

Embodied Carbon: Developing a Client Brief



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1. Overview

With the increasingly successful reduction of operational energy (and thus carbon emissions) in the built environment, the industry's next challenge is to reduce the carbon intensity of the structures themselves (embodied carbon). We know that clients will play a critical role in this work as what clients ask for, the supply chain works to deliver. UK-GBC also understands that embodied carbon is an area that many clients are just beginning to address.

This guide is designed for those who need to write **effective** briefs for commissioning their first embodied carbon measurements, but who may be at an early stage of embodied carbon knowledge. It is not a how-to guide for measuring carbon, or which method or tools should be adopted.

This guide has been written by the industry, for the industry. The guidance provides straightforward information on how to develop a brief and 'get the job done'. For those looking for greater depth of knowledge, there is [Supporting Guidance](#) with links to further detailed information.

Embodied Carbon: Developing a Client Brief has been led by a team at the UK-GBC, supported by a specialist working group. At key points in the development process the guide has gone to wider UK-GBC member review (primarily with clients). UK-GBC would like to thank all those who have contributed to this new guide.

"UK-GBC's vision is of a built environment that is fully decarbonised. This has to include both embodied and operational carbon. As operational carbon reduces, the relative significance of embodied carbon increases. So we will continue to advocate for embodied carbon to become a mainstream issue in building design, construction and maintenance. Indeed, we will be encouraging our client members and other clients in the industry to create their own embodied carbon briefs by making effective use of this guidance.

Also, through our work with cities and other local and national authorities, we will be encouraging the assessment of embodied carbon within the public sector planning and procurement process."

Julie Hirigoyen
CEO, UK Green Building Council



2. Introduction

The purpose of this guide is to set out clear and practical guidance to enable built environment clients to start requesting embodied carbon measurement.

2.1 What does this guidance do?

The purpose of this guide is to set out clear and practical guidance to enable built environment clients to begin requesting embodied carbon measurements. This includes understanding the outcomes from an assessment and how to start acting on the results.

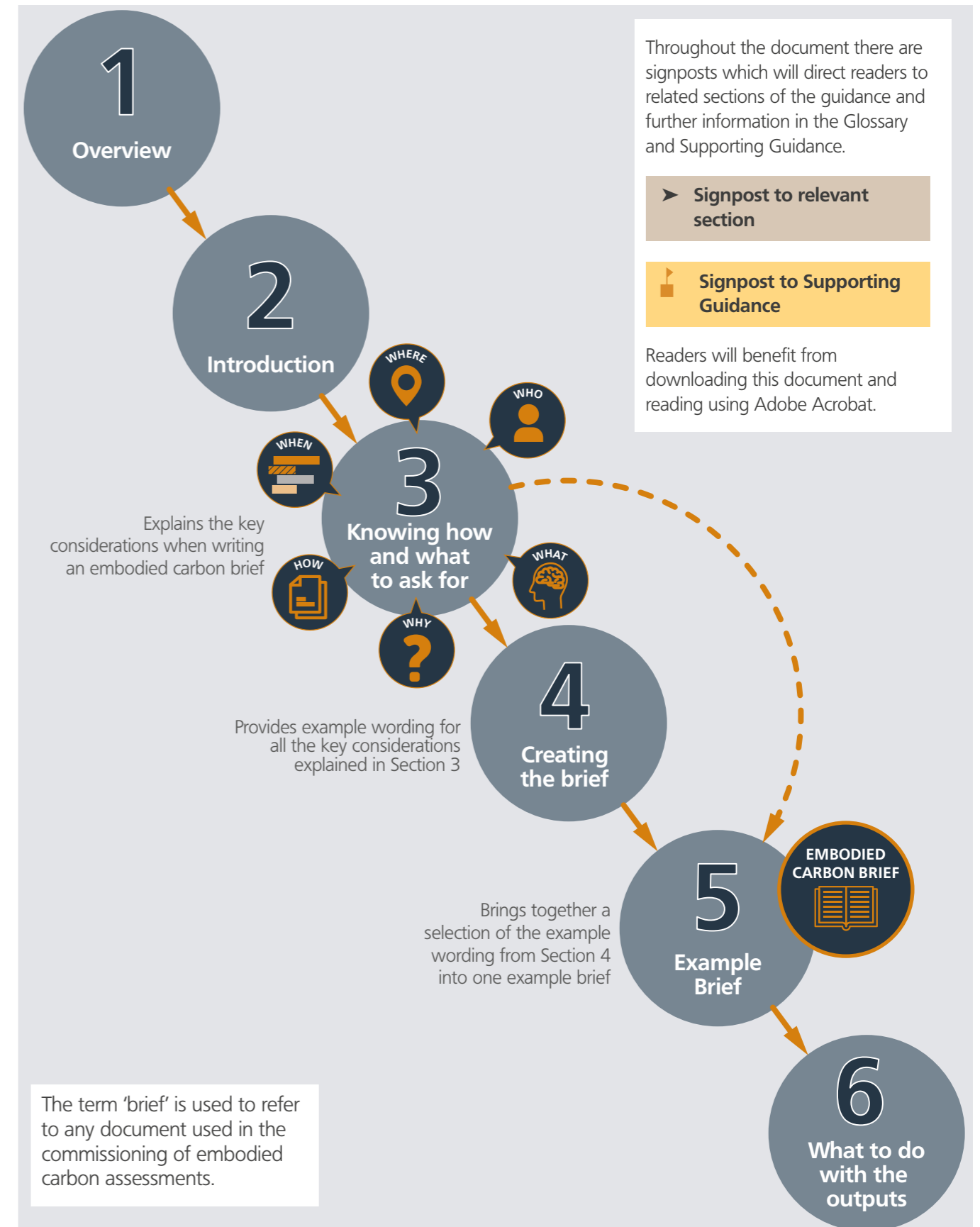
This guide has been produced in response to extensive consultation. Feedback from the UK-GBC membership indicates a difficulty in knowing exactly where and how to start the process of measuring embodied carbon. Much guidance exists on embodied carbon measurement and this document aims to complement it with a focus on the contractual demands that clients place on their supply chains.

The intended audience is clients who are aware of the importance of embodied carbon and want to commission an embodied carbon measurement but do not know where to start.

The guidance explains some of the basics of embodied carbon, gives an overview of some suggested approaches, provides example clauses to propel embodied carbon requirements down the supply chain and gives practical tips on how to use the outcomes of an assessment. The guidance is appropriate for any capital investment intervention in the built environment such as new build, refurbishment or renewal whether in buildings, infrastructure or other built assets. The Supporting Guidance builds on the topics with a greater level of detail.

The guidance does not, nor is it intended to, set out a methodology or standard for embodied carbon measurement, nor does it compare products or give guidance on product level assessments. Rather, it helps to set out a usable framework for clients to begin to develop an approach to embodied carbon measurement within their organisations. Also, this guidance is not intended to diminish the need to address the operational carbon of assets in use.

2.2 How to use this guide



2.3 Why focus the guidance on clients?

Construction projects are initiated by clients. Clients are usually the instigators of project's sustainability agenda. As part of this, clients may set out a requirement to measure embodied carbon. Thus, by increasing awareness and action on embodied carbon at the client level, it will be introduced to the industry as the supply chain responds to clients' requests.

This guidance has been developed in collaboration with UK-GBC members, with a particular focus on clients. Members from the client side and the supply chain have contributed content and provided feedback.

The following groups were identified as being 'clients' and form the primary audience:

- investors (pension funds, private equity funds etc.)
- REITs (real estate investment trusts)
- developer-landlords
- owner occupiers and tenants
- local authorities
- infrastructure clients

Embodied carbon is the total greenhouse gas (GHG) emissions generated to produce a built asset. This includes emissions caused by extraction, manufacture/processing, transportation and assembly of every product and element in the asset.

2.4 What is embodied carbon?

Embodied carbon is the total greenhouse gas (GHG) emissions (often simplified to "carbon") generated to produce a built asset. This includes emissions caused by extraction, manufacture/processing, transportation and assembly of every product and element in an asset. In some cases, (depending on the boundary of an assessment), it may also include the maintenance, replacement, deconstruction, disposal and end-of-life aspects of the materials and systems that make up the asset. It excludes operational emissions of the asset.

Some of the other commonly used definitions within the built environment sector include:

"Carbon emissions associated with energy consumption (embodied energy) and chemical processes during the extraction, manufacture, transportation, assembly, replacement and deconstruction of construction materials or products."^[1]

"The carbon dioxide emissions associated with making a building – as distinct from using it – are referred to as embodied carbon. More precisely, embodied carbon covers greenhouse gas (GHG) emissions that arise from the energy and industrial processes used in the processing, manufacture and delivery of the materials, products and components required to construct a building."^[2]

"Embodied carbon, sometimes referred to as capital carbon, refers to the emissions associated with the creation of an asset. Capital carbon is being adopted in the infrastructure sector because it accords with the concept of capital cost"^[3]

In terms of the Greenhouse Gas (GHG) Protocol for emissions accounting, the embodied carbon of built assets is included within Scope 3 emissions.^[4]

2.5 Why is it important?

2.5.1 High level context

At a global level, buildings account for 32% of energy use and 30% of energy-based GHG emissions. These emissions will continue to rise under a business-as-usual scenario.^[5] The embodied carbon impacts and the impacts of other built asset types are not accounted for, which makes the impact of the whole built environment larger. To play its part in limiting global temperature increase to 2°C, the built environment sector must reduce its emissions by a total of 84 GtCO₂ by 2050.^[5]

As part of the Paris Agreement, member states will have to transition to net zero-carbon economies.^[6] So far, 91 countries have included elements of commitments relating to buildings in their Nationally Determined Contributions (NDCs) (these are the national declarations of commitment).

In the UK, the Low Carbon Routemap^[7] and the 2015 Routemap Progress Report highlight that the sector needs to find a further 39% reduction in carbon emissions^[8] from the 1990 baseline in order to meet the Government's target to reduce carbon emissions in the built environment by 50% by 2025^[9]. Longer term, deeper reductions will be needed to reach the UK's Climate Change Act target of 80% reduction by 2050 from a 1990 baseline.

Consideration of embodied carbon within the built environment at the initial design and construction stages, especially by the construction and property sectors, is necessary in order to achieve the required GHG reductions (see Figure 1). The relative significance of embodied carbon is increasing, as both the grid decarbonises and operational emissions decrease due to increased efficiency (see Figure 1).

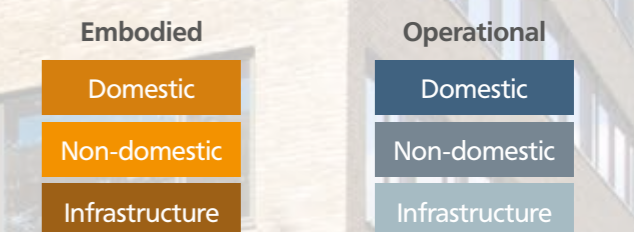
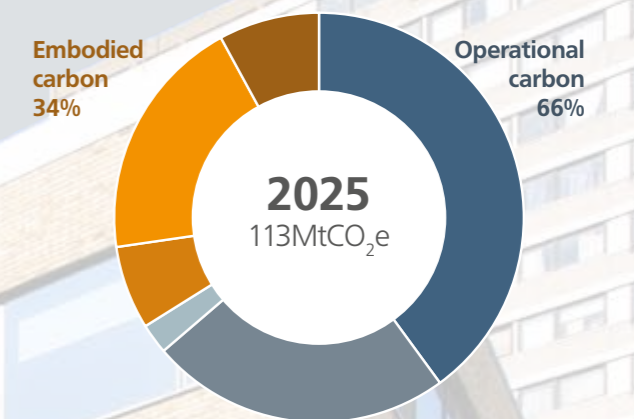
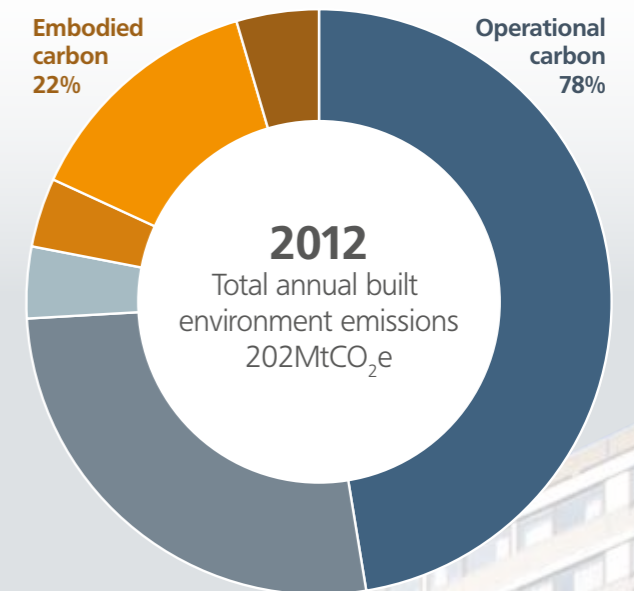


Figure 1 Increasing significance of embodied carbon (in 80% emissions reduction scenario)^[10]

Embodied carbon has been recognised in infrastructure with regulation in specific sectors. For example, in the rail industry, the High Level Output Specification (HLOS) requires consideration of traction and no-traction carbon emissions from railway activities. Similarly, Ofwat^[11] required all water companies to produce a capital and operational carbon footprint of their proposed 2010-2015 asset investment and management programme.^[12]

At an organisational level, industry standards such as PAS 2080:2016 *Carbon management in infrastructure* are encouraging all companies to begin effectively managing their 'carbon footprints', with a strong emphasis on embodied carbon.

The aim of this guidance is to help all built environment clients to start effectively measuring embodied carbon.

2.5.2 Why is it important to a client organisation?

There are now a variety of reasons, beyond the environmental, motivating client organisations to measure their embodied carbon impact. The embodied carbon impact at an asset level is more significant than has been previously thought. Recent figures show that over a 30-year period, embodied emissions account for more than 50% of the total carbon emitted for some building types. Consequently, addressing embodied carbon is a critical part of reducing a client's overall carbon impact. See (Figure 2).

Commercial and Operational

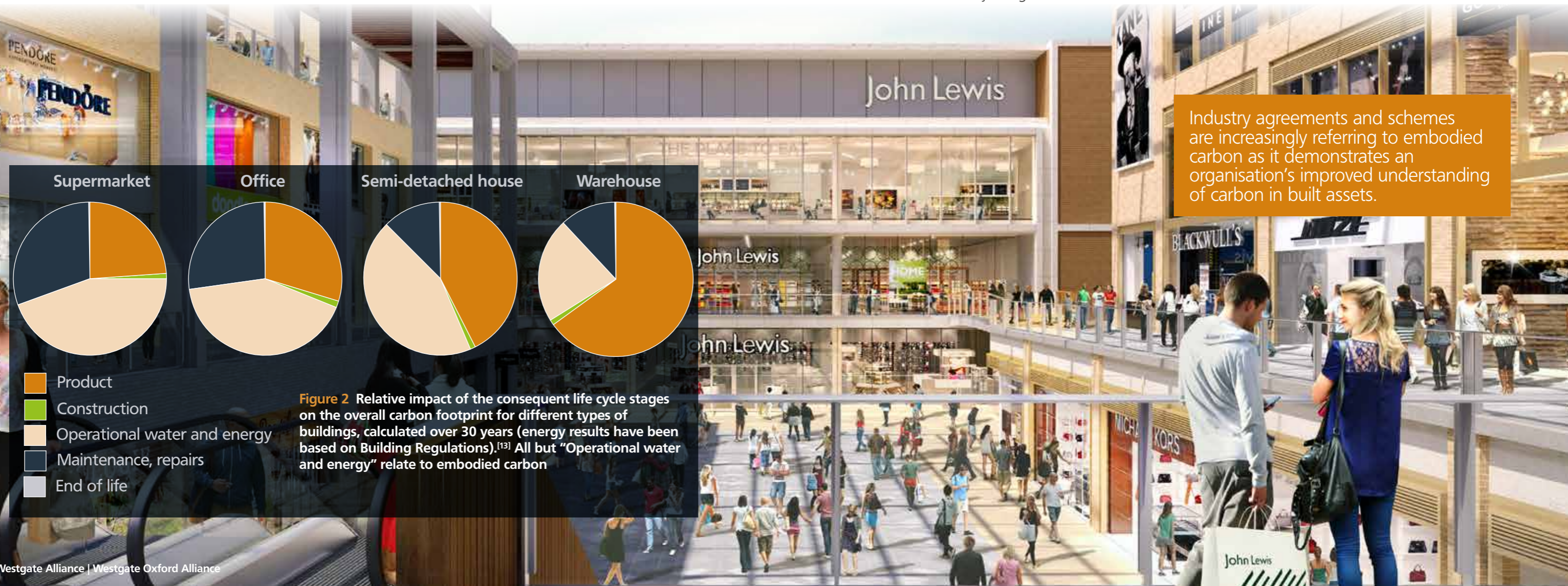
The economic case for considering embodied carbon has been outlined in other industry research. The findings include:

- Relatively low cost when compared to many operational carbon saving solutions;
- Encourages lean design and drives resource efficiency;
- Unlocks innovation, provides competitive advantage and export potential;
- Gives further insight into GHG risks and opportunities;
- Can be a helpful tool for clients to compare assets, dependent on a common assessment framework, demonstrating embodied carbon improvement over time; and
- Can assist in achieving credits in some building assessment sustainability rating schemes.

