UK GBC

The voice of our sustainable built environment

EMBODIED CARBON

Improving your modelling and reporting

NOVEMBER 2023

UK Green Building Council
ukgbc.org

ADVANCING NET ZERO

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FOREWORD

Climate change is a clear priority across the built environment sector and our commitments are now translating into meaningful action. And these changes are urgently needed, because our industry is responsible for almost 40% of global carbon emissions according to the United Nations and our planet cannot achieve net zero unless we play our role in full.

Like many other sectors, our initial focus has been on tackling the emissions over which we have the most direct control and influence. For many of us, that has meant reducing the direct emissions from our construction activities, as-well-as creating buildings and environments which use less energy over their operational lifespans. But it is not the complete picture and we now need to apply the same focus to the more complex challenge of embodied carbon.

By nature, these emissions are harder to measure. They occur throughout our supply chains in a mix of different places and settings. They relate to many different processes we don't control. And measuring these emissions accurately and fairly is a hugely complex challenge in itself.

But we are making progress. Industry has started to accept its responsibility and we are now beginning to measure and report the carbon impacts of our buildings.

This report from UKGBC explores the need to improve embodied carbon modelling and reporting and the need for greater consistency. It provides useful explanations and approaches for achieving greater accuracy and more reliable reporting, as well as making the case for standard approaches to modelling to drive positive change throughout the industry.

Berkeley Group are pleased to have supported this project as a partner of the UKGBC Advancing Net Zero programme as we are committed to reducing our embodied carbon. Over the last two years we have begun to understand our impact but we can only achieve this through measurement and reporting of our embodied carbon. There is a need for clear guidance that helps to provide industry with a consistent approach. This report will help practitioners to achieve this.

Louise Clarke
GROUP HEAD OF SUSTAINABILITY
BERKELEY GROUP

In the UK, UKGBC's Whole Life Carbon Roadmap shows embodied carbon makes up 20% of the built environment sector's emissions. As energy production decarbonises, the importance of these emissions will only increase.

Currently, embodied emissions from materials are not reported clearly in our UK emissions tracking. Furthermore, the Climate Change Committee (CCC) report to the UK Government in June 2023 noted that planning for the 'requirement of mandatory whole life carbon assessments for public and private buildings by 2025' was overdue by more than a year, despite industry leading the way with proposals such as Part Z. Whole life carbon analysis is the key tool we have to ensure embodied emissions are reported and the scale of the problem is understood so we can focus on reductions.

This UKGBC release is well timed to coordinate with the September 2023 release of the updated RICS Whole Life Carbon assessment (WLCA) Standard and the Built Environment Carbon Database (BECD). The key aims of both documents are to ensure consistency of measurement and reporting of embodied and operational emissions alongside advocating for the regular measurement and reporting at all stages, including in-use.

The primary aim of UKGBC's guidance are to amplify and expand the principles in the RICS WLCA Standard so it will be used more robustly in practice. Transparency and alignment are key. This is because the uptake quantifying embodied carbon in our built environment must be undertaken with urgency; these are near-term emissions, that we must reduce to slow the pace of the climate and biodiversity emergency.

This document is a call to arms for analysts, tool providers, design teams and clients to collaborate and speed our transition to reducing embodied carbon emissions in the built environment. While national regulation has not yet been implemented, the industry has to come together to show it is ready.

Louisa Bowles
HEAD OF SUSTAINABILITY
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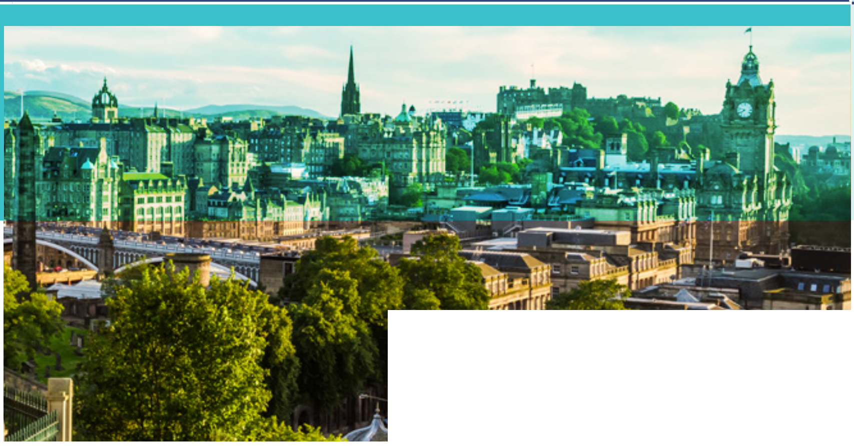

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1 EXECUTIVE SUMMARY

This report focuses on refining and improving the practices of embodied carbon modelling and reporting within the construction industry. It is aimed at practitioners undertaking embodied carbon modelling, and especially those who are new to the practice. Widespread embodied carbon reporting is essential for the construction industry to effectively address its environmental impact and, as the practice is undertaken with increasing frequency, it's important to ensure that it continues to be rigorous and reliable. Moving to greater transparency and consistency will enable informed decision-making and more sustainable practices across the construction sector.

To write this report, UKGBC brought together a Task Group of industry experts with experience in carrying out embodied carbon assessments. To provide further context, the Task Group also undertook an embodied carbon assessment on a real-life project, giving direct and live insight into the challenges outlined in this report. This is supplemented through a literature review of existing guidance and studies, the most important of which are signposted throughout this report.

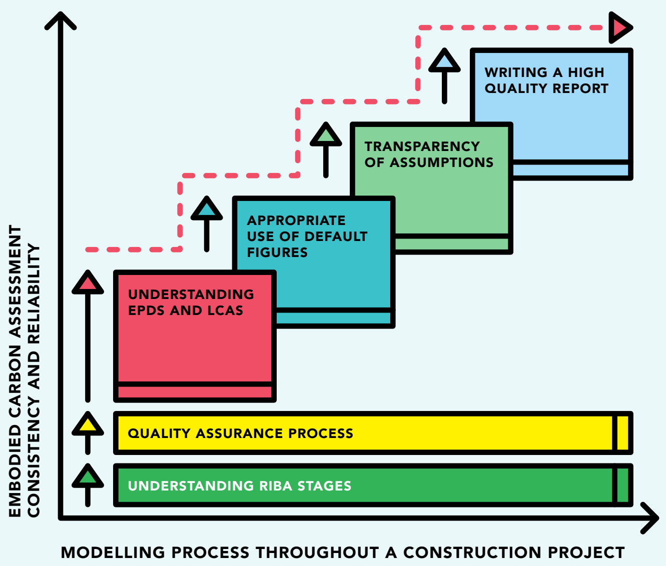
Overall, the project concluded there is a need for greater transparency in the decisions and assumptions made by assessment practitioners during the modelling process. Some of these decisions are actively made by the individuals themselves, while others are the result of default assumptions within the software and tools used for modelling (e.g., EC3, eTool, OneClickLCA, and Preoptima).

To help the industry improve its understanding of and consistency in embodied carbon assessments, this report contains key sections on:

- how to understand and use Life Cycle Assessments (LCAs) and Environmental Product Declarations (EPDs);
- default assumptions within the RICS Whole Life Carbon Assessment (WLCA) Professional Standard and an explanation of how they're used within modelling tools;
- how to establish a Quality Assurance process for embodied carbon assessments;
- how embodied carbon assessments can be expected to develop and change across RIBA Stages; and
- how to write high-quality embodied carbon assessment reports.

The diagram below is a simple visual representation of these sections and how they collectively support an individual practitioner in improving their embodied carbon modelling and reporting process.

FIGURE 1:
Steps to improve consistency and reliability in your embodied carbon assessments.



