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Counting the *upfront* carbon in Cat B office fit out

A cross-sector industry report that seeks to establish upfront carbon performance levels for ***key elements*** within a Cat B office fit out

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This research on individual building elements aided a wider project by a cross sector team, that sought to define a performance level for upfront carbon in Cat B office fit out.

This research was led by Zoë Glander from Overbury, with research of individual building elements prepared by the following contributors:

MEP

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Alice Jackson – Hoare Lea

With special thanks **Phil Guthrie** from Hydrock

Furniture

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Lucy Bagshaw – tp bennett

Ana Rita Martins – MCM

Phil Towle – The Furniture Practice

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Catering

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Joinery

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With special thanks to **Gordan Emm, Matt Lawrence and Trevor Baker** (Brown & Carroll), **Emilie Metcalf and Sam Read** (BA Joinery), **Gary Lynch** (Specialist Joinery Group), **Sarah Mann** (Taylor Made Joinery) and **Paul Willingale** (Shadbolt)

Temporary works

Toby Sowood – Mace Consult

Adam Bora – Mace Consult

Staircases

Akos Brandecker – Living Building Consultancy

Reuse

Flavie Lowres – FIS (Finishes & Interiors Sector)

Nick Woodmore – Landsec

Alison Grant – HLW

Elemental research: at a glance

The question:
How can performance levels for individual fit out elements inform a performance level for upfront carbon in Cat B office fit out?

Why is it important?
It is acknowledged that a single performance level for Cat B projects that are so variable in scope and scale is challenging. More granular analysis of elemental performance levels may in fact be of greater practical benefit to teams looking at carbon optioneering on fit out projects. This research sought to understand performance levels relating to some of the building elements where there is limited analysis shared to date; MEP, furniture, catering kitchens, joinery and staircases. It also sought to review the challenges of collecting data and accounting for elements of work where approaches by LCA practitioners vary, as is the case for temporary works, reused items and joinery.

So what do we do?
This research serves as a starting point for interested stakeholders to benchmark elements with their own fit out projects. It also allows transparent discussion within the wider industry about the research that is still needed to refine the process of accounting for these elements and reducing the carbon impact of each element. Ultimately, it's hoped research such as this will help us to understand the impact of individual building elements better and reduce the impact of fit out over time.

Day-to-day, what part can everyone play?
The advice varies depending on the element and the table below gives you a high-level summary. This full report should be consulted for the knowledge gathered and important next steps for each element. Dive into the detail, volunteer to help drive knowledge about an element forward, and where a performance level exists; begin using this to inform carbon optioneering and reduction on your fit out projects.

Element	Upfront Performance Levels	Research methods
Mechanical, electrical and public health (MEP)	Performance level: 47kg CO_2e/m^2 GIA	Desktop research Case Studies Architype projects
Furniture	Performance level: 37 kg CO_2e/m^2 GIA	Desktop research Case Studies Product research
Joinery	Performance levels: Tea points: 2,223 kg CO_2e/unit Bespoke tables: 599 kg CO_2e/unit Reception desks: 3,487 kg CO_2e/unit Storage shelving: 517 kg CO_2e/unit Bathroom vanities 634 kg CO_2e/unit	Manufacturer interviews Case Studies Product research
Staircases	Requires continued research to develop a performance level	Manufacturer interviews Desktop research
Catering kitchens	Performance levels: Small kitchen (30m²): 4,686 kg CO_2e/m^2 Medium kitchen (55m²): 2,878 kg CO_2e/m^2 Large kitchen (98m²): 2,214 kg CO_2e/m^2	Achitype projects Product research
Temporary works (TW)	Requires continued research to develop a performance level	Desktop research
Reuse	Requires continued research to develop a performance level	Desktop research & Case Studies

Contents

Part 1 is available from
www.overbury.com/carbon-in-cat-b-fit-out

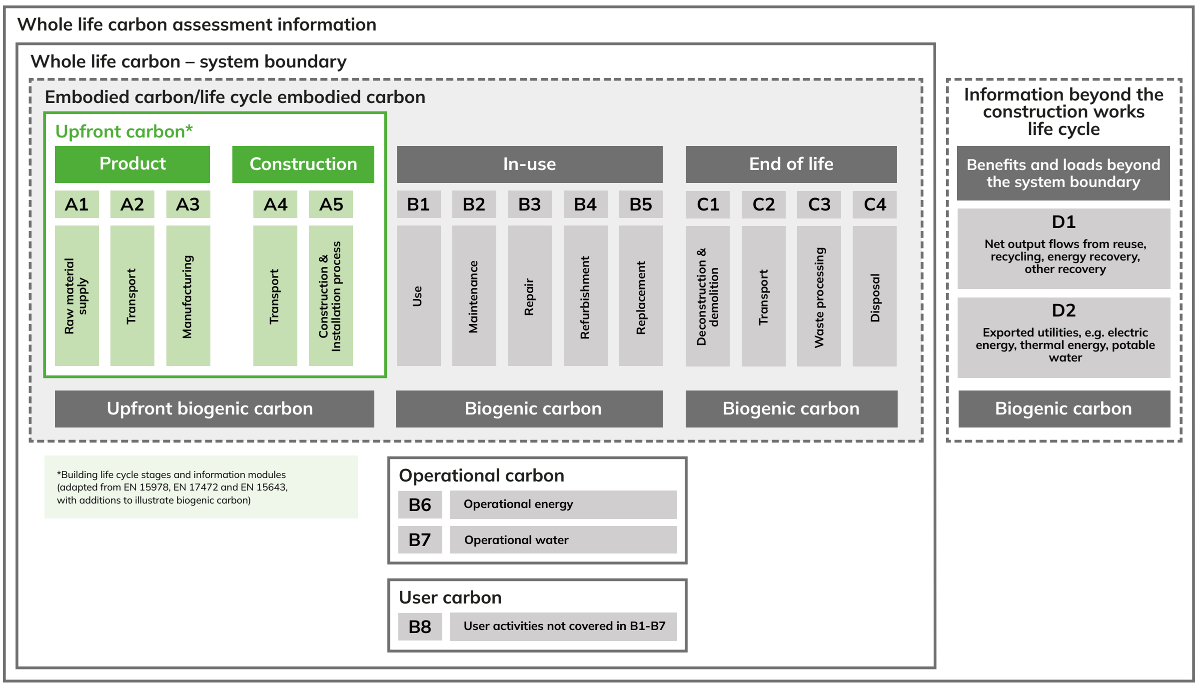
Individual building elements: Introduction

To achieve net zero carbon targets, we need to account for and understand the upfront carbon (life cycle modules A1-A5) contributions of all the building elements of a Cat B fit out project.

Alongside the research described In Part 1 of this whitepaper, we undertook studies to:

- Give the primary (Part 1) research group a more detailed understanding of each building element to help with its analysis.
- Establish upfront carbon performance levels for elements and sub-elements to inform the final total number for Cat B fit out provided to the Net Zero Carbon Building Standard.

While each building element research project differs slightly, their broad purpose was to:
- Understand the range of product/material/assembly types for each element.
- Review the availability of upfront carbon data for each element.
- Assess how each element is currently accounted for in a Whole Life Carbon Assessment. How could a consistent process be created to avoid variable results from different life cycle assessment practitioners/tools?
- Identify the proportion of upfront carbon contributed by each element of a fit out. Which elements should be a focus for decarbonisation?
- Improve project planning and decision-making so that architects, specifiers and developers can make more informed, lower-carbon choices.
- Boost data transparency and accountability to promote responsible manufacturing practices and supply chain sustainability.
- Accelerate progress towards net zero by highlighting gaps in data and research and suggestions for improvement and collaborative efforts.



1.0 Mechanical, electrical and public heath (MEP)

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This research has been prepared by Will Belfield and Alice Jackson from Hoare Lea, supported by dialogue with Phil Guthrie from Hydrock. Phil's input ensured the scoping of a Cat B fit out didn't significantly overlap with Cat A and core services analysis undertaken by the NZCBS.

Will Belfield
Hoare Lea

Alice Jackson
Hoare Lea

Context

MEP equipment can account for as much as half of a fit out's upfront carbon emissions – especially when Cat A services are stripped out and fitted as new. Yet, when it comes to WLCAs, this important area is often misunderstood, underestimated or excluded altogether.

Recent years have seen a drive for more sustainable MEP, with corporate commitments such as Building Services Engineers Declare and MEP 2040 applying pressure.

Larger manufacturers are starting to produce Environmental Product Declarations, while the launch of Chartered Institute of Building Servicess Engineers TM65 in 2021 enables estimates of the embodied carbon of MEP items without an EPD.

At the same time, a shift to all-electric buildings will see fugitive emissions from refrigerants become an issue, and we must pay attention to the carbon impact of this.

Methodology & results

To establish the upfront carbon performance level for MEP in Cat B fit outs, this research group undertook a two-step process:

1. A theoretical assessment of a typical Cat A to Cat B scope fit out, in order to define appropriate boundaries expected from a sufficiently detailed analysis of MEP.
2. Statistical analysis of a dataset of building WLCAs, which had been collected as part of a wider call for evidence.

This study looks exclusively at the upfront carbon (A1-A5) emissions within the dataset of building WLCAs.

MEP is wide ranging, so work began by defining the study's scope.

Two things were first established:

- The assumed starting position from Cat A installation
- Expected scope of Cat B design

As part of the theoretical assessment, it was assumed that a Cat A fit out would have full MEP for an open floor plan, including items like fan coil units, mechanical ventilation, lighting fixtures, power supply and capped services for items such as water.

MEP elements were then classified into four categories of a typical fit out:

- Always included
- Sometimes included
- Already present with potential for alterations
- Never expected to be in scope

This was based on the '5.0 Services' section of the RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition (2023) (RICS PS WLCA 2nd edition). See pages 19 & 20 for the full list of assumed scope of MEP for a Cat B fit out.

Theoretical Assessment

The assessment of fit out from Cat A to Cat B was based on theoretical design. This gave context when analysing the WLCA datasets, as well as better understanding of the scope where there was limited data beyond a singular MEP number.

The theoretical design was also based on a Cat B fit out that retained or modified as much Cat A equipment as possible. It ranges for each element across the scope of the fit out; the number being calculated accounted for approximately 30% strip of existing Cat A.

Additional equipment that required quantifying within the Cat B number included:

- Communication equipment for SER rooms
- Minor modification to sprinkler systems
- Some on-floor additional WC facilities
- Public health equipment servicing catering areas
- Modifications to ductwork
- Modifications to low-temperature hot water, chilled water and condensate pipework, including new pipework where necessary
- Movements of fan coil units, including new units where necessary
- New local cooling systems (DX/CRAC) to comms rooms
- Additional ductwork ancillary equipment such as VAV boxes, fire dampers and attenuators
- Electrical infrastructure to support small power items
- Additional security items and fire detection

Items not included were:

- Catering equipment – this is addressed in a separate study. (See section 3.0 of this whitepaper)
- A5 emissions associated with the site utility output involved with installing MEP equipment – this will be accounted for on a project-wide basis when considering full scope of the fit out.
- Upfront carbon of the base-build Cat A items that weren't used – it's assumed that these would have been accounted for in any analysis of the base-build and Cat A fit out.

This provided context to the analysis of the WLCA datasets.

Separately to the theoretical assessment, the MEP upfront carbon emissions from the WLCA datasets were plotted in graphs to determine median, first quartile (Q1), third quartile (Q3), interquartile range (IQR), upper fence (Q3 + (1.5*IQR)) and lower fence (Q1 – (1.5*IQR)) numbers. (See Figures 1-3 below.)

By finding a median, the results aren't skewed by exceptionally high or low values. Also, it's possible to identify outliers that fall outside the lower and upper fences.

Statistical Analysis of WLC Datasets

Figure 1 is an initial view of all Cat A to Cat B datasets. It shows clear outliers – those of zero (suggesting MEP was not accounted for) and those above the upper fence. These outliers were then removed.

Figure 2 shows two sets of results: 10-20 kg CO_2e/m^2 GIA (gross internal area) and 45-55 kg CO_2e/m^2 GIA.

Where figures were very low, the data was deemed not to have captured all elements of the Cat A to Cat B scope as defined on page 20 & 21.

