Delivering Policy CC6: Embodied carbon

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1 Introduction

Buildings contribute to climate change through emissions of greenhouse gases resulting from the materials, construction, and use over their entire life. This is known as a building's Whole Life Carbon (WLC) emissions. In the built environment, WLC is composed of (i) operational carbon and (ii) embodied carbon. Operational carbon encompasses the emissions associated with the energy used to operate a building such as heating, hot water, ventilation, and lighting; and it is regulated[a] under Part L of the Building Regulations [1]. Embodied carbon emissions are those associated with the materials used, construction, maintenance, demolition, and waste disposal within the asset [2]. These are accurately represented in BS EN 15978-1 [3], where the different lifecycle stages are defined in four modules which are subsequently broken down into further stages (Figure 1).

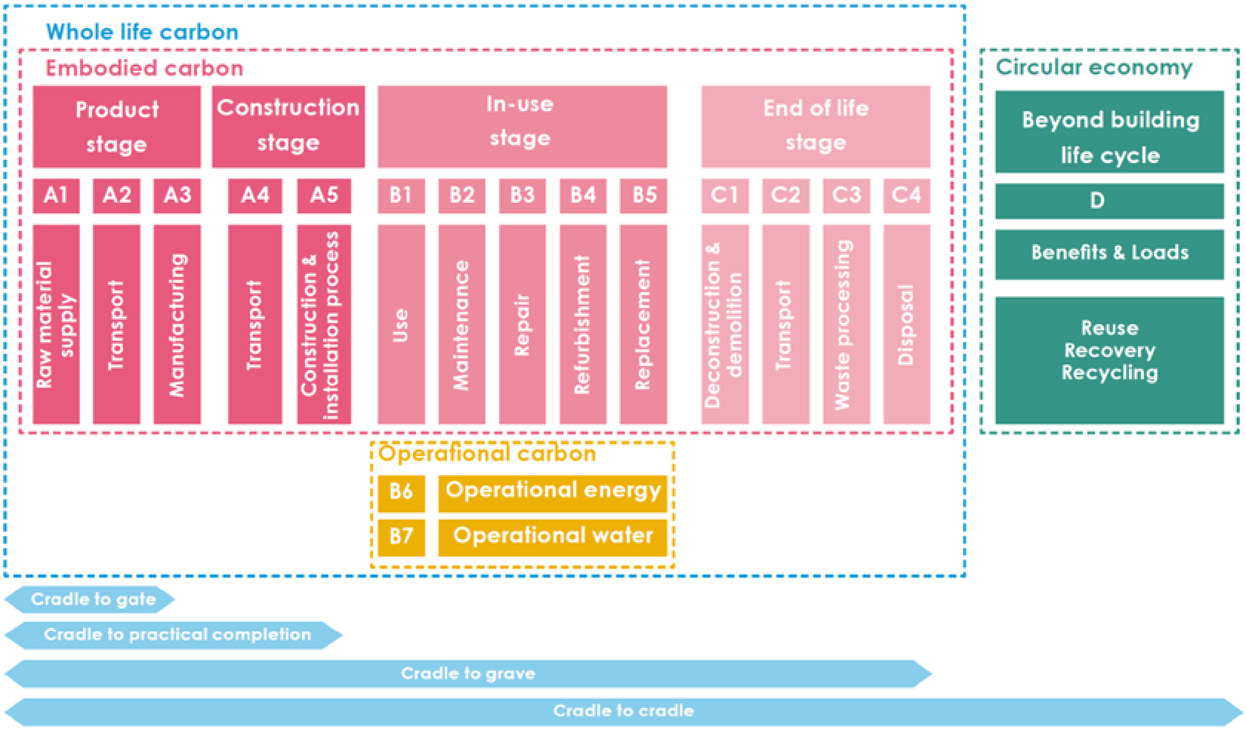

Figure 1. Lifecycle stages defined by BS EN 15978-1[3]

Module A covers 'Upfront' emissions associated with the production and construction stages. Module B covers the in-use stage and includes the embodied carbon arising from maintenance activities, and the operational carbon from energy and water use. Module C covers the End-of-Life emissions arising from the demolition and waste processing. Together, emissions from modules A, B, and C (excluding Operational Carbon stages B6 and B7) make up Embodied Carbon.