Additionally, industry agreements and schemes are increasingly referring to embodied carbon as it demonstrates an organisation's improved understanding of carbon in built assets. For example:

- Clients signing up to Science Based Targets take a progressive approach to the measurement and reduction of all carbon emissions^[14]; and
- Companies opting to sign up to the RE100 are bringing embodied carbon emissions into stark contrast against annual operating emissions.

Additionally, some planning authorities are beginning to acknowledge embodied carbon.



Reputational

Organisations are seeking to better understand and manage “what matters most” to their stakeholders.^[15] An initial embodied carbon assessment can be commissioned using a high level approach. As clients carry out more projects, they can build on their embodied carbon knowledge and ask for more information to a greater level of detail. Similarly, investor rating and measurement indices are starting to include assessment of embodied carbon. For example:

- The Dow Jones Sustainability Index (DJSI) now includes a section about the life cycle assessment of building materials;
- The FTSE4Good Index asks questions on lifecycle studies and related carbon emissions reductions;
- The CDP includes voluntary reporting of Scope 3 emissions;^[16]
- The GRESB survey has a significant volume of questions on new construction and major renovations.^[17]

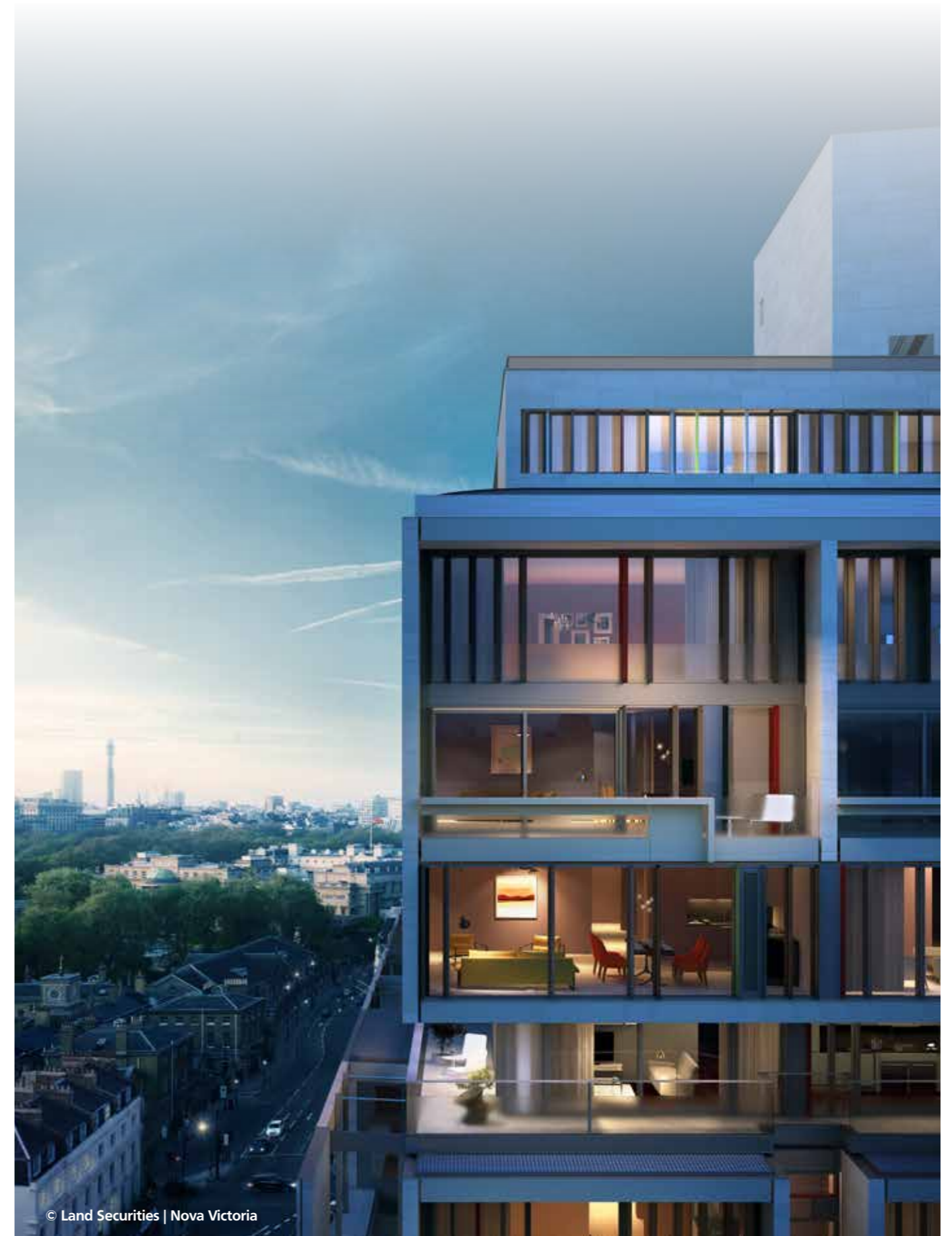
Reporting on Scope 1 and 2 GHG emissions has become more widespread in the built environment in the past few years. A few companies have begun to explore Scope 3 emissions measurement at an organisational level, such as their employee travel. Beyond this, only a small minority have begun to measure Scope 3 emissions at an asset level. By measuring and reporting embodied carbon, built environment clients can take demonstrable action on Scope 3 emissions.

Environmental

The environmental reasons for addressing carbon are well documented. Some of the most compelling reasons include:

- Embodied carbon can form a key part of any corporate climate change strategy;
- Addressing embodied carbon offers an attractive, one-time opportunity to make a significant saving in a shorter period of time, whereas operational carbon savings unfold over a longer period of time;^[18]
- Consideration of embodied carbon at design stage can facilitate greater resource efficiency.

Embodied carbon forms an aspect of many ESG (environmental, social and governance) analysts' research reports, which are used to judge the quality of a company/investment and its ability to manage its sustainability responsibilities.



3. Knowing how and what to ask for

This guidance provides a structure for clients to begin building their embodied carbon knowledge and move towards developing a brief for their first embodied carbon assessment.

An initial embodied carbon assessment can be commissioned using a high level approach. For example, an assessment of the high intensity embodied carbon elements^[9] e.g. the structural frame. As clients carry out more projects, they can build on their embodied carbon knowledge and ask for more information to a greater level of detail in each assessment e.g. the fixtures and fittings.

Clients can communicate their embodied carbon assessment requirements more effectively by:

- understanding the key considerations of an embodied carbon brief;
- being aware of the variables within the assessment and how they impact the calculation;
- understanding what decisions could be taken and the factors that influence those decisions.

Figure 3 represents the key considerations of an embodied carbon brief. Each key consideration has variables within it which can impact on the final embodied carbon calculation.

It should be noted that there is no “starting point” for this process. By exploring these key considerations simultaneously, clients will build their knowledge base in order to write their first embodied carbon brief. As such, the following sections can be read in any order.



Figure 3 The key considerations of an embodied carbon brief

3.1 Who?

Decide who is responsible for each stage of the embodied carbon measurement process



3.1.1 Who should engage in the embodied carbon process?

Clients can own the embodied carbon process to ensure that it remains a priority throughout the project. This can be achieved by assigning responsibility to one person to deliver the embodied carbon assessment, thereby ensuring a continued focus and awareness across the whole project team. This is especially important when interacting with the design and contractor teams who will be responding to the brief in terms of how decisions impact the measurement and reduction of embodied carbon. In these cases, it may be beneficial to use a common framework which designates responsibilities to each party, such as PAS 2080.^[20]



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3.2 When?

Decide when the embodied carbon measurement process will start, how many iterations are required and their frequency



3.2.1 Starting point, iterations and frequency

The starting point for an assessment on a project affects the level of impact that can be had on the embodied carbon outcome.

Embodied carbon reduction is best tackled by measuring as early as possible during design so that reduction opportunities can be highlighted and acted upon. Clients can outline the intent to measure and reduce embodied carbon before conceptual design begins. This should ensure that the project team is conscious of this intent during the design phase.

► **Section 6.3 Reducing embodied carbon**

The greatest value can be derived when embodied carbon assessments are treated as an iterative exercise rather than a one-off activity. Clients who commission an early assessment at the conceptual design stage may find it valuable to repeat the study in order to compare the original design with both the progressed design and the final as-built product.^[21] This comparison will reveal how the embodied carbon impact has changed between the project stages.

► **Section 4.6 Starting point, iterations and frequency**

3.3 Where?

Decide where the main interaction points are for the project(s)



3.3.1 Where are the decision points?

Clients can assess where to engage in the project according to where there are *critical decision points* rather than specific actors, roles or responsibilities. As project teams move from one construction phase to the next, more construction details are “locked in” through the decisions made. These are the critical decision points which also “lock in” embodied carbon. Clients can review where these decision points are in advance, ensure that any decisions are taken according to the embodied carbon brief, and then capture data as required.

These critical decision points also affect a client’s commercial team. The design and material choices will affect layout and product specifications which, in turn, affect aesthetics, comfort, durability and saleability.

Table 1 identifies major embodied carbon decisions that can be taken at particular stages during the construction process.

3.3.2 The impact of different project procurement routes

There are many different procurement processes that are used to commission a project. Different procurement routes will use differing approaches to producing and issuing tender information and communicating client requirements. Therefore, it is important to discuss the best route with the project management team to ensure that the embodied carbon requirements are understood and clearly set out.

In addition to setting out clear requirements, a clear line of responsibility should also be established to ensure the assessment work is completed to the level of detail specified. In many circumstances this means clients (either themselves or via their project representatives) will instruct a third party consultant to undertake an embodied carbon assessment. Sometimes in design and build contracts this responsibility will be passed directly to the contractor, who in turn may employ a consultant to undertake the embodied carbon assessment.



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Table 1 Embodied carbon and work stages

Project stages	Embodied Carbon – actions and processes	Scale of opportunity to influence embodied carbon
Brief	Creation of embodied carbon “brief”, setting out boundary, measurement points, information/data points, presentation format etc. This also needs to be included as part of the tender and procurement process, which are essential parts in undertaking and reducing embodied carbon. Some structural decisions are made very early on in the process which can affect embodied carbon.	
Design	At this point, the structural frame can be examined more easily, which is where a large proportion of embodied carbon emissions are locked in, e.g. the amount of cement replacement materials (CRMs) in the foundations. As the design reaches final sign off, ability to influence decreases.	
Build	Clients can influence a limited range of materials choices.	
Handover	There are no further opportunities to influence the embodied carbon of the build. However, clients will be able to influence, guide and recommend for the fit-out. An embodied carbon assessment at this stage can be valuable as a benchmark against future projects, assuming there has been consideration at earlier stages of how to gather the requisite data.	
Operation	It is not appropriate to do an embodied carbon assessment of the original build at this stage as reductions cannot take place. Significant future opportunities arise however when looking at fit out, replacement cycles of plant and materials or when a major renovation is due. However, at this stage a high level assessment of the original build materials could be undertaken which may help to understand the impacts of the assets.	

3.4 How?

Decide how to incorporate embodied carbon through existing in-house documents



Consider how embodied carbon objectives and requirements are to be communicated to the design and construction teams. The requirements can be embedded in a wide range of documents such as:

- scopes of service;
- Employer’s Requirements;
- specifications;
- requests for proposal; and
- construction contracts.

The method used to communicate requirements may also depend on when measurement processes start and any iterations required.

➤ [Section 3.2 When?](#)

3.5 Why?

Recognise the drivers for the organisation to start to measure embodied carbon and what the objectives of the assessment are



Context and ambitions

Embodied carbon is just one aspect of the many sustainability concerns of a client. Explaining the full context of the organisation's approach to sustainability allows the supply chain to respond to the embodied carbon measurement request appropriately.

This context could include:

- identifying any current company carbon or GHG requirements
 - compulsory reporting standards e.g. mandatory GHG reporting
 - voluntary reporting standards e.g. CDP
- any environmental management system requirements that could be impacted by, or have an impact on, the embodied carbon data gathering process.

Preparing a statement of relevant long term ambitions and short term objectives will help make the supply chain aware of the environmental and carbon specific aims of the client organisation. This can help to:

- align reporting needs;
- aid with carbon transparency; and
- improve data efficiencies further down the line.

The statement could also be specific to property portfolio objectives such as developing a common assessment framework in order to compare projects and demonstrate carbon performance over time.

► **Section 4.1 Context, ambitions and aims for the example wording**

3.6 What?

Understand what the embodied carbon brief should contain and what decisions are needed for each element.



This section gives specific instructions on what is included in the embodied carbon calculation, which includes multiple variables. In order to fully understand the embodied carbon figures, it is worth considering how changing a variable of the calculation will impact the final result.

The calculation and the variables should not change, in order to ensure consistency of measurement within a portfolio. This is preferable to enable meaningful comparisons.

► **Supporting Guidance: 6. Setting up meaningful comparisons**

However, calculation variables may change, such as if a more sophisticated assessment is performed. Consequently, it will not be possible to compare measurements with previous assessments.

Some reporting or assessment schemes determine what and how embodied carbon is assessed.

► **Supporting Guidance: 5. Whole built asset level assessment methodologies requirements for embodied carbon**

3.6.1 What are the objectives for an embodied carbon assessment?

It is useful to establish what is to be achieved from knowing the embodied carbon impact of a built asset. Consider the following:

- "I simply want an appreciation of embodied carbon quantities in my asset."
- "I want to know the embodied carbon emissions of my asset at every stage of the design and delivery process."
- "I want to see reductions in the embodied carbon footprint of my asset."

The objective will inform the choice of embodied carbon assessment boundary.

Clients are advised to use their first measurement as an opportunity to drive down embodied carbon through design and construction choices.

3.6.2 Boundaries

The boundary sets the scene for assessment and further defines the emissions to be included or excluded according to the life cycle of the built asset.

The brief includes the most appropriate boundary for an assessment. Put simply, understanding where to draw the boundary is essentially deciding which of these scenarios is a better fit:

Scenario 1:

"I would like to know the carbon critical hotspots and how much carbon has been generated in delivering my asset, as it stands when I get the keys"

Scenario 2:

"I would like to know how much carbon has been generated in delivering my asset, and I also want to know how much will be generated when I operate, maintain and dispose of my asset in the future."

