17

Euston Tower

Carbon Assessments

17.1 Methodology and Assumptions

17.1.1 General

This section presents the results of a whole life-cycle carbon assessment (WLCA) for the options presented in Section 16. The WLCA is conducted as a comparative study to evaluate the carbon impact of the degree of structural retention of the existing tower. The following paragraphs describe the general assumptions used across the different options to establish a fair comparison, before presenting the results of the assessments.

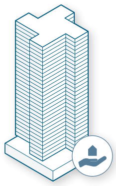
It is important to initially understand that a full cost plan based embodied carbon assessment was not undertaken for options in this assessment. Rather carbon estimates were derived from indicative calculations and data taken from the portfolio data from the project consultants. This data is shown transparently in terms of life-cycle stages [A-C] and [A1-A5] values for each building element under each option. The consultants involved each have a portfolio of more than 40 buildings delivered to RICS methodology WLCA, and thus an excellent understanding of what the appropriate carbon performance of each building element under each option would be in a reasonable delivery scenario. For most elemental categories, this portfolio data was utilised to inform the selection of appropriate data.

The options assessed and the key differences between them is summarised in Figure 17.1. The Major Refurbishment is included in this Section as a bookend, though it has been shown not to be feasible in Volume One.

Least Deconstruction

FEASIBILITY STUDY VOLUME ONE

Existing Envelope

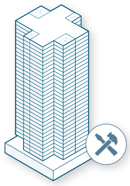


Major Refurbishment

New MEP
New finishes
New facade

GIA 53,263m²
36 storeys
3.2m floor to floor
EUI 104 kWh/m²/yr

RETENTION AND PARTIAL EXTENSION

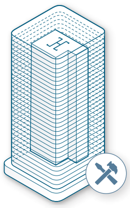


Max Retention

New MEP
New finishes
New facade
Extended floorplates
New core elements
(additional to retained)

GIA 71,166m²
36 storeys
3.2m floor to floor
EUI 95 kWh/m²/yr

RETENTION AND EXTENSION

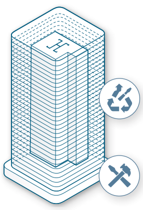


"Full" Retention

New MEP
New finishes
New facade
Extended floorplates
Some new columns
New core elements
(additional to retained)

GIA 92,484m²
36 storeys
3.2m floor to floor
EUI 99 kWh/m²/yr

Extended Floorplates

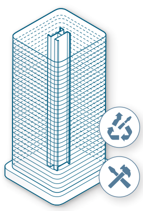


Retain Interstitial Slabs

New MEP
New finishes
New facade
New floorplates
(additional to retained)
New columns
New core elements
(additional to retained)

GIA 77,898m²
30 storeys
3.84-3.98m floor to floor (office)
4.27m floor to floor (lab-enabled)
EUI 95 kWh/m²/yr

PARTIAL RETENTION AND EXTENSION

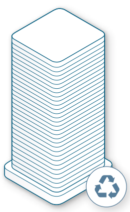


Retain the Core

New MEP
New finishes
New facade
New floorplates
New columns
New core elements
(additional to retained)

GIA 77,898m²
30 storeys
3.8m floor to floor (office)
4.1m floor to floor (lab-enabled)
EUI 95 kWh/m²/yr

NEW BUILD



Fully New Build

New MEP
New finishes
New facade
New floorplates
New columns
New core
New substructure

GIA 77,898m²
30 storeys
3.8m floor to floor (office)
4.1m floor to floor (lab-enabled)
EUI 90 kWh/m²/yr

Most Deconstruction

Figure 17.1 Overview of key assumptions for each option appraised in the WLCAs

17.1.2 Method Statement

Carbon Factors [A1-A3]
Three categories in particular typically dominate the emissions on commercial office and/or lab-enabled buildings: structures, building services and facades. Additional work was undertaken in these three categories to ensure that the values provided were appropriate for each option.

Material specification is consistent across options for all building elements,

The structural embodied carbon calculations have been based on benchmark data from RICS and The Inventory of Carbon and Energy (ICE). Typical new build and refurbishment materials quantities (steel, concrete, and reinforcement) have been calculated and a corresponding embodied carbon rate per square metre attributed to each construction type. Carbon factor assumptions are shown in Figure 17.2. Each of the proposals have been assessed to calculate the proportion of new and existing structure for the particular scheme (including additional substructure elements, as required) and the total structural embodied carbon calculated on a pro-rata basis.

The building services embodied carbon calculations have been based upon best practice industry benchmark data for new build and refurbishment scenarios as outlined in "WBCSD Net-zero buildings Where do we stand?". This guidance has been utilised to provide a clear prediction of the overall MEP services embodied carbon per square meter [A-C] to be attributed for each of the options appraised.

The $kgCO_2e/m^2$ GIA impact of facades is directly linked to the facade area to floor area ratio. Therefore, to calculate the appropriate GIA intensity impact, it was important to first measure the area of the facade under each option and use this metric to determine the overall intensity impact. Instead of a consistent GIA-based intensity metric, which does not appropriately reflect varied facade area to floor area ratios, facades are applied with a consistent $kgCO_2e/m^2$ facade surface area (FSA) impact. This is also in accordance with the latest calculation methodologies such as the September 2022 CWCT Guidance, and also reflects how facade manufacturers typically report results. Within the early feasibility studies, a calculation of facade resulted in a GIA-based performance of 114.2 $kgCO_2e/m^2$ GIA. Working backwards, this equates to an FSA-based impact of 352 $kgCO_2e/m^2$ FSA [A1-A5]. This reflects a reasonable level of performance that would be expected for the proposed facade typology and was therefore the rate used for the facades within options. With the differing GIAs and facade areas, this therefore resulted in a custom GIA-based façade intensity metric that reflected the specifics of that particular option.

As all internal walls, doors, finishes and fittings would be replaced in every option, the intensity metric utilised remains the same throughout all assessed options, reflecting the fact that the same target performance rates could be achieved under each option and so as not to give preferential treatment to any single option within these categories.

MATERIAL	ELEMENT	$KGCO_2E/M^2$ [A1-A5]	NOTES
Steel	Structural steel generally excluding connections and ancillaries	1.79	Average UK supply (BCSA)
Steel	Facade connection	1.79	Average UK supply (BCSA)
Steel	Connections and ancillaries	2.51	Typical UK BOF
Steel	Reinforcing bar	0.84	Average UK supply
Concrete	In situ and precast concrete generally	0.19	Average UK cement mix

Figure 17.2 Carbon factors [A1-A5] used for structural assessment

Transportation Emissions [A4]
Transport emissions [A4] were not split out from [A1-A3] and [A5] when reporting upfront emissions using the internal benchmark values and therefore these are not set out material-by-material. However, as the majority of data that underpins the intensity allocations came from internal portfolios of data (particularly from Sweco), based on design information from other projects, it is reasonable to state that all values for transport are in accordance with the design values set out within the RICS Professional Statement "Whole life carbon assessment for the built environment (2017)" methodology. These are the distances that should be applied when actual procurement information remains unknown.

Construction Site Energy Use and Waste [A5]
This section can be separated into two parts: construction site emissions [A5s] and construction site waste [A5w]. The methodology for each is set out below.

For [A5s], it is understood that there is a strong link between emissions from site and the time spent on site to deliver the particular option (i.e. construction programme). For this reason, main contractor Lendlease were asked to make an assessment of programme length against each option within the feasibility study. These were assessed against a new build, which from Sweco's portfolio of new construction buildings typically had an [A5s] impact of approximately 30 $kgCO_2e/m^2$ GIA, and a completion programme of around 72 months provided by Lendlease. The 30 $kgCO_2e/m^2$ GIA was then apportioned based on the comparable allocated programme for the other options within the options appraisal.

Although site impacts are not wholly dictated by the length of programme, given that they are also impacted by complexity of works and elementally-specific considerations, this method of apportionment was deemed an appropriate way to reflect the fact that the emissions from site activities associated with a lighter refurbishment were not going to be to the same scale as a deconstruction and rebuild scheme. Input from a main contractor on programme lengths helped to support and underwrite the methodology so that it was specific to each option.

[A5w] impacts were calculated in a similar way to [A4], i.e. not separated from the [A1-A5] values. As the data largely came from portfolio databases of the involved consultants, [A5w] can be assumed to be applied as per the RICS Professional Statement "Whole life carbon assessment for the built environment (2017)" methodology. The [A5w] data therefore uses default WRAP waste values as applied within software such as One Click and is included within reported [A1-A5] values.

Assumptions for Life-cycles of Materials
Assumptions for life-cycle replacement of materials has been completed on an element-by-element basis rather than the coarser 15-year cycle set out in guidance such as the GLA's "Whole Life Carbon Assessment Guidance (March 2023)". Different elemental categories will typically have different levels of replacement over the life-cycle. All assessment studies are observed over a 60-year reference study period (RSP).

Firstly, for each option in the feasibility study, the [A-C] impact of each building element is apportioned between life-cycle categories [A1-A5] and categories [B-C]. This is informed by Sweco's design stage portfolio data from a large sample of buildings of relevant use type, which demonstrate how carbon emissions are typically distributed between life-cycle stages. Given that all of these data sources are informed by the same life-cycle allocation method (informed itself by guidance within the RICS Professional Statement "Whole life carbon assessment for the built environment"), there is a strong correlation between life-cycle stage distribution between projects, which has informed the allocations within the options appraisal.

This method is important for elements such as facades. Ensuring that carbon is distributed appropriately within the life cycle stages of facades ensures that the [B-C] impacts are not unfairly allocated or weighted. Only secondary facade materials over the RSP are typically replaced in facades (typically at year 25-30), not the entire system, so only 25% of [A-C] emissions usually fall within [B-C]. This method therefore helps to better reflect realistic life-cycle embodied carbon emissions for each element, and demonstrated why the basic GLA method is not appropriate in most cases.

Elemental categories which typically include replacement are then isolated. The following replacement cycles are then allocated to the relevant categories:

- Facades & external doors
  30 years, 1 replacement over RSP (secondary components only)
- Internal walls & doors
  30 years, 1 replacement over RSP
- Finishes
  10 years, 5 replacements over RSP
- FF&E
  10 years, 5 replacements over RSP
- Building Services
  15 years, 3 replacements over RSP
- Refrigerants
  15 years, 3 replacements over RSP (to align with building services).

Substructure and superstructure elements are considered to last the whole RSP and therefore do not have replacement emissions allocated to them.

The impacts associated with demolition and temporary works all fall within [A1-A5] and therefore are not relevant to the [B] emissions.

It is acknowledged that even within single elemental category different materials may have different replacement cycles (for example in building services, ASHPs may be replaced every 15 years, light fittings every 20 and ducts every 40), the chosen method still allows for an additional layer of granularity compared to the basic GLA method and helps to demonstrate the different life-cycle replacement cycles between elemental categories.

Methodology for Calculating Building Services Emissions
Assumptions for the embodied carbon calculations have been based on data from "WBCSD Net-zero buildings Where do we stand?". This report presents and discusses the results of six case studies developed from Arup projects using whole life carbon assessment of buildings based on the WBCSD Framework and enabled appropriate benchmarks to be taken for the new office construction and major refurbishment options as a baseline life-cycle estimate for [A1-A5] and [B-C], with an overall [A-C] value provided for each option.

Due to the early design stage and the limited maturity of the information available at feasibility stage, these published, industry-recognised benchmarks have been applied to the Partial Retention and Extension, and New Build options, with engineering judgment applied to account for the difference in anticipated embodied carbon for the remaining options.

The summary of the rationale is outlined in Figure 17.3.

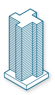
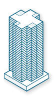
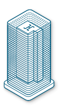
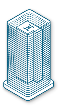
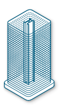
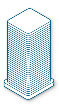
	OPTION	$KGCO_2E/M^2$ [A-C]	DIFFERENCE	NOTES
	Major Refurbishment	427	+4% against baseline estimate for refurbishment	Services are constrained with compromised distribution routes and additional offsets around existing downstands and satellite cores. Existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Partial Extension - Max Retention	415	+1% against baseline estimate for refurbishment	Services are constrained with compromised distribution routes and additional offsets around existing downstands. Existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Extension - "Full" Retention	411	Baseline estimate for refurbishment	*WCBSD benchmark assumption for refurbished office.* Services are constrained with compromised distribution routes and additional offsets around existing downstands and satellite cores. Existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain Interstitial Slabs	378	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	378	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	362	Baseline estimate for new build	*WCBSD benchmark assumption for new build office.* All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.3 Basis of estimation for building services embodied carbon [A1-A5]

Methodology for Calculating Operational Energy Use
Due to the early design stage and the limited maturity of the information available at feasibility stage, published, industry-recognised benchmarks have been applied to the New Build options.

In a similar manner to the approach taken for the embodied carbon, engineering judgment has then been applied to account for the difference in anticipated energy use intensity for the remaining options accounting for the compromised installation of the MEP services.

Typical high-rise office buildings in London currently consume ca. 140 - 160kWh/m^2 of energy. The Low Energy Transformation Initiative (LETI) energy performance targets for commercial office buildings outline a suite of interventions which have been used to target a benchmark performance of the New Build option against the LETI 2025-2030 target of 90 kWh/m^2 GIA.

This target has then been proportioned to match the various scenarios to predict the energy consumption that could be anticipated, recognising the resulting impact the constrained service installation and the compromised fabric and service integration may have on the central plant sizing, and increased energy associated with the pressure drop increase for fan and pump systems.

Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

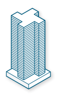
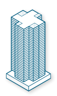
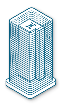
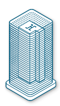
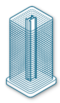
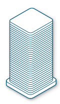
	OPTION	EUI (KWH/ M^2/YR)	DIFFERENCE	NOTES All options assume all-new facade with all-electric MEP and fully new plant. Differences in EUI are due only to constraints for services distribution.
	Major Refurbishment	104	+15%	Services are constrained with compromised distribution routes and additional offsets through the basement downstands and existing risers sizes with consequential impact on SFP and pump energy use.
	Retention and Partial Extension - Max Retention	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Retention and Extension - "Full" Retention	99	+10%	Services are constrained with compromised distribution routes and additional offsets around existing downstands but optimised over the existing floor plates. Existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain Interstitial Slabs	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	95	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	90	Baseline estimate for new build	All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.4 Basis of estimation for energy use intensity (kWh/m^2/year)

Methodology for Calculating Deconstruction Emissions
A comprehensive Pre-demolition Audit has been conducted, as detailed in Volume One. This contained significant quantified detail on the existing materials, products and systems within Euston Tower, which have facilitated a more detailed assessment of the demolition impacts of each option within the feasibility study.

Importantly, consistent metrics for existing materials have been provided within the Pre-demolition Audit (tonnes of material). The materials were scheduled out and run through One Click LCA, using the percentage targets for reuse, recycling, recovery, and landfill for each identified material/ product to split the quantities, and model their end of life impacts in life-cycle modules [C2-C4] with accuracy, using One Click's end of life (EoL) activity selection tool. This provided a total kgCO_2e [C2-C4] for all materials based on their differing end of life treatments.

These emissions were then assigned to the various feasibility options based on the material to be removed and retained under each scenario.

Life-cycle module [C1], which covers the emissions associated with the physical process of demolition, has been calculated based on the percentage of material retained compared to that removed. The RICS Professional Statement notes that, in the absence of specific information, WLCA modellers are to assume that [C1] emissions equate to 3.4 kgCO_2e/m^2. However, as with the method under [A5s], clearly there would be fewer emissions associated with a lighter refurbishment compared to a full deconstruction & rebuild under [C1]. The mass of materials removed has therefore been used to scale the RICS metric: the less material removed, the lower the kgCO_2e/m^2 value. This is more appropriate for demolition than a programme-based metric as the data is available to understand the extent of material removed under each option. Therefore, the [C1] factor for the Major Refurbishment is significantly lower than for the New Build option.

It is noted that by the guidance of RICS, demolition emissions should technically be reported separately. However, for the purposes of this feasibility study, it is thought that deconstruction emissions need to be included in the WLCA, as this is surely a critical part of the decision-making. Therefore, all emissions associated with demolition in each option have been included in the [A1-A5] values, to show the various impacts of deconstruction on the WLCA during the site preparation phase. This also accords with the forthcoming RICS Professional Statement Second Edition, which will look to include demolition emissions in [A5] reporting.

Level of Detail
The carbon assessments herein are feasibility stage assessments. They cover the main building elements, are not based on detailed bills of quantities / cost plans, and contain no contingencies. It is acknowledged that the carbon estimates are likely to be lower than a detailed WLCA that forms part of a full planning application, but they are appropriate for comparison between development options at this stage of development, and as all are undertaken on the same basis, provide a genuine comparison.

Lab-enabled Spaces
The initial comparisons in this Section assume all areas are fit out and operated as office to enable like-for-like comparison (including those that have higher floor to floor heights to accommodate potential lab fit outs). The flexibility to offer spaces to lab users is a benefit in some options, but is not considered a driver.

It is acknowledged that lab spaces generally have to respond to more stringent ventilation and power criteria, resulting in higher embodied carbon of mechanical installations and higher energy consumption.

Accordingly, where lab-enabled spaces are present in the options the uplift for fit out and operation as a lab space is shown separately. This is applicable to the: Partial Retention and Extension - Retain Interstitial Slabs, Partial Retention and Extension - Retain the Core, and New Build options.

The lab-enabled floors represent approximately the following proportion of above-podium GIA in each relevant option:

- Retain Interstitial Slabs (Office and Lab) 23%
- Retain the Core 33%
- New Build 33%.

Methodology for Calculating Building Services Emissions for Lab-enabled Spaces

It is acknowledged that there is a paucity of high quality data on the embodied carbon impacts of lab-enabled spaces. The allowances for the office-only estimates (as detailed in Figure 17.3) have been used as a starting point and uplifted accordingly.

In this case, the increased embodied carbon is associated with the more intensive services provision demanded by lab-enabled spaces. The following are assumed:

- Air Handling Units (AHUs) typically 50% larger
- Provision of Fan Coil Units (FCUs) to offset higher cooling loads
- Provision of ducts, grilles, chilled water pipework, insulated to the FCUs above
- Provision of larger capacity for small power distribution commensurate the electrical demands (see overleaf).

The estimates for building services embodied carbon have been taken as 2x that for the office-only cases. These figures reflect a "full-building" figure, and are therefore pro-rated according to the extent of the lab-enabled space in each relevant option.

There is no impact on the structure or facade, as this is already accounted for as part of the base build in the estimates in Figure 17.3.

The summary of the rationale is outlined in Figure 17.5.

OPTION	KGCO$_2$E/M^2 [A-C]	DIFFERENCE	NOTES
Major Refurbishment	n/a	n/a	No lab-enabled spaces possible.
Retention and Partial Extension - Max Retention	n/a	n/a	No lab-enabled spaces possible.
Retention and Extension - "Full" Retention	n/a	n/a	No lab-enabled spaces possible.
Partial Retention and Extension - Retain Interstitial Slabs	756	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
Partial Retention and Extension - Retain the Core	756	-8% against baseline estimate for refurbishment	Service installation unconstrained on the floor plate and cores but existing basement is compromised with offsets and dual distribution anticipated.
New Build	725	Baseline estimate for new build	*2x WCBSD benchmark assumption for new build office.* All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.5 Basis of estimation for building services embodied carbon [A1-A5] for lab-enabled spaces

Methodology for Calculating Operational Energy Use for Lab-enabled Spaces

Similar to that for the embodied carbon, good data on Energy Use Intensity (EUI) for lab-enabled spaces is scarce, thought it is expected that lab-enabled spaces have 3-5x higher EUIs than offices.

The following are assumed:

- The power allowances recommended in the BCO Science Guide 2021 were cross referenced with the British Land Labs Guide
- An allowance for 24-hour operation for fridges and freezers, fume cupboards, chemical stores, other automated equipment, and the like.

The estimates for building services EUI carbon have been taken as 3x that for the office-only cases (see Figure 17.4). These figures reflect a "full-building" figure, and are therefore pro-rated according to the extent of the lab-enabled space in each relevant option.

The summary of the rationale is outlined in Figure 17.6.

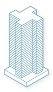
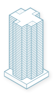
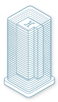
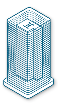
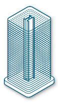
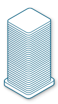
	OPTION	EUI (KWH/ M²/YR)	DIFFERENCE	NOTES All options assume all-new facade with all-electric MEP and fully new plant. Differences in EUI are due only to constraints for services distribution.
	Major Refurbishment	n/a	n/a	No lab-enabled spaces possible.
	Retention and Partial Extension - Max Retention	n/a	n/a	No lab-enabled spaces possible.
	Retention and Extension - "Full" Retention	n/a	n/a	No lab-enabled spaces possible.
	Partial Retention and Extension - Retain Interstitial Slabs	285	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	Partial Retention and Extension - Retain the Core	285	+5%	Service installation unconstrained on the floorplate and cores but existing basement is compromised with offsets and dual distribution anticipated.
	New Build	270	Baseline estimate for new build	All new basement and services distribution. Optimised SMEP to achieve industry benchmarks for new build construction.

Figure 17.6 Basis of estimation for energy use intensity (kWh/m²/year) for lab-enabled spaces

17.2 WLCA Results

17.2.1 Major Refurbishment

An option for refurbishment is explored with the aim of returning the tower to operation with the least intervention possible.

A summary of the interventions and results is shown in Figure 17.7.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.8 and Figure 17.9 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 19 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are small given the limited extent of intervention in the proposal. An allowance of 5 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. No new carbon emissions are envisaged in the substructure, as the proposal reuses the existing foundations and basement as is. In the superstructure, 50 $kgCO_2e/m^2$ is allowed for, covering works necessary to support the existing structure.

Facades
The existing facade is removed and replaced with a new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development. The new facade is supported on the existing tower's structure.

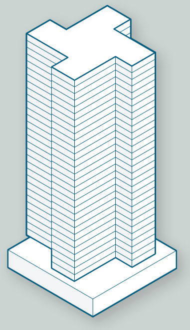
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,600 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 156 $kgCO_2e/$ m2GIA [A1-A5] and 223 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 122 $kgCO_2e/m^2$ [A1-A5] and 406 $kgCO_2e/m^2$ [A-C].

