, and wastage rates affect how efficiently materials are utilised.
- Designing for disassembly and adaptability aligns with circular economy principles, emphasising the ability to reuse and recycle façade components. While these considerations may not be easily quantifiable, they contribute to the overall sustainability of a project. The potential for reuse and recycling at the end of a building's life can influence the embodied carbon over the entire life cycle of the project. The embodied carbon of a façade systems extends beyond just the construction phase. Considering end-of-life scenarios and the potential for material reuse or recycling is crucial for a comprehensive assessment of the project's environmental impact.
- The optimisation of embodied carbon is averaged when assessed over GIA, particularly when considering transparent and opaque proportions of the envelope with the specified Window-to-Wall Ratio for different building archetypes which will have a significant impact on overall embodied carbon of the façade.

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23 IStructE Beyond Portland Cement: Low-carbon alternatives https://www.istructe.org/resources/guidance/beyond-portland-cement-low-carbon-alternatives/

- When normalising the embodied carbon value over the GIA and considering both opaque and transparent areas in the specified ratio, the reduction for office archetypes reaches 6-9%. This reduction is achieved through the substitution of terracotta rainscreen panels and their associated metal substructure with a lighter solution in terms of embodied carbon contribution. This alternative involves a timber rainscreen and the selection of a higher proportion of recycled aluminium in the curtain walling aluminium framing. Further optimisation, such as specifying recycled glass for the curtain walling system, could result in an additional reduction in embodied carbon.
- For the residential archetype, the reduction of embodied carbon is 9% when considered as averaged across the GIA of the development. This reduction is attributed to the substitution of terracotta rainscreen panels with a brickwork finishing for the external wall and the replacement of aluminium framing with composite framing in the window system. If timber is accepted in compliance with potential updates in building regulations in the foreseeable future, the incorporation of timber assembly for residential buildings could lead to an additional reduction in embodied carbon emissions.
- Timber facades, if properly treated and maintained, can last between 30 to 60 years. This means that within the RSP (Reference Study Period) of a carbon assessment they are most likely replaced. They require regular maintenance, such as sealing and staining, to protect against moisture, UV radiation, and pests. On the other hand, traditional rainscreens, often made from materials like metal, stone, or composite panels, can exceed 60 years (usual RSP) with minimal maintenance, making them more convenient over time. Timber is a renewable resource with a lower embodied carbon content, acting as a carbon sink during its growth, and generally has a lower environmental impact during production. In contrast, traditional materials like metal, terracotta and bricks have higher embodied carbon due to energy-intensive production processes, although some can be recycled. It is therefore crucial to highlight that from an upfront carbon perspective, timber results are less carbon intensive, but in a whole life carbon assessment (and in some specific environmental conditions) this option needs to be further evaluated against other façade components with a longer lifespan.

Services

- This study found that making a reduction in MEP embodied carbon was also likely to lead to a reduction in cost as less HVAC plant and distribution systems would be needed to serve the building. Reducing the embodied carbon of the MEP system by swapping out the HVAC system led to between 1-2% saving on the embodied carbon of the building, while saving between 0.5-1.5% of the total build cost.

Summary of Key Points

This report has found that all building typologies can improve upon the current GLA benchmark for upfront embodied carbon using design practices widely available on the market. The intervention measures assessed in this report include measures that save both cost and carbon (reducing grid spans, simplifying internal finishes and optimising MEP systems) alongside measures that save carbon at increased cost or constraints (optimising façades, incorporating use of timber elements and using recycled materials such as low carbon steel, and cement replacements). Table 5-1 shows that implementing all of these measures achieves carbon savings of 22-26% across the archetypes assessed. Carbon figures have been shown here both including and excluding demolition, construction activities and external works. Whereas cost uplifts have been shown both including and excluding potential cost savings from intervention measures.

Table 5-1 – Summary of cost and carbon results for each archetype.

	A1-A5 'Upfront' Embodied Carbon with all measures applied	A1-A5 excl. Demolition, Facilitating and External Works	Cost Uplift of Interventions [%]	Cost Uplift of Interventions [%] (discounting cost savings)
Large Office	633	579	-1.5%	1.9%
Mixed-use	618	583	-2.4%	1.3%
Residential	720	685	-0.7%	4.1%
Small Office	884	849	1.7%	3.5%

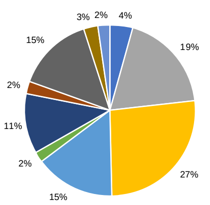
Overall, Table 5-1 shows that carbon reductions can be achieved within 2-4% of traditional construction costs, even when all potential cost saving measures (such as reducing grid spans) are negated. If the cost savings achievable from these measures are realised in practice this analysis has demonstrated that the lower carbon options could be delivered at lower cost than traditional building measures. However, these designs may result in different building characteristics such as reduced spans and altered internal fitouts, the effect of which (such as impact on GIA) has not been accounted for in the cost model.

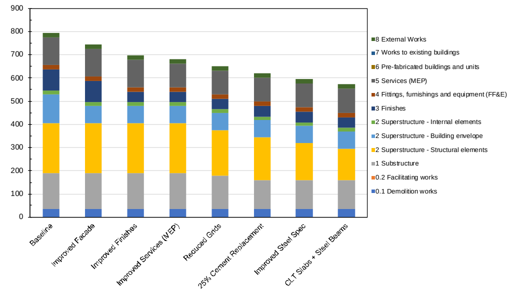
Achieving further reductions is possible. However, this would require more innovative construction methods than those presented in this study, such as industry wide adoption of calcined clay cement, higher use of timber and significantly more use of recycled materials, not widely adopted or available on the market at scale within current regulatory frameworks. The availability of low carbon construction products and solutions is a key constraint, many solutions are reliant on limited source material, e.g. recycled aluminium for window framing. Therefore, the pathway towards net zero is expected to require focus on reuse of structure and other materials from of existing buildings, adopting a retrofit first approach by promoting building retention and the circular economy.

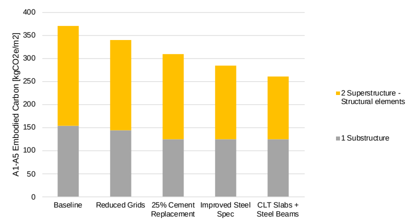
Appendix A

RESULTS TABLES

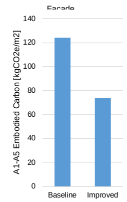
Large Office

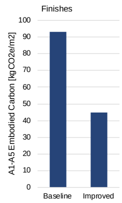


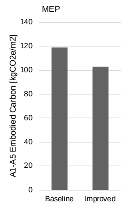




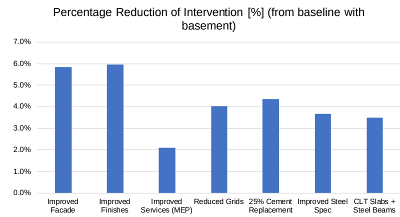
A1-A5 Embodied Carbon Impact [kgCO2e/m2]	Scope / Methodology	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
GIA [m2]										
0.1 Demolition works	RICS (2023) Assumption	35	**35**	35	35	35	35	35	35	35
0.2 Facilitating works	Excluded									
1 Substructure	IStructE (WSP Tool)	80	**154**	154	154	154	145	125	125	125
2 Superstructure - Structural elements	IStructE (WSP Tool)	216	**216**	216	216	216	195	184	159	136
2 Superstructure - Building envelope	CWCT (WSP Tool)	142	**124**	74	74	74	74	74	74	74
2 Superstructure - Internal elements	WSP LCA Data (+15%)	16	**16**	16	16	16	16	16	16	16
3 Finishes	WSP LCA Calculation	93	**93**	93	45	45	45	45	45	45
4 Fittings, furnishings and equipment (FF&E)	GLA Benchmark	19	**19**	19	19	19	19	19	19	19
5 Services (MEP)	CIBSE TM65 (WSP Tool)	119	**119**	119	119	103	103	103	103	103
5.1 Renewables	CIBSE TM65 (WSP Tool)	21	21	21	21	21	21	21	21	21
6 Pre-fabricated buildings and units	Excluded									
7 Works to existing buildings	Excluded									
8 External Works	GLA Benchmark	19	**19**	19	19	19	19	19	19	19
RICS 2.0 Construction Factor	RICS (2023) Assumption	40	**40**	40	40	40	40	40	40	40
Sub-total		**800**	**856**	**806**	**758**	**742**	**712**	**681**	**656**	**633**
Sub-total (excl. Demolition, Facilitating and External Works)		*746*	*802*	*752*	*704*	*688*	*658*	*627*	*602*	*579*







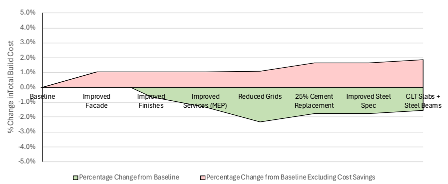
	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Reduction of Intervention [%] (from baseline with basement)	*5.8%*	*6.0%*	*2.1%*	*4.0%*	*4.4%*	*3.7%*	*3.5%*
Percentage Reduction Total [%] (from baseline with basement)	*6%*	*11%*	*13%*	*17%*	*20%*	*23%*	*26%*



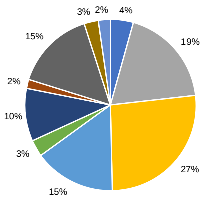
Cost Impact by RICS Category [£/m2]		Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
0.1 Demolition works	Excluded									
0.2 Facilitating works	Excluded									
1 Substructure			**391**	391	391	391	393	402	402	402
2 Superstructure - Structural elements			**406**	406	406	406	378	383	383	390
2 Superstructure - Building envelope			**417**	446	446	446	446	446	446	446
2 Superstructure - Internal elements			**227**	227	227	227	227	227	227	227
3 Finishes			**281**	281	236	236	236	236	236	236
4 Fittings, furnishings and equipment (FF&E)			**96**	96	96	96	96	96	96	96
5 Services (MEP)			**902**	902	902	882	882	882	882	882
6 Pre-fabricated buildings and units	Excluded									
7 Works to existing buildings	Excluded									
8 External Works	Excluded									
Prelims, Overhead and Profit (20%)	20%		**544**	550	541	537	532	535	535	536
Sub-total			3266	3301	3246	3223	3191	3209	3209	3216

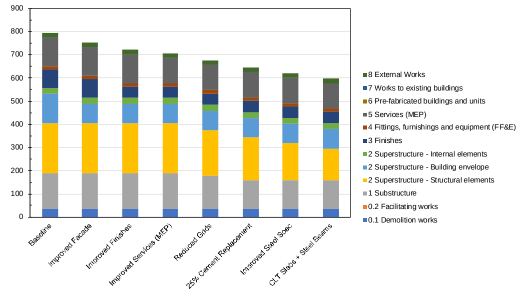
Percentage Cost Impact by RICS Category [%]	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
1 Substructure			0%	0%	0%	0%	2%	0%	0%
2 Superstructure - Structural elements			0%	0%	0%	-7%	1%	0%	2%
2 Superstructure - Building envelope			6%	0%	0%	0%	0%	0%	0%
2 Superstructure - Internal elements			0%	0%	0%	0%	0%	0%	0%
3 Finishes			0%	-19%	0%	0%	0%	0%	0%
4 Fittings, furnishings and equipment (FF&E)			0%	0%	0%	0%	0%	0%	0%
5 Services (MEP)			0%	0%	-2%	0%	0%	0%	0%

