



RICS professional standards and guidance, UK

Whole life carbon assessment for the built environment

1st edition, November, 2017



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RICS professional standards and guidance

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Document status defined

RICS produces a range of professional standards, guidance and information documents. These have been defined in the table below. This document is a professional statement.

Publications status

Type of document	Definition	Status
Standard		
International standard	An international high-level principle-based standard developed in collaboration with other relevant bodies.	Mandatory.
Professional statement		
RICS professional statement (PS)	A document that provides members with mandatory requirements or a rule that a member or firm is expected to adhere to. This term also encompasses practice statements, Red Book professional standards, global valuation practice statements, regulatory rules, RICS Rules of Conduct and government codes of practice.	Mandatory.
Guidance and information		
RICS code of practice	Document approved by RICS, and endorsed by another professional body/stakeholder, that provides users with recommendations for accepted good practice as followed by conscientious practitioners.	Mandatory or recommended good practice [will be confirmed in the document itself]. Usual principles apply in cases of negligence if best practice is not followed.
RICS guidance note (GN)	Document that provides users with recommendations or approach for accepted good practice as followed by competent and conscientious practitioners.	Recommended best practice. Usual principles apply in cases of negligence if best practice is not followed.
RICS information paper (IP)	Practice-based information that provides users with the latest technical information, knowledge or common findings from regulatory reviews.	Information and/or recommended best practice. Usual principles apply in cases of negligence if technical information is known in the market.
RICS insight	Issues-based input that provides users with the latest information. This term encompasses thought leadership papers, market updates, topical items of interest, white papers, futures, reports and news alerts.	Information only.
RICS economic / market report	A document usually based on a survey of members, or a document highlighting economic trends.	Information only.
RICS consumer guides	A document designed solely for use by consumers, providing some limited technical advice.	Information only.
Research	An independent peer-reviewed arm's-length research document designed to inform members, market professionals, end users and other stakeholders.	Information only.

1 Introduction

1.1 Background

Climate change is one of the greatest environmental challenges of our time. Global warming due to anthropogenic or 'human-generated' greenhouse gas (GHG) emissions to the atmosphere, referred to as carbon emissions (see 2.1), may have severe adverse environmental, social and financial effects around the world if temperature levels continue to rise. International treaties and initiatives, the most important being the Paris Agreement (COP21) adopted in December 2015, aim to restrict the impact of global warming by mitigating carbon emissions. Reducing carbon emissions also contributes to limiting resource depletion and reducing pollution.

Sizeable carbon emissions arising from the built environment are attributable not only to the use of built assets – operational emissions (Scopes 1 and 2) – but also to their construction – embodied emissions (Scope 3), see *Appendix 2: Glossary*. Operational emissions result from energy consumption in the day-to-day running of a property, while embodied emissions arise from producing, procuring and installing the materials and components that make up a structure. These also include the lifetime emissions from maintenance, repair, replacement and ultimately demolition and disposal. More detail on the terminology with respect to embodied, operational and whole life carbon is given in 3.2.4.

The built environment industry has so far been addressing mainly operational emissions via reduction targets in building regulations (Part L), planning requirements by local authorities and sustainability assessment rating schemes

(BREEAM, LEED, etc.) with the embodied aspect of carbon emissions not being fully addressed. To acquire an overall understanding of a built project's total carbon impact, it is necessary to assess both the anticipated operational and embodied emissions over the whole life of the asset. Considering operational as well as embodied carbon emissions together over a project's expected life cycle constitutes the whole life approach.

A whole life carbon approach identifies the overall best combined opportunities for reducing lifetime emissions, and also helps to avoid any unintended consequences of focusing on operational emissions alone. For example, the embodied carbon burden of installing triple glazing rather than double can be greater than the operational benefit resulting from the additional pane. Therefore, whole life carbon needs to be effectively integrated into the sustainability agenda in order to achieve a lower carbon future.

Figure 1 illustrates typical breakdowns of whole life carbon emissions for different building types, highlighting the relative weight of operational and embodied carbon. The whole life figures illustrated have been calculated in line with the modular structure of EN 15978 and account for all components making up the finished building covering a cradle to grave scope (modules [A–C]) over a 60-year life cycle. Embodied and operational emissions were estimated at the design stage. Grid decarbonisation has been applied to emissions due to electricity consumption over the life of the building, embodied and operational. Decarbonisation scenario used: slow progression from the National Grid *Future Energy Scenarios 2015*.

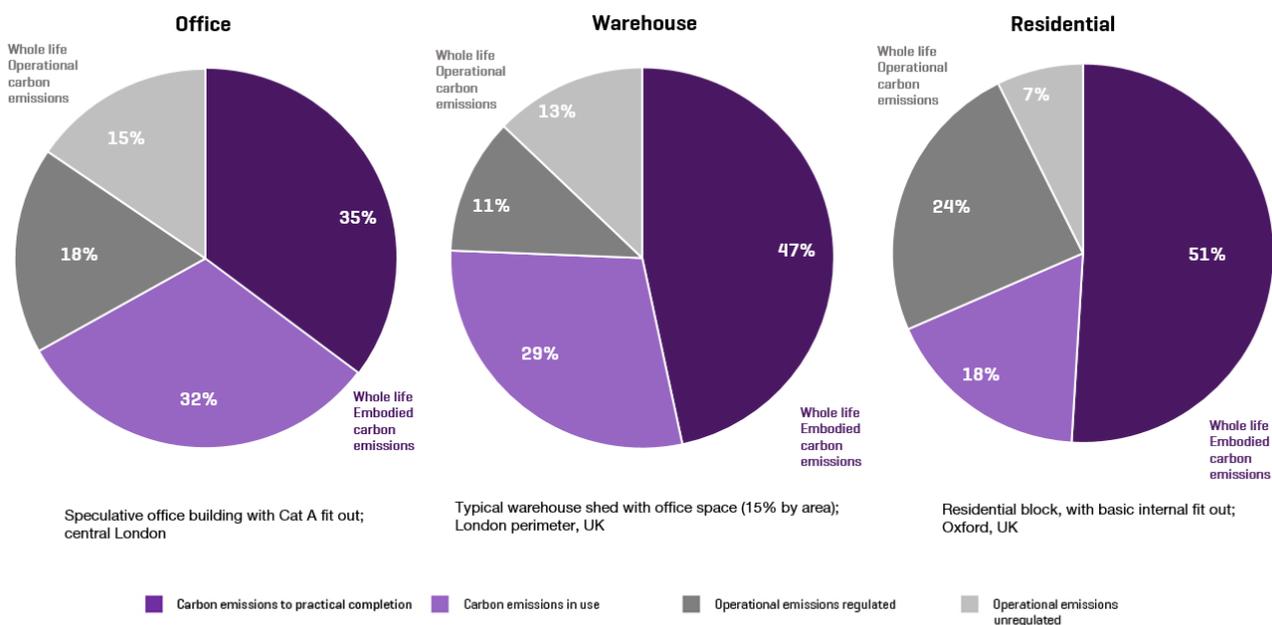


Figure 1: Total whole life carbon emissions breakdown for different building types © Sturgis Carbon Profiling

The framework for appraising the environmental impacts of the built environment is provided by EN 15978: 2011. It is part of the EN 15643 family of standards for the sustainability assessment of buildings. It sets out the principles for whole life assessment of the environmental impacts from built projects based on life cycle assessment (LCA).

In practical terms, aspects of the EN 15978 methodology have been subject to varying interpretations by practitioners and clients: different scopes commissioned according to different client requirements, varying assumptions made and poor-quality data selectively and/or inappropriately used. It has therefore become apparent that a harmonised approach to the practical application of the standard has been lacking.

This has led to the erratic implementation of EN 15978 and subsequently to significant discrepancies in the results of assessments. It has also led to substantial disparities in carbon figures among similar projects. Such variations have undermined the reliability of carbon measurement, discouraging stakeholders from confidently adopting whole life carbon thinking in their projects. More clarity and consistency around the implementation of whole life carbon assessment is therefore needed to boost credibility and uptake across the built environment.

Relevant work in this area has been undertaken (International Energy Agency (2016), Energy-Efficient Building European Initiative (2012), BCO (2012), etc.), including the RICS guidance note *Methodology to calculate embodied carbon* (2014). The latter provided high-level guidance on whole life carbon measurement consistent with the EN 15978 methodology. This professional statement addresses the need for technical details of the numerous aspects influencing whole life carbon calculations for built projects. It expands on and supersedes the prior RICS publication, with emphasis on the practical implementation of the EN 15978 principles. It also sets out more detailed calculation and reporting requirements.

1.2 Development process

In response to the challenge of the inconsistent application of EN 15978 principles described, a working group was assembled to address this issue and provide mandatory principles and practical guidance for whole life carbon assessment to be adopted across the industry.

This RICS professional statement is the result of a 16-month Innovate UK co-funded project. This was led and project managed by Sturgis Carbon Profiling, with a working group comprising Arup, Atkins Faithful + Gould,

Sustainable Business Partnership, Land Securities, Laing O'Rourke, Cambridge University, and RICS. The project was supported by the UKGBC, Argent, Grosvenor, Legal & General, M&S, Derwent London, HS2 and Higgins. The process to develop this professional statement consisted of the following:

- **Preparation and background knowledge:** relevant academic and industry literature including standards have been carefully reviewed to establish a solid rationale – see *Appendix 3: References*.
- **Analysis of case study assessments:** five diverse built assets were selected (residential, office, retail, retrofit and infrastructure) in order to be representative of most project types. Each of these case studies has been separately assessed by different consultants (SCP, SBP, F+G). The results were made available to Cambridge University on a confidential basis to perform an impartial comparative analysis of the assessments submitted.
- **Review of findings:** Cambridge University processed the results, identifying discrepancies in the interpretation and implementation of the standard. The core project team met over a six-month period to review the inconsistencies identified and come to collectively agreed positions.
- **Consolidation of outputs and compiling of guidelines:** the draft guidelines have undergone peer review by a specialist panel and the feedback examined and incorporated into the document as appropriate. The technical authors further consulted with LCA and construction experts and also collected, reviewed and cross-referenced where possible empirical carbon data to substantiate any assertions.

1.3 Objectives

The fundamental objective of whole life carbon measurement is the mitigation of carbon impact in the built environment. Better understanding and consistent measurement of the whole life carbon emissions of built projects will in turn enable comparability of results, benchmarking and target setting to achieve carbon reductions.

This professional statement is intended to standardise whole life carbon assessment and enhance consistency in outputs by providing specific practical guidance for the interpretation and implementation of the methodology in EN 15978 in carbon calculations – see section 2 for more detail. This is to achieve coherent and comparable results that can be used to benchmark the whole life carbon performance of built assets.

The specific objectives of this professional statement are to:

- provide a consistent and transparent whole life carbon assessment implementation plan and reporting structure for built projects in line with EN 15978
- enable coherence in the outputs of whole life carbon assessments to improve the comparability and usability of results
- make whole life carbon assessments more 'mainstream' by enhancing their accessibility and therefore encourage greater engagement and uptake by the built environment sector
- increase the reliability of whole life carbon assessment by providing a solid source of reference for the industry
- promote long-term thinking past project practical completion, concerning the maintenance, durability and adaptability of building components and the project as a whole; and
- promote circular economic principles by encouraging future repurposing of building components, as well as of the project as a whole, through quantifying their recovery, reuse and/or recycling potential.

1.4 Further impact

Under the overarching objective of facilitating a lower carbon and more resource-efficient model for the built environment, this professional statement is expected to have a number of knock-on effects encouraging actions in this area.

Benchmarking: conducting whole life carbon assessments in accordance with this professional statement will put all studies on the same basis and provide consistency among results enabling meaningful comparisons at different levels: per building element category, per life cycle stage as well as for entire projects throughout their life. Collection of carbon outputs

in a structured fashion to populate a database will subsequently facilitate sensible benchmarking that will set the bar for carbon performance in the built environment industry. RICS will be providing an online data gathering platform for the results of the assessments to be entered in.