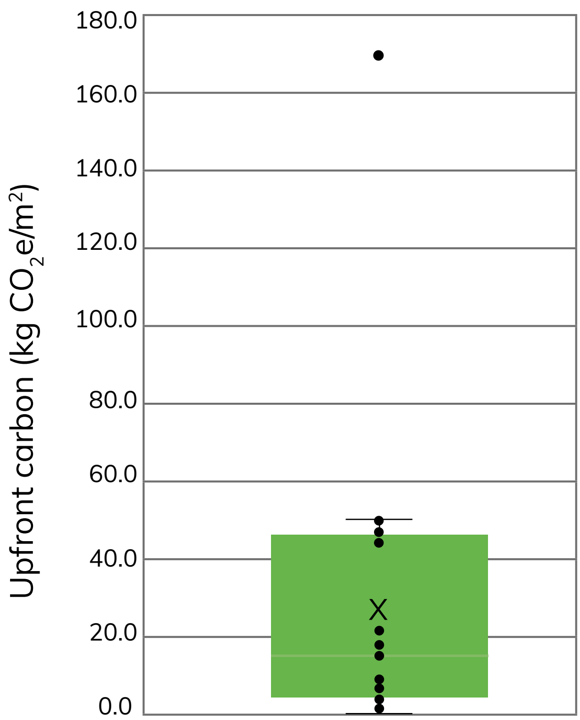

Figure 1: All MEP upfront embodied carbon (A1-A5) results from datasets. Standard deviation: 36 kg CO_2e/m^2 GIA

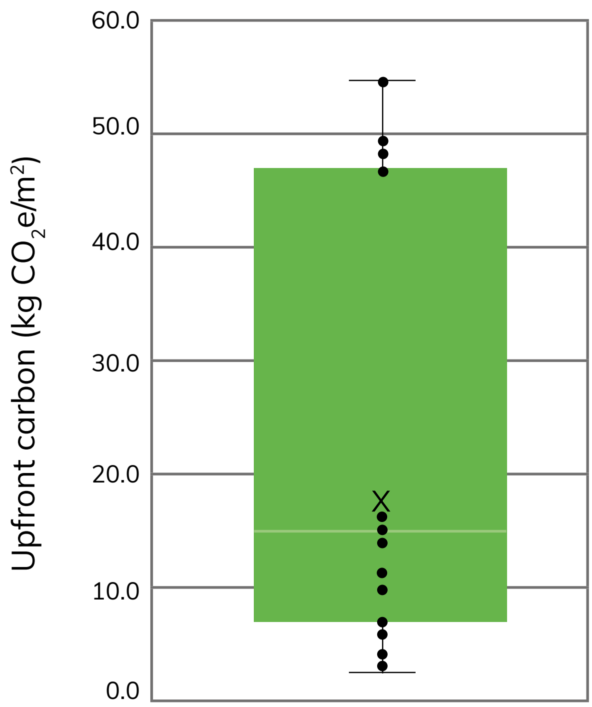

Figure 2: MEP upfront embodied carbon (A1-A5) results from datasets, excluding outliers. Standard deviation: 18 kg CO_2e/m^2 GIA

Based on the review of MEP elements on page 20 & 21, the following was identified as the minimum scope of equipment included in a fit out Cat A to Cat B:

- Cables and cable containment
- Electrical infrastructure
- Server/data equipment

In the theoretical assessment, these items came to 25 kg CO_2e/m^2 GIA – a number that might be expected for a project that makes no alterations to the existing ceiling MEP. With this in mind, when it came to reviewing the datasets, data points under 25 kg CO_2e/m^2 GIA were ruled out. These were seen as either underestimations of the impact of MEP or reflective of only a light-touch fit out. The remaining data points are summarised in Figure 3. The median of these results is 47 kg CO_2e/m^2 GIA

In reality, there are likely to be significant modifications to the existing services and fittings, such as the addition of feature lighting and the replacement of fan coil units and associated pipe and duct work. In light of this, and in alignment with the results of the assessment, the median value of 47 kg CO_2e/m^2 was found to be an appropriate up front carbon performance level.

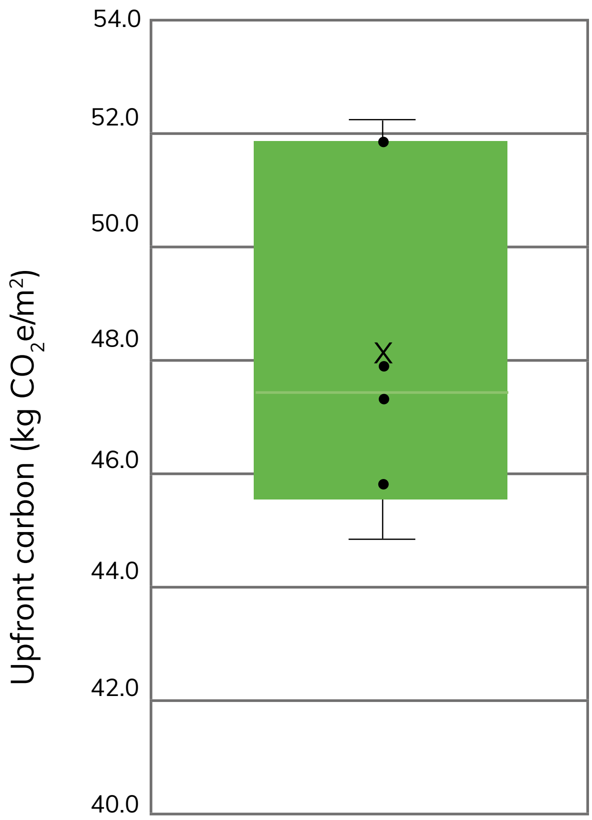

Figure 3: MEP upfront carbon (A1-A5) results from datasets, including only those above 25 kg CO_2e/m^2 GIA and excluding outliers. Standard deviation: 3 kg CO_2e/m^2 GIA

Limiting factors of this research

Scope of assessment

This research explores only upfront carbon emissions A1-A5, not lifecycle modules B1-B5 or C1-C4.

This has particular limitations for MEP due to the following:

- Material replacement (B4) can be high for certain MEP elements, like lighting fittings and communication installations.
- Use (B1) includes refrigerants, which means these significant emissions haven't been considered. It's noted that, for fit outs, the only refrigerants typically in scope are those within any additional local cooling systems. Designers should aim to specify units that use refrigerants with low global warming potential (GWP). The best for fit out equipment is R32, which has a GWP of 675 kg CO_2e.
- It may be the case that a Cat A space uses a variable refrigerant flow (VRF) heating system. This will likely need to be modified for Cat B fit out, which means the refrigerant within the system that's already been primed and commissioned will need to be pumped down. This will inevitably cause some leakage.

Consideration should still be given to these lifecycle modules during design.

Furthermore, this study looks to cover a 'typical' Cat A to Cat B fit out. In reality, there'll be large and varied scope in MEP installation and strategy. For example, some workplace developments require significant data centre equipment on site, while some have special items such as saunas.

Source of information

The dataset itself also posed limitations:

- Determining MEP embodied carbon impacts has seen rapid development since the launch of CIBSE TM65 in 2021. As such, detailed assessments have been used more frequently based on design stage information, with limited as-built case studies available.
- The case studies collected gave insufficient detail to explain what was in and out of scope for each WLCA, so an element of interpretation has been employed.
- Significant resource is required to establish material quantities due to the complexity of different MEP strategies. Smaller projects will likely not do this. This was evident in the number of assessments that recorded zero or near-zero values for MEP elements.
- The assessment of a typical Cat A to Cat B fit out relied on some CIBSE TM65 calculations for particular elements. These aren't third-party verified.

Recommendations for further action or research

Based on the limitations of this research and the data collected, the following is recommended:

1. Expand the scope to look at lifecycle modules B4-B5 and C1-C4. Examine the impact of material replacement, refurbishment and end-of life scenarios.
2. Benchmark the fugitive emissions associated with refrigerants (B1). Explore the types of refrigerant used, their total charge and their likely leakage rates.
3. Develop further tools and guidance to support the calculation of material quantities for common MEP equipment. This will make estimating the likely impact of MEP more accessible to a wider range of projects.
4. Encourage manufacturers to provide more data on the carbon associated with MEP equipment.
5. Encourage developers and consultants to share as-built MEP carbon data for verification of the proposed performance level.
6. Expand research to look at other building use types – e.g. retail units, which see frequent new fit outs.
7. Examine the impact of strip outs and alterations to Cat A services that never meet their intended life.
8. Establish whether Cat A can and should be avoided altogether.

Practical use of results

As expected, it was evident when assessing the data in this research that MEP is largely underestimated in WLCAs. This is a result of both the limited availability of carbon data and the complexity of determining material quantities.

This study concludes that an upfront carbon performance level for MEP in a Cat B fit out taken from a Cat A state :

47 kg CO_2e/m^2 GIA

Project leaders should consider this current performance level, and develop their own list of element inclusions, to ensure their numbers are realistic and appropriate. If a project will significantly exceed this figure, it should be justified and accounted for.

Scope of fit out

Key

- Included by occupier
- Typically included in contractor scope
- Sometimes included in contractor scope
- Element already present, possible alterations / removed or replaced
- Never in scope / basebuild

Element (based on RICS WLCA PS 2nd edition) - reporting table	Typical scope for project taking from Cat A to Cat B	Should be captured within the scope of measurement	Assume excluded due to lack of data / ability to model or likelihood of being included in scope
5.1.1 Sanitaryware	● (green)	✓	
5.1.2.1 Cold water systems	● (purple)	✓	
5.1.2.2 Cold water storage			✓
5.1.3.1 Surface water / rainwater / foul water drainage	● (green)	✓	
5.1.3.2 Water reuse systems	● (black)		✓
5.2.1.1 Heat & hot water generation equipment	● (black)	✓	
5.2.1.2 Heat &hot water distrubtion, control, ancillaries, emitters, exchangers / terminal units	● (black)	✓	
5.2.1.3 Heat storage equipment	● (black)	✓	
5.2.2.1 Cooling generation equipment	● (black)	✓	
5.2.2.2 Coolingemitter, exchangers / terminal units, ancillaries and control, distrubtion, storage	● (black)	✓	
5.2.3.1 Air movement	● (black)	✓	
5.2.4.1 Air terminals	● (black)	✓	
5.2.4.2 Duct work & ancillaries	● (black)	✓	
5.2.4.3 Control dampers, attenuation and fire safety related to ventilation equipment	● (black)	✓	
5.3.1.1 Internal lighting	● (black)	✓	
5.3.1.2 External lighting (if part of works)	● (black)	✓	
5.3.1.3 Emergency lighting	● (black)	✓	
5.3.1.4 Other lighting	● (blue)	✓	
5.3.2.1 Electrical power	● (purple)	✓	
5.3.2.2 ELV/communications/security	● (black)	✓	
5.3.2.3 IT & data	● (blue)		✓
5.3.2.4 BMS	● (purple)		✓
5.3.2.5 Electricity back up generation	● (green)	✓	
5.3.2.6 Fire detection & alarm	● (black)	✓	
5.5.1.1 Sprinkler system	● (black)	✓	
5.5.1.2 Firefighting systems	● (black)		✓
5.5.1.3 Lightning protection/earth bonding	● (black)		✓
5.5.2 Fuel installations			✓
5.5.2.2 Lift, stair lift, lifting platform	● (green)		✓
5.5.2.3 Escalators and moving walkways	● (green)		✓
5.5.4 Specialised and communal waste disposal	● (black)		✓
5.5.5 Specialist installations & maintenance	● (green)		✓
5.5.6 Builder work in connection with services	● (purple)		✓

2.0 Furniture

2.0 Furniture

This research has been prepared by Lucy Bagshaw and Veronica Baroni from tp bennett; Molly Macaulay from Overbury and Morgan Lovell; Ana Rita Martins from MCM; and Phil Towle and Alex Webb from The Furniture Practice.

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Context

Furniture, Fittings and Equipment (FFE) poses several challenges when it comes to measuring upfront carbon:

- **Limited data.** Lack of high-level manufacturer data, such as WLCAs, EPDs and even PAS 2080s, makes it difficult to assess carbon impact, especially for items beyond loose fit furniture
- **Expense of providing data**. While costs have decreased significantly over recent years, product-level EPDs are perceived as being high cost. Suppliers must provide multiple EPDs to meet the required level of data quality, and this can inhibit smaller suppliers.
- **Lack of agreed methodology**. There's no standardised method for measuring, reporting or assessing embodied carbon for furniture items with a multitude of variations. Resulting GWP results are inconsistent, underestimated and difficult to compare.
- **Uninformed specifying**. Selection of furniture often takes place with little or no scrutiny of its embodied carbon performance.
- **Neglect of product replacements**. The replacement of furniture items between fit out cycles is rarely accounted for.
- **Under-reporting**. The relative climate impact of FFE is largely overlooked and undervalued – mostly due to lack of data.

Methodology & results

Selection of fit outs

This research was based on the furniture in six Cat B office fit outs – a combination of single floorplates encompassing the client's total leased/owned footprint and typical floorplates with a variety of furniture (i.e. not a client suite or trading floor, for example).

Each floorplate was then sub-categorised into component area typologies representing different furniture requirements.

The floorplans were all RIBA(Royal Institute of British Architects) stages 2-3 – i.e. not as-built – and may have had minor alterations by the time of construction.

All projects featured some bespoke joinery elements, but not an excessive amount, and were considered 'typical' fit outs.

Projects ranged in size from 1,500m^2 GIA to 3,175m^2 GIA, with an average of 2,294m^2 GIA.

Process of analysis

A variety of EPDs and WLCAs of circa 70 different product types was gathered as part of The Furniture Practice's Scope 3 emissions analysis.

PlanetMark was appointed to review and report on the Scope 3 emissions of The Furniture Practice according to the GHG Protocol.

