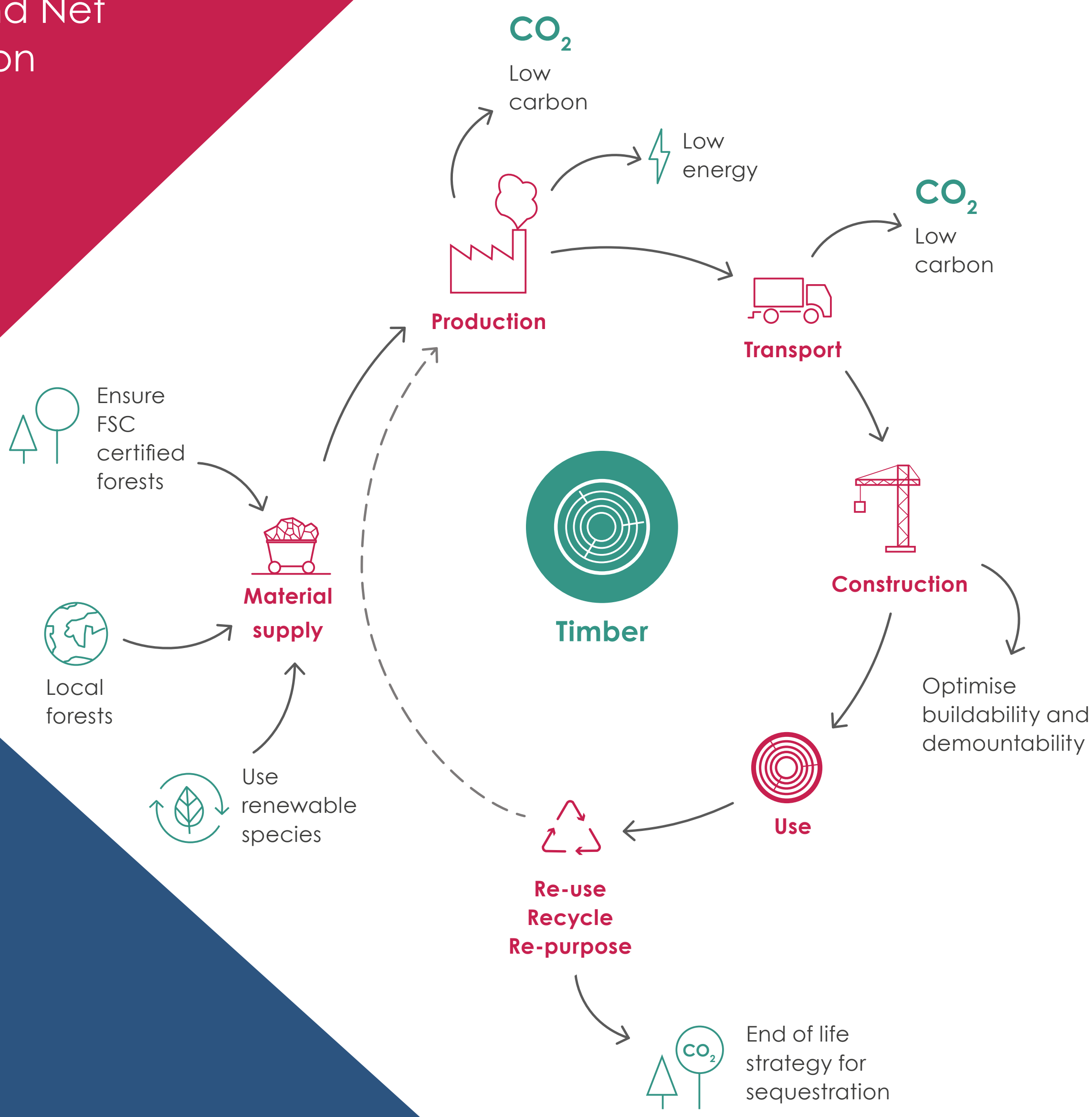
LETI Low Embodied Carbon Specification and Procurement Guide

For Low and Net Zero Carbon Buildings



LETI

About LETI

LETI is a voluntary network of over 1,000 built environment professionals, working together to put the UK and the planet on the path to a zero carbon future. Our vision is to understand and clarify what this means in the built environment and develop the actions needed to meet the UK climate change targets.

We do this by:

→ **Engaging with stakeholders** to develop a robust and rapid energy reduction approach, producing effective solutions to the energy trilemma of security, sustainability, and affordability.

→ **Working with local authorities** to create practicable policy to ensure the regulatory system is fit for purpose, placing verified performance at its core.

→ **Encouraging and enabling collaboration** between a large, diverse group of built environment professionals.

→ **Providing technical guidance to support exemplar development,** enabling pioneers who aspire to go beyond the current regulatory frameworks

Our volunteers are made up of developers, engineers, housing associations, architects, planners, academics, sustainability professionals, contractors and facilities managers, with support and input provided by local authorities and other organisations.

Originally the 'London Energy Transformation Initiative' (LETI) was established in 2017 to support the transition of the London's built environment to meet Net Zero Carbon. Since then, LETI has formed as a Community Interest Company and altered our name to become the 'Low Energy Transformation Initiative', but predominantly we are known as LETI. This reflects our interest in all UK zero carbon policy and regulation.

LETI has focused on providing guidance on defining what good looks like in the context of the climate emergency, publishing guidance documents, one-pagers, case studies and opinion pieces.

For more information on LETI, please see:
www.LETI.uk

LETI

With thanks to all who contributed to this guide:

1. Alex Johnstone
2. Clara Bagenal George
3. Clare Murray
4. Clodagh Cant
5. Duncan Cox
6. Elaine Toogood
7. Erica Russell
8. Francesca De Petris
9. Joe Jack Williams
10. Julia Messenger
11. Kallum Desai
12. Louisa Bowles
13. Magdalena Kraska
14. Milena Stojkovic
15. Mirko Farnetani
16. Nancy Jonsson
17. Nuno Correia
18. Phil Obayda
19. Romane Sanchez
20. Sidonie Immler
21. Simon Perks
22. Sukriye (Rae) Robinson

Contents

Executive Summary

A roadmap to low carbon

This guide has been created to support designers and contractors who are facing the difficult task of trying to reduce embodied carbon without a clear roadmap to follow. When LETI started work on this guide we were determined that it would offer practical advice that could be applied at different scales of building. We have consulted widely with industry experts to provide their thoughts on how to manage the procurement process and specifications, offering you an approach which we hope you can develop and adopt to your projects. This work includes an embodied carbon reduction roadmap for projects, suggesting how embodied carbon reduction can be brought into the early stages of the design process, as well as learning from the final build. This document also includes guidance on material efficiency and specification, provided in a series of material guides and finally, three case studies, specifically chosen to illustrate the embodied carbon reduction roadmap.

Using the expertise of our LETI volunteers we mapped out our initial ideas, guided by only a few examples. However, as we have refined the contents, we have seen many elements of the approach provided in this guide being used by major clients, designers, engineers and contractors. Whilst we know that low embodied carbon contracts are not yet seen on all major projects, and only a few smaller ones, it is important that the lessons learned from these major contracts can be utilised by others that seek to introduce low embodied carbon specification and procurement practices. We have tried to illustrate the importance of this multi-tier supply chain approach in the three case studies within this guide.

We accept that implementation of reduction in embodied carbon through procurement is still in its infancy, many elements are still being tested and that this guide can only be a point-in-time assessment of current practices. Yet, we hope that it allows the industry to bring embodied carbon to the attention of more clients and provides all tiers within the supply chain an opportunity to contribute to the reduction of carbon.

Other considerations

Carbon emissions are only one of the many environmental sustainability indicators that should be considered and controlled through sustainable procurement. Carbon emissions occur throughout the life cycle of a product or building element, and entire building or asset, including manufacture, transportation, construction, use, maintenance, replacement and end of life scenarios such as demolition. Assessment and reporting of whole life carbon (WLC) is the recognised approach to reduce carbon emission in the built environment.

This publication focuses on reducing upfront embodied carbon emissions, which is typically a significant proportion of WLC emissions. However, attention should be given to ensure that a focus on upfront emissions does not negatively impact on WLC, especially with regards to operation, length of service life and end of life scenarios.

It should be noted that the intent of this guide is not to compare materials against others but is designed to steer designers and contractors to low embodied carbon approaches for specific materials

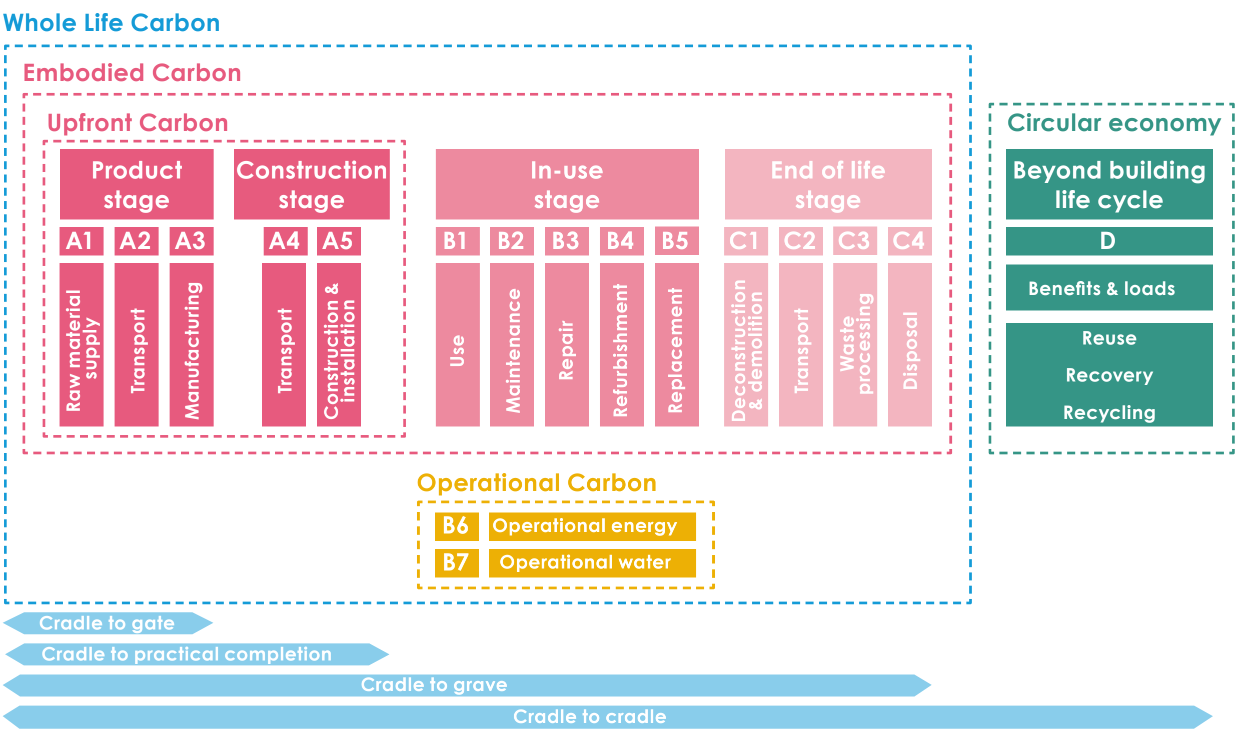
It is also important at the outset to establish some critical terms used within this document.

'Whole Life Carbon' emissions are the sum total of all asset related GHG emissions and removals, both operational and embodied over the life cycle of an asset including its disposal (Modules: A0-A5; B1-B7; B8 optional; C1-C4, all including biogenic carbon). Overall Whole Life Carbon asset performance includes separately reporting the potential any benefits or loads from future repurposing of the asset's resources: material/component reuse, recycling, energy recovery, etc. reuse, and recycling (under Module D).

'Embodied Carbon' for Life Cycle Embodied Carbon: 'Embodied Carbon' emissions of an asset are the total GHG emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A0-A5, B1-B5, C1-C4).

'Upfront Carbon' (buildings): 'Upfront Carbon' emissions are the GHG emissions associated with materials and construction processes up to practical completion (Modules A0-A5), with A0 assumed to be zero for buildings. Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion.

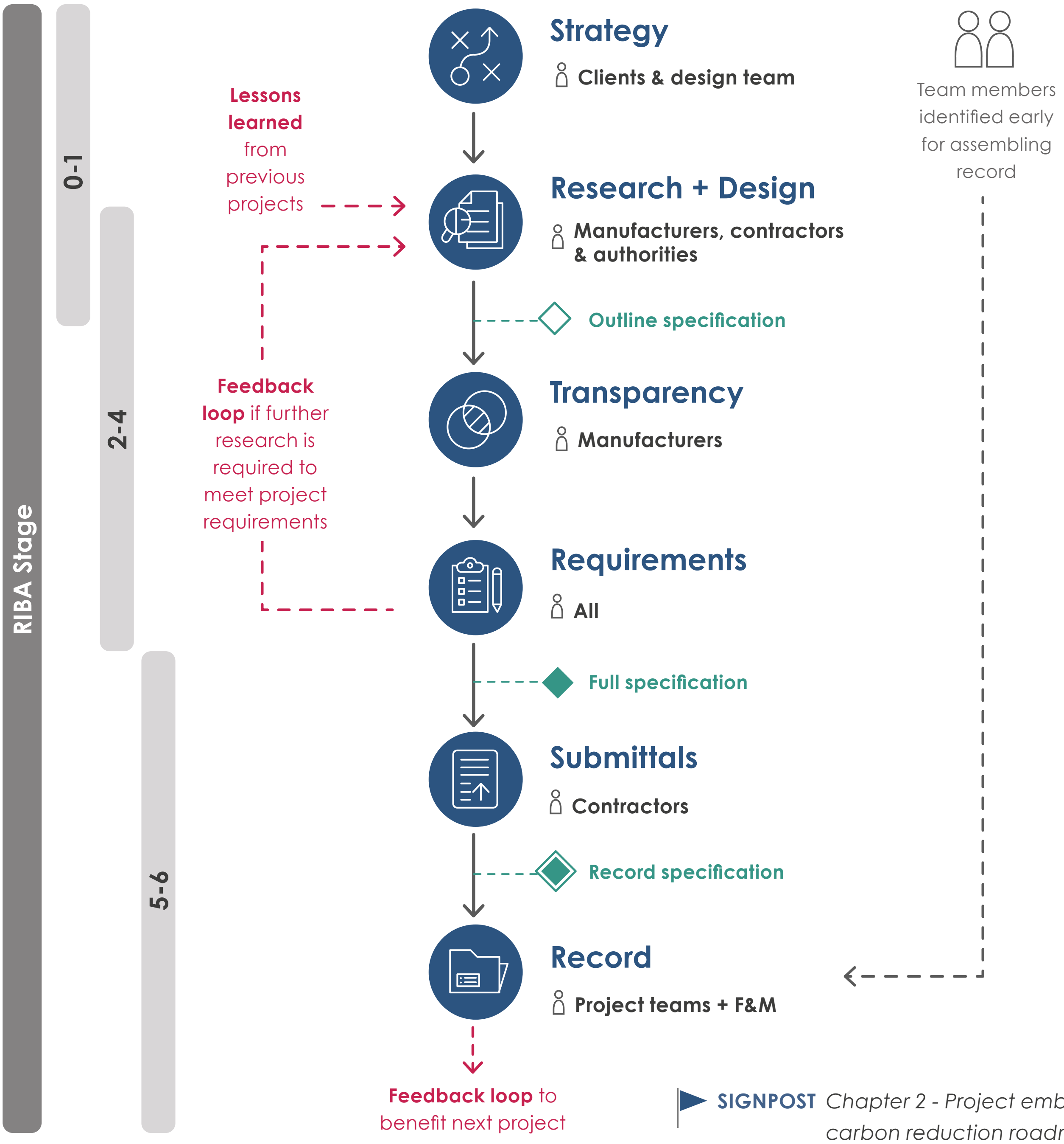
SIGNPOST *WLCN - Carbon Definitions for the Built Environment, Buildings & Infrastructure*



Specification and procurement quick start guide

1 Make a successful carbon reduction roadmap

A successful carbon reduction roadmap developed by the project team would typically consist of the following:



SIGNPOST *Chapter 2 - Project embodied carbon reduction roadmap*

② Use specification to ensure low carbon procurement

SIGNPOST *Chapter 3 - Types of specification*

Two types of specifications:

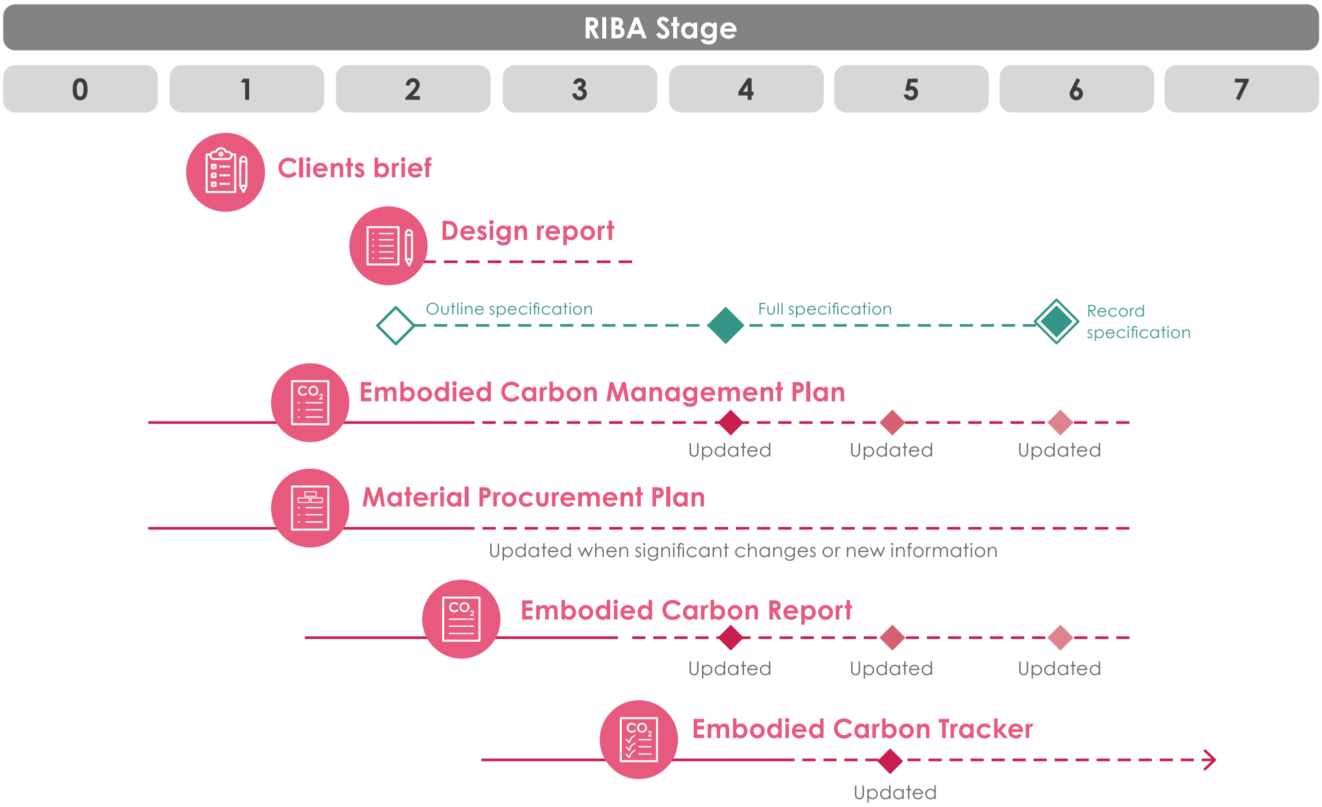
① Prescriptive
- Specific requirements
- Challenge: higher cost

② Performance based
- Overall ambition
- Challenge: fitting carbon budget

③ Document embodied carbon

SIGNPOST *Chapter 4 - Embodied carbon assessment and procurement*

The project's embodied carbon limits should be incorporated into different types of documents for improved assessment and procurement.