There are two aspects to benchmarking; comparing a project against itself over time – 'dynamic' – and comparing a project against other similar projects – 'static':

- **'Dynamic' benchmarking** is where a whole life carbon assessment for the project is carried out at an early design stage thus providing a baseline to compare the results of later assessment iterations, so as to monitor the carbon progress of the project.
- **'Static' benchmarking** is the collection and analysis of whole life carbon results from the 'as built' stage. This will enable realistic benchmarking based on the actual carbon footprint of construction projects.

Carbon target setting: once credible benchmarking is in place, relevant targets, 'static' and/or 'dynamic' can be set for the whole life carbon performance of built assets. Clear and quantifiable whole life carbon targets will aid the pursuit of emissions reductions. The incorporation of such targets into sustainable development policies for the built environment, planning requirements, building rating schemes like BREEAM, etc., contractual obligations and legislation/building regulations, constitutes a future aspiration to steer the industry.

Longer-term thinking: early consideration of likely future climate change impacts and the development of appropriate adaptation strategies will promote the resilience of built assets.

The advancements in the quality, scrutiny and availability of carbon data as well as their integration with BIM should further improve the accessibility, accuracy and ease of conducting whole life carbon assessments.

1.5 Standards referred to in this professional statement

Table 1 provides an overview of the key standards referred to this publication, giving their titles in full and regional jurisdiction.

Standard	Full title	Regional jurisdiction
EN 15978: 2011	Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method	European standard
EN 15804: 2012 + A1: 2013	Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products	European standard
PAS 2050: 2011	Specification for the assessment of the life cycle greenhouse gas emissions of goods and services	UK document
PAS 2080: 2016	Carbon management in infrastructure	UK document
ISO 21930: 2017	Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services	International standard
ISO/TS 14067: 2013	Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification	International standard
ISO 14025: 2006	Environmental labels and declarations – Type III environmental declarations – Principles and procedures	International standard
ISO 14040: 2006	Environmental management – Life cycle assessment – Principles and framework	International standard
ISO 14044: 2006	Environmental management – Life cycle assessment – Requirements and guidelines	International standard
EN 16449: 2014	Wood and wood-based products. Calculation of the biogenic carbon content of wood and conversion to carbon dioxide	European standard
EN 16485: 2014	Round and sawn timber. Environmental Product Declarations. Product category rules for wood and wood-based products for use in construction	European standard
EN 16757: 2017	Sustainability of construction works. Environmental product declarations. Product Category Rules for concrete and concrete elements	European standard

Table 1: Key European and international standards referred to in this professional statement

2 Scope

This professional statement provides requirements and supporting guidance for conducting whole life carbon assessments for construction projects in line with EN 15978. It also focuses on the interpretation and practical implementation of the EN 15978 methodology. This publication should be read in conjunction with EN 15978 and EN 15804 (see Table 1).

This professional statement can be applied to all types of built assets, including buildings and infrastructure. It is suitable for the assessment of both new and existing assets as well as refurbishment, retrofit and fit-out projects. More detailed guidance on carbon management for infrastructure specifically is given in PAS 2080: 2016.

The metric for assessing the climate change impacts of greenhouse gas (GHG) emissions is Global Warming Potential (GWP). This is expressed in units of CO₂ equivalent (CO₂e) over 100 years, commonly referred to as 'carbon emissions'. This publication explicitly addresses GWP only, as it is central to gauging a project's contribution to climate change. However, the calculation principles set out in this professional statement can be expanded to cover further environmental impact indicators as specified in EN 15978.

This professional statement provides mandatory requirements and guidance on assessing the carbon emissions arising from built projects throughout their life. It addresses all components making up a built asset over all life stages – from extracting raw materials and manufacturing constituent building products through operation and disposal, and any future potential beyond End of Life (EoL). All aspects of whole life carbon assessment covered are explained and put in context, including the timing and frequency at which whole life carbon assessments should be undertaken. The publication also provides practical guidance for organising the assessment results.

Three core principles form the rationale of this publication, in line with its objectives:

1. Consistent whole life carbon measurement

Whole life carbon assessments need to be reliable and comparable. Therefore, consistency in methodology and the assumptions and data used is required. This professional statement emphasises the practical implementation of the existing and widely accepted environmental performance assessment methodology of EN 15978. This is to facilitate coherence in the calculations even at early design stages where detailed project-specific information might not yet be available.

2. Comprehensive modular structure

The requirements and guidance cover all components of a built project over its entire life cycle. These features are addressed in a modular fashion, in line with EN 15978. The

building parts to be considered are organised in categories and the project life cycle broken down into different life stages. This is to address all aspects influencing whole life carbon in a structured way and enable flexibility in the scope without compromising consistency.

3. Integration of whole life carbon assessment into the design process

For whole life principles to be integrated into the design, procurement and construction processes and beyond, and for project teams to be engaged in a timely fashion, carbon assessments should be carried out at key project stages from concept design to practical completion. Appropriate timing and sequencing of carbon assessments will help identify carbon reduction opportunities and monitor a project's progress in achieving them.

The requirements and guidance provided can be incorporated into carbon measurement software tools and BIM, constituting the wireframe for carbon calculation algorithms.

This professional statement is intended primarily for a UK audience: sustainability consultants, building designers, contractors as well as policy makers, regulators and client bodies, as the numeric assumptions provided throughout are based on UK locations and standard practices. Appropriate geographic adjustments highlighted in the professional statement will enable the requirements and guidance to be applied in other countries remaining aligned with the international methodology of EN 15978

3 Requirements and guidance for conducting whole life carbon assessments

This section outlines mandatory requirements and relevant supporting guidance for carrying out whole life carbon assessments. Requirements, i.e. the mandatory principles that must be followed by practitioners, are given in bold type. Where relevant, the specific sub-section of EN 15978 and/or EN 15804 being referred to is provided at the outset.

3.1 General guidance

Whole life carbon assessments should be undertaken in a sequential fashion during the design, procurement, construction and post-completion stages, starting as early as at concept design stage (RIBA Stage 2 or equivalent). Early stage assessments are recommended to establish a baseline carbon estimate for the project, to integrate whole life carbon into the design process and to identify carbon reduction potential while there is significant capacity to influence decisions. This is to enable project teams to fully engage and understand the impacts of whole life carbon assessments on the project as a whole. Further assessments at later project stages are advisable for monitoring the carbon budget progress as the project develops and providing the actual carbon footprint at practical completion.

As a minimum, a whole life carbon assessment must be carried out before the commencement of the technical design (RIBA Stage 4 or equivalent) of the project.

At least one other whole life carbon assessment should be conducted for each project after practical completion to represent the 'as built' carbon position. Interim assessments and carbon impact studies should be carried out as appropriate, according to the nature of each project. Whole life carbon savings for a project can only be quantified and claimed when whole life carbon assessments have been carried out at a minimum of two different points in time, in a similar fashion to estimating operational carbon emissions savings between different stages, e.g. DER vs. TER in SAP (see *Appendix 2: Glossary*).

To provide a holistic view of the GWP, whole life carbon assessments should, where possible, account for all components relating to the project during all life stages.

The minimum scope that must be covered is as follows:

Minimum requirements for whole life carbon assessment	
Building parts to be included – see 3.2.2	1. Substructure 2. Superstructure
Life stages to be included – see 3.2.4	Product stage [A1–A3] Construction process stage [A4–A5] Replacement stage [B4] for facade Operational energy use [B6]
Assessment timing	At design stage – prior to technical design

Table 2: Minimum requirements for whole life carbon assessment

Different levels of detail in the design and specification of the built asset are available at different project stages. The data sources and approaches suggested throughout this publication are prioritised to achieve the highest quality and accuracy possible. However, the stated order of preference is subject to applicability and availability given the project stage at which the assessment is conducted.

Details on what results should be disclosed and guidance on how to structure and present them can be found in 3.6.

3.2 Determining the object of the whole life carbon assessment

The following sub-sections provide guidance on defining what needs to be taken into account for the complete whole life carbon assessment of a built project. A number of mandatory requirements are set out to enable consistency. Any selective scope and boundaries, beyond the mandatory stipulations, should be aligned with the assessment objectives and should be clearly identified and justified. Specific reporting requirements are set out – see 3.6 – to aid transparency and comparability of the results from different assessments and also ensure the functional equivalence between compared projects.

3.2.1 Spatial boundaries

Determining what should be included in a whole life carbon assessment is necessary for consistency purposes. This section explains the requirements concerning the components that need to be accounted for, clarifying and expanding on the detail of EN 15978; section 7.1.

A whole life carbon assessment should consider all building components and works relating to the project, including any external works within the site boundary (see 3.2.2). The site boundary needs to be in line with the definition and intended use of the built asset, including all contiguous land that is associated with the project and that supports its operations. A town planning red line can serve as the site boundary where available. When shared or communal spaces are involved, these should be allocated as appropriate based on reasonable proportions deriving from respective floor areas of the adjoining properties, number of occupants or other metrics of capacity for each built asset, taking into account their respective types of use.

3.2.2 Building physical characteristics

This section outlines the building parts, elements and components to be included in a whole life carbon assessment. It relates to EN 15978; 7.5.

A complete whole life carbon assessment should cover all items listed in the project's Bill of Materials (BoM), cost plan or as identified in other design information (drawings, specifications, etc.) that fall under the building element categories specified in Table 3.

Table 3 outlines the building parts, based on the BCIS breakdown, that should be covered in the whole life assessment, as applicable to each project. The proposed building component scope is covering and expanding on the relevant scopes specified in *BREEAM Assessor guidance note GN08* and in the *Evaluation of embodied energy and CO₂e for building construction (Annex 57)*.

New build projects assessed are considered to commence their development on a cleared, flat site for consistency purposes. Demolition works are often decoupled from new construction projects, hence the responsibility for any emissions arising from demolition is not necessarily solely attributable to the new build project. Therefore, all carbon emissions associated with works as listed under 'Demolition' in Table 3, should be reported separately and not aggregated with the rest of the project emissions. However, due to potential opportunities for recovery, reuse and recycling, and for improving the deconstruction and demolition process, pre-demolition assessments should be carried out where possible.

For retrofit projects, the equivalent state to that of 'a cleared flat site' as described for new build, is represented by any retained elements. Any removal and/or stripping out of building elements to get the structure to the 'cleared flat site' equivalent state should be treated as demolition works and reported separately.

	Building part/Element group	Building element
	Demolition	0.1 Toxic/Hazardous/Contaminated Material treatment
		0.2 Major Demolition Works
0	Facilitating works	0.3 & 0.5 Temporary/Enabling Works
		0.4 Specialist groundworks
1	Substructure	1.1 Substructure
2	Superstructure	2.1 Frame
		2.2 Upper floors incl. balconies
		2.3 Roof
		2.4 Stairs and ramps
2	Superstructure	2.5 External Walls
		2.6 Windows and External Doors
2	Superstructure	2.7 Internal Walls and Partitions
		2.8 Internal Doors
3	Finishes	3.1 Wall finishes
		3.2 Floor finishes
		3.3 Ceiling finishes
4	Fittings, furnishings and equipment (FF&E)	4.1 Fittings, Furnishings & Equipment incl. Building-related* and Non-building-related**
5	Building services/MEP	5.1–5.14 Services incl. Building-related* and Non-building-related**
6	Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units
7	Work to Existing Building	7.1 Minor Demolition and Alteration Works
8	External works	8.1 Site preparation works
		8.2 Roads, Paths, Pavings and Surfacing
		8.3 Soft landscaping, Planting and Irrigation Systems
		8.4 Fencing, Railings and Walls
		8.5 External fixtures
		8.6 External drainage
		8.7 External Services
		8.8 Minor Building Works and Ancillary Buildings

Table 3: Building element groups to be considered (based on the BCIS SFCA)

* Building-related items: Building-integrated technical systems and furniture, fittings and fixtures built into the fabric. Building-related MEP and FF&E typically include the items classified under Shell and core and Category A fit-out.

** Non-building-related items: Loose furniture, fittings and other technical equipment like desks, chairs, computers, refrigerators, etc. Such items are usually part of Category B fit-out.