During this analysis, the data relating to each product was split into four categories:

- Purchased goods and services (A1-A3)
- Transport emissions (A4-A5)
- Use of sold products emissions (B)
- End of life emissions (C1 -C4)

Although there are identified potential improvements in data quality (noted below), PlanetMark assessed that this method provided a data quality score of 14 out of 16.

This data was collated into furniture categories, with an average upfront carbon-per-category calculation based on the mean of the data within each category. This enabled The Furniture Practice to create a list of performance levels; A1-A5 carbon-emissions-per-kilogram figures across a variety of product types for the purposes of this research.

All furniture was considered as 'new,' not refurbished or remanufactured in any way.

This research group was focused on loose furniture rather than the full scope of the FFE element, which excluded the following:

- Fitted/bespoke joinery elements, such as reception desks, tea points and decorative screens
- Equipment and appliances
- Fitted floor finishes
- Wall finishes, like wood panelling
- Acoustic panelling
- AV and IT equipment
- Free-standing planters and plants
- General space lighting fixtures
- Decorative accessories

Product performance levels were then applied by product type and multiplied by the quantity of products in an area typology for each project example. In this way, it was possible to calculate a total kg CO_2e/m^2 GIA for each project example.

By providing the mean of all six project examples, the research group arrived at an average of 37 kg CO_2e/m^2 GIA for loose furniture, with a standard deviation of 12.44. These figures ranged from 26.35 CO_2e/m^2 GIA to 60.90 CO_2e/m^2 GIA. There was no real consistency between the tonnage of carbon and the m^2, as there was a small range between the CO_2e/m^2. For example, the largest fit out we studied was 3,175m^2 GIA which came to 109 tonnes of carbon, just for the furniture, but the floor only consisted of 200 desks, whereas a 700+ desk floor came to 139.8 tonnes of carbon but only 2,300m^2. Given our timescales, it would be interesting to see a greater range of data and greater range of m^2 across case studies.

There was discussion within the group that furniture can vary according to industry sector and purpose of design. For example, more cellular offices call for less furniture, while more meeting rooms use fewer pods which are very high in carbon.

Limiting factors of this research

Several factors impeded this research:

- **Limited range of projects**. The research lacks breadth of different client types (e.g. legal, tech, media), which meant a narrow representation of furniture typologies, quantities and size.
- **Data inaccessibility**. The lack of manufacturer-issued EPDs and readily available data limits the project's ability to comprehensively assess the full upfront carbon impact of furniture. The team found between 1-8 (mean of 4) upfront carbon calculations were available for each furniture category. We found around 50% of furniture manufacturers have carbon information, but some 80% of these are lower-level carbon data such as FIRA (Furniture Industry Research Association) declarations rather than third-party-verified EPDs.
- **Varied finishes and materials**. A multitude of different product specifications means the data varies dramatically, with many outliers. E.g. a side chair could be fully upholstered with timber legs or unupholstered with metal sled base.
- **Dimensional discrepancies**. Furniture dimensions don't necessarily correlate with their purpose/occupancy. E.g. a meeting table is quantified by number of seats, not size in metres, so a 6-person table may be as big as a 10-person table, or vice versa.
- **Unit quantity vs linear metre discrepancies**. Some data points were not possible to directly apply to quantities of products that were reported in linear meters, or vice versa. This created some outlier results.
- **Biogenic carbon**. This may be accounted for in some WLCAs contributing to each category performance level. Since this research only looks at lifecycle stages A1-A5, these instances could positively skew the data within a category.
- **Unknown amount of joinery calculated by other sub-groups**. While it was deemed that this research group selected 'typical' floorplates, they may have been joinery heavy. A separate research team reviewed the impact of joinery which can be found in section 4.0 of this whitepaper.

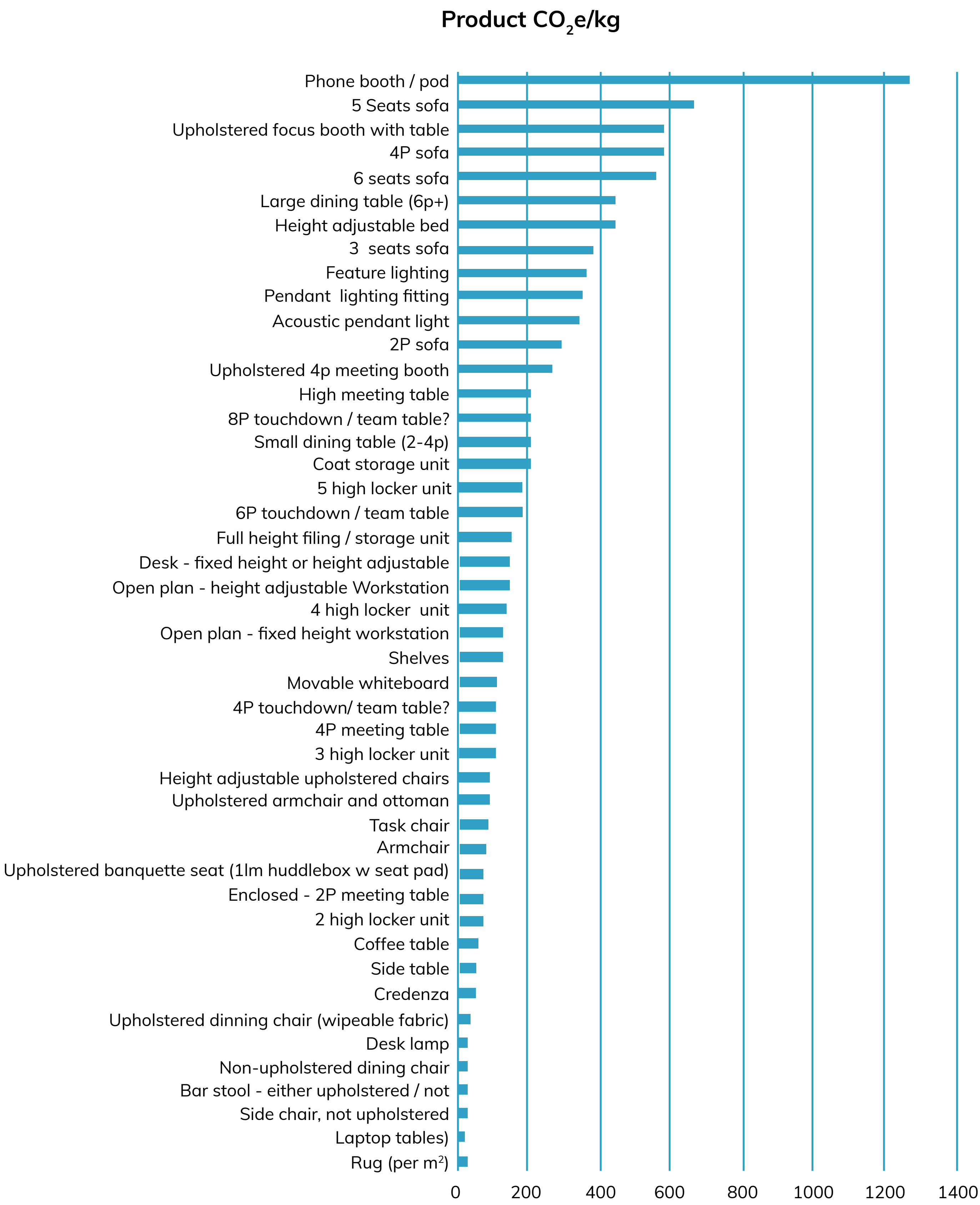
The hierarchy below may be helpful for manufacturers in selecting a format/process for provision of product carbon data. The list is bespoke and should be reviewed for each project as more evidence options become available. Manufacturers should aim to provide carbon data that fulfils the top end of the scale.

- Product Specific Type III External EPD conforming to EN 15804, with a minimum cradle to gate scope
- Product Specific Type III External EPD conforming to ISO 21930, with a minimum cradle to gate scope
- Product Specific Type III External EPD conforming to ISO 14067, with a minimum cradle to gate scope
- Product Specific Type III External EPD conforming to ISO 14025, ISO 14040 and ISO 14044, with a minimum cradle to gate scope
- Industry-wide/generic EPD
- Product-specific Type III Internal EPD
- PEP (Product Environmental Profile)
- Product-specific LCA which conform to ISO 14025, ISO 14040 and ISO 14044, with a minimum cradle to gate scope
- TM65 Mid-Level Calculation
- TM65 Basic Calculation
- FIRA Carbon Footprint Tool
- Other embodied carbon data (generic LCAs or industry datasets)
- Other embodied carbon data (proxy product data)
- Other embodied carbon data (other types not listed above)

Recommendations for further action or research

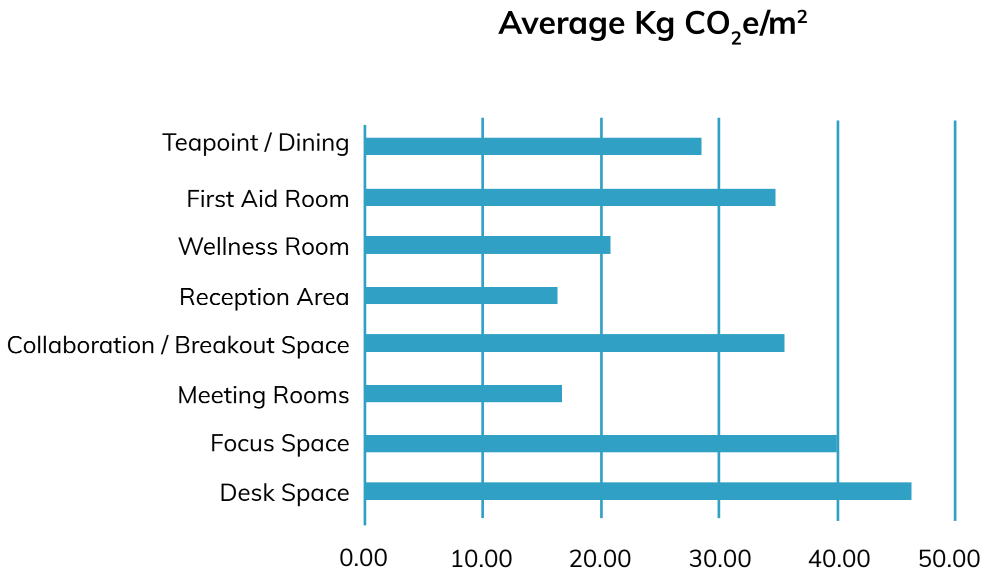
To address these limitations and advance the understanding of upfront carbon in commercial furniture, this research group recommends the following:

- **Review more project datasets**. These should include a variety of project sizes and client type.
- **Assess more product LCAs**. Also increase the accuracy of materials in product category types.
- **Analyse reuse embodied carbon vs new**. This will inform project decarbonisation strategies. A separate research team reviewed how reuse of different elements can be accounted for, which can be found in section 7.0 of this whitepaper.
- **Analyse by sector or area typology**. Compare open plan vs cellular office space, for example.
- **Analyse by RIBA stages**. Look at any variation from early-stage plans to as-built plans/post occupancy.
- **Analyse every sub-group of building elements**. This will give a holistic average for all product and material types – i.e. not using different projects to measure different elements.
- **Standardise methodologies for manufacturers**. Advocate for an agreed WLCA process with strict product category rules for furniture.
- **Standardise education for manufacturers**. Develop resources that increase understanding of sustainable practices, circular economy benefits and the importance of data transparency in embodied carbon accounting.
- **Collaborate as an industry**. Share knowledge, data and processes between manufacturers, researchers and specifiers to develop standardised methodologies and data-sharing protocols.
- **Identify priority areas**. Conduct research to find key data gaps and target these areas for investigation and improvement. Start with high-carbon products like upholstered booths and sofas, as referenced in this report.


Product CO_2e/kg
Phone booth / pod
5 Seats sofa
Upholstered focus booth with table
4P sofa
6 seats sofa
Large dining table (6p+)
Height adjustable bed
3 seats sofa
Feature lighting
Pendant lighting fitting
Acoustic pendant light
2P sofa
Upholstered 4p meeting booth
High meeting table
8P touchdown / team table?
Small dining table (2-4p)
Coat storage unit
5 high locker unit
6P touchdown / team table
Full height filing / storage unit
Desk - fixed height or height adjustable
Open plan - height adjustable Workstation
4 high locker unit
Open plan - fixed height workstation
Shelves
Movable whiteboard
4P touchdown/ team table?
4P meeting table
3 high locker unit
Height adjustable upholstered chairs
Upholstered armchair and ottoman
Task chair
Armchair
Upholstered banquette seat (1lm huddlebox w seat pad)
Enclosed - 2P meeting table
2 high locker unit
Coffee table
Side table
Credenza
Upholstered dinning chair (wipeable fabric)
Desk lamp
Non-upholstered dining chair
Bar stool - either upholstered / not
Side chair, not upholstered
Laptop tables)
Rug (per m^2)
0
200
400
600
800
1000
1200
1400

Practical use of results

This research achieved a greater understanding of the average carbon intensity of loose furniture in different settings. The information can provide guidance on which areas should be targeted as a priority for decarbonisation efforts.