Consequently, the principal boundaries to consider are:

Cradle-to-completed construction:

This will best reflect **scenario 1** above (references BS 15978 modules A1 to A5).*

Cradle-to-grave:

This will best reflect **scenario 2** above (references BS 15978 modules A1-A5, B1-B5 and C1-C4 and, optionally, D.)

Supporting Guidance: 2. What is the technical basis for identifying "life cycle stages"?

There are other considerations that may be taken when setting the boundary. Clients may opt to look at issues relating to the boundary, such as the procurement route, future ownership and management as appropriate to the maturity of their embodied carbon knowledge.

Clients may wish to use a boundary aligned with future tenure arrangements. This boundary could be called "cradle-to-transfer of ownership" and could be used in situations where clients wish to build, operate, maintain and then sell. It would cover BS 15978 modules A1-A5, B1-B5.

* BS EN 15978:2011 Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

Boundaries and Procurement, Ownership and Management

When considering the boundary, it is also worthwhile to consider how the asset is to be procured, constructed, and managed, along with whether any ownership will be retained post-handover. This is useful because the perspectives of a developer-landlord differ from speculative developers or an owner-occupier. The assessment results can help decision-making, especially for long-term issues, such as future climate change scenarios. Decisions on material choices will differ based on the embodied carbon impact, which depends on the reference study period of the assessment.

The reference study period is the duration of time used in the assessment. For example, in a cradle-to-grave assessment, the reference study period(s) could be 20 years, 60 years or 100 years i.e. the period of time for which the client wants information.

Consider the following examples of how scenarios, boundaries and reference study periods interact:

Example A: The company will be selling the asset on completion and therefore the company will not have information on the asset's use after the sale. An appropriate boundary for this situation could be cradle-to-completed construction.

Example B: The company may sell the asset on completion but is still weighing up options to occupy or manage the asset for a minimum term of 5-10 years. Selecting cradle-to-construction with an additional, alternative calculation which includes the maintenance, repair and replacement cycles for the period under consideration.

Example C: The company will retain the asset on completion and occupy and manage the asset for a minimum of 25 years. In this case the company may wish to conduct a cradle-to-grave assessment as it will include all the operational impacts they are likely to incur over the operational period.

Example D: The company will occupy a tenanted area of a shell and core developed asset and will be responsible for the fit-out, as well as future management and maintenance, for the period of approximately 10 years. An appropriate boundary is cradle-to-grave for the fit-out materials, which can be used to inform the embodied carbon impact of the maintenance, repair and replacement cycles.

Example E: The company is planning to retain and operate the asset for 10 years at which point they are required to demolish the asset. In this case, they may be interested in a cradle-to-grave assessment to minimize future carbon liabilities and identify opportunities to recover value from the materials/carbon already invested in the building.

Best practice for whole-life carbon assessment is to consider multiple reference study periods and present results as a series of scenarios.

A practical starting point is a commitment to a cradle-to-completed construction boundary. This provides a well-balanced picture of the embodied carbon footprint of the asset in question as it stands in reality, regardless of the ownership structure and future tenure.

Over time, it would be advisable for clients, particularly those involved in ongoing operation and maintenance, to be more involved in cradle-to-grave issues. Using a wider boundary offers the opportunity for a more in-depth understanding of:

- the impact of decisions at the capital expenditure stage which affect embodied carbon on the operational carbon in the use stage; and
- the embodied carbon impact of maintenance and replacement cycles.

Understanding both of these issues can help clients with design decisions and materials choices.

➤ Section 4.2 Assessment boundary and reference study period for the example wording



Assumptions and Certainty

Two issues to be aware of when undertaking an embodied carbon calculation are:

- the level of certainty of the data available at the time of assessment; and
- the standardised assumptions that are made about the life cycle of assets e.g. maintenance regimes.

Embodied carbon assessments are estimates unless the calculation is performed on an as-built asset with a complete embodied carbon data set and only measuring up to the point of handover. Consequently, the level of uncertainty in an assessment depends on where the project is in the life cycle and how far into the future the calculation is taken.

If the starting point is at the conceptual design stage of a project, the assessment will be based on assumptions and best guesses as to what materials the final asset may contain. As the design progresses, certainty around the materials in the asset increases and therefore, the embodied carbon assessment becomes more certain. It is recommended that provision is made in the brief to repeat the assessment

throughout the design stages to make the final assessment as accurate as possible.

Certainty also decreases the further into the future life cycle of the asset that the assessment covers. When looking over the whole asset life, the less certain the data becomes given that the future management and operational regime are unknown and cannot always be predicted accurately. In scenarios where the maintenance regime and replacement cycle is not known, assumptions have to be made in order to give a reasonable embodied carbon estimate. An awareness that these assumptions have been used is valuable in understanding the final result of an embodied carbon assessment.

Where possible, stating the known, or assumed, operational regimes and end of life scenarios of the asset is recommended. Where there are unknowns, clients can engage with the assessors in order to determine the most appropriate assumptions. This will prevent assessors having to make arbitrary assumptions. Transparency of the assumptions will assist with future comparability across a client's portfolio.

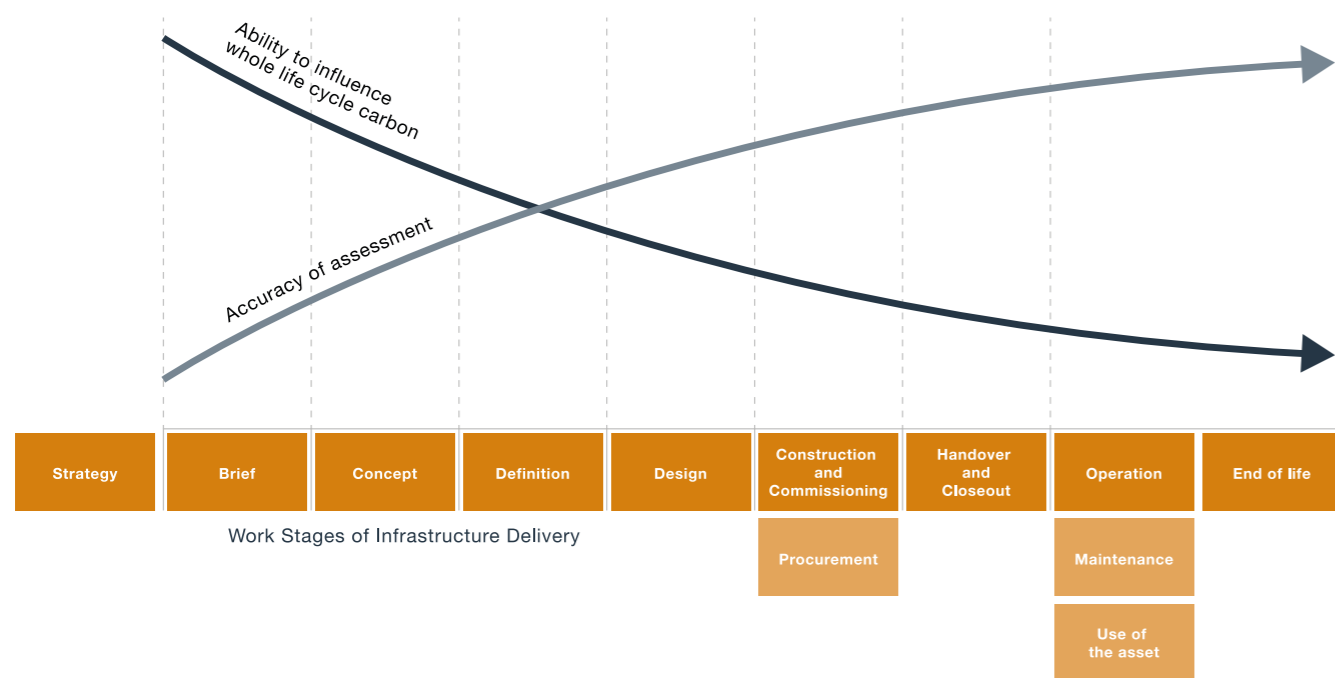


Figure 4 Conceptual diagram showing ability to influence carbon reduction across the different work stages of infrastructure delivery^[22]

3.6.3 Assessment scope

The assessment scope sets out what is included and excluded from the embodied carbon measurement.

The assessment scope may be defined as:

- a project level, e.g. new construction or fit-out;
- an asset level;
- an activity level, e.g. solely the structure of a single asset or across a portfolio.

The scope will also include a description of the physical parameters of an asset e.g. gross floor area (GFA). This is necessary to enable the results to be suitably presented. It is good practice to include a description of the use of an asset.

► Section 4.7 Presenting the results

It should be noted that the scope is distinct from the boundary of the assessment. The boundary defines the life cycle stages to be included. The scope defines the particular emissions that are included or excluded in every life cycle stage of the boundary.

Scope considerations might include:

- Is there a physical or geographical boundary? e.g. is the curtilage of the assessment site clearly defined?
- Is there a project boundary with an associated cost plan?
- What level of detail is needed? e.g. Can the 80:20 rule be applied in order to identify the high intensity/high volume embodied carbon areas?
- What activities are included? e.g. Will the embodied emissions of the materials and the construction site emissions of every single activity on the project be included?
- Define any exclusions from the assessment. e.g. demolition emissions.

► Section 4.3 Assessment scope for the example scope wording

3.6.4 Assessment standards and calculation methodology

For embodied carbon assessments of built assets, the use of the standard BS 15978 is becoming an industry norm.^[23] This standard sets out a basic methodology for life cycle assessment (LCA) in buildings by splitting the life cycle into modules. These modules are used to structure the embodied carbon calculation.

► Supporting Guidance: 2. What is the technical basis for identifying "life cycle stages"?

For civil engineering works there is a pending standard, prEN 15643-5:2016 *Sustainability of Construction Works – Sustainability Assessment of Buildings and Civil Engineering Works – Part 5: Framework for the Assessment of Sustainability Performance of Civil Engineering Works*.^[24]

For the infrastructure sector, there is also PAS 2080 which is a carbon management framework.

Finally, RICS has produced a detailed embodied carbon calculation methodology which builds on the BS 15978 assessment standard.^[25] Currently, assessors will typically choose either to use this methodology or develop their own approach. Conforming to one or more of the above standards and methodologies can provide a more robust process for, and a greater degree of confidence in, any calculations of embodied carbon figures.

► Supporting Guidance: 3.1 Presenting LCA results in a structured format

► Section 4.4 Assessment standards and calculation methodology for the example scope wording

3.6.5 Data and tools

Embodied carbon calculations need conversion factors to convert quantities of materials into embodied carbon figures. For this, there are a number of data sources available. The assessment standards or calculation methodologies do not endorse particular embodied carbon data sources (with the exception of environmental product declarations (EPDs)).

If multiple assessments are being conducted, defining which dataset and tool are used in the embodied carbon calculations will improve the consistency of the results.

Supporting Guidance: 4.1 Data and 4.3 Tools

Data Quality

The quality of data in embodied carbon assessments varies according to its source. There are data quality standards, which clients can specify to ensure a robust approach to embodied carbon calculations is adopted.

Supporting Guidance: 4.1 Data

Clients can also specify if the assessment should use verifiable data (and can request proof for audit, if required). It is recommended to ask an assessor to outline which standards can be complied with and to verify all data sources used in the calculations.

Section 4.5 Data and tools for the example wording

3.6.6 Presenting the figures

The final part of the brief specifies how the embodied carbon assessment should be presented. It is useful to have the information broken down in a variety of ways in order to make easier comparisons between assets. Comparisons between assets which have used exactly the same boundary and the same calculation methodology are possible.

Supporting Guidance: 6. Setting up meaningful comparisons

The results of an assessment might be broken down by:

- Structural building elements, e.g. substructure, superstructure etc.;
- Components, e.g. walls, floors, cladding etc.;
- Carbon sources, e.g. transport, materials, site activities etc.;
- Work package; and
- Location.

Presenting the data in a variety of ways highlights issues such as:

- where the carbon hotspots are;
- what kind of control the client has over them;
- how the asset will be affected by proposed mitigation measures; and
- who should be involved in the mitigation measures decisions.

The data should be presented in line with the requirements set out in the scope which should include physical parameters of an asset e.g. tCO₂e/m² GFA. The results of the assessment can also be normalised in terms of the functionality of an asset e.g. kgCO₂e/FTE. These intensity metrics should be in line with a client's normal practice.

Supporting Guidance: 8. Targets

Best practice is also to request that the timing of emissions is clearly stated e.g. where maintenance and repair cycles are considered.

As well as presenting the figures, the assessment should detail all assumptions that have been made, e.g. maintenance regimes, and be reported within the relevant section of the output, e.g. the assumed maintenance regime is reported within the boundary section.

Section 4.7 Presenting the results for the example wording

Section 6. What to do with the outputs?



4. Creating the brief – Putting pen to paper

This section is designed to help with writing the embodied carbon brief and provides example wording. Below are suggested sections to include which cover the major elements of an embodied carbon commissioning document.

Each section includes:

- An explanation as to why the section should be included;
- Example wording.

In the example wording, where content is highlighted in <> brackets, individual company information should be inserted.

4.1 Context, ambitions and aims

The brief starts by informing the assessor of the need for the embodied carbon assessment. This could include:

- the company specific context;
- relevant sustainability objectives;
- relevant overall carbon aims;
- previous experience and/or studies in embodied carbon measurement and reduction; and
- identifying any drivers and objectives as to why this data is required.

Example wording:

Example 1:

<Organisation name> has committed to achieving lower embodied carbon emissions in line with 2050 targets and it is aiming to achieve a carbon neutral status by 2030.

Example 2:

<Organisation name> is undergoing its first steps into embodied carbon assessment and would like to understand the embodied carbon impact of its assets. There is also an overarching company objective to explore our Scope 3 emissions as part of our CDP reporting process. Ongoing embodied carbon assessment forms part of our ISO 14001 certification.

Example 3:

<Organisation name> has an interest in delivering low impact assets and is therefore interested in measuring the embodied carbon impact. Sustainability is a core value of our business and we seek to make all of our new assets carbon neutral by 2025. We will achieve this through operational efficiency and through reducing embodied impacts.

Example 4:

<Organisation name> would like to understand the relationship between cost, efficiency and low embodied carbon buildings.

Optional wording 1:

The embodied carbon assessment must also be aligned with, and deliver compatible data for, our existing carbon processes including:

- *ISO 14064-1 Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.*
- *ISO 14064-2 Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.*
- *The Greenhouse Gas (GHG) Protocol Scope 3 Standard;*
- *PAS 2080:2016 Carbon management in infrastructure.*

Additional wording:

- *Regular embodied carbon reporting of our assets which informs our selection of materials, products and suppliers throughout the project and on future projects.**

* This wording can be used independently or in addition to the preceding points.



4.2 Assessment boundary and reference study period

The brief sets the most relevant boundary for an organisation's interests and future planning. The example wording refers to the two most often used boundary conditions for clients as well as using the potential "cradle-to-transfer of ownership" boundary.

Example wording:

Example 1:

The boundary to be used is cradle-to-completed construction, comprising BS 15978 modules A1-A5.

Example 2:

The boundary to be used is cradle-to-grave, comprising BS 15978 modules A1-A5 and B1 to B5 over a 30-year reference study period. Module D benefits are to be excluded.

Example 3:

The boundary to be used is cradle-to-grave, comprising BS 15978 modules A1 to C4 (excluding B6 and B7) i.e. including demolition, transport, waste processing and disposal, over a 60-year reference study period. Module D benefits are to be included.

Example 4:

The boundary to be used is "cradle-to-transfer of ownership", comprising BS 15978 modules A1 to C4 (excluding B6 and B7) over a 20-year reference study period.

Example 5:

The boundary to be used is "cradle-to-transfer of ownership", comprising BS 15978 modules A1 to C4 (excluding B6 and B7) over 10-year, 20-year and 60-year reference study periods.

4.3 Assessment scope

This section defines the scope of the assessment, which may be at a project, asset or activity level, e.g. new construction, a refurbishment or strip out/fit out. If helpful, further detail can be given around which project activities are included and excluded from the calculation.