④ Specify and procure low carbon materials

SIGNPOST *Chapter 5 - Materials guide*

Focus on the big wins for each project by ascertaining where the greatest reductions can be made for specific products/materials.

⑤ Case studies

SIGNPOST *Chapter 6 - Case studies*

1

Introduction

1.0 Introduction

This document is aimed primarily at construction sector professionals - architects, designers, clients and contractors to help deliver low carbon project aspirations.

1.1 Purpose of this guide

The LETI Embodied Carbon Primer was created to help designers to make embodied carbon reduction strategies on projects. The Low Embodied Carbon Specification and Procurement Guide is intended to support that process by considering specification and procurement in more detail, thereby helping to reduce the embodied carbon performance gap between the design intent and the reality of construction.

Design and construction is a complex process, with many factors, processes and issues to consider. Until recently embodied carbon has not been a significant factor of consideration. This guide aims to share the collective experience of low embodied carbon project delivery, to provide greater understanding of the barriers and opportunities and raise awareness of techniques that can be employed to reduce the embodied carbon of new construction. In particular, the need for greater engagement between all members of the supply chain.

The key questions this guide seeks to address are:

→ What needs to be included in a specification to give contractors scope to deliver construction projects with low embodied carbon?

→ What are the issues in the procurement process that prevent the realisation of intended embodied carbon savings, and how can they be addressed?

→ How can the design team work better with contractors, suppliers and manufacturers to deliver low embodied carbon?

To assist the users of this guide an overview of the different types of specification and procurement that exist in the industry are outlined in the following paragraphs.

1.2 Types of specification

There are different types of specifications that can be produced for construction projects, depending on Work Stages, type of procurement and agreed risk allocation of the project. These can be broadly categorised as:

Outline Specifications:
Outline Specifications aim to describe the main components of a construction project sufficiently to indicate the design intent (including main materials and proposed products) and some information on performance and preliminaries, where known at this stage. This is to provide information to the cost consultant in order to prepare approximate quantities. They are usually delivered at the end of RIBA Stage 3 and are normally not used for tender purposes. Any net zero carbon ambitions or requirements should already be included at this stage.

Full Specifications:
Full Specifications are written legal documents forming part of the contract documents for construction projects. They describe the scope of work, any materials or products that are to be used, standards to be complied with, tolerances, methods of installation, and quality of workmanship. A concise specification will allow the contractor to price the works as accurately as possible for their tender return. It is therefore crucial that to help direct the contractor, carbon targets (overall or specific) or products selected to meet carbon targets and requirements are provided in the specification.

Record Specification:
Record Specifications (or As-Built Specifications) are compiled by the contractor and incorporate all changes, documenting the products, methods, and materials incorporated into the completed works. To allow full life cycle analysis and documentation, they should ideally also give information on as-built carbon.

1.3 Types of procurement

Specifications also need to be tailored to the type of contract the client and contractor are planning to engage in:

Traditional procurement:
Traditional contracts require a full specification at tender stage for the contractor to price the works. The contractor usually does not come on board until a late stage (Tender) when the design and material choices are mostly fixed, this restricts any information from the contractor regarding their supply chains feeding into the early decision making regarding embodied carbon. Pre-contract Service Agreements (PCSAs) can be a useful tool to unlock this information earlier. To ensure the contractor can price and build the Works, the tender specification needs to be concise and complete as to which and how embodied carbon goals are to be achieved.

Design and Build contracts
In Design and Build procurement, the main contractor is responsible for both the design and construction work on a project, for an agreed lump-sum price. Descriptive specifications are produced to form part of the Employer's Requirements, usually at Stage 3 and handed over to the contractor. These specifications need to clearly indicate the net zero ambitions. Two stage tendering allows the contractor to give input on embodied carbon earlier on. Either way, the carbon targets to be achieved need to be clearly identified in the specification for the contractor to price and mechanisms identified to ensure they are delivered upon.

Other types of contracts:
There are many other types of construction procurement, with specifications playing a vital part in documenting requirement. These include collaborative contracts, management contracts, contracts with incentives for low carbon procurement.

Industry experience indicates that contracts which allow early collaboration across the value chain increase the opportunity to maximise the reduction of embodied carbon. To assist the user of this guide it is important to have familiarity of the different types of specification and procurement that exist in the industry as an overview which are outlined in the following paragraphs.

Integrated Project Insurance (IPI) procurement model
This is a procurement model introduced by the Government approximately ten years ago and has been utilised succesfully by several projects.

As per the Government's definition, this model "unlocks the potential of integrated collaborative working" by aligning client's functional needs with all other team members' interests, working within a culture of collaboration, and by setting a cap of financial exposure for all parties. This provides an environment of shared responsibility for a project.

A single integrated project insurance covers the usual insurance products such as PI, contractor's insurance, latent defects and cost overrun, fostering creativity and collaboration as it removes the conflicts related to insurance concerns.

IPI types of contracts facilitate management of projects with ambitious and high-risk objectives such as those related to embodied carbon limits, where collaboration and shared risk allow to mitigate uncertainties related to market volatility, data availability and supply chain fluctuations, which may otherwise stifle creativity and create procedural obstacles.

2

Project embodied carbon reduction roadmap

2.0 Project embodied carbon reduction roadmap

For a low carbon strategy to be successfully delivered, clients and designers need to be engaged in the carbon reduction process from the outset of the project. Whilst projects will inevitably progress through the linear RIBA Plan of Work Stages, designing for low carbon, much like most design processes, is iterative.

That said, designers should be aware of the opportunities that are available to them at each stage of the process. Opportunities exist to reduce the carbon footprint of a building through retrofit and re-use. Pre-demolition audits and research into local salvaged materials also can be key to reducing embodied carbon but still need to be specified. Industries across the building spectrum are advancing their efforts to reduce embodied carbon through new manufacturing processes and with new product development. It is therefore imperative that designers continually engage with contractors and manufacturers to learn what is available, and to understand what impact these selections have on project design and to the procurement process. As a minimum they must determine the following:

→ What products are available on the market?
→ What product is appropriate to the project?
→ What impact these selections have on the design, the procurement processes and embodied carbon?

With the industry moving rapidly, the early research carried out by the design teams needs to be ratified throughout the design process. This will ensure that the specifications can provide the contractors with adequate scope and flexibility to deliver the project within the carbon targets established. Depending on project time-scales and the rapid development of approaches there may be the ability to improve on initial targets and this flexibility should be enabled while ensuring clear limits are set.

A project-specific embodied carbon reduction roadmap should enable all members of the project team to coalesce around and make time for the iterative activities that need to be undertaken across each stage of the project. This will ensure that impactful opportunities are considered at the appropriate juncture of the project development, and avoid measures/changes being introduced at a late stage where it can negatively impact both cost and programme.

It should be recognised that depending on the expertise of the design and construction team, additional specialist appointments, programme and fees may be required to develop an appropriate project carbon reduction strategy and implement it successfully. This should be raised at the earliest opportunity on commencement of the project with the client and project managers.

A successful carbon reduction roadmap developed by the project team would typically consist of the following six steps:

1. Strategy
2. Research + Design
3. Transparency
4. Requirements
5. Submittals
6. Record

It has been recognised as best practice within the industry that a minimum three full carbon analyses should be undertaken. (See Chapter 3, Section 3.5 for further information).

SIGNPOST *Chapter 3 - Types of specification*

Steps of a successful carbon reduction roadmap:

Strategy: Prepare whole life carbon reduction strategies with client and design team at the earliest stage of the project to set project targets for embodied carbon, set key project dates for delivery of information and identify appropriate opportunities.

Research + Design: Engage with manufacturers, contractors and relevant authorities to determine appropriate material, product and component selection based on performance and design requirements, whole life carbon impact and procurement implications. Refer to chapter 4.2 for the different types of deliverables that are available for managing sustainable procurement.

SIGNPOST *Chapter 4 - Embodied carbon assessment and procurement*

Transparency: Specify products and materials from manufacturers who can supply verified product declarations.

Requirements: Expand specifications to capture contractual criteria and targets relevant to reducing embodied carbon such as Global Warming Potential (GWP) data provided in Environmental Product Declarations (EPD), waste rate reduction; transportation and responsible sourcing. Include requirement to record procured and as-built carbon data.

Submittals: Engage with contractors to ensure that relevant GWP data and material information are included in the contractor's submittals.

Record: Obtain final as-built material data to calculate as-built embodied carbon of project. Project teams should identify at an early stage which party will be responsible for assembling this information. Record information for the O+M Manual, including information regarding maintenance and recovery. The collection of record information on carbon will benefit the project team as part of a feed back loop for future projects. In addition, any gaps that have occurred between design data and record data can be identified. Sharing this information with the wider value chain allows future strategies to engage with this issue. Finally, the procurement strategy of products/ materials should be presented to the Facilities and Management Team to inform their in-operation procurement decisions.

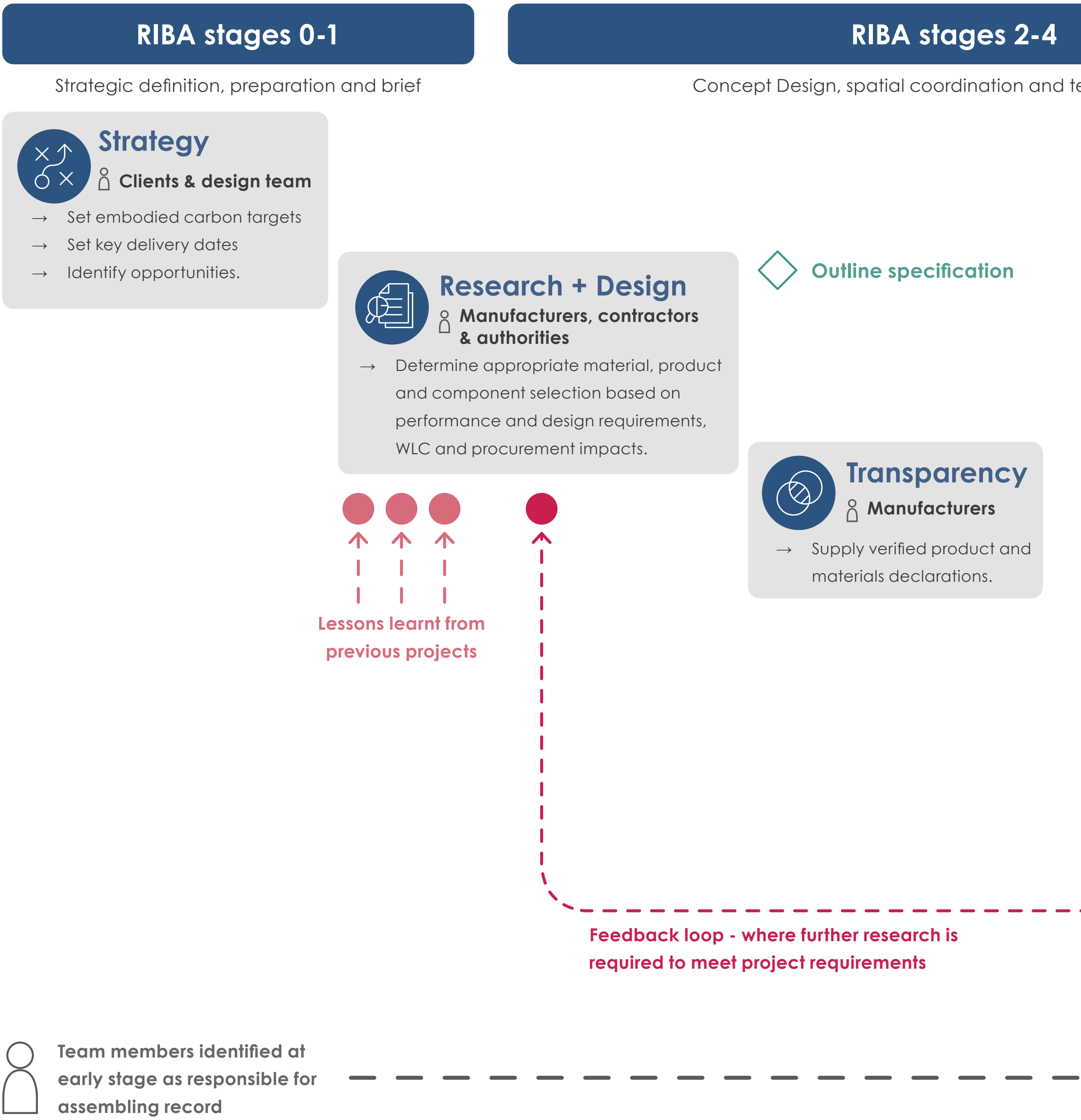


Figure 2.1 - Steps of a successful carbon reduction roadmap

echnical design

RIBA stages 5-6

Manufacturing, construction and handover

Requirements

All

- → Expand specifications to capture set criteria and targets (GWP data, waste rate reduction, transportation, responsible sourcing)
- → Include requirement to record procured and as-built carbon data.

Full specification

Submittals

Contractors

- → Ensure relevant GWP data and material information are included.

Record specification

Record

Project teams + F&M

- → Calculate final as- built embodied carbon of project from data
- → Record information for the O+M Manual (including maintenance and recovery)
- → Collect and share data with wider value chain, enabling industry to gauge design vs. record data gap and propose strategies
- → Procurement strategy to inform facilities & management in operation decisions.

Feedback loop of carbon information collection to benefit next project

3

Types of specification

3.0 Specification

A lot of good work is already being undertaken in terms of Life Cycle Assessments, overall targets being set and carbon reduction strategies developed at early stages of the project. In order to achieve these net zero ambitions, specifications play an important role in ensuring they are retained throughout the tender process and subsequent construction stages. It is therefore crucial to document requirements, methods for implementation and checking to ensure net zero ambitions are delivered upon on site.

3.1 Introduction

There has been a rapidly growing awareness within the sector of the importance that low embodied carbon procurement plays in supporting the climate emergency. This has not just been acknowledged by industry pioneers but increasingly is being incorporated in public sector requirements and client briefs. Accreditations such as LEED utilise carbon accounting and offer Materials and Resources (MR) credits, which consider the lifecycle impact of materials. Public bodies such as Greater London Authority and London Boroughs have included whole life carbon requirements within the London Plan, a statutory Spatial Development Strategy. A proposed new Approved Document Z as part of the Building Regulations Part Z will require carbon assessments to be undertaken. Finally, The Construction Playbook 2022, advises that for more complex public projects "the whole life carbon assessment approach should be clearly laid out in the technical specification/ specification of requirements".

As highlighted in Chapter 1, section 1.2, specifications are legal documents and form part of the contract set for a project. They are an essential source of information for the contractor in determining performance, quality, material, and workmanship requirements and being able to price and programme the work. It is therefore important to lock-in embodied carbon requirements into the specification to ensure the contractor meets the targets set for a project.

SIGNPOST *Chapter 1 - Introduction*

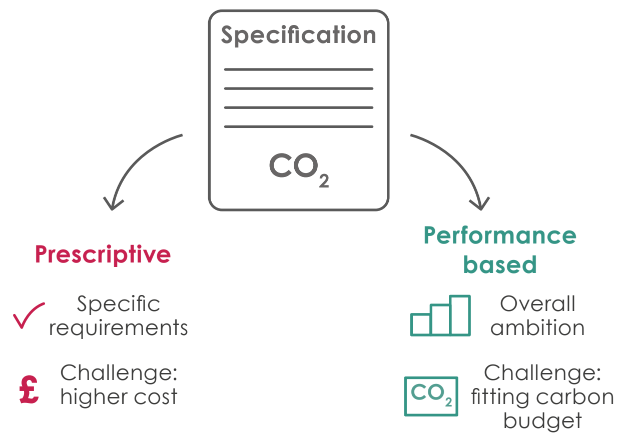
Detailed below are two types of specifications, which deal with low carbon procurement in different ways:

→ **Prescriptive specifications,** which set very specific requirements for certain products, elements or materials. For instance, a specific product is chosen or must have an EPD to prove a set carbon target is achieved.

→ **Performance based specifications,** which set an overall ambition for a contractor and give the freedom to achieve this in the best way their supply chains can provide.

The guide reviews both approaches, drawing on reflections from projects which achieved success.

The choice between these types of specifications depends on many factors, including type of project, type of contract, client requirements and aspirations, stage of project, and product or material for which the specifications are required.



It is generally recognised that the more flexible the specifications are (performance-based specifications), the easier it is for contractors to negotiate with suppliers over materials selection, which can result in reduced cost and minimised impact on project schedule. On the other hand, too much flexibility in specifying carbon requirements might lead to a general lack of control over the process, with materials being procured that do not fit into the overall carbon budget. Risks related to the latter approach can be minimised by assigning more carbon-competent resources to collaborate and get involved in the procurement process and introduce 'do-check-review' steps at regular intervals to verify the project is still within target. Often a combination of the two specification types is utilised for projects.

Carbon requirements introduce challenges into traditional procurement processes that require project teams to review the project procurement methodology as early as possible in the project life. Project teams must engage with the value chain to get more accurate information and have the possibility to influence the procurement process.

3.2 Prescriptive specification

This form of specification is a detailed materials and workmanship specification, reflecting the design solution and enabling a firm bill of quantities to be produced. Specific products and materials may be named, and the assembly will be described and supported with drawn information and schedules. However enough detail should be provided to allow for approved equivalents. Where products are not named, reference to published standards that govern the composition of materials are made (e.g. British Standards) or detailed requirements as to the materials composition are stated. The contractor may be required to provide some fabrication details, but design responsibility typically remains with the designer.

A prescriptive approach is used where the design of the building, or certain parts thereof are fixed at the point of tender and the contractor has relatively little influence on design changes.

Key considerations to reduce embodied carbon using this approach include:

→ **Specifications should clearly indicate quantifiable requirements** (e.g. recycled content, embodied carbon as stated in EPDs), how a certain carbon value is to be achieved (e.g. via cement replacement or other methods), or specific products that achieve the embodied carbon requirements.

→ **Clarity should be provided on the tolerance levels accepted for any deviation from specification.** Any contractor alternative proposals as part of requests for substitutions must be acceptable to the architect/engineer. For example, if the contractor offered an 'equivalent product', but the GWP figures deviated from specification by more than an acceptable rate as agreed before tender it would not be considered an equal alternative.

3.3 Performance approach

Performance specifications are typically used where a contractor or a specialist manufacturer has responsibility for the design, based on the criteria set in the specification. Specific performance values and targets that are to be met are listed as quantitative measurable requirements (e.g. maximum embodied carbon limit) or if applicable, any relevant codes and standards against which the performance requirements are then evaluated.

With this approach, it is important to set a final target/ KPI, and embodied carbon budget per element, which needs to be achieved (or improved on). To do this, a detailed carbon analysis needs to be provided to the contractor at point of tender. This should act as a baseline for the carbon target on the project. The detailed carbon analysis provides assurance that the overall carbon reduction targets can be met. The analysis should include at a minimum a list and description of materials to be used in the project, with preliminary quantities (volumes or weight), the carbon emission factors associated with them, and the total carbon emissions. The carbon analysis should be verified at regular intervals during the project, reflecting changes in the design and allowing flexibility to make changes in the materials, while ensuring the whole carbon reduction targets are still met.

As long as the overall targets and ambitions for carbon reduction are achieved, this approach allows the contractor and supply chain the flexibility to develop their own specific solutions. However, although with this approach a contractor can bring experience of low carbon options within the supply chain, it should be noted that low carbon buildings start with a low carbon design from an early stage. If a contractor is only involved from RIBA Stage 4, they will have limited ability to reduce carbon.