The building element groups listed in Table 3 are based on the BCIS *Elemental standard form of cost analysis*, 4th edition to facilitate consistency and interoperability between BoQs/cost plans and carbon assessments. The category reporting breakdown is adjusted to specifically suit the purposes of whole life carbon assessment by identifying building elements that are likely to have high relative importance in carbon terms. Therefore, certain items are distinguished from the broader BCIS element groups and should be reported separately, e.g. superstructure is divided into three subcategories. Building services are broken down into two subcategories to account for building-related and non-building-related items respectively, as per EN 15978 guidance.

Reasonable assumptions should be made for any provisional sums allowances in the cost plan in consultation with the cost consultant and design team.

A minimum of 95 per cent (EN 15804; 6.3.5, p.25) of the cost allocated to each building element category (0–7 of Table 3) should be accounted for in the assessment. Items excluded should each account for less than 1 per cent of the total category cost. In case the coverage is lower than recommended, this should be clearly indicated and the actual percentage of coverage stated alongside the carbon calculation results. Cost has been selected over physical characteristics, such as mass, to determine the coverage cut-off point as it is more practical than determining the exact quantities of all items to be included, especially at early design stages.

The subtotal carbon budget of each category should be multiplied by the following adjustment factor to account for the impacts of the items not quantified:

Coverage adjustment factor = (100% / % of cost covered in the given category)

If cost data is unavailable, the same principles apply to the mass or area of elements as appropriate.

3.2.3 Reference study period

This section determines the reference study periods (RSP) to be used for whole life carbon assessments, based on the principles outlined in EN 15978; 7.3.

The RSPs that must be used for the purposes of whole life carbon assessment are defined as follows for the different types of uses of built assets:

- **domestic projects: 60 years** (BREEAM 2014 New Construction – Mat 01 Life cycle impacts; LEED v.4)
- **non-domestic projects: 60 years** (BREEAM 2014 New Construction – Mat 01 Life cycle impacts; LEED v.4)
- **infrastructure: 120 years** (according to case studies in PAS 2080).

The proposed RSPs are fixed to enable comparability between the whole life carbon results for different projects. They are intended to:

- be broadly representative of typical required service lives of the different building types
- allow for a sufficient period of time for the property to undergo wear and tear and specifically the replacement cycles of major building components and systems; and
- stretch across a time period in the future that is reasonably predictable.

When the RSP is longer than the required service life (design life) of a project specified in the brief, reasonable project-specific scenarios should be developed to cover the period until the end of the RSP specified.

When the RSP is shorter than the required service life, the project should be assessed for the duration of the RSP on a cradle-to-grave basis – modules [A–C] (see 3.5.4) – allowing for a sensible EoL scenario (see 3.5.4), even though the project is expected to have further service life beyond the RSP.

In addition to the mandatory RSPs specified, whole life carbon emissions can also be reported against the required service life as determined in the project brief or any other relevant time period of interest to the body commissioning the assessment.

3.2.4 Life cycle stages – overview

Whole life thinking involves considering all life cycle stages of a project, from raw material extraction, product manufacturing, transport and installation on site through to the operation, maintenance and eventual material disposal. This section refers to EN 15978; 7.4. It also considers the future potential for recovery, reuse and/or recycling. EN 15978 introduces a modular approach to a built asset’s life cycle, breaking it down into different stages, as shown in Figure 2.

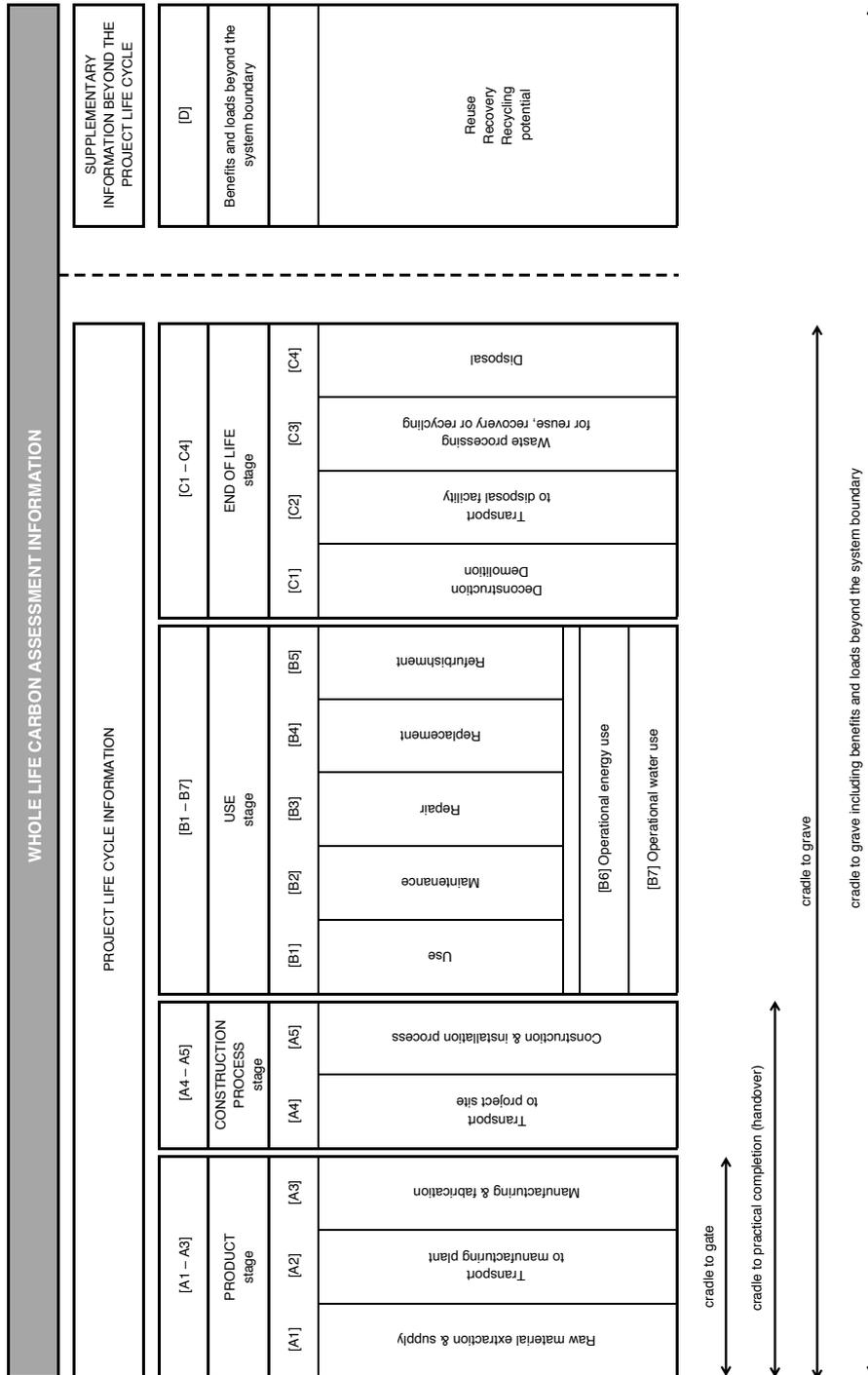


Figure 2: Modular information for the assessment as per EN 15978 including typical system boundaries © BSI

Term	Definition
Embodied carbon to practical completion [PC-CO ₂ e]	Comprises stages [A1-A5]
Embodied carbon over the life cycle [LC-CO ₂ e]	Comprises stages [A1-A5], [B1-B5] & [C1-C4]
Whole life carbon [WL-CO ₂ e]	Comprises stages [A], [B] & [C], [D] to be reported separately

Table 4: Basic terminology for embodied and whole life carbon

The life cycle stage modules enable transparency and flexibility in the assessment. They also provide a standardised structure for comprehensive and coherent reporting, with clusters that can be looked at individually as well as in conjunction with one another.

A complete whole life carbon assessment should account for all emissions arising over the entire life of a built asset. It should also account for any future reusability and/or recyclability of its different constituent elements – modules [A] to [D]; cradle to grave including impacts beyond the system boundary – as applicable to each project.

The boundaries of the whole life carbon assessment and the life cycle stage modules covered must be explicitly stated and justified in the report.

Clear boundaries are critical for transparency and subsequent consistency and credibility of carbon results. Assessments covering the cradle to grave scope [A] to [C] are encouraged. Nevertheless, where more restricted scopes are instructed to fit the needs of specific projects, these must be identified and the life cycle stages included in the assessment clearly declared.

Module [D] must be communicated separately and not aggregated with the cradle-to-grave [A] to [C] carbon figures.

This is primarily due to its inherent future uncertainty. More details on the requirements and structure for reporting the carbon results can be found in section 3.6 *Reporting requirements*.

For new builds, all life cycle stages as described above are applicable. For existing buildings that are to undergo refurbishment works, all life cycle stages are applicable for any new elements installed to the building. For existing items being retained, only emissions associated with use [B], [C] and beyond [D] should be considered over the life

cycle. The emissions from the product and construction stages [A] sit with the existing building and therefore lie outside of the scope of the project under study.

3.2.5 Floor area measurement

This section specifies how the floor areas of the built assets being assessed need to be determined.

Floor areas from the following sources must be used and clearly stated in the whole life carbon assessment in the following order of preference and subject to availability at the different project stages: 1. BIM model, 2. Bill of quantities (BoQ) or cost plan, 3. Consultants' drawings.

Floor area measurements used in whole life carbon assessments should be in accordance with the *RICS property measurement*, 1st edition (2015) professional statement which incorporates the International Property Measurement Standards (IPMS). The unit of measurement for floor area should be Gross Internal Area (GIA) to better represent the entirety of the built asset.

3.2.6 Quantities measurement

This section refers to EN 15978; 9.1–9.3. It specifies how the quantities of the materials and/or products that make up the building components to be included in the whole life carbon assessment need to be determined.

Material quantities from the following sources must be used and clearly stated in the whole life carbon assessment, in the following order of preference and subject to availability at the different project stages: 1. Materials delivery records, 2. BIM model, 3. Bill of quantities (BoQ) or cost plan, 4. Estimations from consultants' drawings.

In the case of existing buildings, actual quantities should be obtained from 'as built' drawings and contractor records, where possible. If this is not possible, site surveys might be required.

The assessment should account for gross material quantities allowing for any losses during transportation and on-site construction processes as appropriate in modules [A4–A5] – see section 3.5 *Life cycle stages*.

RICS property measurement and the BCIS elemental standard form of cost analysis should be followed. In case of uncertainty regarding the quantities in the cost plan or BoQ, the cost consultant should be contacted by the assessor to provide relevant clarifications and/or reasonable assumptions in line with the cost model. Any assumptions made should be explicitly stated in the whole life carbon assessment report.

3.2.7 Units of measurement

The whole life carbon assessment results must be reported using the following units: kgCO₂e/m² NIA, or any clearly stated metric multiples thereof as appropriate, e.g. tCO₂e.

The total carbon results also need to be normalised as follows for the different project types:

- Buildings; planning use classes A1–A5, B1, C1–C4, D1–D2: kgCO₂e/m² NIA.
- Buildings; planning use classes B2–B8: kgCO₂e/m³ of internal building volume.
- Infrastructure; bridges, roads, railway lines, power lines, water and fuel pipelines: kgCO₂e/km.
- Infrastructure; waste and water treatment: kgCO₂e/m³ of water or waste treated.
- Infrastructure; power stations incl. dams, oil rigs, wind turbines: kgCO₂e/kWh produced.
- Infrastructure; transport hubs: kgCO₂e/passenger and kgCO₂e/m² NIA.
- Infrastructure; telecommunication: kgCO₂e/Mbps.

The use type of the built asset should mandate appropriate additional normalisation units to ensure fair and meaningful comparisons with peer projects.

Where normalisation against units other than those specified, e.g. kgCO₂e/m² NIA, is considered suitable for project-specific and/or comparative purposes, the assessor should in addition to the mandatory units above, also report against the preferred metrics.

3.3 Carbon data sources

3.3.1 Allowable carbon data

This section refers to EN 15978; 8.4 and 10.3 and determines the carbon data sources that are allowable for use in whole life carbon assessments.