Progress hinges on increased data transparency from manufacturers and collaboration across the industry. By actively pursuing the suggested research initiatives and implementing the practical recommendations, we can improve decarbonisation efforts in the design and specification of loose furniture.

3.0 Catering kitchens


Caution
Dangerous
Machine

3.0 Catering kitchens

This research has been prepared by Lauren Hunter from Impactloop.

Lauren Hunter
Impactloop

Context

When it comes to measuring upfront carbon performance levels in Cat B office fit outs, commercial catering equipment presents several challenges:

- Lack of EPDs, WLCAs and PAS 2080s
- No standardised methodology
- Limited scrutiny of equipment for embodied carbon performance

The result is data reporting that's inconsistent at best; poor or missing at worst. This leads to a potentially significant underestimation of the carbon impact of catering kitchens.

Methodology & results

This research was based on the catering kitchens of four Cat B fit outs – two under construction and two in planning.

Data was taken from 107 catering equipment manufacturers, with a focus on the following factors:

- Detailed material breakdowns to work out accurate upfront carbon
- End-of-life policies and material recovery options
- REACH declarations showing material composition

Due to the limited availability of industry-specific data, this research used the CIBSE TM65 to calculate minimum carbon footprints. It also used standard kitchen functionalities and typical capacity requirements to assume data for high-output brands with multiple units.

Upfront Carbon Data - Commercial Catering Equipment Typical Kitchen specification (Based on data available)

Average upfront carbon impact of commercial kitchens based on available data

Type	A1 kg CO_2e	Standard	Note
Combi Oven - Electric	1454	TM65 Basic	
Induction Range	3336	TM65 Basic	
Fryer	677	TM65 Basic	
Infill bench	230	TM65 Basic	
Infill bench	359	TM65 Basic	
Chargrills - Electric	1134	TM65 Basic	
Salamander Grill - Electric	543	TM65 Basic	
High Speed Microwaves	2350	TM65 Basic	
Warewashing	544	TM65 Basic	
Warewashing	1196	TM65 Basic	
Refrigeration	638	TM65 Basic	
Refrigeration	1395	TM65 Basic	
Refrigeration	1831	TM65 Basic	
Refrigeration	1636	TM65 Basic	
Refrigeration	1977	TM65 Basic	
Food Prep - Mixer	1242	TM65 Basic	
Food Prep - Slicer	892	TM65 Basic	
Bespoke Extraction	1606	TM65 Basic	
Zinc Shelving systems - complete	260	TM65 Basic	Medium Extracts
Zinc Shelving systems - complete	246	TM65 Basic	
Zinc Shelving systems - complete	173	TM65 Basic	
Heated Drawer systems	314	TM65 Basic	
Heated Drawer systems	438	TM65 Basic	
Fabrications	1553	TM65 Basic	
Combi Oven - Electric	928	TM65 Basic	
Combi Oven - Electric	2466	TM65 Basic	Medium / large kitchens only
Bespoke Cold Storage	37502	TM65 Basic	Modular system used a medium rule
Bespoke Cold Storage	38649	TM65 Basic	Modular system used a medium rule
Bain Marie	1056	TM65 Basic	
Fryer	755	TM65 Basic	
Mulitfunction Pan	1947	TM65 Basic	
Refrigerated Drawers	1414	TM65 Basic	
Food Prep - Mixer	1950	TM65 Basic	
Food Prep - Mixer	2380	TM65 Basic	
Food Prep - Slicer	116	TM65 Basic	
Heated food transport cart	1354	TM65 Basic	
Chilled Food transport cart	1572	TM65 Basic	
Wash Hand Basin	103	TM65 Basic	
Bins	26	TM65 Basic	
Taps	8	TM65 Basic	
Air sanitiser	172	TM65 Basic	
Janitorial Sink	213	TM65 Basic	
Taps	60	TM65 Basic	
Fly killer	14	TM65 Basic	
Soap dispenser for basin	8	TM65 Basic	
Gastronorm Trolley	72		

Figure 1: Upfront carbon in commercial catering equipment, based on 4 corporate build specifications

Key findings

- There's a significant data gap in commercial catering. Only 47 out of 107 manufacturers provided usable material data, despite common equipment being specified across projects.
  - This suggests a lack of understanding about the data required to substantiate sustainability claims.
- While sustainability is often cited as a fit out project goal, evidence indicates a lack of active investigation or data requests when choosing catering equipment.
  - This gap between aspiration and practice highlights a need for increased education and awareness across the industry regarding the importance of embodied carbon and the data required to verify sustainability claims.
- A1 raw material calculations proved the most readily available form of data. Broader data coverage across the entire equipment lifecycle is needed.
  - Again, this points to an industry-wide lack of understanding.

Based on a library model and expansion assumption, the team's analysis revealed:

- Significant variances in upfront carbon footprints for different kitchen sizes (see Figures 2-4):
  - Small kitchen (30m^2): 4,686 kg CO_2e/m^2
  - Medium kitchen (55m^2): 2,878 kg CO_2e/m^2
  - Large kitchen (98m^2): 2,214 kg CO_2e/m^2

By choosing brands of equipment with lower upfront carbon, the impact of a small, medium or large commercial catering kitchen could be reduced by between 11 and 17%.

This highlights the substantial impact of more informed decision-making – and the need for greater education and transparency in the industry.

- Only 2 out of 107 manufacturers had end-of-life policies in place to minimise their 'products whole life carbon impact'.
- Only 7 out of 107 manufacturers had responsible sourcing certificates, such as ISO14001 or BES6001.

Upfront Carbon Data - Commercial Catering Equipment
Small Kitchen - 30 m²
Typical specification (based on data available via TM65 Basic)

Type of Product	Quantity	A1 kg CO_2e	Size of Account	kgCO_2e Total	Note
Combi Oven - Electric	1	1456		1454	
Induction Range	1	3336		3336	
Fryer	2	677		1354	
Infill bench	2	230		460	
Infill bench	2	359		718	
Chargrills - Electric	1	1134		1134	
Salamander Grill - Electric	1	543		543	
High Speed Microwaves	1	2350		2350	
Warewashing	1	544		544	
Warewashing	1	1196		1196	
Refrigeration	3	638		1914	
Refrigeration	2	1395		2790	
Refrigeration	2	1831		3662	
Refrigeration	1	1636		1636	
Refrigeration	1	1977		1977	
Food Prep - Mixer	1	1242		1242	
Food Prep - Slicer	1	892		892	
Bespoke Extraction	1	1606	-20	1285	Medium kitchen used as rule
Zinc Shelving systems - complete	2	260		520	
Zinc Shelving systems - complete	2	246		492	
Zinc Shelving systems - complete	2	173		346	
Heated Drawer systems	1	314		314	
Heated Drawer systems	1	438		438	
Fabrications	1	1553	-20	1242.4	Medium kitchen used as rule
Combi Oven - Electric		928			
Combi Oven - Electric		2466			Medium/large kitchens only
Bespoke Cold Storage	1	37502	-20	30,000	Modular system used as a medium rule
Bespoke Cold Storage	1	38649	-20	30919	Modular system used as a medium rule
Wash Hand Basin	2	103		206	
Bins	4	26		104	
Taps	4	8		32	
Air sanitiser	1	172		172	
Janitorial Sink	1	213		213	
Taps	2	60		120	
Fly killer	2	14		28	
Soap dispenser for basin	2	8		16	
Gastronorm Trolley	1	72		72	

Carbon intensity of 30m² kitchen (total) 93,721 kg CO_2e
Carbon intensity of 30m2 kitchen (per m² of kitchen) 4,686 kg CO_2e/m^2

Figure 2: Upfront carbon in commercial catering equipment. Small kitchen 30m².

Upfront Carbon Data - Commercial Catering Equipment
Medium - 55 m^2
Typical specification ((based on data available via TM65 Basic)

Type of Product	Quantity	A1 kg CO_2e	kg CO_2 Total	Note
Combi Oven - Electric	2	1454	2908	
Induction Range	2	3336	6672	
Fryer	4	677	2708	
Infill bench	2	230	460	
Infill bench	2	359	718	
Chargrills - Electric	1	1134	1134	
Salamander Grill - Electric	2	543	1086	
High Speed Microwaves	1	2350	2350	
Warewashing	2	544	1088	
Warewashing	1	1196	1196	
Refrigeration	4	638	2552	
Refrigeration	4	1395	5580	
Refrigeration	4	1831	7324	
Refrigeration	2	1636	3272	
Refrigeration	2	1977	3954	
Food Prep - Mixer	2	1242	2484	
Food Prep - Slicer	1	892	892	
Bespoke Extraction	1	1606	1285	Medium Kitchen used as rule
Zinc Shelving systems - complete	4	260	1040	
Zinc Shelving systems - complete	4	246	984	
Zinc Shelving systems - complete	4	173	692	
Heated Drawer systems	1	314	314	
Heated Drawer systems	2	438	876	
Fabrications	1	1553	1242.4	Medium kitchen used as rule
Combi Oven - Electric		928		
Combi Oven - Electric	2	2466	4932	Medium/large kitchens only
Multifunction Pan	1	2204	30,000	Modular system used a medium rule
Bespoke Cold Storage	1	37502	30919	
Bespoke Cold Storage	1	38649	38649	
Wash Hand Basin	2	103	206	
Bins	6	26	156	
Taps	4	8	32	
Air sanitiser	1	172	172	
Janitorial Sink	1	213	213	
Taps	2	60	120	
Fly killer	4	14	56	
Soap dispenser for basin	2	8	16	
Gastronorm Trolley	2	72	144	

Carbon intensity of 55m^2 kitchen (total) 158,282 kg CO_2e
Carbon intensity of 30m2 kitchen (per m^2 of kitchen) 2,878 kg CO_2e/m^2

Figure 3: Upfront carbon in commercial catering equipment. Medium kitchen 55m^2.

Upfront Carbon Data - Commercial Catering Equipment
Large - 98 m²
Typical specification (based on data available via TM65 Basic)

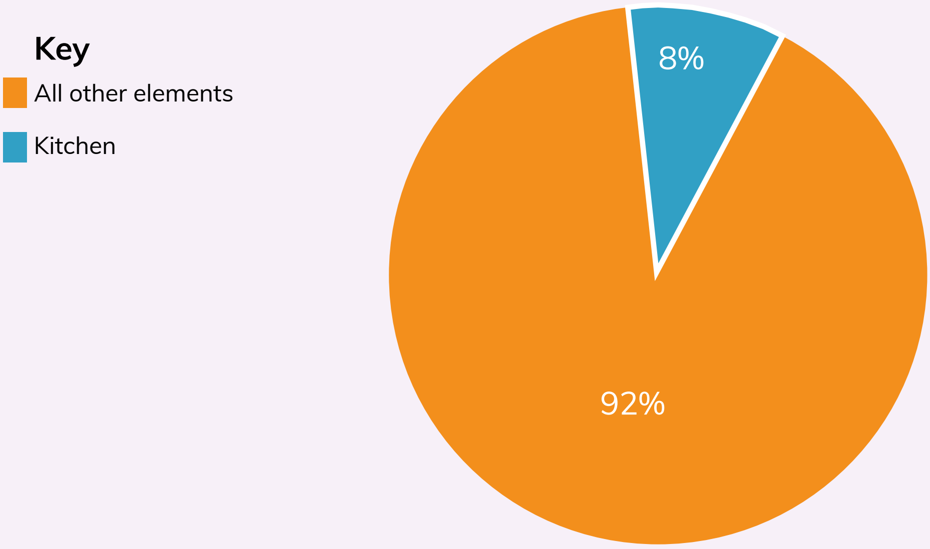
Type of Product	Quantity	A1 kg CO_2e	Size Account	kg CO_2 Total	Note
Combi Oven - Electric	2	1454		2908	
Induction Range	3	3336		10008	
Fryer	2	677		1354	
Infill bench	2	230		460	
Infill bench	2	359		718	
Chargrills - Electric	2	1134		2268	
Salamander Grill - Electric	2	543		1086	
High Speed Microwaves	2	2350		4700	
Warewashing	2	544		1088	
Warewashing	1	1196		1196	
Refrigeration	4	638		2552	
Refrigeration	4	1395		5580	
Refrigeration	4	1831		7324	
Refrigeration	2	1636		3272	
Refrigeration	6	1977		11862	
Bespoke Extraction	3	1606		1285	Medium Kitchen used as rule
Zinc Shelving systems - complete	6	260		1560	
Zinc Shelving systems - complete	6	246		1476	
Zinc Shelving systems - complete	6	173		1038	
Heated Drawer systems	1	314		314	
Heated Drawer systems	2	438		876	
Fabrications	1	1553	Increase 50%	2174	Medium kitchen used rule
Combi Oven - Electric		928			
Combi Oven - Electric	4	2466		9864	Medium / large kitchens only
Bespoke Cold Storage	2	37502		30919	Modular system used a medium rule
Bespoke Cold Storage	2	38649		77298	
Bain Marie	2	1056		2112	
Fryer	2	755		1510	
Multifunction Pan	2	1947		3894	
Refrigerated Drawers	4	1414		5656	
Food Prep - Mixer	2	1950		3900	
Food Prep - Mixer	1	2380		2380	
Food Prep - Slicer	2	116		232	
Heated food transport cart	4	1354		5416	
Chilled food transport cart	4	1572		6288	
Wash Hand Basin	4	103		412	
Bin	10	26		260	
Taps	10	8		80	
Air Sanitiser	3	172		516	
Janitorial Sink	2	213		426	
Taps	3	60		180	
Fly Killer	4	14		56	
Soap dispenser for basin	4	8		32	
Gastronorm Trolley	6	72		432	

Carbon intensity of 30m² kitchen (total) 216,962 kg CO_2e
Carbon intensity of 30m2 kitchen (per m² of kitchen) 2,214 kg CO_2e/m^2

Figure 4: Upfront carbon in commercial catering equipment. Large kitchen 98m².