2 CALLS TO ACTION

In order to successfully roll out embodied carbon assessments across industry, as consistently called for by UKGBC, the following actions are needed. These are mainly aimed at three key stakeholders:

- The practitioners undertaking embodied carbon assessments
- Modelling tool providers
- National and local policy makers

GREATER CONSISTENCY: Industry must fast-track efforts to embed greater consistency across modelling tools.

One avenue for achieving this is by embedding the RICS WLCA Professional Standard methodology as the foundation for embodied carbon assessments within modelling tools. This would mean the default figures given by RICS (such as product specifications, transport distances, and waste percentages) are the starting point for modelling, and only deviate once specified by the user. When a user does specify otherwise (i.e., as designs become more specific), they should be able to show justification and transparency on their modelling input.

GREATER TRANSPARENCY: Embodied carbon reports need to clearly highlight and describe any significant assumptions which have been made during the modelling process.

The quality of embodied carbon assessment reports must be improved by including comprehensive project information, clear emission factors and their sources, material quantities, and transparent results. The most significant assumptions and modelling decisions need to be made clear, along with the reasons why they were made.

Outputs from modelling tools also need to be interoperable, allowing for the model from one tool to be opened, analysed, and edited within another. This will allow for greater transparency and consistency throughout projects – especially when modelling assessments move between design teams across project stages. It will allow for full transparency on assumptions and inputs used at early design stages, that inform decisions made at a later date.

STRONGER REGULATION: We need responsible regulation from government to accelerate industry action on embodied carbon.

Whilst this report lays out several ways by which practitioners can improve the consistency and reliability of their embodied carbon modelling and reporting, for widespread progress, it's clear that national level regulation is urgently required. Currently, measurement and mitigation at project level is typically voluntary, with no national-level policy in place.

UKGBC calls for mandatory measurement and reporting of Whole Life Carbon for new buildings and major refurbishments, initially for large buildings (>1000m^2) and residential developments (>10 dwellings). This must be followed by progressive limits on emissions over time.

Alongside these measures, planning reforms should prioritise reuse of existing buildings and assets over demolition and new build. More details are set out in UKGBC's Whole Life Carbon Roadmap.

UPSKILLING: We need an official education route through accreditation schemes to improve the expertise of assessors, further enhancing the reliability of assessment results.

Whilst the number of embodied carbon (and more broadly, whole life carbon) assessments increases, the development of practitioner accreditation programs is necessary to ensure the competence and expertise of assessors, further enhancing the reliability of assessment results.

3 INTRODUCTION

3.1 BACKGROUND

Despite being a significant source of carbon emissions in the UK, embodied carbon emissions are currently unregulated, and measurement and mitigation within construction is typically voluntary. As highlighted by UKGBC's **Net Zero Whole Life Carbon Roadmap**, the accurate and consistent measurement and reporting of embodied carbon has become increasingly important to ensure meaningful and credible progress towards net zero carbon goals can be achieved..

To achieve this, it's essential that embodied carbon moves quickly from being a challenge only addressed by leading organisations, to one that is tackled by stakeholders across the built environment industry. While many leading developers and infrastructure organisations measure and optimise the embodied carbon footprint of their projects, it is far from being mainstream practice. As the need and demand increases, this report will drive further understanding, consistency, and reliability in embodied carbon assessments. It builds upon UKGBC's previous work, **Embodied Carbon: Practical Guidance, Developing A Client Brief**, and is written in consideration of the 2023 update to the **RICS Whole Life Carbon Assessment Professional Standard**.

Embodied carbon reporting in the construction industry faces challenges, resulting in excessive time spent trying to comprehend the differences between reports and understand the various inputs, assumptions, and scope that have been used to produce the results. Some of the causes of these challenges include:

- a lack of clear and standardised information, making it difficult to compare results between projects;
- a lack of transparency, which hinders readers from fully understanding the environmental impacts associated with specific building materials, processes, and design choices; and
- misrepresentation of the true sustainability performance of a project, leading to erroneous conclusions and misguided decision-making.

3.2 WHAT DOES THIS GUIDANCE DELIVER?

This report aims to:

- give insight into common variations within the modelling process: where it happens, how to understand it, and how to mitigate any negative impacts;
- give clarity on the typical assumptions made during the modelling process, and how they can be used to support a more consistent and comparable approach to embodied carbon assessments;
- help embodied carbon practitioners create transparency within their assessments and reports, and give recommendations on how to improve reliability of results;
- promote the philosophy that during early project stages, embodied carbon assessments are to be recognised as a design tool used to drive down whole life carbon, rather than an accounting tool; and
- build on existing guidance and continue to drive the consistent measurement of embodied carbon throughout the built environment.

3.3 TARGET AUDIENCE

This report is a guide for practitioners undertaking embodied carbon assessments, to recommend how to improve the transparency and reliability of results. It will be used to upskill new practitioners, supporting the need to strengthen embodied carbon skills from the early adopters and innovators to the industry majority. Furthermore, this work re-emphasises the need for embodied carbon assessments to be mandated across the industry, with clear regulation that ensures consistent outcomes.

3.4 DEVELOPING THE GUIDANCE AND HOW IT IS WRITTEN

This report aims to:

1. Firstly, this project brought together the experience of over thirty professionals (the Task Group) to review the current standard of embodied carbon modelling and reporting and highlight areas for improvement.
2. Secondly, to provide further understanding, a subset of the group undertook embodied carbon assessments for a real-life project, across Concept and Technical Design stages.
3. Finally, the project builds upon the learnings and results from recent academic studies that have compared modelling tool performances and variances across embodied carbon assessments.

By combining these three approaches, this guidance presents recommendations for improving the quality and consistency of embodied carbon calculations. Some of these recommendations are proofs of concept, some can be immediately implemented, and some are requests to modelling tool developers.

3.5 MODELLING METHODOLOGY

A case study project was selected based on the availability of design information for the following RIBA stages:

- Concept Design (RIBA Stage 2)
- Technical Design (RIBA Stage 4)

The approach to modelling was extensively discussed during various workshops throughout the duration of the project. One of the key factors influencing variation in embodied carbon assessments in the industry is how the tools and their users interact with project information. How an assessor interprets project information can vary significantly depending on their experience and understanding of building materials and construction methods. Previous research has shown that different assessors starting from the same information will make different assumptions leading to variation in results [1].

The embodied carbon modelling was undertaken using EC3, eTool, OneClick, and Preoptima, with a different individual using each tool. This method wasn't intended to be academically rigorous (i.e., using controlled variables), but rather as a representation of the variation seen in industry, and therefore was set up to highlight the commonly seen challenges.

For the embodied carbon assessment of Concept Design, a cost plan based on the RIBA Stage 2 design was used as the primary data source for extracting material quantities and specifications. A bespoke LCA Excel template was created as a standard data inventory to be used by assessors of all tools. The process also included making assumptions to fill data gaps, for example, assuming reinforcement quantity based on volume of concrete and assuming quantities of materials in roof and wall build-ups. This ensured that material quantities information was given to each modeller, without restricting the modeller's individual interpretation.

The same approach was adopted for the Technical Design stage assessment, using the RIBA Stage 4 cost plan and outline specification document as the primary source of data.

The embodied carbon assessments followed the RICS WLCA Professional Standard and was conducted for Modules A-C.

3.6 GUIDANCE LAYOUT AND OVERVIEW

This report is split into two key sections:

4 **Guidance for improving your modelling and reporting:**
- Selecting appropriate EPDs
- How assessments change across RIBA Stages
- The need for transparency on assumptions
- Establishing a quality assurance process
- How to write a high-quality report

5 **Concept ideas for further improvements in the modelling and reporting process:**
- Using a variance range
- Understanding assessment completeness through as-built benchmarks

The following diagram gives an overview of this report's structure and conclusions. It highlights that the key sources of variability come from modeller assumptions and inputted data. Some of these modeller inputs are chosen by the user, while some are default assumptions embedded within the modelling software.