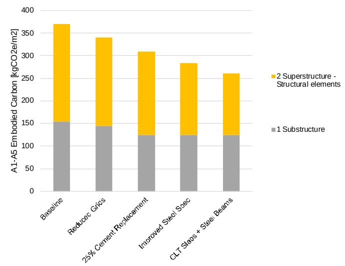
Total Cost Impact by RICS Category [%]	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Change from Intervention		1.1%	-1.7%	-0.7%	-1.0%	0.5%	0.0%	0.2%
Percentage Change from Baseline		1.1%	-0.6%	-1.3%	-2.3%	-1.8%	-1.8%	-1.5%
Percentage Change from Baseline Excluding Cost Savings		1.1%	1.1%	1.1%	1.1%	1.6%	1.6%	1.9%

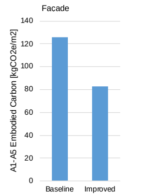


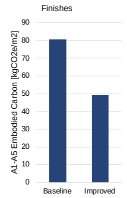
Mixed Use

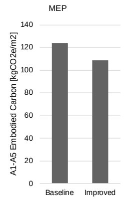






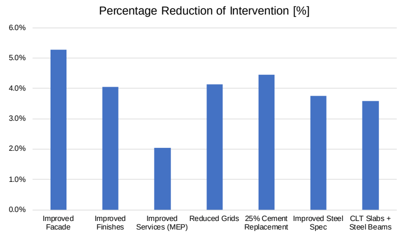






A1-A5 Embodied Carbon Impact by RICS Category [kgCO2e/m2]	Scope / Methodology	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
GIA [m2]										
0.1 Demolition works	RICS (2023) Assumption	35	**35**	35	35	35	35	35	35	35
0.2 Facilitating works	Excluded									
1 Substructure	IStructE (WSP Tool)	80	**154**	154	154	154	145	125	125	125
2 Superstructure - Structural elements	IStructE (WSP Tool)	216	**216**	216	216	216	195	184	159	136
2 Superstructure - Building envelope	CWCT (WSP Tool)	144	**126**	83	83	83	83	83	83	83
2 Superstructure - Internal elements	WSP LCA Data (+15%)	26	**26**	26	26	26	26	26	26	26
3 Finishes	WSP LCA Calculation	81	**81**	81	49	49	49	49	49	49
4 Fittings, furnishings and equipment (FF&E)	GLA Benchmark	14.5	**14.5**	14.5	14.5	14.5	14.5	14.5	14.5	14.5
5 Services (MEP)	CIBSE TM65 (WSP Tool)	115	**124**	124	124	109	109	109	109	109
5.1 Renewables	CIBSE TM65 (WSP Tool)	21	21	21	21	21	21	21	21	21
6 Pre-fabricated buildings and units	Excluded									
7 Works to existing buildings	Excluded									
8 External Works	GLA Benchmark	19	**19**	19	19	19	19	19	19	19
RICS 2.0 Construction Factor	RICS (2023) Assumption	40	**40**	40	40	40	40	40	40	40
Sub-total		**751**	**816**	**773**	**742**	**727**	**697**	**666**	**641**	**618**
Sub-total (excl. Demolition, Facilitating and External Works)		*716*	*781*	*738*	*707*	*692*	*662*	*631*	*606*	*583*

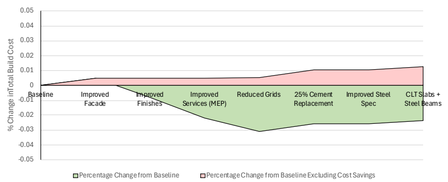
		Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Reduction of Intervention [%]	Percentage Re	*5.3%*	*4.0%*	*2.0%*	*4.1%*	*4.4%*	*3.8%*	*3.6%*
Percentage Reduction Total [%]	Percentage Re	*5%*	*9%*	*11%*	*15%*	*18%*	*21%*	*24%*



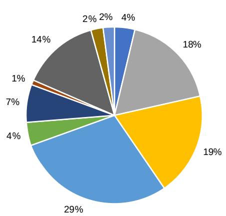
Cost Impact by RICS Category [£/m2]		Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
0.1 Demolition works	Excluded									
0.2 Facilitating works	Excluded									
1 Substructure			**391**	**391**	**391**	**391**	**393**	**402**	**402**	**402**
2 Superstructure - Structural elements			**406**	**406**	**406**	**406**	**378**	**383**	**383**	**390**
2 Superstructure - Building envelope			**418**	432	432	432	432	432	432	432
2 Superstructure - Internal elements			**136**	136	136	136	136	136	136	136
3 Finishes			**799**	799	761	761	761	761	761	761
4 Fittings, furnishings and equipment (FF&E)			**41**	41	41	41	41	41	41	41
5 Services (MEP)			755	755	755	714	714	714	714	714
6 Pre-fabricated buildings and units	Excluded									
7 Works to existing buildings	Excluded									
8 External Works	Excluded									
Prelims, Overhead and Profit (20%)	20%		**589**	592	584	576	571	574	574	575
Sub-total			3536	3553	3507	3458	3427	3444	3444	3452

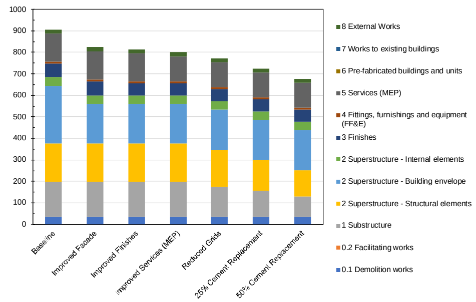
Percentage Cost Impact by RICS Category [%]	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
1 Substructure			0%	0%	0%	0%	2%	0%	0%
2 Superstructure - Structural elements			0%	0%	0%	-7%	1%	0%	2%
2 Superstructure - Building envelope			3%	0%	0%	0%	0%	0%	0%
2 Superstructure - Internal elements			0%	0%	0%	0%	0%	0%	0%
3 Finishes			0%	-5%	0%	0%	0%	0%	0%
4 Fittings, furnishings and equipment (FF&E)			0%	0%	0%	0%	0%	0%	0%
5 Services (MEP)			0%	0%	-6%	0%	0%	0%	0%

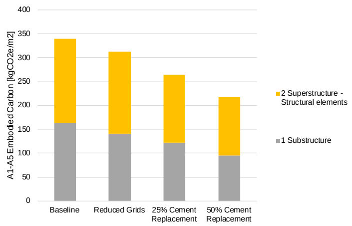
Total Cost Impact by RICS Category [%]		Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Change from Intervention	Percentage Ch	0.5%	-1.3%	-1.4%	-0.9%	0.5%	0.0%	0.2%
Percentage Change from Baseline	Percentage Ch	0.5%	-0.8%	-2.2%	-3.1%	-2.6%	-2.6%	-2.4%
Percentage Change from Baseline Excluding Cost Savings	Percentage Ch	0.5%	0.5%	0.5%	0.5%	1.0%	1.0%	1.3%

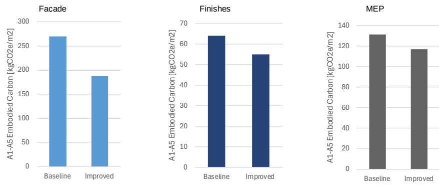


Residential



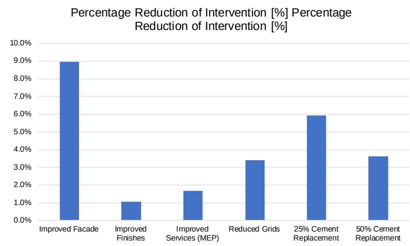






A1-A5 Embodied Carbon Impact by RICS Category [kgCO2e/m2]	Scope / Methodology	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
GIA [m2]									
0.1 Demolition works	RICS (2023) Assumption	35	**35**	35	35	35	35	35	35
0.2 Facilitating works	Excluded								
1 Substructure	IStructE (WSP Tool)	67	**164**	164	164	164	141	122	95
2 Superstructure - Structural elements	IStructE (WSP Tool)	176	**176**	176	176	176	171	143	122
2 Superstructure - Building envelope	CWCT (WSP Tool)	302	**270**	187	187	187	187	187	187
2 Superstructure - Internal elements	WSP LCA Data (+15%)	39	**39**	39	39	39	39	39	39
3 Finishes	WSP LCA Calculation	64	**64**	64	55	55	55	55	55
4 Fittings, furnishings and equipment (FF&E)	GLA Benchmark	8.5	**8.5**	8.5	8.5	8.5	8.5	8.5	8.5
5 Services (MEP)	CIBSE TM65 (WSP Tool)	110	**131**	131	131	117	117	117	117
5.1 Renewables	CIBSE TM65 (WSP Tool)	21	21	21	21	21	21	21	21
6 Pre-fabricated buildings and units	Excluded								
7 Works to existing buildings	Excluded								
8 External Works	GLA Benchmark	19	**19**	19	19	19	19	19	19
RICS Construction Factor	RICS (2023) Assumption	40	**40**	40	40	40	40	40	40
Sub-total		**910**	**928**	**845**	**836**	**822**	**794**	**747**	**720**
Sub-total (excl. Demolition, Facilitating and External Works)		*875*	*893*	*810*	*801*	*787*	*759*	*712*	*685*

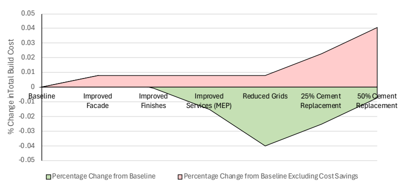
		Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
Percentage Reduction of Intervention [%]	*Percentage Reduction of Intervention [%]*	*8.9%*	*1.1%*	*1.7%*	*3.4%*	*5.9%*	*3.6%*
Percentage Reduction Total [%]	*Percentage Reduction Total [%]*	*9%*	*10%*	*11%*	*14%*	*20%*	*22%*



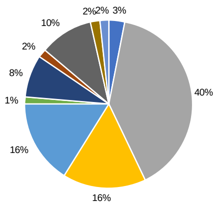
Cost Impact by RICS Category [£/m2]		Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
0.1 Demolition works	Excluded								
0.2 Facilitating works	Excluded								
1 Substructure			**461**	461	461	461	422	434	461
2 Superstructure - Structural elements			**737**	737	737	737	679	725	767
2 Superstructure - Building envelope			**794**	824	824	824	824	824	824
2 Superstructure - Internal elements			67	67	67	67	67	67	67
3 Finishes			**1188**	1188	1154	1154	1154	1154	1154
4 Fittings, furnishings and equipment (FF&E)	included in finishes								
5 Services (MEP)			**645**	645	645	589	589	589	589
6 Pre-fabricated buildings and units	Excluded								
7 Works to existing buildings	Excluded								
8 External Works	Excluded								
Prelims, Overhead and Profit (20%)	20%		**778**	784	778	766	747	758	772
Sub-total			4668	4705	4665	4598	4481	4551	4635