The below pie chart and table show the upfront carbon contribution of a medium-size catering kitchen in relation to other parts of a major Cat B fit out. The 7.7% result (rounded to 8% in the pie chart) is based on the performance level of 190 kg CO_2e/m^2 GIA (arrived at through the main research described in Part 1 of this whitepaper) and the medium kitchen, as described above, accounting for 2,878 kg CO_2e/m^2 over $55m^2$.

Major Project ($10,000m^2$) with Medium Kitchen



	Size (GIA)	Upfront carbon performance level (kg CO_2e/m^2 GIA)	Total (kg CO_2e/m^2)	Percentage
Total project assumed sized	$10,000m^2$	190	190* $10,000m^2$ =1,900,000	92%
Total Kitchen assumed size	$55m^2$	2,878	2878 * $55m^2$ =158,290	8%
		Total project	2,058,290	

Limiting factors of this research

Several factors impacted the scope and conclusions of this research:

- **Limited data**. Lack of manufacturer EPDs and other data significantly hampered the ability to assess full embodied carbon impact.
- **Incomplete responses**. Many manufacturers provided partial data or none at all.
- **Inaccurate methodology**. Without industry-specific methodologies, the CIBSE TM65 Basic was used to calculate minimum carbon footprint, which gave only estimations rather than precise results.

It's worth noting that TM65 Basic covers only A1 lifecycle stages, not an A1-A3 total. This is important when comparing other results in this whitepaper, where A1-A3 values have been found. It also means carbon emissions from refrigerants (B1) aren't captured, and these can be significant. Finally on this, the TM65s used for this research aren't third-party verified.

Due to the limited data, upfront carbon calculations are based on two things:

- **Library model**. This uses manufacturer data submitted in December 2023. It adheres to the CIBSE TM65 Basic standard. (Unfortunately, this research was still missing data from some key manufacturers, including those of the chosen refrigerators and the two most common dishwashers. Instead, data was taken from the next leading comparable manufacturers of these items.)
- **Expansion assumption**. The library data was then applied to specific equipment categories based on standard functionalities and capacity requirements.

Recommendations for further action or research

Based on the limitations of this research and the data collected, this team recommends the following actions:

For manufacturers

- **Share data**. Provide transparent and detailed carbon data in the form of EPDs or following established standards like PAS 2080.
- **Standardise reporting**. Collaborate with industry stakeholders to develop a standardised method of reporting carbon data – one that ensures consistency and ease of use.
- **Source responsibly**. Source materials only from suppliers who are committed to sustainable practices.

For the wider industry

- **Standardise education**. Develop resources to increase manufacturer understanding of sustainable practices, circular economy benefits and the importance of data transparency in carbon accounting.
- **Identify data gaps**. Prioritise these areas for further investigation.
- **Identify carbon hotspots**. Focus carbon reduction efforts on these areas.
- **Collaborate on methodology**. Work together – as manufacturers, researchers and specifiers – to develop standardised methods for measuring, reporting and assessing embodied carbon.

Right now, there's a cross-industry initiative led by Impactloop and Overbury to provide an addendum to TM65 for catering equipment. Anyone interested in taking part in this working group should contact Lauren Hunter lauren@loopcycle.io and Rebecca Boorman Rebecca.Boorman@overbury.com.

4.0 Joinery

4.0 Joinery

This research has been prepared by Elina Grigoriou and Laura Salinas from Grigoriou Interiors, with support from Richard Moore from Thorpes Joinery, Gordon Emm, Matt Lawrence and Trevor Baker from Brown & Carroll, Emilie Metcalf and Sam Reed from BA Joinery, Gary Lynch from specialist Joinery, Sarah Mann Taylor Made Joinery and Paul Willingale from Shadbolt.

Elina Grigoriou
Grigoriou Interiors

Laura Salinas
Grigoriou Interiors

Context

The joinery component of an office fit out includes many variables – from differing workshop processes (machinery, packaging, transportation) to differing levels of design (off-the-shelf vs bespoke). This makes it difficult to measure or find an average performance level of upfront carbon.

Methodology & results

Scope

This research looked at the different types of specialist joinery elements found in a typical fit out:

- Tea points
- Booths
- Window seating
- Banquette seating
- Bespoke tables
- Ceiling features
- Reception desks
- Storage shelving
- Bathroom vanities
- WC cubicles
- Bar counters
- Fitted wardrobes
- Column casing
- Feature walls / panelling
- Feature signage

It didn't look at general joinery such as doors, architraves and skirtings. This is for two reasons:

1. It was immediately clear that the carbon impact of specialist joinery items overshadowed that of general joinery, so it was decided to keep focus on the former.
2. During the period of this research, progress was noticed in the area of general joinery, with door companies beginning to publish their EPDs. (We'd like to recognise Forza Doors as the first UK door manufacturer to do so and we're encouraged to see others follow suit.)

Methodology

Initial exploration and data collection

The team first met with manufacturers, and looked at real-life examples of joinery, to help scope and define the boundaries of this research.

Detailed descriptions and drawings of each element were created to ensure clarity on materials, processes and manufacturer impact, wherever possible.

It was important to clarify:

- Overlaps with furniture items and other specialist areas
- Presence of integrated lighting and other electrical components
- Method of modelling and assumptions made for different items

For each item of joinery, the following data was then collected:

- Workshop drawings
- Material components and specifications
- Material quantities
- Fabrication processes
- Transportation energy use
- Packaging practices, materials and quantities
- Workshop energy use and waste

Data development and modelling

It was also important to clarify the use of energy and resources in the manufacturing stage – i.e. in the workshop.

Every joinery company has its own way of doing things in terms of design and operation. For example, some may be more efficient thanks to their newer machinery or the vicinity of their other business teams. Some may operate close to their customers, while others are in remote parts of the country or even overseas, and their location may affect the format of their data. It could be blended as a single manufacturing entity or presented as separate parts of the process.

An approach was decided for overhead operating data, but this will need ongoing review to ensure alignment with EPD standards and the Greenhouse Gas Protocol.

For example, there's a risk of overlap between the operational and production impact of manufacturing joinery, which means double counting their Scope 2 and 3 emissions.

For the purpose of this study, Scope 1 and 2 emissions not associated with the workshop space itself were excluded.

Assumptions, variations and definitions of quality level:

- **Quality**. Perceived quality levels are arbitrary and don't necessarily align with higher or lower embodied impacts. What's key, and where the team focused its efforts, are:
  - Location of materials
  - Manufacturing processes
  - Waste associated with joinery design and related intricacies
- **Detailed information**. Instead of making generic material allocations and typologies, the team used specific examples of typical designs and sizes found in the architype modeling that is described in Part 1 of this whitepaper. This ensures that any changes in specification or size can be tracked as modelling evolves.
- **Variations.** There's huge variation in size, selection and location of joinery elements. IThe industry needs clarity on how modeling and results will be related to carbon budgets and the delivery of project
- **Data sources.** Where EPDs exist for products and materials, the team used them. Most timber-based elements have EPDs, and many metal elements have generic metal typology EPDs, but smaller detail fixings must be modelled as closely as possible to the specification of other similar generic data.
- **Process energy**. For fabrication site energy consumption, the team used average data provided by the various workshops' current calculations.
- **Transport legs.** All materials are assumed to have two transport legs each.

Results

General

It's clear that an approach is needed to sit midway between a fully verified piece of data and a pre-verified methodology – one that reflects both the project-specific carbon impacts and the bespoke nature of joinery works.

It's also evident that the location and operational efficiencies of manufacturers and their workshops inform just over a third of data accuracy, and requires tailoring.

Below are the results of some of the specialist joinery elements that were studied:

Small & medium fits out	Total kg CO_2e/unit* (A1 - A5)
Tea points	2,223
Bespoke tables	599
Reception shelving	3,487
Bathroom vanities	634

*Table 2: OneClick carbon emissions results that relate to A1-A5 stages, for 1 unit of the joinery element. *Excluding biogenic carbon.*

Energy and waste

Commonality was found in that most workshops use a combination of energy sources – that produced on site (solar or energy recovery) and that supplied (by national grid). But some of the national grid energy comes through different renewable tariffs, and so these carbon emissions profiles vary and need verifying.

Almost no workshops use energy meters to monitor their energy use, and this is a key recommendation for next steps.

Another recommendation is to link the measurement of both energy use and material waste. Offcuts and discarded packaging are routinely used for energy recovery on site, yet no workshops appear to measure these amounts. In the case of biogenic-related materials, such as cardboard and timber, it's important to report accurate emissions.

Limiting factors of this research

Certain areas of this research are less than reliable because the data were self-reported by different workshops with variable methods of data measurement, collection and calculation. Attempts were made to harmonise and verify, but it was impossible to review certain areas in detail, including:

- Energy supply
- Energy process time and allocations per item
- Waste recovery quantities

Other factors were found to be more reliable because they're linked to formally issued data:

- Volume and product specifications – these are named and based on detailed drawings and quantities
- Quantity of materials – EPDs were used, or matched closely, and localised where appropriate
- Type of vehicles and packaging – these are general but common for most joinery companies

Recommendations for further action or research

Based on the limitations of this research and the data collected, the team recommends the following actions:

- Install meters to monitor, measure and collect more data on energy consumption in workshops.
- Install waste stream monitoring systems to measure the use of waste for energy recovery in workshops.
- Install more renewable energy systems in or near workshops.
- Review the existing and similar French joinery pre-verified FDES (French EPD) calculators for lessons learned and possible collaboration. These are an excellent tool, which we recommend sharing with industry colleagues. https://www.de-boisdefrance.fr/ and https://de-bois.fr/fr
- Design joinery to use low-carbon materials in the first place.
- Develop joinery with full details on its assembly and disassembly.
- Review and compare the GHG Protocol and EPD standards to ensure a consistent approach between product WLCA and company-wide carbon reporting.
- Consider how tailored information and site-specific impacts can be reliably collected for each project. This could be a pre-verified audit of their database on annual visits/submissions.
- Educate manufacturers on embodied carbon modelling. It's important to upskill teams and support an industry-wide shift that works around companies' need to stay competitive and yet move forward collectively on an issue that affects us all.

5.0 Temporary works

5.0 Temporary works

This research has been prepared by Toby Sowood and Adam Bora from Mace Consult.

Toby Sowood
Mace Consult

Adam Bora
Mace Consult

Context

As the term suggests, temporary works (TW) are only used on fit outs for a limited proportion of a project's design and construction time. This may be one reason why the upfront carbon associated with the use of TW is often excluded from WLCAs. But there are other factors too, including a lack of industry-agreed methodologies and manufacturer data such as EPDs.

More research is needed in this area to properly inform the impact of TW on whole life carbon models.

Methodology & results

This research sought to look at the upfront carbon performance levels for common TW items used on an average Cat B office fit out. These include:

- Hoarding
- Scaffolding
- Signage
- Temporary fencing
- Temporary lighting
- Temporary power supply
- Temporary heating/cooling units
- Temporary platforms
- Hoists
- Edge protection
- Portaloos
- Temporary offices
- Temporary flooring systems
- Protective sheeting

As TW items are used on site for only a portion of a project's duration, the upfront carbon associated with them can't be given simply as the total of lifecycle stages A1-A3.

The project using the TW is responsible for a percentage share of the upfront carbon of the product, proportional to the length of time it uses these items.

The share of TW carbon for which a project is responsible is described by Equation 1 below.

$$EC_{A13} = \frac{ECF_{A13}}{L \times Ut_{mod}}$$

Equation 1: Carbon calculator for temporary works.

This is taken from a carbon calculator technical note produced by Groundforce Shoreco.

https://www.vpgroundforce.com/gb/footer-links/useful-links/carbon-calculator-technical-note/

- ECA13 is the total embodied carbon per week
- ECFA13 is the embodied carbon factor (total embodied carbon of the product)
- L is the lifetime of the product

Utmod is the average utilisation (percentage of time for which the item is leased out)

Lifecycle stages A4 and A5 can be calculated as normal, while stage C3 is the responsibility of the supplier and so no calculation is required by the contractor.

Results at this point in time are limited for several reasons:

- Most TW items don't yet have EPDs associated with them, so the ECFA13 value is often unknown.
- TW is often discounted from carbon assessments so there's little data.
- Utilisation factors are often difficult to obtain from suppliers.
- TW is quite limited on fit out projects.