External works
No new carbon emissions are envisaged for external works as the existing is retained as is.

Site activities
The site programme is anticipated to be a relatively short duration given the limited interventions in the proposal. An allowance of 9 $kgCO_2e/m^2$ [A1-A5] is included which is pro-rated from an allowance for a full new construction with an estimated programme duration of 22 months provided by Lendlease.



Retain
& Retrofit

Major Refurbishment

A refurbishment to return tower to operation aiming to be as unintrusive as possible. Structures are retained and strengthened with new facades, internal finishes, FF&E, and MEP anticipated.

- New internal finishes
- FF&E
- New MEP
- New facade
- New floorplates
- New columns
- New core
- New substructure

Retained structure	89 % (carbon) / *90 % (vol)*
GIA	*53,263 m^2*
Upfront carbon	*406 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,125 $kgCO_2e/m^2$ [A-C]*
Operational energy	*104 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.7 Overview of key assumptions and results for the carbon assessment

Operational energy and carbon
Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is worse than current best practice due to compromised distribution routes and additional offsets through the basement downstands and existing risers sizes with consequential impact on SFP and pump energy use.

The EUI is estimated as 104 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.8 and Figure 17.9 respectively.

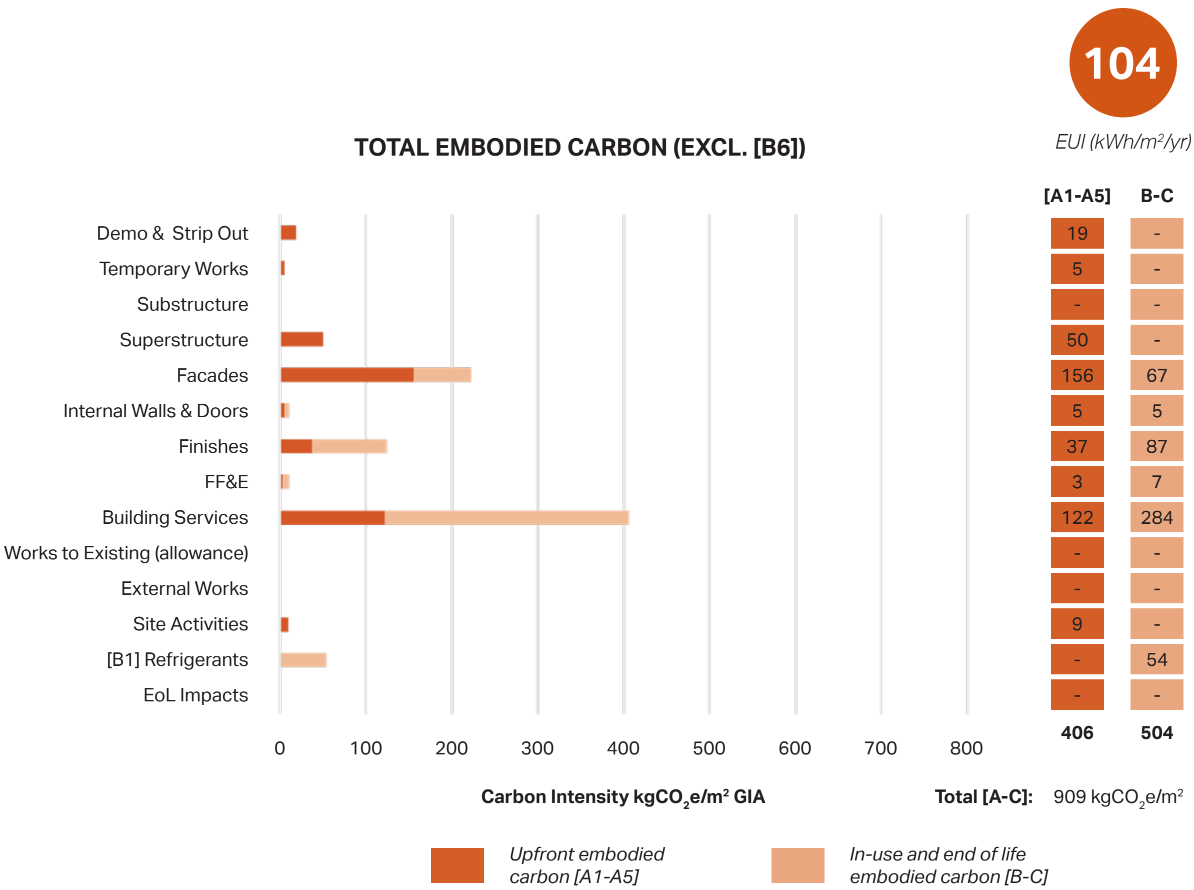
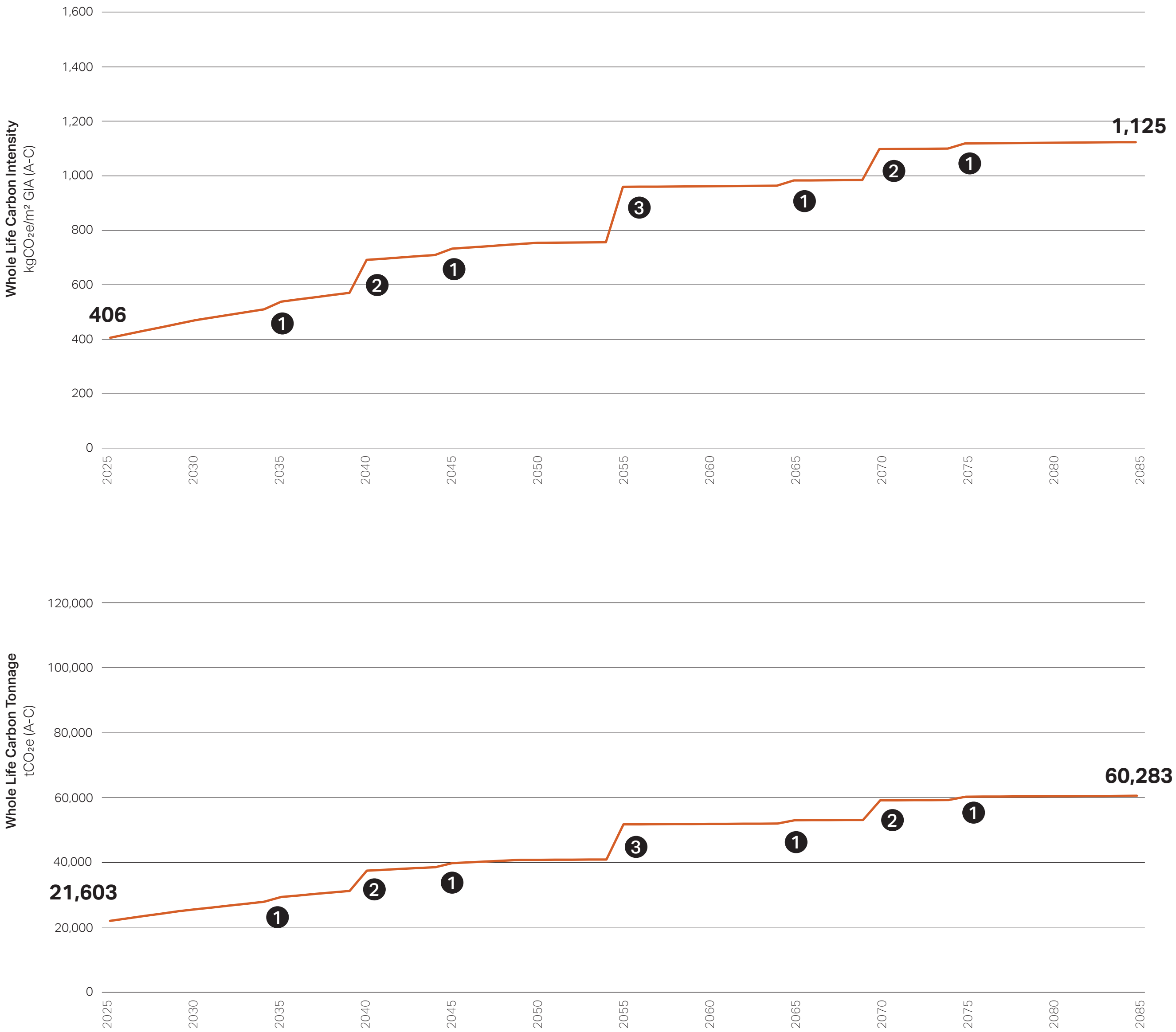


Figure 17.8 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1 *Finishes and FF&E are replaced*

2 *Building services are replaced as they reach end of service life*

3 *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.9 Whole life-cycle carbon estimate with interventions over time

17.2.2 Retention and Partial Extension - Max Retention

An option for refurbishment is explored with the aim of returning the tower to operation with the maximum structural retention possible.

A summary of the interventions and results is shown in Figure 17.10.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.11 and Figure 17.12 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 14 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are small given the limited extent of intervention in the proposal, but still greater than the Major Refurbishment due to the works required for the floorplate extension. An allowance of 10 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. A small allowance of 15 $kgCO_2e/m^2$ is made for the additional substructure required to support the external cores and extended floorplate. In the superstructure, 55 $kgCO_2e/m^2$ is allowed for, covering the additional material in the floorplate extension.

Facades
The existing facade is removed and replaced with a new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development. The new facade is supported on the existing tower's structure.

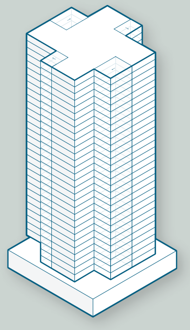
The proposed facade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over the facade area. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 114 $kgCO_2e/m^2$ GIA [A1-A5] and 162 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 119 $kgCO_2e/m^2$ [A1-A5] and 395 $kgCO_2e/m^2$ [A-C].

External works
No new carbon emissions are envisaged for external works as the existing is retained as is.

Site activities
Compared to the major refurbishment, the site programme is anticipated to be slightly longer owing to the additional work required on the floorplate extension. An allowance of 17 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 40 months.



Retain
& Refurbish

Retention and Partial Extension - Max Retention

A refurbishment to return tower to operation.
Structure is entirely retained and floorplates extended, but keeping within the existing loading capacity.
New facades, internal finishes, FF&E, and MEP are anticipated.

New internal finishes	Extended floorplates
FF&E	New columns
New MEP	New core elements
New facade	New substructure

Retained structure	93 % (carbon) / *92 % (vol)*
GIA	*71,166 m²*
Upfront carbon	*398 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*886 $kgCO_2e/m^2$ [A-C]*
Operational energy	*95 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.10 Overview of key assumptions and results for the carbon assessment

Operational energy and carbon
Since the Retention and Partial Extension scheme is not dependent on the existing satellite cores for MEP distribution, an improved operational energy performance is assumed compared to the major refurbishment scheme.

The EUI is estimated as 95 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.11 and Figure 17.12 respectively.

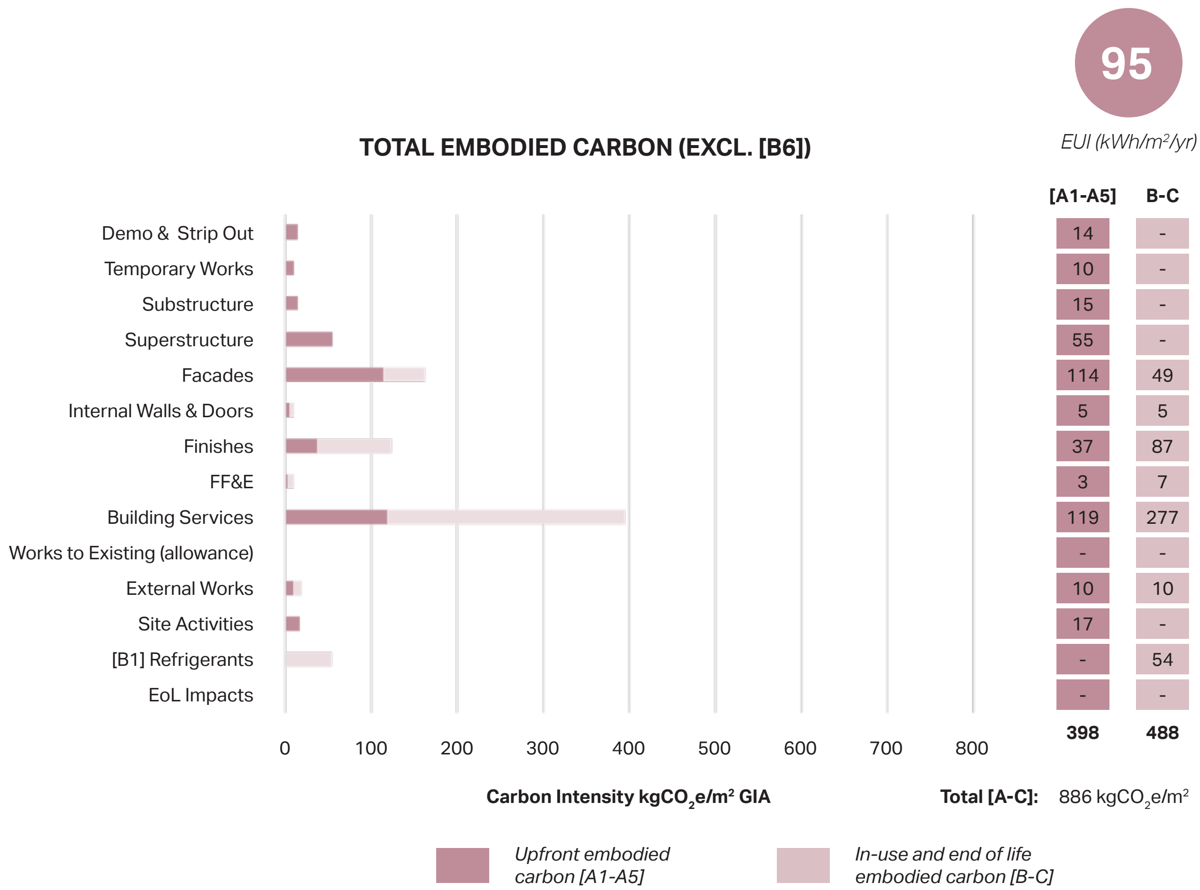
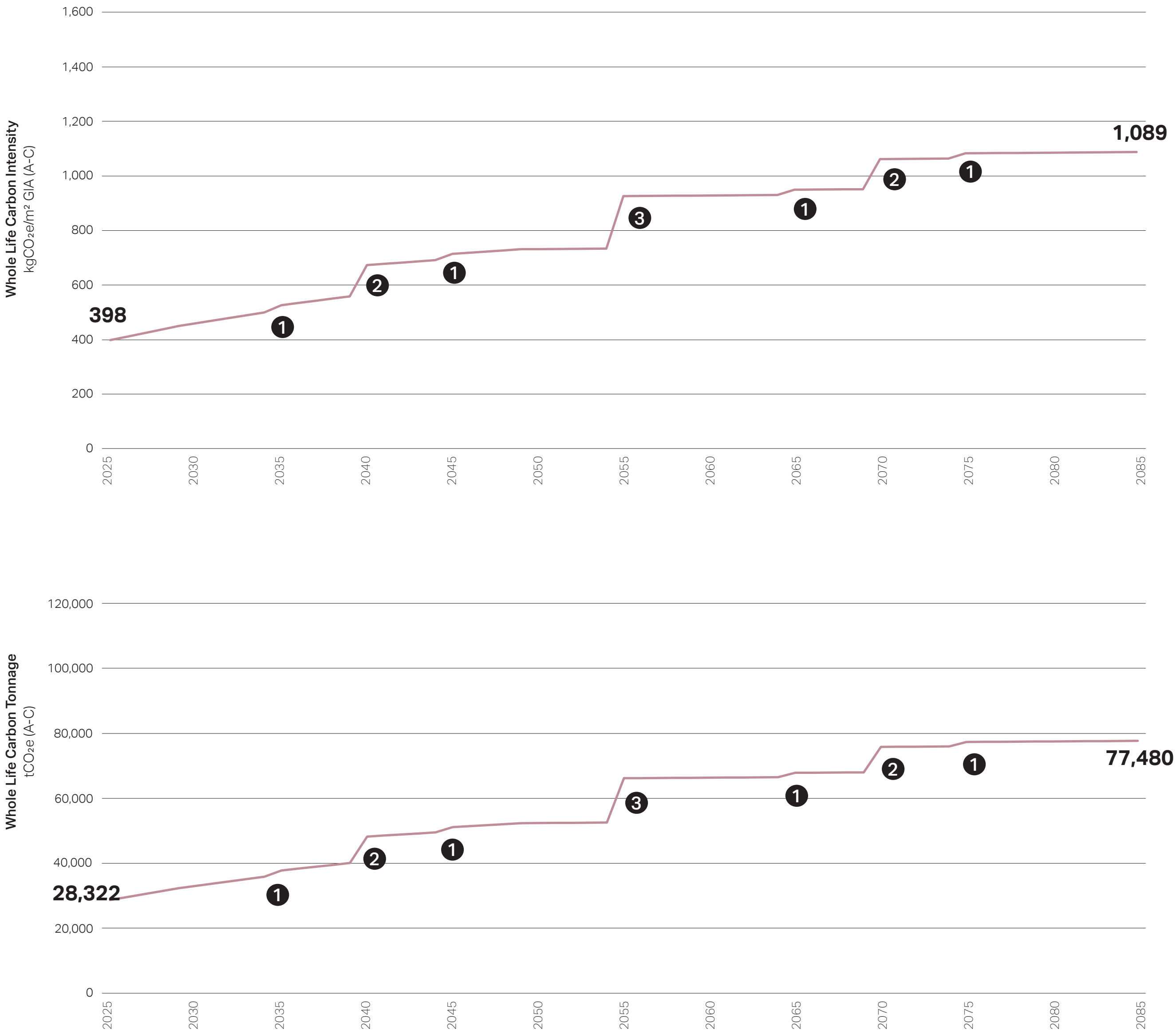


Figure 17.11 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1. *Finishes and FF&E are replaced*
2. *Building services are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.12 Whole life-cycle carbon estimate with interventions over time

17.2.3 Retention and Extension - "Full" Retention

A retention and extension is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible.

A summary of the interventions and results is shown in Figure 17.13.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.14 and Figure 17.15 respectively.

Demolition and strip out

The emissions calculated in relation to the demolition and strip out are estimated at 17 $kgCO_2e/m^2$.

Temporary works

Emissions associated with temporary works capture the full-height temporary works required to support exposed slab edges during demolition and construction, and the temporary protection required to protect workers and slabs below, wherever existing slabs are demolished. An allowance of 22 $kgCO_2e/m^2$ is included.

Structures

Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

While the aim for the superstructure is to retain as much as possible, there are nonetheless significant structural interventions required to deliver the extended floor plates. The existing satellite cores are removed, and the floor plates are trimmed back and stabilised on the north, west and south sides. At a high level, the new works comprise additional primary structure, supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area, and the extensions to the floor plates. These works are estimated as 158 $kgCO_2e/m^2$

Facades

A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,500 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 89 $kgCO_2e/m^2$ GIA [A1-A5] and 128 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E

For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants

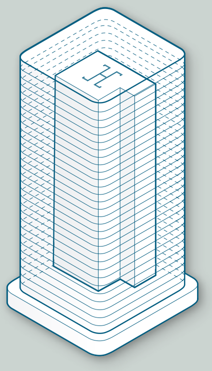
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 117 $kgCO_2e/m^2$ [A1-A5] and 390 $kgCO_2e/m^2$ [A-C].

External works

One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.

Site activities

Compared to a new build, the site programme is anticipated to be somewhat shortened owing to the extent of retention in the proposal, although the programme will be impacted by requiring a more careful deconstruction. An allowance of 19 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 45 months.



Retain
& Refurbish

Partial Retention and Extension - "Full" Retention

A deep refurbishment retaining substructure, core, and superstructure. New facade, internal finishes, FF&E, and MEP anticipated.

New internal finishes	Extended floorplates
FF&E	Additional columns
New MEP	New core
New facade	New substructure

Retained structure	84 % (carbon) / *85 % (vol)*
GIA	*92,484 m^2*
Upfront carbon	*512 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,210 $kgCO_2e/m^2$ [A-C]*
Operational energy	*99 $kWh/m^2/yr$*
Number of storeys	*36 storeys*
Floor to floor height	*3.2 m (office only)*

Figure 17.13 Overview of key assumptions and results for the carbon assessment

Operational energy and carbon
Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is worse than current best practice due to compromised distribution routes and additional offsets around existing downstands (but optimised over the floorplates).

The EUI is estimated as 99 kWh/m²/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.14 and Figure 17.15 respectively.