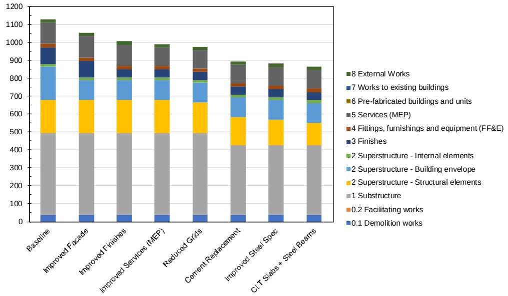
Percentage Cost Impact by RICS Category [%]	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
1 Substructure			0%	0%	0%	-9%	3%	6%
2 Superstructure - Structural elements			0%	0%	0%	-9%	6%	6%
2 Superstructure - Building envelope			4%	0%	0%	0%	0%	0%
2 Superstructure - Internal elements			0%	0%	0%	0%	0%	0%
3 Finishes			0%	-3%	0%	0%	0%	0%
4 Fittings, furnishings and equipment (FF&E)								
5 Services (MEP)			0%	0%	-10%	0%	0%	0%

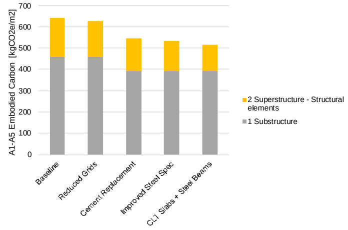
Total Cost Impact by RICS Category [%]		Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	25% Cement Replacement	50% Cement Replacement
Percentage Change from Intervention	Percentage Ch	0.8%	-0.8%	-1.4%	-2.5%	1.5%	1.8%
Percentage Change from Baseline	Percentage Ch	0.8%	-0.1%	-1.5%	-4.0%	-2.5%	-0.7%
Percentage Change from Baseline Excluding Cost Savings	Percentage Ch	0.8%	0.8%	0.8%	0.8%	2.3%	4.1%

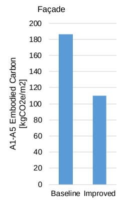


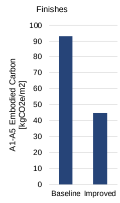
Small Office

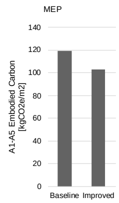






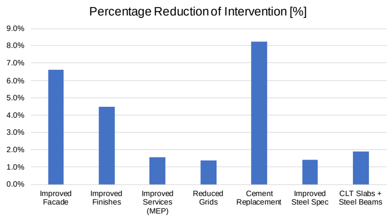






A1-A5 Embodied Carbon Impact by RICS Category [kgCO2e/m2]	Scope / Methodology	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams	
GIA [m2]											
0.1 Demolition works	RICS (2023) Assumption	35	**35**	35	35	35	35	35	35	35	
0.2 Facilitating works	Excluded										
1 Substructure	IStructE (WSP Tool)	154	**458**	458	458	458	458	391	391	391	0.442258
2 Superstructure - Structural elements	IStructE (WSP Tool)	184	**184**	184	184	184	170	155	142	125	
2 Superstructure - Building envelope	CWCT (WSP Tool)	248	**186**	110	110	110	110	110	110	110	
2 Superstructure - Internal elements	WSP LCA Data (+15%)	16	**16**	16	16	16	16	16	16	16	
3 Finishes	WSP LCA Calculation	93	**93**	93	45	45	45	45	45	45	
4 Fittings, furnishings and equipment (FF&E)	GLA Benchmark	19	**19**	19	19	19	19	19	19	19	
5 Services (MEP)	CIBSE TM65 (WSP Tool)	119	**119**	119	119	103	103	103	103	103	
5.1 Renewables	CIBSE TM65 (WSP Tool)	21	21	21	21	21	21	21	21	21	
6 Pre-fabricated buildings and units	Excluded										
7 Works to existing buildings	Excluded										
8 External Works	GLA Benchmark	19	**19**	19	19	19	19	19	19	19	
RICS Construction Factor	RICS (2023) Assumption	40	**40**	40	40	40	40	40	40	40	
Sub-total		**824**	**1150**	**1074**	**1026**	**1010**	**996**	**914**	**901**	**884**	
Sub-total (excl. Demolition, Facilitating and External Works)		*789*	*1115*	*1039*	*991*	*975*	*961*	*879*	*866*	*849*	

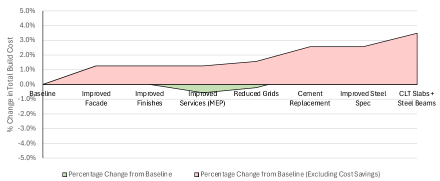
Total Carbon Impact [%]		Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
Percentage Reduction of Intervention [%]	*Percentage Reduction of Intervention [%]*	*6.6%*	*4.5%*	*1.6%*	*1.4%*	*8.2%*	*1.4%*	*1.9%*
Percentage Reduction Total [%]	*Percentage Reduction Total [%]*	*7%*	*11%*	*12%*	*13%*	*21%*	*22%*	*23%*



Cost Impact by RICS Category [£/m2]		Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
0.1 Demolition works	Excluded									
0.2 Facilitating works	Excluded									
1 Substructure			**988**	988	988	988	988	1018	1018	1018
2 Superstructure - Structural elements			**366**	366	366	366	377	382	382	416
2 Superstructure - Building envelope			**703**	748	748	748	748	748	748	748
2 Superstructure - Internal elements			**273**	273	273	273	273	273	273	273
3 Finishes			**281**	281	236	236	236	236	236	236
4 Fittings, furnishings and equipment (FF&E)			**69**	69	69	69	69	69	69	69
5 Services (MEP)			**902**	902	902	882	882	882	882	882
6 Pre-fabricated buildings and units	Excluded									
7 Works to existing buildings	Excluded									
8 External Works	Excluded									
Prelims, Overhead and Profit (20%)	20%		**716**	725	716	712	715	722	722	728
Sub-total			4298	4352	4298	4274	4288	4329	4329	4370

Percentage Cost Impact by RICS Category [%]	Baseline without basement	Baseline	Improved Facade	Improved Finishes	Improved Services (MEP)	Reduced Grids	Cement Replacement	Improved Steel Spec	CLT Slabs + Steel Beams
1 Substructure			0%	0%	0%	0%	3%	0%	0%
2 Superstructure - Structural elements			0%	0%	0%	3%	1%	0%	8%
2 Superstructure - Building envelope			6%	0%	0%	0%	0%	0%	0%
2 Superstructure - Internal elements			0%	0%	0%	0%	0%	0%	0%
3 Finishes			0%	-19%	0%	0%	0%	0%	0%
4 Fittings, furnishings and equipment (FF&E)			0%	0%	0%	0%	0%	0%	0%
5 Services (MEP)			0%	0%	-2%	0%	0%	0%	0%

Total Cost Impact [%]		Improved Facac	Improved Finisl	Improved Servic	Reduced Grids	Cement Replac	Improved Steel	CLT Slabs + Steel Beams
Percentage Change from Intervention	Percentage Ch	1.3%	-1.3%	-0.5%	0.3%	1.0%	0.0%	0.9%
Percentage Change from Baseline	Percentage Ch	1.3%	0.0%	-0.6%	-0.2%	0.7%	0.7%	1.7%
Percentage Change from Baseline (Excluding Cost Savings)	Percentage Ch	1.3%	1.3%	1.3%	1.6%	2.5%	2.5%	3.5%



Appendix B

STRUCTURAL MODELLING ASSUMPTIONS

APPENDIX B: STRUCTURES MODELLING DETAILS

DESIGN ASSUMPTIONS

BASELINE STRUCTURAL SYSTEMS

The following table outlines the baseline information used in the analysis, based on the layouts and massing shown in Section 3.1

Table A-1 – Baseline Structural Systems Used in Calculations

	Large Office and Mixed Use	Residential	Small Office
Upper Floor Slabs	130mm C25/C30 NWC on composite deck (Multideck 50-V3)	250mm C32/40 NWC flat slab	130mm C25/C30 NWC on composite deck (Multideck 50-V3)
Beams	Primary beams typically - UB610x229x125 Secondary beams typically - UB406x140x46	N/A	Primary long span beams typically – UB 533x210x109 Secondary and primary short span beams typically - UB 406x140x40
Stability	300mm C32/40 NWC core walls	300mm C32/40 NWC core walls	225mm C32/40 NWC core walls
Columns*	UC 356x406x393	500mm square C32/40 NWC	UC 203x203x86
Ground floor slab	300mm C32/40 NWC	325mm C32/40 NWC	275mm C32/40 NWC
Foundations	600mm dia 23m long piles with pilecaps	600mm dia 23m long piles with pilecaps	600mm dia 23m long piles with pilecaps
Basement**	600mm dia 14m long contiguous piled wall with capping beam and 300mm liner wall	600mm dia 14m long contiguous piled wall with capping beam and 300mm liner wall	600mm dia 14m long contiguous piled wall with capping beam and 300mm liner wall

* Columns have been sized for the loading requirements at ground floor. There may be an opportunity to reduce the size of the columns at the upper stories however the columns contribution to the overall embodied carbon is very small. Therefore, reducing the size of the columns will have a very small or negligible difference on the overall embodied carbon value.

** See section 4.1.6 for further details on the inclusion of a basement in calculations

GRIDS

Baseline grid dimensions have been informed by a database of WSP projects. On commercial projects in London, we have seen a gradual move from larger grids of 13.5-15m to the 9-12m range over the last couple of years (reduction in carbon being one of the main drivers here), with a small number reducing to the 7.5m range. The 12m baseline and 9m improvement grids were selected to align to the most common BCO grids. Whilst we do see some examples of the 7.5m grids this is still quite unusual and just represents the next level of improvement in standard BCO grid spacing.

LOADS

Design live loads have been specified in line with BS EN 1991-1-1:2002 Eurocode 1: Actions on structures to ensure compliance with Building Control. Roof loads are reduced compared to the typical floor loads as they are designed for maintenance use. The full design loads are specified below:

All loads in kN/m^2	Large Office and Mixed Use	Residential	Small Office
Typical floor			
Live load	3.50	1.50	3.50
SIDL	0.85	1.80	0.85
Roof			
Live load	0.60	0.60	0.60
SIDL	1.80	1.80	1.80
Basement			
Live load	2.50	2.50	2.50
SIDL	4.00	2.50	4.00

STEEL

10% EAF - Specifying EAF in high quantities can cause large project reductions but do not currently affect the wider supply chain and global efforts towards decarbonisation. It is for this reason that only a small percentage of EAF steel is used as a comparison in this study. In reality, this 15% EAF steel also represents other lower carbon steel technologies such as Direct Reduced Iron (DRI).

Sizing – steel sizes have been based on the minimum weight required for the spans. This is based on efficient sizing rather than minimising structural zones and floor to floor heights which would require heavier sections, potentially even a change from UB sections to stockier UC sections. For example, for a 12x12m span, the steel weight is around 30kg/m^2 but if the steel sizes were reduced to a maximum 580mm deep this would increase to around 50kg/m^2, an increase of 2/3 – which shows the impact of allowing sufficient floor zones for an efficient structure.