The assessor must explicitly state the data sources used in the whole life carbon assessment.

The following are acceptable sources of carbon data for materials and products, in order of preference:

- **Type III environmental declarations (EPDs and equivalent) and datasets in accordance with EN 15804**
- **Type III environmental declarations (EPDs and equivalent) and datasets in accordance with ISO 21930**
- **Type III environmental declarations (EPDs and equivalent) and datasets in accordance with ISO 14067**
- **EPDs and datasets in accordance with ISO 14025, ISO 14040 and 14044**
- **Type III environmental declarations (EPDs and equivalent) and datasets in accordance with PAS 2050.**

Type III environmental declarations should be issued by a designated programme operator adhering to the requirements of ISO 14025.

Where there is no specific qualifying carbon data for items included in the assessment, then allowable carbon information available for equivalent or closely similar products, that complies with the above requirements, should be used.

The most recent geographically and technologically appropriate data should be selected depending on project location and subject to anticipated supply chains.

Carbon data for modules [A1–A3], [B1], [B2], [B3], [C1], [C3], [C4] and [D] should be retrieved from the allowable carbon data sources specified and used in line with the project-specific scenarios developed at building level. Carbon figures for the remaining life stages [A4], [A5], [B4–B7], [C2] should be calculated on a project-specific basis, considering the project location, likely procurement routes, anticipated operation and maintenance schedules and EoL scenarios. Where EPD data is used for these modules, the carbon values should be adjusted accordingly to fit the project-specific scenarios.

EN 15804 – section 6.3.7 suggests that specific product data should be no older than five years and generic data no older than ten years.

Table 5 (overleaf) presents the recommended use of different types of data as adjusted for PAS 2080 from EN 15978.

Preferred data	Selected work stages				
	Strategy, Brief and Concept	Design	Construction and commissioning	Operation	End of life
Generic: data typical of the type of component, product and/or material to be used	X	X	O	O	O
Specific: data specific to a manufacturer's particular component, product and/or material	O	X	X	X	X
Average: data averaged across different manufacturers or production sites /lines for the same product and/or material	X	X	X	X	X
Collective: data created according to BS EN 15804 representing a category of products	O	X	X	X	X
Measured: data gathered from direct measurement for a component, product and/or material			X	X	X
Other	O	O	O	O	O

NOTE Cross (X) represents the preferred use of data; Circle (O) represents alternative sources if available.

Table 5: Recommended use of different data types as per PAS 2080 © BSI

3.3.2 Allowable carbon conversion factors

The most recent GHG conversion factors for company reporting as issued by designated bodies (currently BEIS 2016 Government GHG conversion factors for company reporting; methodology paper for emission factors for the UK or equivalent sources for different countries) should be used for calculating the carbon equivalent (CO₂e) impact of transport, fuel consumption, refrigerants and water supply. The conversion factors should account for both direct and indirect GHG emissions – Scopes 1, 2 and 3, including WTT (Well To Tank) and T&D (Transmission and Distribution) impacts as applicable.

3.4 Factors influencing the assessment

3.4.1 Carbon sequestration

Biogenic carbon

CO₂ is absorbed from the atmosphere by trees during their growth through photosynthesis. The carbon element of the CO₂ absorbed remains locked into the timber until its EoL. The sequestered carbon should though only be considered a benefit in the scope of whole life carbon assessment when the timber is sustainably sourced – certified by FSC, PEFC or equivalent. This is to ensure that any trees felled are being substituted with a minimum of the same number of trees planted and therefore not contributing to deforestation and not compromising the overall carbon-absorbing capacity of woodlands.

Regarding the EoL of timber products, when wood is discarded and left to decompose such as when being landfilled, CO₂ as well as CH₄ (methane) are released. CH₄ has a GWP 28 times that of CO₂ according to the latest IPCC report, as declared by the Greenhouse Gas Protocol. It is therefore crucial from a whole life carbon perspective to take the EoL impacts of timber into account in the calculations.

Carbon sequestration must only be taken into account when the following criteria are met: 1. The whole life carbon assessment of the project includes the impacts of the EoL stage [C] and 2. The timber originates from sustainable sources (certified by FSC, PEFC or equivalent).

Robust audit trails in the timber supply chain will ensure that sufficient information is in place to support carbon sequestration reporting.

The biogenic carbon stored (sequestered) in timber elements must be calculated based on the formula provided in EN 16449:

$$P_{CO_2} = \frac{44}{12} \times cf \times \frac{\rho_{\omega} \times V_{\omega}}{1 + \frac{\omega}{100}}$$

P_{CO_2} : sequestered carbon dioxide – biogenic carbon oxidised at EoL

cf : carbon fraction of woody biomass (dry)

ρ_{ω} : timber density at the given moisture content

V_{ω} : timber volume at the given moisture content

ω : moisture content of timber product.

The default values to be used in the carbon sequestration calculations in the absence of more specific data for the timber element under study are as follows, according to EN 16449:

$cf = 50\%$; $\omega = 12\%$.

Where separate carbon sequestration figures calculated to EN 16449 are available from allowable data sources for the project-specific items, these can be used in the assessment. Otherwise, the carbon sequestered in timber elements should be based on the EN 16449 formula given.

It is worth noting that the carbon sequestered within the timber constitutes one of its inherent physical properties, rather than a consequence, such as carbon emissions, arising from a certain process. Therefore, when sequestration is allowed to be taken into account according to the criteria stipulated, the carbon locked within timber items is considered to be embedded within the material and transferred with it. Where timber is being reclaimed and reused, it is assumed that the sequestered carbon is retained and carried forward within the timber elements being recovered and used in a subsequent project – see EN 16485; 6.3.4.2. The sequestered carbon should therefore be accounted for in module [D] as a potential future benefit locked within products deriving from recovered timber – see section 3.5.5.

Special care needs to be taken regarding timber formwork which has a particularly short service life and leaves the project system even before practical completion – effectively still within the construction stage [A5]. To ensure the carbon impact of timber formwork is fairly allocated, the

following simplified approach should be followed for whole life carbon assessments.

A plausible scenario for the EoL of the formwork should be worked out in liaison with the design team and project contractor. If the formwork is being either landfilled or incinerated, the associated emissions can be calculated as per 3.5.3.4 and reported under module [C4]. Where the formwork is expected to be reused several times in different projects, the sequestered carbon and the subsequent disposal emissions [C4], according to the anticipated EoL scenario, should be divided by the number of expected reuses. The resulting figure should be included in the assessment to avoid shifting the EoL emissions burden to the last project the formwork is being used in. This approach is also proposed to encourage more holistic thinking about the use of timber formwork based on what the potential is in the long run, rather than simply within the very limited boundary of the project under study. In the absence of more specific information, timber formwork can be assumed to be reused three times and incinerated at the end of its life.

Carbon sequestration figures should be reported separately, but can be included in the total product stage figures [A1–A3] provided the specified conditions are met. Given satisfactory evidence, the benefit of carbon sequestration can be claimed for other plant-based materials (e.g. bamboo, etc.) as long as these are sustainably sourced and the treatment at the end of their life is included in the whole life carbon assessment.

Carbonation of CaO and Ca(OH)₂

Building elements containing cementitious materials and/or lime, such as concrete and mortar, have the potential to absorb CO₂ when their surfaces are exposed to the air as the contained calcium oxide (CaO) and calcium hydroxide (Ca(OH)₂) react with CO₂ in the atmosphere. This natural process is called carbonation.

Concrete contains calcium hydrated oxides and therefore undergoes carbonation when left exposed. However, carbonation beyond a certain level is not desirable in reinforced concrete as it may have adverse effects (corrosion) on the robustness of the embedded steel bars. It is therefore purposefully limited via appropriate mix design and reinforcement cover allowances (EN 1992-1-1; BS 8500).

The carbonation process occurs over the life of concrete elements and should therefore be accounted for in the use [B1] – see 3.5.3.1 – and EoL stages – 3.5.4, where applicable. Carbonation rates depend on the duration of exposure, concrete designation and the exposure conditions including any concrete surface treatments. It should therefore be pointed out that carbonation will only affect exposed concrete elements whose surfaces are untreated/uncoated. It should also be noted that there is a maximum CO₂ absorbing capacity associated with any given quantity of cementitious material which varies depending on the influential factors specified. Once this is

reached, no further carbonation can take place.

Data from EPDs or equivalent sources can be used to account for the impact of carbonation in stages [B1] and [C3]/[C4], provided that the conditions in the scenario selected in the data source coincide with the anticipated project-specific ones. In case the assumptions are either not sufficiently transparent or diverge from what is expected to apply to the specific project being assessed, carbonation figures should either not be taken into account or adjusted accordingly.

Detailed guidance on calculating and reporting the carbon uptake from carbonation is given in EN 16757.

3.4.2 Future energy projections – Decarbonisation

Current national and international environmental policies call for the mitigation of GHG emissions to limit the effects of climate change. The energy sector is a major carbon emitter and will subsequently need to significantly decarbonise over time to be consistent with statutory requirements. In addition to the energy sector, the manufacturing industry is also anticipated to become cleaner due to greener practices as mandated by legal requirements and carbon route maps in accordance with the Paris Agreement.

EN 15978 and EN 15804 suggest that current practices shall apply to any future projections and do not allow for decarbonisation in the calculations of life cycle environmental impacts in an effort to limit the uncertainty factors influencing the results of the assessments. To enable consistency with current standards, applying decarbonisation is not a mandatory requirement in carbon calculations. It is, however, important to provide a realistic estimate of the whole life carbon emissions of a project by considering future decarbonisation. This may prompt stakeholders to think more broadly about the actual life cycle impacts of built projects. Therefore, decarbonised figures should also be reported alongside the non-decarbonised ones.

A moderate approach towards future decarbonisation is suggested for calculating projected emissions. Appropriate adjustments should be made to the carbon conversion factors to capture the decarbonisation impact.

For UK projects, a conservative ‘slow progression’ scenario from the latest Future Energy Scenarios developed by National Grid, should be used to calculate the decarbonisation adjustment coefficients to be applied to the respective carbon conversion factors based on modest future projections. Similar scenarios produced from designated bodies should be used for different countries and assessors should clearly identify and explain the decarbonisation scenarios used in line with the guidance above.

The future energy carbon intensity should be determined as follows:

Carbon intensity_{Year x} =

carbon conversion factor (a) × decarbonisation adjustment coefficient (%)_{Year x} (b)

- (a) Allowable carbon conversion factor for energy source as per 3.3.2.
- (b) Coefficient calculated based on the diminishing projected trajectory of the applicable decarbonisation scenario, assuming 100% for the year of the project's practical completion. A recent, relevant and plausible scenario is illustrated in the National Grid's *Future Energy Scenarios 2016* (see Figure 5.2.4 of the publication).

The annual carbon intensity should be calculated in accordance with the stated equation applying the diminishing trend from the selected decarbonisation scenario to the original allowable carbon conversion factor. The trend line for future carbon emissions should be used to estimate the decarbonisation adjustment coefficient, i.e. the reduction that should be applied to the carbon intensity every year.

Decarbonisation is only relevant to emissions that will arise in the future, i.e. during the use and EoL of a project – stages [B] and [C], and it can affect the carbon figures considerably. Therefore, the decarbonisation factors are applicable to operational emissions [B6] and [B7] and to exported energy in module [D], as these are the areas decarbonisation is expected to have the most significant impact on. Furthermore, the decarbonisation adjustment coefficients, calculated as described, are also applicable to any recurring embodied carbon impacts over the life cycle of the project for maintenance, repair, replacement & refurbishment – stages [B2–B5], to account for the anticipated decarbonisation of the manufacturing industry. For simplification purposes and due to high uncertainty, the EoL emissions [C] do not need to be adjusted.

3.5 Life cycle stages

This section refers to EN 15978; 7.4. EN 15978 is structured in a series of modules – see 3.2.4 – that cover all stages of the life cycle of a project. The following sections provide further detail and practical guidance on each of the modules to enable consistency of interpretation when conducting a whole life carbon assessment.