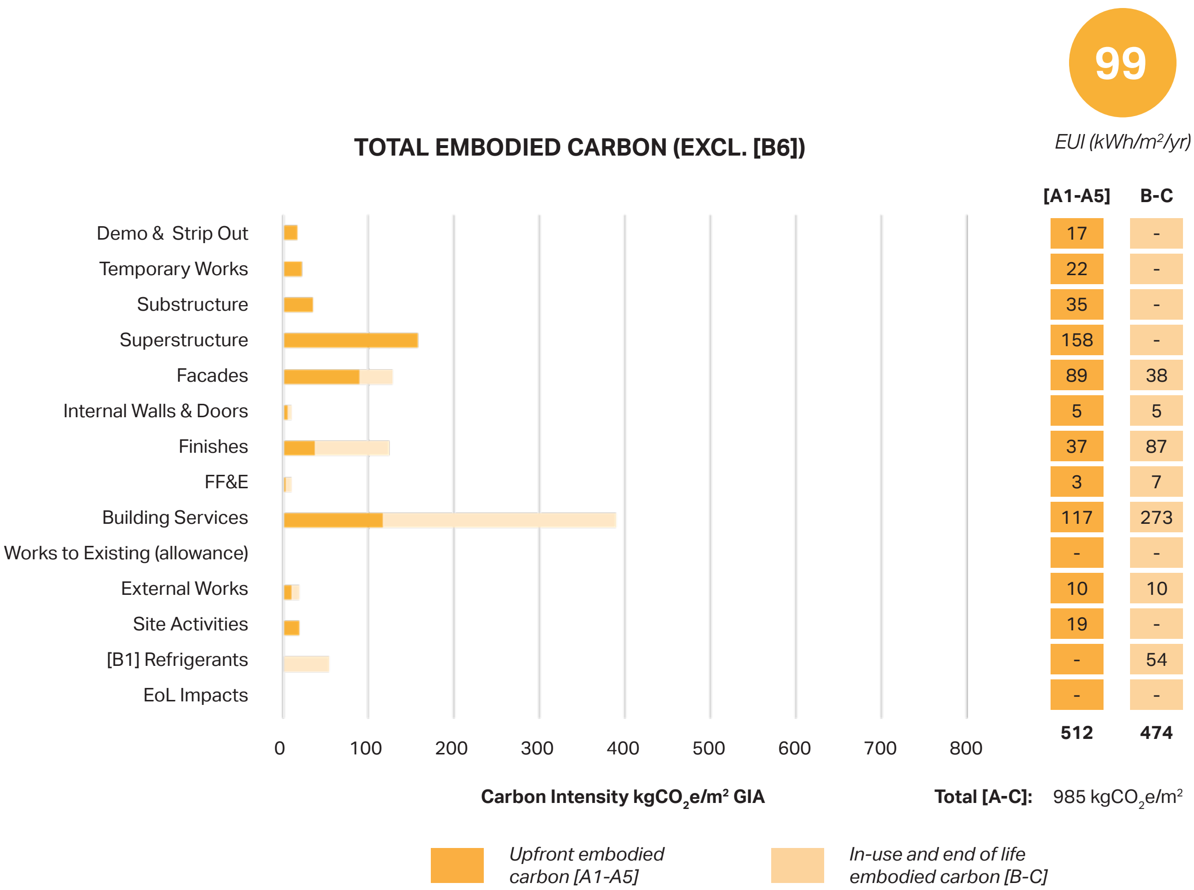
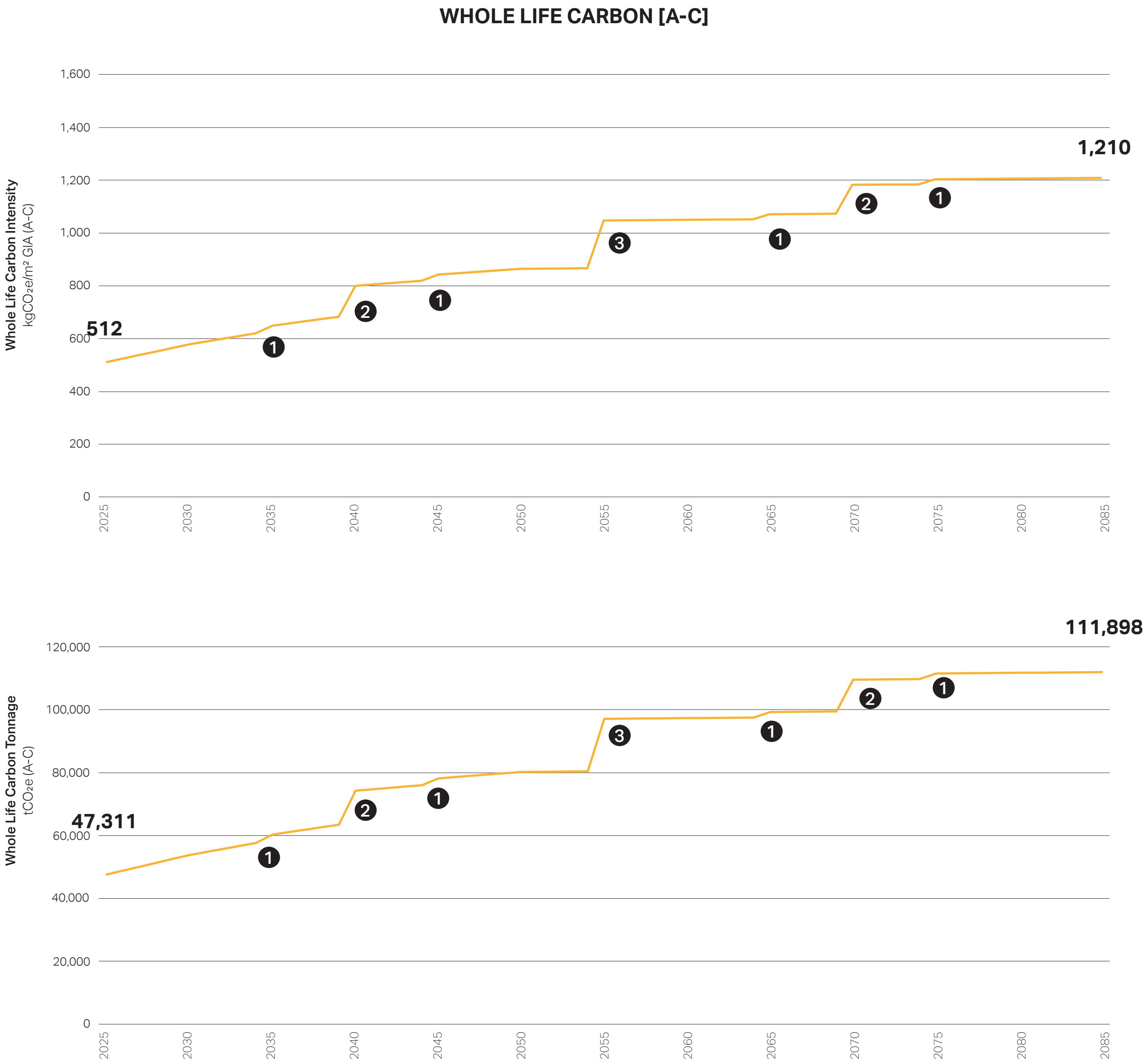


Figure 17.14 Breakdown of embodied carbon by building element



1. *Finishes and FF&E are replaced*
2. *Building services are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.15 Whole life-cycle carbon estimate with interventions over time

17.2.4 Partial Retention and Extension - Retain Interstitial Slabs

An option that retains interstitial slabs is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible.

This option is similar to retention and extension, but where every approximately 6th slab is retained, and 4 new slabs in between, delivering improved floor to floor heights and greater flexibility.

A summary of the interventions and results is shown in Figure 17.16.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.17 and Figure 17.18 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 20 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works capture the full-height temporary works required to support exposed slab edges during demolition and construction, and the temporary protection required to protect workers and slabs below, wherever existing slabs are demolished. An allowance of 22 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

While the aim for the superstructure is to retain as much as possible, there are nonetheless significant structural interventions required to deliver the retention of the interstitial slabs and the extension thereof. The existing satellite cores are removed, and the floor plates are trimmed back and stabilised on the north, west and south sides, the retained columns are supported and the interstitial slabs are removed. At a high level, the new works comprise additional primary structure, supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area, additional stability of the retained columns, the extensions to the floor plates and the new floor plates. These works are estimated as 258 $kgCO_2e/m^2$

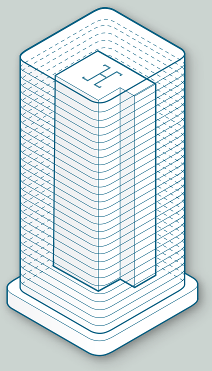
Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,500 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 106 $kgCO_2e/$ m2GIA [A1-A5] and 152 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 108 $kgCO_2e/m^2$ [A1-A5] and 359 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.



Retain
& Refurbish

Partial Retention and Extension - Retain Interstitial Slabs

Retention of substructure, core and interstitial floor plates. Interstitial floor plates extended with new superstructure, and new facade, internal finishes, FF&E, and MEP. Re-use demolition arisings on site where possible.

- New internal finishes
- New FF&E
- New MEP
- New facade
- Additional and extended floorplates
- Additional columns
- New core
- New substructure

	Office-only	Office & lab
Retained structure	38 % (carbon) / *42 % (vol)*	
GIA	*77,898 m²*	
Upfront carbon	*627 kgCO_2e/m² [A1-A5]*	*654 kgCO_2e/m² [A1-A5]*
Whole life carbon	*1,288 kgCO_2e/m² [A-C]*	*1,479 kgCO_2e/m² [A-C]*
Operational energy	*95 kWh/m²/yr*	*141 kWh/m²/yr*
Number of storeys	*30 storeys*	
Floor to floor height	*3.84-3.98 m (office)* *4.27 m (lab)*	

Figure 17.16 Overview of key assumptions and results for the carbon assessment

External works
One of the benefits of this scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.

Site activities
Compared to a new build and in contrast to the other retention options, the site programme is anticipated to be longer owing to the complexity of the retention in the proposal. An allowance of 23 $kgCO_2e/m^2$ is included based on an allowance e input from Lendlease.

Operational energy and carbon
Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is somewhat worse than current new build best practice due to compromises in the distribution in the existing basement with offsets and dual distribution anticipated (but optimised over the floorplates).National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.17 and Figure 17.18 respectively.

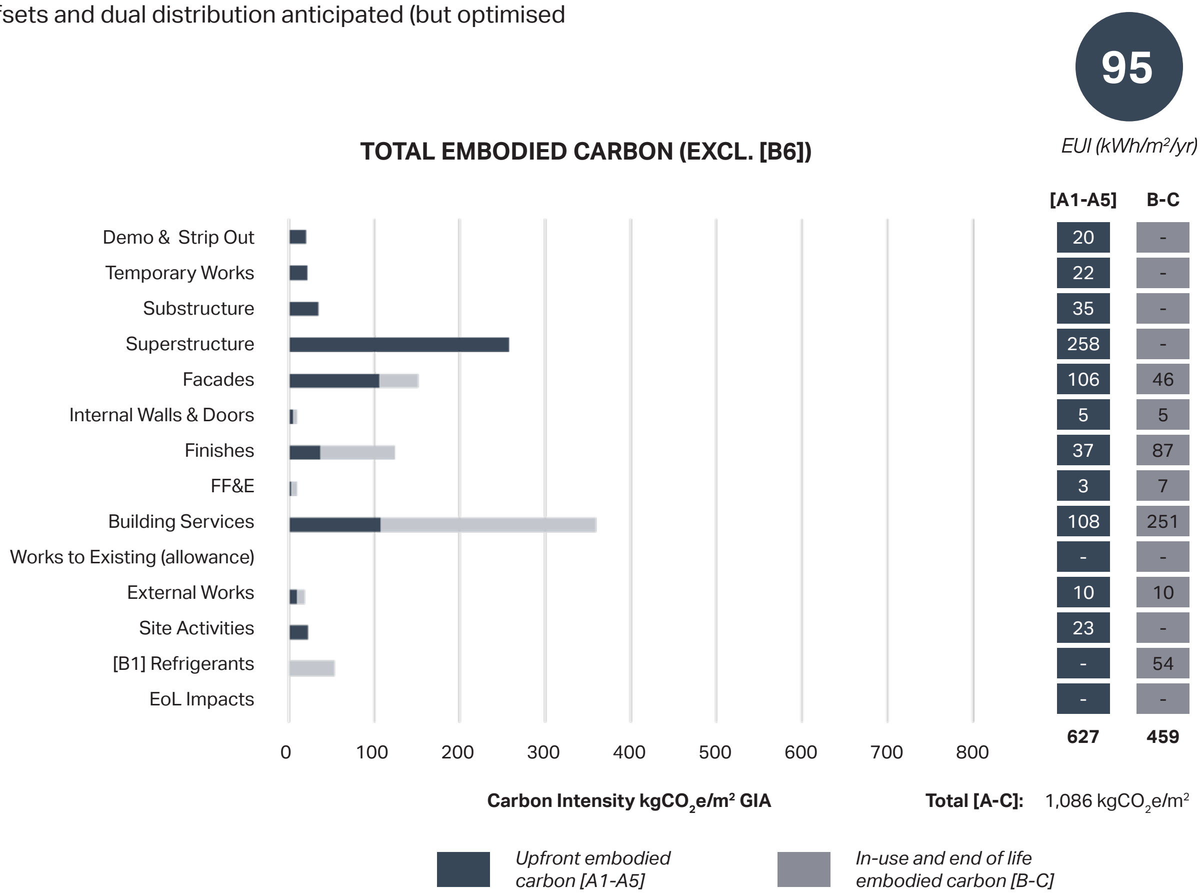
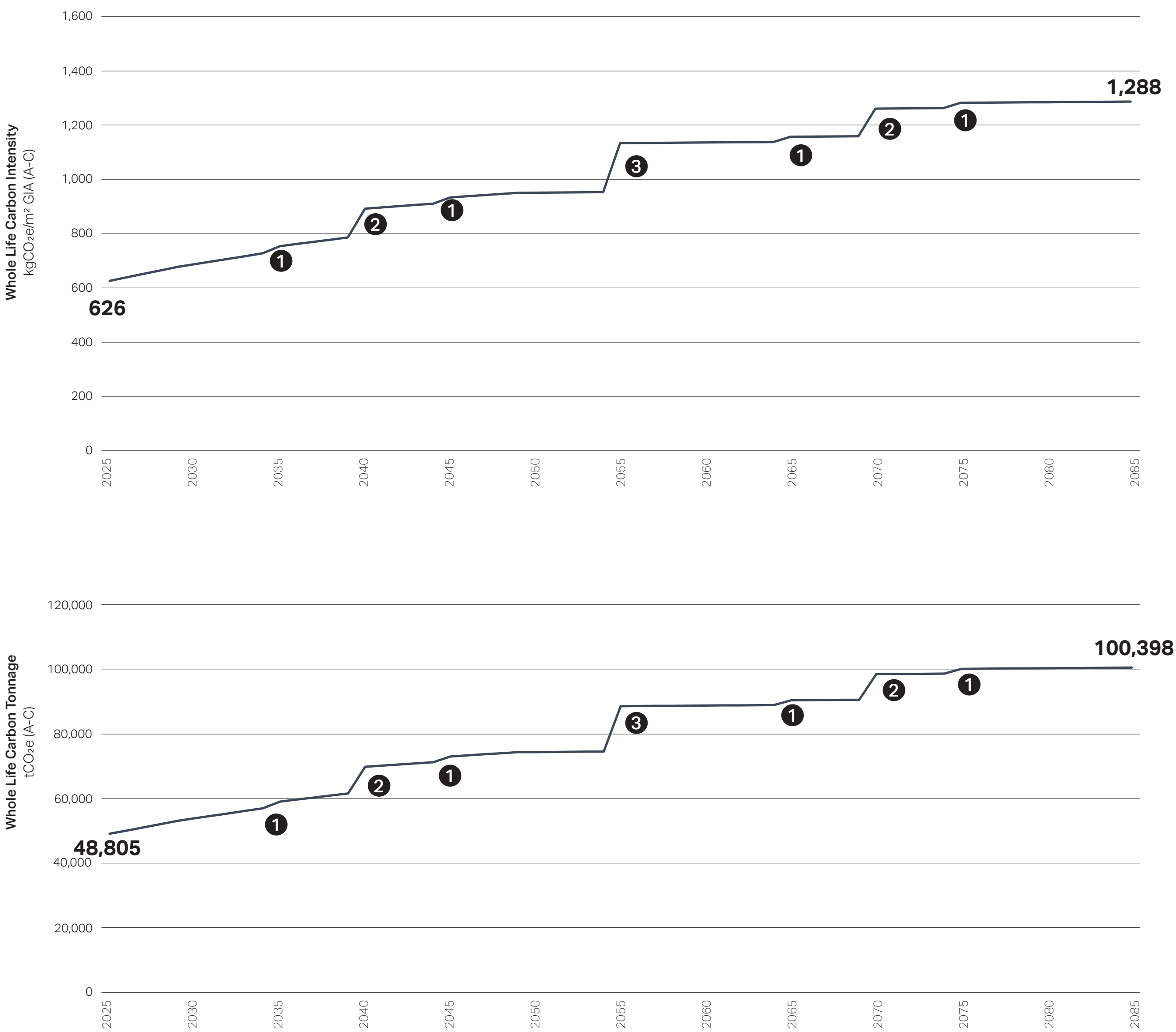


Figure 17.17 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1. *Finishes and FF&E are replaced*
2. *Building services are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.18 Whole life-cycle carbon estimate with interventions over time

Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5] 654 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6] 523 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6] 1,177 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6] 1,479 $kgCO_2e/m^2$.

The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.19 and Figure 17.20 respectively.

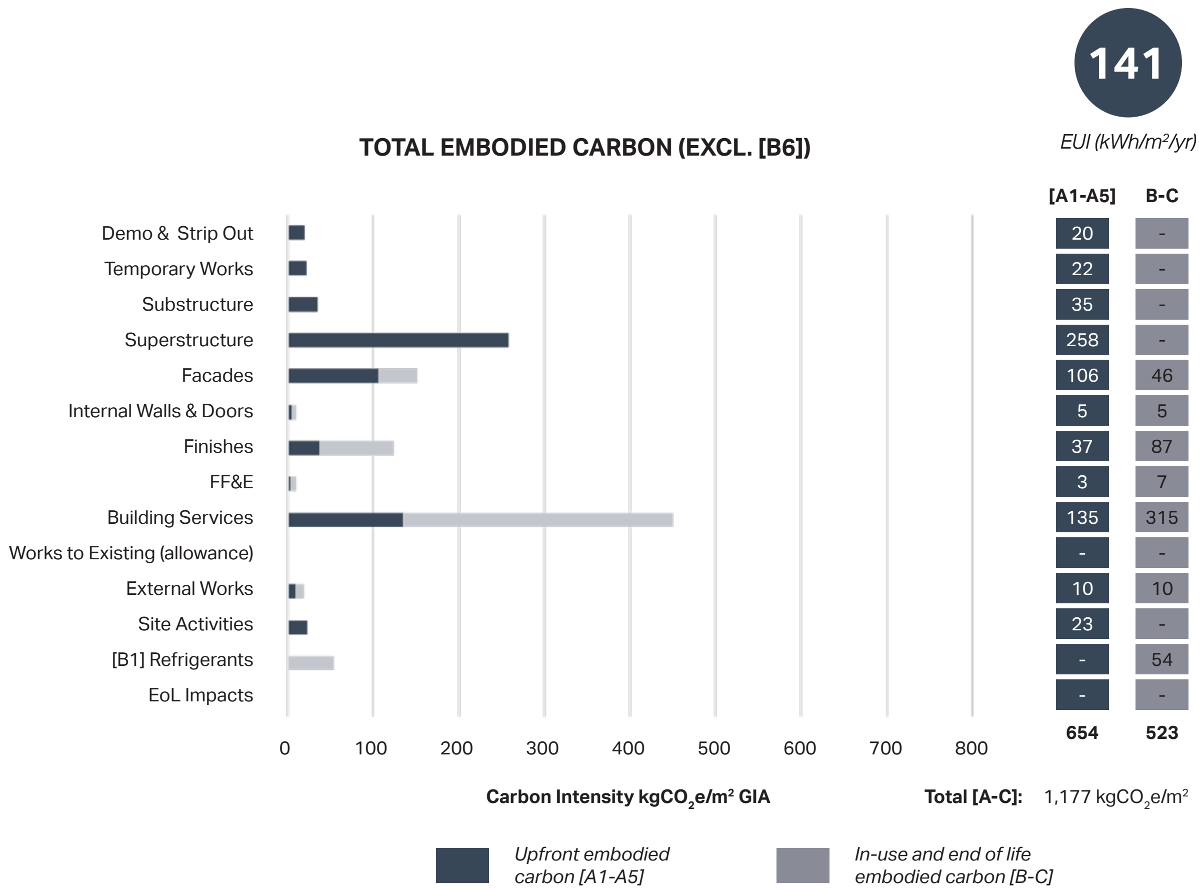
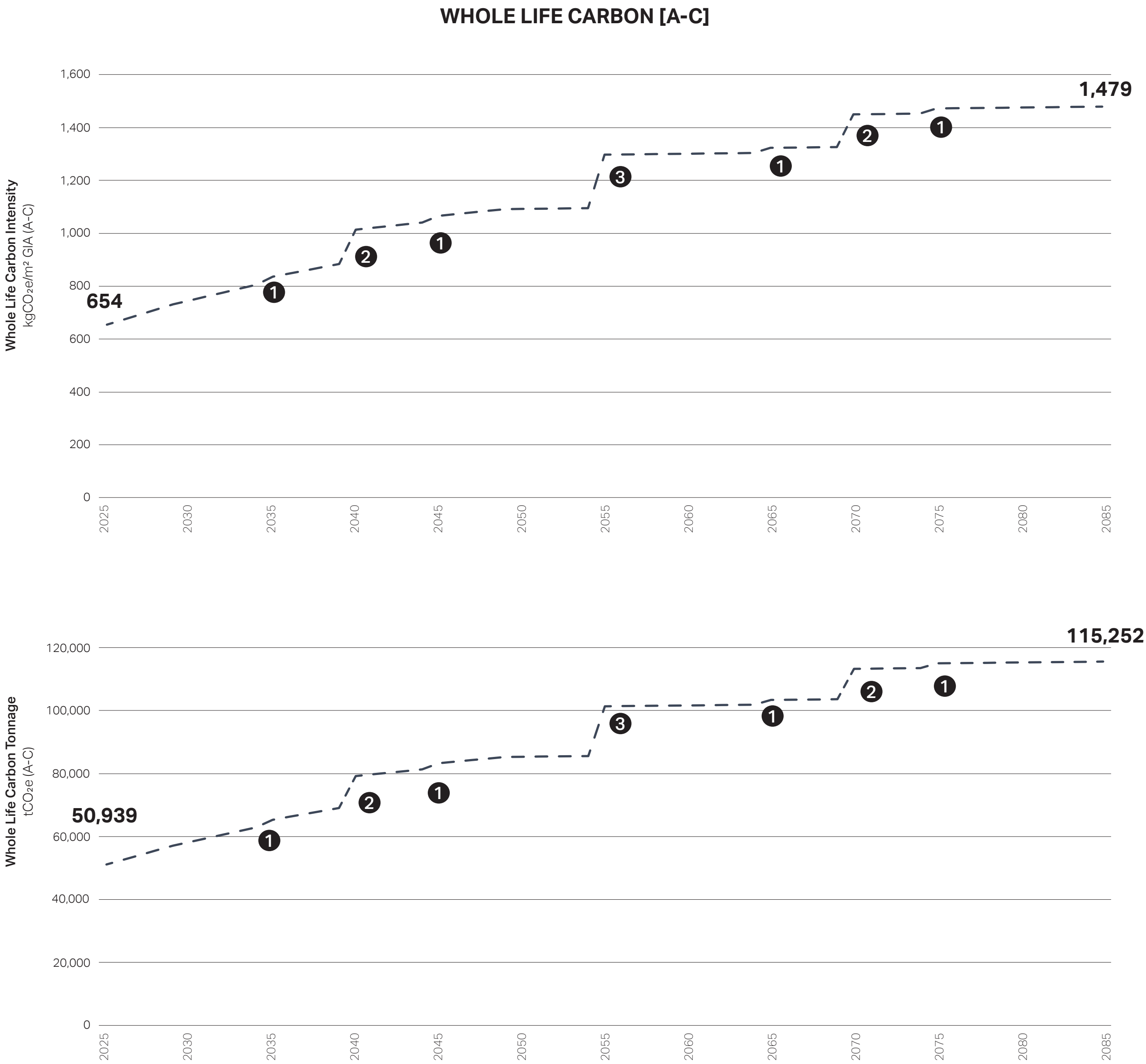


Figure 17.19 Breakdown of embodied carbon by building element for lab-enabled scenario



1. *Finishes and FF&E are replaced*
2. *Building services are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.20 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.2.5 Partial Retention and Extension - Retain the Core

A partial retention and extension is explored with the aim of updating the tower to modern standards while retaining as much of the existing building as possible. This option is similar to the retention and extension, but with entirely new floorplates delivering improved floor to floor heights and greater flexibility.