Key considerations to reduce embodied carbon using a performance specification approach include:

→ **A clear set of requirements**: this needs to be set (even if this is just that embodied carbon will be measured) and incorporation of the requirements into the tender questions.
→ **Ongoing engagement and advice:** a professional should be available to the contractor where indicative products are being proposed there should be a resource available (see Carbon Champions definition in Section 3.6) to undertake a comparative carbon analysis on the element.
→ **Preparation of options:** there may be compromises related to low carbon procurement cost or program (for example, if incorporating additional cement replacement in concrete longer curing time may be required). Options will need to be discussed openly across the value chain, including client, design team and contractor.
→ **Highlight embodied carbon requirements at tender** to explain why they have been incorporated and if any relative tolerance or variation is acceptable.
→ **Contractor's experience.** Include a question at tender stage regarding the contractors specific experience in emissions reduction through materials and products procured.
→ **Embodied carbon review process** should be made clear to the contractor and the relevant required paperwork highlighted (see also: 3.5 Sustainability Submittals).
→ **Supply chain engagement** is required to communicate the embodied carbon requirements and the contractor needs to include these requirements in their own procurement packages.

3.4 Implementation

Including embodied carbon requirements into specifications depends on the procurement route and the type of specification produced. There is no set way of providing this information and It can be done in a variety of ways suited to each project.

It is clear however, that embodied carbon emissions requirements need to be included in the specifications. The specifications should also include the type of submittals and the mechanism for verification of the comprehensiveness and compliance of the requirements.

Depending on the type of contract the project is adopting, the verification mechanisms could vary greatly. For example, the contract may require that there are material selection checkpoints that require embodied carbon verification and acceptance.

However, if the contractor is not required to submit each individual material transmittal (this could be the case of certain Design and Build contracts), a different compliance verification mechanism might be required. This could be actioned through the production of 'embodied carbon compliance reports' or 'embodied carbon budget calculations', to be provided at regular steps during the design and construction stage of the project, and also through additional submittals at construction stage.

3.5 Sustainability submittals

In addition to the general list of submittals called out in the specifications that the contractor is required to provide, a further type of submittal will need to be added to the list: Sustainability Submittals. These submittals should provide a declaration of embodied carbon, and should be listed in the Submittal Schedule forming part of the contract documents. The specification may state specifically in the work sections which submittals are to be provided by the contractor, or set out a more general requirement for the contractor in the A-Section. Several methods for providing evidence to validate the embodied carbon limits of materials set out in the specification are available (see following page) .

Submittal requirements should cover all tender, post contract and post completion submittals that are required to ensure low embodied carbon limits are being met. A clear strategy needs to be set and agreed with the client, as to who evaluates the sustainability submittals and has the capability and authority to reject or accept those when they are submitted by the contractor.

Example 'Sustainability Submittals' for monitoring embodied carbon:

Example 1: Setting-out specific submittal requirements

Sustainability submittals for embodied carbon monitoring:

a) Provide '**Sustainability Submittals'** as listed in the relevant Work Sections of the Specification, including but not limited to:

i) Environmental Product Declarations (EPD): Based on ISO 14025 or EN 15804 +A2 or ISO 21930 shall be Type III environmental declarations. Environmental Product Declarations shall have at least a cradle to gate scope.

ii) Cradle to Cradle Certified®.

iii) Declare Label.

iv) TM65 for MEP equipment

b) Prepare **low embodied carbon action plans** including the following:

i) List of all proposed products with Environmental Product Declarations.

ii) List of proposed products complying with requirements for embodied carbon targets set in b the Specification

c) **Low carbon progress reports**: With each valuation and application for payment, submit reports comparing actual construction and procurement activities with Low Carbon Action Plans.

d) Post Contract:

i) Submit **"As-built" upfront embodied carbon assessment report**, using the final material quantities to calculate the embodied carbon for the project and compare the result to the detailed design phase embodied carbon calculation and target.

ii) Commission an independent and qualified third party to verify the As-built carbon performance of the project.

Example 2: Setting overall embodied carbon targets for a building type

The Contractor shall achieve the overall building embodied carbon targets for 2030 as set out in the LETI Publication "Embodied Carbon Target Alignment" for the relevant building type:

i) Office: LETI 'C' Rating (<600 $kgCO_2e/m^2$ upfront embodied carbon)

Example 3: Setting specific targets for products (e.g. plasterboard)

Sustainability performance requirements:

Provide sustainability submittal such as an Environmental Product Declaration (EPD); Type III - EPD with Third party certification or acceptable equivalent indicating compliance with the following:

i) Global Warming Potential (GWP): Standard plasterboard with 12.5mm thickness: Not greater than 0.39 $kgCO_2e/kg$ (A1-A3).

Example 4: Setting carbon targets for generic materials

The Contractor shall procure low carbon metals, meeting aesthetic, durability, workability and performance requirements considering embodied carbon ISO 21930 modules A1-A3 per the below targets:

i) Aluminium: < 6.83 $kgCO_2/kg$.

ii) Steel: < 2.45 $kgCO_2/kg$.

Footnote: these targets and values are examples only and should not be taken as representative good practice.

3.6 Roles & process

The effectiveness of specifications that support embodied carbon reductions is increased when the following steps are implemented:

Appointing an 'Embodied Carbon Lead': a competent and experienced professional should be appointed to be the custodian of the embodied carbon reduction process and should be retained throughout the construction process to assess alternative proposals regarding carbon. They manage the overall carbon reduction process, including the collation and review of documentation, the verification of carbon targets throughout the different project stages.

Assigning 'Embodied Carbon Champions': these are design team representatives who manage the portion of activities related to a specific design team function e.g. structures, and report back to the Embodied Carbon Lead at regular intervals with results of research or changes related to their discipline. They are responsible for ensuring the individual teams' carbon targets are met and are essential for delivering net-zero carbon outcomes.

Early supply chain engagement: it is important to review market solutions for low carbon materials and products at the beginning of the project whether directly by the design team or via the contractor. Engaging with the supply chain at early design stage allows a preliminary embodied carbon analysis based on early procurement strategy and identifies ranges of suitable A1-A3 embodied carbon coefficients for each material, which can then be included in the specifications or in a separate tender document (see Chapter 4, Section 4.2).

SIGNPOST *Chapter 4 - Embodied carbon assessment and procurement*

Set targets: clear ambitions and targets need to be set early, ideally by the client. This needs to be communicated to the contractor team and cascaded through the entire supply chain.

Embodied carbon analysis: this should include as a minimum a detailed list and description of materials to be used in the project, with preliminary quantities (volumes or weight), the carbon emission factors associated with them, and the total carbon emissions.

It has been recognised as best practice within the industry that at a minimum three full carbon analyses at the following project life stages should be conducted:

1. RIBA Stage 1 to 3: initial carbon analysis to determine carbon strategy in design.
2. Prior to tender: analysis is updated and acts as a benchmark for the contractor to meet or improve on.
3. As-Built: it is important to measure and monitor to determine final overall carbon emissions to determine achievement of set targets.

Continuous monitoring: it is recommended that the embodied carbon analysis be reviewed at all design and construction stages, supported by regular workshops with suppliers. This will allow any advances in manufacturing innovation and market availability of specified products to be considered.

4

Embodied carbon assessment and procurement

4.0 Embodied carbon assessment and procurement

Who needs to be communicating

Client Design team Contractors Authorities Suppliers

4.1 Procurement and embodied carbon

RIBA recommends that a procurement strategy be set at Stage 1, along with sustainability outcomes. When setting the procurement strategy, this should take into account not just environmental factors such as embodied carbon, but also social and economic considerations. These will set the requirements for the selection of suppliers for the purchase of materials and products for a project. Considerations related to net zero, circular economy and waste, water use and pollution, employment and inclusiveness, health, local economy, etc. should be included into the overall sustainability performance of the project.

The procurement process will vary depending on the type of project and client, type of contract and required outcomes.

At the time of the publication, there is no unique or officially recognised methodology for the inclusion of carbon emission factors or of broader environmental and social aspects into the procurement process of a construction project. However the following references can provide useful guidance:

→ CIRIA (C695) 2011 'Guide to sustainable procurement in construction' and BS ISO 20400:2017 'Sustainable Procurement' provide guidance including how to engage stakeholders, integrate sustainability into specifications and procurement process, select suppliers, and effectively managing the process. These documents provide useful and specific guidance to promote sustainable procurement into the project by understanding and engaging the supply chain more effectively.

→ The Government also provides guidance on the 'Flexible Framework' tool, a self-assessment tracker which allows organisations to measure and monitor their progress on sustainable procurement over time (https://www.gov.uk/guidance/sustainable-procurement-tools).

4.2 Deliverables

At every stage of the project, starting from the client brief, requirements for sustainable procurement should be clearly stated and the mechanism for incorporation of sustainability requirements put in place through a process of:

1. Deliverable production
2. Validation
3. Implementation
4. Verification

Depending on the type and complexity of the project, the project's embodied carbon limits may be incorporated into different types of documents. The following section outlines some of the key deliverables and suggests where within the timeline they currently may appear. However, it should be noted that there is much greater pressure to bring embodied carbon related activity early in the procurement process and it is anticipated these suggested timelines will flex in relation to project and development in practices.

Client's Brief: The Brief is first developed by the client in collaboration with the design team during RIBA Stage 1 to form the basis of design or can get implemented into subsequent documents, eventually forming part of the contract.

The client may already have very specific requirements related to products, material and equipment which inform the procurement. A specific example of this is seen in clients with large branded or franchised portfolios of buildings, where they already have detailed briefs or sustainability manifestos, which are given to designers at the beginning of the projects as a basis of design. Designers or 'Design and Build' contractors then produce their procurement documents based on such requirements. In other situations, the client may look to their appointed design team to advise on best practice or set specific sustainability targets for the project.

Embodied Carbon Management Plan: the Embodied Carbon Management Plan is an independent document which should refer to agreed embodied carbon limits, clarify roles and responsibilities, illustrate methodology for implementation, monitoring and reporting of achievements. It should be incorporated into the programme together with all other project deliverables.

Ideally it is first produced by the Embodied Carbon Lead (or other appointed specialist) at RIBA Stages 1-2, then updated throughout the project when either significant changes occur or as new information becomes available. It is likely that it will be updated at RIBA Stage 4, forming part of the tender documentation and at RIBA Stages 5-6 if linked to contractual requirements.

Design Report: can contain a chapter or section where the embodied carbon limits are detailed, and how this is reflected into the selection of materials or in the chosen design and construction strategies.

Materials Procurement Plan: A Material Procurement Plan prepared at the early stages of the project, after consultation with quantity surveyors (QS), the supply chain and adequate market research, is the first step in ensuring successful implementation of embodied carbon accounting.

A Material Procurement Plan is a document which describes the process of identification and selection of suppliers in order to procure the materials/products that satisfy the project requirements, which will include embodied carbon limits.

It is often provided for larger projects, or for projects undergoing a formal building certification (e.g. BREEAM, CEEQUAL), containing all requirements related to materials and their procurement (see below for further details).

Updated throughout the project when either significant changes occur or as new information becomes available. The Material Procurement Plan can be linked to the Embodied Carbon Management Plan.

It must be noted that due to the high variability of embodied carbon data and material availability in the market, the Material Procurement Plan should be regularly monitored and verified through a Life Cycle Analysis, as market conditions can change significantly throughout the lifetime of a project.

Embodied Carbon Report or Embodied Carbon Compliance Report: often present in larger projects which have an embodied carbon target objective. The embodied carbon report can be a standalone deliverable included in the tender package for the contractor so it can be translated into a construction deliverable. Embodied carbon limits will require verification at different stages, from the procurement stage, throughout the construction stage up until project completion.

The project may require a formal embodied carbon accounting process (see definition 'Embodied Carbon Accounting'), included in the embodied carbon report. However, qualitative requirements may also be included in the embodied carbon report even when a formal calculation is not required.

First produced at Stages 2-3 by the Embodied Carbon Lead (or other appointed specialist), when sufficient information is available in terms of project description and/or general materials selection. Then updated throughout the project when either significant changes occur or as new information becomes available. This document, with the results of the Embodied Carbon Tracker, informs the embodied carbon chapter of the Design Report. It is likely that it will be updated at Stage 4 and possibly at Stages 5-6, depending on the document being linked to contractual requirements of verification, handover, operation and maintenance, etc.

Embodied Carbon Tracker: monitoring and reporting tool to provide updates on embodied carbon calculations for the project. It can be generated at early stages of the project, providing estimates for different design options and then updated regularly to reflect design changes. Later on it can be used during construction as a monitoring tool to incorporate data resulting from the procurement process.

It could also be carried forward to Stage 7, depending on the document being linked to contractual requirements of verification, handover, operation and maintenance.

The Embodied Carbon Tracker needs to be linked and/or an appendix to the Embodied Carbon Plan.

7. Summary: it is important to include references to any of these additional documents listed above in the specification, so they form part of the tender and contract set and anchor the requirements within the procurement process.

In a 'traditional' procurement process the attention has been put mostly on cost and delivery time, in combination with other criteria related to quality assurance, performance, and country of origin, with different weightings applied to each criterion. It is essential that limits for embodied carbon emissions of materials be incorporated in quality and performance criteria and given appropriate weighting – along with other environmental and social performance criteria, as required. Depending on project priorities and challenges (e.g. programme, fast tracking, supply scarcity, etc.) the weighting might vary, however the carbon emission criteria should have a significant place in the selection process.

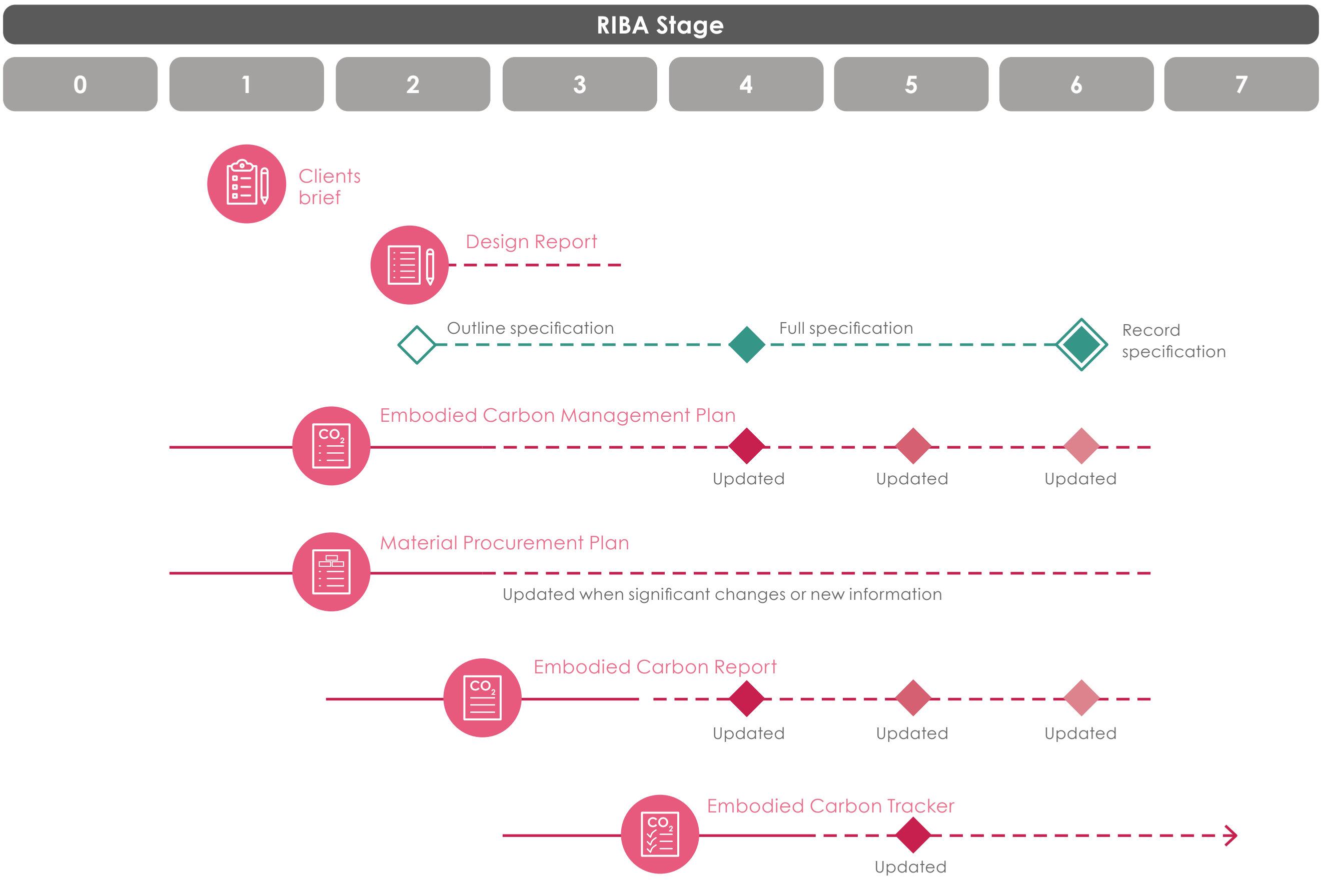


Figure 4.1 - Key embodied carbon deliverables

4.3 Professional advice

Including sustainability criteria into the procurement process will affect resources as it also introduces requirements for specialised competency and knowledge. Such additional requirements might be in the form of personnel with adequate qualifications and experience assigned to any of the tasks related to quality assurance and verification of sustainability compliance within the procurement process, examples of such roles are provided in Chapter 3, Section 3.6. The lack of clarity of such a professional role might compromise the correct implementation of sustainability strategies.

SIGNPOST *Chapter 3 - Types of specification*

The discussion of how to embed sustainability professionals into the roles and responsibility matrix of the project should be taken up with the client at early stages of the project and cascaded into all the subsequent stages of the project until project completion.

4.4 Further information

Carbon datasets

Embodied carbon emissions are a relatively new measure of material credentials with high variability both in their range of values and in reliability of sources and data availability. The high variability of values can be attributed to the complexity and relative immaturity of data measurement by many material manufacturers, the lack of alignment of methods of assessment and reliable data. It is also compounded by a rapid rate of product innovation which is bringing new lower carbon products to market. Carbon datasets are repositories of information, that are being constantly or periodically updated. Datasets can include manufacturer specific or product carbon emission data, but also global and national averages in the form of 'generic EPDs'. It is important to use the most appropriate data sets for products depending on where they are likely to be sourced. Several datasets are available, which provide measured emissions or suppliers' data (e.g. in form of EPDs) some of which are free and some of which require a paid subscription.

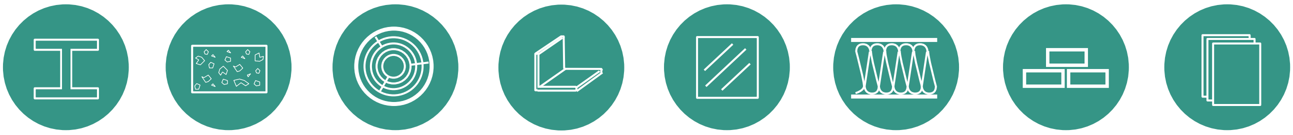
Some of the most recognised and used datasets are listed below:

→ DEFRA carbon emission factors
→ ICE Bath Database v3
→ Ecoinvent LCI dataset
→ Eco Platform
→ Envirodec

5

Materials guide

5.0 Materials guide



Steel | Concrete | Timber | Aluminium | Glass | Insulation | Brick | Gypsum

This section of the guide details an approach to good specification and procurement for particular materials. Design teams should focus on the big wins for each project by ascertaining where the biggest reductions can be made for specific products/ materials and subsequently setting appropriate embodied carbon limits. Each material guide is broken into the following categories:

→ Effective specification
→ Successful low carbon procurement
→ Communication
→ Additional considerations / specification clauses

Whilst individual materials often have their own unique low carbon specification and procurement strategies there are a number of commonalities in overall approach. The key driver for successful specification and procurement of low embodied carbon materials is to have a clear ambition at the beginning of the project to deliver a low embodied carbon building, and to engage with suppliers as early as possible.