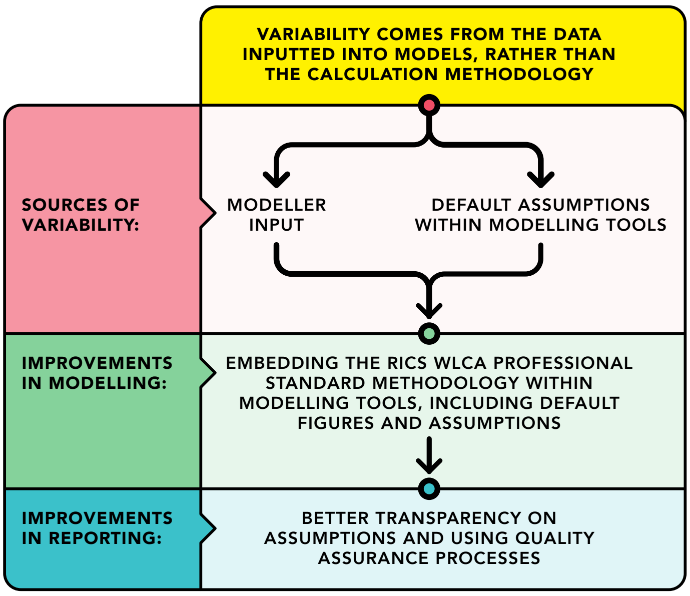


FIGURE 2:
Overview of report structure and key themes.

The conclusion that the modeller's input has a significant impact on the variability of results aligns with other key industry studies [1] [2].

[1] F Pomponi, A Moncaster, and C De Wolf, Furthering embodied carbon assessment in practice: Results of an industry-academia collaborative research project May 2018 .
[2] E Marsh, S Allen, and L Hattam. Tackling uncertainty in life cycle assessments for the built environment: A review March 2023

4 GUIDANCE FOR IMPROVING YOUR MODELLING AND REPORTING

4.1 INTRODUCTION

This section of the guidance is specifically aimed at practitioners undertaking embodied carbon assessments. It covers five topics to give greater understanding and direction, support learning, and to ultimately increase consistency and transparency in assessments across industry.

The topics covered are:

4.2 UNDERSTANDING EPDS AND LCAS

Accurate embodied carbon assessments depend on standardised Environmental Product Declarations (EPDs) and Life Cycle Assessments (LCAs) that outline a product's manufacturing and usage impacts. Using representative data is vital for precise results, therefore this section signposts to industry guidance on assessing data quality and reliability.

4.3 HOW ASSESSMENTS CHANGE ACROSS RIBA STAGES

Embodied carbon assessments should be updated at key RIBA Stages to track progress and reduce embodied carbon as designs develop. However, assessment approaches at each stage vary due to changing design and data availability. This section explains how these assessments evolve across RIBA Stages, aiming to enhance consistency, reliability, and understanding of differences in results. The 'UKGBC's RIBA Stages guide for Embodied Carbon Assessments' supplement outlines a project team's approach for each stage, including contingency plans and reliance on robust data.

4.4 THE NEED FOR TRANSPARENCY ON ASSUMPTIONS

The modelling analysis undertaken by the Task Group revealed significant discrepancies due to varied assumptions like default product specifications, waste factors, and cost plan interpretations. Reports must highlight key assumptions, which significantly affect outcomes, for improved accuracy and informed decision-making.

4.5 HOW TO WRITE A HIGH-QUALITY REPORT

This section emphasises the importance of high-quality reports, addressing challenges like inconsistency, lack of clarity, and misleading claims. The section presents guidelines for producing excellent reports, including presenting project information, emission factors, and quantities transparently. Improved reporting promotes informed decisions, reduces environmental impact, and fosters a sustainable construction industry.

4.6 ESTABLISHING A QUALITY ASSURANCE PROCESS

This section introduces the importance of documenting and internally reviewing assumptions and inputs within an embodied carbon assessment. It offers guidance on establishing a Quality Assurance (QA) process. The provided QA tables detail the process for robust and consistent assessments, including materials inventory and input quality review.

4.2 UNDERSTANDING EPDS AND LCAS

INTRODUCTION

Environmental Product Declarations (EPDs) and Life Cycle Assessments (LCAs) represent a standardised method of reporting the impacts incurred due to manufacturing and using a product. Embodied carbon assessments are reliant on using both EPDs and LCAs for appropriate materials and product data. It's therefore critical that representative data is used, otherwise, the final embodied carbon assessment could be inaccurate, no matter how good the analysis is.

There are many excellent EPD and LCA explainers in industry already, for a greater in-depth understanding, we've linked to publications to the right. These cover how EPDs and LCAs are developed, how to read them, and how to understand them.

ASBP The Alliance for Sustainable Building Products

The Institution of StructuralEngineers

cpa construction products association

Building Transparency

There are several aspects to an EPD or LCA that need understanding to assess whether it is an accurate representation of the product used on site. This is discussed in detail within the **Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment**, and the **RICS Whole Life Carbon Assessment Professional Standard 2023**. Both publications give methodologies through which you can assess and grade the quality of data being used in your embodied carbon assessment.

The elements to consider within these pieces of guidance are:

TEMPORAL	GEOGRAPHICAL	COMPLETENESS	RELIABILITY
How recently was the EPD published?	Does all the data in the EPD represent the manufacturing location?	Are there any gaps in the assessment, or are all relevant processes included?	Is all the data based on verified measurements?
PRODUCT SPECIFICITY	**INSTALLATION SPECIFICITY**	**SUPPLY CHAIN DATA**	**TECHNOLOGY**
Is it an exact product match or an average representation?	Is the installation impact considered, product-specific, or an average?	Is the EPD built from supplier-specific data or sectoral averages of material production?	Is the manufacturing technology represented within the EPD specific to the product?

TABLE 1:
Sources of variation within an EPD.

LEARNINGS FROM THE TASK GROUP

During early-stage modelling, cost plans are typically used as the source of material quantity data. It's common during this phase for cost plans to give an outline without any product specifics. It's therefore the modeller's responsibility to ensure appropriate and representative products are used within the embodied carbon assessment.

When undertaking the modelling analysis within the Task Group, the cost plan was the source of material quantity data used during the concept phase, and at this point the concrete strength hadn't been specified. With some modellers selecting C40/50, and some C25/30, this led to significant differences in embodied carbon, shown in Figure 3, especially in concrete-heavy elements, such as the substructure.

The RICS WLCA methodology includes default figures for use at early design stages when there are unknowns about material choices. Standardisation in this manner is important at early design stages, as it removes variability due to unknowns, creating consistency and comparability at early stages. However, not all modelling tools use the RICS default figures as their starting point, with some always requiring user input, and others using their own default figures. The above example of the substructure is particularly clear as it shows variability across concrete specification, transport distances, and waste factors.

As a modeller, it's important to understand when to use default figures, generic sector-level data and when to use product-specific data. Generic data (which can be sourced from ICE, IMPACT, and BECD databases, or sector-level EPDs) can be used at early design stages to take the first modelling steps beyond the default figures. Product-specific EPDs should then be used when there is reasonable certainty that the product will be used in the project.