A summary of the interventions and results is shown in Figure 17.21.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.22 and Figure 17.23 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 21 $kgCO_2e/m^2$.

Temporary works
Emissions associated with temporary works are relatively low given the lessened extent of temporary works required in the proposal compared to those with greater retention. An allowance of 15 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are low for a building of this scale, due to the total retention of the existing foundations and basement. Additional substructure is proposed only where the extended tower comes down outside the footprint of the existing foundations. This is estimated as 35 $kgCO_2e/m^2$.

Similar to the retention and extension option, the existing satellite cores are removed, but the existing floorplates and columns are removed in their entirety. The new works therefore comprise new primary structure, all new floor plates, and supplementary stability systems at the perimeter to counteract for the modified core arrangement and increased wind area. These works are estimated as 262 $kgCO_2e/m^2$.

Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

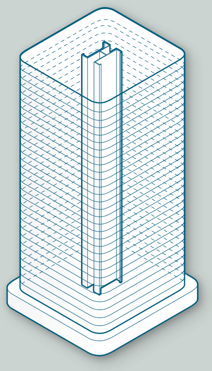
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,100 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 104 $kgCO_2e/$ m2GIA [A1-A5] and 149 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 108 $kgCO_2e/m^2$ [A1-A5] and 359 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.

External works
One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.



Retain & Refurbish

Disassemble & Reuse

Partial Retention and Extension - Retain the Core

Retention of substructure and core. Floor plates extended with new superstructure, and new facade, internal finishes, FF&E, and MEP. Re-use demolition arisings on site where possible.

- New internal finishes
- New FF&E
- New MEP
- New facade
- New floorplates
- New columns
- New core
- New substructure

Retained structure	25 % (carbon) / *31 % (vol)*	
GIA	*77,898 m²*	
	Office-only	Office & lab
Upfront carbon	627 *$kgCO_2e/m^2$ [A1-A5]*	666 *$kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,288 $kgCO_2e/m^2$ [A-C]*	*1,562 $kgCO_2e/m^2$ [A-C]*
Operational energy	*95 kWh/m²/yr*	*162 kWh/m²/yr*
Number of storeys	*30 storeys*	
Floor to floor height	*3.8 m (office)* *4.1 m (lab)*	

Figure 17.21 Overview of key assumptions and results for the carbon assessment

Volume 1: Assessing the Existing Building
Volume 2: Pathways for Alternative Uses
Vol 3
Introduction
Lettability & Daylighting
Establishing a New Baseline
Retention Options Appraisal
Carbon Assessments
Resource Efficiency & Future Proofing
Conclusion

Site activities

Compared to a new build, the site programme is anticipated to be somewhat shortened owing to the extent of retention in the proposal, although the programme will be impacted by requiring a more careful deconstruction. An allowance of 27 $kgCO_2e/m^2$ is included which is pro-rated from an allowance for a full new construction based on the length of the programme using programme input from Lendlease. The assumed programme length is 64 months.

Operational energy and carbon

Notwithstanding the all-new MEP systems and facade, the proposal's overall operational energy performance is somewhat worse than current new build best practice due to compromises in the distribution in the existing basement with offsets and dual distribution anticipated (but optimised over the floorplates).

The EUI is estimated as 95 $kWh/m^2/year$ estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.22 and Figure 17.23 respectively.

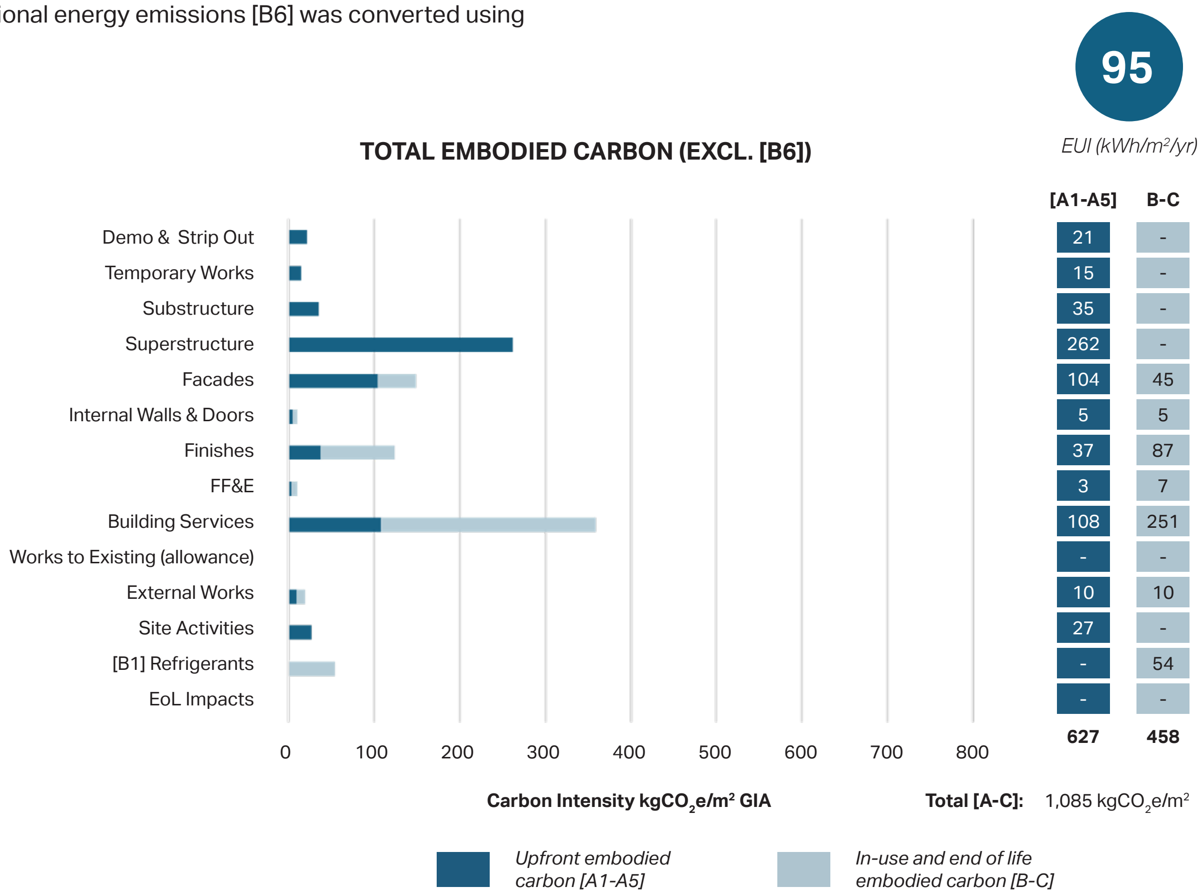
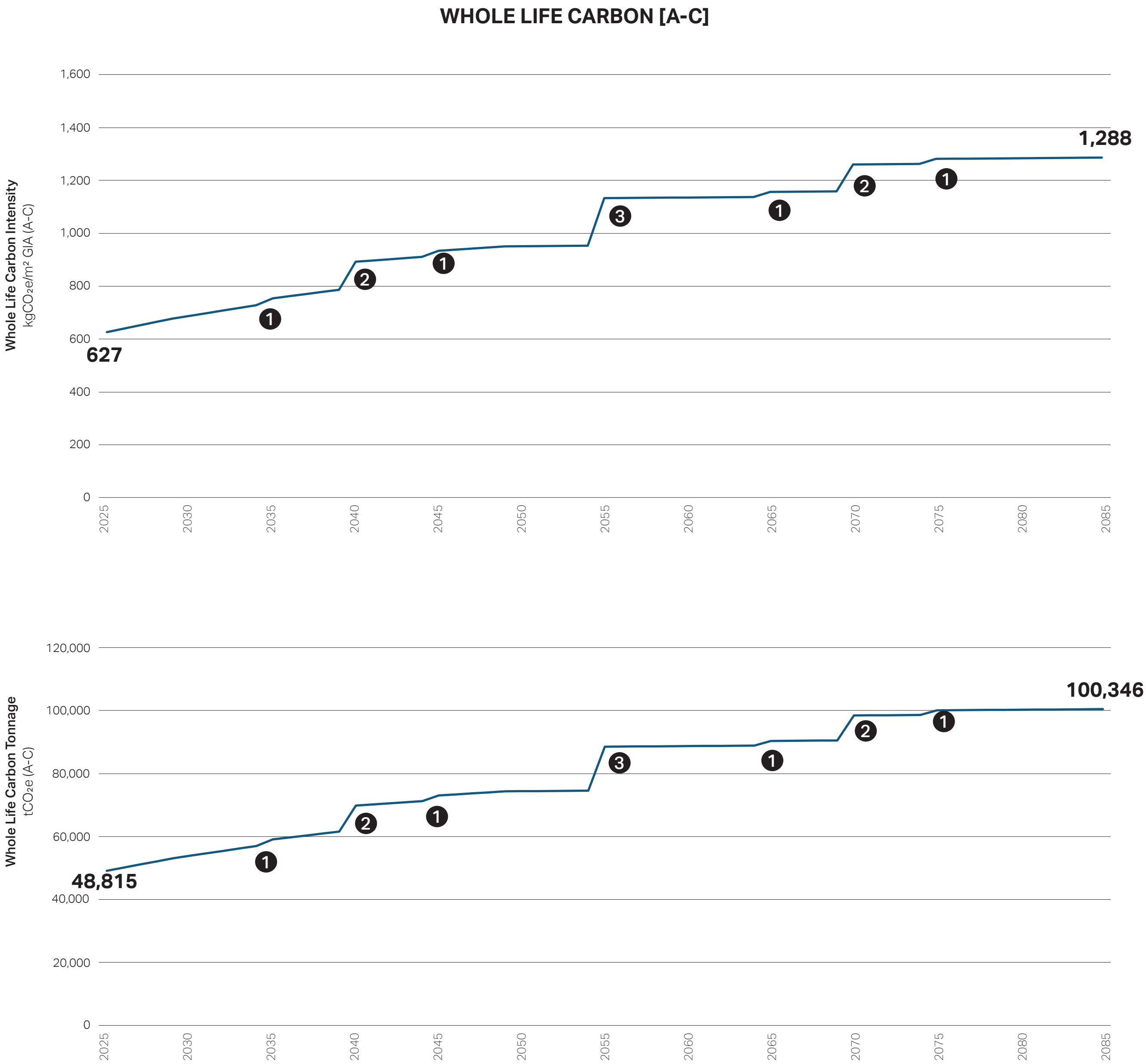


Figure 17.22 Breakdown of embodied carbon by building element



1 *Finishes and FF&E are replaced*

2 *Building services and refrigerants are replaced as they reach end of service life*

3 *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.23 Whole life-cycle carbon estimate with interventions over time

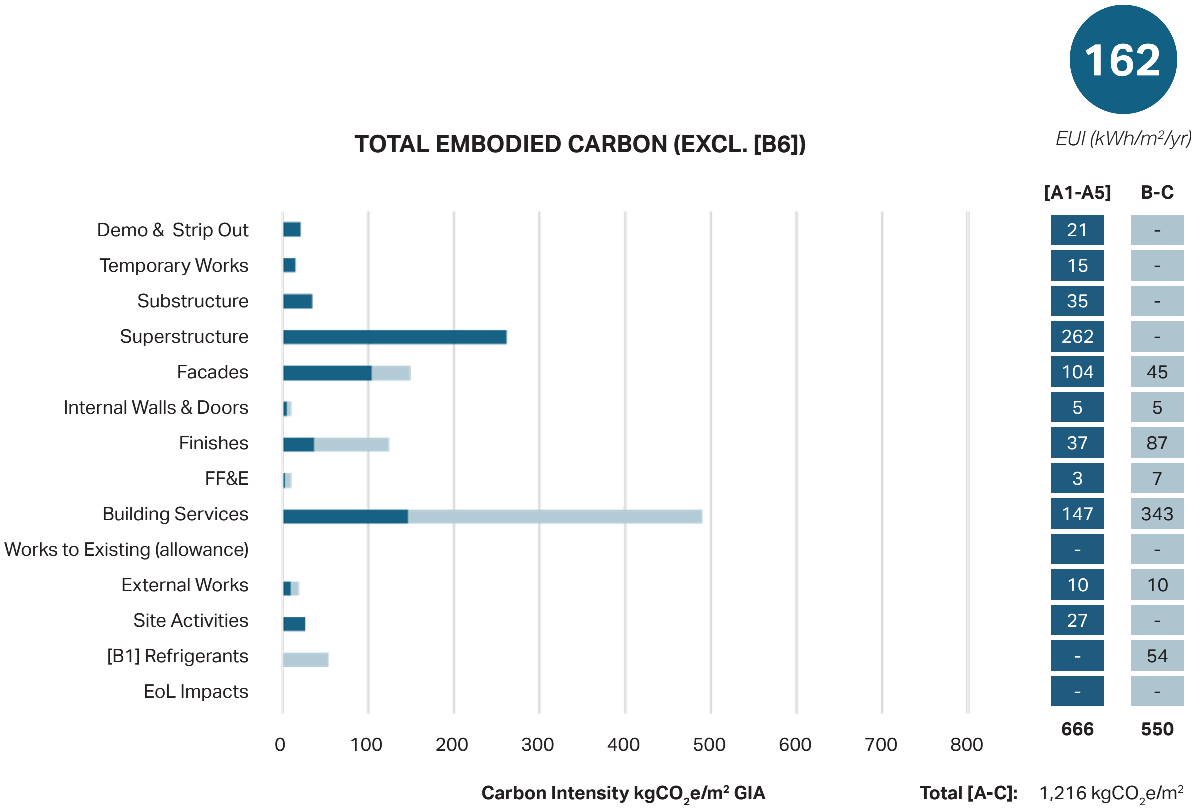
Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5]
  666 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6]
  550 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6]
  1,216 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6]
  1,562 $kgCO_2e/m^2$.

The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.24 and Figure 17.25 respectively.

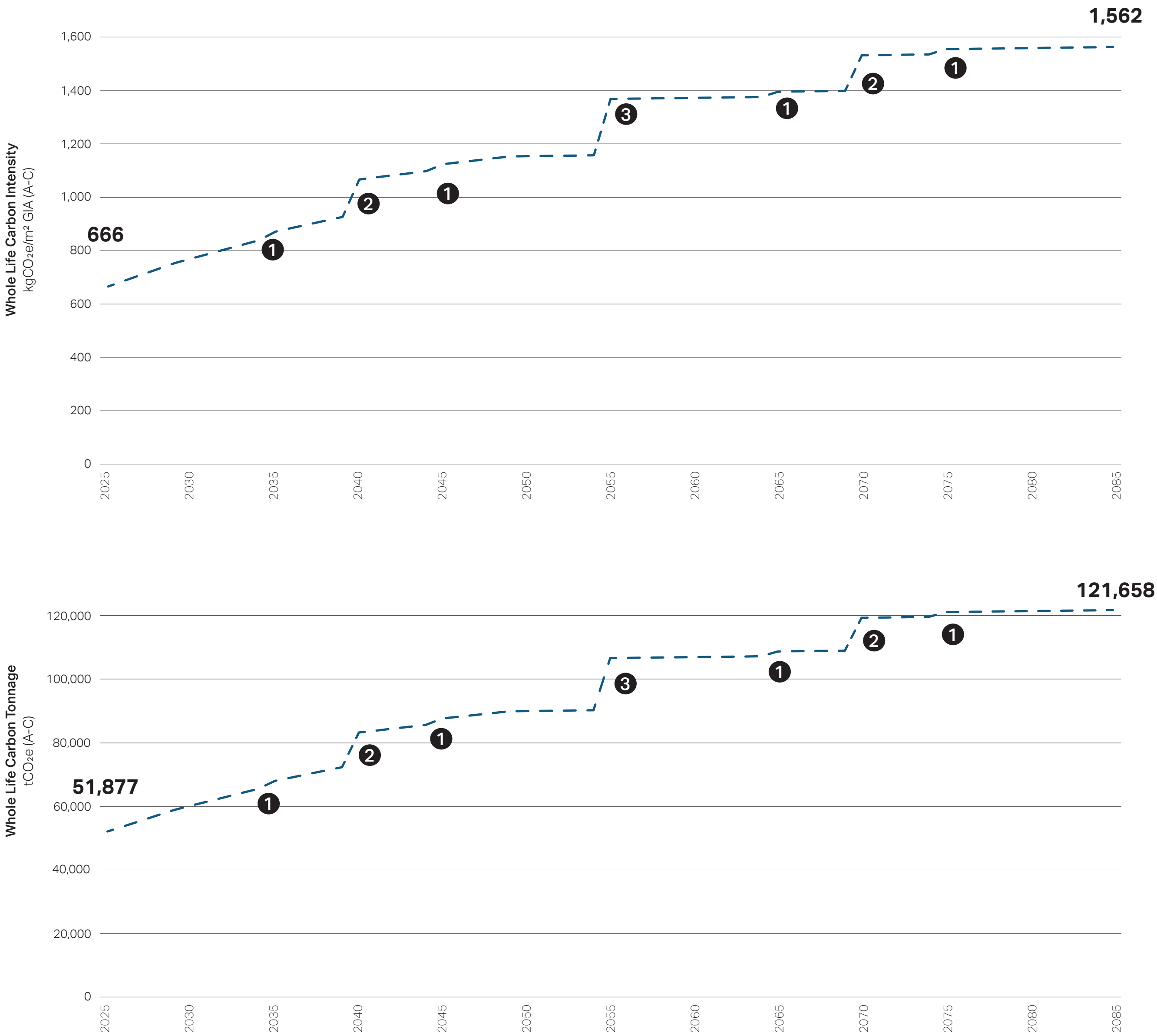


	[A1-A5]	B-C
Demo & Strip Out	21	-
Temporary Works	15	-
Substructure	35	-
Superstructure	262	-
Facades	104	45
Internal Walls & Doors	5	5
Finishes	37	87
FF&E	3	7
Building Services	147	343
Works to Existing (allowance)	-	-
External Works	10	10
Site Activities	27	-
[B1] Refrigerants	-	54
EoL Impacts	-	-
	666	**550**

Total [A-C]: 1,216 $kgCO_2e/m^2$

Figure 17.24 Breakdown of embodied carbon by building element for lab-enabled scenario

WHOLE LIFE CARBON [A-C]



1. *Finishes and FF&E are replaced*
2. *Building services and refrigerants are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are replaced at the same time*

Figure 17.25 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.2.6 New Build

A new build scheme is explored with the aim of delivering a tower to modern standards with no compromises imposed by the existing building. This option delivers 100% new build comprising all-new: foundations and basement, frame and primary structure including cores, floorplates, facade, finishes, FF&E, and MEP systems.

In the appraisal, this option is intended as a bookend to the other options, studying what would be the impact of a totally unconstrained build.

A summary of the interventions and results is shown in Figure 17.26.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.27 and Figure 17.28 respectively.

Demolition and strip out
The emissions calculated in relation to the demolition and strip out are estimated at 24 $kgCO_2e/m^2$.

Temporary works
Of all the options, emissions associated with temporary works are lowest given the lessened extent of temporary works required in the proposal compared to those with greater retention. An allowance of 10 $kgCO_2e/m^2$ is included.

Structures
Carbon estimates for the structures have been provided by Arup. The carbon emissions for the substructure are significantly higher than any of the other options, due to the totally new foundation and basement proposed. Providing new foundations and basement helps to de-risk the construction programme since the new building is no longer in any way structurally-reliant on the existing. This is estimated as 72 $kgCO_2e/m^2$.

For the superstructure, the works comprise new primary structure, floor plates, and stability systems. The stability system is delivered by perimeter bracing and the new cores are free to be positioned flexibly as they are not used as part of the stability system. These works are estimated as 262 $kgCO_2e/m^2$.

Facades
A new, high-performance facade that is commensurate with the modern performance standards expected in a high-end London development is assumed to replace the existing facade.

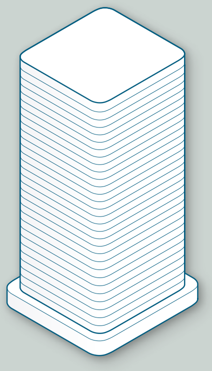
The proposed façade system is estimated as 352 $kgCO_2e/m^2$ FSA [A1-A5] over a facade surface area of 23,100 m^2. As noted in the methodology, the per m^2 facade area carbon emissions are consistent, the form factor (the ratio of facade surface area to gross floor area) influences the figures when reported on a per m^2 GIA basis. This results in 104 $kgCO_2e/$ m2GIA [A1-A5] and 149 $kgCO_2e/m^2$ GIA [A-C].