Example wording:

Asset Function:

The asset being assessed will be an <office/ shop/residential building/mixed use development incorporating residential and retail tenants with a bus terminal>.

Example 1:

The scope is limited to an assessment of the structural components (sub-structure, superstructure and façade) of <project(s)/ asset(s)>.

Example 2:

The scope is limited to the fit-out of <project(s)/ asset(s)> including floor and wall finishes as well as major interior items.

Example 3:

The scope is limited to an assessment of <project(s)/asset(s)> including earthworks, demolition, all construction materials, construction operations and maintenance.

Example 4:

The scope of the assessment will include direct and indirect GHG emissions associated with <project(s)/asset(s)/activity(ies)>.

Example 5:

The scope of the assessment will exclude emissions from design stage (paper and office consumption) and worker commuting activities.

4.4 Assessment standards and calculation methodology

The brief then sets out any standards or calculation methodologies to which the assessment should conform. The calculation methodology is a choice between the RICS Methodology or the assessor's own approach. Calculations which do not use these standards or methodologies should request the assessor to justify this choice and explain the approach used.

Example wording:

Example 1:

All assessments undertaken must have their methods conform with BS 15978:2011 *Sustainability of construction works – Assessment of environmental performance of buildings*

Example 2:

The methodology for calculation will be based on the RICS 2014 *Methodology to Calculate Embodied Carbon*. Any deviations from this must be justified and agreed.

Example 3:

The methodology for calculation will conform to BS 15978:2011 and will also use the RICS *Methodology to calculate embodied carbon*. Data gathering shall conform to ISO 14025:2010 *Environmental labels and declarations. Type III environmental declarations. Principles and procedures*. An audit trail shall be presented.

4.5 Data and tools

The next step is to request that the data sources are disclosed in the report. Clients may outline which embodied carbon data, databases and calculation tools are preferred. This section could also stipulate the data quality control rules.

Example wording:

The following industry data and/or databases are preferred for embodied carbon calculations:

- Environmental Product Declarations (EPDs)
- Proprietary data and databases
- The University of Bath ICE database

The following calculation tools are preferred:

- <particular data set or data tool>
- Any proprietary tools may also be considered if they are demonstrated to create materially similar outputs as the other accepted tools. Differences in calculations should be justified.

Data quality:

- The assessment shall include a general commentary on data quality for the project.
- Scoring of data quality for each data source is also recommended.*

* This wording can be used independently or in addition to the preceding points.

4.6 Starting point, iterations and frequency

The brief states the stages at which the assessment will take place i.e. the starting point and details any further iterations. If this embodied carbon assessment is the first, it can be used as a baseline for future comparisons. It should be noted that the starting point has an impact on the opportunities for embodied carbon reductions.

Example wording:

Example 1:

Three iterations of the assessment are required.

1. *Concept design stage.*
2. *Detailed design stage.*
3. *Handover stage.*

For the second and third assessments, differences to the initial assessment shall be provided and explained.

Example 2:

The initial assessment will be at the detailed design stage. Two further iterations are required prior to the construction phase and a final as-built assessment. These iterations align to our standard gate process stages <gate references>.

Example 3:

The starting point will be at briefing stage and there will be periodic iterations of the assessment. <Organisation name> wishes to frequently monitor the embodied carbon and understand how material selection may affect the final outcome. Number and timing of iterations are to be agreed in conjunction with the embodied carbon assessor.

Example 4:

The results of the assessment are required at handover stage. It is the assessor's responsibility to advise as to the most appropriate stages to engage in order to deliver a robust assessment.

Optional wording (as required):

Where the first assessment is to be before product selection, initial calculations should be based on <RICS component benchmarks> or use estimated quantities and <choice of database>. This generic data should be substituted for detailed product data as the design progresses and subsequent iterations of the assessment are prepared.

4.7 Presenting the results

The brief states the way in which the final assessment is presented. This will include all assumptions that have been made.

A comprehensive breakdown of the results will enable the client to better understand where the embodied carbon impact lies. This depth of understanding can be used to inform decisions made at later stages in the project and on future projects.

Clients can request a list of reduction strategy suggestions e.g. the top five which would have the

most impact. Alternatively, the list of suggestions could be based on parameters such as the materials used in the elements and components, or reductions achievable in each project stage after the assessment.

The example wording uses generic terminology for breakdowns of building elements and components. Official RICS terminology can be used to avoid confusion and different interpretations. Alternatively, in-house terminology can be used for the breakdown detail.

Example wording:

Assumptions:

All assumptions must be clearly stated.

Clients can choose any of the following potential breakdown examples that are appropriate.

The results of the assessment shall be presented in the following way:

- Total kgCO₂e per building element as defined as: <substructure; superstructure; cladding; exterior works; services; and any other major element>.
- Total kgCO₂e per material as defined as: <foundation concrete, structural steel, etc.>.
- Total kgCO₂e per major building component as defined as <frame, internal and external walls, floors, roof, windows and doors, etc.>.
- Total kgCO₂e per work package.
- Total kgCO₂e by location.

Additionally, the breakdown shall include:

<The results are required both as a total embodied carbon figure for the cradle-to-grave assessment and dis-aggregated into the BS 15978 life cycle stages A, B and C.>.

<The results shall include intensity metrics, as defined by: <kgCO₂e per m²> and <tCO₂e per £100k cost, <kgCO₂e per passenger>.

<Each breakdown should be expressed as a proportion (%) of the total embodied carbon footprint>.

The assessment shall provide the top <five> suggestions for reducing embodied carbon impact (including the reasoning) to inform the next stage of the project.

5. Example Brief

The example brief below assembles a selection of the example wording from Section 4 into a single document.

EMBODIED CARBON BRIEF

Context and company objectives

<Organisation name> has an interest in delivering low impact assets and is therefore interested in measuring the embodied carbon impact. Sustainability is a core value of our business and we seek to make all of our new assets carbon neutral by 2025. We will achieve this through operational efficiency and through reducing embodied impacts.

The embodied carbon assessment must also be aligned with, and deliver compatible data for, our existing carbon processes including:

- ISO 14064-2 "Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements".
- Regular embodied carbon reporting of our assets which informs our selection of materials, products and suppliers throughout the project and on future projects.

Boundary

The assessment will report on three boundaries, as defined using BS 15978:2011 "Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method".

1. Cradle-to-completed construction, comprising BS 15978 modules A1-A5.
2. "Cradle-to-transfer of ownership", comprising BS 15978 modules A1 to C4 (excluding B6 and B7) over 10-year, 20-year and 60-year reference study periods.
3. Cradle-to-grave, comprising BS 15978 modules A1 to C4 (i.e. including demolition, transport, waste processing and disposal) over a 60-year reference study period.

Scope of the embodied carbon assessment

Asset function: The asset being assessed will be a mixed use development incorporating residential and retail tenants.

The assessment shall include the structural components (sub-structure, superstructure and façade). The fit-out, floor and wall finishes, as well as major interior items, are included.

The assessment will exclude emissions from design stage (paper and office consumption) and worker commuting activities.

Assessment standards and calculation methodology

The methodology for calculation will conform to BS 15978:2011 and will also use the RICS "Methodology to calculate embodied carbon". Data gathering shall conform to ISO 14025:2010 "Environmental labels and declarations. Type III environmental declarations. Principles and procedures". An audit trail shall be presented.

EMBODIED CARBON BRIEF 2

Data and tools

The following industry data and/or databases are preferred for embodied carbon calculations:

- Environmental Product Declarations (EPDs)
- Proprietary data and database
- GaBi database

The following calculation tools are acceptable:

- Impact-compliant tools
- Any proprietary tools may also be considered if they are demonstrated to create the same outputs

The assessment shall include a general commentary on data quality for the project. Scoring of data quality for each data source is recommended.

Starting point, iterations and frequency

The starting point will be at briefing stage and there will be periodic iterations of the assessment. <Organisation name> wishes to frequently monitor the embodied carbon and understand how material selection may affect the final outcome. Number and timing of iterations are to be agreed in conjunction with the embodied carbon assessor.

Where the first assessment is to be before product selection, initial calculations should be based on RICS component benchmarks or use estimated quantities and the GaBi database. This generic data should be substituted for detailed product data as the design progresses and subsequent iterations of the assessment are prepared.

Presenting the results

All assumptions must be clearly stated.

The results of the assessment shall be presented in the following way:

- Total kgCO₂e per building element as defined as: substructure, superstructure, cladding, exterior works, services, and any other major element.
- Total kgCO₂e per material as defined as: foundation concrete, structural steel, etc.
- Total kgCO₂e per major building component as defined as: frame, internal and external walls, floors, roof, windows and doors, etc.
- Total kgCO₂e per work package.
- The results shall include intensity metrics, as defined by: kgCO₂e per m² and tCO₂e per £100k cost, kgCO₂e per residential occupant.
- Each breakdown should be expressed as a proportion (%) of the total embodied carbon footprint.

The assessment shall provide the top five suggestions for reducing embodied carbon impact (including the reasoning) to inform the next stage of the project.

The brief starts by informing the assessor of the need for the embodied carbon assessment. This could include:

- the company specific context;
- relevant sustainability objectives;
- relevant overall carbon aims;
- previous experience and/or studies in embodied carbon measurement and reduction; and
- identifying drivers and objectives for the data.

The brief sets the most relevant boundary for the organisation's interests and future planning.

This section defines the scope of the assessment, which may be at a project, asset or activity level e.g. new construction, refurbishment or strip out/fit out. If helpful, further detail can be given around which project activities are included and excluded from the calculation.

This section sets out any standards or calculation methodologies to which the assessment should conform. The calculation methodology is a choice between the RICS Methodology or the assessor's own approach. Calculations which do not use these standards or methodologies should request the assessor to justify this choice and explain the approach used.

Clients may outline which embodied carbon data, databases and calculation tools are preferred and request that the data sources are disclosed. This section could also stipulate the data quality control rules.

This section states the stage at which the assessment will take place i.e. the starting point, and details any further iterations. If this embodied carbon assessment is the first, it can be used as a baseline for future comparisons. It should be noted that the starting point has an impact on the opportunities for embodied carbon reductions.

This section states the way in which the final assessment is presented. This will include all assumptions that have been made. A comprehensive breakdown of the results will enable the client to better understand where the embodied carbon impact lies. This depth of understanding can be used to inform decisions made at later stages in the project and on future projects.

Clients can request a list of reduction strategy suggestions, e.g. the top five which would have the most impact. Alternatively, the list of suggestions could be based on parameters such as the materials used in the elements and components, or reductions achievable in each project stage after the assessment.

6. What to do with the outputs?

Use of the embodied carbon assessment depends on when the assessment was carried out. If the assessment was undertaken at conceptual design stage, the embodied carbon report can give clients an opportunity to make decisions at subsequent stages in the project to reduce the predicted embodied carbon outcome.

If the assessment was undertaken to understand the as-built embodied carbon, this could be used as a benchmark for future projects. Earlier initial assessments and frequent iterations throughout the construction process will reveal more opportunities for embodied carbon reduction.

6.1 Benchmarking

Once the first assessment is completed, a benchmark exists with which to compare future projects. Direct comparisons can be made between assets which have had the same boundaries, scope, assessment methodology etc. applied. Comparisons of the embodied carbon between different typologies may be useful, however, the degree of fit-out will vary considerably e.g. embodied carbon of warehouses as compared to a retail building.

If built assets are not part of the core business, or the client is a “pop-up” client created to deliver a one-off asset, the embodied carbon data is useful to publicly publish the embodied carbon data or feed into an industry collective benchmark project, e.g. Embodied Carbon Database.^[26]

Supporting Guidance: 7. Benchmarks

6.2 Target setting

A target is not necessary for a client to commission an initial embodied carbon assessment. It is more important to ensure clarity of the objectives of the exercise and how the outputs will be used. As more assessments are completed, it will become easier to set a target. Embodied carbon targets can be as simple as a reduction against an initial calculation or can be an absolute figure for the defined scope. Clients should be mindful of using accurate like-for-like comparisons.

The same caveats of similar boundaries, scope, methodologies etc. that exist for benchmarking, apply for target setting.

Supporting Guidance: 8. Targets

6.3 Reducing embodied carbon

It is recommended that in order to maximise the opportunity for embodied carbon reduction, assessments are undertaken as early on in the design process as possible.

As a client’s knowledge of embodied carbon increases, assessments undertaken earlier in the design phase become easier to commission and use for decision-making. This in turn will lead to increased opportunities to take action on reducing the embodied carbon impact of projects and activities.

The embodied carbon and work stages (Table 1) is aligned with the carbon reduction curve (Figure 5).

Supporting Guidance: 9. Major wins

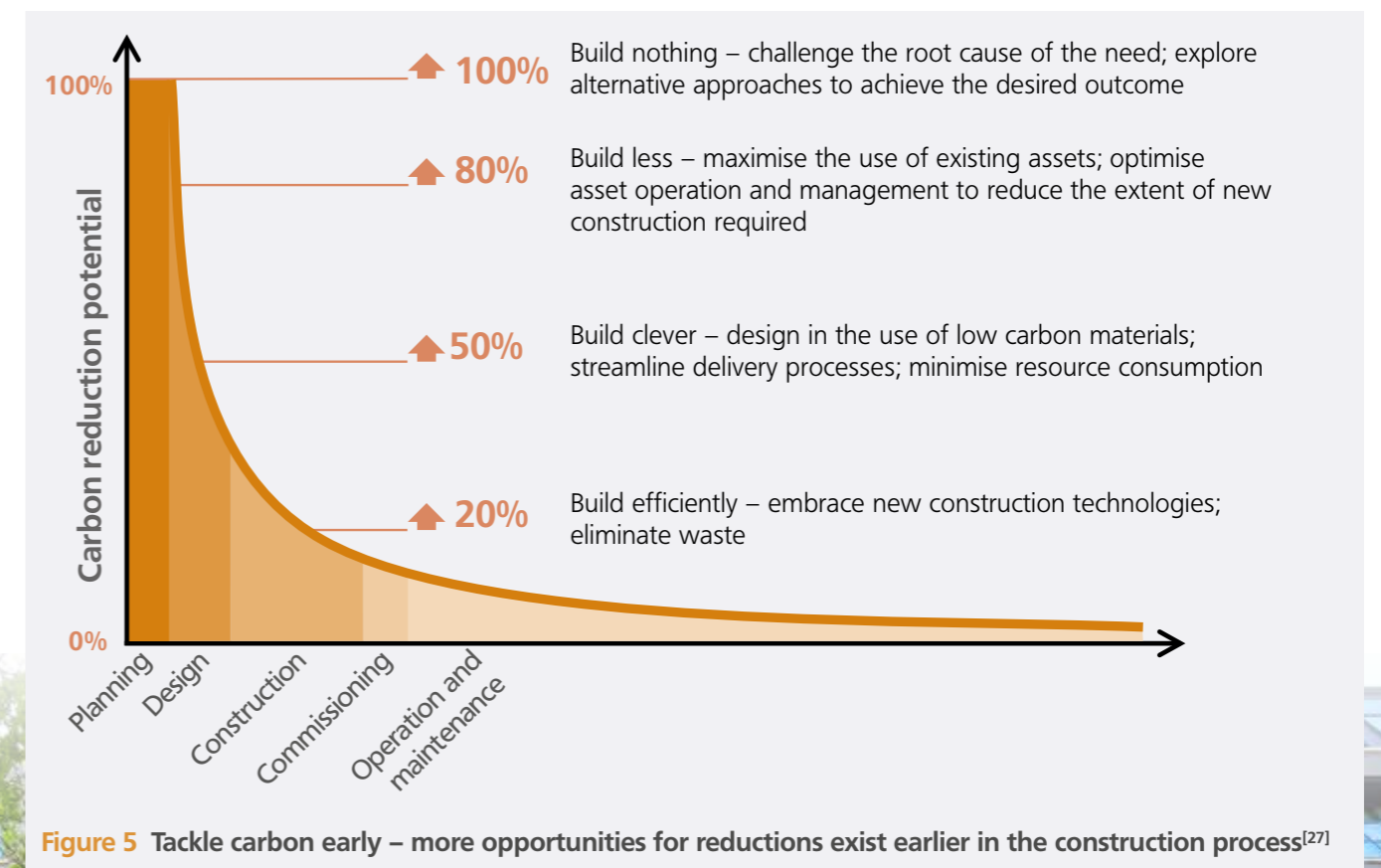


Figure 5 Tackle carbon early – more opportunities for reductions exist earlier in the construction process^[27]



7. Glossary

Boundary (or system boundary): An LCA boundary determines which processes to be included in the LCA study.