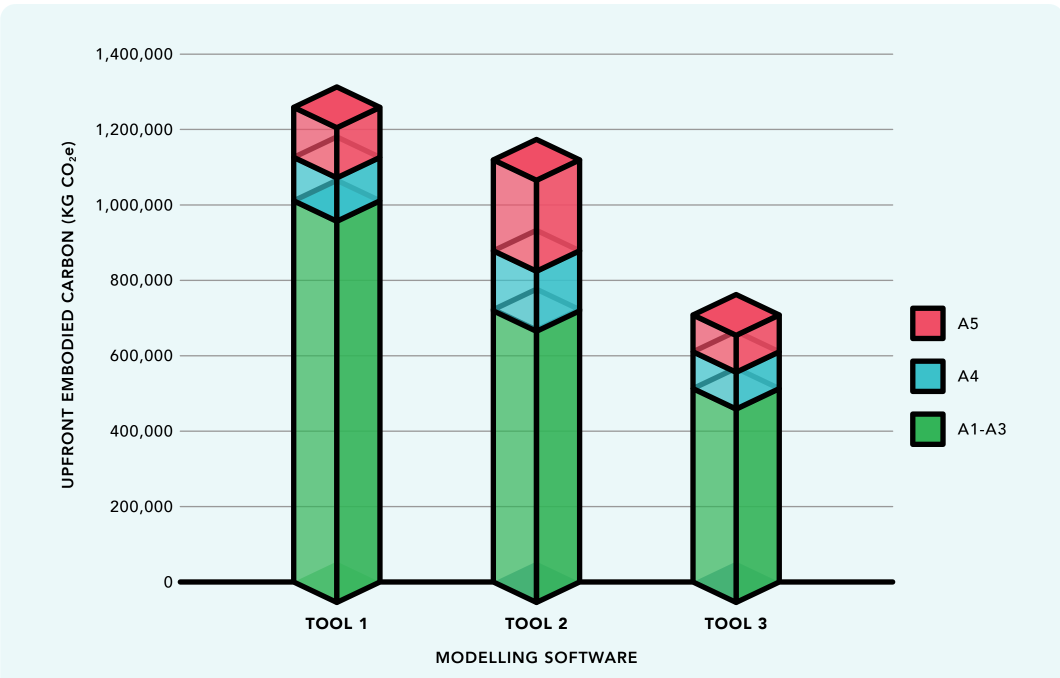


FIGURE 3:
Substructure of upfront embodied carbon at Concept Design stage.

4.3 HOW ASSESSMENTS CHANGE ACROSS RIBA STAGES

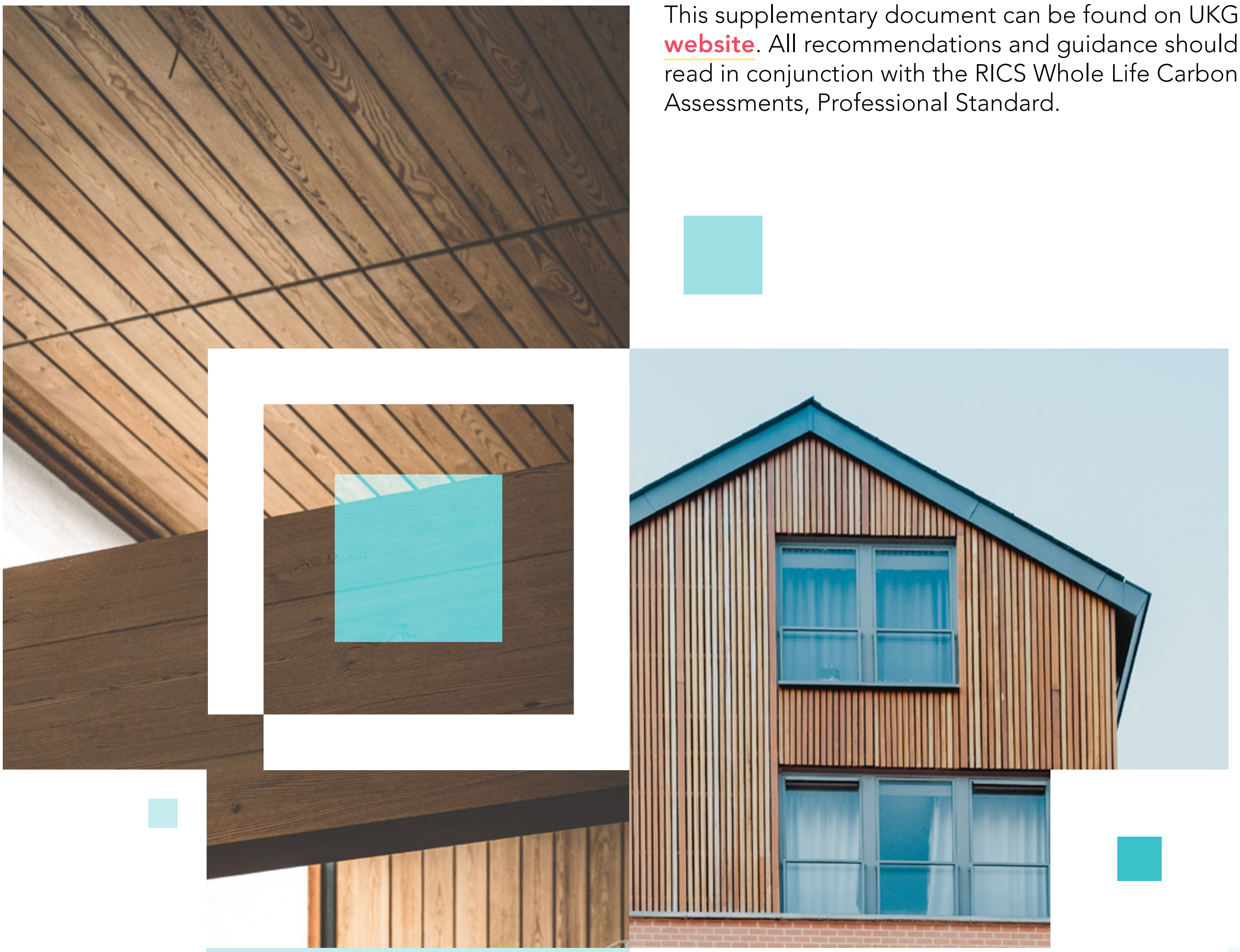
INTRODUCTION

Embodied carbon assessments, and more broadly WLCAs, are updated across the RIBA Stages to track progress and identify options to further reduce embodied carbon as the design and development progresses. However, the detail and process for embodied carbon assessments can vary considerably across the RIBA Stages due to availability and changes in design information and product and carbon data. It is therefore important to recognise these differences and how this affects the approach at each RIBA Stage.

LEARNINGS FROM THE TASK GROUP

The supplementary document '**UKGBC's RIBA Stages guide for Embodied Carbon Assessments**' sets out how a project team might approach embodied carbon assessment at each RIBA Stage. It also gives guidance on how to help manage expectations and increase the understanding of potential variance as a project develops. This aims to improve the consistency and transparency of a project's embodied carbon assessment as the design develops, whilst improving the understanding of any changes that may occur in the assessment outcomes.

This supplementary document can be found on UKGBC's **website**. All recommendations and guidance should be read in conjunction with the RICS Whole Life Carbon Assessments, Professional Standard.



4.4 THE NEED FOR TRANSPARENCY ON ASSUMPTIONS

INTRODUCTION

Transparency and consistency throughout embodied carbon assessments are essential to ensure the level of quality and content remains reliable, especially as they're undertaken with increasing frequency across industry.

Embodied carbon reporting in the construction industry faces challenges, resulting in excessive time spent trying to comprehend the differences between reports and understand the various inputs, assumptions, and scope that have been used to produce the results (for example, when comparing projects or embodied carbon assessments from different consultants across a project lifetime). As discussed earlier in this document, some of the causes of these challenges include:

- a lack of clear and standardised information, making it difficult to compare results between projects;
- a lack of transparency hinders readers from fully understanding the environmental impacts associated with specific building materials, processes, and design choices; and
- misrepresentation of the true sustainability performance of a project, leading to erroneous conclusions and misguided decision-making.