GroundForce Shoreco estimates that steel products have an upfront carbon performance level of 3 kg CO_2e per week. This assumes a 10-year lifetime of the product.

This number applies to steel scaffolding, which is sometimes used on fit outs, but different suppliers will have different product lifetimes, and this will affect the product's weekly embodied carbon.

More work needs to be done to determine approximate lifetimes for the TW items listed above, and more EPDs are needed for each of them.

Saying that, contractors can still use the above equation for carbon calculations by following these steps:

1. Engage TW suppliers to obtain product lifetime, utilisation factor and EPD.
2. If these values are unknown, use industry averages or estimates based on available data.
3. Substitute values into the equation to determine weekly upfront carbon.
4. Multiply ECA13 by the number of weeks the TW is to be used to calculate the total carbon for which the project is responsible.

Recommendations for further action or research

This work provides a methodology to help project teams and contractors calculate the upfront carbon of multiple-use TW items. But it has its limitations and doesn't apply to all TW.

To improve the understanding of embodied carbon in TW, the following actions are recommended:

- Trial the above methodology to identify any weaknesses in it and give real estimates of upfront carbon.
- Encourage manufacturers to produce more data for TW, including EPDs, product lifetimes and average utilisations.
- Encourage the supply chain to have this data readily available.
- Carry out more research into different types of TW to create a bespoke methodology for each one.

6.0 Staircases

6.0 Staircases

This research has been prepared by Akos Brandecker from Living Building Consultancy with special thanks to Leyton Group.

Akos Brandecker
Living Building Consultancy

Context

Staircases form an integral part of many large office fit out projects. They help promote vertical circulation across floors, increase collaboration between teams, and provide a healthier and more environmentally friendly alternative to lifts.

Each staircase tends to be unique in design; it needs to suit the building (floor height, number of floors, connectability, etc.). Then there are various technical specifications (like capacity, sound and reverberation) to consider. Finally, the client and architect will choose from a range of aesthetic finishes (glass, paint, cladding panels, decorative timber and so on). Of course, the number of potential finishes – and their associated carbon impact – is vast and so this analysis looks only at the overall structure of a typical staircase. And this largely comes down to its use of steel – by far the most commonly used material.

Steel has a remarkable strength-to-weight ratio, good formability and can be integrated with other materials, making it ideal for both off-site prefabrication and rapid on-site assembly.

Even with its focus honed on staircase structure, this was still faced with limited data as to origins and quantities of steel. Further research is needed to provide an upfront carbon performance level to substantiate the team's findings on steel, and to examine all the other elements of a typical internal staircase.

Methodology & results

This research was undertaken in partnership with Leyton Group, a well-known steel staircase fabricator, as well as two of the UK's largest steel merchants and multiple steel manufacturing companies and mills.

We reviewed the design of several staircases to understand common elements and help guide our research. Documentation confirming the sourcing and original rolling locations of steel for staircases was limited with only projects with whole life carbon modelling targets being able to provide this. Of the five projects we reviewed as part of this research, all had sourced steel sections from several mills both in the UK and Europe, ranging from 7-24 sourcing origins for steel used on a single project.

While over 90% of the steel reviewed was supported by Environmental Product Declarations, the they had a huge range of A1-A3 embodied carbon numbers between 589 - 3660 kg CO_2 eq. per tonne for plates and 646 - 3058 kg CO_2 eq. per tonne for box sections.

With the especially wide range of embodied carbon numbers in steel sections, we were unable to present a carbon performance level for staircases at this stage. This work will continue, and we are hoping to undertake representative LCA modelling to account for the fabrication, transportation and installation impact of staircases.

We are actively looking for fabricators or anyone with relevant information to participate in the ongoing research required.

Limited availability of low-carbon steel for staircases

Staircases are almost exclusively made of hot or cold rolled plates and structural hollow sections. Although, the UK already has four mills available that use electric arc furnaces, at the time of this research, none of these mills were producing suitable sections and sizes for the fabrication of steel staircases.

Primary and Secondary Steel Production Sites in the UK	Company	Sections Produced
Aldwarke, Rotherham	Liberty Steel	Automotive bars, semi-finished products, rebar, engineering bars
Shepcote Lane, Sheffield	Marcegaglia Group	Merchant bar, wire rod, stainless steel
Brightside lane, Sheffield	Sheffield Forgemasters (owned by the UK Minstry of Defense)	Open- die forging for defense sector
Tremorfa, Cardiff	Celsa Steel UK	Reinforcing bars and coils, wire rods, merchant bars

While access to low-carbon steel in Europe is much more readily available, with countries like Italy already producing 80% of their output from EAF, the EU remains heavily reliant on imported steel to meet demand. This further limits opportunities for import and can significantly increase lead times for specific orders.

Staircase companies face similiar struggles in the European market as only a limited number of EAF mills currently produce the required section types.

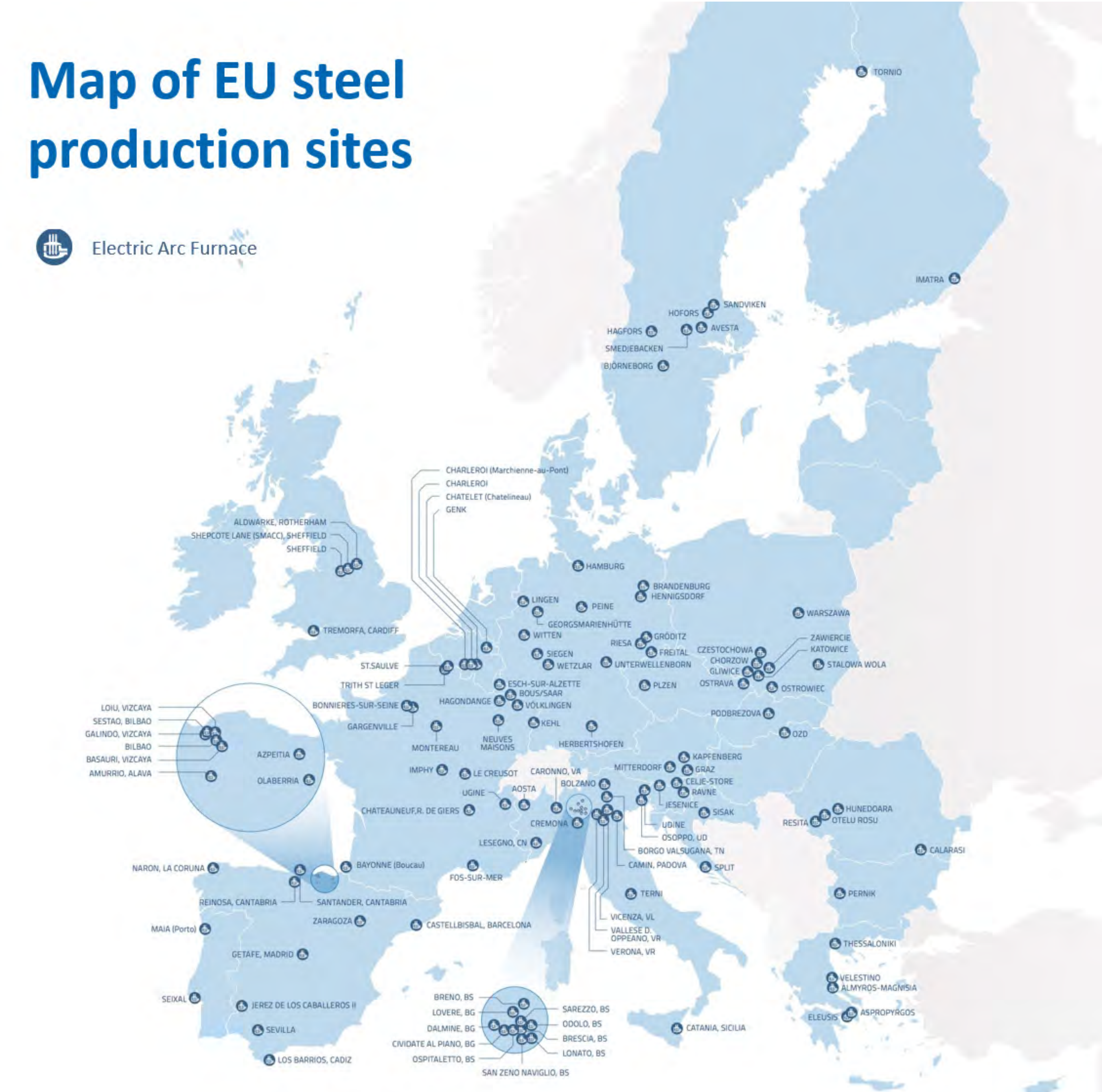


Figure 1: Map of EU steel production sites: European Steel Association (EUROFER)
www.eurofer.eu/about-steel/learn-about-steel/where-is-steel-made-in-europe

Limiting factors of this research

Poor traceability of steel. Steel is procured and fabricated through a complex supply chain that involves multiple merchants bound to various technical requirements and design specifications. BS EN 1090 sets the standards for steel (and aluminium) structures, including CE marking, manufacturing controls and traceability of origin. These standards include a range of Execution Classes 1 to 4, with 4 being the highest. Only Execution Classes 3 and 4 require full traceability for steel, and this is achieved through test certificates issued by each mill for a specific rolling cycle.

Traditionally, internal staircases are procured using Execution Class 2, which tends to include data on steel quantity, but not traceability, This in turn gives very low confidence in the carbon factors that need to be applied as EPDs cannot be associated with each piece of purchased steel.

Complex supply chain for steel. In most cases, the specification and section size of steel required for a fit out is readily available from stock. It means fabricators may only place orders for individual elements of a staircase as and when they need them. In one project we reviewed, this resulted in steel being sourced from 16 different mills from countries spanning two continents. This sort of disparate supply chain makes it very difficult to accurately account for the carbon impact of a staircase – not least it requires cross-referencing test certificates, delivery notes and fabrication cutting details.

Mixed availability of recycled steel. Second-hand steel from leftover or returned stock, as well as recovered steel from demolition sites, is becoming more readily available. Some stockists now specialise in the reuse of steel (e.g. Cleveland Steel & Tubes Ltd). However, certain grades and shapes of steel section are still not available for reuse, as they can be difficult or expensive to remove from a demolition or dismantling site.

Staircases are generally fabricated using a combination of sheet/plate products and hollow sections, with some supporting structural sections (e.g. angles, PFC, UB and UC sections). As plate and box sections are predominantly used to make smaller, more intricate designs, these are rarely available from demolition projects in pieces large enough to warrant them entering the reuse market.

Questionable credibility of 'green steel'. While many manufacturers are making progress in their shift towards low-carbon processes (e.g. using biofuel technology, Carbon Capture and Usage (CCU) and Electric Arc Furnaces (EAF)), it's important to scrutinise claims of 'green steel'.

Reporting methods differ from manufacturer to manufacturer, as do the key figures, value chains and life cycle stages covered in their reports. Some manufacturers use carbon offsetting, or carbon insetting credits, in their reporting, but these have no actual impact on a product's A1-A3 carbon content. Also, the type and amount of sustainable steel available on the market will greatly depend on the steel grades and section sizes required, with some shapes needing secondary and tertiary processing.

The A1-A3 upfront carbon content for steel sections that's typically required for staircase fabrication can range from 300 kg CO_2e per tonne of steel all the way to 4,000 kg CO_2e per tonne.

Recommendations for further action or research

This research is far from concluded, and we'll continue to incorporate project-specific data as it becomes available.

At this point, we can only make general recommendations to help improve the quality and availability of carbon data for staircases, and this should enable better understanding of staircase performance levels in future.

- Execution Class 3 procurement should be required as part of the design and tender process. It's the only way to achieve full traceability of steel. But this needs to be requested along with agreement that a schedule of such information will be kept up to date live during the project or at specific points to align with WLCA production.
- Low-carbon steel should be specified at the time of ordering. Advance orders can help streamline the number of origins for steel and provide an opportunity to specify which mills steel is sourced from (locking in the carbon content).
- Claims of 'green steel' should be scrutinised before choosing manufacturers. Low-carbon measures and reporting methods are variable, and some are misleading.
- Be mindful that not all sections or grades of steel are available in low-carbon form. Nor can they be found on the reuse market. Some have an inherently higher carbon content due to their additional processing, or they're too difficult or costly to remove from demolition projects.

7.0 Reuse

7.0 Reuse

This research has been prepared by Flavie Lowres from FIS, Alison Grant from HLW, Nick Woodmore from Overbury (now Landsec) and Toby Sowood from Mace.

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Context

The reuse of products and materials in building projects has many carbon-saving benefits. It means reducing:

- Waste from strip out
- Use of virgin resources
- Embodied carbon of overall fit out

But, despite a growing interest in reuse in recent years, data on reused items remains limited and this makes it difficult to measure carbon impact.

There are many parameters when it comes to reuse. EPDs, for example, are based on a process of manufacturing over time, but this sort of data is intangible for reused products.

Where a manufacturer takes control of the whole process, it may be possible to do the calculations and create an EPD. But these scenarios are rare. (See Appendix A.)