Whilst clients and design teams can set ambitious limits, effective communication is key. Specifiers can challenge contractors and manufacturers to procure materials that enable the project embodied carbon limits to be met, however, manufacturers and contractors are best placed to determine the feasibility of procuring these low carbon materials and the impact they have on cost, project delivery and the environment. An early and open dialogue can ensure there are no specification surprises that are not feasible and ultimately lead to embodied carbon limits not being met. Additionally contractors may also have experience of which suppliers can offer low carbon products, have EPDs in place or where suppliers are unable to substantiate their low carbon material claims.

This guide is for the major material elements only and does not include secondary elements such as fixings, finishes and packaging. Designers should therefore be mindful of the inter-relationship of material selection for their whole life cycle carbon analysis. Some structural elements, will require linings to meet an equivalent fire performance for example.

For each material selected, a common approach should be followed:

→ Embodied carbon limits should be set at the beginning of the project.
→ Where available, refer to third party verified product or manufacturer specific EPDs at tender stage.
→ Early engagement with contractors and manufacturers will help achieve carbon ambitions or enable the design team to revisit their low carbon strategy.
→ Understand the full life cycle embodied carbon profile of materials including: transportation, construction, repair and replacement, end of life, and the waste associated with each stage.

5.1 Carbon emissions from waste and transportation

Waste

Emissions from waste and transportation may arise in different life cycle stages of the project:

→ Stages A1-A3: Wastage rates are a huge area of concern and pertinent to upfront embodied carbon. Waste in stages A1-A3 should be included as part of the EPD. Waste is also generated on site through installation processes which is captured in stage A5.
→ End-of-life: It might not be possible to predict end-of-life waste emissions at the design stages of the project. In some cases, information from the contractor and waste facilities providers for similar projects can help assess the potential for recovery of certain construction materials.
→ Excavations/Demolition: emissions from demolitions are site specific, so they can be estimated only at a stage when site surveys and clearance plans have been completed. Excavations can be taken into consideration at design, but might need to be updated as changes might occur based on site accessibility, soil conditions, etc.
→ Maintenance, repair and replacement: Emissions from the repair, maintenance and replacement of project elements, should be taken into account at design stages and assessment of embodied carbon. Information on the life span of individual materials or products is provided by guidance manuals or suppliers (e.g. warranty sheets), however often what is provided in these documents may not correspond exactly to the life of the element.
→ Strategies to improve material efficiency and reduce waste (and therefore carbon) through the whole life cycle can be usefully established at design stage through Circular Economy Workshops.

Transportation

At design stage, it may be difficult to estimate transport related emissions due to uncertainties related to the supply chain and market availability. Any reported estimates should always state exact assumptions. An initial procurement research can provide preliminary considerations which could help reduce transport related carbon. The following areas should be considered as a minimum:

→ Transportation type and frequency
→ Proximity to site
→ Impact on local economy.

Not all transport is equal in terms of carbon. A diesel truck emits far more CO_2e per kilometer than a shipping vessel, meaning that a shorter distance covered by road, may end up being more carbon intensive than a longer distance covered by sea.

Local suppliers do not always guarantee the lowest carbon emissions, as other suppliers might have more efficient production systems relying on renewable energy. Procuring from local suppliers however benefits the local economy, so a broader cost benefit analysis might be required to make the most sustainable choice.

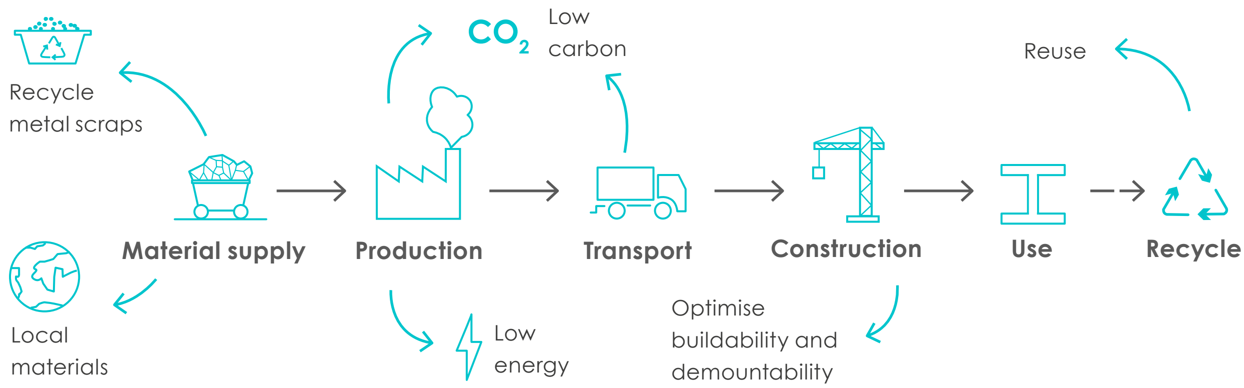
Transport emissions also include the transportation of the materials for disposal at the end of their life.

Steel

Watch points

- Minimise **raw material,** maximise recycled content
- **Low energy** production
- **Low carbon** production (renewable energy/electric)
- **Local** materials (raw material and production)
- Low carbon **transportation** (i.e. ships vs trucks vs train)
- Project **affordability** (viability for client)
- Optimise **buildability** and demountability

Life cycle



Communication

- **Fabricators** contacted to confirm section size **availability** and understand **limits**
- **Misconceptions** on reuse of steel clarified
- Share successes!

5.2 Steel

Steel has a very high embodied carbon per weight compared to most other construction materials, but is generally required in less quantity. Steel is an appropriate material for re-use and is also potentially infinitely recyclable.

The embodied carbon of steel varies greatly, depending on the production technology, energy source for manufacturing, and the proportion of scrap metal used as a raw material. Less energy is required to make steel from scrap, and so steel made with a high proportion of scrap will have lower embodied carbon. Higher technical grades of steel are typically made with less scrap in order to control quality, and so have higher embodied carbon. High alloy and galvanised steels are likely to have higher carbon footprints per unit of mass, but this can be compensated for by better performance characteristics, either requiring less steel to achieve the same performance, or by having a longer effective use life therefore reducing the overall lifetime carbon footprint.

It is estimated that over 80% of available iron and steel scrap is recycled. However, this is only sufficient to meet around 30% of current global demand for steel, with the remainder being produced from iron ore.

The potential to reduce emissions through further increases in the use of scrap metal is limited. International efforts to reduce the carbon emissions of steel production focus on material efficiency, and on reducing the carbon emissions of steel-making, whether the steel is made from iron ore or scrap metal.

In the UK, steel is produced both from scrap, through the electric arc furnace (EAF) process, and from iron ore through the Blast Furnace - Basic Oxygen Furnace (BF-BOF) route. Some steel elements are only available by the BF-BOF method and therefore effective communication with suppliers and fabricators on what is available can help to select the most appropriate sections. For example, fabricated plate girders are, at the time of writing, not available from EAF steel mills, with typical 'off-the-shelf' section sizes only available. Reducing emissions for EAF production requires steel makers to use low carbon sources of electricity. Reducing emissions for steel made from iron ore requires the adoption of new technologies such as steel-making using hydrogen rather than coal, and carbon capture with storage.

Unfortunately, the EAF method is reliant on scrap steel and cannot meet current demand, although there is a lower embodied carbon impact from EAF steel there may not always be availability. Responsible specification and procurement of steel is important to lower the embodied carbon in our designs today, whilst guiding the industry to lower embodied carbon steels in the future.

Effective specification

Consideration of steel grades and section sizes should be given flexibility in the design and specification, by adopting lower grades (e.g. S275) where appropriate and elements that can be produced using the EAF method without significant changes to manufacturing will enable the lowest embodied carbon steels to be procured. At the time of publishing there is no significant price difference between EAF or BF-BOF, but market drivers may vary over time, so design teams should seek further cost guidance on their projects. The quantity of recycled steel can also be specified. Recycled/scrap steel is utilised in the EAF method and is often procured from Europe where there is greater supply. Steel has a high level of carbon emissions associated with its production and manufacturing phase.

Similarly with other materials, the transportation of steel (especially if shipped) has much lower emissions than manufacture. However, transportation emissions should always be calculated to ensure the location of sourced material does not have a significant impact as often steel is sourced from a variety of international locations across the globe.

Specify a maximum embodied carbon / Global Warming Potential (GWP) quantity rather than considering the manufacture method. EPD's can be found on the EPD programme operators, i.e. BRE GreenBook Live, Eco Platform, International EPD, etc. CARES digital records have a large volume of data from 110 steel producers with 99% of steel used in the UK recorded, and non-CARES producers also publish their own EPD's. It is best to be specific, and depending on the project, design teams should set project-specific targets that are at the lowest end of the spectrum of carbon emission figures as is achievable. The CARES average steel EPD is based solely on europe based steel production.

EAF production is at capacity in UK with effectively all available scrap being reused. Specifiers should therefore seek to source steel products that have the lowest embodied carbon for a given proportion of scrap. Specifying on this basis ensures that steelmakers are incentivised to reduce their GHG emissions whether they make steel through the EAF route or BF-BOF route. Suppliers should provide data both on the proportion of scrap that was used as input material to produce the steel in the product, and on the GWP of the steel itself, as provided through the EPD.

The ResponsibleSteel programme will be introducing three GHG emissions performance bands to facilitate procurement of steel on this basis. A basic threshold will be required for steel to be sold as ResponsibleSteel certified. A 'lower embodied carbon' performance band will identify steel that meets more demanding specifications, and a 'near zero' performance band will identify steel that is produced using close to the minimum possible emissions for the given proportion of iron ore or scrap used as a raw material.

Some suppliers are beginning to offer 'low carbon steel' but we would recommend requesting EPDs to fully understand the embodied carbon of the product. The product should have lower embodied carbon compared to other available steels.

Any steel product that includes carbon offsetting should be discounted to only consider the upfront embodied carbon for different steel providers, i.e. A1-A5. Supporting suppliers producing low embodied carbon steelwork products does help to monetise this industry, funding research into reducing the embodied carbon of future steel, and accelerating change. As more designers prioritise low carbon steel in their specifications, the louder the message will be to other suppliers that they too will need to move towards low carbon production or risk not being specified.

Successful low carbon procurement

The UK steel industry has struggled financially in recent years, so making the choice to procure low embodied carbon steel outside the UK could impact the UK's steel industry and it's ambitions to strive towards Zero Carbon steel. However, pushing the industry in the UK towards Zero Carbon steel can be a positive step toward net-zero ambitions. All members of the procurement team can commit to Steel Zero, which is a commitment to procuring, specifying or stocking 100% net zero steel by 2050 at the latest.

Re-use of existing steel elements is the cheapest (and most sustainable) option, but may be difficult in practice. There are currently a number of websites listing structural steel sections and other products available for re-use. As re-used steel becomes more available this should be the highest priority. Structural steel is now commonly being marked with QR codes to help inform future re-use potential.

There is a perceived risk from insurers of adopting re-used steel, however following guidance and with more project team engagement, this can be shown to be of no additional risk. The Steel Construction Institute has provided guidance note SCI P427 which details the procedures of testing and conformity that must be followed to allow steelwork from existing buildings to be re-used elsewhere.

Communication

Steel fabricators should be contacted to confirm what section sizes are available from EAF and high scrap sources, and to understand if there are any limits requiring rationalisation or if it is acceptable to use the most efficient section across multiple section sizes to align with design efficiency. This could help to drive industry forward to change suppliers behaviour and help specification and procurement decisions on the next project.

Additional considerations / specification clauses

Below is a list of additional considerations that can be required in a specification or to look out for during procurement:

→ Specifying the maximum carbon content of the steel in line with one of the ResponsibleSteel (2022) performance bands.

→ Requiring the steel supplier/contractor to have committed to a long term and medium term emissions reduction pathway (e.g. they have a Science Based Target [SBT] in place or/and have signed up to SteelZero or Race to Zero).

→ Requiring the steel supplied to meet a low carbon steel criterion, which they have developed through conversations with the Steel Zero initiative.

→ Requiring the steel supplier/contractor to be members of BCSA and Steel for Life.

→ Requiring the steel supplier/contractor to be certified through either the Eco-Reinforcement scheme operated by BRE Global, or the 'Sustainable Constructional Steel Scheme' operated by CARES, or other third party accredited scheme that follows the principles of BS8902.

→ Requiring the steel supplier/contractor to be a [Gold member / Silver or Gold member] of the BCSA Steel Construction Sustainability Charter or have defined and made public its commitment to sustainability and ethical trading through an equivalent independent assessment system.

→ Requiring the steel supplier/contractor to have signed up to the principles of responsible sourcing as defined in BES 6001 or BS 8902.

→ Requiring the steel supplier/contractor to demonstrate environmental performance of products through a recognised system of environment labelling, or supplier operation of an EMS certified to BS EN ISO 14001.

5.2.1 References

1 - *SteelZero* [Online]. https://www.theclimategroup.org/steelzero-members

2 - *Cares Steel Certification* [Online]. https://www.carescertification.com/

3 - *Structural Steel Reuse* [Online]. Available from: https://steel-sci.com/assets/downloads/steel-reuse-event-8th-october-2019/SCI_P427.pdf

4 - *British Constructional Steelwork Association* [Online]. https://steelconstruction.org/

5 - https://www.theclimategroup.org/steelzero

6 - ResponsibleSteel [Online]. https://www.responsiblesteel.org/

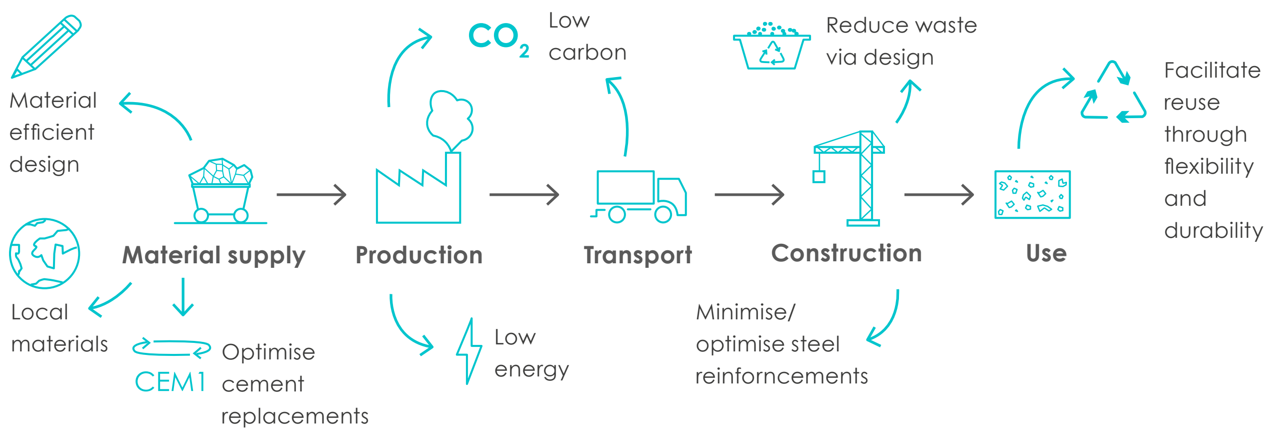
7 - CELSA Steel UK [Online]. https://www.celsauk.com/

Concrete

Watch points

- **Material efficient**/lean design of structure
- **Engage** with supply chain to establish low carbon
- Don't over specify performance
- Optimise **cement replacements**
- **Reduce waste** through design and construction
- Minimise **energy** use and carbon production
- Minimise/optimise **steel** reinforcement
- **Local materials** (local economy & minimised transport)
- Low carbon **transportation** (capacity/optimisation)
- **Facilitate reuse** through flexibility and durability

Life cycle



Communication

Concrete suppliers contracted to establish **lowest carbon options** available

Include **carbon reduction** as a stated **specification requirement**

5.3 Concrete

Concrete is the second most widely used material on the planet after water. It is therefore imperative to use, specify and procure concrete responsibly. There is a huge variation in how concrete can be used and specified, with a wide range of associated embodied carbon. This versatility, however, also offers opportunity to significantly reduce embodied carbon through considered design and specification.

Effective specification

There are two key strategies for reducing the embodied carbon associated with concrete in construction:

→ Leaner design solutions that reduce the volume of concrete required
→ Enabling the production of concrete with a lower embodied carbon per m^3

SIGNPOST *Embodied Carbon Primer Fig 6.1 and Section 8.0*

These two strategies should be applied in tandem as they are interrelated. For example higher strength concrete may have a higher CO_2e/m^3 than a lower strength concrete but permit more efficient structural solutions (e.g. slimmer columns) and thus less volume. The majority of the embodied carbon in reinforced concrete comes from its cementitious content (around 70% using CEM1), and around 25% comes from steel reinforcement, so aiming to reduce the amount of cement and steel required, and using lower GWP alternatives for these constituent materials are principle areas of focus for low carbon specification and procurement of concrete. As a general rule this means not over specifying the performance requirements of the concrete, especially strength, and allowing secondary cementitious material (also known as cement replacements) such as GGBS, fly ash, SILICA FUME and powdered limestone to be used.

There are however numerous other carbon reduction techniques which will depend on project particulars and different manufacturing processes of concrete, so being too prescriptive is likely to be less successful than taking a holistic and collaborative approach. Available solutions are also likely to evolve with changing standards, manufacturing techniques, availability of raw material, and the decarbonisation of Portland cement. It is therefore appropriate, especially for projects with longer procurement and construction programmes, to enable flexibility in how embodied carbon reductions are achieved.

For pre-manufactured concrete products, such as blockwork and lintels, specific products and their associated carbon credentials can be established through manufacturers information, and thus specified to set the performance requirements of these elements.

There are five different potential routes for concrete cast insitu specification defined in BS8500, depending on the scale of the project, and the expertise and responsibility of the design team. A performance based specification, i.e. a designated concrete or 'designed' concrete based on designation, are the simplest methods, and most common ways to specify ready-mixed concrete for most situations. For a performance based specification an embodied carbon benchmark can be added along with other performance merits required such as strength and durability. Since a recommended minimum cement content and range of cement types are permitted for each designated strength class, the low carbon preferences can also be specified. Most of the larger concrete producers also offer proprietary low carbon concrete mixes.

For larger projects, particularly infrastructure, a concrete technologist may be employed to develop and take responsibility for a 'Prescribed concrete', where the exact composition and constituents of the concrete is defined, thus offering alternative routes for reducing the embodied carbon of the concrete,

A benchmarking system for the carbon intensity of concrete related to strength classes is being developed by the Low Carbon Concrete Routemap published by the Institute of Civil engineers (ICE) and should help to simplify the process of lower carbon concrete specification as it evolves in response to available data.

Sample carbon values are also available through the embodied carbon footprint database published by the Circular Ecology Footprint database (commonly known as the Inventory of Carbon & Energy (ICE) database).

All concrete mixes to BS 8500 are based on Portland cement (or CEM I) but most contain secondary cementitious materials (SCMs) which have a much lower CO_2e than CEM I. The current most common replacement cements currently used in the UK are ground granulated blast furnace slag (GGBS) and fly ash (FA) with up to 85% cement replacement possible in the current BS 8500. It is anticipated that the next versions of BS 8500 will facilitate greater use of limestone and calcined clays through the use of multi-component cements. Large quantities of replacement can have a negative effect on early strength gain but a positive effect on reducing the temperature during construction, helping to reduce reinforcement where early age thermal (EAT) cracking governs design. Tools and construction techniques are developing to limit potential impact on programme which may be most prevalent in colder weather. Alternative innovative concretes using low carbon cements such as belite cement, Pozzolan cement and Metakaoline are available and in development but not yet covered by BS 8500 so are currently limited in potential application and availability. Alkali Activated Cementitious Materials (AACM's) and Geopolymers can however be specified using PAS 8820 with performance testing required for use. Thus additional time and cost may need to be factored into the design and construction programme until they become more mainstream.