Boundaries and BS 15978: Embodied carbon assessments often use the *BS 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method*.^[28] This standard is a whole life cycle assessment (LCA) standard. The standard splits the lifecycle into 17 modules, each defining the source of environmental impacts, including the sources of embodied carbon^[29]. These modules are then referenced to draw the embodied carbon boundary.

Carbon hotspot*: The carbon significant aspect of a project which should be targeted for reduction. Carbon hotspots represent not only carbon-intense or high volume elements but also quick wins, where measurement data is more easily available and where carbon reductions are possible.

Capital Carbon: refers to emissions associated with the creation of an asset. Capital carbon is being adopted within the infrastructure sector because it accords with the concept of capital cost. (Going forward, the related term “embodied carbon” will continue to be used at a product-level, whereas capital carbon will have greater relevance at an asset-level).^[3]

CDP: Formerly known as the Carbon Disclosure Project, this organisation works with corporations to disclose their GHG emissions.

Carbon emissions, CO₂e, CO₂eq, greenhouse gas emissions (GHGs): Shorthand terms for the emissions of any of the number of greenhouse gases (GHGs) that affect climate change. Carbon emissions are usually expressed as CO₂ equivalent (CO₂e or CO₂eq), which is a unit of measurement based on the relative impact of a given gas on global warming over a given time horizon i.e. the global warming potential (GWP). For example, over a 100-year time horizon excluding climate-carbon feedbacks, methane has a GWP of 28, which means that 1 kg of methane would have the same impact on climate change as 28 kg of carbon dioxide and thus 1 kg of methane would count as 28 kg of CO₂e.

Cradle-to-completed construction: an LCA system boundary which combines all emissions from extraction, manufacturing and the transport of materials to site together with the emissions generated during construction. This may or may not include emissions associated with supporting services, such as design, worker travel to and from site etc.

Cradle-to-grave boundary: an LCA system boundary term which combines all emissions up to and including the end of life scenarios. It will include demolition emissions but the calculation will change depending on what happens at the end of life.*

DJSI: The Dow Jones Sustainability Indices evaluate the sustainability performance of the largest 2,500 companies listed on the Dow Jones Global Total Stock Market Index.

Environmental Product Declaration (EPD): An environmental product declaration is a verified and registered document that communicates transparent and comparable information about the life cycle environmental impact of products.

FTSEGood: The FTSE4Good Index Series is designed to measure the performance of companies demonstrating strong Environmental, Social and Governance (ESG) practices. Transparent management and clearly-defined ESG criteria make FTSE4Good indexes suitable tools to be used by a wide variety of market participants when creating or assessing sustainable investment products.

Greenhouse gas emissions (GHGs): A collection of gases that, when present in the atmosphere, trap infrared radiation in the form of heat, causing a warming process called the greenhouse effect.

Global Real Estate Sustainability Benchmark (GRESB): An investor-driven benchmark for the environmental, social and governance performance of real estate assets.

Global warming potential (GWP): a relative measure of how much a given mass of greenhouse gas is estimated to contribute to global warming over a given time interval. It is expressed relative to carbon dioxide which has a GWP of 1. These factors are regularly updated, and it is recommended to use the latest factors from the Intergovernmental Panel on Climate Change (IPCC). Most assessments adopt GWP factors over a 100 year-time horizon.

GWP of principal greenhouse gases over 100 years excluding climate-carbon feedbacks^[30]

Greenhouse Gas	GWP	Typical sources
Carbon dioxide (CO ₂)	1	Energy combustion, biochemical reactions
Methane (CH ₄)	28	Decomposition
Nitrous oxide (N ₂ O)	265	Fertilisers, car emissions, manufacturing

Life Cycle Assessment (LCA): LCA is a technique by which to assess the environmental impacts of a product’s life. This encompasses from raw material extraction to disposal and can also include the recycling stage.

Operational Carbon*: Carbon emissions’ association with energy consumption (operational energy) while the building is occupied. This includes the regulated load (e.g. heating, cooling, ventilation, lighting) and unregulated/plug load (e.g. ICT equipment, cooking, refrigeration appliances).

RE100: RE100 is a collaborative, global initiative of influential businesses committed to 100% renewable electricity, working to massively increase demand for - and delivery of - renewable energy. Companies joining RE100 are encouraged to set a public goal to procure 100% of their electricity from renewable sources of energy by a specified year. RE100 was created by The Climate Group in partnership with CDP, as part of the We Mean Business coalition.

Science Based Targets (SBT) Initiative: The Science Based Target initiative has been set up by CDP, The UN Global Compact, the World Resources Institute and WWF to ensure that GHG reduction targets are consistent with the pace recommended by climate scientists to limit the worst impacts of climate change.

Whole life carbon: Another term for cradle-to-grave carbon emissions**. When referring to assets, ‘whole life carbon’ usually refers to total operational and embodied carbon emissions.

* For other boundary definitions, see the Supporting Guidance.

** Indicates the definition is based on RICS 2014 Global Guidance Methodology to calculate embodied carbon.



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10. Based on the 80% reduction scenario reported in the 2013 Green Construction Board Low Carbon Routemap. Data has been updated to the baseline reported in the Green Construction Board's Low Carbon Routemap for the Built Environment 2015 Routemap Progress - Technical Report. Available at <http://greenconstructionboard.org/otherdocs/2015%20Built%20environment%20low%20carbon%20routemap%20progress%20report%202015-12-15.pdf>
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13. RICS Professional Guidance, 2014. Methodology to calculate embodied carbon of materials. 1st edition. Available at: http://www.rics.org/Global/Methodology_to_calculate_embodied_carbon_1st_edition_PGguidance_2014.pdf
14. "An ambitious and measurable Scope 3 target with a clear time-frame is required when Scope 3 emissions cover a significant portion (greater than 40% of total scope 1, 2 and 3 emissions) of a company's overall emissions. The target boundary must include the majority of value chain emissions as defined by the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (e.g. top 3 categories, or 2/3 of total scope 3 emissions)." Web: sciencebasedtargets.com, 2016
15. Trucost, Oct 2016. More Carbon Disclosure and Target Setting in North America, but are Companies Focused on "What Matters Most"
16. Scope 3 emissions in this context are scope 1, 2 and 3 emissions from the development process.
17. GRESB sections include 'Environmental attributes of building materials', 'Location and transport' and 'Specification and purchasing of rapidly renewable materials, low embodied carbon materials, and recycled content materials'. It also has a section on the percentage of real estate assets which have a certification. The potential for embodied carbon certification for listed property companies may become more important.
18. The social cost of carbon (SCC) measures the full cost of an incremental unit of carbon (or greenhouse gas equivalent) emitted now, calculating the full cost of the damage it imposes over the whole of its time in the atmosphere. Because the amount of damage caused by each incremental unit of carbon in the atmosphere depends on the concentration of atmospheric carbon today and in the future, the SCC varies according to the emissions and concentration trajectory the world is on. HM Government. Social Cost of Carbon. Available from: <https://www.gov.uk/government/collections/carbon-valuation-2#social-cost-of-carbon>
19. RICS use the term 'carbon critical' to indicate essential elements that will have a high contribution to the overall carbon footprint – be that because they are particularly carbon intense or simply used in large volume. See Table 3 in the RICS 2014 methodology for a suggested set of 'carbon critical' hotspots. Available from: http://www.rics.org/Global/Methodology_to_calculate_embodied_carbon_1st_edition_PGguidance_2014.pdf
20. PAS 2080 may be useful for larger clients where there are multiple actors. PAS 2080 is written for infrastructure projects, however, it is easily adapted to buildings.
21. If the embodied carbon assessment is commissioned at handover, without prior commissioning of embodied carbon data gathering at the start of the project, it is unlikely that a complete data set for an assessment will be available.
22. BSI, 2016. PAS 2080:2016, Carbon Management in Infrastructure. Available at <http://shop.bsigroup.com/forms/PASs/PAS-2080/>
23. There are various assessment standards for GHG emissions at corporate levels which are covered in Section 3.5 however, these are generally considered suitable for organisational emissions but not for embodied carbon assessments at a built asset level.
24. prEN 15643-5:2016 is currently a draft standard. Publication is due 25th October 2017
25. RICS Professional Guidance, Global. Methodology to calculate embodied carbon of materials. 1st edition, 2014. Available from: http://www.rics.org/Global/Methodology_to_calculate_embodied_carbon_1st_edition_PGguidance_2014.pdf
26. WRAP, 2017. Embodied Carbon Database. Available at <http://ecdb.wrap.org.uk/>
27. HM Treasury, 2013. Infrastructure Carbon Review. Available at: <https://www.gov.uk/government/publications/infrastructure-carbon-review>
28. PAS 2080 can also be used. It presents modules covering all impacts for infrastructure projects.
29. With the exception of Module B6 which is exclusively operational energy use and module B7 which considers operational water use
30. IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.7. Available from: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf



Embodied Carbon: Supporting Guidance

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1. Introduction

The Supporting Guidance complements the information provided previously and acts as a springboard for further research. The Supporting Guidance is not designed to be read sequentially. Each section can be read independently. It signposts to existing resources frequently used in industry and provides short explanations where necessary.

The Supporting Guidance references many resources which use life cycle assessment (LCA) as the main approach as opposed to solely embodied carbon assessment, which is one of multiple impacts measured within an LCA.

2. What is the technical basis for identifying “life cycle stages”?

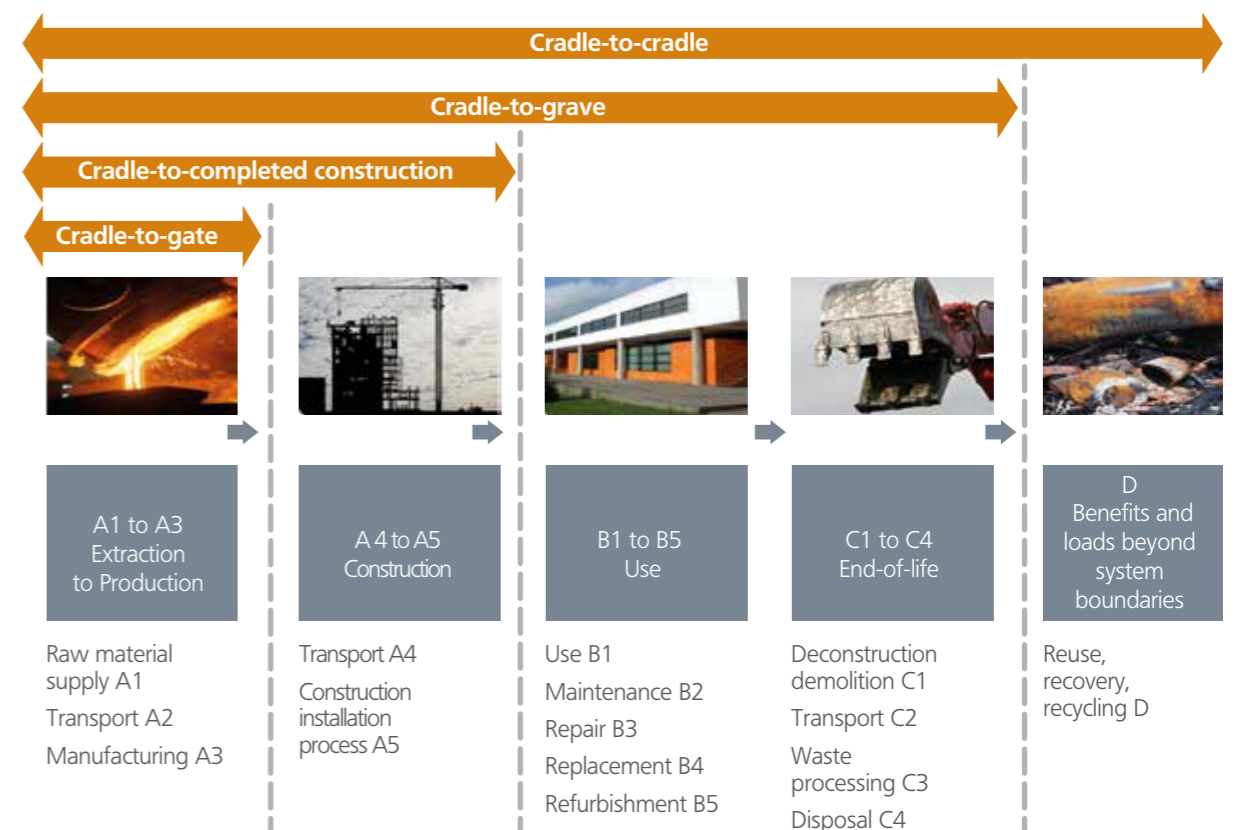
Assets or products have environmental impacts throughout their whole life. LCA provides an approach to understand and measure these impacts at each life cycle stage. All LCAs require boundaries to be defined (system boundaries), which reflect the life cycle stages and processes. For example, whether the environmental impacts associated with the manufacturing of the site plant need to be included or not.

LCA practice is governed by the following international standards, which provide guidance on life cycle stages:

- a) BS EN ISO 14040:2006 *Environmental management. Life cycle assessment. Principles and framework*; and
- b) BS EN ISO 14044:2006 *Environmental management. Life cycle assessment. Requirements and guidelines*.

Embodied carbon measurement is included in the calculation method for evaluating the environmental performance of built assets, as set out in the European standard, BS EN 15978:2011 *Sustainability of construction works – Assessment of environmental performance of buildings*. BS 15978 uses a modular approach, in which each life cycle stage is assessed separately. (Guidance Figure 1)

The interaction between these standards (and others) is detailed in Section 3.



Guidance Figure 1 LCA information modules for the construction sector (BRE)

The various life cycle stages commonly referred to are:

- i. Cradle*-to-gate (A1 to A3): from resource extraction to the factory gate, covering the manufacture of the respective construction products and materials;
- ii. Cradle-to-site (A1 to A4): cradle-to-gate, plus the delivery of the products to site;
- iii. Cradle-to-completed construction (A1 to A5): cradle-to-site, plus the actual construction phase or the process of installing the product in the built asset;
- iv. Cradle-to-grave (A1 to C4): cradle-to-completed construction, plus the use of the products in the built asset, the use of the built asset itself, the end of life processes covering demolition and final disposal;
- v. Cradle-to-cradle (A1 to C4 and beyond): this is essentially a cradle-to-grave study that further evaluates the reuse of the product, parts of the built asset, or all of the built asset in a 'new life'; this terminology is associated with a circular economy approach.

In addition, "Cradle-to-transfer of ownership" could be used in situations where clients wish to build, operate, maintain and then sell. It would cover modules A1-A5, B1-B5.

3. Standards and industry reference documents

There are a number of standards and guidance covering LCA. These can be categorised as:

- international standards which define an overall framework and set out the overarching principles of LCA for all sectors
- sector-specific standards, which build on the standards above, and are specifically relevant to the built environment. Many of these focus on the quantification or reporting of impacts at either the product or asset level.