Also, the decision to reuse is usually ad hoc. Contractors might not know until a project is well underway whether a building is fit to donate any of its parts. For a fit out to make use of inherited parts, t's a case of matching the right quantity of the right type of product, in the right condition, at the right time.

Progress is slowly being made, with more products being reused and more reuse-specific EPDs being produced. But EPDs are not always the best approach to access data where the process of reusing a product is done on an ad hoc basis. There's a strong and urgent need to establish a standardised process to calculate the upfront carbon of reused products to ensure more consistent results.

Methodology & results

Carbon calculations are based on scenarios rather than EPDs

Given the challenges described, this research team found very few EPDs for reused products. (See Appendix A.)

Instead, they looked at different scenarios in which reuse could happen. (See Table 1.) These point to different carbon calculations depending on the situation and type of reuse.

Table 1: Methodology to calculate upfront carbon performance for reused products.

	Scenario	Carbon Calculation	Notes
a	Product is reused in-situ	A1-A3: 0 A4: 0 A5: 0	If product doesn't move = no impact
b	Product moves from building A to building B - ad hoc	A1-A3: 0 A4: transport distance from A to B (km) * weight (tonne) * kg CO_2e/tkm A5: same as installation of new	Carbon emission factors for transport: 0.88 kg CO_2e/tkm for rigids 0.38 kg CO_2e/km for artics 2.41 kg CO_2efor vans Fuel is assumed to be diesel (see DEFRA conversions for other fuels and vehicles) A5: can be based on an EPD or calculated in an LCA tool to match actual impacts

	Scenario	Carbon Calculation	Notes
c	Product moves from building A to storage to building B - ad hoc (c1) and formalised (c2) approaches	c1. Ad hoc1 A1-A3: 0 A4: transport distance from A to storage and from storage to B (km) * weight (tonne) * kg CO_2e/tkm A5: same as installation of new	A5: can be based on an EPD or calculated in an LCA tool to match actual impacts Note: this scenario doesn't consider the carbon impact of storage space – something that should be looked into in the future A value per m^3 of storage could be the unit (as items may be stored upwards as well as across an area) It might be useful to assess storage indoors (in controlled conditions) vs outdoors
		c2. Formalised Same as scenario (d) below	A5: can be based on an EPD or calculated in an LCA tool to match actual impacts
d	Product moves from building A to manufacturer to building B - formalised approach		A5: can be based on an EPD or calculated in an LCA tool to match actual impacts These next scenarios assume a level of reprocessing, which would ideally include carbon impact for A1-A3. Currently, the practice is to default to a value of zero but this may put manufacturers who have produced an EPD at an unfair disadvantage. The research group discussed this value being a % of the impact of a new product to encourage people to create an EPD. A1-A3 for reused steel is 46 kg CO_2e per tonne (see EMR EDP) whereas new steel is 2,000-3,000 kg CO_2e per tonne (according to ICE), meaning a 98% saving. Reused raised access flooring tile saves 82% of carbon vs new product when comparing A1-A3 (rmf_eco_range_1.pdf (rmf-services.co.uk). If the industry were to assume a default value for A1-A3 where there's no EPD, we'd suggest this being 20% of the impact of a comparable new product. This will depend on the level of reprocessing for each product, but would avoid accounting for the manufacture stage as being zero, which in most cases is incorrect.

	Scenario	Carbon Calculation	Notes
		d2. If there's an EPD for reused product A1-A3: EPD value for reused product	Few EPDs for reused products exist (see Appendix A) A4: if distance from building A to manufacturer is unknown, use 120km as a baseline based on RICS WLCA PS 2nd edition assumptions for national transport
		A4: transport distance from building A to manufacturer and from manufacturer to building B (km) * weight (tonne) * e CO_2e/tkm A5: same as installation of new	A5: can be based on an EPD or calculated in an LCA tool to match actual impacts
		d3. If there's an EPD for a similar reused product A1-A3: EPD value + 30% uplift A4: transport distance from building A to manufacturer and from manufacturer to building B (km) * weight (tonne) * kg CO_2e/tkm A5: same as installation of new	If an EPD for a similar reused product exists, the company that produced the EPD should be rewarded for its efforts and others should be encouraged to do the same. A 30% additional impact therefore seems fair having taken an approach that's used in France where there's no EPD for the actual product – see: Foire aux questions - Inies "Comment demander la création et/ou la mise à jour d'une Donnée Environnementale par Défaut (DED)?" A5: can be based on an EPD or calculated in an LCA tool to match actual impacts

[1] conversion-factors-2021-condensed-set-most-users.xls (live.com)
[2] ad hoc scenario considers that reuse is happening as a one-off and there are therefore no EPD available
[3] formalised scenario is when the processing a specific product is a recurring process and EPD might therefore be available

Until more reuse information is included in EPDs, it's still possible to make rough estimates using building LCA tools based on BoQs of the system. (See Appendix B.)

Partial reuse

When a product is made of different parts, it may be possible to reuse some of these components, if not all. (See Figure 1.)

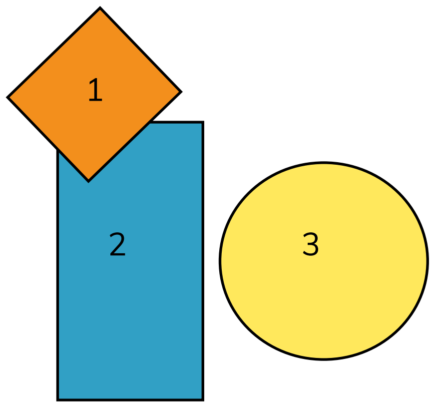


Figure 1: An item that can be partially reused

In some cases, only components 1 and 2 might be reused (in-situ or in the scenarios described in Table 1 above) and component 3 might be replaced. When calculating carbon impact with regards to reused products, it's important to establish what's actually being reused and what's new.

See these examples of multi-component products:

- **Lighting systems:** consider the chassis, diffuser and electrical components as separate elements – most notably, powered vs unpowered – with the powered elements most likely to be replaced in a refurbishment. All elements could be further broken down if required – e.g. chassis into extrusion, end cap into fixings/gaskets – and then these would also need to be quantified.
- **Glazed partitions:** consider two main components – glass and frame. Unless reused in-situ, it's likely that the glass be reused, but not the frame.
- **Raised access flooring:** consider two main components – pedestals and pans. Some reuse schemes will take back the pans and remanufacture them for a second life, but pedestals tend to be new, unless left in-situ (see scenario A in Table 1 above).

Limiting factors of this research

- This research suffered from a lack of formalised approach and data (such as EPDs) for reuse of products.
- It's difficult to create formulae that will cover the breadth of items that may be reused in fit outs. This is due to the different ways products and materials are reused – and their reuse is calculated.
- For some products, stage A4 and A5 figures are not provided on the as-new EPD, which means taking an alternative approach. (See notes in Table 1.)

Recommendations for further action or research

There are several areas where, as an industry, more work is needed:

- Create more EPDs for reused products where there's an industry-formalised process.
- Consider (and show in EPDs) the breakdown of carbon impact per product component – e.g. where some components are reused and others are as-new.
- Review the impact of storing reused products – i.e. the heating, cooling, lighting and logistics of storage.
- Evolve the work in this whitepaper into a playbook that gives a methodology for different levels of intervention/re-manufacture in the reuse process.
- Consider a whole life carbon approach. While there are obvious savings to be made from product reuse at lifecycle stages A1-A3, it's important to ensure that products are reinstalled in a way that will enable their reuse again in the future. Most examples of reuse happen locally, so generally stage A4 is small, but this must remain the case so that reused products aren't transported great distances to a manufacturer or repair centre. It's also important that products last for as long as the fit out in which they're installed – or designed in layers that allow easy repair/replacement if this is likely to happen sooner than it would for a new item.
- Where there's no EPD, determine a default value that can be replaced when manufacturer data becomes available. This could be allocated for stages A1-A3 when a product is taken back to a manufacturer for repair/refurbishment. It would save manufacturers who have completed EPDs from being placed at a disadvantage, as currently the value for this is assumed to be zero.

Practical use of results

As a result of this research, the following insights should be noted:

Before deciding to reuse building products or materials, project leaders should do calculations based on Table 1 to ensure that reuse will actually save carbon. In some cases, where extensive remanufacturing is required in order to reuse an item, a new item will in fact have less carbon impact.

It may not always be possible to reuse 100% of a product, but efforts can and should still be made to reuse as much as possible. Page 86 for case studies where even partial reuse was shown to provide substantial carbon savings

This whitepaper will continue to be updated as more EPDs are produced for reused products, and methodologies are tested on a larger range of projects. Future updates may result in a change to the methodology shown in Table 1. Those interested in progressing this work through sharing case studies should get in touch with the research group.

EPDs for reused products

Here are some of the (very few) examples of EPDs that we found for reused products:

- RMF – raised access flooring panels: S-P-02586 - RMF Recycled Raised Floor Panels (environdec.com). This EPD is for a 600x600mm raised flooring panel (not including pedestal).
- Fischer lighting – lighting systems, including a reused solution: md-20037-en_fischer-lighting.pdf (epddanmark.dk). This EPD is for a lighting system used for 15 years in an office in Denmark.
- Gamle Mursten ApS – reused bricks: Reused bricks for new built and refurbishment (epddanmark.dk). This EPD is for a tonne of used bricks (whole and half) that are machine cleaned and hand sorted. (It expired in 2022, but is still useful as a point of reference.)
- Reused steel reusable-steel-edp-2023.pdf (windows.net). This EPD is for a tonne of reusable steel (mainly).

Reuse Case studies

The following case studies demonstrate how projects used our methodology, as shown in Table 1, to calculate the carbon impact of their reused products and materials.

Project Name	Confidential technology client
Location	Ireland
Size	4,180m^2
Type	In-situ office refurbishment
Completion date	December 2023

Glazed Partitions

	Scenario from table 1 above	Project scale	Calculation of upfront carbon
Glazed partitions that remained in-situ	a	Area: 354.7m^2	A1-A3: 0 A4: no transport = 0 A5: no installation = 0
Glazed partitions reused - moved from building A to building B	b	n/a	n/a
Quantity of new product installed	n/a	Area: 148.5m^2 A1-A5: 1m2 of glazed partition = 152 kg CO_2e/m^2 (According to EPD for new product)	A1-A5: 152 x 148.5 = 22,572 kg CO_2e
Comparison if entire package was new	n/a	Area: 503.2m^2 A1-A5: 1m2 of glazed partition = 152 kg CO_2e/m^2 (According to EPD for new product)	A1-A5: 152 x 503.2 = 76,486 kg CO_2e
CONCLUSION: The reuse of glazed partitions led to a carbon reduction of 76,486 - 22,572 = 53,914.4 kg CO_2e or 53,914.4/4,180m^2 = 13 kg CO_2e/m2 GIA of refurbished space			

Workstations

	Scenario from table 1 above	Project scale	Calculation of upfront carbon
Workstations that remained in-situ	a	Area: 90.7m^2 Equivalent to 81 workstations	A1-A3: 0 A4: no transport = 0 A5: no installation = 0
Workstations reused – moved from building A to building B	b	Area: 380.8m^2 Equivalent to 340 workstations Mass: 21,790 kg Distance between building A and building B: 252km (by diesel truck) A5: 1.03 kg CO_2e/m^2 GIA (according to EPD for new product)	A1-A3: 0 A4: 21,790/1,000 x 252 x 0.88 = 4,832 kg CO_2e A5 (as per new installation): 1.03 x 380.8 = 392.2 kg CO_2e Total A1-A5: 4,832 + 392.2 = 5,224.2 kg CO_2e
Comparison if entire package was new	n/a	Area: 503.2m^2	
		A1-A5: 1m2 of workstation = 104 kg CO_2e/m^2 GIA (according to EPD for new product) Environmental Product Declaration: Ratio Desk (nsf.org)	
CONCLUSION: The reuse of workstations led to a carbon reduction of 52,236.8 - 5,224.2 = 47,012.5 kg CO_2e or 46,353.5/4,180m^2 = 11 kg CO_2e/m^2 GIA of refurbished space			