Fire protection - an allowance for fire protection of steelwork has been included in the analysis.

CONCRETE

Concrete embodied carbon rates have been based on UK averages with an option to replace cement (the most carbon intensive constituent of concrete) with Ground Granulated Blast Furnace Slab (GGBS) which is a by-product of steel production using blast furnaces (BOF). As the industry transfers steel making away from BOF to EAF or DRI to create lower carbon steel, GGBS becomes a diminishing finite resource. Therefore, specifying high amounts of GGBS only depletes the global stocks faster. However, the 25% cement replacement with GGBS has been used as a comparison that is representative of other growing technologies such as Multi Component Cements (MMC) that use a mixture of cement replacements and reduce the embodied carbon to a lower rate of using just GGBS. Calcined clays also have potential to be a good medium-term route to low carbon concrete. Although it has a higher embodied carbon per weight compared to GGBS, it can be used in higher quantities from an environmental perspective due to the much higher availability.

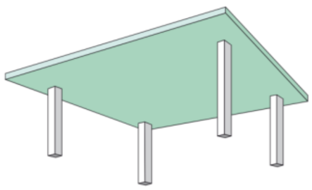
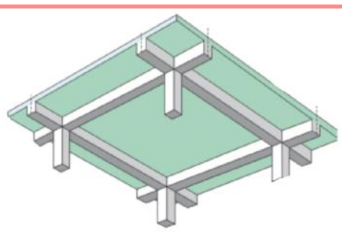
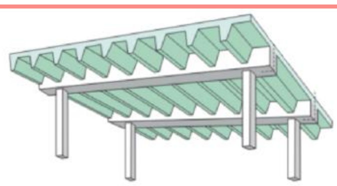
Further information on options for low carbon concrete specification can be found on the IStructE's Concrete Technology Tracker at https://www.istructe.org/resources/guidance/concrete-technology-tracker/

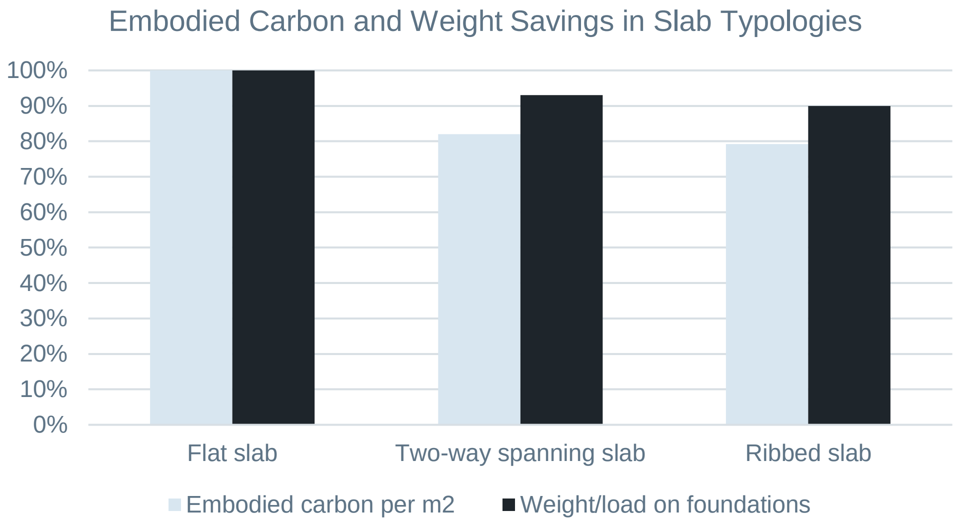
CLT

Fire protection and acoustic treatment - Fire protection and any required acoustic layers have been included in the calculations to make the CLT comparable with options such as concrete framing that have inherent resistance. An allowance for connections has also been included.

FLOOR STRUCTURE OPTIONS

In Section 4.1, within the analysis of different options for decreasing the embodied carbon in the structural design, a CLT slab is put forward as an alternative to a reinforced concrete flat slab (for the residential option) or composite concrete and metal deck slab (for the office options). These should not be assumed as the only structural floor options and each project should be reviewed with regard to all appropriate solutions. Further examples of different slab types, along with additional high-level analysis, are provided below but by no means represent all options available.

	Flat slab	**Two-way spanning slab**	**Ribbed slab**
			
Slab depth (mm)	200	150	275
Beam depth (mm)	0	550	550
Relative embodied carbon (slabs only)	100%	82%	79%
Relative weight/load on foundations	100%	93%	90%



Weight is noted alongside embodied carbon values as it can have a large impact on foundations or existing structures (where extending) and therefore the embodied carbon impacts of an efficient and lightweight slab are more than the values for the slab itself.

The above comparison also shows the impact that different types of slabs can have on structural zones, and that allowance of a deeper structural zone can result in a more efficient and therefore lower carbon slab.

EMBODIED CARBON FACTORS

The methodology to calculate the embodied carbon of the structural elements has been based on RICS Professional Standard Revision 2 and IStructE's *How to Calculate Embodied Carbon Revision 2.* The carbon factors used are as follows:

Table A-2 Baseline Structural Embodied Carbon Factors

	Waste Rate	Empty Running Factor	A1-A3 ($kgC0_2e/kg$)	A4 ($kgC0_2e/kg$)	C2 ($kgC0_2e/kg$)	C4 ($kgC0_2e/kg$)	A5w Disposal Factor ($kgC0_2e/kg$)
Concrete in-situ	0.05	1	0.130	0.0050	0.0087	0.0012	0.1449
Reinforcement	0.05	0.43	0.760	0.0320	0.0406	0.0013	0.0722
Steel	0.01	0.43	1.740[1]	0.0214	0.0176	0.0013	1.7802
Timber frames (Glulam)	0.02	0.43	0.280	0.1867	0.1894	0.8280	1.4841
Timber floors (CLT)	0.1	0.43	0.250	0.1867	0.1894	0.8280	1.4541

[1] Base embodied carbon rate of 1.74 $kgCO_2e/kg$ – This is based on recommendation from the RICS Professional Standard and IStructE's *How to Calculate Embodied Carbon Revision 2* and represents

the embodied carbon of the average UK consumption as an overall blend of different methods of steel production as procured and used in the UK. Therefore, the final embodied carbon of steel in as-built projects will likely vary from this and may show an uplift in embodied carbon when compared to earlier stage calculations.

A 15% contingency factor has been applied to both superstructure and substructure elements as per RICS Version 2 to allow for project uncertainty based on the fact the study is equivalent to an early project phase assessment.

COST ASSUMPTIONS

The structural costs have been based on typical market data. For the baseline situation, the approach is fairly standardised, however the analysis strategy for lower carbon options contains certain nuances that are clarified below:

CONCRETE

Currently there is no uplift in material cost for concrete when cement replacement in the form of GGBS is used to create lower carbon mixes, as the production costs of GGBS are actually lower than those of Portland cement. However, as stated above, as the industry moves away from GGBS as the default cement replacement, newer technologies are coming to the market. These are presently available in limited supply and require additional testing to prove performance where they are not covered by current technical standards, which is likely to increase costs until they are available and certified on the mass market.

It is estimated that an increase of up to 30% more for a lower carbon concrete option is acceptable considering the limited impact on overall budgets as shown in the analysis results.

It should also be noted that market pressure on the concrete supply chain is important to encourage adoption of new approaches and the use of “standard” mixes should be challenged throughout the design.

STEEL

In the current structural steel market, there is no cost difference between BOF and EAF steel. Re-used steel is often available at a lower cost than virgin steel, but additional testing is required to prove its appropriateness, therefore conservatively this has been kept as cost neutral.

Appendix C

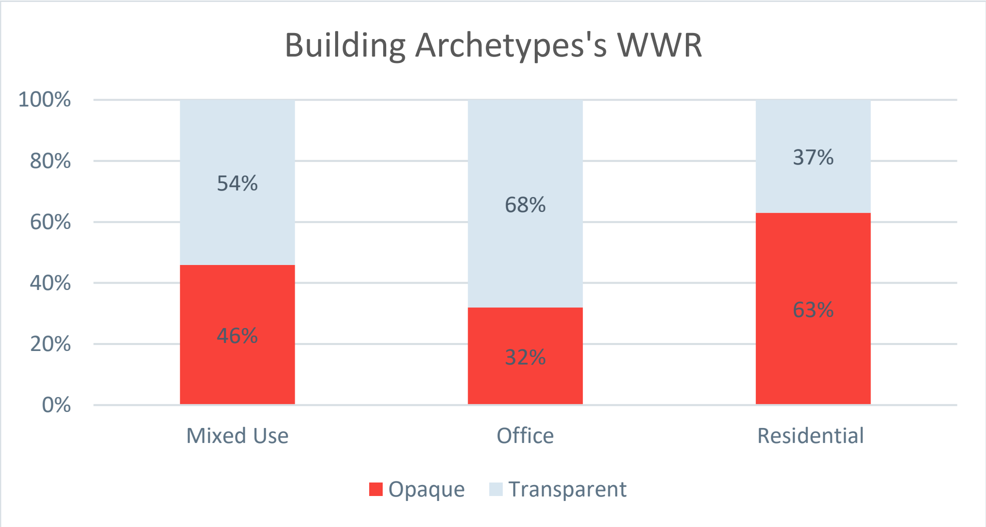
FACADE MODELLING ASSUMPTIONS

APPENDIX C: FAÇADE MODELLING DETAILS

Two scenarios are evaluated for each building archetype:

- TYPICAL SYSTEMS
- OPTIMIZED SYSTEMS

For each scenario the façade surface area (FSA) is split between opaque and transparent in the proportions reported below.