LEARNINGS FROM THE TASK GROUP

Even when assessments are carried out based on identical initial data, the potential for discrepancies remains. There are many possible causes for this, with some of the most prominent being:

- differing assumptions for product specifications at early stages. This is especially acute in concrete specification where higher strength concrete usually has higher emissions;
- differing figures for waste factors, construction, and transport emissions. Assumed figures can vary, either due to different default figures within the tools, or individual decisions based on experience and expertise; and
- differing modeller interpretations of an early-stage cost plan, where lack of detail leads to uncertainty and variance in interpretation.

Furthermore, the various modelling software have a range of methods for users to input material data, from giving the modeller responsibility to ensure all relevant materials are included for an element (e.g., the cost plan may just list a 'brick wall', however it's not clear whether the foundation was to be included), to tools that use templates where multiple items are grouped together to produce a single input for a building element (e.g., by selecting the brick wall in the software, then the foundation is automatically included).

This demonstrates the importance of the modeller being aware of the inclusions within the model, selecting appropriate products, and default options that create consistency across models.

For modelling software, transparently showing the assumptions needs to be standard practice, with the aim of providing a clear audit trail that allows models to be rigorously tested and verified. This means starting from the RICS default figures, and then as decisions are made across the project to use more accurate data, being transparent about the assumptions made and giving space for additional explanation from the modeller.

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4.5 HOW TO WRITE A HIGH-QUALITY EMBODIED CARBON ASSESSMENT REPORT

INTRODUCTION

High-quality embodied carbon reporting is essential for assessing, understanding, and mitigating the environmental impact of the construction industry, which constitutes a significant proportion of UK greenhouse gas emissions.

The aim of this section is to highlight areas of good practice to incorporate into report writing, taken from the experiences of practitioners within the Task Group who have reviewed a wide range of embodied carbon reports.

LEARNINGS FROM THE TASK GROUP

Basic project information

Essential project information should be clearly presented to provide context on the assessment, as required as part of the RICS WLCA Professional Standard. It should be positioned or referenced as part of the opening text to aid the reviewer in fully understanding the context of the assessment.

Clear presentation of emission factors, material quantities, and results

A good embodied carbon report clearly states the emission factors and quantities used in the assessment. This ensures that stakeholders can accurately assess the environmental impact of the construction project and can understand the key factors that led to the final result.

It should be clear which type of data has been used as the emissions factor (e.g., generic database, LCA, or EPD) and the source of that data. To supplement this, there should also be a brief description as to why that data source has been used.

Clear presentation of assumptions

Within a published report, the key assumptions across all modules should be made clear to allow for a thorough understanding and verification of how the final figure was reached. This is especially important for the assumptions that have the largest impact on the outcome.

Consistent data representation

The data within the report should be controlled and consistent, ensuring that the same data is always represented in the same way. This reduces the risk of confusion or misinterpretation. This is particularly important when the report is being used by multiple stakeholders, each of whom may have different levels of familiarity with the data.

Use of publicly available data

By using publicly available data (such as EPDs, or data from established industry databases), the report can be independently verified, increasing its trustworthiness. This not only enhances the credibility of the report but also allows for independent verification of the results.

Rigorous quality assurance process and verification

A high-quality report undergoes not only a thorough quality assurance process, but also a third-party verification process by an independent expert. This ensures the highest level of accuracy, consistency, and reliability in the reported results.

Design process and interpretation

A clear and descriptive account of the embodied carbon reductions employed, and their respective impact, should be immediately identifiable to the reader of any report. The clear reporting of each measure's individual effectiveness will help to better educate clients on how their development has achieved the results and the best solutions to employ on future projects. The report should also highlight the areas of high emissions intensity within the building, and describe why they exist.

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4.6 ESTABLISHING A QUALITY ASSURANCE PROCESS

INTRODUCTION

This section is written for individuals and organisations who are new to embodied carbon assessments, as guidance on how to establish a quality assurance process. Documenting and internally reviewing assumptions and inputs into a life cycle assessment is important to establish consistency in a modelling approach.

LEARNINGS FROM THE INDUSTRY GROUP OF PROFESSIONALS – AN OUTLINE QUALITY ASSURANCE PLAN

The supplementary tables, given in Appendix A, outline a quality assurance process that could be followed to support a consistent approach. The tables should ideally be completed in real-time whilst undertaking the assessment to ensure amendments are captured effectively. This should be completed at each RIBA Stage, or with each revision of the assessment.

The quality assurance process follows a basic format, with a checklist of information to be completed by the modeller, and then reviewed and accepted by the auditor. The checklists are split across two sections. The first includes questions on core topics such as project scope, sources of information, and modelling software. The second relates to the consistency and quality of information that is inputted into the modelling software.

	MODELLER	AUDITOR	DATE
QUALITY ASSURANCE SECTION 1	Who carried out the embodied carbon assessment	Who reviewed the modeller's work	Date of the audit completion
QUALITY ASSURANCE SECTION 2	Who carried out the embodied carbon assessment	Who reviewed the modeller's work	Date of the audit completion

TABLE 2:
Quality assurance process structure.

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5 CONCEPTS FOR IMPROVING THE MODELLING AND REPORTING PROCESS

5.1 INTRODUCTION

This section introduces two ideas, still within the proof-of-concept stage, to show potential options for improving embodied carbon assessments. They're designed to show that with more benchmark data, obtained through a national database such as BECD, embodied carbon modelling and reporting can be improved to support strategic decisions that reduce emissions across the built environment.

These proof-of-concepts are presented here to gather feedback from industry and highlight potential options that could be developed further, either by UKGBC or other parties.

1. **Using a variance, or tolerance [1], range when presenting embodied carbon modelling outcomes**
   - A variance range is proposed to assist in highlighting potential fluctuations in results as a project progresses through RIBA stages. This variance range could support the RICS WLCA Professional Standard calculations of the 'contingency factor' within the overall WLCA Uncertainty Factor.
2. **Using as-built data from comparative projects to support early design-stage assessments**
   - The completeness of an early design-stage embodied carbon assessment can be understood by comparing against the as-built data of similar projects. Comparing the design stage model with data from a similar built project would give an overview of how the embodied carbon is distributed across the relative elements. This could support with knowing whether the embodied carbon assessment effectively reflects the total amount of materials expected to be used during construction.

[1] **The RICS WLCA Professional Standard** refers to 'UKGBC's approach for using tolerance ranges'. The use of the phrase 'tolerance range' was part of an early draft of this report, which has since been updated to use the phrase 'variance range'. The phrase tolerance range here is just used to assist in facilitating readers who have been referred to this document by the RICS WLCA Professional Standard.

5.2 USING A VARIANCE RANGE

INTRODUCTION

Embodied carbon assessments tend to increase in reliability and accuracy as the design progresses, and it could be helpful to understand and show how variance can occur across the RIBA Stages.

Changes across RIBA Stages can be due to many reasons but typically result from either increased clarity in design, or changes in the design itself. Presenting a +/- range could provide a gauge of the variance, depending on the stage of the project, and may be a beneficial approach to take in addition to the uncertainty factor defined within the RICS WLCA Professional Standard.

LEARNINGS FROM THE TASK GROUP

Across the four modelling tools, the average absolute (either an increase or decrease) change, per element, is shown in Table 3:

	ELEMENT	AVERAGE ABSOLUTE CHANGE FROM CONCEPT TO TECHNICAL DESIGN
1.0	Substructure	17%
2.1	Frame	55%
2.2	Upper Floors	20%
2.3	Roof	34%
2.4	Stairs & Ramps	8%
2.5	Ext. Walls	31%
2.6	Windows & Ext. Doors	13%
2.7	Int. Walls & Partitions	14%
2.8	Int. Doors	27%
3.0	Finishes	12%
5.0	Services (MEP)	9%

TABLE 3:
Average absolute change per element, from Concept to Technical Design.