All aspects relating to each of the EN 15978 modules as listed here are discussed in the sections below:

- [A1–A3] Product stage
- [A4 and A5] Construction process stage: transport to site and construction installation process
- [B1] Use
- [B2] Maintenance
- [B3 and B4] Repair and replacement
- [B5] Refurbishment
- [B6] Operational energy use
- [B7] Operational water use

- [C1] Deconstruction and demolition process
- [C2] Transport
- [C3] Waste processing for reuse, recovery or recycling
- [C4] Disposal
- [D] Benefits and loads beyond the system boundary.

3.5.1 [A1–A3] Product stage

This section refers to EN 15978; 7.4.2 and 8.4, and EN 15804; 6.3.4.2. The product stage deals with the carbon emissions attributable to the cradle to gate processes; raw material supply, transport and manufacturing. This section provides additional detail to assist calculation of the carbon emissions for these stages. The processes covered by [A1–A3] frequently occur in several steps, where components are manufactured and then transported to a further fabrication plant for assembly into a system. All of these interim steps need to be taken into account.

The carbon emissions attributable to the product stage [A1–A3] of the items included in the whole life carbon assessment must be calculated by assigning suitable embodied carbon factors to the given elemental material quantities.

Therefore: [A1–A3] = Material quantity (a) × Material embodied carbon factor (b)

Acceptable carbon data sources are specified in 3.3.1.

The assessor needs to ensure that (a) and (b) are measured against the same metric, e.g. per kg, and adjusted accordingly using, e.g. material densities where necessary. Density data should be sourced from the relevant EPD used or from technical documentation provided by the product supplier. If specific density information is unavailable, average data representative of the type of item should be used with their source clearly stated. Project team members, such as the structural engineer, cost consultant, etc., should be consulted for clarification on material assumptions if necessary.

Where comprehensive specification for products and/or materials is available, the corresponding carbon data should be used. However, at early design stages the technical specification is likely to be indicative and the cost plan or BoQ not yet providing detailed information on building components and product types. Subjective material selections made early in the design process due to a lack of detailed information on technical specification can heavily influence the product stage carbon emissions [A1–A3]. This can lead to significant discrepancies between results for similar projects. Therefore, in such instances, generic data representative of standard, market average specifications should be used in the assessment. This data should be refined at later project stages as product specific information becomes available.

To ensure baseline consistency, the following specifications must be used in the absence of detailed information – see Table 6.

	Material	Details	Specification
1.	Concrete	Piling	C32/40 20% cement replacement [1]
		Substructure	C32/40 20% cement replacement [1]
		Superstructure	C32/40 20% cement replacement [1]
		Generic concrete	C16/20 0% cement replacement [1]
2.	Steel	Reinforcement bars	97% Recycled Content [2]
		Structural steel sections	20% Recycled Content [3]
		Studwork/Support frames	Galvanised steel, 15% Recycled Content [4]
3.	Blockwork	Precast concrete blocks	Lightweight blocks for building envelope Dense blocks for other uses
4.	Timber	Manufactured structural timber CLT, Glulam, etc.	100% FSC/PEFC [5]
		Formwork	Plywood
		Studwork/Framing/Flooring	Softwood
5.	Aluminium	Cladding panels	Aluminium sheet, 35% Recycled Content [6]
		Glazing frames	Aluminium extrusions, 35% Recycled Content [6]
6.	Plasterboard	Partitioning/Ceilings	Min. 60% Recycled Content [7]
7.	Insulation	To floors, roofs & external walls	PIR

Table 6: Default specifications for main building materials

The values in Table 6 are based on average industry standard practice.

The assessor should clearly indicate for which items the generic assumptions of Table 6 have been used due to lack of detailed information. These assumptions should be updated according to project-specific information as it becomes available.

Notes on Table 6:

[1] Low end industry averages developed from consultation with design and supply chain specialists, in alignment with relevant concrete specification standards: BS EN 206: 2013 and BS 8500-1: 2016.

[2] UK CARES EPD for Carbon Steel Reinforcing Bar – Sector Average, BRE, 2016.

[3] UK manufactured structural steel sections are currently manufactured mainly via the BOS (Basic Oxygen Steelmaking) route. This process utilises approximately 20 per cent of recycled steel scrap (C. Broadbent – Steel’s recyclability: demonstrating the benefits of recycling steel to achieve a circular economy, 2015. Also TATA steel information).

[4] WRAP Choosing construction products – Guide to the recycled content of mainstream construction products, 2008.

[5] As suggested by contractors, it constitutes standard practice for manufactured timber used in construction to be sustainably sourced under 100 per cent FSC or PEFC certification. The Government’s Timber Procurement Policy (TPP 2013) and the GLA Group Responsible Procurement Policy (2016) further underpin timber sustainable sourcing as a requirement. Sustainable timber sourcing (legally harvested and traded timber) is also mandatory for obtaining BREEAM certification.

Please note that FSC Mixed certification is not acceptable as 100 per cent FSC.

[6] Global Aluminium Recycling Committee (GARC) (2009). Global Aluminium Recycling: A Cornerstone of Sustainable Development suggests an average of 32 per cent recycled content in aluminium products – p.30. Certificates from European aluminium product manufacturers suggest an average of 35 per cent recycled content.

[7] Following review of EPDs for the most widely used plasterboard types. Also, average of standard and good spec as suggested by WRAP Choosing construction products – Guide to the recycled content of mainstream construction products, 2008.

3.5.2 [A4 and A5] Construction process stage

This section refers to EN 15978; 7.4.3 and 8.5, and EN 15804; 6.3.4.3. Modules [A4] and [A5] respectively capture the emissions associated with the transportation of the materials and components from the factory gate to the project site and their assembly into a building.

3.5.2.1 [A4] Transport emissions

This section refers to EN 15978; 7.4.3.2 and 8.5, EN 15804; 6.2.3.

Transport emissions must include all stages of the journey of the products following their departure from the final manufacturing plant to the project site, taking into account any interim stops at storage depots and/or distribution centres.

Transport emissions should be calculated as follows:

$$[A4] = \text{Material or system mass (a)} \times \text{transport distance (b)} \times \text{carbon conversion factor (c)}$$

Material or system mass (a):

Should be obtained from acceptable sources as specified in 3.2.6 and account for any material losses during transport wherever possible.

Transport distance (b):

Should be calculated based on the distance between the manufacturing location and the project site, and is subject to the anticipated supply chain route of each item. When specific sourcing information is unavailable, the transport scenarios in Table 7 should be used in whole life carbon assessments for UK-based projects. Similar default scenarios should be developed for different countries. The assessor, in consultation with the design team, should reasonably allocate the anticipated products and components into each of the categories: locally, nationally, European and globally manufactured, to inform the transport scenario.

Carbon conversion factor (c):

Based on the selected mode of transport, suitable carbon conversion factors should be used – see 3.3.1.

The above assumptions should be updated as project-specific evidence from the main contractor and sub-contractors becomes available.

The transport of people and commuting of employees is excluded from the calculations as the emissions associated with these activities are not attributable to the project but to the individual employees.

Transport scenario	km by road*	km by sea**
Locally manufactured e.g. concrete, aggregate, earth	50 [1]	-
Nationally manufactured e.g. plasterboard, blockwork, insulation	300 [1]	-
European manufactured e.g. CLT, façade modules, carpet	1,500 [2]	-
Globally manufactured e.g. specialist stone cladding	200 [3]	10,000 [3]

Table 7: Default transport scenarios for UK projects

* Means of transport assumed as average rigid HGV with average laden – average laden as per BEIS carbon conversion factors.

** Means of transport assumed as average container ship.

Notes on Table 7

[1] EeB Guidance Document, Part B: Buildings – Operational guidance for life cycle assessment studies of the Energy-Efficient Buildings Initiative, p.199.

[2] Generic distance for items assumed to be sourced from continental Europe, e.g. Austria.

[3] Generic distance for items assumed to be sourced from Eastern Asia.

The above distances are applicable to projects located in the UK and include a generic allowance for interim storage depots before reaching the construction site. These should be adjusted accordingly based on project location if in a different country.

3.5.2.2 [A5] Construction – installation process emissions

This section refers to EN 15978; 7.4.3.3 and 8.5, EN 15804; 6.2.3.

The carbon emissions arising from any on- or off-site construction-related activities must be considered in [A5]. This includes any energy consumption for site accommodation, plant use and the impacts associated with any waste generated through the construction process, its treatment and disposal.

The following figure can be used as an average for building construction site emissions, in the absence of more specific information: **1400kgCO₂e/£100k** of project value (BRE Meeting Construction 2025 Targets – SMARTWaste KPI p.3, footnote 9). The cost figure is based on the date of the publication, March 2015, and should be adjusted to current value in accordance with CPI. Average data from contractors’ site emissions monitoring suggest similar levels of construction emissions. This rate should be refined by substitution with site monitoring data provided by the project contractor as these become available.

Where construction emissions [A5] data are available from the component/product EPDs or equivalent allowable sources, these figures should be handled with care, as they need to be cross-referenced against project-specific building construction practices. If the assembly and

construction methods anticipated coincide with those specified in the respective EPDs, then the data from them can be used in the assessment.

Appropriate allowances for site waste should be made. The carbon impacts from the product stage and transport of site waste, and any emissions associated with its disposal, should be included in the calculations. Installation and deconstruction impacts can be assumed as zero as the wasted material is not being installed.

In the absence of project-specific information, default assumptions on site waste rates for the different materials should be determined based on the standard wastage rates provided by the WRAP net waste tool reference or equivalent. These rates should be applied to the corresponding material quantities provided to allow for wastage during construction. Any site waste data from component/product EPDs or equivalent allowable sources should be overridden by the rates from WRAP for consistency purposes, as EPD-specific site waste rates may vary largely according to different installation/construction assumptions for different product applications, locations, etc. For bespoke items prefabricated off-site to suit project-specific needs, e.g. CLT elements, the site waste rates can be taken as 0 despite default WRAP rates suggesting otherwise.

The WRAP rates should be refined by substitution with specific information and/or site monitoring data provided by the project contractor/subcontractors as these become available.

The carbon emissions associated with any waste generated during the construction process should be accounted for in accordance with the principles outlined for the product and transport stage [A1–A3] and [A4] – see 3.5.1 and 3.5.2 – and EoL stages [C2–C4] – see 3.5.4.

Depending on the disposal scenarios developed for site waste, the following carbon impacts are applicable to the respective waste quantities. Provided the current high diversion from landfill rates for site waste, a 90 per cent recovery per 10 per cent landfill assumption can be taken as default for site waste disposal– see section 3.5.4. The selection of on-site or off-site reuse or recycling scenarios for the different items should be based on project-specific information.

Site waste disposal scenarios		
Disposal to landfill/incineration	Reuse or recycling on-site	Reuse or recycling off-site
[A1–A3] + [A4] + [C2] + [C4]	[A1–A3] + [A4] + [C3]	[A1–A3] + [A4] + [C2] + [C3]

Table 8: Site waste disposal scenarios

3.5.3 [B1–B7] Use stage

This section refers to EN 15978; 7.4.4.1 and 8.6.1, EN 15804; 6.3.4.4.1.

The use stage must capture the carbon emissions associated with the operation of the built asset over its entire life cycle, from practical completion to the end of its service life as determined in 3.2.3.

This includes any emissions relating to operational energy and water use as well as any embodied carbon impacts associated with maintenance, repair, replacement and refurbishment of building components.

Reasonable scenarios should be developed for the maintenance, repair, replacement, refurbishment and operation of the building based on project-specific information and consultation with the project team.

3.5.3.1 [B1] In use emissions

This section refers to EN 15978; 7.4.4.2 and 8.6.2, and EN 15804; 6.3.4.4.2.

The in use module [B1] captures the emissions arising during the life of a building from its components, e.g. the release of GHG from HFC blown insulation.

Any carbon emitted from building components during the life of the building must be reported in [B1].

Carbon emissions released from building elements and the impact of potential carbon absorption should be accounted for. Particular attention should be paid to any emissions arising from refrigerants, insulation blowing agents, paints, etc. over the life cycle of the project. Data on refrigerant leakage thresholds should be provided by the MEP consultant in accordance with relevant regulations. Data from DEFRA, EPDs, C2C (Cradle to Cradle) certification reporting, manufacturers' declarations and other relevant specialist documentation can be used.