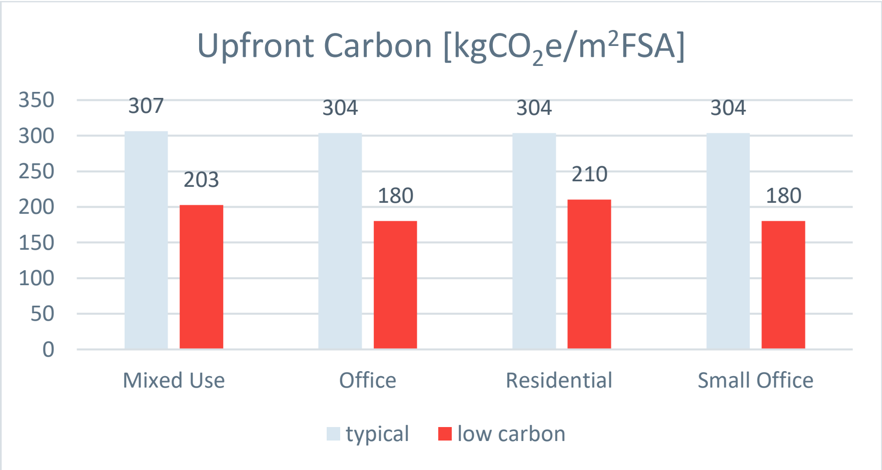


The mixed use is a combination of different building uses:

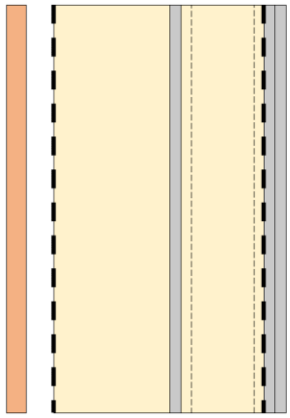
- 43% OFFICE
- 43% RESIDENTIAL
- 14% RETAIL

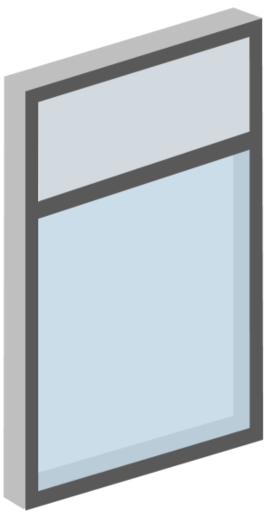
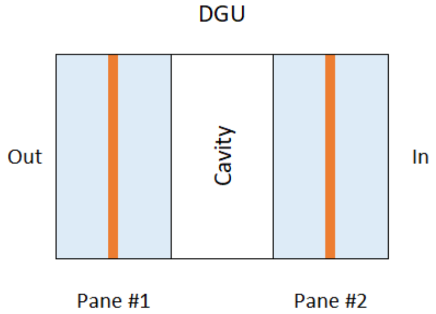
Hence the opaque and transparent façade systems are also a combination of systems.

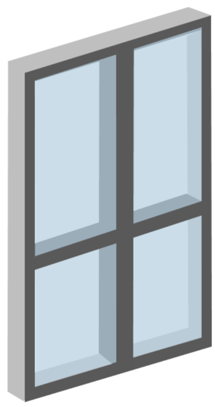
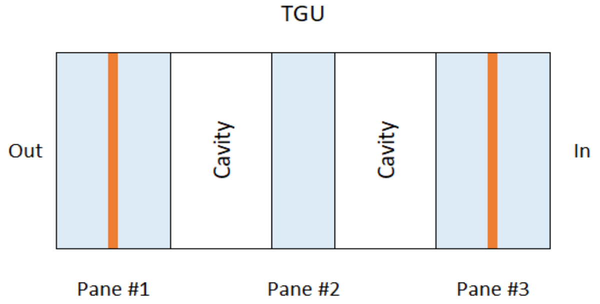
Upfront carbon (A1-A5) figures per each scenario are collected in the following graphs per each building archetype.



Tables below list materials included in the opaque and transparent build ups.

OPAQUE BUILD-UP (From interior to exterior)	
Plaster Board	
Vapour Control Layer	
Framing System	
Mineral Wool	
Cement Particle board	
Mineral Wool	
Breather Membrane	
Rainscreen Cladding and substructure	

TRANSPARENT BUILD-UP CURTAIN WALLING	
Framing	
Double Glazed Unit (66.2-16-66.2 laminated heat strengthened low iron glass with selective coating applied in face 4)  	
Bracketry System (Cast-in channel, Bracket, Firestop)	
Opaque Spandrel (sandwich panel made of two sheets of 1mm each of aluminium and 200 mm of mineral wool and a terracotta rainscreen with substructure)	

TRANSPARENT BUILD-UP WINDOW SYSTEM	
Framing	
Triple Glazed Unit (44.2-14-6-14-44.2 laminated heat strengthened low iron glass with selective coatings applied in face 4 and 6)  	

Appendix D

BUILDING SERVICES (MEP) MODELLING ASSUMPTIONS

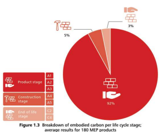


Figure 1.3 Breakdown of embodied carbon per life cycle stage; average results for 180 MEP products

Product Life Stage Typical MEP product	
A1-A3	0.92
A4-A5	0.05
C2,C4	0.03
Scale Up Factor from A1-A3 to A1-A5	1.05
Scale Up Factor from A1-A5 to A1-5,C2-4	1.03

Conservative Buffer Factor	Factor (%)
Conservative Buffer Factor	130%

Complexity Factor	Factor (%)	Description
Low Complexity	130%	Pipes, cables, ducts and valves, fire alarm devices, access control, cable containment, electrical outlets, busbars
Medium Complexity	140%	Pumps, luminaires, radiators, control panels, lighting control devices, sensors, thermal store
High Complexity	160%	Air handling units, heat pumps, boilers, heat interface units, chillers, generator, MVHR, switchgear, UPS

Refrigerant Leakage Scenarios	B1 annual leakage rate	C1 end of life recovery rate	Description
Type 1	2%	99%	Package heat pump or chiller, where no refrigerant is managed on site
Type 2	4%	98%	Heat pump or chiller where some works to refrigerant pipework are carried out on site
Type 3	6%	97%	VRF systems where a large amount of refrigerant pipework is installed and filled on site

Refrigerant GWP

Type	Refrigerant	Ozone depletion potential	Global warming potential over 100 years (kg CO2eq)
	SF6		24300
CFC	R11	1	4750
	R125		3740
HCFC	R22	0.055	1810
HCFC	R407c	0	1774
HFC	R410a	0	2256
HFC	R134a	0	1530
HFC	R32	0	677
HFC	R32	0	631
HFO	R513A	0	631
HFO	R454B	0	531
HFO	R454C		166
HFO	R123	0.012	77
HFO	R1234yf	0	0.501
HFO	R1234ze (E)	0	1.37
Hydrocarbon	R290 (propane)	0	0.02
Natural	R744 (CO2)	0	1
Natural	R717 (ammonia)	0	0
Natural	R718 (water)	0	0

Material Carbon Factor

Material	kgCO2e/kg	Density kg/m3	Thermal Conductivity	Lifespan (CIBSE Guide M)
ABS	3.76	1060		30
Aluminium	13.1	2700		30
Brass	4.8	8470		30
Cast iron	1.52	7200		30
Ceramic	0.7	2300		30
Copper	3.81	8790		30
Concrete (precast with reinforcement)	0.249	n/a		30
Electronic component	49	n/a		30
Expanded polystyrene	3.43	30	0.03	30
Glass	1.44	2400		30
Insulation (general)	1.86	50	0.045	30
Iron	2.03	7000		30
Lithium	5.3	530		30
Plastics (general)	3.31	910		30
Polyamide	9.14	1150		30
Polycarbonate	7.62	1200		30
Polyethylene	2.54	960		30
Polyurethane foam	4.55	30	0.025	30
Printed wiring board, mixed mounted	154	n/a		30
PVC pipe	3.23	1390		30
PVC	3.1	1390		30
Rubber	2.85	1100		30
Silicon	13.8	2330		30
Stainless steel	4.4	7930		30
Steel (general or galvanised)	2.97	7820		30
Zinc	4.18	7120		30
Timber (general)	0.493	540		30
Mineral Oil	1.4			30
Cardboard	0.821			30

ICE DATABASE

Plastics	kgCO2e/kg
General	3.31
ABS	3.76
General Polyethylene	2.54
High Density Polyethylene (HDPE) Resin	1.93
HDPE Pipe	2.52
Low Density Polyethylene (LDPE) Resin	2.08
LDPE Film	2.6
Nylon (Polyamide) 6 Polymer	9.14
Nylon (polyamide) 6,6 Polymer	7.92
Polycarbonate	7.62
Polypropylene, Orientated Film	3.43
Polypropylene, Injection Moulding	4.49
Expanded Polystyrene	3.29
General Purpose Polystyrene	3.43
High Impact Polystyrene	3.42
Thermoformed Expanded Polystyrene	4.39
Polyurethane Flexible Foam	4.84
Polyurethane Rigid Foam	4.26
PVC General	3.1
PVC Pipe	3.23
Calendered Sheet PVC	3.19
PVC Injection Moulding	3.3
UPVC Film	3.16

Insulation	kgCO2e/kg	Density	Lifespan (CIBSE Guide M)	Thermal Conductivity
General Insulation	1.86	50	30	0.045
Cork	0.19	200	30	0.07
Fibreglass (Glasswool)	1.35	25	30	0.04
Rockwool	1.12	120	30	0.045
Expanded Polystyrene	3.29	30	30	0.03
Thermoformed Expanded Polystyrene	4.39	30	30	0.03
Phenolic Foam	4.54	45	30	0.02
Polyurethane Flexible Foam	4.84	30	30	0.03
Polyurethane Rigid Foam	4.26	30	30	0.03
Cellular Glass			30	
Cellulose			30	0.23
Flax (Insulation)	1.7		30	
Paper wool	0.63		30	
Mineral wool			30	
Woodwool (loose)			30	
Woodwool (Board)	0.98		30	
Wool (Recycled)			30	

Pipe Material	kgCO2e/kg	Density	Lifespan (CIBSE Guide M)
HDPE Pipe	2.52	960	20
PVC Pipe	3.23	1390	20
Copper	3.81	8790	45
ABS	3.76	1060	20
Steel, UO Pipe (very large diameters)	3.02	7820	35
Steel, welded pipe	2.78	7820	25
Iron	2.03	7000	
Stainless steel	4.4	7930	
HV Cable			
MV Cable			
LV Cable			
Busbar			

Misc	kgCO2e/kg
Calcium Silicate Sheet	0.13
Chromium	5.39
Cotton, Padding	1.28
Cotton, Fabric	6.78
Damp Proof Course/Membrane	4.2
Flax	1.7
Fly Ash	0.008
Grit	0.007
Ground Limestone	0.032
Glass Reinforced Plastic - GRP - Fibreglass	8.1
Lithium	5.3
Mandolite	1.4
Mineral Fibre Tile (Roofing)	2.7
Manganese	3.5
Mercury	4.94
Molybedenum	30.3
Nickel	12.4
Perlite - Expanded	0.52
Perlite - Natural	0.03
Quartz powder	0.023
Shingle	0.3
Slag (GGBS)	0.083
Silver	6.31
Straw	0.01
Terrazzo Tiles	0.118
Vanadium	228
Vermiculite - Expanded	0.52
Vermiculite - Natural	0.032
Water	0.0008
Wood stain/Varnish	5.35
Yttrium	84
Zirconium	97.2
Cardboard	1.29
Paper	1.49

Office (Baseline)