Internal walls & doors, finishes, and FF&E
For internal walls & doors, finishes, and FF&E, a benchmark figure has been assumed in the absence of design information at this stage.

Building services and refrigerants
All-new MEP systems are proposed with carbon estimates provided by Arup. The fundamental room-side and central systems are proposed to be the same across all options, refer to methodology in Section 17.1.2. MEP embodied carbon is estimated as 103 $kgCO_2e/m^2$ [A1-A5] and 344 $kgCO_2e/m^2$ [A-C].

This assumes that the fit out is for office only including in the spaces with larger floor to floor heights that are designed as lab-enabled. This is chosen to provide a like for like comparison with the other options since they cannot accommodate any laboratory spaces, and the laboratory MEP equipment is more carbon intensive than that for offices.

External works
One of the benefits of the retention and extension scheme is that its scope is sufficiently wide to unlock improvements to the public realm. An allowance of 19 $kgCO_2e/m^2$ is included. For consistency the same assumptions have been used across all scenarios that deliver upgrades to the public realm.



Demolish
& Recycle

New Build

Option demolishes and recycles the full existing tower. No structure is retained (including foundation and substructure).

New internal finishes	New floorplates
New FF&E	New columns
New MEP	New core
New facade	New substructure

	Office-only	Office & lab
Retained structure	*0 %*	
GIA	*77,898 m²*	
Upfront carbon	*660 $kgCO_2e/m^2$ [A1-A5]*	*698 $kgCO_2e/m^2$ [A1-A5]*
Whole life carbon	*1,312 $kgCO_2e/m^2$ [A-C]*	*1,572 $kgCO_2e/m^2$ [A-C]*
Operational energy	*90 $kWh/m^2/yr$*	*158 $kWh/m^2/yr$*
Number of storeys	*30 storeys*	
Floor to floor height	*3.8 m (office)* *4.1 m (lab)*	

Figure 17.26 Overview of key assumptions and results for the carbon assessment

Site activities

The fully new build scheme is anticipated to have a construction programme of 72 months. This is somewhat mitigated by not needing to do as much of a careful deconstruction. An allowance of 30 kgCO_2e/m^2 is included for a full new construction based on the length of the programme using programme input from Lendlease.

Operational energy and carbon

The proposal's overall operational energy performance is current best practice due to optimised packaging and distribution.

The EUI is estimated as 90 kWh/m^2/year estimated by Arup. Operational energy emissions [B6] was converted using National Grid FES 2021 'steady progression' scenario, with a change in carbon factor applied every 5 years, until 2050.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.27 and Figure 17.28 respectively.

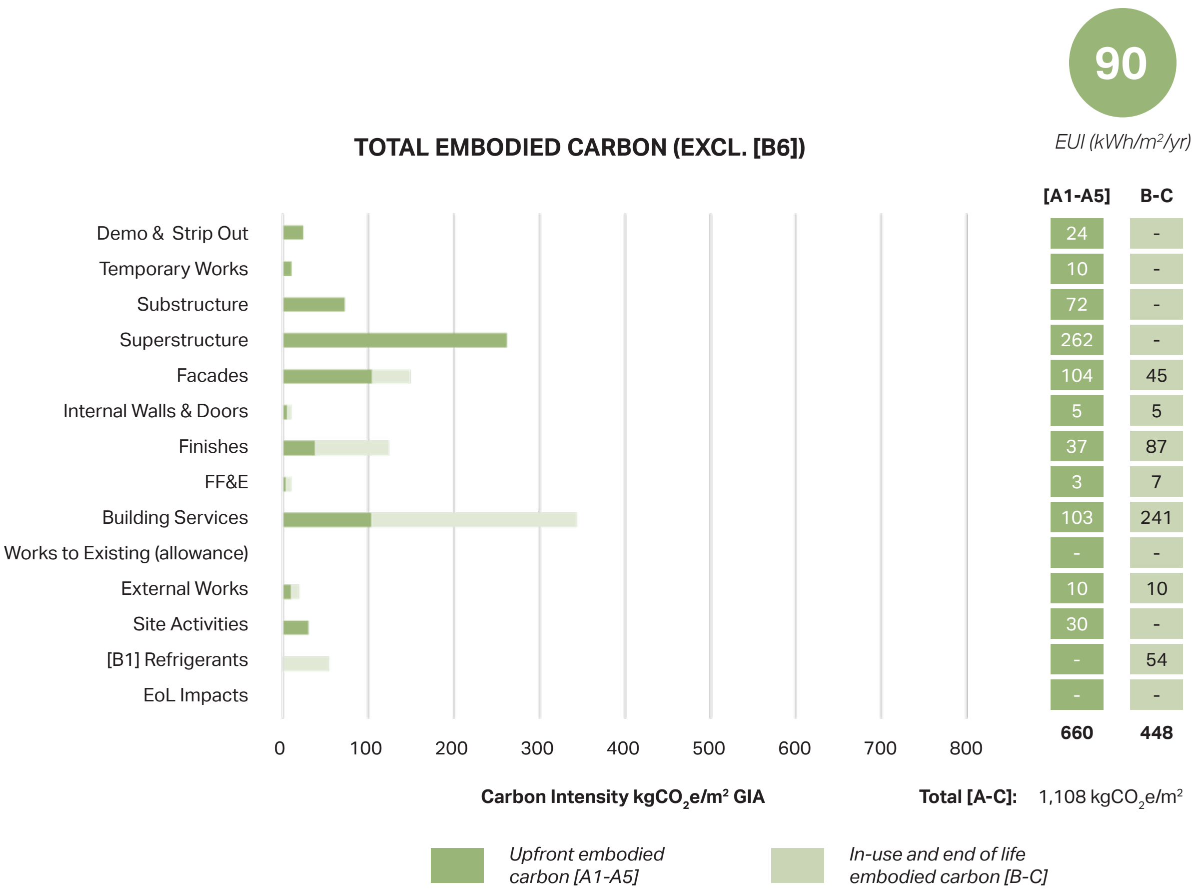
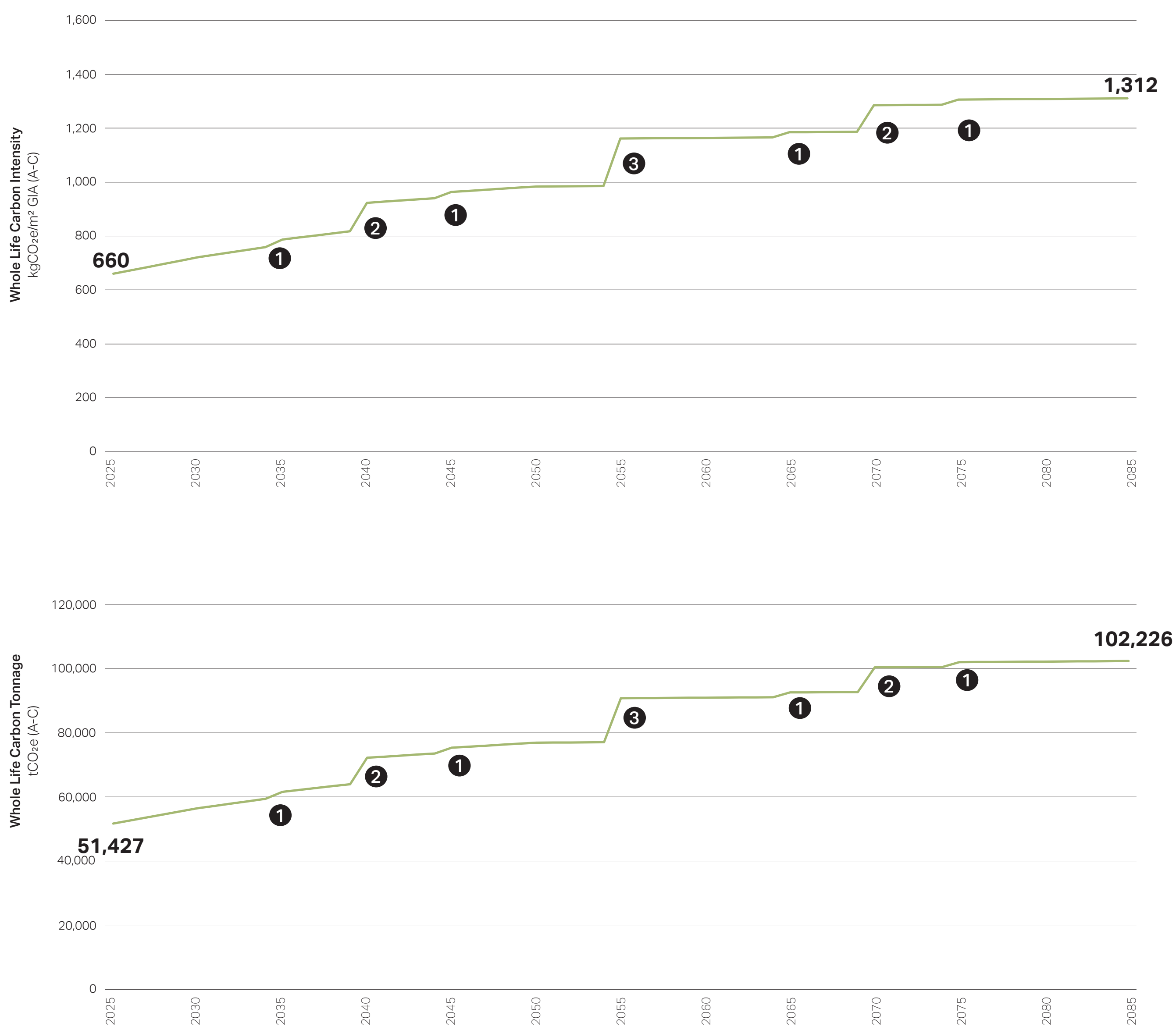


Figure 17.27 Breakdown of embodied carbon by building element

WHOLE LIFE CARBON [A-C]



1. *Finishes and FF&E are replaced*
2. *Building services and refrigerants are replaced as they reach end of service life*
3. *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are done at the same time*

Figure 17.28 Whole life-cycle carbon estimate with interventions over time

Lab-enabled

The comparisons in this Section assume all areas are fit out as office to enable comparison. If this option had the lab-enabled spaces fit out and operating as labs, considering the increased intensity for building services embodied carbon and energy demand, the following would result:

- Total upfront embodied carbon [A1-A5] 698 $kgCO_2e/m^2$
- In-use embodied carbon [B-C, excl. B6] 539 $kgCO_2e/m^2$
- Whole life-cycle carbon [A-C, excl. B6] 1,234 $kgCO_2e/m^2$.
- Whole life-cycle carbon [A-C, incl. B6] 1,572 $kgCO_2e/m^2$.

The embodied carbon results and EUI are blended according to the split of office-only and lab-enabled space thought the whole building. Assumptions are presented in Section 17.1.2.

The breakdown of embodied carbon by building element, and the whole life-cycle estimates are shown in Figure 17.29 and Figure 17.30 respectively.

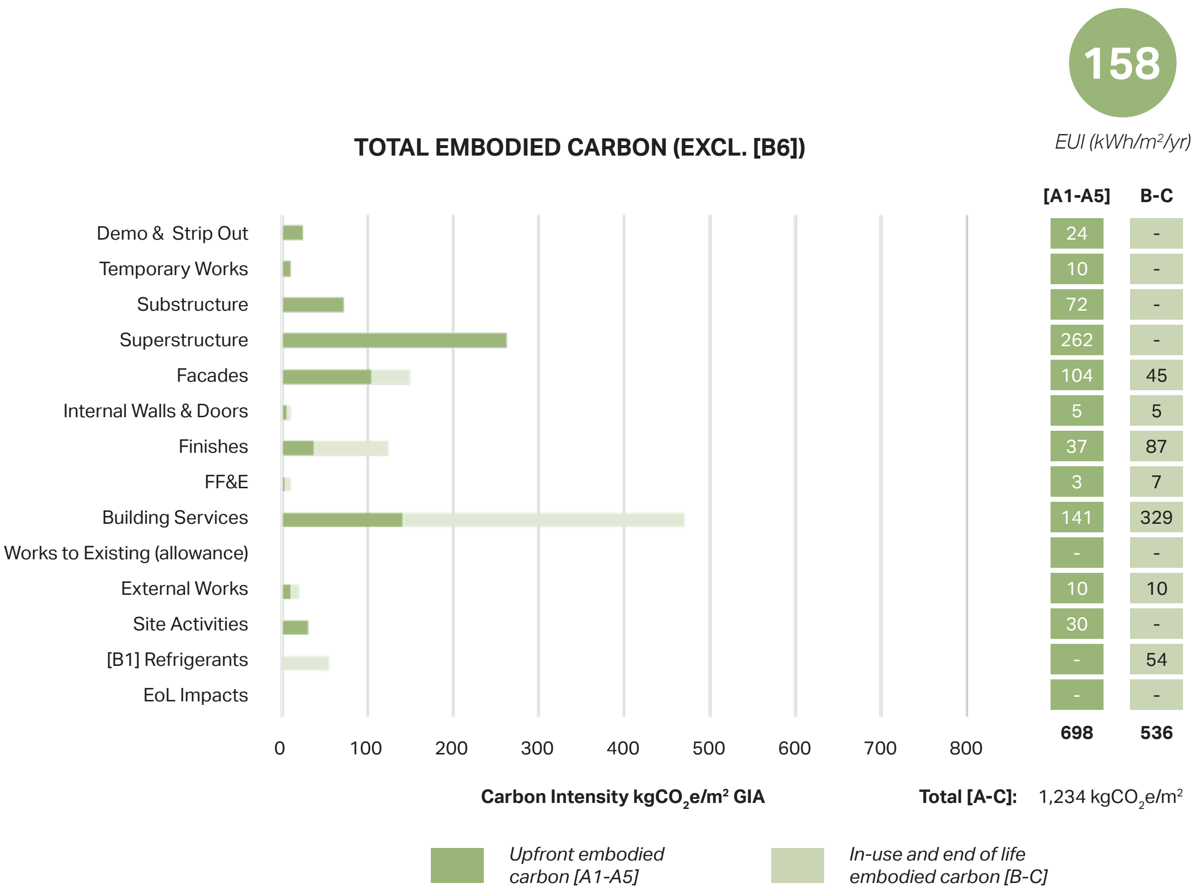
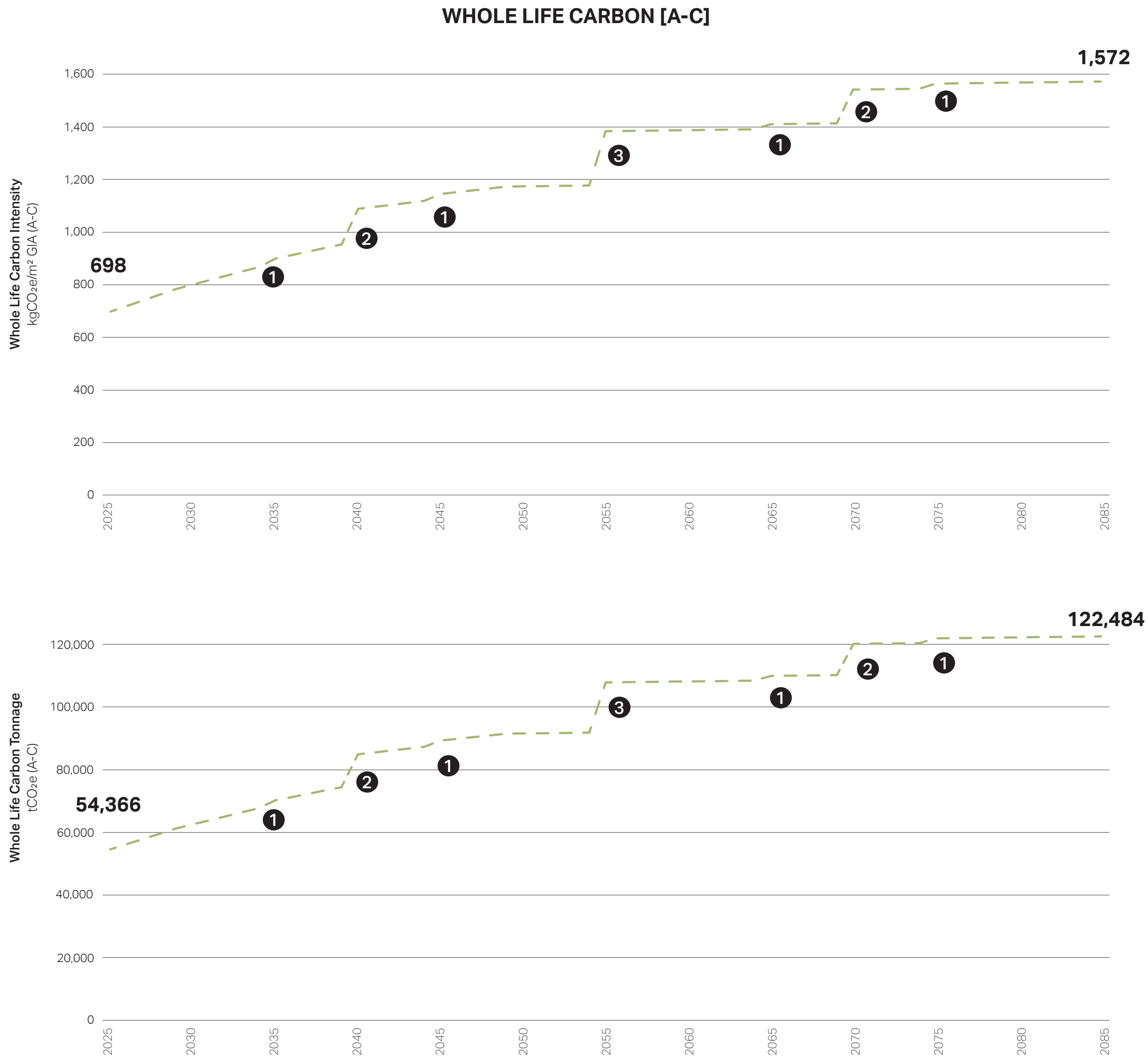


Figure 17.29 Breakdown of embodied carbon by building element for lab-enabled scenario



1 *Finishes and FF&E are replaced*

2 *Building services and refrigerants are replaced as they reach end of service life*

3 *Secondary components in the facade systems are replaced as they reach end of service life, assuming new IGUs throughout. Internal walls and doors are replaced. Finishes and FF&E are done at the same time*

Figure 17.30 Whole life-cycle carbon estimate with interventions over time for lab-enabled scenario

17.3 Summary and Comparison

17.3.1 Embodied carbon by building element

The comparative breakdown of embodied carbon by building element is shown in Figure 17.31. The breakdown is split for office-only scenarios above, and for those where the lab-enabled space is fitted out and operating as lab below.

Office-only
In total tonnage terms, which should be the primary measure, the Major Refurbishment and Retention & Partial Extension - Max Retention have the lowest upfront and whole life-cycle carbon, but deliver significantly less floor area. Notwithstanding that they retain the existing building's compromised floor to floor height, both options are unlikely to be viable considering the work required to replace existing plant and facades, and in the case of the latter, the additional cantilever structure and external cores.

Between the remainder of the options, the upfront carbon is similar due to different areas delivered, with the Partial Retention and Extension - Retain the Core option having the lowest whole life-cycle carbon, as it best balances the upfront spend and operational energy in use. Noting that is comparative, in absolute terms, to the Partial Retention and Extension - Retain Interstitial Slabs option, but it delivers this carbon performance without the limitations or buildability complexity imposed by retaining the interstitial slabs.

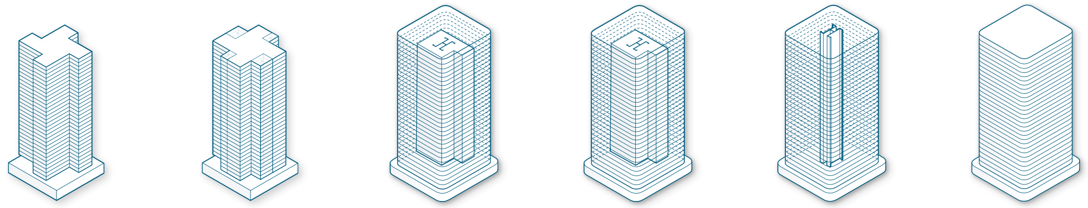
In intensity terms, the Retention & Partial Extension - Max Retention option has the lowest upfront and whole life-cycle carbon, owing to the extent of intervention. There is greater spread across the other options. The Retention & Extension - "Full" Retention option is relatively low because of the larger area delivered than other extension schemes. The options that introduce new floor to floor heights and less compromised floorplates (Partial Retention & Extension - Retain Interstitial Slabs, Partial Retention and Extension - Retain the Core, and New Build) are similar, both upfront and considering whole life-cycle carbon.

Office & lab
The options that do not introduce new floor to floor heights cannot accommodate lab-enabled spaces.

The Partial Retention and Extension - Retain Interstitial Slabs option has the lowest carbon performance of the three options, but this is because it delivers less lab-enabled area (approximately 23% of GIA compared to 33% for the others), being constrained by which slabs can be retained.

If the lab areas were normalised throughout, the trends would follow that for the office-only scenarios, and the Partial Retention and Extension - Retain the Core option would deliver the lowest carbon performance by all measures.