Generic EPD's for selection of UK concrete products are available and provide a useful indicator of achievable CO_2e figures. These can be regarded as a benchmark to improve upon through low carbon specification.

There are also product specific EPDs for concretes and cements by manufacturers.

Successful low carbon procurement

Since concrete may be used for different aspects of a building it is useful to allocate a carbon budget to different packages of work e.g. ground works or superstructure. Reducing the volume of concrete required for each application is the first priority, before producing the specification. Since some of the lowest carbon solutions may have an impact on the construction programme, client support may be required to align carbon objectives with other project requirements, such as cost and time on site. Early and ongoing collaboration with manufacturers and contractors will help determine the lowest carbon solutions available in concrete for that project.

Concrete cast in-situ is usually supplied ready mixed from a local batching plant, but smaller, more basic mixes, can be batched on site. Since site batched concrete (using the standardised prescribed (ST) designation route for specification in BS 8500) is required to have higher cement content to compensate for lack of accuracy compared to an equivalent GEN concrete, their CO_2e/m^3 is higher and should typically only be used for small quantities because of the high embodied carbon footprint. If, in procurement, a concrete shifts from site batching to ready-mixed, the equivalent GEN designation should be identified for supply.

Communication

Engagement with concrete suppliers to establish the lowest carbon options available for each application is key. Unlike other major construction materials, concrete used in the UK is typically manufactured in the UK, using locally sourced materials. This offers the opportunity to more easily engage with likely suppliers and manufacturers to establish available low carbon solutions.

Include carbon reduction as a stated specification requirement to alert the entire concrete supply chain of its requirement, since different mix designs may be chosen during construction to suit weather conditions, travel distances and programme needs.

Additional considerations / specification clauses

Below is a list of additional considerations that can be required in a specification or to look out for during procurement:

→ Use the appropriate concrete strength
→ Consider specifying 56 day or 90 day strength were appropriate
→ Allow the use of admixtures
→ Do not use small aggregate unless necessary, keep to 20mm maximum.
→ Reinforcement supplier/contractor to be certified through either the Eco-Reinforcement scheme operated by BRE Global, or the 'Sustainable Construction Steel Scheme' operated by CARES, or other third party accredited scheme that follows the principles of BS8902.
→ Concrete to be responsibly sourced to BES 6001 or for precast to demonstrate environmental performance of products through a recognised system of environment labelling, or supplier operation of an EMS certified to BS EN ISO 14001
→ Consider exposing the concrete where possible, since additional fire linings are often not required.
→ Facilitate the future refurbishment and re-use of concrete elements to optimise its long life potential.

5.3.1 References

1 - *Specifying Sustainable Concrete* [Online]. Avaialble from: https://www.concretecentre.com/Publications-Software/Publications/Specifying-Sustainable-Concrete.aspx

2 - *Concept 4* (free online tool for early comparisons of material efficiency and CO_2e of structural solutions.) [Online]. Available from: https://www.concretecentre.com/Resources/Publications/Concept-Design-Tool-Version-4.aspx

3 - *How can we reduce the embodied carbon of structural concrete?* [Online]. Available from: www.istructe.org/journal/volumes/volume-99-(2021)/issue-2/how-can-we-reduce-the-embodied-carbon-of-concrete/

4 - *How to specify lower carbon concrete* [Online]. Available from: www.istructe.org/resources/guidance/how-to-specify-lower-carbon-concrete/

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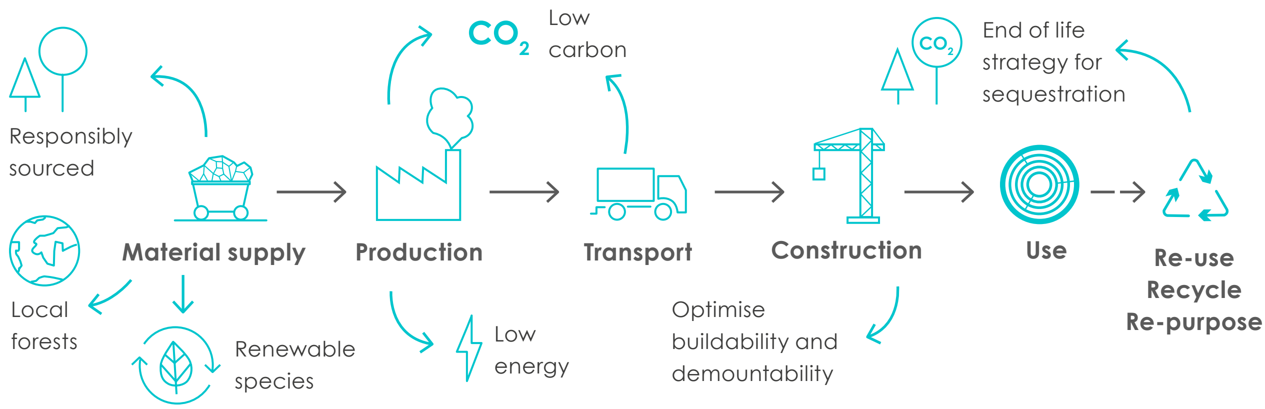
6 - Zero carbon concrete [Online]. Available from: https://www.theclimategroup.org/concretezero

Timber

Watch points

- Ensure **FSC** certified forests
- Use **renewable species**
- Low carbon **energy** in processing methods
- **Local** forests (local economies & minimise transport)
- Low carbon **transportation** (i.e. ship vs. truck vs. train)
- £££ Project **affordability** (viability for client)
- Optimise **buildability** and demountability
- **End-of-life** strategy for sequestration (chemicals, glues etc.)

Life cycle



Communication

- **Design team** to engage with a **cost consultant** early to avoid overpricing
- Collaboration between **designer** and **supplier** to mitigate **risk of change**
- **Timber suppliers** to inform on UK local **engineered timber** options
- Adopt a **Whole Life Cycle** approach with narrative on **end-of-life, re-use, disposal** and **carbon sequestration** considered
- Discuss **prefabrication** with contractors early to **avoid construction sequencing issues**

5.4 Timber

The specification of timber elements within a project offers an opportunity to reduce the overall embodied carbon footprint of new and refurbished developments. Timber has lower associated carbon emissions when compared with steel and concrete and has the added benefit of sequestering carbon through its growing phase. However, the sourcing of timber and its full life cycle is particularly important in ensuring that the low carbon benefits of the material are realised. There is a danger that false accounting of carbon sequestration, lack of sustainable timber sourcing and ill-thought through end-of-life material planning could lead to higher carbon emissions than are estimated

It is imperative that timber is sourced from sustainable forestry practices and that the timber is re-used or re-purposed at the end-of-life if carbon sequestration is to be included in the embodied carbon calculation.

Some designs do show that the choice of timber can actually increase the upfront carbon budget particularly in long span grid arrangements. However a developed specification and procurement approach will assist the design team in ensuring the full benefits of timber can be taken advantage of.

Effective specification

Timber should be sourced from sustainably managed forests under a certified scheme such as FSC or PEFC. This ensures that any forests felled for the production of building timber will be sourced from well managed forests and/or recycled materials. Refer to the UK government guidance on sustainable timber.

Timber specification should consider durability of the material to extend the service life. Issues such as weather-tightness, insect attack, and temp/humidity control can impact paints, finishes, external coatings and service life.

Successful low carbon procurement

Timber may or may not physically carry the FSC trademarks. Proof that FSC-certified timber products have been procured, as specified, is the invoice from the supplier, which should clearly state the applicable FSC claim/s and their FSC certificate code. Only FSC-certified organisations can make FSC claims on their invoices and delivery notes.

To check if your supplier holds FSC certification visit info.fsc.org

It is recommended to source timber locally, however, it should be noted that most engineered timber products are imported from continental Europe. This can expose the project to more extreme price fluctuations and this needs to be factored in accordingly. Transportation of timber can be more impactful than other materials due to the lower carbon emissions associated with timber in LCA stages A1-A3 therefore a bigger proportion of the embodied carbon is associated with the movement of the material.

Currently engineered timber products are not produced in the UK however it is anticipated that this will change and availability is evolving at a rapid rate. It may be pertinent for specifiers to discuss with engineered timber manufacturers to understand if products are starting to become available more locally or whether there is an anticipation that local products will become available during the construction phase of the project and the procurement strategy can be developed accordingly.

Discussions with timber suppliers regarding sustainable adhesives and fire retardants should be conducted early. Some adhesives and fire retardants are very toxic and can not come into contact with waterways etc. This can impact the end-of-life viability of the material to be recycled or re-purposed and therefore the carbon sequestered into the product can not be accounted for in whole life carbon assessment as potentially the only use for the material at the end-of-life is to be used as fuel and carbon is released back into the atmosphere.

Other forms of laminating processes are being brought forward to eliminate the use of adhesives such as NLT (nail laminated timber) and DLT (dowel laminated timber) and feasibility of these products should be discussed.

Communication

Contractors that have limited experience in building in timber will often feel more comfortable using more 'traditional' materials. A Whole Life Cycle approach is critical for comparing timber against other materials in fully capturing its benefits. With this approach it is important to have a narrative on end-of-life and the impacts of disposal/re-purpose so that the full advantages of timber can be factored, including carbon sequestration.

Typically mass timber buildings and timber elements such as Cross Laminated Timber (CLT), cassette panels and Unilam have longer lead-in times and require the design team to collaborate with the manufacturer in finalising detailed designs.

With mass timber buildings the sequencing of construction is different for contractors and this can create issues. Early discussions around prefabrication is essential. Similarly Design for Manufacture and Assembly (DfMA) needs early investment and decision-making to ensure regulatory compliance otherwise there might be changes later which will lead to variation costs.

The design team should engage with a knowledgeable cost consultant early to ensure 'overpricing' is not factored in unnecessarily. Cost comparisons between different whole systems approaches should be considered. Whilst engineered timber may have an uplift on cost there can be benefits elsewhere. For example a timber arrangement can lead to reductions in substructure volumes owing to the lighter load of the building and can negate the need for finishes, i.e. ceilings, where the timber can be left exposed.

A timber solution can be less flexible than alternate materials and therefore it becomes hard to implement late design changes. Close collaboration between designer and supplier is necessary to mitigate risk of late change owing to poor communication early in the design process. However, it should be noted that in some instances timber can be more flexible in terms of late servicing changes. Holes can be drilled as long as fire barriers are maintained.

Where a 'Just-in time' delivery approach is desired, early and effective communication between the project delivery team and the material supplier is necessary to ensure timber factory production slots are not missed. A 'Just-in-time' delivery approach, however, has the added benefit that the timber avoids the risk of damage from water on site.

Contractors should demonstrate familiarity with timber as a construction material and should provide a moisture control plan to highlight the delivery, storage and preparation of mass timber. This will help to avoid warping of the timber and reduce avoidable waste.

Additional considerations / specification clauses

UK regulations have stringent requirements regarding combustible materials which are counter to the Government's push for low carbon materials. Ensure agents from the local authority and a fire engineer are consulted to ensure fire regulations on timber are being adhered to. Additionally this may have an insurance risk and specialists should be consulted.

Timber need not be considered purely for mass-timber solutions, it can be considered as a hybrid construction with cementitious toppings or a steel frame. However, it is important to note that this can impact the end-of-life scenario for the timber and the design team should understand if these arrangements can be designed for recycling, re-use and re-purpose.

As timber is becoming more popular the supply rate into the construction industry is becoming more challenging. Full understanding and clarity of where the timber is coming from is necessary for accurate carbon accounting.

Long spans need metal flitch beams and designing for deconstruction may need bolted steel plate connections. Connections can increase the cost of the product and impact end-of-life potential.

Timber is not only a building material but also used for formwork, packaging and temporary works. Procurement of this timber needs also to be considered.

Timber has health benefits to internal air quality during use as well as a reduction of noise and dust on site when used in off-site manufacture.

5.4.1 References

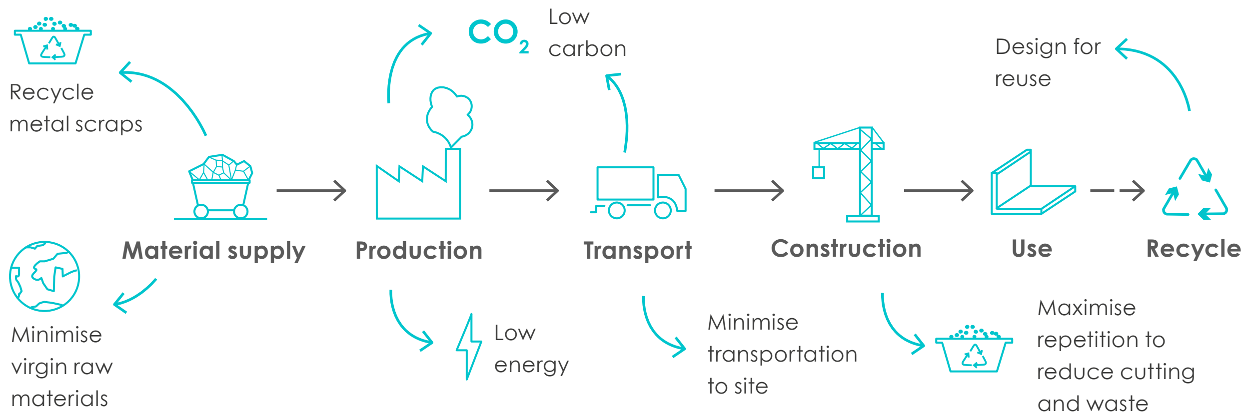
1 - *Timber Procurement Policy (TPP): prove legality and sustainability* [Online]. Available from: https://www.gov.uk/guidance/timber-procurement-policy-tpp-prove-legality-and-sustainablity

Aluminium

Watch points

- **Minimise** quantity of aluminium specified
- Maximise use of **recycled content**
- Opt for manufacturing using **renewable energy**
- Design for **reuse and recycling**
- Maximise **repetitions** to minimise cutting and waste
- Low carbon **transportation** (capacity/optimisation)
- Minimise use of virgin **raw materials**

Life cycle



Communication

Aluminium suppliers to provide clarity on **sourcing** of aluminium

Review **aluminium** sourcing from **WLC** assessment **early**

Design team to explore **reuse potential** of aluminium from **demolition phase**

5.5 Aluminium

After cement and steel, aluminium manufacturing is the third highest source of greenhouse gas emissions in the construction materials sector.

Aluminium is an essential construction material with unique properties, including light weight, ease of extrusion to any shape, and excellent durability. It can typically be found in façade, cladding, windows, panels and partition walls.

Primary aluminium is produced by smelting bauxite or nepheline ore using electrical electrolysis, an energy intensive process. Aluminium can, be infinitely recycled, without any loss of quality and recycling only uses around 5% of the energy needed to produce primary aluminium; highlighting the imperative of recycling as much aluminium as possible at the end-of-life of each product. Aluminium scrap can be classified as pre-consumer (never used as a product, extrusions, industrial and fabrication scrap) or post-consumer (at the end of the life, including façades, windows and elements dismounted from buildings). The UK produces around 10m tonnes of recycled metal each year. Whilst Aluminium materials are on the market with up to 75% recycled content (1.5 -2.3 kgCO_2e per kilogram of aluminium), around 75% of all aluminium produced is still in use today and the recycled material supply chain does not currently offer enough material to cover the demand.

Aluminium is typically used in window framing, façade secondary supports and rain-screen cladding.

An alternative to recycled material is offered by a number of aluminium producers, who provide a low carbon primary smelted product. Most of these products are manufactured using renewable energy, especially hydro power. Today, primary aluminium production in Europe generates about 6.7 kg CO_2e per kg of material produced; the carbon intensity for aluminium produced in China is three times higher. China accounts for an estimated 57% of world primary production, with 5% coming from Europe (International Aluminium, 2020).

Effective specification

Before producing specifications, designers should reduce the volume of aluminium in products and components and, where possible, replace it with other lower carbon alternatives. Where aluminium is used, designers should first try to minimise the amount of material used for the design task by understanding its limitations (extrusion size or application) and maximize repetition to reduce cutting and waste. Also ensure panels are not over-sized as these will have associated higher levels of embodied carbon.
Finally, they should aim to understand the fabrication process and its impact on carbon, including the carbon emissions associated with different finishes (e.g. powder coated likely to be lower than anodized) and any transport of materials between specialist finishers.

Aluminium should be specified from a source that uses less carbon-intensive production methods, i.e. has a high recycled content and/or is produced using renewable energy. Average global recycled content in aluminium is 62%.

When writing specifications, the designers should set the embodied carbon target range, rather than the precise specification of post and pre-consumer scrap, as this would make sourcing of the product more difficult. Note that high recycled content can be more expensive with some manufacturers, due to a more challenging supply chain.

Wherever possible, ask manufacturers to produce project-specific EPDs. There are a limited number of EPDs for certified aluminium and aluminium products on the market. The European Aluminium Association provides links to a number of EPDs .

Cradle to Cradle certification may also be available.

It is important to consider the finishes i.e. PPC v anodised as this may have an impact on the carbon footprint largely due to transportation of the material.

Successful low carbon procurement

The projects need a buy-in from client, developer and contractor who are committed to reducing embodied carbon and understanding the full aluminium process from bauxite mine to extrusion to reclaiming and recycling. Façade contractors are likely to have complex supply chains, and limited flexibility, and they particularly need to be engaged at an early stage of design development. Product procurement needs to be accessible, lean and not detrimental to the project programme or cost.

Long distance transport of aluminium between the extraction, processing, fabrication and application of different finishes can add a significant impact on the embodied carbon of the final product as aluminium is typically transported multiple times before it becomes an end product. Primary aluminium is produced in countries around the equator (i.e. Australia, China, Brazil, India, Guinea, Indonesia, Jamaica, Russia and Suriname). For some products, the processing takes place in Germany, while finishes can be applied in Italy, after which the product would be delivered to site. For this reason, it is essential that the designers understand the manufacturing process, and make informed decisions before specifying a particular finish.

Communication

Discussions with aluminium suppliers can provide clarity on where aluminium is currently sourced. This can present opportunities for specifying 'cleaner' grid factory locations as well as helping to determine the transportation profile

The current volume of aluminium available for recycling is limited but is expected to increase as building stock from the last few decades undergo renovation and the market for recycled aluminium production expands. The design team should therefore explore the re-use potential of aluminium that becomes available during any demolition phase and should actively engage with the pre-demolition waste audit team when appointed to understand potential for re-use. Additionally the design team should engage early with facade contractors to establish demolition aluminium re-use in façades.

Additional considerations / specification clauses

Inventories of all aluminium components in the building should be kept to ensure the material is tracked and can be recycled.