Guidance Table 1 Standards (LCA and sector-specific)

Standards	Description
Overall framework standards for life cycle assessment	
BS EN ISO 14040:2006 <i>Environmental management. Life cycle assessment. Principles and framework.</i>	This standard describes the principles and framework to carry out life cycle assessment (LCA), including goal and scope definition, inventory, impact assessment, interpretation and reporting.
BS EN ISO 14044:2006 <i>Environmental management. Life cycle assessment. Requirements and guidelines.</i>	This standard specifies requirements and provides guidelines to carry out life cycle assessment (LCA) studies.
International standards for built assets and construction products	
BS ISO 21931:2010 <i>Sustainability in building construction. Framework for methods of assessment of the environmental performance of construction works. Buildings.</i>	This standard provides a general framework for improving the quality and comparability of methods for assessing the environmental performance of built assets.
BS ISO 21930:2007 <i>Sustainability in building construction – Environmental declaration of building products (EPDs).</i>	This standard provides the principles and requirements for Environmental Product Declaration (EPD) of building products.
European standards for built assets	
BS EN 15643-2:2011 <i>Sustainability of construction works – Assessment of buildings. Part 2: Framework for the assessment of environmental performance.</i>	This standard provides the specific principles and requirements for the assessment of environmental performance of buildings taking into account technical characteristics and functionality of a building. This standard is relevant to all building types, new and existing.

* The term "cradle" refers to the extraction stage of the primary resources of any product.

Standards	Description
BS EN 15978:2011 <i>Sustainability of construction works - Assessment of environmental performance of buildings. Calculation method.</i>	This standard specifies the calculation method, based on LCA to assess the environmental performance of a building. It also provides guidance on the reporting and communication of the outcome of the assessment. This standard is relevant to all building types, new and existing.
pr EN 15643-5 <i>Sustainability of Construction Works - Sustainability Assessment of Buildings and Civil Engineering Works - Part 5: Framework for the Assessment of Sustainability Performance of Civil Engineering Works. (In development).</i>	This standard is still in development, but will aim to provide the specific principles and requirements for the assessment of environmental performance of civil engineering works.
European standards for construction products	
BS EN 15804:2012+A1:2013 <i>Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products.</i>	This standard provides core rules for EPD for construction products and services.

BS = British Standard/UK only
 EN = European standard
 ISO = International standard

Carbon specific standards

In addition to LCA standards which cover a broad range of environmental impacts, a number of standards specifically address carbon emissions.

BSI, the UK national standards body, has developed a publicly available specification (PAS) specifically for carbon assessment, PAS 2050:2011 *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*. PAS 2050 builds on the international LCA standards and provides guidance on how to calculate the carbon footprint of goods and services for all sectors. Products can be certified against this standard.

BSI has also published PAS 2080:2016 *Carbon management in infrastructure*, which aims to help all members of the infrastructure value chain understand and manage carbon associated with the development of infrastructure assets from cradle-to-grave. Although written for infrastructure, it is possible to adapt this process to buildings. Companies can be accredited to this specification.

Through the GHG Protocol partnership, The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) have published a range of city, corporate and product greenhouse gas accounting and reporting standards*. The embodied carbon of built assets is included within the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* which acts as a supplement to the widely used *Corporate Accounting and Reporting Standard*.

3.1 Presenting LCA results in a structured format

There are several standards that guide the user on the reporting and communication of the results of an LCA.

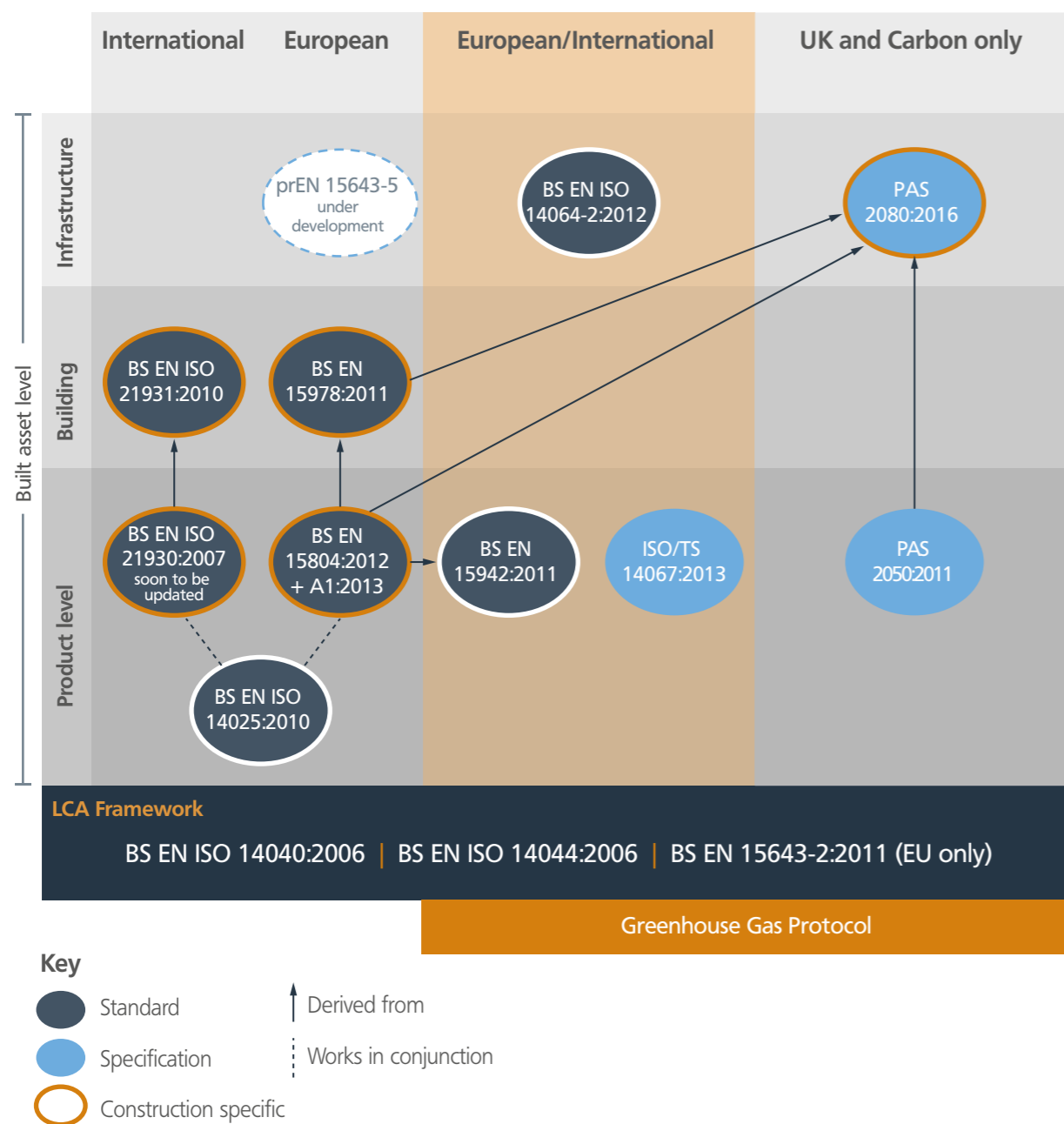
Guidance Table 2 Standards (LCA reporting and communication)

Use	Title	Description
Reporting and communication of LCA results.	BS EN ISO 14025:2010 <i>Environmental labels and declarations. Type III environmental declarations. Principles and procedures.</i>	This standard establishes the principles and specifies the procedures for developing EPDs. This standard requires that the LCA study has been carried out in accordance with relevant LCA standards referenced earlier.
Reporting and communication of LCA results for construction products.	BS EN 15942:2011 <i>Sustainability of construction works. Environmental product declarations. Communication format business-to-business.</i>	The aim of this standard is to harmonise the way in which EN 15804 compliant EPDs are communicated in Europe.

* For a full list of GHG Protocol standards see: <http://ghgprotocol.org/standards>

Use	Title	Description
Reporting and communication of embodied (and operational) carbon studies of products and factories/ organisations.	BS EN ISO 14064-2:2012 <i>Greenhouse gases. Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.</i>	This standard provides guidance on the quantification, monitoring and reporting of activities which cause greenhouse gas (GHG) emissions at project level.
	ISO/TS 14067:2013 <i>Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication.</i>	A technical specification which details the principles, requirements and guidelines for the quantification and communication of the carbon footprint of products (both goods and services).

Guidance Figure 2 provides an overview of the standards landscape.



Guidance Figure 2 Overview of the LCA related standards

4. Calculation methodologies, data and tools

To aid the calculation of embodied impacts of built assets, a number of methodologies and tools have been derived and published complementary to the standards referenced above. These methodologies provide a “how-to” set of instructions reflecting the focus or bias of respective sources. Datasets have been developed with the aim of providing robust sources of data for assessments and calculations. Below is a non-exhaustive list of examples of data sources (and datasets), methodologies and tools are given below.

4.1 Data

LCA studies for built assets use a variety of data sources. Some sources are free and publically available; others are only available through specific tools.

The following is a selection of data and data sources. All of these are the results of LCA studies which have been done at construction product or element level. These individual results can then be used within a whole built asset assessment.

Environmental Product Declarations (EPDs)

There are two types of EPDs available:

- Proprietary EPDs - these cover products from a specific manufacturer;
- Generic EPDs - these typically cover a product type and are created by a group of manufacturers.

EPDs are based on manufacturing data and, for the construction industry, should comply with either ISO 21930 (international) or EN 15804 (Europe).

EPDs are verified and published by established EPD programme operators according to the requirements of ISO 14025. Examples of EPD sources include:

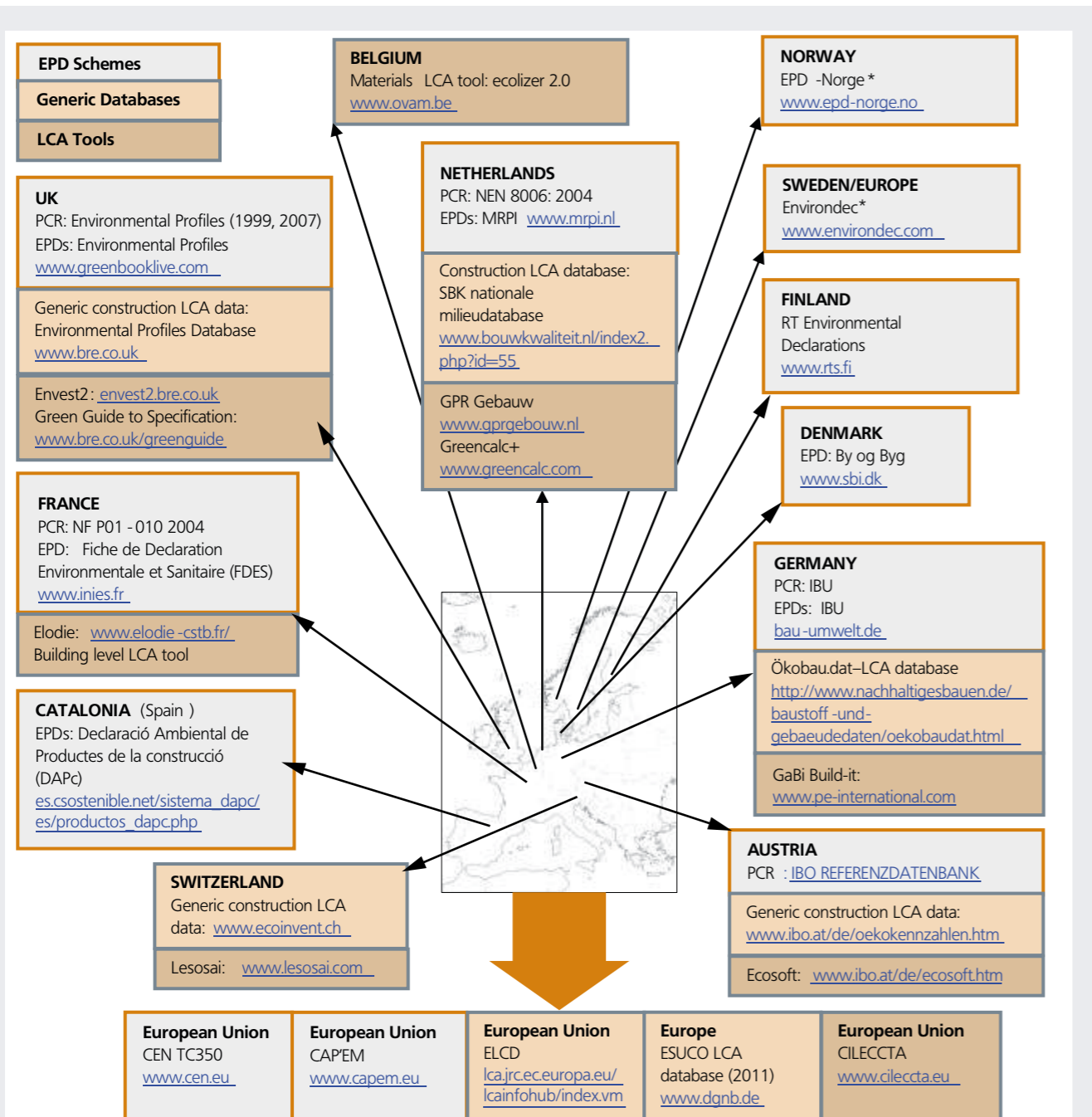
- BRE Global’s EPD programme publishes its verified EPDs on BRE’s Green Book Live website: <http://www.greenbooklive.com/search/scheme.jsp?id=272>
- ECO Platform, an association of European EPD programmes and stakeholders, provides a listing service for EN 15804 compliant EPDs generated by its members: <http://eco-platform.org/list-of-all-eco-epd.html>

In 2010 the CPA collated a number of international EPD sources. This is reproduced in Guidance Figure 3.

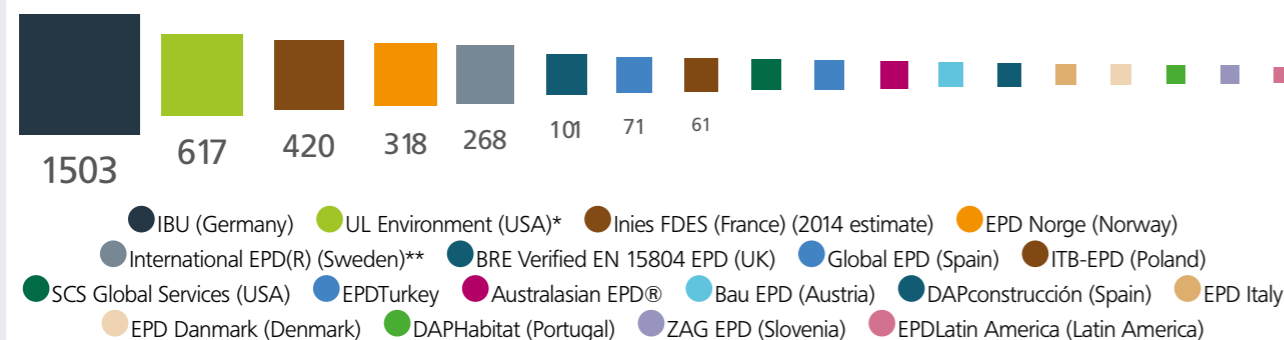
CESMM4 Carbon and Price Book 2013 Mott Macdonald

Focused on civil engineering*. This book includes carbon values (provided by BRE and therefore will give results similar to the Green Guide to Specification) alongside costs. Data is reported in kgCO₂e per unit for all materials and processes.

* CESMM4 Carbon and Price Book has been compiled using the latest update of the Civil Engineering Standard Method of Measurement (CESMM4). Available at: <http://www.rics.org/uk/shop/CESMM4-Carbon-Price-Book-2013-19402.aspx>



Guidance Figure 3 National EPD schemes with the Product Category Rules the schemes use and links to those EPD for construction products that have been published. Includes the generic databases of LCA or LCI data for construction products and building level LCA tools available across Europe*



Guidance Figure 4 Which EPD Programmes publish verified EN 15804 EPD and how many are there now?†

* CPA, 2010. A guide to understanding the embodied impacts of construction products. Correct as at 2010.