	Major Refurbishment		Retention & Partial Extension - Max Retention		Retention & Extension - "Full" Retention		Partial Retention & Extension - Retain Interstitial Slabs		Partial Retention & Extension - Retain the Core		New Build	



OFFICE-ONLY

	Major Refurbishment		Retention & Partial Extension - Max Retention		Retention & Extension - "Full" Retention		Partial Retention & Extension - Retain Interstitial Slabs		Partial Retention & Extension - Retain the Core		New Build	
WLC Intensity *[A-C]*	*1,125 kgCO_2e/m²*		*1,089 kgCO_2e/m²*		*1,210 kgCO_2e/m²*		*1,288 kgCO_2e/m²*		*1,288 kgCO_2e/m²*		*1,312 kgCO_2e/m²*	
WLC Tonnage *[A-C]*	*60,283 tCO_2e*		*77,480 tCO_2e*		*111,898 tCO_2e*		*100,398 tCO_2e*		*100,346 tCO_2e*		*102,226 tCO_2e*	
	[A1-A5]	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**
Demo & Strip Out	19	-	14	-	17	-	20	-	21	-	24	-
Temporary Works	5	-	10	-	22	-	22	-	15	-	10	-
Substructure	-	-	15	-	35	-	35	-	35	-	72	-
Superstructure	50	-	55	-	158	-	258	-	262	-	262	-
Facades	156	67	114	49	89	38	106	46	104	45	104	45
Internal Walls & Doors	5	5	5	5	5	5	5	5	5	5	5	5
Finishes	37	87	37	87	37	87	37	87	37	87	37	87
FF&E	3	7	3	7	3	7	3	7	3	7	3	7
Building Services	122	284	119	277	117	273	108	251	108	251	103	241
Works to Existing (allowance)	-	-	-	-	-	-	-	-	-	-	-	-
External Works	-	-	10	10	10	10	10	10	10	10	10	10
Site Activities	9	-	17	-	19	-	23	-	27	-	30	-
[B1] Refrigerants	-	54	-	54	-	54	-	54	-	54	-	54
EoL Impacts	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	**406**	**504**	**398**	**488**	**512**	**474**	**627**	**459**	**627**	**458**	**660**	**448**

OFFICE & LAB

N/A as these options do not accommodate lab-enabled uses

	Major Refurbishment		Retention & Partial Extension - Max Retention		Retention & Extension - "Full" Retention		Partial Retention & Extension - Retain Interstitial Slabs		Partial Retention & Extension - Retain the Core		New Build	
WLC Intensity *[A-C]*	*n/a*		*n/a*		*n/a*		*1,479 kgCO_2e/m²*		*1,562 kgCO_2e/m²*		*1,572 kgCO_2e/m²*	
WLC Tonnage *[A-C]*	*n/a*		*n/a*		*n/a*		*115,252 tCO_2e*		*121,659 tCO_2e*		*122,484 tCO_2e*	
	[A1-A5]	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**	**[A1-A5]**	**B-C**
Demo & Strip Out							20	-	21	-	24	-
Temporary Works							22	-	15	-	10	-
Substructure							35	-	35	-	72	-
Superstructure							258	-	262	-	262	-
Facades							106	46	104	45	104	45
Internal Walls & Doors							5	5	5	5	5	5
Finishes							37	87	37	87	37	87
FF&E							3	7	3	7	3	7
Building Services							135	315	147	343	141	329
Works to Existing (allowance)							-	-	-	-	-	-
External Works							10	10	10	10	10	10
Site Activities							23	-	27	-	30	-
[B1] Refrigerants							-	54	-	54	-	54
EoL Impacts							-	-	-	-	-	-
TOTALS							**654**	**523**	**666**	**550**	**698**	**536**

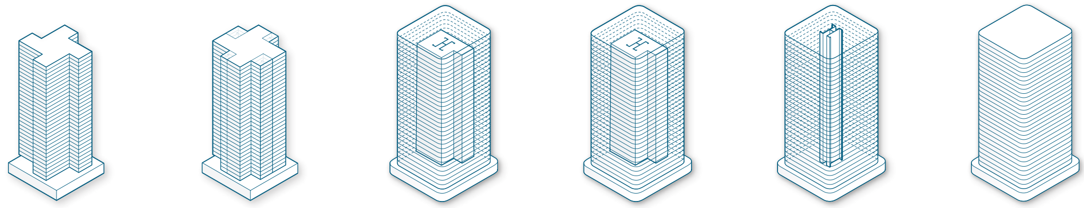
Figure 17.31 Breakdown of embodied carbon by building element

17.3.2 Whole life-cycle carbon

The comparative whole life-cycle estimates are shown in Figure 17.32. The curves for office-only are shown as solid curves, and those where the lab-enabled space is fitted out and operating as lab are shown as dashed curves.

The same considerations described in Section 17.3.1 apply.

	Major Refurbishment	Retention & Partial Extension - Max Retention	Retention & Extension - "Full" Retention	Partial Retention & Extension - Retain Interstitial Slabs	Partial Retention & Extension - Retain the Core	New Build

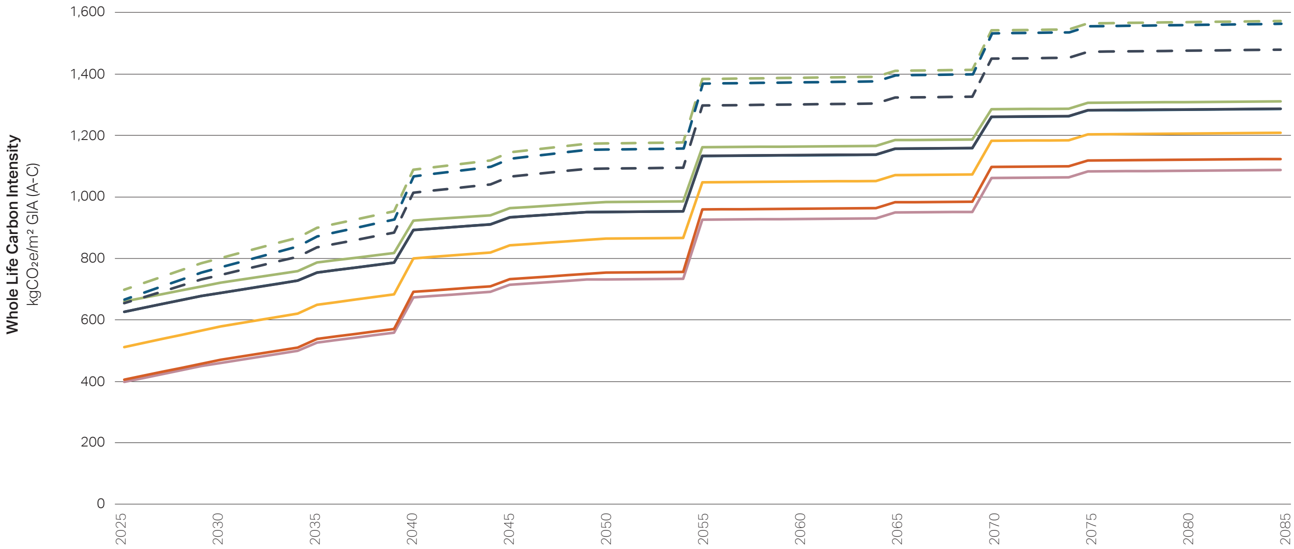


OFFICE-ONLY

WLC Intensity *[A-C]*	*1,125 kgCO$_2$e/m^2*	*1,089 kgCO$_2$e/m^2*	*1,210 kgCO$_2$e/m^2*	*1,288 kgCO$_2$e/m^2*	*1,288 kgCO$_2$e/m^2*	*1,312 kgCO$_2$e/m^2*
	60,283 tCO$_2$e	*77,480 tCO$_2$e*	*111,898 tCO$_2$e*	*100,398 tCO$_2$e*	*100,346 tCO$_2$e*	*102,226 tCO$_2$e*

OFFICE & LAB

WLC Intensity *[A-C]*	*n/a*	*n/a*	*n/a*	*1,479 kgCO$_2$e/m^2*	*1,562 kgCO$_2$e/m^2*	*1,572 kgCO$_2$e/m^2*
WLC Tonnage *[A-C]*	*n/a*	*n/a*	*n/a*	*115,252 tCO$_2$e*	*121,659 tCO$_2$e*	*122,484 tCO$_2$e*



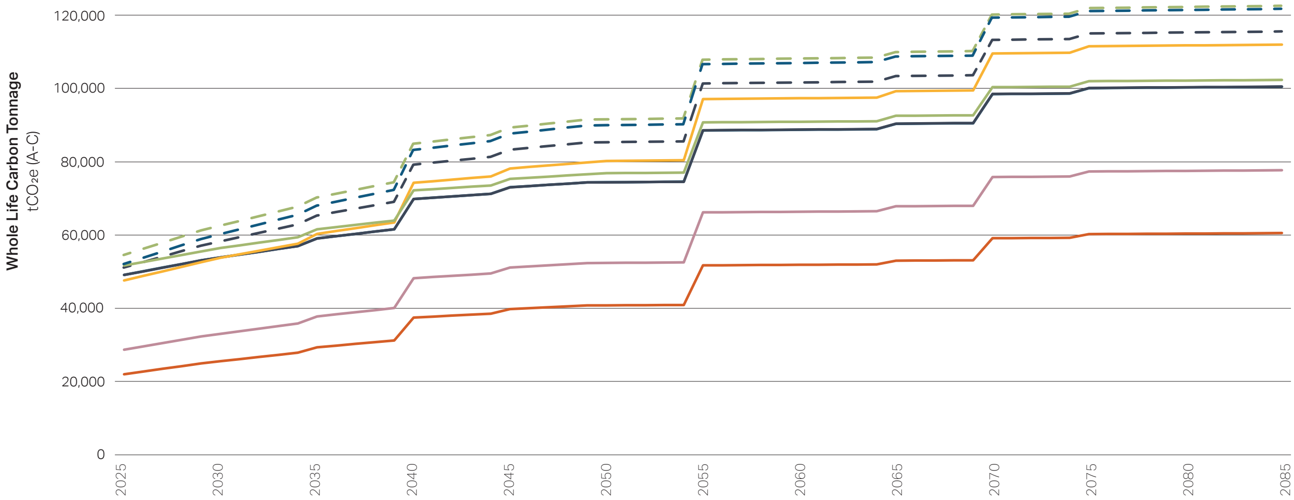
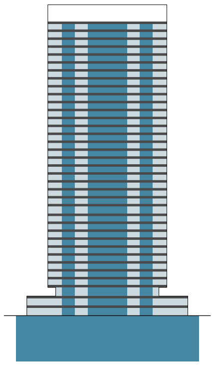


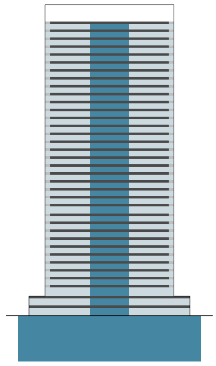
Figure 17.32 Whole life-cycle carbon estimate over time for all options

The matrix on this page summarises and compares the options presented for carbon assessments in this section. More detail against each of these considerations is contained within the respective sections.

Major Refurbishment

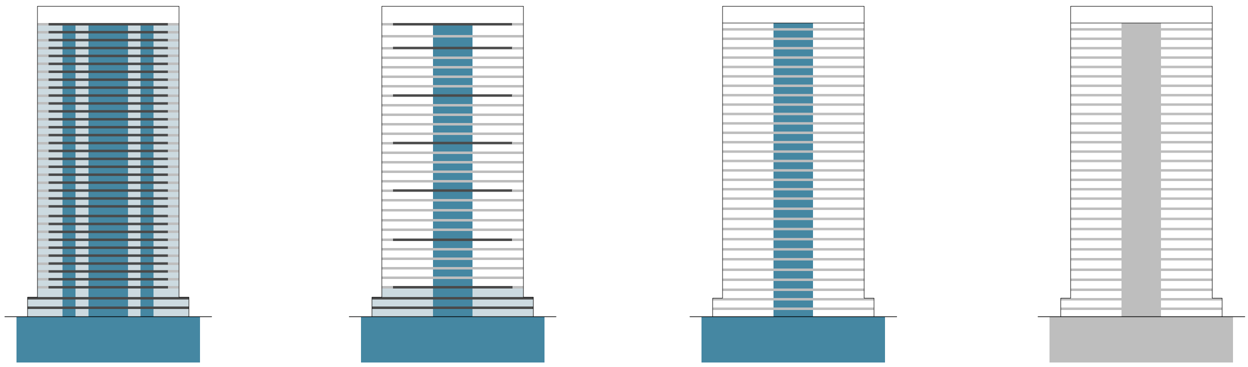


Retention & Partial Extension - Max Retention



	Major Refurbishment	Retention & Partial Extension - Max Retention
Retained structure	89% (carbon) 90% (vol)	93% (carbon) 92% (vol)
GIA	53,263 m^2	71,166 m^2
Upfront carbon [A1-A5]	21,603 tCO_2 406 $kgCO_2e/m^2$	28,322 tCO_2 398 $kgCO_2e/m^2$
Whole life-cycle carbon [A-C]	60,283 tCO_2 1,125 $kgCO_2e/m^2$	77,480 tCO_2 1,089 $kgCO_2e/m^2$
EUI	104 $kWhm^2$/year	95 $kWhm^2$/year
Floor to floor height	3.2 m (office)	3.2 m (office)

** The area of lab-enabled space delivered in this option is lower than the other options, due to constraints on retaining slabs. See Section 17.1.2. If the lab areas were normalised throughout, the trends would follow that for the office-only scenarios, and the Partial Retention and Extension - Retain the Core option would deliver the lowest carbon performance by all measures.*



Retention & Extension - "Full" Retention	**Partial Retention & Extension -** Retain Interstitial Slabs		**Partial Retention & Extension -** Retain the Core		**New Build**	
84% (carbon) 85% (vol)	38% (carbon) 42% (vol)		25% (carbon) 31% (vol)		0%	
92,484 m^2	77,898 m^2		77,898 m^2		77,898 m^2	
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
47,311 tCO_2 512 $kgCO_2e/m^2$	48,805 tCO_2 627 $kgCO_2e/m^2$	50,939 tCO_2 654 $kgCO_2e/m^2$	48,815 tCO_2 627 $kgCO_2e/m^2$	51,877 tCO_2 666 $kgCO_2e/m^2$	51,427 tCO_2 660 $kgCO_2e/m^2$	54,366 tCO_2 698 $kgCO_2e/m^2$
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
111,898 tCO_2 1,210 $kgCO_2e/m^2$	100,398 tCO_2 1,288 $kgCO_2e/m^2$	115,252 tCO_2 1,479 $kgCO_2e/m$	100,346 tCO_2 1,288 $kgCO_2e/m^2$	121,659 tCO_2 1,562 $kgCO_2e/m^2$	102,226 tCO_2 1,312 $kgCO_2e/m^2$	122,484 tCO_2 1,572 $kgCO_2e/m^2$
	Office-only	Office & lab*	Office-only	Office & lab	Office-only	Office & lab
99 $kWhm^2$/year	95 $kWhm^2$/year	141 $kWhm^2$/year	95 $kWhm^2$/year	162 $kWhm^2$/year	90 $kWhm^2$/year	158 $kWhm^2$/year
3.2 m (office)	3.84 - 3.98 m (office) 4.27 m (lab)		3.8 m (office) 4.1 m (lab)		3.8 m (office) 4.1 m (lab)	

18

Euston Tower

Resource Efficiency & Future Proofing

18.1 General

CPG Energy efficiency and adaptation Paragraphs 9.10 - 9.12 set out suggestions for how developments may optimise resource efficiency at various stages of a project life-cycle.

All major applications and new buildings are required to submit a resource efficiency plan. This requirement is acknowledged, and a detailed response will form part of the Circular Economy Statement and Whole Life-cycle Carbon Assessment (WLCA) to be submitted as part a full planning application.

This section briefly sets out the strategies and approaches for resource efficiency, the principles of which are applicable regardless of the development option pursued.

Figure 18.1 Original Euston Tower under construction, photo undated thought to be ca. 1968

18.2 Design Stage

18.2.1 Deconstruction, Reuse, Recycling

The carbon impacts of these proposed interventions would be mitigated, so far as possible, by a detailed deconstruction, reuse, and recycling strategy.

This strategy would, strategically and transparently, analyse the materials to be removed as part of the proposals, and seek alternative uses that maintain as much of the material value as possible. The aim would be to both minimise waste, and also, to reuse these materials (and their historic, associated carbon emissions) in the most beneficial manner possible. The strategy is shown schematically in Figure 18.2.

As part of this strategy, a pre-demolition audit has been conducted, identifying the materials to be removed as part of the proposals. While there exist established routes for avoiding waste going to landfill, many materials are, in fact, downcycled, that is, they are modified and used as materials at lower value (they can also never be returned to the value that they had).

By focussing on the key material hotspots, those that are either large in carbon or quantity (or both, see Figure 18.3), the strategy will be to move as many of these key materials up the hierarchy, as is technically and feasibly possible. Acknowledging that the largest material fraction is concrete (for which a genuine recycling route does not yet exist at scale), this will endeavour to use these materials beneficially elsewhere so that their historical carbon emissions continue to be used. Tangible progress has been made on innovative ways of reusing disused concrete. More information is contained in the Circular Economy Statement that accompanies the full planning application.

All deconstruction materials on site will be carefully segregated so that their optimal end of life routes can be achieved. Examples of strategies for facade materials are presented in Volume One Section 7.5.

A Circular Economy Statement focussing on material reuse and recycling is submitted as part of a full planning application.

MATERIAL REUSE AND RECYCLING HIERARCHY

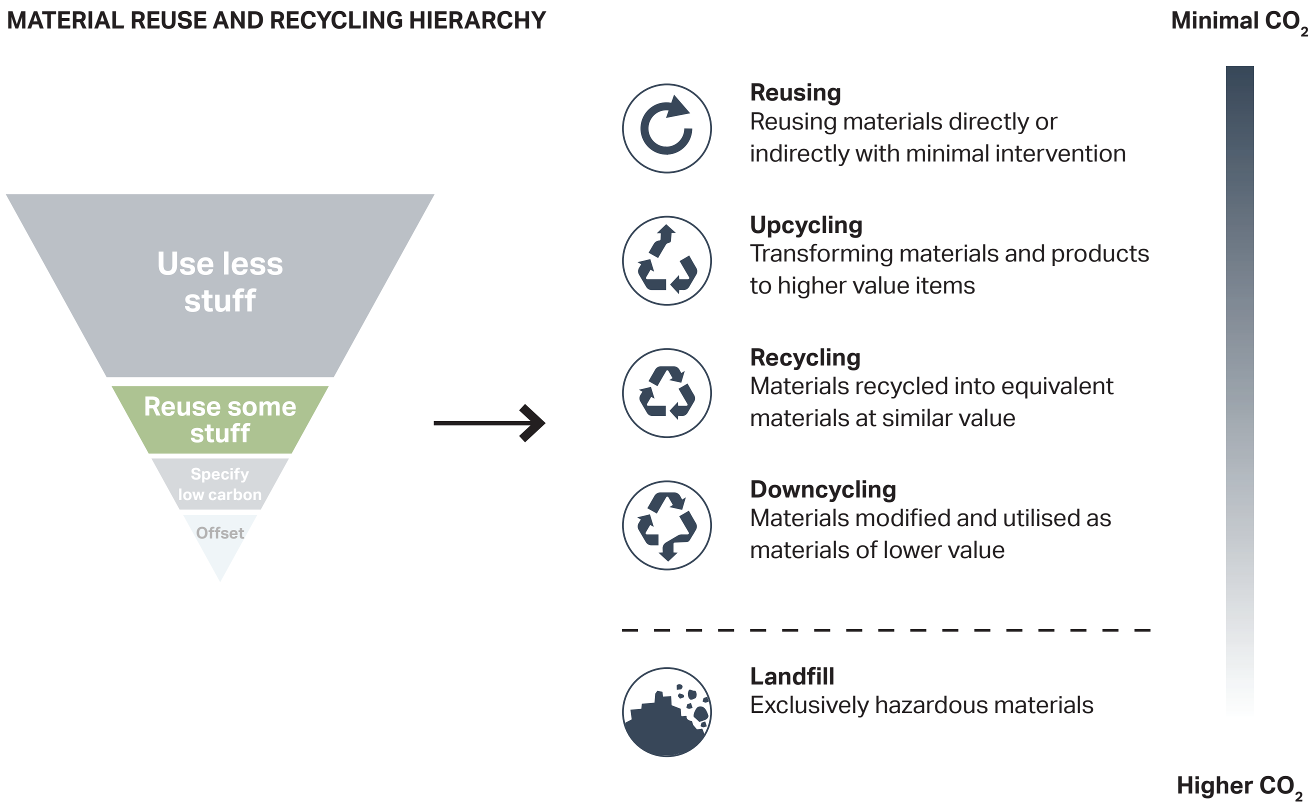


Figure 18.2 Hierarchy for material reuse and recycling

MOST IMPACTFUL MATERIALS FOR REUSE AND RECYCLING

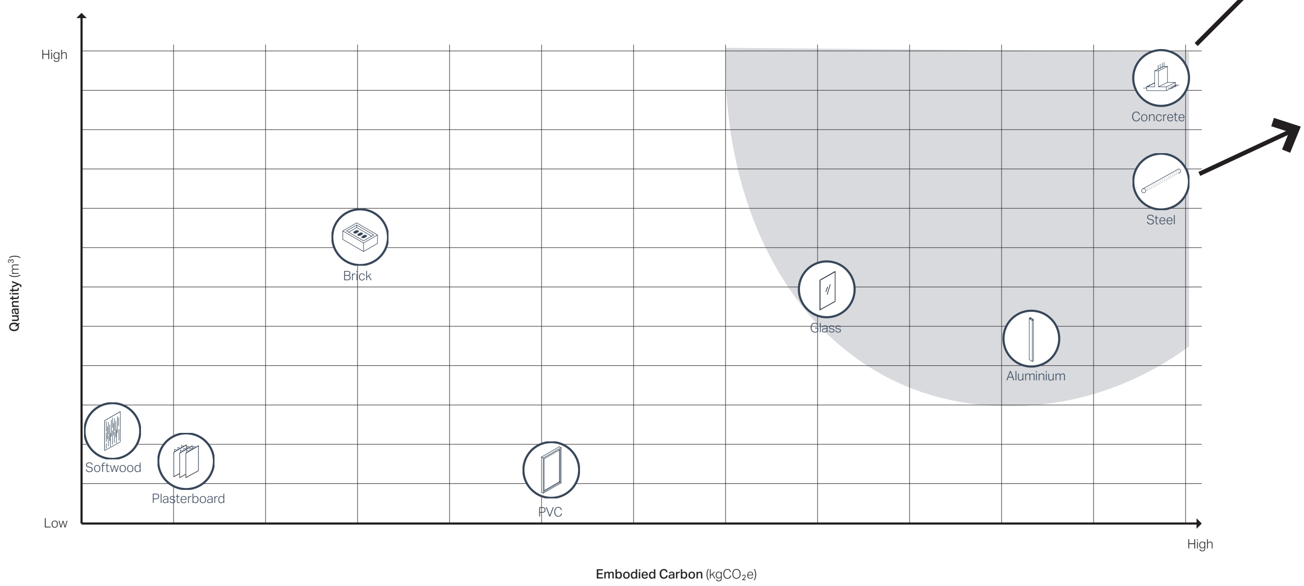


Figure 18.3 Diagram for identifying key material hotspots

18.2.2 Use Less Stuff

For the new build elements, the design approach is to use as little as possible, be that material, energy, or carbon.