As a visual example, Figure 4 shows these changes in embodied carbon assessment result, per element, specifically for only one of the modelling tools:

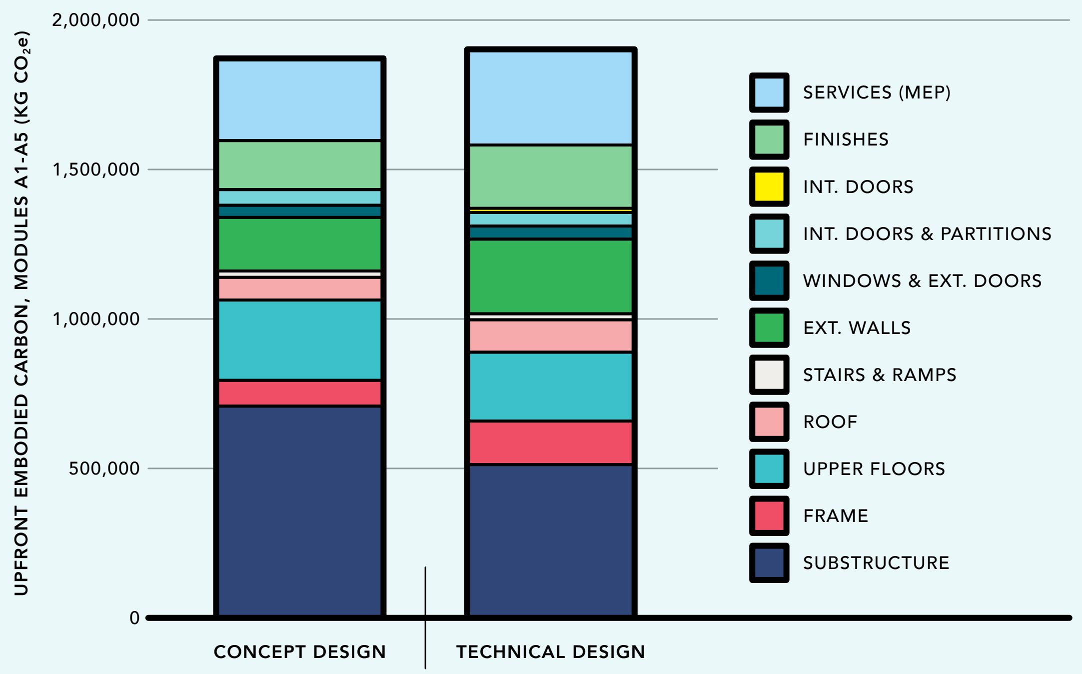

FIGURE 4:
Change in embodied carbon per element from Concept to Technical Design for Tool 3.

Using a variance range to represent design uncertainty

Throughout the design process, there are unknowns and estimations which aren't represented by presenting embodied carbon as a single value. Presenting a value within a variance range is suggested to capture this uncertainty. The proposal given here is intended as a proof-of-concept and a starting point from which a more detailed analysis could be undertaken to define variance ranges based on industry data.

Variances can be applied when reporting embodied carbon at each RIBA Stage and are likely to decrease as the design and construction progress. Variances should still be utilised during the as-built phase, as uncertainties in the analysis may remain – especially for products without an EPD for which alternative methods of carbon accounting have been employed (e.g., CIBSE TM65 or use of generic data). The variance range is applied on an elemental basis and the figures given could be modified by the project team if there's reason to do so (e.g., early design certainty).

The ranges given below have been developed by the Task Group, based on their collective experience. The figures have been given per sub-category according to GLA, building upon the elements within the RICS WLCA Professional Standard. The variance ranges would be applied to the embodied carbon total per sub-category (e.g., facades), giving an overall variance range for the project, weighted by proportion of embodied carbon per element.

	RICS CATEGORY	SUB-CATEGORY TO ALIGN WITH GLA BENCHMARKS	RIBA 0/1	RIBA 2	RIBA 3	RIBA 4	RIBA 5	RIBA 6
1.1	Substructure	Substructure	± 20%	± 10%	± 5%	± 5%	± 2.5%	± 1%
2.1	Frame	Superstructure	± 20%	± 15%	± 10%	± 5%	± 2.5%	± 1%
2.2	Upper Floors							
2.3	Roof							
2.4	Stairs & Ramps							
2.5	Ext. Walls	Façade	± 30%	± 25%	± 20%	± 20%	± 10%	± 1%
2.6	Windows & Ext. Doors							
2.7	Int. Walls & Partitions	Fit-out	± 15%	± 15%	± 15%	± 10%	± 10%	± 5%
2.8	Int. Doors							
3.1	Wall Finishes							
3.2	Floor Finishes							
3.1	Wall Finishes							
3.3	Ceiling Finishes							
4.1	FFE	FFE	± 20%	± 20%	± 20%	± 20%	± 20%	± 5%
5.0	Services	Services	± 30%	± 30%	± 30%	± 30%	± 20%	± 20%
8.0	External Works	External Works	± 20%	± 10%	± 5%	± 5%	± 2.5%	± 1%

TABLE 4: Example variance ranges per element.

Using a variance range alongside the RICS WLCA uncertainty factor

The RICS 2023 update introduces an WLCA uncertainty factor, comprised of factors for contingency, data quality, and quantity uncertainty. If appropriate, it could be possible to use the RICS contingency factor as a starting point, from which adjustments can be made by bringing in further aspects that may affect the factor that you choose to use. These include:

CLIENT:

- Client experience of asset class
- Track record of sticking to the brief and propensity to introduce change
- Quality of the brief

DESIGN:

- Expertise level in the team
- Design team experience of the asset class
- Maturity of the design (completeness and level of detail)
- Extent of third-party ‘buy in’, (e.g., User groups, Planning Officers, Fire Officers)
- Extent of innovation included

PROJECT RISKS:

- Availability of data regarding elements to be retained and reused
- Availability and quality of ground information and below ground services

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5.3 UNDERSTANDING ASSESSMENT COMPLETENESS THROUGH AS-BUILT BENCHMARKS

INTRODUCTION

The recently launched Built Environment Carbon Database opens the door for new methods understanding the completeness of an embodied carbon assessment, by comparing early design stage assessments with the as-built data of similar projects.

It is possible to build this comparison by using the weighting of embodied carbon per element of a similar project. Comparing the design stage model with as-built data from a similar project would give an overview of how the embodied carbon is distributed across the relative elements. At early design stages, this could support with knowing whether the embodied carbon assessment effectively reflects the total amount of materials expected to be used during construction.

It's important to note that this method would only be effective should the comparison project be highly similar to the project under consideration. Considering this, it's only proposed as a potential option for identifying significant omissions during early design stages. At early design stages, material omissions may be missing from the cost plan due to the lack of detail inherent at concept design.