† Anderson, J., 2013. ConstructionLCA's 2017 Guide to Environmental Product Declarations. Available from: <https://infogr.am/47216efb-7256-4a5e-acc3-04ce046cbdf8>

The Green Guide to Specification

The Green Guide to Specification is based on the BRE Environmental Profiles Methodology and results are based on generic data from UK industry. The Green Guide is maintained as an online resource. It is not envisaged that there will be an update to the Green Guide beyond 2021, as BRE is moving towards a whole building level assessment (see IMPACT section below).

The Green Guide gives LCA results for building elements. Some elements are only formed of a single product, such as floor covering, insulation and windows. Other elements combine several products together e.g. an external wall, which includes insulation, brick, blocks and plasterboard.

Each element is given a rating from A+ to E based on an overall "Ecopoint" score (derived from the LCA results). The Green Guide also reports the kgCO₂e/m² from cradle-to-grave over a 60-year study period.

The Inventory of Carbon and Energy (ICE) Database

The database was developed by the University of Bath as a research project and the current version was last updated in 2011. The ICE Database holds data, sourced from a large literature review, for the most commonly used products in construction. The database uses a combination of industry averages of materials and values from studies available at the time (this includes some non-UK sources). Cradle-to-gate carbon values are expressed in kgCO₂ or kgCO₂e and MJ. Other third party databases can be selected from the following source: <http://www.ghgprotocol.org/Third-Party-Databases>

It is worth noting that, depending on the data and data sources used, the results of LCA studies for whole built assets may vary. Despite the common principles defined by the framework standards, there are variations in how they are interpreted. This must be kept in mind when comparing results.

Section 6. Setting up meaningful comparisons

Data quality

Different sources of data used to carry out an LCA are not all of the same quality. Quality is defined as:

- the robustness of the process used to gather the data;
- the compliance with standards (Section 3. Standards and industry reference documents);
- the relevance (geographical and product specific); and
- the age of the data.

Documents such as "Construction Scope 3 (Embodied) Greenhouse Gas Accounting and Reporting Guidance"† provide guidance on data quality.

4.2 Methodologies

Several methodologies exist to implement principles laid out in LCA standards. They can be used to calculate embodied impacts of built assets. They are also implemented within various tools (See Section 4.3). The most commonly cited methodologies available are:

- RICS Methodology to calculate embodied carbon‡
This guidance builds on BS 15978 and sets out how to calculate the impacts for each life cycle stage. It also provides background information to estimate the carbon emissions associated with construction projects from cradle-to-grave. This document also provides carbon reduction strategies.

* Aizlewood, C et al., 2007. Environmental weightings - their use in the environmental assessment of construction products. BRE, Watford. Available at <https://www.brebookshop.com/details.jsp?id=287511>

† Greater London Authority (GLA), 2013. Construction Scope 3 (Embodied): Greenhouse Gas Accounting and Reporting Guidance. Available at: https://www.london.gov.uk/sites/default/files/gla_construction_scope_3_embodied_greenhouse_gas_accounting_and_reporting_guidance_vfinal_1.pdf (See Table 72, pp.27-28)

‡ RICS, 2014. "Methodology to calculate embodied carbon". Available at: http://www.rics.org/Global/Methodology_to_calculate_embodied_carbon_1st_edition_PGguidance_2014.pdf

- The “Construction Scope 3 (Embodied) Greenhouse Gas Accounting and Reporting Guidance” written for the Greater London Authority (GLA) contains a series of recommendations which aims to improve the understanding and consistency of the accounting and reporting of embodied emissions within the construction sector from cradle-to-grave. This document also provides guidance on how to carry out calculations to measure the embodied carbon impact of buildings.
- BRE has an in-house methodology based on BS 15978 on how to calculate the environmental impact of buildings, including embodied carbon, which embedded in the IMPACT specification is derived from this methodology (See Section 4.3).
- The InnovateUK funded project “Implementing Whole Life Carbon in Buildings (IWLCIB)” aims to harmonise the approach to embodied carbon calculations of whole built assets, in accordance with BS 15978 and the RICS Methodology. This methodology will be available from summer 2017.

4.3 Tools

A number of tools are commercially available to measure the embodied impact of built assets. These enable the user to enter general data about the building design which then generates LCA results. Examples of these tools include, but are not limited to the following:

IMPACT compliant tools

The IMPACT compliant tools are all based on the same methodology and data in line with BS 15978 requirements. These currently include:

- IES-ve IMPACT plug-in (BIM enabled tool)
- eTool;
- Bionova†.

The IMPACT LCA and the construction data are representative of the UK. More information on IMPACT compliant tools: <http://www.impactwba.com/>.

Tally

This whole-building assessment tool is designed to work with Revit and has been developed by Kieran Timberlake, ThinkStep and Autodesk. The tool incorporates data from the GaBi database, alongside some EPD, with data representative of the USA. More information can be found at: <http://choosetally.com/>

Infrastructure tools

The following selection of tools have been developed for infrastructure assets:

- The Rail Carbon Tool is a web-based tool that allows rail carbon footprints to be calculated, assessed, analysed and reported. Carbon reduction options are evaluated using verified carbon factor data. <https://www.railindustrycarbon.com>
- The Highways England Carbon Emissions Calculation Tool has been developed to calculate carbon emissions for operational, construction and maintenance activities. <https://www.gov.uk/government/publications/carbon-tool>.
- The Environmental Agency’s Carbon Planning Tool provides a mechanism for assessing carbon over the whole life of built assets. It enables carbon quantification but also implementation of mitigation strategies. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/571707/LIT_7067.pdf
- Transport Scotland has developed a Carbon Management System, based on a series of spreadsheets. <http://www.transport.gov.scot/environment/carbon-management-system>.

* Greater London Authority (GLA), 2013. Construction Scope 3 (Embodied): Greenhouse Gas Accounting and Reporting Guidance. Available at: https://www.london.gov.uk/sites/default/files/gla_construction_scope_3_embodied_greenhouse_gas_accounting_and_reporting_guidance_vfinal_1.pdf (See Table 72, pp.27-28)

† Undergoing testing as at February 2017.

Other tools

The following tools are available in other countries based on their respective national data sets (this is not an exhaustive list):

- Elodie (France): <http://editions.cstb.fr/Products/Elodie>
- Baubook eco2soft (Austria): <http://www.ibo.at/en/ecosoft.htm>
- Athena Impact Estimator (North America): <http://www.athenasmi.org/our-software-data/overview/>
- Rapiere (UK): <http://rapiere.net/> – beta version, not commercially available yet.

It is likely that embodied carbon assessors will have their own bespoke tools. Clients should discuss the use of these on a case by case status.

5. Whole built asset level assessment methodologies requirements for embodied carbon

Whole built asset sustainability assessment schemes are currently one of the main drivers for measuring the embodied carbon of a built asset.

The most commonly used and relevant schemes for the UK are:

- **BREEAM**: applicable to UK new (BREEAM UK NC2014) and refurbished non-domestic (BREEAM UK RFO 2015) buildings projects
- **Home Quality Mark (HQM)**: applicable to UK new domestic dwellings only
- **LEED v4**: applicable to all building types, US standards based but is used on projects in the UK
- **Ska Rating**: applicable to non-domestic fit outs, mainly offices and retail units
- **CEEQUAL version 5**: applicable to civil engineering, infrastructure, landscaping, and public realm projects.
- **BREEAM Infrastructure**: applicable to new infrastructure assets. This scheme is at pilot stage with projects able to register for assessment.

This section provides an overview of the schemes’ requirements in terms of measuring the embodied carbon impact using an LCA approach. It is worth noting that the required assessment methodologies for these various schemes are specific to each scheme. The scheme assessors should be consulted for further guidance on these aspects.

5.1 BREEAM

The following detail is based on the BREEAM UK New Construction 2014 scheme. Most BREEAM schemes for buildings use a similar approach, with the exception of BREEAM In-Use.

The most relevant issues to the embodied carbon impact of buildings are included in the Materials section:

- Mat01: Life cycle impacts;
- Mat02: Hard landscaping and boundary protection; and
- Mat04: Insulation.

Credits for all three are based on the Green Guide ratings and aim to encourage the specification of products and building elements with lower environmental impact (see Section 4.1). There are also extra points for increased use of products with EPDs.

In addition, Mat01 awards “Innovation Credits” for the use of whole building LCA software tools. Credits are awarded where the design team has:

- used an IMPACT compliant or equivalent tool to measure the environmental impact of the asset; and
- demonstrated how the use of the tool has benefited the asset in terms of measuring and reducing its environmental impact.

Further information on how to comply with the requirements of Mat01 innovation credits are provided in GN08*.

BREEAM published its strategy for the future development of its materials section and states that it will be moving towards a whole building LCA approach†.

5.2 The Home Quality Mark (HQM)

HQM is part of the BREEAM family of whole built asset sustainability assessment schemes. It is used to provide a customer focused assessment of the impacts and benefits relating to the design, construction and location of new homes in the UK. It replaces the Government’s Code for Sustainable Homes which was withdrawn for new registrations in 2015. The scheme is currently operating as a beta version and is due to be updated in late 2017.

Embodied environmental impact of homes is mainly addressed in assessment issue 19 “Environmental impact from construction products”. This follows a similar approach to that outlined for BREEAM (see above). Credits are awarded for the use of products with EPDs and for a whole building level environmental impact assessment. The assessors can either choose:

- the HQM materials reporting tool (foundation route); or
- an IMPACT compliant tool (comprehensive route).

Results (expressed in Ecopoints‡ per occupant) are then compared against the benchmark to estimate the number of eligible credits.

5.3 LEED v4

The sections most relevant to the embodied environmental impact of buildings are:

- MR Credit: Building Life-Cycle Impact Reduction; and
- MR Credit: Building Product Disclosure and Optimization—Environmental Product Declarations.

MR Credit -“Building Life-Cycle Impact Reduction encourages the reuse or renovation of existing buildings”:

LEED requires a building level LCA and demonstration of a 10% reduction (minimum) in impact, compared with a notional baseline building. The results must be presented against the following impact categories:

- global warming potential (greenhouse gases), in kg CO₂e;
- depletion of the stratospheric ozone layer, in kg CFC-11;
- acidification of land and water sources, in moles H⁺ or kg SO₂;
- eutrophication, in kg nitrogen or kg phosphate;
- formation of tropospheric ozone, in kg NO_x, kg O₃ eq, or kg ethene; and
- depletion of non-renewable energy resources, in MJ.

The 10% improvement must be demonstrated in at least three of the six impact categories listed above and one of the three must be global warming potential.

* www.breeam.org

† <http://www.breeam.com/filelibrary/Briefing%20Papers/Strategic-Approach-to-the-Selection-and-Procurement-of-Construction-Materials-and-Products.pdf>

‡ <http://www.bre.co.uk/page.jsp?id=3737>

The notional baseline and the assessed buildings must:

- Be of comparable size, function, orientation, and operating energy performance (as defined in EA Prerequisite Minimum Energy Performance).
- Use a service life of at least 60 years to fully account for maintenance and replacement.
- Be measured using the same life-cycle assessment software tools and data. Data sets must be compliant with ISO 14044.

MR Credit - Building Product Disclosure and Optimization—Environmental Product Declarations:

LEED encourages the use of products with “critically reviewed” LCA and/or EPDs. It also encourages the use of products that can demonstrate that they have less of an impact than the industry average.

5.4 Ska

The sections most relevant to the embodied environmental impact of buildings are:

- D19 “Green materials specification”
- M01 “Greener blockwork”
- M02 “Greener bricks”
- M03 “Greener screed”
- M04 “Greener insulation”
- M07 “Greener raised floors”
- M08 “Greener partitions”
- M09 “Greener glazed partitions”
- M10 “Greener ceilings”
- M11 “Greener hard floors”
- M12 “Greener carpets”
- M14 “Greener paints”
- M15 “Greener polishes & varnishes”
- M16 “Greener wallpaper”
- M17 “Greener doors”
- M18 “Greener kitchen fittings”
- M19 “Greener workstations and tables”
- M20 “Greener desk chairs”
- M22 “Greener other furniture”
- M23 “Greener blinds and curtains”

For all of these sections, Ska recommends the use of products with an EPD. Some of the sections (D19, M07, M10, M08, M12, M14, M11, M04, M09 and M17) refer to the use of the Green Guide to Specification. Embodied carbon is covered in the scope of EPDs or Green Guide Specifications but is not assessed on its own within Ska.

Ska does not require an overall embodied carbon measurement for the whole project.

5.5 CEEQUAL v5

CEEQUAL addresses LCA under section 8 – Physical Resources, Use and Management.

The sub-section 8.2 addresses Embodied Impacts at full LCA level and at an embodied carbon level. The greater the level of detail in the assessment the greater the score. The scheme rewards both LCA studies and the use of LCA for reducing the impacts of the project.

Sub-sections 8.2.1 and 8.2.2. include:

- Section 8.2.1 Life Cycle Assessment:
 - Embodied carbon footprint assessment
 - LCA, but only for key construction materials
 - Full LCA covering all life cycle stages
- Section 8.2.2 Implementing reductions identified in the LCA

It is worth noting that the LCA methodology used needs to be in line with:

- ISO 14040;
- ISO 14044;
- EN 15942; and
- EN 15804.

5.6 BREEAM Infrastructure

BREEAM Infrastructure is still at a pilot stage. Currently, LCA is addressed at both project and materials levels. Several approaches are envisaged, the most comprehensive allowing more credits to be awarded. The assessment of embodied carbon is rewarded even though a full LCA enables the assessor to achieve more credits.

6. Setting up meaningful comparisons

Meaningful comparisons of assessments are made viable by ensuring each assessment report retains the same:

- System boundaries;
- Typology and functional unit i.e. assets should be as close to like-for-like as possible e.g. comparing offices to offices and not offices to warehouses;
- All requisite scenario assumptions;
- Data sources;
- Results reported at a disaggregated level including the same measurement/functional units e.g. kgCO₂e per m².

Future proofing reporting in this manner is advisable to ensure comparability in a field that is rapidly advancing in sophistication.

If clients wish to compare two projects, it is possible, although not recommended due to costs, to retrospectively adjust a calculation to different data sources/assumptions/quantities/boundaries and make a fair comparison.

Comparisons can also be made to a baseline. Baselines could include:

- a comparative baseline from an existing asset within a client portfolio;
- comparing an embodied carbon measurement from a baseline design; or
- comparing using publicly available benchmarks, such as the Embodied Carbon Database.

Whatever baseline is chosen, to be meaningful, the comparison should be made with the criteria identified above.

7. Benchmarks

Understanding embodied carbon performance relative to others can assist in making the assessment more meaningful. Benchmarks for embodied carbon in built assets are currently scarce.

Examples of available benchmarks include:

- Embodied Carbon Database[†], the only free and publicly available benchmark;
- RICS Methodology to calculate embodied carbon from May 2014 contains benchmarks for different building types;[‡]
- Company benchmarks, which are useful as they can be tailored to a client's needs; and

In addition, academic research studies can also be used for benchmarking. However, they have not been written for a commercial audience. Such studies include

* It is worth noting that results may refer to differing area metrics e.g. Net Living Area (NLA), Net Internal Area (NIA), Gross Internal Area (GIA), Gross Floor Area (GFA).

† Embodied Carbon Database, 2014. WRAP. Available at: <http://ecdb.wrap.org.uk/>

‡ RICS, 2014. Methodology to calculate embodied carbon. Available at <http://www.rics.org/uk/knowledge/professional-guidance/guidance-notes/methodology-to-calculate-embodied-carbon-global-guidance-note-1st-edition/>

- "Material quantities and embodied carbon dioxide in structures". The research conducted embodied carbon measurement of 200 buildings in America and Europe*.
- "Life Cycle Assessment (LCA) and Life Cycle Energy Analysis (LCEA) of Buildings and the Building Sector: A Review"[†].