RICS Category	RICS Category 2	RICS Category 3	RICS Category 4	RICS Scope Items	Number of Units	COMMERCIAL RICS Shell and (	Number of Units2	COMMERCIAL RICS CAT A Fit C	Number of Units3
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Thermostat			1		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Thermal meter			1		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Cold water meter		1No. water meter per office or r	12		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pumps/booster set	3	1No. booster pumpset (opt)	3		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Other meters		5No. additional landlord water r	5		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pipework		50 m per level 35mm diameter	400		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			6m per fixture point, average siz	1089		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. flex connection per fixture	181		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Valves		1No. water shut off valve per toi	12		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. ball valve per fixture	181		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Storage tank		1no. tank, water conditioner	1		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	CAT 5 system		2 No. packaged Cat 5 break tan	2		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Treatment and filtration system		UV filtration	1		
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Pumps	3	2 pump sets	6		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Piping		90m per level for rainwater syst	720		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage			4m secondary distribution per fi	726		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Rainwater storage tank			1		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Attenuation			1		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Pumps			3		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Sewage piping		115m per level for soil, waste ai	920		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Condensate piping		0.03m of 100mm pipework per r	272		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Cistern			64		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Traps			16		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Drain		0.03m of 100mm pipework per r	272		
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage					7m condensate drain per 32m2	1488
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Air heat pump	3	assume 60-80w per m2 for prim	544		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Calorifier		2No. storage calorifiers	2		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Pipework				15m of 20mm diam LTHW pipev	3189
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Insulation				15m Insulation per 32m2 NIA of	3189
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	FCUs				1No. FCU per 32m2 NIA	213
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Wet radiator		1No. radiator per 100m2	91		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Underfloor heating		underfloor heating to main rece	851		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Pumps	3				
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Hot water meter		10No. primary heat meters and	12		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Pipework		For centralised system distribut	480		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			For secondary HWS distribution	181		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1No. flex connection per fixture	50		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1m of LTHW 100mm diameter p	99		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Air curtains		air curtains to main entrances	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Heat exchanger	3	Allow 1No. per office tenancy if required			
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Valves		1No. thermostatic mixing valve	42		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			plus 1No. ball valve per each m	42		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			valve sets per each main piece	42		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Pumps	3	Allow for 1No. primary set of pu	3		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			Allow for secondary pump set (2	3		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Pressurisation unit		1No. pressurisation unit	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Dosing pot		dosing pot	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Deaearator unit		deaearator unit	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribu	Dirt separator		dirt separator	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Hot water store	3				
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Buffer vessel		Allow 2No. LTHW buffer vessels	2		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Expansion vessel.			1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.1 Cooling generation equi	Heat pump	20	Reversible heat pump generates cooling, so no additional plant needed			
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Buffer vessel		2No. CHW buffer vessels	2		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Expansion vessel for cooling			1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pumps	3	1No. primary set of pumps	3		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage			secondary pump set (2 to 3Nos	3		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Dosing pot			1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pipework, pipe insulation		1m of CHW 125mm diameter pi	313		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage					15m of 25mm diam CHW pipew	3189
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Deaearator unit		deaearator unit	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Dirt separator		dirt separator	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pressurisation unit		1No. pressurisation unit	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Valves		valve sets per each main piece	50		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Fan coil units	25	1No. fan coil units per lift lobby	8		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries a		137	1No. fan coil unit per 25m2 for r	34		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries a		20	trench cooling to double height glazed facades			
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage			10No. dedicated cooling units li	10		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Primary heat meters		10No. primary heat meters and	10		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.3 Air movement	Fans	2	1 twin toilet extract fans per toil	16		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.3 Air movement		2	5No. small fans for miscellaned	5		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.3 Air movement	MVHR		5No. MVHR units for miscellane	5		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.3 Air movement	AHU	2	Allow air handling units total loa	14		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.3 Air movement		2	1.5/l/s/ms for basement air han	2		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.4.1 Air terminals	Grilles		1No. grille per 350/GIA m2	26		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.4.1 Air terminals					4No. Supply grilles per 32m2 NI	851
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.4.1 Air terminals	VAV		1No. CAV/VAV per office tenanc	12		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.3 Air movement	5.2.4.1 Air terminals	CAV		1No. CAV/VAV per office tenanc	12		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries	Ductwork		1m2 surface area of plain ductv	151		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries			aliclad to 15% of ductwork area	23		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries			1m2 surface area of plain ductv	1814		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries					1m2 surface area plain ductwor	1512
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries					10m of 200mm diam circular du	2126
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	VAV damper		1No. motorised damper per offi	12		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1No. motorised damper per 15r	76		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment					5No. VCDs per 32m2 NIA	1063
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	Fire damper		1No. damper per 300/GIA m2 fc	30		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	Fume and smoke extraction		mechanical smoke extract syst	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			a roof mounted smoke extract fa	1		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			2No. basement smoke extract f	2		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	Fire rated fans	2				
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	Acoustic attenuation		4No. attenuators per office vent	48		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1No. per tenancy duct branch o	32		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenu	Fire rated ductwork		25m2 per level of fire rated duct	200		
5 Services (MEP)	5.2 Heating, Ventilation and Co	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1m2 of fire rated ductwork per 1	597		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Internal light fixtures		1No. lighting fixture per 4m2 of l	567		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. Lighting fixture per 3m2 of	2268
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Light control		1No. PIR sensor per 30m2 NIAn	76		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting			1No. LCM per 30m2	303		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. LCM per 30m2 NIA	227
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. PIR sensor per 30m2 NIA	227
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Cable		25m lighting cabling per fixture	14175		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					25m lighting cabling per fixture	56700
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Lighting		1m of linear lighting per 5m2 of	454		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. Exit light per office tenant r	12
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildin	External light fixtures		Allow 1No. external light per 80/	114		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildin	Cable		Allow 40m of lighting cabling pe	4560		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting	Emergency lighting		Allow additional 25% of total lig	142		
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting					Additional 25% of total lights to	567
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power cable				6m of cable per power points (s	4082
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Cable trays containment		1m of 200mm cable tray includ	1008		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1m of 200mm cable tray includi	340
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1m of 200mm cable tray includi	340
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Panel board/ distribution		1No. split distribution board	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. mechanical distribution bo	12		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. landlords distribution boa	3		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. miscellaneous distributioi	4		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			0.135A per GIA m2 for main swi	1225		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Back up equipment	1	27VA per GIA m2 for life safety (	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Busbar		tenant rising busbar per tenanc	12		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Transformer	2				
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Sockets				1No. Cleaners socket per 50m2	136
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Switches	2	1000A main life safety switchpa	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			15No. automatic transfer switcl	15		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Low voltage		10m of cable per power point	4124		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Small power		1No. small power points per 22i	412		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1No. Small power points per 10	680
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power supply				1No. Power supply to FCU per 3	213
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	CCTV equipment		1No. CCTV camera per 450/GI/	21		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Security head		security head end (rack, server	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Access control door		1No. access control door per 5(	19		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Intercom points		10No. intercom points	10		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Induction loop		1no. Induction loop per receptic	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	wifi equipment		Landlord Wifi/WAP: allow for 1N	2268		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	computers		Allow 1No. data points per 40 tc	227		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	data cabinets		Allow for 2No. data cabinet per	3		

5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	BMS/controllers on fan coils				1No. FCU unitary controller per	213
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Main controller system with computer (headend)		Allow 5No. main control panels	5		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Cabling required		25m of control cabling per point	15120		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS					35m of cabling to the outstation	7442
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Sensors for temperature statistics		Assume 1 point per 15/GIA m2	605		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Small panel		and 1No. small panel per floor	8		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	UPS back up generation		10-20KVA, 10min. static local U	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Fire alarm including detection		Allow 1No. main fire alarm pane	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. field device per 28/G	324		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm					1No. Smoke detector with soun	272
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Cabling		Allow 30m of fire alarm cable pe	9720		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Public Address and Voice Alarm (PAVA)		Allow for PAVA panel	1		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. speaker per 130/GIA m2	70	1No. speaker per 130/GIA m2	70
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. emergency voice co	13		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled refuge syst	2		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1no. main panel	2		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled alarm per D	8		
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Breakglass				Allow 1No. breakglass unit per c	12
5 Services (MEP)	5.4 On site renewable energy ge	5.4.1 On site renewable energy	5.4.1.1 Renewable energy - elec	Solar PV panel		1m2 of photovoltaics panel per	567		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pipes		150m main distribution pipewo	182		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			Allow 3m of 20mm diam. pipew	567		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system					3m of 20mm diam pipeworks av	2268
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Heads		1No. sprinkler heads per 12m2	189		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system					1No. Sprinkler heads per 9m2 o	756
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Valves		zone valves 1No. per office and	12		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			zone valves 1No. per floor	8		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			3No. miscellaneous zone valve	3		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Tank	1	180m3 of sprinkler tanks	1		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pumps	5	3Nos. sprinkler pumps	3		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Dry and wet riser		Allow 2No. dry riser inlets per fl	2		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			Allow 1No. dry riser outlet per fl	1		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			Allow 10m of 100mm pipework	10		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	AOV controls/ sensors		Allow 1No. per fire fighting stair	1		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Fire suppression system.		Allow for gaseous fire suppressi	1		
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.3 Lightning protection/ear	Lighting conductor		Allow for 1m of Cu/Al tape per 1	567		
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	pipes		Allow 100m of 40mm diameter	100		
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	Pumps		Pumpset	1		
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	Fuel storage tank		fuel tank	1		

Office (Low Carbon)