5.5.1 References

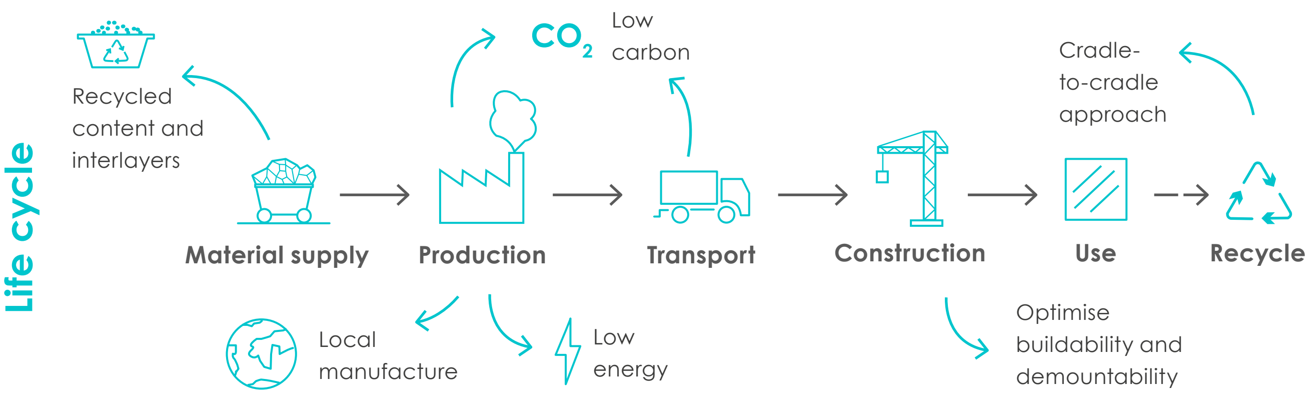
1 - *European Aluminium* [Online]. https://european-aluminium.eu/

Glass

Watch points

- **Balance** embodied carbon and performance
- Maximise use of **recycled content** (aim for >30%)
- Look for **recycled interlayers** (PVP/ionplast)
- Low and clean **energy** production
- **Local manufacture** if possible
- Low carbon **transportation** (i.e. ship vs. truck vs. train)
- Project **affordability** (viability for client)
- Optimise **buildability** and demountability
- **Cradle-to-cradle** approach for material lifecycle

Life cycle



Communication

Industry guidance needed on **recycling end-of-life** building glass

Developers to support transition to **low carbon glass**

Design team to consider **recovery** and **deconstruction**, choosing **recyclable** products

5.6 Glass

Soda-lime glass accounts for 90% of all the manufactured glass. It is made up of 70-74% silica, along with sodium carbonate, lime, magnesium oxide and aluminium oxide to enhance its performance. With its unique translucent properties, glass is used for curtain walls, façades, windows, skylights, partitions, lamps and tubes.

Glass can be indefinitely recycled in a 'closed loop' however it often finds its way to landfill. Recycled glass can have a second use as insulation or aggregate. In the UK, most waste glass from renovation and demolition works is crushed into aggregates for use in road building, or sent to landfill. Although turning glass into aggregates is categorised as 'recycling', its benefits are limited, and in life-cycle terminology, this is referred to as 'down-cycling' as its qualities are gradually reduced as it moves down the value chain. Conversely, closed loop recycling, where glass is turned into other glass products (container or facade glass), delivers far greater environmental benefits and carbon savings.

Effective specification

One of the key considerations when specifying glass is designing for whole-life carbon, i.e. considering both the operational and embodied carbon impacts. For example specifying triple glazing can help reduce energy consumption in cold and temperate climates, but prior to specification, the resultant operational savings should be compared against the increase in embodied carbon due to additional panes of glass. Additional panes of glass could also result in the reduction of on site systems sizing and off-site renewables as the higher thermal performance of the facade can reduce the energy demand of the building. This reduction in system sizing can also lead to reductions in system embodied carbon as there will be reduced material volumes. Other factors such as internal loads, size of panes, acoustics, structural performance should also be considered.

While the U-value (and the number of glazing panels) can have a significant impact on embodied carbon, other performance metrics such as the g-value or glass coatings have minimal impact on embodied carbon. However, there is limited guidance on which coatings and interlayers are easier to manage/ recycle at the end of life.

Where possible, recycled interlayers (PVB and ionoplast) should be specified.

Whenever possible, specify the percentage of recycled content. A large proportion of raw materials (35% or more) can be replaced by cullet/ recycled materials if they are available at the right quantities, quality and price (UKGBC, 2018). Glass recycling saves significant amounts of raw materials. Every metric ton of crushed waste glass (cullet) used to make new glass reduces the need for 1.2 metric tons of virgin raw materials (sand, lime, soda and additional minerals). Furthermore, cullet melts at a lower temperature than virgin raw materials, hence less energy is used and the carbon impact reduced. Substituting one metric ton of cullet for raw materials saves 322 kWh gas and approximately 0.3 metric tons CO_2. We currently only recycle about 1% of glass from construction, although glass bottles are recycled at a rate of 95%. A pre-demolition audit can help to improve that recycling rate.

Low-iron glass typically has higher embodied carbon than mid-iron glass.

Be clear, avoid using any contradictory performance language. Performance specifications should state upfront embodied carbon limits and it should be noted that laminated glass presents problems for recycling.

Successful low carbon procurement

Emphasis should be given to where glass is coming from and the supply chain route. For example, glass produced in China has a high embodied carbon content and it is recommended that carbon conscious projects look to sourcing from Europe.

End-of-life options depend on the type of glass. Ask for a cradle-to-cradle analysis, including the recyclability of every unit within the glazing system.

Some manufacturers have developed a recovery system for glazing units (e.g. Saint Gobain).

Glazing size can limit the procurement and transport options, thus resulting in increased embodied carbon values.

Recycled glass is an energy intensive process too and the carbon footprint may not be captured in EPDs for these processes.

Additional considerations / specification clauses

Insulated glazing units generally have a warranty of 10 years, and expected service life of 20-25 years.
If post demolition or refurbishment the glazing units are to be reused in another building, check the impact on code compliance, health and safety and building insurance premiums. Interstitial gas levels should be checked when they are being re-used as there is often argon leakage throughout the life cycle of insulated panels.

More industry guidance is needed on recycling end-of-life building glass back to glass, recycling of interlayers and ways to increase the percentage of recycled content in glass.

Most glass goes into residential applications and has the biggest potential for recycling. However, recovering glass from smaller buildings is not practical without industry support / legislation. Removing glass from commercial projects is easier due to sufficient tonnages, but due to time requirements, there is a financial pressure not to do it.

Developers' support is necessary to accelerate the transition to low carbon glass.

Recycling of laminated glass is available in the vehicle industry, but it is not currently done on a wide scale in the construction industry.

Design for glass recovery and consider end of life; where feasible design for deconstruction or choose products which are easy to de-construct and recycle.

Embodied carbon for windows shows a strong dependence on the typology of the frame, with wooden windows having the best performance.

5.6.1 References

1 - *5 steps to meeting those low-carbon goals* [Online]. Available from: RIBAJ, https://www.ribaj.com/products/sustainable-windows-low-carbon-omissions-dalston-works-cors-dyfi-nature-reserve-velfac

2 - *Glass from Glass* [Online]. Available from: https://ukgbc.s3.eu-west-2.amazonaws.com/wp-content/uploads/2018/09/05151714/VerdeSW1CaseStudy_FINALISSUE1.pdf

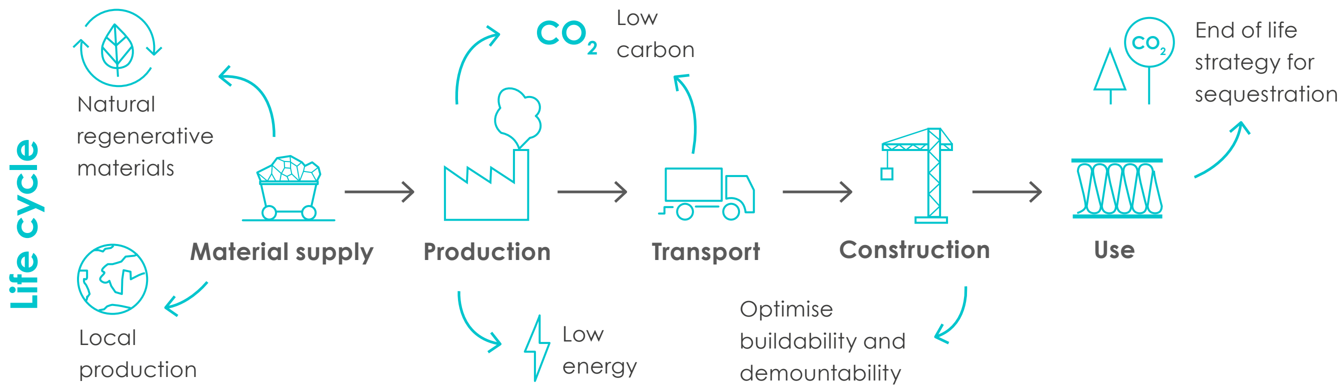
3 - *Centre for Window and Cladding Technology: How to Calculate the Embodied Carbon of Facades: A Methodology* [Online]. Available from: https://www.cwct.co.uk/pages/embodied-carbon-methodology-for-facades

4 - *Trosifol* [Online]. Available from: https://www.trosifol.com/products/architecture/recycled/

Insulation

Watch points

- Look for **natural,** bio-based materials
- Low carbon/fossil free **energy** in processing methods
- Low carbon **transportation** (i.e. ship vs. truck vs. train)
- Optimise **buildability** and demountability
- **End-of-life** strategy for sequestration
- **Consider** embodied carbon and performance



Communication

Ask for **product specific EPDs**

Designer to **inform users** on EC and lifespan of products

Suppliers to be engaged on the **performance service life** of different insulation types

5.7 Insulation

There are many different insulation material types on the market, with varying thermal performance levels, so when trying to compare embodied carbon, several factors need to be taken into account to ensure you are comparing like-for-like and are making the right choice.

The main types of materials used for insulation:

- Organic synthetic: Plastic, in the form of foam that has either been expanded or extruded
- Mineral (including glass) fibre, in board, batt or sprayed form
- Natural materials, in batt or sprayed form

Organic synthetic, i.e. Thermoplastic and thermosetting plastic insulation, made from petrochemicals includes:

→ Expanded or extruded Polystyrene (XPS and EPS)
→ Phenolic Foam (Phenol-formaldehyde resin with a foaming agent)
→ Polyurethane (PUR)
→ Polyisocyanurate (PIR)

Mineral based:

→ Stone mineral wool (made from quarried igneous rock and recycled steel waste and often called rockwool)
→ Glass mineral wool (made from silica sand, recycled glass, limestone and soda ash and often just called mineral wool)
→ Foamed cellular glass insulation (made from crushed glass, mixed with carbon)
→ Perlite (hydrous igneous glass with an amorphous structure expanded to loose fill insulation material - volcanic origin)
→ Vermiculate (similar to perlite but not of volcanic origin)

Natural insulation:

→ Woodwool or wood fibre insulation (from saw mill residue and forestry cuttings bound with polyolefin fibres and added ammonium phosphate)
→ Cellulose (made from recycled newspapers treated with boric acid and borax) in sprayed or slab form
→ Expanded cork insulation (made from bark harvested from the Quercus suber- Cork oak trees and can be in slab or board form)
→ Hemp
→ Sheep's wool
→ Flax

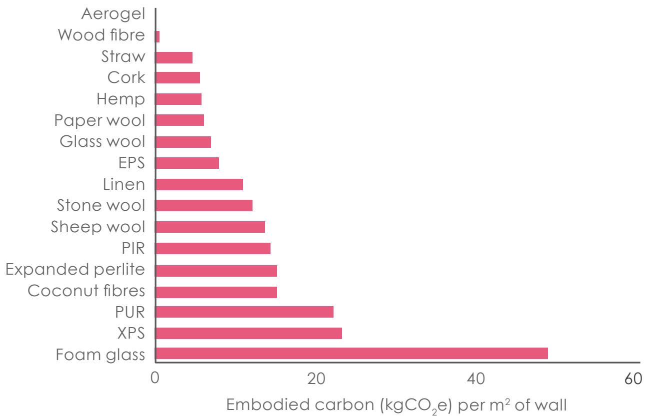


Figure 5.1 - Insulation embodied carbon (A1-A3) for materials with same u-value (table data source: 2050-materials.com)

Effective specification

Always compare different products based on the same performance requirements achieved, e.g. thermal conductivity (U-value) or acoustic performance (Rw). Due to the differing nature of materials, this will result in different thickness of insulation required for different insulation types. Fire resistance, strength and durability may also vary between types.

High performing thermal insulation materials may require less thickness and therefore less quantity (overall m^3) than lower thermally performing materials. This might result in an overall lower total embodied carbon figure.

Insulation greatly reduces space heating demand and thus operational carbon during a building's lifespan, so adding insulation should always be a priority following the 'fabric-first' approach. Designing for a high performance facade can increase the upfront embodied carbon in a project as greater depths of insulation materials are often specified. The first step when specifying the thickness of insulation is to calculate the thickness of insulation required such that the space heating demand target is met. Both the operational and embodied carbon impacts of insulation materials should be considered in a WLC model.

SIGNPOST *Climate Emergency Design Guide Chapter 1*

See LETI opinion piece 'Operational Carbon in Whole Life Carbon Assessment' on how to understand whole life carbon implications of design decisions.'

SIGNPOST *LETI opinion piece Operational Carbon in* Whole Life Carbon Assessments

Many closed-cell spray foams and rigid foam products have high GWPs, natural materials such as cellulose, sheep's wool, and straw have a low GWP.

Natural insulation materials (like cork, woodwool, wool,etc.) may also sequester carbon. Sequestration is currently not always reflected in embodied carbon assessments, but is certainly to be kept in mind, and might form part of calculations in the future.

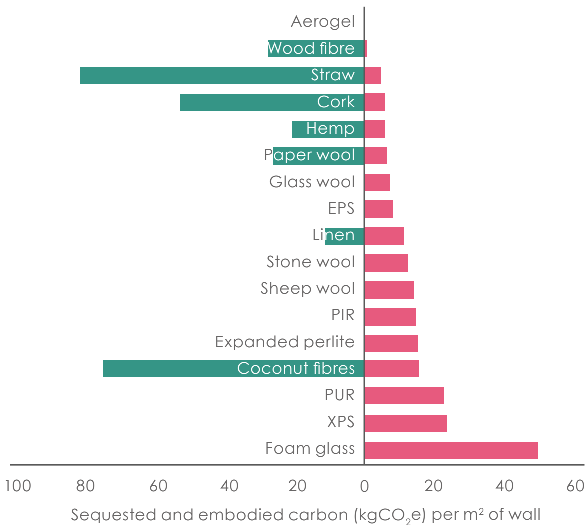


Figure 5.2 - Insulation sequestration and embodied carbon (A1-A3) (table data source: 2050-materials.com)

Also consider the lifespan of insulation materials. Some materials are inert (e.g. glasfibre slabs), with a long lifespan and when loose laid and undamaged can be re-used at the end of the building's lifespan without loss of performance, where as others are limited to single use applications.

Not every insulation material is suitable for every location and use. Criteria like fire performance, breath-ability, loading requirements, space availability, performance requirements (acoustic, thermal) etc. might exclude certain insulation material types.

Successful low carbon procurement

Start to consider insulation requirements and sustainability aspirations for projects early on in the process to allow for required build-ups in the design.

Look at whole life carbon emissions and consider durability of insulation as well as performance and embodied carbon.

Make sure requirements are communicated clearly in the specification to allow contractors to price and source accordingly.

Communication

The insulation industry already provides a lot of information on embodied carbon in their products. However it should be noted that often EPDs produced in the insulation industry are generic, i.e. industry average. Where possible secure product specific EPDs, which will give a far more accurate embodied carbon footprint.

The designer should advise/ inform the building owner on embodied carbon and lifespan of products chosen to justify their choice.

Whole-life carbon impacts should be discussed when selecting insulation. Trade-offs between up-front embodied carbon and the long-term reductions in operational carbon should be considered, particularly if there is an impact to the durability/lifespan of the product. Suppliers should be engaged to understand the performance service life of different insulation types.

Additional considerations / specification clauses

Transport related embodied carbon is typically negligible due to the lightweight nature of insulation slabs. Therefore the distance between site and location of manufacturing is less important than other materials.

Look at the whole build-up: Some insulation types (cellular glass) can be used for waterproofing, therefore other materials/ membranes may not be required.

Check what can be done at the end of life. Some insulation types are take-back products and can be recycled in the factory.

Other technologies such as aerogels (low-density material made from silica and air) and nano-insulation materials (NIMs), made from hollow silica nanospheres are being developed and may become more available in the future. These may achieve very low u-values and utilise less space than conventional insulation materials, however information on embodied carbon is not yet widely available.

Insulation plays a key part in the fabric first approach to reducing operational energy, and it is therefore critical that attention is given to the detailing and installation of insulation as well as robust thermal bridging details in order to capitalise on its benefits.

5.7.1 References

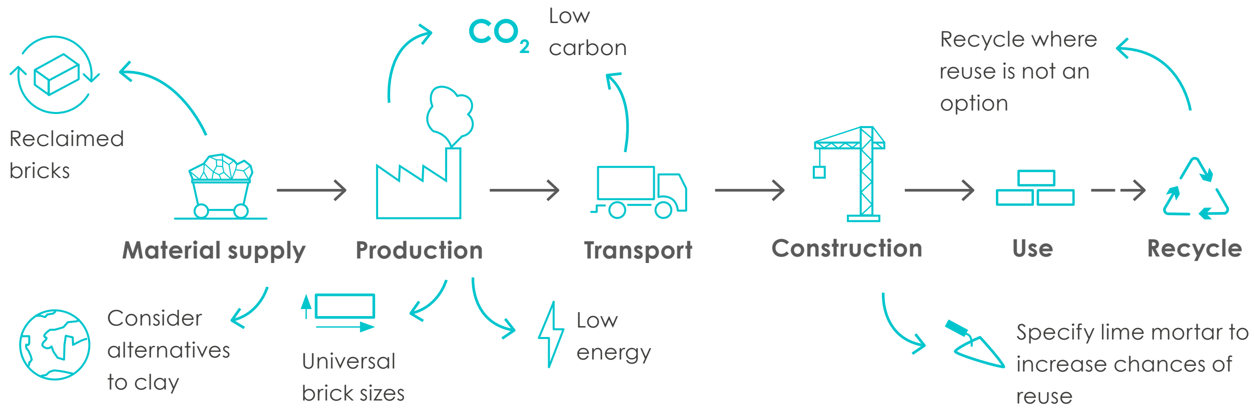
1 - *2050-materials.com* [Online]. https://2050-materials.com/

Brick

Watch points

- Maximise the use of **reclaimed bricks**
- Ca_2SiO_4 Specify **calcium sillicate** rather than clay bricks
- Low carbon/fossil fuel free **energy** in processing methods
- Specify **lime mortar** to increase chances of brick reuse
- Low carbon **transportation** (i.e. ship vs. truck vs. train)
- Universal brick sizes will increase **reusability**
- CO_2 **End-of-life**, recycle where reuse is not an option

Life cycle



Communication

Contact **original brick manufacturer** when recycling/reusing

Encourage **material passports** for easier brick **reuse**

5.8 Brick

Brick manufacture requires the firing of clays at high temperatures and, whilst coal has been replaced primarily by gas as the direct source of energy for UK manufacturers, the process is associated with high carbon emissions. Currently 1.85million bricks are produced in the UK (ONS, 2022) but the UK is also a major importer of bricks from the EU, India, Pakistan and Turkey. Whilst the use of brick has declined since the 1970s, brick continues to be an important material, with approximately 80% of new build homes being brick built.

Brick clay is the primary material used for bricks, which include natural materials such as silica (sand) and alumina (clay). Silica prevents raw bricks from cracking, shrinking and warping; alumina, mixed with water, gives the brick plasticity to be moulded and dried. Iron oxide is also commonly added which allows the silica to fuse in the furnace at lower temperatures, increases durability and gives a red colour. The balance of these ingredients, as well as the presence of lime, stones, and organic matter, affects the strength, uniformity and density of the brick. The majority of UK brickworks are situated close to a source of brick clay but specific colour requirements or brick properties may require other materials to be used.

Most bricks are formed or shaped either by extrusion, pressing or moulding. Clay bricks are dried between 80-120°C for up to 40 hours, to prevent them exploding in the kiln, and then fired at around 2,000 degrees. Carbon emissions come from both the fossil fuels used in the drying process and the clays also generate process emissions during brick manufacture, which are technologically difficult to abate. The Brick Development Association (BDA) provide an LCA for a generic UK brick which covers all brick types and production process and is based on data representative of 99% brick production by BDA members.