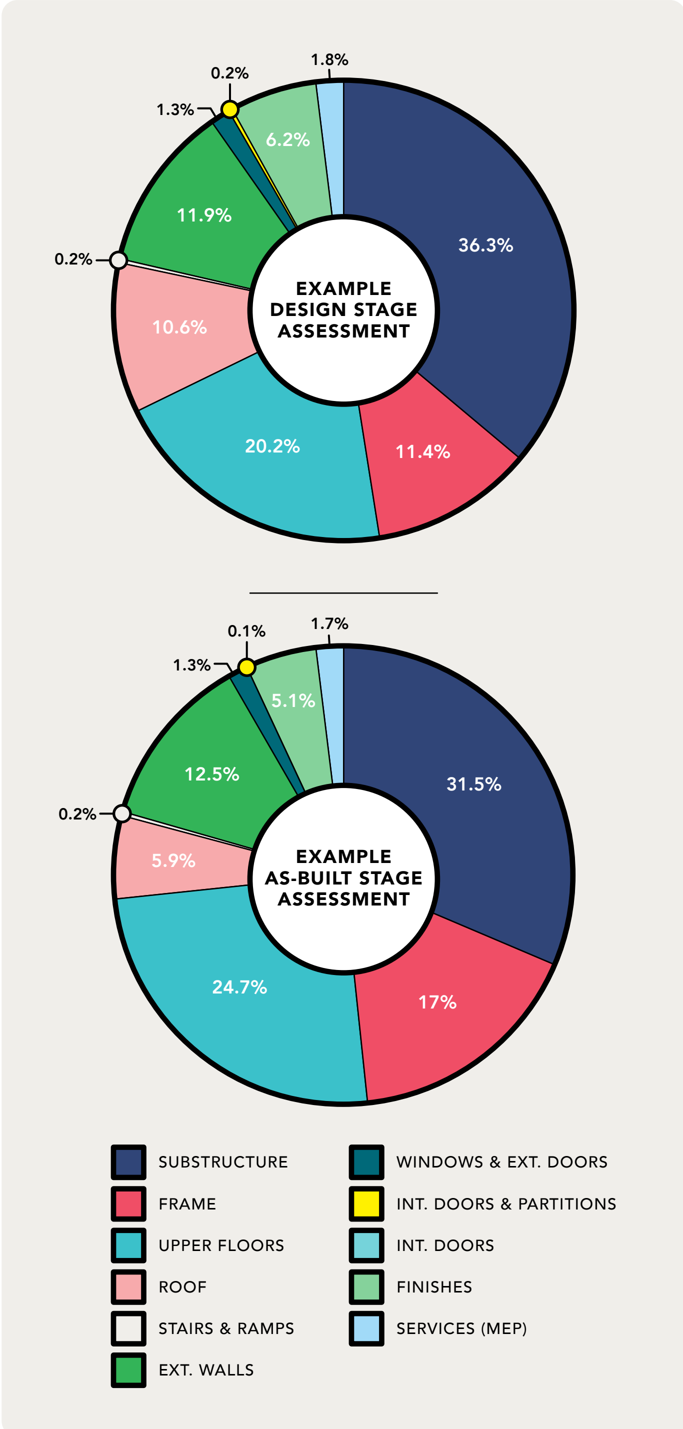

FIGURE 5:
Comparing a Design Stage embodied carbon assessment with an As-Built assessment of a comparative project.

Proof-of-concept for using benchmarks to understand assessment completeness

The methodology is a proof-of-concept to create a comparison tool that could enable practitioners to understand how their initial assessments compare to the as-built data of existing buildings. Furthermore, it's intended to support practitioners to communicate that comparison with colleagues or clients as necessary.

The proposal uses a simple methodology:

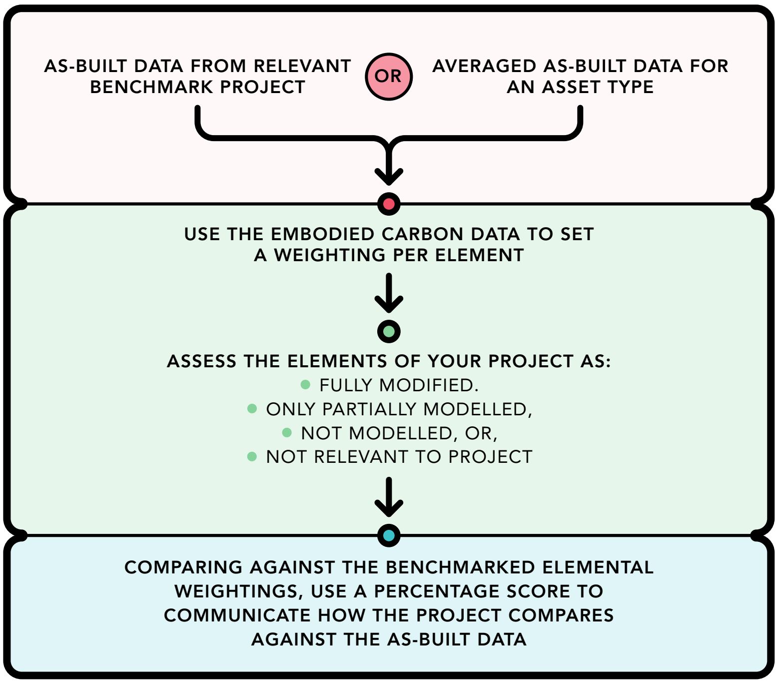

FIGURE 6:
Benchmarking scope methodology.

A supplementary Excel tool has been created to show the full proof-of-concept. It's been made using the 'averaged as-built data' approach, by taking the relative element weightings from the GLA London Plan Guidance for Whole Life Carbon Assessments. Four examples have been made: for retail, office, schools, and residential.

Note: The Excel tool uses GLA's data which doesn't contain weightings for: Biogenic Carbon, Pre-Construction Stage, Operational Energy Use, Operational Water Use, User Activities, Deconstruction/Demolition, External Impacts.

6 SUMMARY

This report uses a modelling analysis and the expertise of industry professionals to highlight and give guidance on the variability of embodied carbon modelling. The guidance was created to support the writing of high-quality reports, underpinned by transparency and consistency.

It highlights the importance of embedding the RICS WLCA Professional Standard into the design process, and especially within modelling tools. Furthermore, by establishing a Quality Assurance process, the guidance lays out a pathway for ensuring precision, coherence, and traceability in the assessment process.

Practitioners are encouraged to, and supported in, understanding the comprehensiveness of embodied carbon assessments, fostering transparency, and refining accuracy. By implementing the Calls to Action, stakeholders will support a shift toward a future where embodied carbon assessment becomes an enduring pillar of environmentally appropriate construction practices.

7 APPENDIX A QUALITY ASSURANCE TABLES

TABLE 1: OVERVIEW

	CONSULTANT	AUDITOR	DATE
QUALITY ASSURANCE SECTION 1	Who carried out the LCA	Who reviewed the Modeller's work	Date of the audit completion
QUALITY ASSURANCE SECTION 2	Who carried out the LCA	Who reviewed the Modeller's work	Date of the audit completion

TABLE 2: INPUT REVIEW

STEP	CONSULTANT COMMENTS *Example comments and supporting notes*	SELF-AUDIT?	AUDITOR COMMENTS	QA PASSED?
1 CONFIRM SCOPE OF ASSESSMENT	*e.g., BREEAM Mat 01, Upfront A1-A5, GLA WLC*	Y/N		Y/N
2 STAGE OF ASSESSMENT	*This should be in line with RICS methodology or relevant body (i.e., BRE or Mat 01)*			
3 ARE ANY OPTIONS BEING CONSIDERED?	*Options appraisals should be discussed early to ensure maximum value is added.*			
4 CONFIRM SOURCES OF INFORMATION	*e.g., BIM model, BOQ, consultants drawings (note these are in order of preference as per RICS PS rev 02*			
5 CONFIRM PERCENTAGE OF MATERIALS INCLUDED IN THE ASSESSMENT	*This can be checked through review of an excel sheet confirming all inputs*			
6 HAVE ALL ASSUMPTIONS MADE BY THE CONSULTANT ON MATERIALS AND QUANTITIES BEEN AUDITED?	*e.g., detailed within the input excel sheet (noted above) and discussed with the QA consultant, following RICS WLCA PS guidance or other appropriate industry guidance*			
7 DOES THE LEVEL OF DETAIL INCLUDED IN THE INPUTS ALIGN WITH THE SCOPE	*e.g. refer to RICS WLCA PS for guidance regarding the level of detail required at each stage.*			
8 WHAT SOFTWARE AND PARAMETERS ARE BEING USED	*Do these align with the Scope and Stage of assessment?*			