Module D covers impacts beyond the building life cycle. It can be thought of – in combination with modules C1 and C3 – as the Circular Economy module. It quantifies the potential future

[a] Note Part L covers regulated emissions only, for example from fixed building services such as heating and lighting. Some unregulated uses for example equipment use or catering are not covered by regulations.

carbon benefits or burdens from current design decisions. It includes the impacts of carbon sequestration, and it should be reported separately as it is not included within targets for 'Upfront' or 'Whole Life Carbon'.

1.1 Importance of reducing embodied carbon emissions

Over time, embodied carbon is projected to make up an increasingly large proportion of emissions associated with the built environment. Ongoing technological advancements to decarbonise the grid through renewable electricity generation and a shift to low-carbon electric heat pumps will reduce operational carbon emissions to very low levels. The proposed 75% reduction in emissions proposed in the 2025 Future Homes Standard (FHS) [4] will place further emphasis on the burden from embodied emissions. Initial analysis suggests regulated energy operational emissions may only be 3% of the lifetime emissions for a typical building. If the UK Net Zero by 2050 target is to be met, embodied carbon reductions need to keep up with reductions to operational emissions.

In order to address this issue, the Low Energy Transformation Initiative (LETI), the UK Green Building Council (UKGBC), and the Royal Institute of Chartered Surveyors (RICS) have produced extensive sector guidance covering definitions, potential pathways, target setting, and calculation methods. These have been designed to standardise performance to meet IPCC recommendations and have been developed alongside the Royal Institute of British Architects (RIBA) and the Institution of Structural Engineers (IStructE).

A building is considered to have Net Zero Carbon (WLC) when it is operationally net zero, made from 100% re-used materials, and 100% of the materials are reusable in future builds (when construction, transport and disassembly are carried out with renewable energy) [5]. There is a school of thought that offsets may be employed to achieve net zero embodied carbon, but this is controversial, and LETI suggests prioritising circularity. Thus, the UK must transition from a linear economy to a circular economy to achieve true net zero embodied carbon buildings. In practice this is hard to achieve in the current UK market and some embodied emissions are unavoidable. However, policies and standards to address embodied carbon requiring emissions to be quantified and their impact to be reduced can make significant reductions in embodied emissions.

Embodied carbon target setting

LETI has developed a letter rating system for four building archetypes to provide alignment in embodied carbon measurements and comparisons [6] (Figure 2). The current average design achieves an E rating, whereas the proposed best practice LETI 2020 Design Target achieves a C rating. Furthermore, the LETI Design Target 2030 achieves an A rating. The RIBA 2030 Climate Challenge [7] built performance target aligns with these ratings as a B rating. While these ratings are targets rather than limits, they are representative of those that exemplary developments should follow if net zero is to be achieved in the building sector.

Upfront Embodied Carbon, A1-5 (exc. sequestration)

	Band	Office	Residential (6+ storeys)	Education	Retail
	A++	<100	<100	<100	<100
	A+	<225	<200	<200	<200
LETI 2030 Design Target	A	<350	<300	<300	<300
	B	<475	<400	<400	<425
LETI 2020 Design Target	C	<600	<500	<500	<550
	D	<775	<675	<625	<700
	E	<950	<850	<750	<850
	F	<1100	<1000	<875	<1000
	G	<1300	<1200	<1100	<1200

Figure 2. Upfront Embodied Carbon Target Alignments values for different developments from LETI [6]

1.2 Exeter Plan– Policy CC6 on embodied emissions

In its 2021 'Net Zero Whole Life Carbon Roadmap' [8], UKGBC recommends local authorities begin to implement requirements for mandatory measurement of WLC, including embodied emissions. Exeter City Council has followed this recommendation by including policy CC6 on embodied carbon in the Exeter Plan [9], as follows:

> *To drive action to reduce embodied carbon emissions, major development proposals will only be permitted where:*
>
> - *The impact on climate change from carbon emissions embodied in the product and construction stages of development is calculated using a nationally recognised carbon assessment method; and*
> - *It is demonstrated that adequate steps have been taken in the product and construction stages of development to reduce this impact.*
>
> *Minor residential development proposals that involve one-for-one replacement of existing habitable dwellings will only be permitted where it can be demonstrated that refurbishment is neither viable nor practical, or where it is demonstrated that the proposed new build performs better than refurbishment in terms of its lifecycle carbon footprint.*

2 Achieving Policy CC6

Exeter City Council provides a checklist[b] reviewing the quantification and mitigation of embodied carbon emissions to aid successful delivery of the policy. Further guidance on achieving the targets set out by Policy CC6 are outlined below.

2.1 Embodied carbon emissions calculation

CC6 focuses on emissions embodied in development materials, also known as 'Upfront Emissions', so embodied carbon quantification is only necessary for BS EN 15978-1 stages A1-

[b] See accompanying checklist document

A5. Quantification of BS EN 15978-1 modules B and C is also encouraged. Nationally recognised approaches to calculate embodied carbon are as follows:

- Standard- Suitable embodied carbon calculation approaches should conform with BS EN 15978-1.
- Methodology- RICS Professional Standard: *Whole Life Carbon assessment for the built environment 2nd edition* [10] provides the most nationally consistent and up-to-date standard for embodied carbon assessments. The London Plan Guidance (LPG): Whole Life-Cycle Carbon Assessments [11] also provides a good methodology, but it is more applicable and comparable to major London developments.
- Data sources- Valid data sources for embodied carbon factors include but are not limited to verified Type III Environmental Product Declarations (EPDs), proprietary data verified and peer-reviewed to conform with ISO 14067 or PAS 2050:2011, the University of Bath ICE Database, RICS Professional Standard default values, or manual calculations using the 'RICS Methodology to calculate embodied carbon of materials' [12].
- Data quality- Data must conform with data quality standards ISO 14064-1, ISO 14064-2, The Greenhouse Gas (GHG) Protocol Scope 3, PAS 2080:2016 Carbon management in infrastructure. All data must be third party verified and should reflect the geographical location of the project.
- Study Periods- Assessments should have a 'cradle to practical completion' reference study period encompassing the product and construction stages (A1-A5).
- Scope- Embodied carbon assessment should cover all items listed in the project's Bill of Quantities, cost plan, or other design information. All building elements should be covered, including Facilitating Works, Substructure, Superstructure, Finishes, Fixed Furniture and Equipment (FF&E) (non-fixed excluded), Building Services, Prefabricated Buildings, Works to Existing Building, and External Works. 95% of the cost allocated to each building element category should be accounted for in the assessment.
- Software tools- BIM based tools offering integration of embodied carbon assessments with the design processes are recommended for ease. Several commercial tools are available. There are also freely available tools such as The Structural carbon tool – Version 2 by IStructE.
- Units- As a minimum for the development, Embodied Carbon should be reported in standard units (overall tCO_2e and kg CO_2e/m^2, gross internal area (GIA)), with a preference for also breaking down these overall numbers into building types.
- Reporting- Reporting forms should be consistent with the calculation method used. Both LETI and RICS provide analogous reporting templates that are standardised and widely used. It is worth noting the reporting template for the RICS Professional Standard 2nd edition is slightly more detailed.

- **Time of assessment-** RICS recommends for the assessment to take place before the commencement of the technical design, during the concept design phase (RIBA Stage 3), as decisions are more influential at this stage. A post-construction assessment is also recommended to represent the 'as built' carbon budget. Interim assessments can be carried out according to the nature of each project.