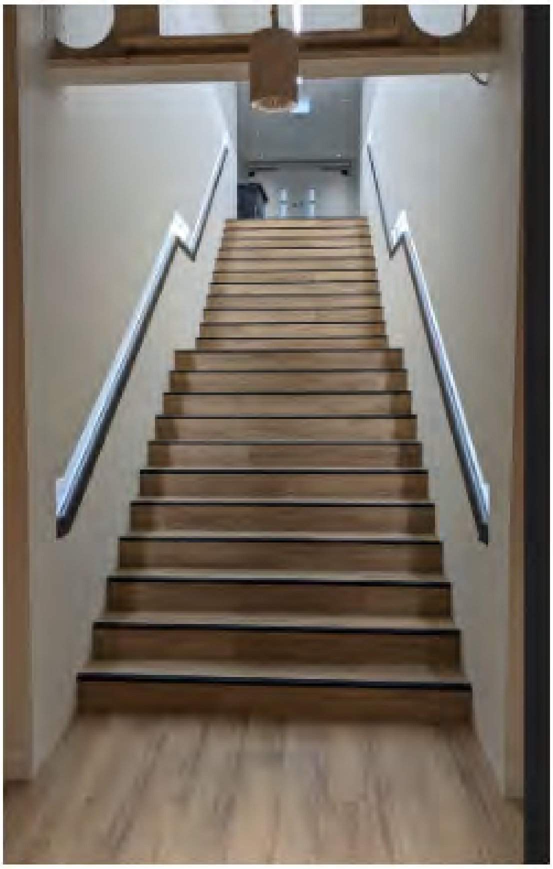
	Scenario from table 1 above	Project scale	Calculation of upfront carbon
Suspended ceiling that remained in-situ	a	Area: 3,605m^2 Impact is zero as product is not moved or reprocessed	A1-A3: 0 A4: no transport = 0 A5: no installation = 0
New product installed	n/a	Area: 126m^2 A1-A5: 1m2 of suspended ceiling = 8.48 kg CO_2e/m^2 (according to EPD for new product) ultima-epd.pdf (armstrongceilings.com)	A1-A5: 8.48 x 126 = 1,068.5 kg CO_2e
Comparison if entire package was new	n/a	Area: 3,731m^2	A1-A5: 8.48 x 3,731 = 31,638.8 kg CO_2e
		A1-A5: 1m2 of ceiling = 8.48 kg CO_2e/m^2 (according to EPD for new product)	
CONCLUSION: The reuse of suspended ceilings led to a carbon reduction of 31,638.8 - 1,068.5 = 30,570.4 kg CO_2e or 30,570.4/4,180m^2 = 7.3 kg CO_2e/m^2 GIA of refurbished space			

Project Name	Kingfisher
Location	London
Size	2,330m^2
Type	New office fit out
Completion date	May 2022

	Scenario from table 1 above	Project scale	Calculation of upfront carbon
Raised access flooring panel reused – moved from building A to building B by manufacturer and stored interim	d3	Area: 2,330m^2 A1-A3: -2.51 kg CO_2e for 1m^2 (based on EPD for reused product)	A1-A3: -2.51 x 2330 = -5,852.3 kg CO_2e A4 and A5 are the same for reused and new tiles, so not considered in this study
Comparison if entire package was new	n/a	Area: 2,330m^2 (based on EPD for new product) A1-A3: 6.2 kg CO_2e for a tile 600x600 mm or 17.2 kg CO_2e for 1m^2	A1-A3: 17.2 x 2,330 = 40,076 kg CO_2e
CONCLUSION: The reuse of raised access flooring led to a carbon reduction of 40,076 - (-5,852.3) = 49,928.3 kg CO_2e or 49,928.3/2,330m^2 = 19.7 kg CO_2e/m^2 GIA of refurbished space			

Project Name	Confidential
Location	London
Size	7,246m^2
Type	Refit - office fit out
Completion date	December 2023

Before



After

Stairs

	Scenario from table 1 above	Project scale	Calculation of upfront carbon
Existing stair structure reused in-situ		Stringer steels: 592 kg Treads: 790 kg Total steel (unknown producer): 1,382 kg	A1-A3: 0 A4: 0 A5: 0 If product doesn't move = no impact
Additional strengthening added to stair structure to upgrade performance		Strengthening to stringer: 973 kg New handrail and back plate: 121 kg Total new steel (unknown producer): 1,094 kg A1-A3: 2.1 kg CO_2e (steel data according to ICE database) Note: structural issues with the existing stairs led to additional steel being used	A1-A3: 2,299 kg CO_2eq A4: unknown A5: 0
CONCLUSION: If the stairs had been installed as new, the estimated carbon impact would have been 1,382 kg steel * 2.1 kg CO_2e for steel (according to ICE) = 2,904 kg CO_2e The reuse of the stairs' steel structure led to a carbon reduction of 2,904 - 2,299 = **605 kg CO_2e**			

8.0 Upfront carbon in Cat B office fit out: Part 1 at a glance

If you are interested to know more about the way in which these research pieces on building elements have helped to arrive at an upfront performance level for Cat B fit out, read on for a summary, or visit to download Part 1 of the report.

www.overbury.com/carbon-in-cat-b-fit-out

Question:

What's the current upfront carbon (lifecycle modules A1-A5) performance level for Cat B office fit out?

Answer:

It's not straightforward. But if you wanted an evidenced average of the current upfront carbon performance level of Cat B office fit out, your number would be 190 kg CO_2e/m^2 (with a lot of caveats to go along side). Read on to find out more and start your next Cat B office fit out project armed with the best available data today to help reduce embodied carbon.

Why is it important?

If we're optimistic, the shell and core plus Cat A of a building are built to last 60 years and 20 years respectively. During this time, there'll be multiple Cat B fit outs. If a fit out takes place every 5 to 10 years, then the Cat B carbon impact could equal that of the shell and core plus Cat A in as little as 20 years. This cumulative Cat B carbon cost is why our research is so important.

So what do we do?

This research serves as a starting point for interested stakeholders to benchmark their own projects, and even set internal up front carbon limits. It also allows transparent discussion within the wider industry about the research that is still needed. From here, we can work with colleagues to build on our findings, refine our methodologies and further inform the wider sector on upfront carbon performance levels in office fit out projects. Ultimately, it's hoped research such as this will help us to reduce the impact of fit out over time.

Day-to-day, what part can everyone play?

1. **Set accountability:** Ensure all team members understand their responsibility for reducing and accounting for carbon emissions during project planning.
2. **Establish baselines and limits:** Understand performance relative to scope, set a baseline, and work towards an internal limit below the industry performance level of 190 kg CO_2e/m^2 GIA, adjusting for project specifics.
3. **Test the draft NZCBS*:** Participate in beta testing during summer 2024 to provide essential feedback for refining the standard.
4. **Engage stakeholders:** Discuss whole life carbon impact with all relevant parties, emphasising the impact of design, procurement and operational choices.
5. **Share and collaborate:** Get involved in further research, share internal knowledge and contribute WLCAs** to improve industry data.

These recommendations aim to integrate carbon accountability into daily practices, engage stakeholders and increase the comprehensive carbon data available for further research.

*NZCBS – Net Zero Carbon Building Standard
**WLCA – Whole Life Carbon Assessments

9.0 Glossary and references

Glossary and references

BREEAM: Building Research Establishment Environmental Assessment Methodology is an environmental assessment method for the built environment and infrastructure used to assess whole life sustainability performance on projects worldwide.

BS EN: BS ENs are British implementations of European standards (ENs). BSI (British Standards Institute) publishes all ENs and withdraws any conflicting British standards. Standards begin with the designation BS EN and use the relevant EN standard's number. They are not a legal requirement but following such standards indicate compliance with best practice.

Cat A fit out: any site preparation works required for the shell and core build, as well as finishes (e.g. raised access floors, suspended ceilings), MEP and fixed FF&E outside of the shell and core scope.

RICS, RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition (2023))

Cat B fit out: A Category B (Cat B) fit out follows on from a Category A fit out and typically includes bespoke partitioning, finishes, carpeting, lighting, kitchen facilities, etc. that are specific to the requirements of the occupier.

RICS, RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition (2023)

CIBSE TM65 (Chartered Institute of Building Services Engineers Technical Memorandum 65): An internationally-applicable methodology for the calculation of embodied carbon in building services engineering. www.cibse.org/tm65#:~:text=TM65%3A%20An%20internationally%2Dapplicable%20methodology,carbon%20in%20building%20services%20engineering

CO_2e : Carbon dioxide equivalent**:** A metric for expressing the impact of all greenhouse gases on a carbon dioxide basis.

RICS, RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition (2023))

Embodied carbon: The embodied carbon emissions of an asset are the total GHG emissions and removals associated with materials and construction processes, throughout the whole life cycle of an asset (modules A0–A5, B1–B5, C1–C4))

RICS, *RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition* (2023)

EPD: Environmental product declaration. A document that clearly shows the environmental performance or impact of a product or material over its lifetime.

RICS, RICS Professional Standard Whole Life Carbon Assessment for the Built Environment, Global 2nd edition (2023)

Fugitive Emissions: Emissions as a result of accidental or unintended release of gases/vapours from pressurised equipment such as HVAC and refrigeration systems.

GHG (greenhouse gas) Protocol: greenhouse gas accounting standards designed to provide a framework for businesses, governments, and other entities to measure and report their greenhouse gas emissions in ways that support their missions and goals. ghgprotocol.org/standards

GLA: Also known as 'City Hall', the Greater London Authority (GLA) was created after a referendum in 1998, when Londoners voted in favour of a directly elected Mayor to represent London's interests, and a London Assembly to scrutinise their work. The GLA's London Plan Policy SI 2 sets out a requirement for development proposals to calculate and reduce WLC emissions as part of a WLC assessment.

Gross internal area (GIA): the area of a building measured to the internal face of the perimeter walls at each floor level. Within the RICS Code of measuring practice, a full list of building areas that are included and excluded are provided.

RICS (2016), RICS professional standards and guidance, Global Code of measuring practice 6th edition

May_2015_Code_Of_Measuring_Practice_6th_Edition.pdf (rics.org)

GWP: Global Warming Potential: All greenhouse gases have an impact on climate change, but they have two characteristics; how powerful their warming effect is and how long they last in the atmosphere. The GWP is a way of being able to compare different greenhouse gases to each other in one standard metric. GWP is how much impact a gas will have on atmospheric warming over a period of time compared to carbon dioxide. https://ahdb.org.uk/knowledge-library/what-is-gwp

ISO: International Standards Organisation. ISO Standards provide detail on a variety of topics and describe the best way to carry out a particular task or activity of the basis of known best practice. They are not a legal requirement.

LEED: Leadership in Energy & Environmental Design. A green building certification programme defining best practices for green buildings, used worldwide.

LETI: the Low Energy Transformation Initiative (LETI) is a voluntary organisation aiming to move the UK towards a zero carbon future. It aims to provide clarification to the built environment on the requirements needed to meet the UKs climate change targets.

NIA: Net Internal area Net internal area**:** the usable area within a building measured to the internal face of the perimeter walls at each floor level. Within the RICS Code of measuring practice, a full list of building areas that are included and excluded are provided.

RICS (2016), RICS professional standards and guidance, Global Code of measuring practice 6th edition,

May_2015_Code_Of_Measuring_Practice_6th_Edition.pdf (rics.org)

NZCBS: Net Zero Carbon Building Standard. The UK's first cross-industry Net Zero Carbon Buildings Standard that brings together Net-Zero Carbon requirements for all major building types, based on a 1.5°C trajectory.

PAS (Publicly Available Specification) 2080: guides the management of carbon across the lifecycle of buildings and infrastructure. Focusing on decarbonizing the built environment and effective carbon management.

bsigroup.com/en-GB/insights-and-media/insights/brochures/pas-2080-carbon-management-in-infrastructure-and-built-environment/

Performance levels: In relation to the NZCBS these levels provide the technical evidence on what can be achieved by the individual sectors, based on benchmarking, case studies and modelling. They're not limits or targets, but will be used to inform the NZCBS limits and targets in the next stage of work.

RICS: Royal Institution of Chartered Surveyors, is a leading professional body working in the public interest to advance knowledge, uphold standards, and inspire current and future professionals. The RICS produces a number of guidance documents for its members and the wider industry that help to ensure standardisation of both construction project quantities measurement and Whole Life Carbon Assessments.

RICS Professional Standard Whole life carbon assessment for the built environment 1st and 2nd editions: The RICS whole life carbon assessment (WLCA) standard is set to become the world-leading standard for consistent and accurate carbon measurement in the built environment. The 2nd edition replaced the 1st edition on July 1st 2024.

RIBA: The Royal Institute of British Architects is a global professional membership body driving excellence in architecture. The RIBA Stages organise the process of briefing, designing, constructing and operating building projects into eight stages and explains the stage outcomes, core tasks and information exchanges required at each stage.

Shell and core: Refers to the first phase of a commercial project where the basic inside (core) and the outer building envelope (shell) are constructed, without adding things like furnishings, interior lighting fixtures, interior walls or ceilings.

RICS, RICS Whole Life Carbon Assessment for the Built Environment, Professional Standard, Global 2nd edition (2023)

SKArating: is an assessment scheme which helps landlords and tenants assess fit-out projects against a set of sustainability good practice criteria. SKA is a toolkit and assessment criteria that is free to use with costs being covered via training and certification. It was released in 2008 and over 12,000 fit out projects have gained certification since that time. **skarating.org/**

Upfront carbon: Upfront carbon emissions are greenhouse gas emissions associated with materials and construction processes up to practical completion (modules A0–A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion.

RICS, RICS Professional Standard Whole Life Carbon Assessment for the Built Environment, Global 2nd edition (2023)

WLCA: A whole life carbon assessment (WLCA) is the calculation and reporting of the quantity of carbon impacts expected throughout all life cycle stages of a project, but also includes an assessment of the potential benefits and loads occurring beyond the system boundary. Whole life carbon refers to the carbon impacts over the entire life cycle of a built asset, from its construction through to its end of life.

RICS, RICS Professional Standard Whole Life Carbon Assessment for the Built Environment, Global 2nd edition (2023) overbury

overbury.com