For embodied carbon, the strategy is to maximise material efficiency in the first instance. For structures and facades this means designing optimised systems, while for MEP the approach is to reduce material intensity through smart and integrated system selection (e.g. the number of local AHUs is driven by the desire not to have underfloor ductwork distribution).

The focus initially is on design. Following design optimisation, low carbon materials will be selected and specified during procurement. Robust and durable materials will also be selected as appropriate, particularly for finishes in areas susceptible to high traffic.

For energy demand, the building will be developed in line with the energy hierarchy (refer to Volume One Section 3).

- **Be Lean** A fabric first approach will be adopted, utilising passive measures to use less energy. This will be achieved with a high performance facade, limiting solar gains through passive shading and limited glazing areas with low g-values. An on-floor plant strategy may be proposed to maximise controllability and reduce energy waste. High efficiency plant and services, combined with facade performance, will ensure a lean building.
- **Be Clean** No existing local networks. The proposal will be enabled for future connection to heat networks.
- **Be Green** An all-electric building using simultaneous air source heat pumps will be proposed to maximise energy efficiency and reduce carbon emissions in operation. This will have a dual benefit of not harming local air quality. Renewable energy will be maximised where possible (heat pumps in heating and photovoltaic panels). REGO-backed electricity will be procured where possible.
- **Be Seen** Building Management Systems (BMS) will be implemented within the Proposed Development. These systems will oversee and monitor the performance of building systems and services, offering insights into equipment and system efficiency as well as overall energy consumption. The BMS will be enabled to continuously monitor and analyse the actual energy performance post-construction.

As the project is GLA-referable, a WLCA and Circular Economy Statement complete with bill of materials will be produced as part of a full planning application.

HIERARCHY OF NET ZERO CARBON DESIGN

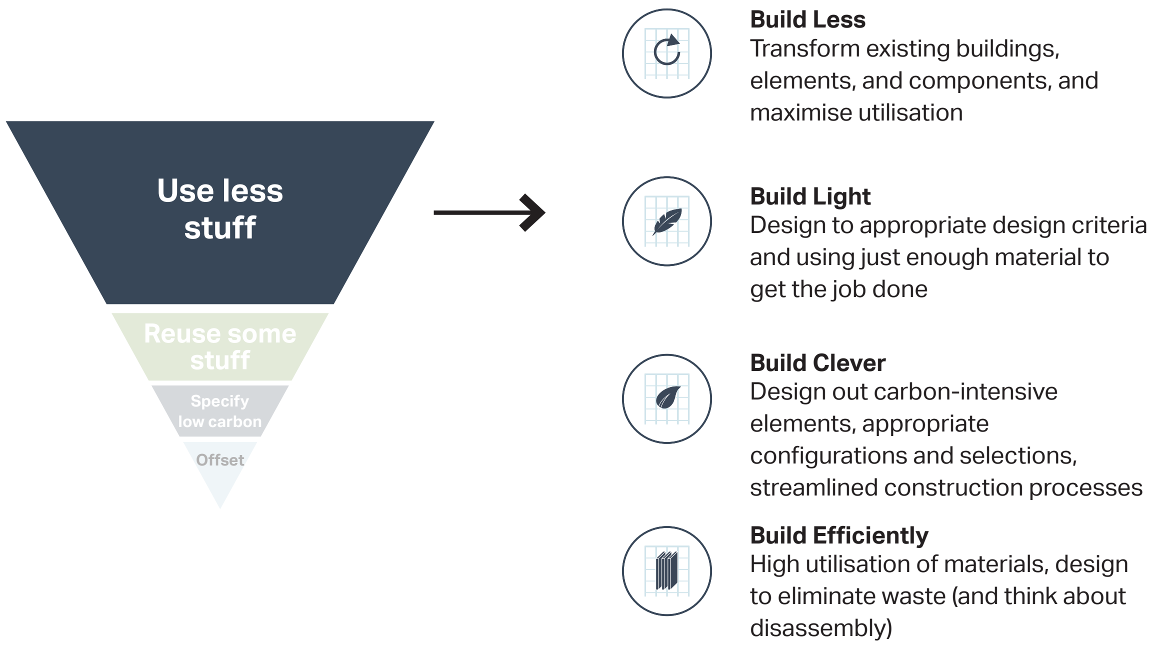


Figure 18.5 Hierarchy for net zero embodied carbon design

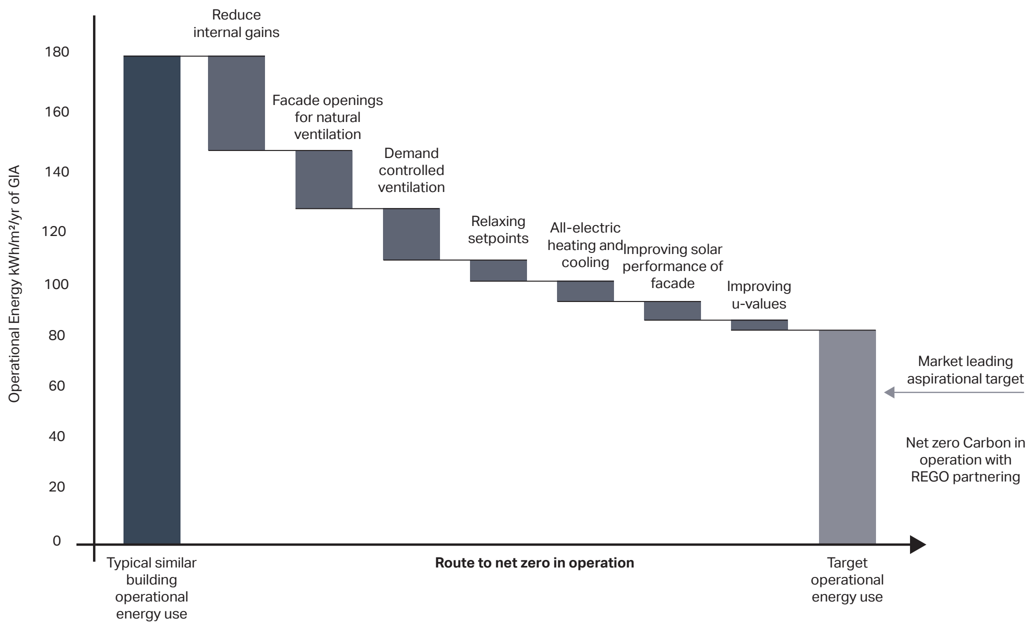


Figure 18.4 Route to net zero carbon in operation

18.3 Construction and Operation Stage

18.3.1 Fossil Fuel-Free Construction Site

During construction, the aim will be to run an best-in-class site, considering all resources used. With Lendlease, it is an ambition to run a fossil fuel-free site, with electric equipment used wherever technically, practically, and feasibly possible. Where this is not the case, alternative fuels will be considered (e.g. HVO provided it is responsibly sourced and palm-oil free).

As detailed in the Pre-demolition Audit in Volume One, waste targets will be in line with the GLA's targets for construction and demolition waste and excavation:

- **CDE** 95% diversion from landfill
- **Excavation** 95% to beneficial use.

A site and operational waste management plan will be submitted as part of a full planning application.

Transportation of materials and waste will be assessed and interrogated as part of the WLCA process, when it comes to procurement. A sustainable procurement plan will be produced in line with the BREEAM requirements, and preference will be given to local sourcing where there is clear benefit to doing so.

As the project is GLA-referable, a post-completion WLCA and Circular Economy Statement complete with bill of materials and end of life routes will be produced, so that actual performance can be tracked.

18.3.2 Best-in-class Metering for NABERS

The aim for the project is to achieve a best-in-class NABERS rating. Because this is based on actual data, this places emphasis on the metering & monitoring strategy during operation. Noting that actual energy demand is contingent on usage and behaviours, the building will be tuned post-completion to optimise its real-world energy performance.

The project will also prototype the British Land Material Passport strategy, collecting and storing data for key materials that facilitates their future reuse or recycling. This will be developed in the later project stages, beyond a planning application.

STANDARD

lendlease

Alternative Fuels
Sustainability

Approver's name and title
Simon Gorski – Managing Director Construction Europe

Last review date:
May 2023

Classification
PUBLIC

Purpose
Lendlease no longer accept liquid and gaseous fossil fuels on any of our construction projects. This is part of our Mission Zero commitment to eliminate all Scope 1 emissions from the fuels we burn, on our journey to achieving Net Zero Carbon by 2025 and Absolute Zero Carbon by 2040. This Standard has been developed to help our Europe business meet the objectives of our Mission Zero Roadmap.

Standard
This Standard applies to liquid and gaseous fossil fuel consumption on all our construction projects, including diesel, petrol, liquid petroleum gas (LPG) and gas to liquid (GTL). Low carbon fuels and energy must be used in their place. These include renewable fuels produced from biomass waste and residue (including HVO), low carbon hydrogen and electric plant and equipment.

For all low carbon fuels used on site, specific evidence must be provided with each delivery, this includes fuel delivery tickets and the associated supply chain traceability documentation when using renewable fuels. This is to confirm the fuel's sustainability credentials. Lendlease accepts renewable fuels from biomass waste and residue except those from palm oil industry related waste feedstocks (such as palm oil mill effluent (POME) and palm fatty acid distillate (PFAD)).

If a construction project must use diesel, petrol, LPG or GTL on-site, a material use justification form must be submitted and approved by a relevant member of Lendlease Construction's Executive Leadership Team (ELT) prior to the specification or use of the fuel. Submission of these to the ELT must come from the Lendlease Project Director.

Contact	Details
Sustainability Europe	SustainabilityEUROPE@lendlease.com

Version 2.0
As at April 2023 Uncontrolled when printed Page 1 of 1

Figure 18.6 Lendlease alternative fuels standard

18.4 End of Life Stage

18.4.1 General

Two of the key principles underpinning our approach are design for long life and flexibility/adaptability, and design for disassembly (demountability).

The lack of adequate capacity for flexibility/adaptability and demountability is one of the aspects that makes working with the existing building so challenging.

This approach can be summarised as ensuring "good bones", meaning a building where the core foundational elements are well-designed, high-quality, long-lasting, and flexible.

The approach uses the “Building in Layers” framework. This means each layer is considered with its own life-cycle, and to support reuse and recycling, different building layers are independent, accessible, and removable while maintaining value, where this is technically, practically, and economically feasible.

The "Building in Layers” framework highlights the importance of the structure. The longevity of the other building layers (facade, services, etc.) is predicated on the longevity of the structure. If the structure cannot be easily adapted to changing requirements, the strategies employed for the other building elements are unlikely to mitigate significant waste and avoid premature obsolescence. This does not diminish the importance of the other building layers, but it highlights that ensuring "good bones" must get the structural elements right. Accordingly, this has been a key focus of our approach.

The following sections outline our approach to these principles, with further information is contained within the circular economy strategy as part of the full planning application.

18.4.2 Baseline and pioneering approach

The baseline position in our approach is a steel-framed building with a "soft core", see Section 18.4.3. Steel framing is proposed as a lightweight solution to minimise load on the retained foundations and enable a load-balancing approach. The steel framing is recoverable at end of life, either for reuse or recycling, and is significantly improved over the in-situ concrete frame in the existing tower.

The ambition for our approach is to explore routes for improving the end of life recoverability of the structural floor systems. This is pioneering and not typically business as usual.

Accordingly, two fundamental structural floor systems are considered:

- Baseline composite metal deck floor system
- Pioneering precast concrete plank system.

The precast option, which could enable better recoverability of the decks, is innovative and bespoke, and therefore needs to be studied, developed, and proven. It is our ambition to continue to study this as the design is developed.

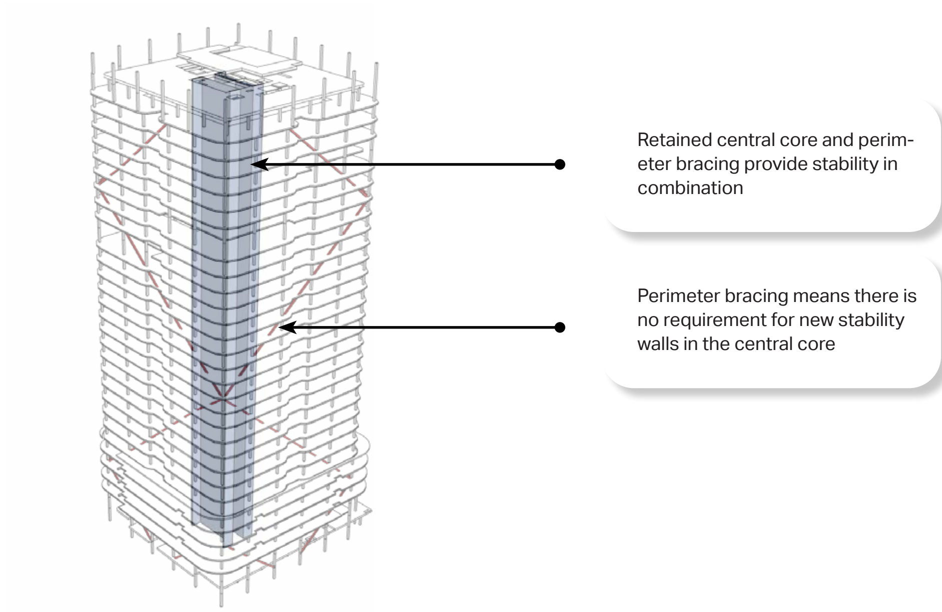
18.4.3 Soft core principle

Adaptability of the structural system is enabled by using a so-called soft core approach.

The overall stability of the structure is derived through the perimeter-braced steel frame and retained central core in combination (maximising use of the existing core’s capacity). This means no new stability walls are required in the central core, and it is therefore free to be adapted as required, which is made easier by it being framed in steel (to minimise self-weight and avoid additional loads on the existing foundations). This is distinct from a typical reinforced concrete stability core, where changes at the core are more challenging to achieve due to their impact on stability.

The principle is shown in Figure 18.7

SOFT CORE PRINCIPLES



Overall stability system

Overall stability is provided by the central core and perimeter bracing in combination. This means there is no requirement for new stability walls in the central core, and the core can be more easily adapted.

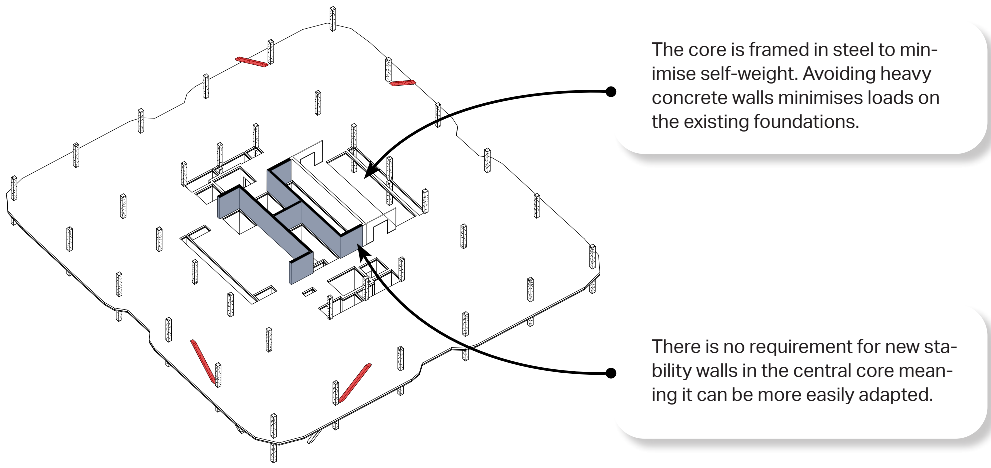


Figure 18.7 Perimeter braced frame enables the soft core approach

18.4.4 Flexibility

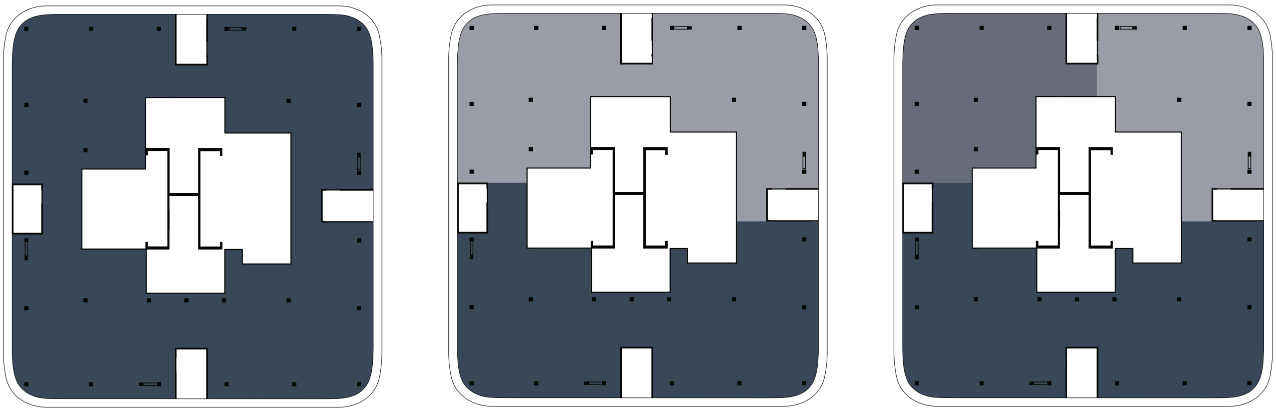
Our understanding of **flexibility** is as per the Greater London Authority's definition: "*A building that has been designed to allow easy rearrangement of its internal fit-out and arrangement to suit the changing needs of occupants*".

Flexibility is likely to accommodate change on a short term time horizon. This means responding to relatively small, and possibly relatively frequent, occupier demands. These changes can occur during leases, or in between leases of different occupiers, such that they may occur several times throughout a building's lifespan, often less than 25 years. These changes should be accommodated in a way that minimises waste, but do not interfere with the overall building operation.

The following measures are proposed to improve flexibility.

BUILDING LAYER	STRATEGY	DESCRIPTION
Structure	Structural grids Soft core	Rational, optimised internal column grid, with regular and clear spans offering flexible layouts. Soft-core principle enables easier flexibility around the core.
Structure	Floor system Soft spots	Composite metal deck floor system is accommodating of local penetrations. Design will include structural soft spots for slab openings, to enable connectivity between multi-floor occupiers for double height spaces and/or other inter-storey connections.
Facade **Space**	Planning grids Potential inclusion of openable vent	Facade and spatial layout is based on a standardised and regular planning grid. This modularity simplifies planning and enhances flexibility in layout design. The 1.5m grid aligns with material dimensions and construction practices. Potential inclusion of openable vents in the facade make it flexible to different occupier demands.
Space	Regular floorplate Multi-tenant layouts	Regular floorplate is suitable for a range of workplace designs. Spatial and core arrangement is designed to enable floors to accommodate multiple tenants across floors, and up to two and three tenants on a single lab-enabled and office floorplate respectively.
Services **Space**	Distribution Climate change allowance	All-air ventilation system with no on-floor ductwork means spatial layouts can be changed without requiring re-configuration of the ventilation system. All power and data distribution is accessible, either exposed at high level on the lab-enabled floors, or within the raised access floor on the office floors. Services designed with an allowance for climate change.

SINGLE AND MULTI-TENANT LAYOUTS



SINGLE TENANT
Allows a single tenant use of the entire floor plate

TWO TENANTS
It is possible to split office levels into two tenancies

THREE TENANTS
It is possible to split office levels into three tenancies

Figure 18.8 Diagram showing indicative multi-tenant layouts

INDICATIVE SOFT SPOT STRATEGY

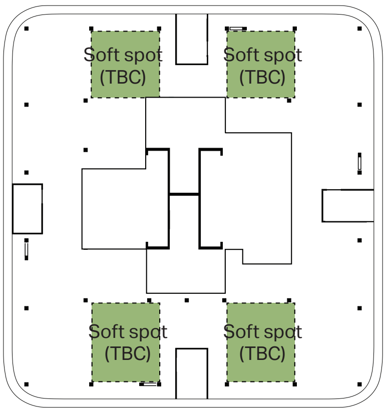


Figure 18.9 Diagram showing indicative soft spot strategy (all locations TBC)

18.4.5 Adaptability

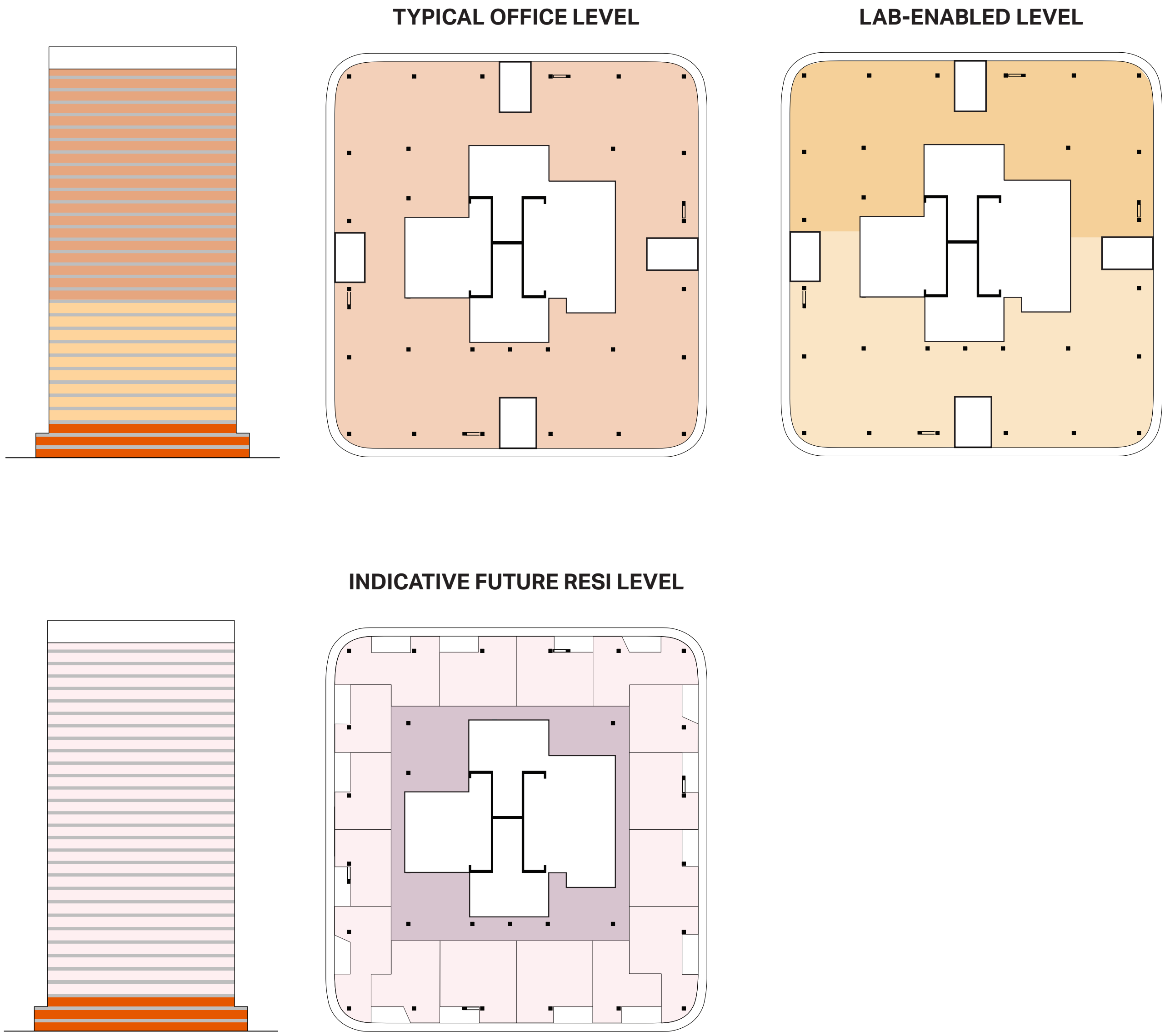
Our understanding of **adaptability** is as per the Greater London Authority's definition: "*a building that has been designed with thought of how it might be easily altered to prolong its life, for instance by alteration, addition, or contraction, to suit new uses or patterns of use*".