Details on how to account for the impacts of the carbonation process in items containing exposed concrete and/or lime are given in section 3.4.1. The carbon absorption by green roofs and facades is considered negligible for green areas of less than 1,000 m² (Getter et al 2009, Whittinghill et al 2014), unless otherwise stated. Carbon absorption potential by green roofs and facades should be supported by relevant evidence, e.g. landscape consultants' report.

3.5.3.2 [B2] Maintenance emissions

This section refers to EN 15978; 7.4.4.3 and 8.6.3, and EN 15804; 6.3.4.4.2.

Built assets with sophisticated cladding and MEP installations require regular maintenance to ensure continued efficiency, good appearance and validity of warranties. All of these repetitive activities involve the use of energy and/or products. These should be accounted for in module [B2].

Module [B2] must account for the carbon emissions arising from any activities relating to maintenance processes, including cleaning, and any products used. Additionally, it should include any emissions from the energy and water use associated with these activities.

Maintenance-related carbon emissions [B2] should be reported for at least the following building element categories – see 3.2.2: 2.3) Roof; 2.5) External Walls and 2.6) Windows and External Doors; 3) Finishes; 5) Services (MEP). Additional items should be included as appropriate if specific information on their maintenance is provided.

Reasonable maintenance scenarios should be developed based on facilities management and maintenance strategy reports, façade access and maintenance strategy, life cycle cost reports, O&M manuals and professional guidance, e.g. CIBSE Guide M, RICS NRM 3, etc.

Relevant carbon data from EPDs should be adjusted according to the project-specific maintenance scenario.

3.5.3.3 [B3] Repair emissions

This section refers to EN 15978; 7.4.4.4 and 8.6.3.

This module [B3] is intended to provide a reasonable allowance for repairing unpredictable damage over and above the maintenance regime. It is therefore applicable to the same building element categories as maintenance emissions.

Module [B3] must take into account the carbon emissions arising from all activities that relate to repair processes and any products used.

Data from facilities management/maintenance strategy reports, façade access and maintenance strategy, life cycle cost reports, O&M manuals, professional guidance, e.g. CIBSE Guide M, should be used to develop scenarios for repair.

In case none of these sources is available, repair emissions should be assumed as equivalent to 25 per cent of maintenance emissions [B2] for the relevant items as specified in 3.5.3.2.

3.5.3.4 [B4] Replacement emissions

This section refers to EN 15978; 7.4.4.5 and 8.6.3.

Over the service life of a building there will be carbon impacts arising from the replacement of items, such as building services equipment, windows and cladding, roof surfaces, interior finishes, etc. These will occur at different cycles depending on the original specification and corresponding life expectancy of the different elements.

Module [B4] must take into account any carbon emissions associated with the anticipated replacement of building components, including any emissions from the replacement process. All emissions arising from the production, transportation to site and installation of the replacement items must be included. This extends to cover any losses during these processes, as well as the carbon associated with component removal and EoL treatment.

The carbon emissions from the replacement of items from the following building element groups – see 3.2.2 – should be reported: 2.3) Roof; 2.5) External Walls and 2.6) Windows and External Doors; 3) Finishes; 4) Fittings, furnishings & equipment; 5) Services (MEP). Additional items should be included if specific information on their replacement is provided.

It should be assumed that items are being replaced on a like-for-like basis and full replacement (100 per cent) of the items is assumed once the specified lifespan is reached.

Appropriate life cycle scenarios that will set out the expected replacement cycles for the different components should be developed and clearly explained in the whole life carbon assessment report. The scenarios should be based on data from facilities management and maintenance strategy reports, façade access and maintenance strategy, life cycle cost reports, O&M manuals, guidance (e.g. CIBSE Guide M and BCIS Life expectancy of building components), international standards (e.g. ISO 15868-5: 2008 Buildings and constructed assets – service life planning, and manufacturers' documentation).

The lifespans provided in Table 9 should be used for the components listed, in the absence of more specific data. These figures should be replaced with the actual life expectancies of the specific items to be used in the project as information becomes available.

Building part	Building elements/components	Expected lifespan
Roof	Roof coverings	30 years
Superstructure	Internal partitioning and dry lining	30 years
Finishes	Wall finishes: Render/Paint	30/10 years respectively
	Floor finishes Raised Access Floor (RAF)/Finish layers	30/10 years respectively
	Ceiling finishes Substrate/Paint	20/10 years respectively
FF&E	Loose furniture and fittings	10 years
Services/MEP	Heat source, e.g. boilers, calorifiers	20 years
	Space heating and air treatment	20 years
	Ductwork	20 years
	Electrical installations	30 years
	Lighting fittings	15 years
	Communications installations and controls	15 years
	Water and disposal installations	25 years
	Sanitaryware	20 years
	Lift and conveyor installations	20 years
Facade	Opaque modular cladding e.g. rain screens, timber panels	30 years
	Glazed cladding/Curtain walling	35 years
	Windows and external doors	30 years

Table 9: Indicative component lifespans

Table 9 contains conservative generic assumptions for the lifespan of items based on information from BCIS Life expectancy of building components (2006); CIBSE Guide M; Scheuer, Keoleian, and Reppe (2003). Life cycle energy and environmental performance of a new university building: modelling challenges and design implications. Energy and Buildings, 35, pp.1049–1064.

3.5.3.5 [B5] Refurbishment emissions

This section refers to EN 15978; 7.4.4.6 and 8.6.4, and EN 15804; 6.3.4.4.2.

Refurbishment, as distinct from replacement, is defined as a planned alteration or improvement to the physical characteristics of the building in order for it to cater for the desired future function identified and quantified at the outset. This would typically involve a predetermined change of use at a point during the service life of the project, as well as a sizeable amount of works to several parts of the building.

Module [B5] must take into account any carbon emissions associated with any building components used in a refurbishment, including any emissions from refurbishment activities. All emissions arising from the production, transport to site and installation of the components used must be included. This includes any losses during these processes, as well as the carbon associated with their removal and EoL treatment.

The calculation of refurbishment emissions [B5] should account for any material additions and variations as per new build – see 3.5.1, 3.5.2 – instead of like-for-like as in replacement – see 3.5.3.4.

3.5.3.6 [B6] Operational energy use

This section refers to EN 15978; 7.4.4.7 and 8.6.5.

This module covers any emissions arising from the energy use of the operation of technical systems in the building over the life of the project.

The operational carbon emissions arising from the energy use of building-integrated systems as projected and/or measured throughout the life cycle of the project must be reported under module [B6].

Operational emissions should include all energy use regulated as per Part L of the Building Regulations, including heating, domestic hot water supply, air conditioning, ventilation, lighting and auxiliary systems.

The life cycle emissions associated with the operation of further building-integrated systems (lifts, safety, security and communication installations) should also be included as part of the total operational emissions [B6] but reported separately where possible.

Carbon emissions from non-building-related systems (e.g. ICT equipment, cooking appliances, specialist equipment, etc.) – unregulated energy use – can represent a significant part of the total operational emissions. Therefore, these should be included in the assessment where possible to provide a more complete picture of the life cycle impacts of the project. Such carbon emissions from unregulated energy use should be reported separately within [B6].

Any impact from waste produced by operational energy use should also be considered including any treatment and transportation these might require.

Where building operation requires fuel to be transported to the site, e.g. gas bottles, oil supply, etc., the transport emissions associated with the fuel delivered should be included in the calculation of operational emissions, as transportation emissions represent upstream transmission and distribution impacts for such fuels.

Data provided by MEP, sustainability and ICT consultants should be used in the operational emissions calculations, e.g. BRUKL submissions, energy modelling results from SBEM and/or dynamic thermal simulation, energy calculations according to CIBSE TM54, etc.

Operational carbon figures according to current practice (Part L of Building Regulations) are typically expressed as CO₂. According to the government's Standard Assessment Procedure (SAP), CO₂ in this instance is representing CO₂e (SAP for Energy Rating of Dwellings, 2012, p.164).

Where on-site renewables are installed (PVs, solar thermal systems, etc.), the whole life carbon assessment report should state how the energy outputs are expected to be used for the specific project. If information on the allocation of the on-site generated energy is unavailable, the assumption that energy produced on-site satisfies building needs first should be adopted. That is, building-related (regulated energy plus lifts, security and communications installations) take priority over non-building-related systems (unregulated energy) being exported to the grid (EN 15978, p.25). Unregulated energy demand can be assumed as equal to regulated for the purposes of this calculation, in the absence of project-specific estimates (BREEAM UK New Construction 2014, Ene 01 Reduction of energy use and carbon emissions – Compliance Note 3.5). The generated energy used to meet operational needs of the building can offset the equivalent amounts of imported energy and their subsequent carbon emissions.

Any benefit accruing from energy produced onsite and exported to the grid should be captured within module [D] – see 3.5.5, as suggested in EN 15978 7.4.4.7, and not discount the total energy demand.

The effect of the anticipated future grid decarbonisation should also be taken into account when estimating the operational carbon impact over the life of the project – see 3.4.2.

A comprehensive assessment of the entire life of a project should inform decision making as accurately as possible. Therefore, considering the impact of climate change when calculating future operational emissions, such as the heating and cooling demand over the service life of the building, is important. It is suggested that in such scenarios the figures used are modelled or adjusted utilising future weather data. Such information should be acquired from the University of Exeter publication On the creation of future probabilistic design weather years from UKCP09 (2011). Other sources of robust national or local data should be used depending on geographic location.

3.5.4.7 [B7] Operational water use

This section refers to (EN 15978; 7.4.4.8 and 8.6.6) and covers the carbon impacts associated with water use during the operation of the building.

All carbon emissions related to water supply and wastewater treatment, over the life cycle of the building (excluding water use during maintenance, repair, replacement and refurbishment that are reported elsewhere), must be reported under module [B7].

Any emissions associated with energy expended from water-related systems, e.g. provision of domestic hot water, etc. should be captured under module [B6].

Estimates on anticipated water consumption in the UK should be made based on the values provided in Table 22 of the BSRIA Rules of thumb – Guidelines for the building services, 5th edition for the respective building type, in the absence of project specific information at early design stages. The estimated water consumption should be replaced by figures provided by the public health and/or MEP consultant and landscape architect as they become available.

Carbon conversion factors for water use and treatment as published by the local water supplier should be used. If unavailable, the relevant generic carbon conversion factors from an allowable source should be used – see 3.3.2.

3.5.4 [C] End of Life (EoL) stage

This section refers to EN 15978; 7.4.5.1 and 8.7.1, and EN 15804; 6.3.4.5.

The EoL stage commences when the built asset has reached the end of its life and will no longer be used. For the purposes of the whole life carbon assessment this is assumed to occur at the end of the reference study period of the building as defined in 3.2.3.

Any emissions arising from decommissioning, stripping out, disassembly, deconstruction and demolition operations as well as from transport, processing and disposal of materials at the end of life of the project must be accounted for in module [C].

The EoL stage is considered complete within the scope of whole life carbon assessment when the site is cleared and levelled to the ground plane and is ready for further use.

The assessor should develop suitable project-specific EoL scenario(s) at a building level as well as individual components level where relevant, based on future intentions provided by the project team, precedent and current EoL practices. The EoL scenario(s) should be clearly stated and explained within the whole life carbon assessment report.

In the absence of specific information, scenarios on the proportion of landfilling, reuse and/or recycling each item at the EoL should be developed according to current standard practice.

Based on UK statistics on Waste (2016) from DEFRA, the suggested default scenario for the EoL for construction and demolition-related items should assume 10 per cent of waste mass to landfill and 90 per cent being diverted, i.e. recovered and repurposed: reused or recycled. With respect to timber waste, 25 per cent should be assumed to be landfilled and 75 per cent incinerated with energy recovery (based on averaged data from Figure 6 of DEFRA (2012) Wood waste: a short review of recent research). The DEFRA statistics are included here as one such source of respected national data. Ratios based on the robust national data should be estimated and applied to projects located in different countries.