TABLE 3: QA SOFTWARE CHECKLIST

STEP	CONSULTANT COMMENTS *Example comments and supporting notes*	SELF-AUDIT?	AUDITOR COMMENTS	QA PASSED?
9 IS THE REFERENCE STUDY PERIOD APPROPRIATE TO THE SCOPE CONFIRMED IN STEP 1/2	*e.g., refer to RICS WLCA Professional Standard for appropriate reference periods*	*Y/N*		*Y/N*
10 DO THE QUANTITIES ENTERED REFLECT THOSE IN THE SOURCES PROVIDED, AND WHERE CALCULATIONS HAVE BEEN MADE (E.G., M² TO M³) ARE THE METHODOLOGY AND VALUES APPROPRIATE				
11 HAVE ALL BUILDING MATERIALS AND QUANTITIES BEEN INPUT INTO THE SOFTWARE	*These values should be taken from the input excel sheet and therefore should be consistent.*			
12 WHERE MATERIALS HAVE BEEN EXCLUDED, HAS JUSTIFICATION BEEN PROVIDED AND VERIFIED				
13 HAVE JUSTIFIABLE EPDS BEEN CHOSEN	*Refer to Carbon Factor Hierarchy from RICS and Whole Life Carbon Network*			
14 TRANSPORT TYPES AND DISTANCES?	*e.g. in lieu of product specific data this should be in line with RICS guidance*			
15 APPROPRIATE END OF LIFE CALCULATIONS?				

TABLE 3: QA SOFTWARE CHECKLIST (CONTINUED)

STEP	CONSULTANT COMMENTS *Example comments and supporting notes*	SELF-AUDIT?	AUDITOR COMMENTS	QA PASSED?
16 HAVE THE RICS CATEGORIES BEEN CORRECTLY ALLOCATED?		Y/N		Y/N
17 IS EACH MATERIAL CLEARLY REFERENCED TO SHOW THE CORRESPONDENCE BETWEEN THE INPUT EXCEL SHEET AND THE SOFTWARE ENTRY				
18 HAVE THE SERVICE LIVES BEEN APPROPRIATELY INPUT FOR EACH ENTRY	*e.g. in line with RICS default service lives (where actual data is not known) or alternatively confirmed by the project team?*			
19 HAS THE BUILDING AREA BEEN INPUT (GIA)				
WHERE APPLICABLE TO THE ASSESSMENT SCOPE:				
20 HAS THE ENERGY CONSUMPTION BEEN INPUT, AND IS THE SOURCE APPROPRIATE	*The source should be appropriate to the scope of the assessment (e.g., TM54 data).*			
21 HAS THE WATER CONSUMPTION BEEN INPUT, AND IS THE SOURCE APPROPRIATE	*The source should be appropriate to the scope of the assessment – refer to RICS PS rev 02.*			
22 HAS THE CONSTRUCTION SITE OPERATIONS TAB BEEN COMPLETED	*e.g. If no project information is available is this based on the RICS 1400kgCO_2e/£100k project value rate (where applicable to assessment scope).*			

TABLE 3: QA SOFTWARE CHECKLIST (CONTINUED)

STEP	CONSULTANT COMMENTS *Example comments and supporting notes*	SELF-AUDIT?	AUDITOR COMMENTS	QA PASSED?
WHERE APPLICABLE TO THE ASSESSMENT SCOPE:				
23 HAS THE EMISSIONS AND REMOVALS TAB BEEN COMPLETED	*Have leakage rates been taken from CIBSE TM65? (where applicable to assessment scope?).*	Y/N		Y/N
24 DO THE % TOTAL IMPACT FOR ALL LIFE-CYCLE STAGES FOR EACH MATERIAL/ CATEGORIES LOOK REASONABLE?	*e.g. are results similar to a previous assessment, do the values meet expectations?*			
25 WHERE RESULTS FALL OUTSIDE OF THE TYPICAL PERFORMANCE EXPECTED FOR THE ASSESSMENT, HAS THIS BEEN INVESTIGATED	*e.g. discussed with Project Lead/ QA consultant, EPDs checked or discussed with the design team?*			
26 HAVE RESULTS BEEN COMPARED AGAINST INDUSTRY BENCHMARKS FOR THAT BUILDING TYPE AND SCOPE, AND SEEM REASONABLE?	*e.g. LETI or RIBA benchmarks or UK NZCBS limits, are benchmarks appropriate for the building type and assessment scope?*			
27 HAVE ALL ASSESSMENT NAMING CONVENTIONS BEEN FOLLOWED	*e.g. BREEAM requirements for export, internal organisational references.*			

8 GLOSSARY

TERMS	DEFINITION
CARBON EMISSIONS	In the context of sustainability, 'carbon emissions' is used as a collective term to describe the emissions of any GHGs.
CARBON FACTORS	A measure of the emissions intensity of a process or fuel.
ENVIRONMENTAL PRODUCT DECLARATION (EPD)	An EPD is a document that quantifies environmental information on the life cycle of a product. It enables the comparison between products fulfilling the same function. The EPD methodology is based on a Life Cycle Assessment (LCA) that follows ISO Series 14040.
EMBODIED CARBON	Embodied Carbon or Life Cycle Embodied Carbon emissions of a product are the total GHG emissions and removals associated with its manufacture, transport, installation, maintenance, and end of life treatment.
EMBODIED CARBON ASSESSMENTS	The term 'embodied carbon assessment' is used to refer to the relevant embodied carbon modules from a whole life carbon assessment or life cycle assessment. These are Modules A, B1-B5, and C.
GHG PROTOCOL	The Greenhouse Gas (GHG) protocol establishes comprehensive global standardised frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.
LIFE CYCLE ASSESSMENT (LCA)	A method for analysing the environmental impact of materials/products/systems/ buildings. The environmental impact is expressed by environmental parameters, each of which shows the magnitude of predicted atmospheric pollution, water pollution, soil pollution, natural resources depletion and so on.
NET ZERO	Net Zero is where all related Greenhouse Gas (GHG) emissions have been reduced in line with a science-based target which aligns with what has been determined to be necessary to stand a reasonable chance of limiting the global temperature increase to 1.5˚C above pre-industrial levels as a minimum. These residual emissions are subsequently responsibly offset to achieve a sum total of zero emissions.
OPERATIONAL CARBON	Operational Carbon are the GHG emissions arising from all energy consumed by a product in-use, over the product's whole life cycle.
PAS 2080	Is a standard covering carbon management in building in infrastructure. This looks at the whole life carbon across the lifespan of the building of infrastructure helping organisations to understand the impacts of their assets.

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TERMS	DEFINITION
RICS WHOLE LIFE CARBON ASSESSMENT PROFESSIONAL STANDARD	Developed by RICS this guidance sets out mandatory principles and supporting guidance for the interpretation and implementation of the EN 15978 methodology.
SCOPE 1	Direct emissions from sources that are controlled or owned by an organisation. This includes any onsite combustion (e.g., from gas boilers for heating, and from company vehicles).
SCOPE 2	Indirect emissions that result from the purchase of electricity, heat, or steam that is generated offsite.
SCOPE 3	Indirect emissions from sources that aren't owned or controlled by an organisation, but that they indirectly affect in their value chain.
WHOLE LIFE CARBON	Whole Life Carbon emissions are the sum total of all the associated GHG emissions and removals, for the embodied, operational and disposal of a product through its whole life cycle.
WHOLE LIFE CARBON ASSESSMENT (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.

UK GBC

The voice of our sustainable built environment

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ADVANCING NET ZERO