RICS Category	RICS Category 2	RICS Category 3	RICS Category 4	RICS Scope Items	Number of Units	COMMERCIAL RICS Shell and (	Number of Units2	COMMERCIAL RICS CAT A Fit O	Number of Unit	Column4
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Thermostat			1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Thermal meter			1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Cold water meter		1No. water meter per office or r	12			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pumps/booster set	3	1No. booster pumpset (opt)	3			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Other meters		5No. additional landlord water r	5			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pipework		50 m per level 35mm diameter	400			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			6m per fixture point, average siz	1089			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. flex connection per fixture	181			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Valves		1No. water shut off valve per toi	12			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. ball valve per fixture	181			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Storage tank		1no. tank, water conditioner	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	CAT 5 system		2 No. packaged Cat 5 break tar	2			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Treatment and filtration system		UV filtration	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Pumps	3	2 pump sets	6			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Piping		90m per level for rainwater syst	720			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage			4m secondary distribution per fl	726			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Rainwater storage tank			1			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Attenuation			1			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Pumps			3			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Sewage piping		115m per level for soil, waste ai	920			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Condensate piping		0.03m of 100mm pipework per	272			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Cistern			64			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Traps			16			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Drain		0.03m of 100mm pipework per	272			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage					7m condensate drain per 32m2	1488	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Air heat pump	3	assume 60-80w per m2 for prim	544			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Water heatpump			2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Calorifier		2No. storage calorifiers	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Pipework				15m of 20mm diam LTHW pipev	1595	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Insulation				15m Insulation per 32m2 NIA ol	1595	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	FCUs				1No. FCU per 32m2 NIA	106	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Wet radiator		1No. radiator per 100m2	91			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Underfloor heating		underfloor heating to main rece	851			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pumps	3					1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Hot water meter		10No. primary heat meters and	12			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pipework		For centralised system distribut	480			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			For secondary HWS distribution	91			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1No. flex connection per fixture	100			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1m of LTHW 100mm diameter p	99			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Air curtains		air curtains to main entrances	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Heat exchanger	3	Allow 1No. per office tenancy if required				1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Valves		1No. thermostatic mixing valve	42			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			plus 1No. ball valve per each ma	42			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			valve sets per each main piece	42			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pumps	3	Allow for 1No. primary set of pu	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			Allow for secondary pump set (2	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pressurisation unit		1No. pressurisation unit	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Dosing pot		dosing pot	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Deaearator unit		deaearator unit	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Dirt separator		dirt separator	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Hot water store	3					1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Buffer vessel		Allow 2No. LTHW buffer vessels	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Expansion vessel.			1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.1 Cooling generation equ	Heat pump	20	Reversible heat pump generates cooling, so no additional plant needed				1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Buffer vessel		2No. CHW buffer vessels	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Expansion vessel for cooling			1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pumps	3	1No. primary set of pumps	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage			secondary pump set (2 to 3Nos	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Dosing pot		dosing pot	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pipework, pipe insulation		1m of CHW 125mm diameter p	313			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage					15m of 25mm diam CHW pipew	1595	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Deaearator unit		deaearator unit	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Dirt seperator		dirt separator	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Pressurisation unit		1No. pressurisation unit	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Valves		valve sets per each main piece	100			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Fan coil units		1No. fan coil units per lift lobby	8			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries a		20	1No. fan coil unit per 25m2 for r	34			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries a		20	trench cooling to double height glazed facades				1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchangers/ terminal units, ancillaries and control, distribution, storage			10No. dedicated cooling units li	10			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.2 Dedicated cooling installa	5.2.2.2 Cooling emitter, exchan	Primary heat meters		10No. primary heat meters and	10			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	Fans	2	1 twin toilet extract fans per toil	16			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement		2	5No. small fans for miscellaneo	5			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	MVHR	12	5No. MVHR units for miscellane	5			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	AHU	2	Allow air handling units total loa	14			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement		2	1.5/l/s/ms for basement air han	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals	Grilles		1No. grille per 350/GIA m2	26			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals					4No. Supply grilles per 32m2 NI	851	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals	VAV		1No. CAV/VAV per office tenanc	12			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals	CAV		1No. CAV/VAV per office tenanc	12			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries	Ductwork		1m2 surface area of plain ductv	151			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries			aliclad to 15% of ductwork area	23			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries			1m2 surface area of plain ductv	1814			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries					1m2 surface area plain ductwor	1512	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.2 Ductwork & ancilleries					10m of 200mm diam circular du	2126	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	VAV damper		1No. motorised damper per offi	12			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1No. motorised damper per 15r	76			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment					5No. VCDs per 32m2 NIA	1063	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	Fire damper		1No. damper per 300/GIA m2 fc	30			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	Fume and smoke extraction		mechanical smoke extract syst	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			a roof mounted smoke extract f	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			2No. basement smoke extract f	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	Fire rated fans	2					1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	Acoustic attenuation		4No. attenautors per office vent	48			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1No. per tenancy duct branch o	32			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, atten	Fire rated ductwork		25m2 per level of fire rated duct	200			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, c	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			1m2 of fire rated ductwork per 1	597			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Internal light fixtures		1No. lighting fixture per 4m2 of	567			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. Lighting fixture per 3m2 of	2268	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Light control		1No. PIR sensor per 30m2 NIAn	76			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting			1No. LCM per 30m2	303			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. LCM per 30m2 NIA	227	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. PIR sensor per 30m2 NIA	227	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Cable		25m lighting cabling per fixture	14175			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					25m lighting cabling per fixture	56700	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Lighting		1m of linear lighting per 5m2 of	454			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. Exit light per office tenant	12	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildin	External light fixtures		Allow 1No. external light per 80	114			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildin	Cable		Allow 40m of lighting cabling pe	4560			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting	Emergency lighting		Allow additional 25% of total lig	142			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting					Additional 25% of total lights to	567	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power cable				6m of cable per power points (s	4082	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Cable trays containment		1m of 200mm cable tray includ	1008			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1m of 200mm cable tray includi	340	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1m of 200mm cable tray includi	340	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Panel board/ distribution		1No. split distribution board	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. mechanical distribution bo	12			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. landlords distribution boa	3			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. miscellaneous distributio	4			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			0.135A per GIA m2 for main sw	1225			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Back up equipment	1	27VA per GIA m2 for life safety g	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Busbar		tenant rising busbar per tenanc	12			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Transformer	2					1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Sockets				1No. Cleaners socket per 50m2	136	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Switches	2	1000A main life safety switchpa	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			15No. automatic transfer switcl	15			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Low voltage		10m of cable per power point	4124			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Small power		1No. small power points per 22	412			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1No. Small power points per 10	680	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power supply				1No. Power supply to FCU per 3	213	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	CCTV equipment		1No. CCTV camera per 450/GIA	21			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Security head		security head end (rack, server	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Access control door		1No. access control door per 50	19			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Intercom points		10No. intercom points	10			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Induction loop		1no. Induction loop per receptic	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	wifi equipment		Landlord Wifi/WAP: allow for 1N	2268			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	computers		Allow 1No. data points per 40 to	227			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.3 IT & Data	data cabinets		Allow for 2No. data cabinet per	3			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	BMS/controllers on fan coils				1No. FCU unitary controller per	106	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Main controller system with computer (headend)		Allow 5No. main control panels	5			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Cabling required		25m of control cabling per point	15120			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS					35m of cabling to the outstation	3721	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Sensors for temperature statistics		Assume 1 point per 15/GIA m2	605			1

5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.4 BMS	Small panel		and 1No. small panel per floor	8			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	UPS back up generation		10-20KVA, 10min. static local U	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Fire alarm including detection		Allow 1No. main fire alarm pane	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. field device per 28/G	324			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm					1No. Smoke detector with soun	272	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Cabling		Allow 30m of fire alarm cable pe	9720			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Public Address and Voice Alarm (PAVA)		Allow for PAVA panel	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. speaker per 130/GIA m2	70	1No. speaker per 130/GIA m2	70	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. emergency voice co	13			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled refuge syst	2			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1no. main panel	2			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled alarm per D	8			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Breakglass				Allow 1No. breakglass unit per c	12	1
5 Services (MEP)	5.4 On site renewable energy ge	5.4.1 On site renewable energy	5.4.1.1 Renewable energy - elec	Solar PV panel		1m2 of photovoltaics panel per	567			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pipes		150m main distribution pipewo	182			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			Allow 3m of 20mm diam. pipew	567			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system					3m of 20mm diam pipeworks av	2268	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Heads		1No. sprinkler heads per 12m2	189			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system					1No. Sprinkler heads per 9m2 o	756	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Valves		zone valves 1No. per office and	12			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			zone valves 1No. per floor	8			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			3No. miscellaneous zone valves	3			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Tank	1	180m3 of sprinkler tanks	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pumps	5	3Nos. sprinkler pumps	3			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Dry and wet riser		Allow 2No. dry riser inlets per flo	2			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			Allow 1No. dry riser outlet per fl	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			Allow 10m of 100mm pipework	10			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	AOV controls/ sensors		Allow 1No. per fire fighting stair	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Fire suppression system.		Allow for gaseous fire suppressi	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.3 Lightning protection/ear	Lighting conductor		Allow for 1m of Cu/Al tape per 1	567			1
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	pipes		Allow 100m of 40mm diameter	100			1
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	Pumps		Pumpset	1			1
5 Services (MEP)	5.5 Other Systems	5.5.2 Fuel installations	5.5.2 Fuel installations	Fuel storage tank		fuel tank	1			1

Residential (Baseline)

RICS Category	RICS Category 2	RICS Category 3	RICS Category 4	RICS Scope Items	Number of Units	Landlord Areas	Number of Units2	Tenant areas	Number of Units3	Number of Units4
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	toilet			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	cistern			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	shower tray			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	bath			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	taps			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	controls			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	shower heads			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	basin units			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	sinks			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	washing machine			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	dishwasher			101			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pipework		40 m per level 35mm diameter	320	5m per connection to kitchen sa	1515	1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			6m per fixture point, average siz	6666			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. flex connection per fixture	1111			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Valves		1No. ball valve per fixture	101			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Storage tank		1No. tank, water conditioner	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	CAT 5 system		1No. packaged Cat 5 break tank	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Treatment and filtration system		UV filtration	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Pumps		Pump set	3			1
						1No. Booster pumpset for BCW	1			1
				Water meter		1No. Incoming water meter	1			1
						2No. Additional landlord water i	2			1
								1No. Water meter to each apart	101	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Piping		4m length of pipe 110mm diam	4			1
								For secondary distribution 4m p	4444	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage					3m 75mm for rainwater per resi	303	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Sewage piping		80m per level for soil, waste, ve	640			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Condensate piping				0.03m of 100mm pipework per	181.44	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Drain				0.03m of 100mm pipework per	181.44	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Air heat pump	3	assume 60-80w per m2 for prim	484			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Water heatpump	101	1No. Primary set of pumps	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Ground heat pump		2-3No. Secondary pump sets	6			1
				Pressurisation unit		1No. Pressurisation unit	1			1
				Dosing pot		1No. Dosing pot	1			1
				Deaearator unit		1No. Deaearator unit	1			1
				Dirt separator		1No. Dirt separator	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	FCUs	101					1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Underfloor heating		Allow for underfloor heating to r	756			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Thermal meters				Allow 1No. heat meter to each a	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pipework		80m per floor 32mm secondary	640			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					10m per fixture point, average s	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. flex connection per fixture	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1m of LTHW 100mm diameter p	231			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Air curtains		Allow for air curtains to main en	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Valves		Allow valve sets per each main p	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. ball valve per fixture point	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. thermostatic mixing valve	1	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pumps				Allow valve sets to each appartr	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipment	Buffer vessel		Allow 2No. LTHW buffer vessels	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	Fans		Allow for 3No. small fans for mis	4			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	MVHR	101			Assume 1nr MVHR unit per apar	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	AHU		Allow air handling unit to reside	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement			1.5/l/s/ms for basement air han	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals	Grilles		Allow 1No. grille per 500/GIA m2	17			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals					1No. grille per 10/ m2 NSA	605	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.2 Ductwork & ancilleries	Ductwork		1 m2 surface area of duckwork p	90			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.2 Ductwork & ancilleries					1 m2 surface area of duckwork p	6048	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, atten	Volume control damper		1No. VCD per grille	17			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, atten	Fire damper		1No. damper per 300/GIA m2 fo	27			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, atten	Acoustic attenuation		4No. attenuators per ventilation	10			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			2No. attenuators per ventilation	8			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, atten	Fire rated ductwork		1No. per tenancy duct branch o	101			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals, (	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment					Allow for 4No. attenautors per N	101	1
						20No. additional for micellanec	20			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Internal light fixtures		1No. lighting fixture per 8m2 of	252			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. lighting fixture per 5m2 of	1210	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Cable		25m lighting cabling per fixture	6300	25m lighting cabling per fixture	30250	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildir	External light fixtures		Allow 1No. external light per 80/	101			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildir	Cable		Allow 40m of lighting cabling pe	4040			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting	Emergency lighting		Allow additional 25% of total lig	63			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Cable trays containment		4m of 200mm cable tray includi	8064			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Panel board/ distribution		1No. landlord's distribution boa	3			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. miscellaneous DB per 2,3(	4			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Busbar		rising busbar 4m per floor	32			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Switches		0.423A per GIA m2 for main swi	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Small power		1No. small power points per 60	134			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1No. small power points per 2m	3024	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power supply		Tap-offs aligned with distributic	3			1
				Cable		15m submains cabling to each a	1515			1
						20m of cabling per power point	2688			1
								3m of cabling per power point	9072	1
				Consumer unit				1No. consumer unit per apartm	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	CCTV equipment		1No. CCTV camera per 250/GIA	33			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Communications				1No. telephone outlet per apart	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Audio visual equipment				1No. media plate per apartment	101	1
				IT equipment/ Data points		1No. data points per 40 to 50/m	202			1
								2No. data points per apartment	202	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Security head		Security head end (rack, server)	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Access control door		1No. access control door to ma	1			1
						1No. per level per core	8			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/S	Intercom points		1No. intercom point to main do	1	1No. intercom unit per apartme	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	UPS back up generation		UPS allowance per kVA	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	Stand by generators within the building line		20VA per GIA m2 for life safety g	1			1
						5No. automatic transfer switch	5			1
				Switchpanel		1000A main life safety switchpa	1			1
						with 15No. Ways submains	15			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Fire alarm including detection		Allow 1No. main fire alarm pane	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. field device per 50/G	162			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm					1No. field device per 10/GIA m2	807	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Cabling		Allow 30m of fire alarm cable pe	4860	Allow 30m of fire alarm cable pe	24210	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Public Address and Voice Alarm (PAVA)		If PAVA required, allow for PAVA	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. speaker per 130/GIA m2	63			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. emergency voice co	12			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled refuge syst	2			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. main panel	1			1
5 Services (MEP)	5.4 On site renewable energy ge	5.4.1 On site renewable energy	5.4.1.1 Renewable energy - elec	Solar PV panel		1m2 of photovoltaics panel per	504			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pipes		150mm main distribution pipev	182			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Heads		1No. sprinkler head per 12m2 ((	168	1No. sprinkler head per 12m2 o	504	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			3m of 20mm diameter pipework	504	3m of 20mm diameter pipework	1512	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Valves		zone valves 1No. per floor	101			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			Valves 2No. extra miscellaneou	2			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Tank		180m3 of sprinkler tanks	60			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Dry and wet riser		2No. dry riser inlets for dry riser	2			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			1No. dry riser outlet per floor pe	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			10m of 100mm pipework incluc	10			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Fire suppression system.		Allow for mechanical smoke ext	1			1
						Allow for a roof mounted smoke	1			1
						1No. motorised damper per 15r	68			1
						2No. basement smoke extract f	2			1
				Fire rated ductwork		25m2 per level of fire rated duct	200			1
						1m2 of fire rated ductwork per 1	531			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.3 Lightning protection/ea	Lighting conductor		Allow for 1m of Cu/Al tape per 1(	504	Allow for 1m of Cu/Al tape per 1(	378	1