Most metals used in construction, such as steel, aluminium and copper, are highly recyclable multiple times without significant degradation in quality. As a result, high recovery rates have been established across the industry due to their reuse and recycling potential as well as the high residual economic value of the scrap. The following rates can be assumed for the EoL treatment of such metals unless indicated otherwise by project-specific data or other substantiated evidence, e.g. national or international statistics. The figures provided in Table 10 should be adjusted according to the project location and corresponding applicable recovery practices.

Metal	Recovery rate		Disposal	
	Repurposing: reuse or recycling		Landfill	
	UK	Global	UK	Global
Steel	96% [1]	85% [2]	4%	15%
Aluminium	96% [3]	85% [4]	4%	15%
Copper	65% [5]	65% [5]	35%	35%

Table 10: Default metal recovery rates

Notes on Table 10

[1] Sansom, M. and Avery N. (2014) Briefing: Reuse and recycling rates of UK steel demolition arisings. ICE Proceedings: Engineering Sustainability. 167; issue ES3

[2] World Steel Association (2016) Addressing climate change through technology transfer and research.

[3] European Aluminium Association (2004) Collection of aluminium from buildings in Europe – A Study by Delft University of Technology.

[4] Global Aluminium Recycling Committee (GARC) (2009) – Global Aluminium Recycling: A Cornerstone of Sustainable Development, p.16.

[5] Table 1, p.6569 – Glöser, S., Soulier, M. and Tercero Espinoza L. A. (2013) Dynamic Analysis of Global Copper Flows. Global Stocks, Postconsumer Material Flows, Recycling Indicators, and Uncertainty Evaluation. Environmental Science and Technology. 21: 1658–1665.

The given assumptions are intended to represent the low end of common practice in the UK. Equivalent data should be used when the project being assessed is located elsewhere.

The recommended default EoL scenarios should be updated according to project specific data relevant to the EoL stages as information becomes available over the progression of the project.

Data for [C] from EPDs and other carbon data sources – see 3.3.1 – should be used in line with the project-specific EoL scenarios developed.

3.5.4.1 [C1] Deconstruction and demolition emissions

This section refers to EN 15978; 7.4.5.2 and 8.7.2.

Deconstruction should cover all site-based activities required to dismantle, deconstruct and/or demolish the built asset being assessed.

The carbon emissions arising from any on- or off-site deconstruction and demolition activities, including any energy consumption for site accommodation and plant use, must be considered in [C1].

An average rate of **3.4 kgCO₂e/m² GIA** (rate from monitored demolition case studies in central London) based on aggregated data should be used in the absence of more specific information.

3.5.4.2 [C2] Transport emissions

This section refers to EN 15978; 7.4.5.3 and 8.7.3.

Any carbon emissions associated with the transportation of deconstruction and demolition arisings to the appropriate disposal site, including any interim stations, must be captured within module [C2].

The transport emissions for the discarded items should be calculated based on the following formula:

$$[C2] = \text{Mass of waste to be transported (a)} \times \text{Transport carbon factor (b)} \times \text{Distance to disposal site (c)}$$

In the absence of project-specific information, default distances to be used for the transportation of redundant items according to the respective anticipated EoL scenarios are given in Table 11. The mode of transport that should be assumed is an average heavy goods vehicle (HGV) with 50 per cent load to account for the vehicles coming to site empty and leaving with a 100 per cent load.

EoL scenario	Transport scenario
Reuse/recycling on site	No transport emissions; [C2] = 0
Reuse/recycling elsewhere	Assumed transport locally – 50km
Landfill/incineration	Average between 2 closest landfill sites

Table 11: Default transport assumptions for different EoL scenarios

3.5.4.3 [C3] Waste processing for reuse, recovery or recycling emissions

This section refers to EN 15978; 7.4.5.4 and 8.7.4.

When materials and/or components are intended to be recovered and reused or recycled after the end of the life of the built asset, any carbon emissions associated with their treatment and processing prior to reaching the end-of-waste state must be included in module [C3].

The calculation of [C3] should follow the EoL scenarios developed by the assessor for each item. Data for [C3] from relevant EPDs should be used, adjusted appropriately to suit the selected EoL scenario. In the absence of specific information regarding the waste processing for items to be repurposed, the default emissions for disposal to landfill – see 3.5.3.4 – should be applied.

3.5.3.4 [C4] Disposal emissions

This section refers to EN 15978; 7.4.5.5 and 8.7.5.

Module [C4] captures the emissions resulting from any processing required prior to disposal and from the degradation and/or incineration of landfilled materials. This is for items not being recovered for reuse and/or recycling.

For elements not expected to be recovered and repurposed, but intended for final disposal either in landfill or incineration, an allowance for the emissions arising from their disposal must be included in [C4].

The calculation of [C4] should follow the EoL scenarios developed by the assessor for each item. [C4] data from relevant EPDs should be used, adjusted appropriately to suit the selected EoL scenario.

Where data for disposal is unavailable or is stated as '0', a generic assumption should be used for the [C4] emissions of inorganic items. The default figure suggested is **0.013 kgCO₂e/kg waste**. This figure has been developed as an average with reference to *BEIS 2016 Government GHG conversion factors* for company reporting (0.01 kgCO₂e/kg waste as an average of all construction waste types reported excluding wood), and Ökobaudat (0.016 kgCO₂e/kg waste).

For timber and other types of bio-based, organic waste where specific data from EPDs or other allowable sources is unavailable, the following rates should be used for the corresponding scenarios:

- Landfilling – no landfill gas recovery: **2.15 kgCO₂e/kg** of timber product (Weight 2011) (Symons, Moncaster and Symons 2013).
- Incineration: equal to sequestered carbon – see 3.3.1 (EN 16485: 2014; 6.3.4.2).

Modern landfill sites often employ techniques to capture the gases arising from organic matter decomposition – methane (CH₄) and carbon dioxide (CO₂). This will have an impact on the corresponding landfill emissions that should be adjusted based on the efficiency of landfill gas capture.

Potential energy recovery from organic waste incineration and/or captured landfill gas burning should be reported within module [D] – see 3.5.5. Organic items carry inherent feedstock energy and their decomposition also gives rise to CH₄ alongside CO₂ with sizeable associated EoL emissions. It is therefore crucial that any EoL emissions are examined in conjunction with potential benefits from energy substitution when incinerated to ensure the most beneficial and environmentally friendly trade-off.

3.5.5 Module [D] Benefits and loads beyond the system boundary

This section refers to EN 15978; 7.4.6 and 8.8, and EN 15804; 6.3.4.6 and 6.4.3.

Module [D] covers any benefits or burdens accruing from the repurposing of elements discarded from the built asset, or any energy recovered from them beyond the project's life cycle. Module [D] is intended to provide a broader picture of the environmental impacts of a project by accounting for the future potential of its components when these are repurposed i.e. recovered and reused and/or recycled. Module [D] captures the avoided emissions (or potential loads) from utilising repurposed items to substitute primary materials. Module [D] can be used as a metric for quantifying circularity and assessing future resource efficiency.

Module [D] includes the potential environmental benefits or burdens of materials and components beyond the life of the project. Module [D] must be reported separately and not aggregated with cradle to grave modules [A–C].

Module [D] is communicated separately as it occurs beyond the life cycle of the project under study and also bears high inherent uncertainty regarding the future treatment of building components. It is, however, important to assess module [D] figures along with cradle-to-grave [A–C] figures to acquire a holistic understanding of the environmental impacts of a built project. This has to take potential future benefits or loads into account and promotes thinking about the future, encouraging connectivity between current and future projects.

Project-specific scenarios for the intended/expected future handling of items beyond the EoL of the project, at

building and/or component level, should be developed and substantiated as appropriate. These should be based on supporting information provided by the project team and the anticipated supply chain. The scenarios should be realistic and feasible.

Different scenarios can be developed for the same project concerning the future recovery and repurposing of items beyond the EoL. Each scenario will therefore result in a different value for [D]. Each scenario should be presented clearly and explained within the whole life carbon assessment report with an indication of its likelihood.

Depending on the extent of reuse and/or recycling anticipated, appropriate boundaries for the potential benefits or burdens should be determined according to what the point of substitution is expected to be for each scenario. Reuse/recycling activity can range from the full reuse of an item as is (e.g. retained structural frame) to individual component reuse (e.g. steel sections, cladding modules, etc.), or material recycling (e.g. glass cullet from discarded windows, concrete crushed into aggregate, plasterboard recycled into new panels).

When full reuse of components in their exact assembled state, i.e. onsite retention, is anticipated in the future, the emissions from both product and construction stages [A1–A5] would be offset alongside any avoided deconstruction, transport and disposal [C1, C2 and C4] impacts. In case of individual element reuse, when this is expected to occur on-site then the offset of product stage [A1–A3] and transport [A4] carbon impacts can be claimed. For all other instances where off-site reuse and/or recycling are anticipated, the scope of the impacts to be taken into account in [D] shall be limited to the product stage [A1–A3].

Module [D] data should be derived from appropriate sources – see 3.3.1 – in accordance with the project-specific scenarios developed. The assumptions made to estimate the [D] figures in the selected sources should be checked against the project-specific ones developed by the assessor. If different, the [D] values should be adjusted to fit the project-specific scenarios. For example, an EPD for precast concrete panels is assuming recycling (downcycling) of the disposed items via crushing into aggregate. Meanwhile the project-specific scenario is anticipating reuse of the discarded panels elsewhere rather than crushing. In such case the [D] figures should be adapted to reflect the reuse scenario for the project under study, based on the principles described.

In the absence of any specific data relating to the future potential of items, the assessor can quantify such benefits or burdens, where applicable, in line with the following guidance.

When an item is fabricated from recovered materials (secondary product), [D] quantifies the avoided or potentially additional emissions when comparing the secondary fabrication with manufacturing a functionally equivalent item from primary materials. Therefore, module [D] contains the benefit from substituting the primary product and not making it from scratch, as well as any emissions stemming from the processing of the secondary (repurposed) product, as follows:

[D] = – [A1–A3] * of substituted primary product + [A1–A3] of secondary product

*[A1–A5] where applicable, as per explanation above, e.g. where components being reused 'as is'.

The products to be substituted by a recycled item should be assumed representative of current standard practice and market averages. For example, assuming glass wool insulation materials feature 30 per cent recycled content on average, then when an item is recycled whose resulting secondary product will substitute glass wool insulation: [A1–A3] of the substituted primary item = [A1–A3] of standard glass wool. That is, with 30 per cent recycled content, rather than glass wool from virgin material.

Any losses in material quantity or quality along the recycling/remanufacturing process should be taken into account when determining the avoided environmental impact of the item substituted. If specific data on the proportion between the reclaimed and the final product is unavailable, a one-to-one equivalence can be assumed. That is, 1kg of bricks reclaimed at the EoL of a project will substitute 1kg of new bricks.

With respect to recycling there are two main routes:

- 1 **Closed loop recycling**, where the discarded product is deemed to be recycled into an item of functional equivalence to the original without changing its inherent properties.
- 2 **Open loop recycling**, where the discarded product is recycled into a different one altering its physical nature, usually being downgraded to a product of lower quality and/or value.

Energy recovered from materials beyond the end-of-waste state, e.g. timber incineration should be accounted for within module [D] as per EN 15804; 6.3.4.5 when the energy recovery rate is higher than 60 per cent. Energy recovery calculations should be conducted based on the net calorific value of the material under study. The type of energy offset – grid electricity, gas – should be determined based on reasonable assumptions applicable to the local practices that enable realistic estimations of the carbon emissions avoided by the energy displaced.

The carbon sequestered in timber or other bio-based materials (biogenic carbon) being repurposed should be taken into account in module [D], where applicable. The impact of module [D] should be considered for every item a repurposing (reuse, recovery or recycling) scenario has been developed for. Therefore, for components being replaced multiple times over the life cycle of the project, module [D] should be accounted for each of the times the item is being replaced and the redundant component is intended to be repurposed.