Clay bricks have the potential to remain in-use for up to 650 years, with a typical life expectancy of 150 years. Reuse of bricks following demolition is feasible, and indeed there is a strong market for reclaimed brick. However reclaiming brick can be problematic, as unlike traditional lime based mortar, modern cement-based mortars make cleaning brick for reuse difficult. Maintenance of brick is limited, with walls most likely to only require restoration of mortar over time.

Bricks are also available in the form of brick slips, usually as part of an external cladding system. The method of supporting the slips varies considerably and is key to the embodied carbon of the system, ranging from steel framing systems to precast concrete panels.

It should be noted that wind-posts, ties and other steel accessories will also need to be considered as part of the overall embodied carbon calculations, as they may significantly increase the total embodied carbon content of the system, particularly when comparing against other alternative systems.

Whilst clay bricks are most commonly used in construction, alternatives such as calcium silicate bricks can be considered in certain applications. Calcium silicate bricks require less energy and produce fewer pollutants during clay firing and offer highly recyclable, reusable and durable bricks that perform like quarried stone. However, calcium silicate bricks have a slower production time which make them less readily available on the market.

Effective specification

Once a kiln is up to temperature it will run most efficiently if production levels are maximised, so ensuring brick requirements are planned well in advance can support this.

Re-use and recycle bricks where possible. Review specification requirements and understand whether there is scope to re-use bricks either from the site or off-site sources. Reused bricks divert demolition material from landfill and have negligible embodied carbon when locally sourced.

Keep the quantity of special bricks, such as glazed bricks, to a minimum as they can have energy intensive manufacturing processes.

Specify local and/ or check the supply chain of where the brick is produced. Coal is the primary fuel used in brick firing in India, Bangladesh and Turkey, with associated higher CO_2e and particulate emissions.

Transportation of bricks in the UK is a minor element of emissions but can add to the embodied carbon footprint of the brick if sourced elsewhere.

Specify calcium silicate bricks rather than clay bricks where appropriate. These require less energy and produce fewer pollutants in fabrication, however, in addition to the slow production times they are prone to expansion and shrinkage. In certain circumstances may cause significant masonry shrinkage.

Since most bricks are used to create brick walls, the specification and procurement of the mortar is a key factor in the embodied carbon of their use. Consideration should be given to the growing range of lower carbon mortars available, and also their method of procurement to avoid waste on site. Many contemporary mortars are provided in on site silos for material use efficiency.

Specify lime mortar to ensure bricks will be reusable in the future. For a circular approach, it is advised to use a mortar which is softer than the brick. Hard concrete mortars (e.g. Portland cement mortar) cannot be removed easily from brickwork, resulting in damaged and broken bricks. Soft mortars (lime) are easier to remove and the brick can therefore be reused.

Include in the specification how bricks can be re-used in the future.

Successful low carbon procurement

Local reclaimed brick should be sourced wherever possible. An unfired brick system with much lower embodied carbon may be suitable for internal non load bearing walls and can also help with humidity regulation.

Bricks originating pre early 20th Century would normally be joined in lime mortar, making it easier to remove; however, the quantity of bricks available for reuse from pre-1940s buildings is diminishing.

Recycling bricks is an environmentally friendly way of eliminating it from the waste stream. Recycled brick can be crushed and used for a number of different applications, including back fill and decorative gabions, or as part of a recycled concrete aggregate for hard core and fill and some lower strength concretes. Research is underway into use of recycled brick dust as a partial cement replacement.

Bricks can be chipped and used in landscapes as a permanent mulch that is weather resistant, or as ballast in roofing, and may have a cost advantage over traditional material. Very finely crushed bricks can be used in place of sand or even go into new bricks. However, crushing bricks is the last resort approach and bricks should be re-used where feasible.

Communication

The quality assurance standard BS EN 771-1 applied to the manufacturing process of new bricks is unavailable for reclaimed bricks. As such, assurance of the reclaimed bricks' performance may need to be obtained from the supplier. Material passports that digitally document relevant data about brick components will aid their re-usability.

Additional considerations / specification clauses

Generally, the cost of sourcing and cleaning, gives a cost uplift to reclaimed bricks, however, compared to other cladding systems, brick retains low life cycle embodied carbon.

Design out the need to cut or grind bricks on site (by designing to standard brick dimensions), as this generates fine silica dust particles, which can get deep into the lungs and cause respiratory disease and cancer.

Intelligent and adaptable design is especially important in brick buildings to allow multiple uses, and to ensure that the building has a lifespan to match the longevity of its construction material.

Concrete facing bricks are also increasingly common in the UK.

At the time of writing this guide, new methods for brick handling and brick production are developing including the following examples:

The REBRICK project aims for a more resourceful handling of demolition waste through automated cleaning of clay bricks. Since the burning of new bricks is very energy and resource intensive, the reuse of bricks saves the environment 0,5 kg CO_2e per brick

Alternatives such as K-Briq are scaling-up production. The bricks are formed of 90% recycled construction and demolition materials and do not require high temperature firing. Consequently emissions are claimed to be around a tenth of those created during traditional brick making. Stonecycling is another upcycled construction waste product.

Facadeclick is a facing brick building system, where bricks 'click' together without mortar or glue, using an HDP (high-density polyethylene) connector. The system is easy to install without specialist skills; it allows for faster construction whilst eliminating error, and unlike wet trade, can be constructed in all weather conditions. The pressure resistance and tensile strength of the wall ties and anchors is substantially higher compared to traditional masonry. The system can be disassembled and re-used.

Using digital fabrication techniques, bricks can be robotically assembled in an additive fashion. Robots can aid assembly processes in prefabrication as well as on site, placing bricks or lifting and moving façade elements, removing human fabrication constraints.

5.8.1 References

1 - *The Rebrick Project* [Online]. http://www.gamlemursten.eu/

2 - *Stonecycling* [Online]. https://www.stonecycling.com/

3 - *Facadeclick* [Online]. https://www.facadeclick.be/index.html

4 - *Kenoteq* [Online]. https://kenoteq.com/

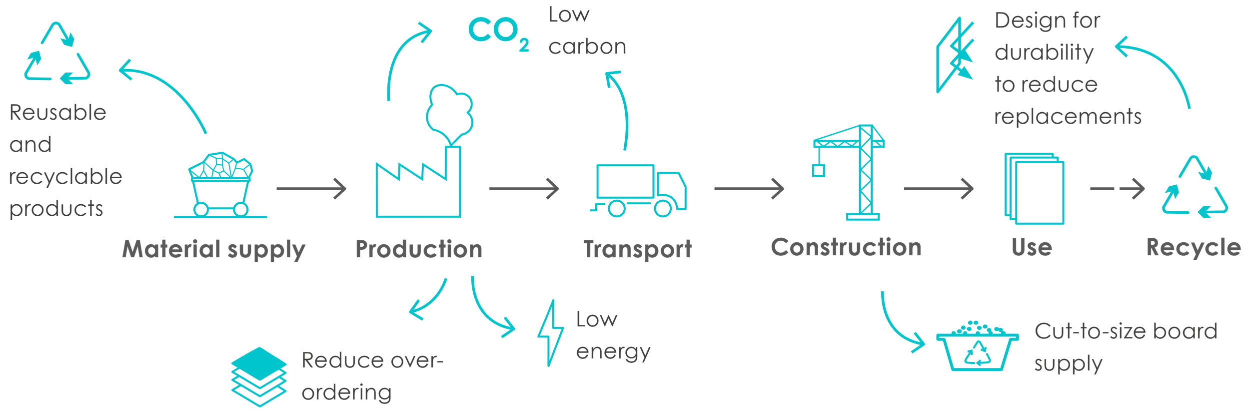
5 - *Brick Development Association* [Online]. https://www.brick.org.uk/sustainability

Gypsum plasterboard

Watch points

- Specify **lightweight** boards where possible
- Look for **reusable** and **recyclable** sources
- Low carbon/fossil fuel free **energy** in processing methods
- Look for **cut-to-size** supply to minimise waste
- Low carbon **transportation** (i.e. ship vs. truck vs. train)
- Reduce the need for **over-ordering**
- Design for **durability** to reduce replacements
- **End-of-life** strategy for recycling

Life cycle



Communication

Contractors and manufacturers to be engaged early to find **best suited board**

5.9 Gypsum plasterboard

Gypsum is a non-hazardous mineral which is endlessly recyclable without any loss in its quality characteristics. The manufacture of gypsum products is moderately energy intensive, but there are no additional process carbon emissions, such as occur in cement manufacture. This provides opportunities for gypsum based products such as sheathing board, to be used as a replacement for more carbon intensive cement products, such as particle board.

Gypsum is used in a wide range of building materials:
→ building plasters, decorative and smoothing plasters
→ plasterboard
→ decorative gypsum moldings, often in conjunction with glass fibre reinforcement (GFRG)
→ fast setting joint compounds for plasterboard joints
→ screeds (anhydrite screeds, often used in conjunction with underfloor heating),
→ floor levelling compounds
→ gypsum based adhesive mortars and gypsum blocks
→ some ceramic tile adhesives.

This chapter focuses on the use of gypsum as a plasterboard, as this is its primary use.

Gypsum may be sourced from mines or quarries or it can be sourced from an industrial by-product. The main type of by-product gypsum is flue gas desulphurisation (FGD) or desulpogypsum (DSG). These by-products have traditionally come from coal-fired power stations, however availability has been sharply reduced as coal is phased out and its place is increasingly being taken up by post-consumer gypsum that is recycled from construction and deconstruction of the built environment. The main carbon benefit of the closed-loop recycling of plasterboard occurs at the end of life part of the life cycle where landfill disposal is avoided. This arises due to the degradation of the paper liner leading to methane generation. Although the proportion of paper is small (typically < 4%w/w), as methane is a potent greenhouse gas (compared to carbon dioxide), the carbon impact can be significant, up to 10% of total lifecycle emissions (Universidad Politécnica de Madrid, 2013). As standard, plasterboards now contain 10-25% recycled gypsum content.

Effective specification

Most plasterboard/ drywall manufacturers supplying the UK market have EPDs for their products, so the designer's specification should require the contractor to provide a product specific Type III EPD for gypsum plasterboard.

Lighter weight boards will be less carbon intensive as they use less water in manufacture, require less energy intensive drying and have reduced carbon emissions associated to the transportation of the lighter weight material. Note that technical products with high functional requirements (e.g. fire, acoustic, impact) tend to have a higher carbon intensity.

Whilst most manufacturers offer recycling schemes, all gypsum types require the same processing, therefore the recycled content of plasterboard has minimal impact on the cradle to gate embodied carbon content. It is estimated by BRE that around 30% of plasterboard purchased is destined to become a waste material, so it is important to try to achieve the required technical performance with less plasterboard. For instance, when using high performance boards in a partition it may be possible to achieve the required acoustic separation with a single layer each side of a stud, rather than two layers of lower-performing products.

For large one-off buildings or housing schemes manufacturers can offer board cut to size, potentially reducing waste from 12% to 3.5% (CIRIA, 2001). A lot of wastage of plasterboard on site stems from specifying board size incorrectly with 32.8% of waste driven by trimming of over-height boards. Waste also comes from over-ordering by the contractor and damaged plasterboard from transport or wrong storage (15.7% of all waste). Contractor specifications should include unused plasterboard take-back by the manufacturer.

Design plasterboard partitions for longevity. It is important to specify the right board for each location and applicable durability requirement, to avoid having to replace plasterboard before its intended lifespan which can be more than 50 years. Incorporate this thinking into new construction, refurbishment or deconstruction planning by ensuring that building elements can be dismantled and different materials segregated for recovery and re-use. The designer should ensure that these durability requirements are captured in the specification. Particular consideration should be considered to limit its use in potentiality wet environments to avoid it being ripped out prematurely. (Gypsum based products are not recommended in areas at risk of flooding for example).

Successful low carbon procurement

Engage with the contractor early on and speak to plasterboard manufacturers to assist in finding the best suited, low-embodied carbon solution for the project. Information on the embodied carbon within different plasterboard materials is not commonly included in product specifications (e.g. British Gypsum White Book online, or Knauf Product Data sheets or Declaration of Performance). Instead request copies of EPDs from the suppliers.

Please note that references to high-recycled content plasterboard in some assessment schemes are no longer relevant as they are no longer on the UK market. Instead check the re-use and recycled content of the material selected.

Additional considerations / specification clauses

Gypsum fibreboard is made using a different industrial process from plasterboard. It is usually more energy intensive and the products are less easily recycled. There is currently no manufacture of gypsum fibreboard in the UK.

Ensure the paint specification is adequate for the plasterboard.

Breathable plasterboard may be more suitable for retrofit projects.

5.9.1 References

1 - *Breathable plasterboard* [Online]. https://adaptavate.com/breathaboard-breathable-plasterboard/

6

Case studies

6.0 Case studies

Three case studies have been developed to present a view across the supply chain on how embodied carbon reductions can be achieved. They demonstrate that a collaborative approach with statutory bodies, clients, designers, manufacturers and contractors, all offering their perspective on the build process, is important.

All the case studies were designed or at build stage before this guide was created but we have indicated how elements of the work undertaken aligns with the LETI Project Carbon Reduction Roadmap.

SIGNPOST *Project carbon reduction roadmap Chapter 2*

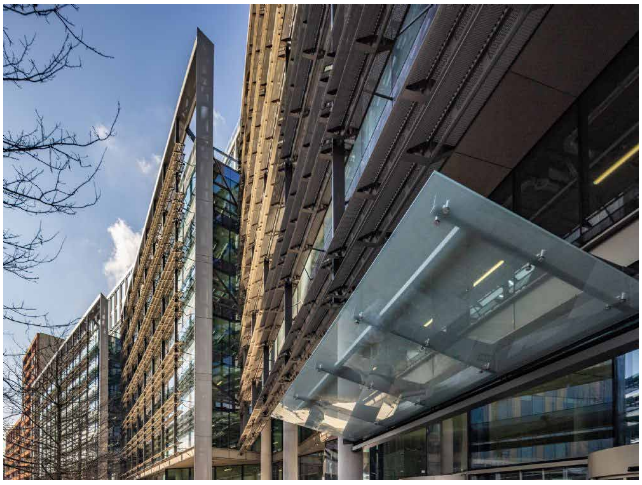
The following case studies are presented in the subsequent pages:

→ 11-21 Canal Reach
→ The Urban Nature Project
→ University of the Arts London - Stratford Waterfront

The text for the case studies is presented as a summary of information provided by key personal working on the project, and is thus written in the first person, reflecting the interview nature of the research carried out by LETI to produce this document. LETI would like to thank those who contributed to the case studies and shared their innovative work.

Case Study 1: 11-21 Canal Reach

Client: Argent
Architect: Bennetts Associates
Contractor: BAM Construct
LETI D Rating: 705kg CO_2e/m^2 (A1-A5)



Project summary

11-21 Canal Reach is a contemporary workplace located in the 'Western Yards' of the King's Cross masterplan, which was completed in 2021. The building is 200 meters long and 12 stories high, providing over 400,000 sq. ft of office space. This itsone of the largest projects to have completed an assessment of embodied carbon.

Project performance can be demonstrated by the following metrics:

→ 10,000 tCO_2e upfront embodied carbon (A1-A5) reduction at as-built stage from RIBA Stage 2.
→ 1,500 tCO_2e upfront embodied carbon (A1-A5) reduction at as-built stage from RIBA Stage 4.
→ 3,970 tCO_2e carbon savings in the concrete frame through high cement replacement.
→ 2,900 tCO_2e carbon savings in the piles through high cement replacement.
→ 1,382 tCO_2e carbon savings in curtain walling through sourcing low carbon aluminium.
→ 1,500 tCO_2e carbon savings through in site energy and fuel through a highly efficient site set up and use of renewable energy.

It is one of the first buildings to publish an as-built LETI rating publicly, achieving a "D" rating. At 705kgCO_2e/m2 (A1-5) 11-21 the projects upfront embodied carbon is around 40% lower than "business as usual" despite being designed six years ago as a large, speculative office building. This highlights the carbon reduction ambition of Argent, Bennetts Associates and BAM throughout the project's life. As well as focusing on embodied carbon, the scheme achieved a BREEAM 'Outstanding' rating as a result of its holistic approach to sustainable design.

Architect view

One of the key elements of success to reduce embodied carbon was that our architectural appointment was to both design and the deliver the building. This meant there was ongoing oversight of the embodied carbon and sustainability requirements on the project. In 2015 it was clear from the onset that the client, Argent, had an ambition to reduce embodied carbon as much as possible, although there were no specific contractual requirements. Even when a tenant was found for the property the whole team were committed to continuing the embodied carbon assessment for learning and best practise."

Argent appointed a carbon consultant (Sturgis Carbon Profiling) to develop options for carbon reduction - this included 'baseline' and 'stretch' targets. Using regular carbon workshops throughout the design process, these options were explored by the design team and contractor.

Tips when specifying low carbon products:

→ Do the research - specifying specific products which exist. There is no use in including a requirement for a specific amount of recycled content if there are no products with that level of recycled content available. We spent additional time on this project researching products including 'wading through greenwash'. Now we have started to build a database of low carbon products we can use on future projects.

→ Consult the supply chain - using a request for information form from the carbon consultant & managed by the contractor, we found that the supply chain was sometimes able to outperform our initial targets. For example, the cladding contractor was able to deliver a much higher recycled content than initially expected. This information can then be worked into the specifications.

Contractor view

Collaboration has been vital on this project. As a contractor we can act as the bridge between the designers and supply chain to deliver low embodied carbon buildings. BAM were brought in at the end of RIBA Stage 2/start of Stage 3 and we worked closely with the designers during detailed design to explore low embodied carbon options. Due to both the embodied carbon requirements and BREEAM Outstanding ambitions we funded an assistant sustainability advisor for the project. They were able to manage the requests for information from our supply chain and identify where we could collaborate to further reduce embodied carbon.

Although the structural and M&E consultants changed during the design process, there was plenty of collaboration with the initial consultants. The architect remained the same throughout and acted as a 'consultant of continuity'. As the contractor, we were able to comment on the low carbon options which were suggested at stage 2 to help the designers understand the feasibility of the suggestions, referencing both cost, risk and program implications. This was particularly important for discussions with the supply chain in relation to cement replacements. This process also ruled out certain products where the lead time would result in significant program delays.
Most of the embodied carbon improvements were made through the stage 2 and 3 design decisions which we then incorporated into subcontractor packages, but some further reductions were achieved through discussions with the supply chain when packages were tendered and confirmed. If any changes were suggested, we worked with both the designers and carbon consultant to ensure that these would not impact the overall carbon targets.

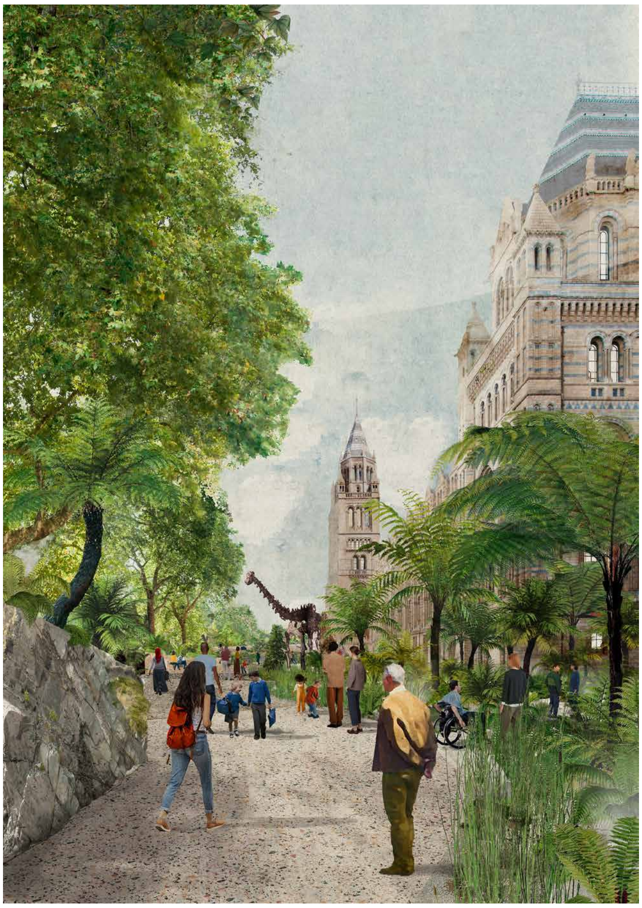
One of the important factors related to embodied carbon is that we continued the modelling and measurement to produce a final as-built figure. This assessment highlighted both the challenge of data management and maintaining buy-in from all parties throughout the construction stage. Communication with the supply chain was important and one method we used was to include embodied carbon as part of our environmental supply chain reviews and our annual awards.