8. Targets

When setting any target, it is important to bear in mind the intended or desired outcome. For embodied carbon, this can be the performance improvement of a specific asset at design stage or a maximum carbon value not to be exceeded.

The three main approaches when setting targets are:

8.1 Comparative targets

Comparative targets take the form of a simple embodied carbon reduction compared to a known baseline. An example could be "ensure the building better than the Embodied Carbon Database average for commercial offices of 867 kgCO₂e/m²".

8.2 Intensity targets

Intensity targets are set using metrics based on a function of the asset's performance e.g. number of occupants which would be expressed as kgCO₂e/FTE.

8.3 Absolute reduction targets[‡]

Absolute reduction targets are usually expressed as a defined reduction of total embodied carbon. e.g. 25% reduction compared to the baseline.

Targets can be set by reviewing an existing assessment of a similar built asset to examine the most likely areas of reduction. Discussions with the carbon assessor are recommended, prior to undertaking the assessment, to establish a reduction target.

9. Major wins

Achieving embodied carbon emissions reductions has the greatest impact if done at the early stages of the construction project when the design and choices of materials can be influenced.

The two major wins for improvement are:

- Retention and re-use – by retaining and re-using elements of an asset 'new carbon' is not introduced;
- High mass elements and assemblies – elements such as the sub-structure or super-structure and assemblies such as walls are the aspects of a design that typically have the highest material volumes and masses. By targeting these high mass items significant gains can be made e.g. reviewing the proposed concrete mixes to incorporate higher levels of cement replacement or recycled aggregate.[§]

* De Wolf et al., 2016. De Wolf, C., Yang, F., Cox, D., Charlson, A., Hattan, A. S. & Ochsendorf, J., 2015. Material Quantities and Embodied Carbon Dioxide in Structures. Proceedings of the ICE - Engineering Sustainability, pp. 93–100. Available from: <http://www.icevirtuallibrary.com/content/article/10.1680/ensu.15.00033>.

† Cabeza, L. F., Rincón, L., Vilariño, V., Pérez, G. & Castell, A., 2014. Life Cycle Assessment (LCA) and Life Cycle Energy Analysis (LCEA) of Buildings and the Building Sector: A Review. Renewable and Sustainable Energy Reviews, 29, pp. 394–416. Available from: <http://linkinghub.elsevier.com/retrieve/pii/S1364032113005777>

‡ Zero Waste Scotland, 2015. Carbon Management: setting targets. Guidance for public sector organisations. Available at: <http://www.resourceefficientscotland.com/sites/default/files/Setting%20Targets.pdf>

§ A useful reference document is "Cutting Embodied Carbon in Construction Projects", WRAP 2011. See Section 10 for link.

10. Other key documents

Title	Author	Year	What does the publication do?
<i>Cutting embodied carbon in construction projects</i>	WRAP	2011	Identifies basic cost-effective actions to reduce the carbon impact of the materials used in your construction projects.
<i>A guide to understanding the embodied impacts of construction products</i>	Construction Products Association	2012	The guide explains: <ul style="list-style-type: none"> • how the environmental impacts of construction products are measured; • what processes and schemes are already established; • what information is generated; • how this is used and assessed at the building level; and • what effect european regulations and emerging european standards will have.
<i>Whole-Life Carbon Footprint Measurement and Offices</i>	British Council of Offices	2012	Provides a methodology for measuring the whole-life carbon footprint of an office.
<i>London 2012 Olympic and Paralympic Games - The legacy: Sustainable Procurement for Construction Projects</i>	Defra	2013	Outlines the key principles, as well as processes and tools used to deliver sustainable development objectives for London 2012 with a focus on construction. Sustainable procurement had an important role to play in relation to other aspects of the event, which for London 2012 were largely in the hands of LOCOG which planned, financed and staged the Games. LOCOG embedded sustainability in its approach but adopted different tools suited to the supply chains involved.
<i>Practical how-to guide: measuring embodied carbon on a project</i>	UK-GBC and BRE	2014	A light-touch guidance note on easy embodied carbon reduction strategies on a construction project.
<i>Tackling Embodied Carbon in Buildings</i>	UK-GBC and The Crown Estate	2015	Addresses the need for new drivers for action on embodied carbon from within the industry itself, specifically a clear explanation of the business case for reducing embodied carbon. It is designed for clients and developers who want to begin to consider and to reduce the embodied carbon impacts of their developments.
<i>Embodied Carbon & EPDs</i>	Jane Anderson, PE International	–	Provides an overview of the UK and EU approach to embodied carbon and provides a list of useful references.

See [7. Glossary](#) for definitions of commonly used terms and phrases.

11. Other Example client briefs



11.1 British Land, Draft Embodied Carbon Scope

Background

British Land expects for all Major developments (>£50m capex) that embodied carbon emissions be measured and reduced. The aim is to reduce the measured as-built emissions arising from product stage and construction of 'landlord' elements by 15% based upon the Stage 2 (Concept Design) Embodied Carbon Account. The structural engineer will champion the embodied carbon review.

BS EN 15978:2011 divides the product stage into three elements – Raw material supply, transportation, and manufacturing process.

This reduction must not be via over provision at concept design stage but demonstrated through clear assessment and detailing. Current benchmarks for each building type are as follows – designs should aim below or to the lower end of these ranges.

Benchmark Ranges

Compiled January 2015 by Atkins (F&G) using industry information (WRAP, RICS) and existing British Land detailed project analysis.

kg CO ₂ /m ²	Residential	Cinema/Leisure	Office	Retail
Sub-structure	120-170	100-130	190-230	230-270
Super structure	180-200	240-260	430-460	240-260
Ex. Cladding	180-200	180-200	110-150	170-190
Landlord M+E	70-90	50-70	70-90	70-90

Requirements for each RIBA stage

Stage 1 – Briefing

Include a requirement in the project brief and relevant appointment documents to undertake an analysis of embodied carbon. A suitable benchmark will be established based on building type and the best practice benchmarks, against which an analysis will be undertaken that will inform design decisions to achieve the embodied carbon reduction target.

Stage 2 – Concept to Planning

- During early Stage 2 undertake a workshop with relevant design team members such as the cost consultant, architect, structural engineer and MEP consultant to confirm roles and responsibilities, and:
 - Establish the appropriate embodied energy benchmark for the building types and based on the above British Land specific benchmarks, and as informed by current industry best practice at the time of review
 - confirm the embodied carbon reduction target
 - agree the sources of embodied data to be utilised
 - discuss opportunities to reduce embodied carbon through the proposed structure and materials selection (at this stage regardless of cost implications)
 - identify potential design challenges or site constraints
- Report on the outline proposals for the project and prepare an 'embodied carbon account' for the development using available industry estimates and initial design concepts. Include the data alongside the cost plan to provide a reasonable level of subdivision.



- Embodied carbon factors are available from existing databases including the Inventory of Carbon and Energy (ICE), obtained from manufacturers' product datasheets, or using Environmental Products Declarations (EPDs).
- At a minimum, the embodied carbon account shall provide a breakdown as follows:
 - Substructure
 - Foundations
 - Basement retaining walls
 - Ground floor construction
 - Superstructure
 - Frame
 - External walls, cladding & exterior works
 - Windows and external doors
 - Roof
 - Upper floors
 - Stairs and ramps
 - Services
- The cost consultant is to assist the architect, the structural engineer, and MEP consultant to agree the embodied carbon account for the development with the client.
- Compare this account with the British Land embodied carbon benchmark(s) that have been set for the development project and submit the embodied carbon account to the client for approval.
- Undertake a follow-up workshop and review implications of the embodied carbon information with the client and the design team and identify opportunities and set recommendations. The design team will use the information to inform structural solutions for the building. Identify specific areas of design where carbon reduction is to be targeted to achieve the minimum target and prepare a 'Carbon Mitigation Plan' that lists the opportunities to be embedded into the design as Stage 2 progresses.
- Provide embodied carbon advice and information to the other consultants for the purpose of establishing a concept design.
- By the end of Stage 2, the opportunities to achieve the embodied carbon target should be clearly understood, and any constraints explained in the Carbon Mitigation Plan.
- Align Stage 2 drawings, specifications and building models to accord with the initiatives to achieve the target.
- Prepare a list of recommendations for review in future stages of design to manage and reduce embodied carbon emissions associated with the development and incorporate into the Carbon Mitigation Plan. The Carbon Mitigation Plan should form a part of, or be summarised and appended to, the Stage 2 for client sign off.

General comments:

- The consultant will declare any data sources used.
- The methodology for calculation will be based on the RICS Methodology to Calculate Embodied Carbon (1st edition).
- Any models produced will be given to BL in a working form.
- British Land may choose to publish these results in its annual report or elsewhere.



RIBA Stage 3 – Developed Design

- The design team shall review the Carbon Mitigation Plan and confirm all Stage 2 recommendations have been considered and fully explored. Carry forward outstanding initiatives into the developed design.
- Comment on design documents prepared by the other consultants in respect of the embodied carbon implications of alternative design and construction approaches. Comment in respect of the design of each element in relation to the allowances therefore contained in the Embodied Carbon Account or any drafts there.
- Undertake a focussed workshop to review the developed design against the embodied carbon account, the reduction target, and the recommendations set out in the Carbon Mitigation Plan and identify any further opportunities to reduce embodied energy - embed these in the developed design.
- Mid to late Stage 3 the embodied carbon account shall be revised for the development based on the developed design prepared by the all consultants and in a form to be approved by the client.
- Agree this account with the client.
- Align Stage 3 drawings, specifications and building models to accord with the design initiatives to achieve the target.
- Opportunities identified at Stage 2 that have not been possible to embed into the developed design should be clearly explained in the Stage 3 report. The Carbon Mitigation Plan should form a part of, or be summarised and appended to, the Stage 3 for client sign off.

RIBA Stage 4 – Technical Design

- Monitor technical design to ensure it accords with the initiatives in the developed design and the opportunities set out in the Carbon Mitigation Plan required to achieve the embodied carbon target.
- The cost consultants and structural engineer shall prepare a list of 'checks' for review during Stage 5, to facilitate the achievement of the carbon reduction target. These will be listed in the Carbon Mitigation Plan, which will be appended to the tender documentation.
- If necessary, prepare a report on information to be requested and procedures to be adopted regarding embodied carbon in inviting tenders for the construction of the development and the contract conditions to be used.
- Input into the tender documentation to ensure all design initiatives required to meet the embodied carbon reduction target are part of the employer's requirements, and have been allowed for within the contractor's proposals.

RIBA Stage 5 – Construction

- The checklist from the Carbon Mitigation Plan will be reviewed by the project team (cost consultant, architect and structural engineer) and the contractors to facilitate the achievement of the parameters established in the approved Embodied Carbon Account from Stage 3.
- The Main Contractor shall revise the embodied carbon account for the development based on the 'as built' materials procured, using where available, manufacturers product datasheets or Environmental Products Declarations (EPDs) (where these are not available use the averages from the database(s)).

11.2 Derwent London, Embodied Carbon Brief

DERWENT LONDON

Available from: https://www.derwentlondon.com/uploads/downloads/Derwent_London_Embodied_Carbon_Assessment.pdf

CONTEXT

As part of our ongoing sustainability programme we are continuing to map and understand our carbon footprint in greater detail. As part of this process we are looking to explore further our Scope 3 emissions by mapping and investigating the embodied carbon footprints of our new developments and major refurbishments, to help us understand its significance and where there are opportunities to reduce our footprint.

From the initial studies undertaken it has been demonstrated that our preferred approach to development i.e. re-energising older buildings to add value and unlock potential, achieves lower embodied carbon profiles when compared to more standard/generic approaches. However, it is important for us to understand exactly where the true reduction opportunities lie and how we can take advantage of them.

To enable us to measure embodied carbon across our project portfolio effectively and consistently we have developed this brief which is designed to guide carbon consultants as to the extent of the assessment and outputs required.

SUMMARY

This brief sets out the base requirements and outputs for an embodied carbon assessment instructed by Derwent London. It is envisaged that any assessment commissioned will be done so at the earliest opportunity, with a target start point of RIBA stage C (Stage 2 in the new plan of work) to capture the design concept, moreover to run through to Stage D (Stage 3) to capture the design development stage. Where required it may be that this assessment window will be extended beyond these stages to capture other aspects, but this will be dealt with on an individual basis.

During the delivery phase of the project the main contractor will be required separately to map the footprint during construction to allow for comparison at project completion.

It is recognised that each consultant practice will have their own format/house style for presenting the results for their assessments; this brief is not intended to direct this, rather set out some of the basic parameters Derwent London requires.

REQUIREMENTS

Framework

- Up until very recently there have no specific 'made-for-purpose' embodied carbon assessment frameworks focused specifically on buildings, however this has changed with the introduction of BS EN 15978:2011, which is becoming the 'pillar' standard in terms of life cycle assessment in buildings.
- It is necessary that all assessments undertaken must have their methods aligned to/conform with BS EN 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method.
- With regards to datasets it is recognised that there are no formally endorsed databases/sets referenced by the above standard or others, outwith Environmental Product Declarations (EPDs), however it is recognised that there a number of well-used industry benchmarks and sources, which include:
 - The Bath ICE Database;
 - Proprietary databases and software packages such as SimaPro; and
 - Environmental Product Declarations (EPDs)
- In addition to these it is understood that many practices will have data obtained from other sources such as first principle studies based on research undertaken elsewhere. As a result it is to be made clear in the method description all the data sources used to complete the assessment – both primary and secondary – and their provenance and treatment i.e. how they have been used and the standards they conform to e.g. PAS 2050 or ISO 14040. Moreover, how issues such as recycled material allocation, timber sequestration, cut-offs and end-of-life have been dealt with.

Assessment boundaries & metrics

- The boundary condition to be used is: [Cradle-to-Completed Construction](#).
- The primary reporting unit is to be: tCO_2e
- As a minimum the assessment is to present the following headline metrics:
 - Total tCO_2e i.e. the total embodied carbon footprint;
 - Total tCO_2e per m^2 (based on Gross Internal floor Area [GIA]);
 - Total tCO_2e per carbon source, split by: materials, transport, site activities/impacts; and waste – also to be expressed as a percentage of the total footprint

- It is recognised that there may be multiple buildings or use types under investigation in an assessment. Where this is the case the above metrics are to be presented for each distinct building/use type.

Results presentation & benchmark comparison

- The assessment as a minimum should present the outcomes from the assessment graphically in the following ways:
 - Total tCO₂e per building element i.e. superstructure, substructure etc and each expressed as a percentage of the total footprint; and
 - Total tCO₂e per major building component i.e. walls, floors etc and each expressed as a percentage of the total footprint
- Commentary should also be provided explaining the results, significant findings, relationships etc.
- The assessment should also provide a benchmark comparison building/s in order to compare the results effectively. Any benchmarks used should be as directly comparable as possible, however it is recognised that this may not always be possible. Therefore, it is acceptable to use a generic benchmark, however full explanation is to be given as to the make-up of the benchmark and its limitations.

Conclusions & reduction opportunities

- Within the conclusion section, the top five reduction opportunities are to be presented together with their reduction potential against the total footprint. These opportunities should be practicable and realistic and in line with the project objectives.
- Where opportunities identified have operational energy implications or require additional analysis using operational energy data to qualify them, these are to be brought to the attention of the Derwent London Development Manager and Head of Sustainability such that an appropriate decision can be made, as to whether these are to be pursued.

WRAP embodied carbon database

- The results from the assessment are to be incorporated into the WRAP Embodied Carbon database of buildings using the prerequisite template which can be found at: <http://www.wrap.org.uk/content/embodied-carbon-database>

11.3 HS2, EIA Scope and Methodology



HS2's publicly available Environmental Impact Assessment for Phase 2A of the works.

Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/506111/HS2_Phase_2a_EIA_Scope_and_Methodology_Report_Final_for_Comms_08-03-2016_WEB_1400.pdf

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