3.6 Reporting requirements

The following section specifies the attributes (assumptions, results, etc.) that need to be disclosed and provides a recommended reporting structure for clarity and transparency. Table 12 can be used for reporting the project specific background information. Table 13 provides an organised template for the carbon results to be reported according to the requirements set out below. The cells shaded in purple indicate the minimum results required to be reported for an assessment.

A full whole life carbon assessment report should contain the following:

- 1 Details of the commissioning body, assessor and verifier if applicable.
- 2 Date of assessment completion.
- 3 A purpose statement declaring the drivers and aims of the assessment.
- 4 A description of the built asset assessed including its main physical and technical characteristics, e.g. number of storeys, floor area, as well as information on its use.
- 5 Declaration of the Reference Study Period used in the assessment.
- 6 A clear statement of the scope and boundaries regarding building parts and project life cycle stages accounted for in the assessment. If restricted scopes are used, justification in line with the aims of the study should be provided.
- 7 A clear indication of the point in time within the project process the assessment was conducted, e.g. early design stage (RIBA Stage 3), on practical completion, etc.
- 8 Explicit declaration of all sources of carbon data, material quantities and all relevant technical information and references throughout the assessment.
- 9 The percentage (%) of material quantities covered for each building element category – see 3.2.2.
- 10 Clear statement and explanation of all assumptions made and scenarios developed to facilitate the carbon calculations such as transport distances and EoL scenarios, including the percentage of quantities covered per building element category.
- 11 Itemised carbon results, separately per: 1. Building element group – see 3.1.2; and 2. Life cycle stage module – see 3.1.4.
- 12 Total carbon results for the cradle-to-grave scope [A] to [C] per building element group; both absolute (in kgCO₂e or appropriate metric multiples thereof) and normalised (in kgCO₂e/unit of measurement, e.g. m²) totals should be reported.
- 13 Total carbon results for each life stage module; both absolute (in kgCO₂e or appropriate metric multiples thereof) and normalised (in kgCO₂e/unit of measurement, e.g. m²) totals should be reported.
- 14 Aggregated carbon results for the cradle-to-grave scope [A] to [C] for all building element groups; both absolute (in kgCO₂e or appropriate metric multiples thereof) and normalised (in kgCO₂e/unit of measurement e.g. m²) totals should be reported.
- 15 Modules [A1–A3] (Product stage) can be reported jointly as a single figure.
- 16 Carbon sequestration figures should be identified separately, but can be included within the total cradle-to-grave figures [A] to [C].
- 17 Carbonation figures are recommended to be identified separately where applicable, but can be included within the respective applicable modules [A3]; [B1]; [C3]; [C4].
- 18 The decarbonised figures for modules [B2]; [B3]; [B4]; [B5]; [B6]; [B7] and [D] should be reported separately.
- 19 Further emissions to be reported separately: 1. Emissions associated with Demolition; 2. Operational emissions for non-building-related systems; 3. Module [D] figures.

The project ID matrix (Table 12) and the results reporting template (Table 13) organise the required items 1–10 and 11–19 respectively in a structured fashion. The minimum results required for submission are highlighted in purple in Table 13.

It is strongly recommended that the outputs of the assessments are entered into the RICS building carbon database to aid the gathering of robust data and subsequent carbon benchmarking for the built environment.

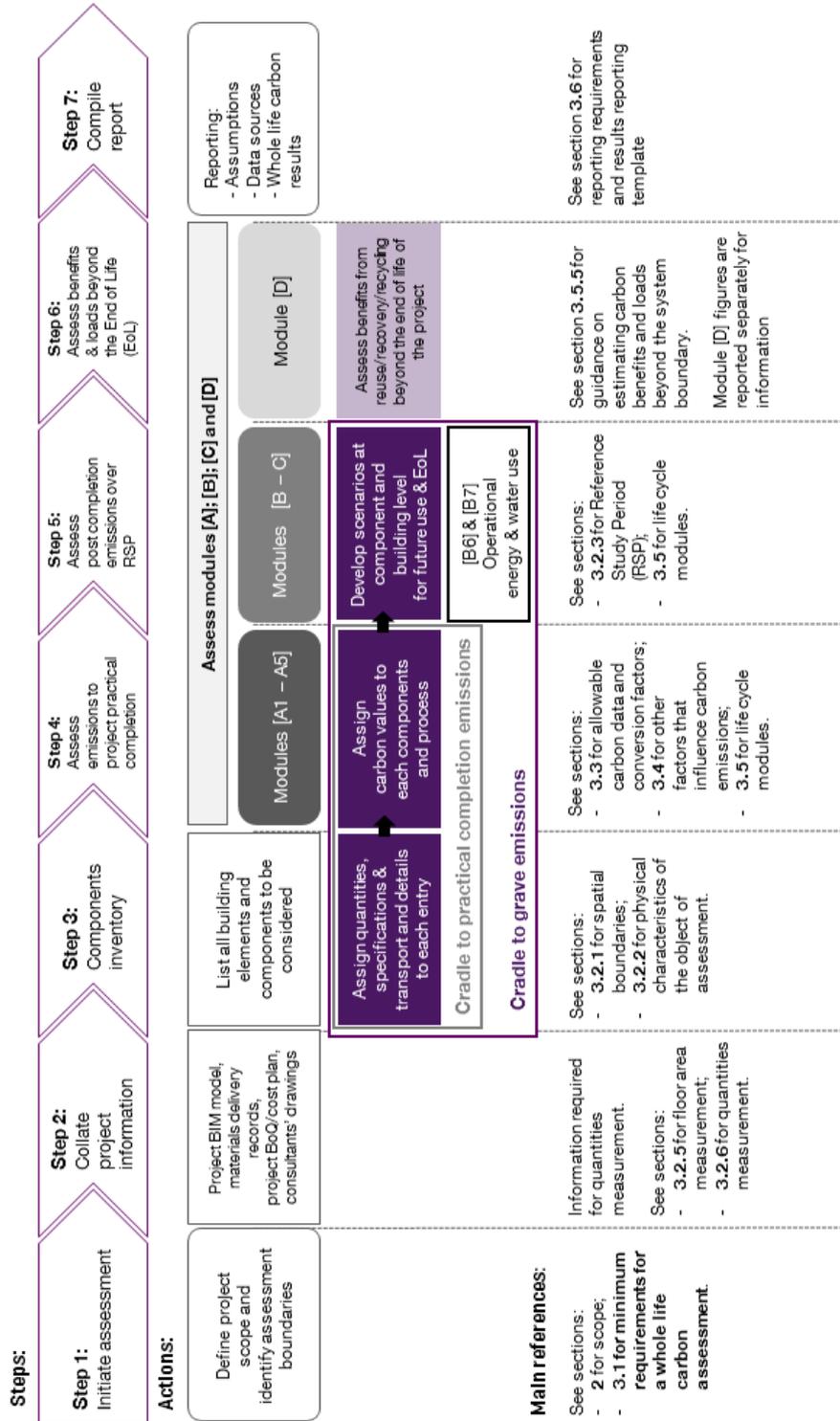
Date of assessment	Date of assessment completion					
Verified by	Verifier name and organisation					
Project type	New build or refurbishment of existing structure					
Assessment objective	Brief assessment purpose statement					
Project location	Full address					
Date of project completion	Anticipated date of practical completion					
Property type	Residential, public/civic, retail, office, infrastructure, etc. State planning use class					
Building description	No. of storeys, structural frame, façade type, basement?, brief description of associated external areas and any ancillary structures					
Size	NIA, GIA, volume, etc.					
Project design life	In years					
Assessment scope	Building parts and life stages/modules included					
Assessment stage	Design stage at which the assessment has been conducted at					
Data sources	List all data sources used in the assessment including building information and carbon data sources					
Building elements coverage	#	Building parts/element groups	Building elements	Coverage [%]		
	0	Facilitating works	0.1 Temporary/Enabling works/ Preliminaries 0.2 Specialist groundworks			
	1	Substructure	1.1 Substructure			
	2	Substructure	2.1 Frame	2.2 Upper floors incl. balconies 2.3 Roof 2.4 Stairs and ramps		
			Superstructure			2.5 External Walls 2.6 Windows and External Doors
			Superstructure			2.7 Internal Walls and Partitions 2.8 Internal Doors
	3	Finishes	3.1 Wall finishes 3.2 Floor finishes 3.3 Ceiling finishes			
	4	Fittings, furnishings and equipment [FF&E]	Building-related Non-building-related			
	5	Building services / MEP	5.1–5.14 Building-related services			
			Non-building-related			
6	Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units				
7	Work to Existing Building	7.1 Minor Demolition and Alteration Works				
8	External works	8.1 Site preparation works 8.2 Roads, Paths, Pavings and Surfacing 8.3 Soft landscaping, Planting and Irrigation Systems 8.4 Fencing, Railings and Walls 8.5 External fixtures 8.6 External drainage 8.7 External Services 8.8 Minor Building Works and Ancillary Buildings				
Assumptions and scenarios	List all assumptions and scenarios used in the assessment including brief justifications					

Table 12: The project ID matrix

Appendix 1: Whole life carbon assessment flowchart

Whole life carbon assessment Recommended sequence of activities to complete an assessment

This diagram is to be read in conjunction with the RICS professional statement *Whole life carbon assessment for the built environment*, 1st edition (2017).



Appendix 2: Glossary

BIM: Building Information Modelling; it is the process of digitally representing and managing the properties of objects.

BoQ: Bill of Quantities: list of materials used in a project.

BREEAM – Building Research Establishment (BRE) Environmental Assessment Method: a well-established UK-based, internationally applied scheme for the evaluation, rating and certification of the sustainability of buildings developed by the BRE.

BRUKL: reporting according to Building Regulations UK Part L.

C2C: Cradle to cradle: product certification scheme based on sustainability and circular economy principles.

Circularity: process considering the potential for recovery, reuse and recycling of items following circular economy principles.

CLT: Cross Laminated Timber: type of engineering timber for structural use.

CO₂e: Carbon dioxide equivalent: metric expressing the impact of all greenhouse gases on a carbon dioxide basis.

COP21: 2015 United Nations Climate Change Conference.

CPI: Consumer Price Index.

DER: Dwelling Emission Rate: actual carbon emissions of a building in accordance with SAP calculations.

EoL: End of Life.

EPD: Environmental Performance Declaration.

FF&E: Fittings, Furnishings and Equipment.

FSC: Forest Stewardship Council: forest certification scheme for sustainable timber sourcing.

GHG emissions: Any gases that contribute to the greenhouse effect that causes global warming. The primary greenhouse gases in the Earth's atmosphere are: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (NO₂), ozone (O₃), chlorofluorocarbons (CFCs) and water vapour (H₂O).

GIA: Gross Internal Area of buildings according to RICS property measurement standards.

Grid decarbonisation: gradual reduction of the energy and carbon intensity of electricity production.

GWP: Global Warming Potential.

HFC: Hydrofluorocarbons.

HGV: Heavy Goods vehicle.

HVAC: Heating, Ventilation and Air Conditioning.

ICT: Information and Communications Technologies.

IPMS: International Property Measurement Standards.

LCA: Life cycle assessment.

LEED: Leadership in Energy and Environmental Design: US-based internationally applied scheme for the evaluation, rating and certification of the sustainability of buildings by the USGBC.

MEP: Mechanical, Electrical and Plumbing equipment.

O&M: Operation and Maintenance.

PEFC: Programme for the Endorsement of Forest Certification: forest certification scheme for the sustainable timber sourcing.

PV: Photovoltaics cells: technology producing electricity from renewable solar energy.

RSP: Reference Study Period – see section 3.2.3.

SAP: Standard Assessment Procedure: calculation method for the energy performance of residential buildings for compliance with the UK Building regulations.

SBEM: Simplified Building Energy Model

Scope 1, 2 and 3:

- Scope 1: direct GHG emissions arising from energy use (combustion) on site.
- Scope 2: indirect GHG emissions arising from the use of purchased electricity, heat or steam.
- Scope 3: other indirect (embodied) GHG emissions, according to the GHG Protocol.

TER – Target Emission Rate: targeted emissions a building needs to achieve in accordance with SAP calculations.

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