Adaptability is likely to accommodate change on a longer term time horizon. This means responding to relatively major, and less frequent, geometric changes. These are unlikely to occur in the short term, possibly only once or twice during a building's lifetime. Accommodating such change is key to preventing premature obsolescence and minimising waste. These types of changes are considered as invasive, and are likely to occur with a period of interference to the overall building operation.

The following measures are proposed to improve adaptability.

BUILDING LAYER	STRATEGY	DESCRIPTION
Structure Space	Loading capacity Riser adaptation Floor to floor height Floor system	Structural loading and floor to floor height have sufficient capacity for a range of future alternative uses (e.g. residential). Soft core principle enables adaptations to the core, such as additional lifts, risers, etc., without impacting on the overall structural stability system. Composite metal deck floor system is accommodating of local penetrations. Floor to floor heights are optimised, and proposed with sufficient capacity to accommodate change of use, without having to deconstruct the floors. The full structure would be retained in this change of use scenario.
Facade	Planning grids Glazing ratio Potential inclusion of openable vent Building in layers	Planing grid and regular floorplate make it possible to retain the facade in a residential conversion. Glazing ratio is limited to control heat gain, and where included, the openable vent could be adapted to provide additional ventilation, or similarly via the inset balconies. Should conversion necessitate a different facade (due to material lifespan or performance), the facade is independent of the primary structure and could be removed without impacting the structure. All primary materials are separable and recyclable.
Services	Plant space Services access	Space for central services, and riser allowances, are likely to accommodate that required for residential use. If needed, structural adaptations are less intrusive due to soft core. All services are accessible and removable via BMU/goods lifts.
Services Space	Multi-use layouts	The design includes lab-enabled spaces, which is achieved through a structural design that allows for the heightened vibration criteria, and an increased floor to floor height to accommodate required servicing provisions. These floors are flexible and can equally function as standard commercial office, without requiring changes to the facade or services provisions.

ADAPTABILITY FOR CHANGE OF USE



KEY

- *Lab-enabled space*
- *Write up space*
- *Office*
- *Residential*
- *Access*
- *Podium amenity*

Figure 18.10 Diagram showing indicative change of use

18.4.6 Design for disassembly

Our understanding of **design for disassembly** is as per the Greater London Authority's definition: "*designed to allow the building and its components to be taken apart with minimal damage to facilitate reuse or recycling*". The final phrase is important to consider, because it implies the importance of recoverability.

Baseline
As outlined in Section 18.4.2, the proposal comprises a steel-framed structure.

The floor structure will be a lightweight solution infilling the steel frame, see Figure 18.11. The baseline position is a composite metal deck. The composite metal deck solution is suited to in-use adaptation as it is accommodating to incorporating new penetrations. This is particularly relevant at the soft core where new risers or penetrations may be needed in the future. The system is proposed as a baseline as it can best balance embodied carbon, programme, circularity, and is a proven solution.

Not only is a steel-framed structure more adaptable than a concrete-framed structure in-use, unlike a typical in-situ concrete system, the proposed steel frame has an established reuse/recycling end of life pathway. Accordingly, in this baseline scenario, the proposed steel frame would be designed to be disassembled at end of life, such that the steel members could be reused. Any members that are found not to be reusable, would be sent for recycling. The composite metal deck will be separated into its constituent materials and recycled using advanced recycling techniques.

BASELINE STRUCTURAL SYSTEM SKETCH

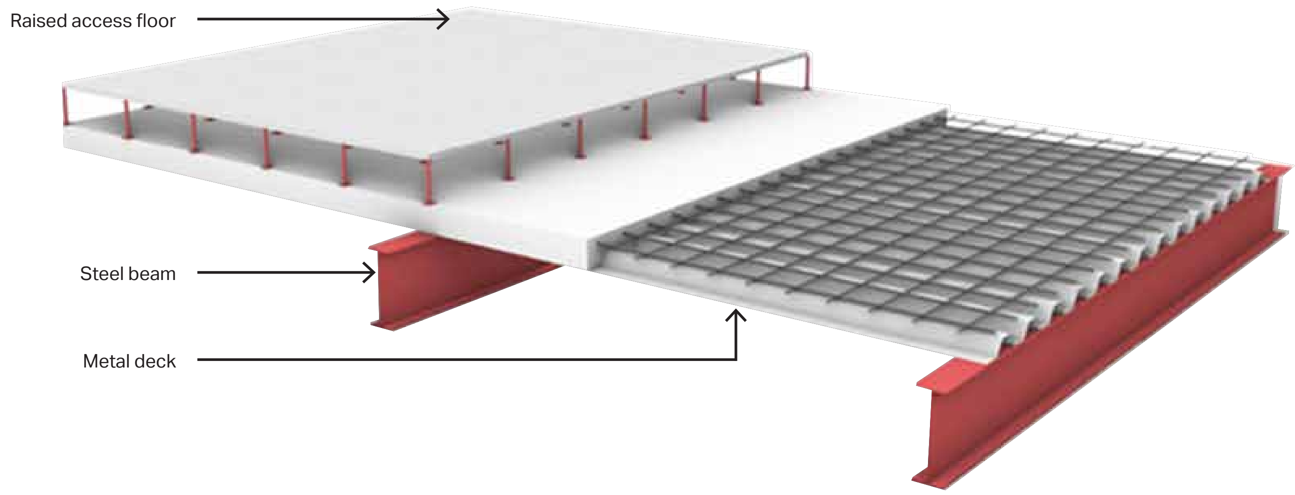
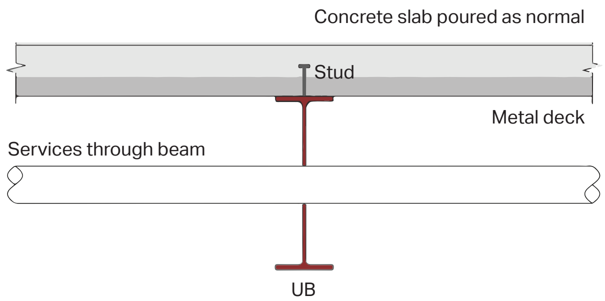


Figure 18.11 Sketch of baseline structural floor system components

FLOOR SYSTEM CONNECTION DETAILS



CONNECTION TO BEAM

A conventional composite metal deck
connected using shear studs

Figure 18.12 Diagram showing conventional (left) and demountable connection to improve recoverability

Pioneering
An alternative floor structure uses precast planks, with the aim of improving the end of life recoverability of the floor systems.

This is a pioneering option, and is being investigated by the project team. It does not represent a commitment to pursuing this route.

In this case, the structural floor system for the new-build portions of the tower would be pre-stressed precast planks, supported on shelf plates and recessed within the beam depth. The planks are grouted together to act as a rigid diaphragm. A sketch of the floor system is shown in Figure 18.13.

Unlike a typical in-situ concrete system, the proposed steel and precast plank structural floor system is constructed using a series of pre-fabricated parts. The intention in the design is to assemble these parts in such a way that facilitates non-destructive disassembly.

The procedure below illustrates indicatively the steps that would be required to disassemble the floor system. Acknowledging that the desire for non-destructive disassembly is in tension with the need to provide a rigid diaphragm action, our ambition is to continue exploring options and ideas that rely on mechanical connections.

1. During constriction, grout would be added between the planks and the beams to provide rigid diaphragm action between the planks. The grout would be broken out, with the intention that it is weak enough to knock off by hand.
2. Each plank contains a steel bar embedded within it and passing through the steel beam for robustness. This is for safety purposes to protect against planks falling should the structural integrity of the primary frame be undermined. The bar would be cut back to facilitate removal.
3. With the grout and steel bar removed, the planks are loose on the shelf angles. They would be lifted out individually, and stored safely for later use.
4. The bare steel frame could be disassembled using any methodology that makes practical sense. If it is to be reused as-is, then the bolts would be unbolted and the beams and columns removed whole. But if it is to be reused in a different application, it may be more practical to cut the connections with an acetylene torch before transporting beams and columns for repurposing.

18.4.7 Risk of Disproportionate Collapse

Euston Tower is a Class 3 building and must conform to appropriate robustness requirements to guard against disproportionate collapse. In all scenarios, effective horizontal and vertical ties will be provided though structural elements as required. A systematic risk assessment of the building will be completed, and the critical situations identified will be designed against. Special care will be taken to ensure that both the reuse of structural elements, and any design to promote ease of deconstruction, will be compatible with these requirements. Note that the floorplates are designed to resist appreciable diaphragm forces arising from lateral loading under wind and as such are inherently resilient.

PIONEERING STRUCTURAL SYSTEM SKETCH

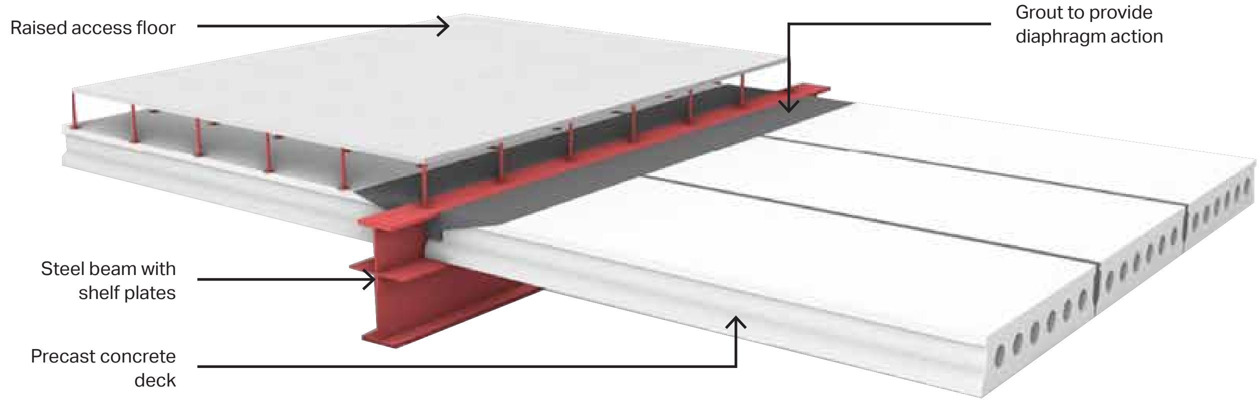
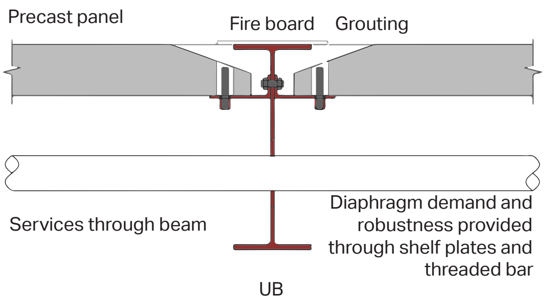


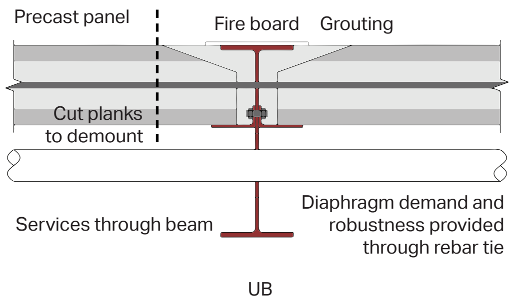
Figure 18.13 Sketch of pioneering structural floor system components

FLOOR SYSTEM CONNECTION DETAILS



IDEAL CONNECTION

Precast planks are wholly recoverable at original size



ALTERNATIVE CONNECTION

Precast planks are recoverable but would need to be cut and therefore shortened during deconstruction

Figure 18.14 Diagram showing ideal (left) and alternative connections

19

Euston Tower

Conclusion

19.1 Conclusion

Sections 17 and 18 have presented approaches to retention of the existing building as part of its redevelopment. They have been assessed systemically and transparently, in respect of architectural, technical, end of life, and carbon considerations. Within these assessments, the following possible options have been studied for a building that retains varying degrees of the existing structure:

- **Major Refurbishment**
  Shown in Volume One not to be feasible.
- **Retention and Partial Extension**
  Max Retention
- **Retention and Extension**
  "Full" Retention
- **Partial Retention and Extension (Disassemble and Reuse)**
  Retain Connective Slabs (Office)
  Retain Connective Slabs (Office and Lab)
  Retain Interstitial Slabs (Office) / (Office and Lab)
  Retain the Core
- **New Build**
  New Build.

Volume One of this Feasibility Study showed that it is not feasible to upgrade the existing building to modern standards within the existing envelope. The resulting space would be compromised and unattractive from a letting perspective, primarily due to its disconnected floor layouts, and low floor to ceiling heights that are not commensurate with the type of space the letting market demands for a building of this scale.

Daylighting levels have been established for a floorplate within the existing envelope and at the existing floor to floor height. By comparison to floorplates not within the existing envelope, it was shown that the areas of well-daylit space reduce materially when the floorplate is extended outwards, even by a small amount. This reduction in well-daylit space is however mitigated with an increased floor to floor height, with the benefit that the absolute area of well-daylit space exceeds that for the floorplate within the existing envelope and at the existing floor to floor height. This provision of a high amount of well daylit space is necessary to create the high quality spaces that are attractive to the large tenants, who are essential to a successful letting strategy for a building of this scale, and to deliver on the environment the Knowledge Quarter is seeking to foster.

In order to provide reasonable on-floor efficiencies, the vertical transportation strategy makes use of double-decker lifts. This presents a compromised position for the use of options which retain existing slabs, while resolving the floor to floor height issues previously described, because the vertical transportation strategy is contingent on having consistent inter-storey heights to avoid prohibitive efficiencies by using single-decker lifts. In addition, there is an unacceptable procurement risk to the development by procuring twin lifts due to their being only a single supplier.

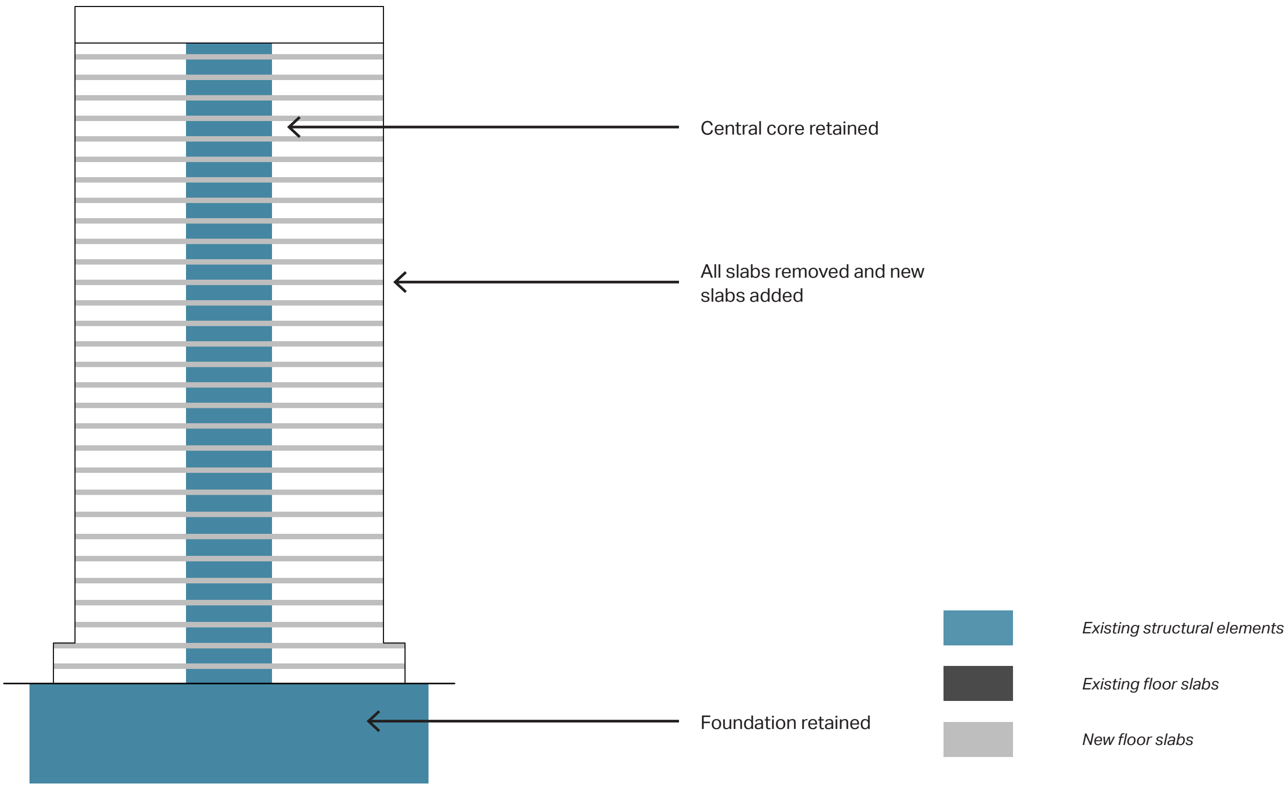
Whole life-cycle carbon assessments (WLCAs) have been conducted for selected options with varying degrees of retention. With respect to total tonnage and intensity of carbon emissions, the Retain the Core option presents the lowest whole life-cycle carbon position when compared with the other options that resolve the floor to floor height issues previously described (Retain Interstitial Slabs and New Build). This is in spite of the Retain the Core Option retaining 31% (by volume) of the existing structure compared to 42% (by volume) for the Retain Interstitial Slabs option.

The Retain the Core and New Build options are relatively similar when considering both total tonnage and intensity of carbon emissions. This is primarily because the majority of the carbon emissions are in the above ground works, where the two options are materially similar, and while the New Build option includes a new basement and central core, the additional carbon associated with constructions is identified to be offset in whole life-cycle terms by its slightly improved operational performance (by comparison to the Retain the Core option).

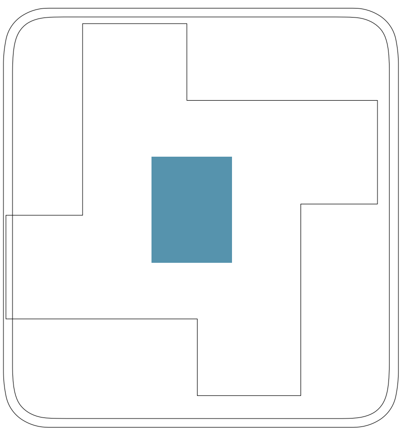
It is acknowledged that the position is prima facie finely balanced from a letting perspective and also in whole life-cycle carbon terms. Both options address the issues around daylighting, floor to floor height and quality of space in a way that can be delivered practically and efficiently. They also do so while offering flexible floorplates with clear spans, unconstrained by the existing building grid, and a floor system that could be adapted over time and disassembled easily at its eventual end of life.

On balance, the Retain the Core option is identified to be preferable. This is because it offers the best balance of structural retention, quality, flexibility, and adaptability. And it does so with a whole life-cycle carbon position that is the lowest of the options that deliver the quality of space which is necessary for the redevelopment of Euston Tower to be successful.

RETAIN THE CORE



ALL LEVELS
Central core retained, floorplates removed



INDICATIVE CORE LAYOUT
Expanded Central Core

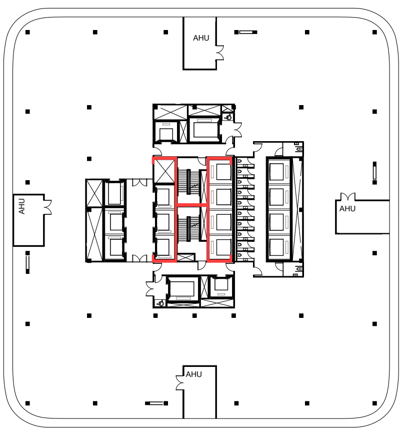


Figure 19.1 Diagram showing retained structural elements and possible core layout in the proposed option

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Euston Tower

Appendices

Appendices

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