Developers should provide valid justification should they decide to take on an alternative approach. It is encouraged for all developers to submit embodied carbon assessments to the Built Environment Carbon Database (BECD) as it will help build knowledge on reducing embodied carbon emissions and it will maximise reporting consistency. Further guidance on assessing embodied carbon can be found at LETI Embodied Carbon Primer [5], RICS Professional Standard: Whole Life Carbon assessment for the built environment 2nd edition [10], UKGBC Embodied Carbon Scope 3 Measurement and Reporting [13], and PAS 2080 framework (2016 Carbon management in infrastructure) [14].

2.2 Embodied carbon emission reduction strategy

Reducing embodied carbon is a broad challenge that can take numerous approaches. LETI establishes a recommended hierarchy to follow when reducing the embodied carbon of each building element [15]:

1. Build less
2. Build light
3. Build wise
4. Build low carbon
5. Build for the future
6. Build collaboratively

In essence, LETI is urging developers to prioritise circularity by building less and building wisely by reusing existing infrastructure, reviewing structural loadings, reducing material quantities, reviewing material efficiency, and ensuring material longevity. If all possible material reductions have been applied, then the next step is to reduce the use of high embodied carbon materials, particularly in the 'big ticket' building elements that provide the greatest carbon reduction opportunities e.g., foundations, upper floors, or framing. Finally, designing for durability, flexibility, and easy disassembly ensures circular economy at the end of life of a building and allows for embodied carbon reductions in future builds.

There are many ways in which embodied carbon can be reduced at each stage in the hierarchy. The LETI Embodied Carbon Primer [5] provides a comprehensive list of 'rules of thumb' that outline the most common ways of maximising opportunities for low carbon design. Although this list is good guidance, it is not all-encompassing and there are numerous alternative methods of reducing embodied emissions.

Common ways of mitigating embodied carbon include removing basements and parking from substructures, using recycled materials, using cement replacement mixes, using renewable elements such as timber or earth, using lime render and mineral wool in the façade, using refrigerants with low GWP and leakage, or preserving/re-using existing superstructures, among many others [5].

For example, although not a direct substitute, general concrete with 70% ground granulated blast-surface slag substitute for cement (GGBS) would have 0.034 kg CO_2/kg of embodied carbon, which is 80% lower than the 0.172 kg CO_2/kg of carbon embodied in reinforced concrete with no cement substitution. Furthermore, for buildings which start with a steel frame structure, using a mass timber structure would have an approximate 12% reduction in embodied carbon [16]. Finally, metals have very high embodied carbon, and their use should therefore be limited, or it must be ensured that they can be recycled at the end of life. For instance, a profiled aluminium façade has 682 kg CO_2e/m^2 of embodied carbon, whereas a flat ceramic façade has 140 kg CO_2e/m^2[5].

To demonstrate that adequate steps have been taken to reduce embodied carbon emissions, developers should adopt the following three-step process:

1. Create an initial baseline embodied carbon assessment based on common practice assumptions. This allows for identification of the 'big ticket' building elements that have the most embodied carbon reduction potential.
2. Apply an embodied carbon reduction strategy to each element, implementing best practice reduction measures.
3. Carry out an optimised embodied carbon assessment illustrating the percentage reduction achieved and the measures implemented to do so.

Alternative demonstrations of active efforts to reduce embodied emissions must provide thorough explanations of the methodology used and must be accompanied by a quantitative assessment of the reduction achieved.

Cost of implementation

Undertaking embodied carbon assessments requires the appropriate assessment tools. The software is commercially available, or there are free alternatives (see Section 2.1). The time associated with embodied carbon assessments varies based on project type, size, and methodology used and should become part of the standard design process.

Significant embodied carbon reductions can be achieved at no additional cost [17]. A recent study by WSP [16], comparing the current industry standard to a set of scenarios with measures to reduce embodied emissions, found that for most typologies the current LETI 2020 Design Target can be achieved with no cost uplift. For LETI's and RIBA's 2025/2030 future targets, a cost uplift of 6-16% is estimated with the range depending on the building type and the reduction measures used. While this study only considered the structural components with the highest embodied carbon (substructure, superstructure, and finishes), it illustrates how better design, better management, and better material choice can substantially reduce embodied emissions at no additional cost, especially if these changes are considered upfront before the design approach is resolved.

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