Residential (Low Carbon)

RICS Category	RICS Category 2	RICS Category 3	RICS Category 4	RICS Scope Items	Number of Units	Landlord Areas	Number of Units2	Tenant areas	Number of Units3	Number of Units4
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	toilet			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	cistern			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	shower tray			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	bath			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	taps			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	controls			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	shower heads			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	basin units			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	sinks			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	washing machine			101			1
5 Services (MEP)	5.1 Public Health	5.1.1 Sanitaryware	5.1.1 Sanitaryware	dishwasher			101			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Pipework		40 m per level 35mm diameter	320	5m per connection to kitchen s	1515	1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			6m per fixture point, average siz	6666			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems			1No. flex connection per fixture	1111			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.1 Cold water systems	Valves		1No. ball valve per fixture	101			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Storage tank		1No. tank, water conditioner	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	CAT 5 system		1No. packaged Cat 5 break tank	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Treatment and filtration system		UV filtration	1			1
5 Services (MEP)	5.1 Public Health	5.1.2 Cold water systems	5.1.2.2 Cold water storage	Pumps		Pump set	3			1
						1No. Booster pumpset for BCW	1			1
				Water meter		1No. Incoming water meter	1			1
						2No. Additional landlord water	2			1
								1No. Water meter to each apart	101	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Piping		4m length of pipe 110mm diam	4			1
								For secondary distribution 4m p	4444	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater/foul water drainage					3m 75mm for rainwater per resi	303	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Sewage piping		80m per level for soil, waste, ve	640			1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Condensate piping				0.03m of 100mm pipework per	181.44	1
5 Services (MEP)	5.1 Public Health	5.1.3 Drainage and rainwater	5.1.3.1 Surface water/rainwater	Drain				0.03m of 100mm pipework per	181.44	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Air heat pump	2	assume 60-80w per m2 for prim	483.84			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Water heatpump		1No. Primary set of pumps	3			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.1 Heat & Hot water genera	Ground heat pump		2-3No. Secondary pump sets	6			1
				Pressurisation unit		1No. Pressurisation unit	1			1
				Dosing pot		1No. Dosing pot	1			1
				Deaearator unit		1No. Deaerator unit	1			1
				Dirt separator		1No. Dirt separator	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Underfloor heating		Allow for underfloor heating to r	756			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					Allow UFH to 90% of appartmen	5443.2	1
								Allow 1No. UFH manifold to eac	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Heat interface unit	101			Allow 1 No. HIU per appartment	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Thermal meters				Allow 1No. heat meter to each a	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pipework		80m per floor 32mm secondary	640			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					10m per fixture point, average s	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. flex connection per fixture	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units			1m of LTHW 100mm diameter p	231			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Air curtains		Allow for air curtains to main en	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Valves		Allow valve sets per each main p	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. ball valve per fixture point	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distribution, control, ancillaries, emitters, exchangers/ terminal units					1No. thermostatic mixing valve	1	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.2 Heat & hot water distrib	Pumps				Allow valve sets to each appartr	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.1 Space heating and hot wa	5.2.1.3 Heat storage equipmen	Buffer vessel		Allow 2No. LTHW buffer vessels	2			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	Fans		Allow for 3No. small fans for mi	4			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	MVHR	101			Assume 1nr MVHR unit per apar	101	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement	AHU		Allow air handling unit to reside	1			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.3 Air movement			1.5/l/s/ms for basement air han	1.512			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals	Grilles		Allow 1No. grille per 500/GIA m	17			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.3 Air movement	5.2.4.1 Air terminals					1No. grille per 10/ m2 NSA	605	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.2 Ductwork & ancilleries	Ductwork		1 m2 surface area of duckwork p	89.6			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.2 Ductwork & ancilleries					1 m2 surface area of duckwork p	6048	1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, atten	Volume control damper		1No. VCD per grille	17			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, atten	Fire damper		1No. damper per 300/GIA m2 fo	27			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, atten	Acoustic attenuation		4No. attenuators per ventilation	10.048			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment			2No. attenuators per ventilation	8			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, atten	Fire rated ductwork		1No. per tenancy duct branch o	101			1
5 Services (MEP)	5.2 Heating, Ventilation and Cc	5.2.4 Ventilation air terminals,	5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment					Allow for 4No. attenautors per N	101	1
						20No. additional for micellaned	20			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Internal light fixtures		1No. lighting fixture per 8m2 of	252			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting					1No. lighting fixture per 5m2 of	1210	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.1 Internal lighting	Cable		25m lighting cabling per fixture	6300	25m lighting cabling per fixture	30250	1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildir	External light fixtures		Allow 1No. external light per 80	101			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.2 External lighting (buildir	Cable		Allow 40m of lighting cabling pe	4040			1
5 Services (MEP)	5.3 Electrical installations	5.3.1 Lighting	5.3.1.3 Emergency lighting	Emergency lighting		Allow additional 25% of total lig	63			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Cable trays containment		4m of 200mm cable tray includi	8064			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Panel board/ distribution		1No. landlord's distribution boa	3			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power			1No. miscellaneous DB per 2,3	4			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Busbar		rising busbar 4m per floor	32			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Switches		0.423A per GIA m2 for main swi	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Small power		1No. small power points per 60	134.4			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power					1No. small power points per 2m	3024	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.1 Electrical power	Power supply		Tap-offs aligned with distributic	3			1
				Cable		15m submains cabling to each	1515			1
						20m of cabling per power point	2688			1
								3m of cabling per power point	9072	1
				Consumer unit				1No. consumer unit per apartm	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	CCTV equipment		1No. CCTV camera per 250/GIA	33			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	Communications				1No. telephone outlet per apart	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	Audio visual equipment				1No. media plate per apartmen	101	1
				IT equipment/ Data points		1No. data points per 40 to 50/m	202			1
								2No. data points per apartment	202	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	Security head		Security head end (rack, server)	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	Access control door		1No. access control door to ma	1			1
						1No. per level per core	8			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.2 ELV/ Communications/	Intercom points		1No. intercom point to main do	1	1No. intercom unit per apartme	101	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	UPS back up generation		UPS allowance per kVA	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.5 Electricity back up gene	Stand by generators within the building line		20VA per GIA m2 for life safety g	1			1
						5No. automatic transfer switch	5			1
				Switchpanel		1000A main life safety switchpa	1			1
						with 15No. Ways submains	15			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Fire alarm including detection		Allow 1No. main fire alarm pane	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. field device per 50/G	162			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm					1No. field device per 10/GIA m2	807	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Cabling		Allow 30m of fire alarm cable pe	4860	Allow 30m of fire alarm cable pe	24210	1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm	Public Address and Voice Alarm (PAVA)		If PAVA required, allow for PAVA	1			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. speaker per 130/GIA m2	63			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. emergency voice co	12			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			Allow 1No. disabled refuge syst	2			1
5 Services (MEP)	5.3 Electrical installations	5.3.2 Electrical services for pow	5.3.2.6 Fire detection & alarm			1No. main panel	1			1
5 Services (MEP)	5.4 On site renewable energy ge	5.4.1 On site renewable energy	5.4.1.1 Renewable energy - elec	Solar PV panel		1m2 of photovoltaics panel per	504			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Pipes		150mm main distribution pipev	182			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Heads		1No. sprinkler head per 12m2 (	168	1No. sprinkler head per 12m2 o	504	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			3m of 20mm diameter pipework	504	3m of 20mm diameter pipework	1512	1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Valves		zone valves 1No. per floor	101			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system			Valves 2No. extra miscellaneou	2			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.1 Sprinkler system	Tank		180m3 of sprinkler tanks	60			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Dry and wet riser		2No. dry riser inlets for dry riser	2			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			1No. dry riser outlet per floor pe	1			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems			10m of 100mm pipework incluc	10			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.2 Fire fighting systems	Fire suppression system.		Allow for mechanical smoke ext	1			1
						Allow for a roof mounted smoke	1			1
						1No. motorised damper per 15r	68			1
						2No. basement smoke extract f	2			1
				Fire rated ductwork		25m2 per level of fire rated duct	200			1
						1m2 of fire rated ductwork per 1	531			1
5 Services (MEP)	5.5 Other Systems	5.5.1 Life safety	5.5.1.3 Lightning protection/ea	Lighting conductor		Allow for 1m of Cu/Al tape per 1	504	Allow for 1m of Cu/Al tape per 1	378	1

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