Key procurement highlights: LETI Project Embodied Carbon Reduction Roadmap

Strategy	→ Set a clear brief and ambition from the start and engage contractors as part of this, preferably as early as possible → Appoint a designer / consultant to act continuously throughout & drive the low carbon ambitions → Appointing an embodied carbon consultant to establish an initial baseline & advise on low carbon options (this is iterative and should include Stages 2, 4 and 6 final as-built reports)
Research	→ Embodied carbon workshop with designers & contractor → Designers reviewing specific products with low carbon credentials → Contractor review low carbon options & implications in terms of availability, suitability, cost, risk, quality and program → Reach out to supply chain to explore 'best case scenarios'
Transparency	→ Ensure carbon calculations and assumptions are shared with all → Sharing of Stage 2 and Stage 4 carbon reports → Be clear on scope and what is included, excluded, assumed and verified
Requirements	→ Specifications outline specific products. Any changes must seek approval → Contractor incorporates carbon requirements into tender packages
Submittals	→ Request for information forms used to capture embodied carbon data → Forms reviewed & sense checked by contractor and by those with carbon expertise → Work with the carbon consultant to sense check figures which have been provided at Stages 2, 4 and as-built
Record	→ Request sense check from the designers to review the post-completion assessment and provide commentary on how reductions were made (or where they were higher than predicted) as part of lessons learnt process → Publish LETI rating publicly

Case Study 2: The Urban Nature Project

Client: The Natural History Museum
Architect: initially McLaughlin and Kim Wilkie, currently Feilden Fowles
Contractor: To be confirmed (not appointed yet)
Sustainability Quality control: MACE Responsible Business



Project summary

Created within the grounds of the Natural History Museum this project, planned for completion by 2024, is designed to expand the biodiversity and educational experience of the site and to create two new, wooden buildings. The first of these is a new garden building which, in the spirit of historic Victorian garden structures, will contain a café with support space for seasonal garden storage and display of exotic plants. There will also be a new learning and activity centre offering vital facilities for scientific work and learning activities and volunteering. The museum, using science-based targets, has set a goal to reach net zero carbon by 2035. This requires the Urban Nature Project to achieve net zero for the build and landscaping; which includes both the operational and embodied carbon.

Client view

Having a net zero target meant that every detail of construction had to be examined. All the elements of the design, construction and disposal were assessed by the projects team, the designers and sustainability consultants for potential carbon savings actions - and a very long list emerged. From this, a framework and KPIs were developed, which were signed off by our project board right at the start of the work. Importantly, input from scientific staff who pushed our team to ensure that regular measurement and reporting were in place. To manage trade-offs and changes, the project not only had a financial budget, but also as a carbon budget.

We accepted that by building net zero there are risks, not everything was going to work as we hoped: gaps in supply chain, skill gaps, or potentially cost premiums. It was important to us that specifications were developed in detail and to help manage these we became embedded in the design team; indeed, any value engineering had to be approved by us.

There have been many successes operating across the whole life cycle: the whole construction process is diesel free; the design has utilised Passivhaus principles to minimise the amount of M&E equipment replacement required in future and deconstruction is being built into material selection.

Sustainability consultant view

We were directly appointed by the client in Stage 1, enabling us to support the museum's sustainability aspirations. We worked with the client to deliver a one-day workshop with key stakeholders, including scientists, the design team and landscape architects, which identified important KPIs and the need for a LCA assessment. The museum was determined that KPIs would be aspirational. The client was interested in going beyond net zero, towards carbon positive. To achieve this we explored onsite ecological carbon offsets. Whilst it is likely the project will need to include off-site, verified carbon offsets to achieve the net zero carbon position, the intent is to utilise the project to better understand how much carbon is sequestered by urban landscaping. This will form part of the scientific monitoring in the gardens.

We worked closely with the designers and were able to offer expertise as specifications were developed and liaised with the cost consultancy team. The specifications have challenged all the project members to consider not just embodied carbon but how to balance this with circularity and recyclability at end of life. Both we and the designers have been talking to suppliers and thinking about what is needed from the whole design, and that has really helped. There have had to be trade-offs, and whilst carbon has been an important element it is not the only factor that has been considered – cost, duration and quality have also mattered. We have realised that it is possible to be overwhelmed by too many options and too much detail, which can detract from the bigger picture of what the project is trying to achieve. So, one of our roles has been to offer guidance on the key issues, to ensure we are all focusing our efforts on those activities which will have the biggest impact on sustainability.

Regular monitoring and reporting, with the project team, to the client has been important. It really has kept a focus on sustainability outcomes. We have seen this when value engineering was carried out, it included sustainability and embodied carbon as a key factor. Value engineering measures which had the potential to reduce carbon as well as cost were prioritised. Where compromises had to be made, we made sure that the impact on the sustainability targets, including embodied carbon, was, if not negligible, then minimal.

Key procurement highlights: LETI Project Embodied Carbon Reduction Roadmap

Strategy	→ Create carbon/environmental and financial project budgets → *"All our work is science based - so we took a whole life approach to carbon. We knew we needed more technical support. We appointed an independent expert to support stakeholder/client/designer carbon strategy development"* **Natural History Museum**.
Research	→ *"You need a strong buy-in from your architect. We included 'Green Credentials' as a procurement requirement"* **Natural History Museum.**
Transparency	→ Design team specify products and suppliers as part of technical specifications submitted → Monthly client/design/expert review meetings → Net-zero carbon targets set.
Requirements	→ Ensure pre-qualification questionnaires, tenders and contractor qualification's include carbon targets. Framework contract with KPIs → Contractor requirement to cascade and train suppliers on KPIs → Client engages in specifications and agrees increased cost solutions if required. Reductions in costs may be expected elsewhere. All changes to specifications must be approved by the client.
Record	→ Carbon expert - ongoing building monitoring.

Case Study 3: University of the Arts London: Stratford Waterfront

Developer: London Legacy Development Corporation
Client: University of the Arts London
Architect: Allies and Morrison
Contractor: MACE

Project summary

The University of the Arts London: London College of Fashion is moving to a single new campus sited at the Queen Elizabeth Olympic Park. The new campus, inspired by 19th century mill buildings, is designed by architects Allies and Morrison and has achieved a BREEAM Outstanding classification. The 41,200 sqm building, providing space for 6500 staff and students, will be handed over to the college in June 2023. It will be day-lit and naturally ventilated, with factory-like steel-framed windows, internal atria for flexible learning, and lots of green spaces. High volumes of recycled concrete have been utilised for the frame and foundations and existing equipment has been used where possible.

Developer view

The University of the Arts London (UAL) building at Stratford Waterfront is an important part of the Stratford Waterfront development as the 'forever home' for the London College of Fashion (LCF).

UAL's brief to the London Legacy Development Corporation (LLDC) for the new LCF building was that it should be designed to last for over a hundred years and that the development should be flexible and adaptable. Early sustainability workshops highlighted that embodied carbon and natural ventilation, along with reduced Mechanical, Electrical and Public Health requirements, were all important elements for the design team to incorporate. As part of the legacy of the London 2012 Olympic and Paralympic Games, LLDC has strong commitments regarding sustainability, to which the UAL building responds.

A 'managed packaged procurement' approach to the construction works has been implemented by LLDC and managed by Mace, as the project management partners for the Stratford Waterfront development. This means that each contractor is directly contracted by the LLDC, which has ensured greater levels of collaboration across the value chain, allowing for more responsive design and increased levels of carbon savings.

With existing and prospective occupants requiring more information around how buildings are future proofed, retrofitted and upgraded, it is now more important than ever to consider procurement in terms of whole life carbon. Such conversations are ongoing and form an important part of the LLDC's climate emergency response.

Client view

Since the early stages of the project, UAL has been heavily involved in helping develop and inform the design of the LCF building at Stratford Waterfront.

During early conversations, UAL identified embodied carbon, natural ventilation and energy modelling as key areas of focus, based on UAL's experience of their currently occupied buildings. The university wanted to incorporate some of its learnings from some of its smaller developments, including a studio build at the Wimbledon College of Art, which in 2017 won the RIBA London Sustainability Award, and a larger academic extension at the Camberwell College of Art. UAL believes that buildings must be places that people feel comfortable in and as a proud challenger of the status quo, the university has worked closely with the LLDC and its contractors to embody this sentiment across the scheme design.

The importance placed on the whole lifecycle impact of the building, as well as a focus on sustainability, cost, material circulatory and ethical build implications has strongly fed into the overall design, which can best be seen across some of the building's façades and fabric. Whilst there is not a $kgCO_2e/m^2$ embodied carbon target, the quantity of embodied carbon is assessed within the lifecycle assessment that is commissioned for each stage of the design. This enabled us to check progress against each stage of the design brief.

Transparent multi-disciplinary conversations between procurement teams at the LLDC and Mace have been important. Close collaboration has been facilitated through the use of an e-portal , which has supported discussions with specialist suppliers. This in turn has provided the university with a wider understanding around some of the trade-offs which need to be made in order to generate carbon efficiencies.

Contractor view

Mace has worked on the London 2012 Olympic and Paralympic Games, from the capital's bid, through to the current transformation of Stratford Waterfront. Mace Consult was first appointed to work on the Stratford Waterfront development in 2016 and has since supported UAL in helping to realise their ambition to deliver a commercially viable BREEAM 'Outstanding' rated building for the LCF.

As the LLDC's project management partners for the Stratford Waterfront development, the Mace Consult team has focused on making the LCF project as sustainable as possible, working directly with the design team to take a prescriptive approach from Stage 2, including on carbon reduction requirements. This approach has been successfully applied across contractor packages, ensuring that both UAL's and the LLDC's sustainability requirements have been upheld.

To deliver on carbon efficiencies, Mace introduced a number of outcome-based targets around the use of recycled concrete and Ground Granulated Blast-furnace Slag (GGBS) content in concrete to reduce the amount of carbon produced during construction. A target of 30% was agreed with the client. Through an online toolkit, Mace monitored the use of recycled concrete and GGBS which has provided valuable data, leading to improved carbon reporting. This has supported positive conversations across the supply chain, which in turn, has resulted in greater embodied carbon savings.

Mace has overseen the implementation of early contractor involvement, which has allowed for improved outcomes on this project as well as closer collaboration between the LLDC, UAL, Mace and manufacturers.

The UAL building has achieved a BREEAM Outstanding rating for design and is on target to achieve Outstanding for the construction phase of the works. This has been achieved through the collaborative efforts of the LLDC, UAL and Mace, who together ensured that sustainability and carbon reduction were embedded from the outset of project and were upheld through continual monitoring throughout both the design and construction phases.

A 'What If?' approach to project materials. Mace approached the development of a low carbon concrete specifications for UAL's LCF building through a collaborative process with the client and developer.

When different carbon reduction options for concrete were considered, cost implications were initially placed to one side, with other trade-offs and impacts considered: a process of questioning that the team described as 'What If?'.

From this baseline, the LLDC and UAL were able to build a more detailed specification for the build, considering a variety of design and cost implications against carbon efficiencies.

Key procurement highlights: LETI Project Embodied Carbon Reduction Roadmap

Strategy	→ Client wanted to pursue BREEAM Excellent at an early stage displaying ambitions on their website and in their briefing documents. → University of the Arts London executive board was engaged with the process. → Whole life carbon is an important sustainability indicator for LLDC. → LLDC introduced a primary site manager supported by long term project manager at Stages 1+2.
Research	→ Sustainability workshops were run by LLDC with client and designer/project team. → The knowledgeable client was able to challenge the design team and considered the risks of innovation. → Deconstruction and fit out were also factored into the embodied carbon assessment.
Transparency	→ Assessed costs of BREEAM Excellent at Stage 3 and moved to Outstanding after contractor assessment. → Designers started looking at embodied carbon at Stage 2. Client agreed a 30% reduction target from baseline. → LLDC/client/designer developed requirements and specifications. → Early discussions were conducted with Tier 2 contractors and specialists to help develop comprehensive specifications.
Submittals	→ Client met procurement teams and engaged in several major elements. Once contracted there was little room for variation.
Record	→ Client carbon ambitions included in specifications. → LLDC and MACE also developed targets. → MACE supported LLDC to work on procurement via managed packages. → LLDC acted as package manager and contracted directly with all packages. → Monthly reporting to client including carbon.

A

Appendix

A1: Definitions

Absolute Zero Carbon: Eliminating all carbon emissions without the use of offsets.

Biogenic Carbon: 'Biogenic Carbon' refers to the carbon removals associated with carbon sequestration into biomass as well as any emissions associated with this sequestered carbon. Biogenic carbon must be reported separately if reporting only upfront carbon but should be included in the total if reporting embodied carbon or whole life carbon.

Carbon Accounting: Process used to measure how much carbon dioxide equivalent (or GHG - greenhouse gas) a product or an activity emits during its life cycle. It follows the standard ISO 14064:2018.

Carbon Budget: Estimated amount of whole life carbon a system can emit.

Carbon Footprint Labelling: Clear identifier of products that have had their carbon footprints certified by the Carbon Trust.

Carbon Neutral: All carbon emissions are balanced with offsets based on carbon removals or avoided emissions.

Carbon Offset: 'Carbon offset' means emission reductions or removals achieved by one entity can be used to compensate (offset) emissions from another entity.

Carbon Sequestration: 'Carbon Sequestration' is the process by which carbon dioxide is removed from the atmosphere and stored within a material – e.g. stored as 'Biogenic Carbon' in 'Biomass' by plants/trees through photosynthesis and other processes.

C2C (Cradle to Cradle Certified®): Globally recognised process, which assesses the safety, circularity and responsibility of materials and products across five categories of sustainability performance: Material Health, Product Circularity, Clean Air & Climate Protection, Water & Soil Stewardship, Social Fairness.

Declare label: Label for building products, designed to help specifiers quickly identify products that meet their project requirements. Declare labels disclose all intentionally-added ingredients.

Embodied carbon accounting: (also called 'carbon budget calculations') refers to the process used to measure how much carbon dioxide equivalent (or GHG - greenhouse gas) a product or an activity emits during its life cycle. The standard ISO 14064:2018 (Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals) defines the requirements for the design, development, management, reporting and verification of a building's GHG inventory. The Greenhouse Gas Protocol provides widely recognised reference standards, courses, guidelines and calculation tools to support designers to measure and monitor carbon emissions.

The most common processes related to carbon accounting include:

Carbon footprint analysis: (also known as greenhouse gas emissions (GHG) assessment) evaluates the GHG emissions related to the manufacture of a product. Emissions of GHGs are converted for that product into carbon dioxide equivalents (CO_2e). It follows the GHG Protocol, ISO/TS 14067 (Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification and communication). Other guidance on carbon footprint analysis includes:

→ RICS Whole life carbon assessment for the built environment, 2017. Update to be released in 2023.
→ PAS 2050 (Specification for the assessment of the

life cycle greenhouse gas emissions of goods and services)

→ PAS 2080 carbon management in infrastructure.

→ EN 15978: 2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method

→ BS EN 17472: 2022 Sustainability of construction works – Sustainability assessment of civil engineering works. Calculation methods

→ ISO 20400:2017 Sustainable procurement — Guidance

→ CIRIA Guide to sustainable procurement in construction (C695), 2011.

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

An EPD is NOT a 'low carbon or green product certificate'. Life cycle carbon is presented in EPDs as 'cradle to grave' and taking in life stages A-C based on the EN 15978 standard.

Some EPDs may include stage D - 'cradle to cradle'. Comparing the results of EPDs is difficult and would need the same product category rules (PCR) to be used for the EPDs being assessed. Whilst EPDs do offer a standardised format of appraisal, users should also note they are snapshot in time; some may be newly created, other nearing the end of a 5 year lifespan.

Greenhouse Gases (GHG): (Often referred to as 'carbon emissions' in general usage): 'Greenhouse Gases' are constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. For these 'Carbon Definitions', we are only addressing the GHGs with Global Warming Potentials assigned by the IPCC, e.g. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), hydrofluorocarbons (HFC's), perfluorocarbons (PFC's), and sulphur hexafluoride (SF_6).

Life Cycle Assessment (LCA): The systematic evaluation of multiple environmental impacts of a product, activity, or process over its entire life cycle. It follows the standard ISO 14044.

Lifecycle Embodied Carbon: The 'Embodied Carbon' emissions of an asset are the total GHG emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A1-A5, B1-B5, C1-C4).

Material Passports: Electronic and interoperable data sets that collect characteristics of materials and assemblies, enabling suppliers, designers and users to give them the highest possible value and guide all towards material loops.

Net Zero (Whole Life) Carbon: A 'Net Zero (whole life) Carbon' Asset is one where the sum total of all asset related GHG emissions, both operational and embodied, over an asset's life cycle (Modules A0-A5, B1-B8, C1-C4) are minimized, which meets local carbon, energy and water targets or limits, and with residual 'offsets', equals zero.

SIGNPOST *Climate Emergency Design Guide Figure A2.2*

Operational Carbon - Energy: 'Operational Carbon – Energy' (Module B6) are the GHG emissions arising from all energy consumed by an asset in-use, over its life cycle.

Operational Carbon - Water: 'Operational Carbon – Water' (Module B7) are those GHG emissions arising from water supply and wastewater treatment for an asset in-use, over its life cycle.

Upfront Carbon Buildings: Upfront Carbon' emissions are the GHG emissions associated with materials and construction processes up to practical completion (Modules A1-A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion.

Whole Life Carbon: Whole Life Carbon' emissions are the sum total of all asset related GHG emissions and removals, both operational and embodied over the life cycle of an asset including its disposal (Modules: A1-A5; B1-B7 (plus B8 and B9 for Infrastructure only); C1-C4). Overall Whole Life Carbon asset performance includes separately reporting the potential benefit from future energy recovery, reuse, and recycling (Module D).

A2: Acknowledgements

Specification and Procurement Guide lead

Duncan Cox - Thornton Tomasetti

Editorial Team

Editor - Duncan Cox – Thornton Tomasetti

Editorial support - Clara Bagenal George – Introba
Graphical editor -Clare Murray - Levitt Bernstein

Working group

Alex Johnstone – Architype
Clodagh Cant – Longevity Partners
Duncan Cox – Thornton Tomasetti
Elaine Toogood – MPA The Concrete Centre
Erica Russell – University of Surrey
Francesca De Petris – Tony Gee and Partners LLP
Julia Messenger - Sage Homes
Magdalena Kraska – Specjalista ds. Planowania Lotniska
Milena Stojkovic – Foster + Partners
Nancy Jonsson – Jonsson Consultants
Phil Obayda – Skidmore, Owings & Merrill (Europe)
Romane Sanchez – Ryder Architecture
Sidonie Immler – Foster + Partners
Simon Perks – Elliott Wood Patnership
Sukriye (Rae) Robinson – Skidmore, Owings & Merrill

Additional materials guidance

Aidoia Paig-Delfin – Wienerberger
Barry Rust – Tata Steel
Els Bleu – Foamglas
Emma Hines – Tarmac
Fatima Salgado – Shay Murtagh
Giulia Jones – Mace Group
Graham Coult – Eckersly O'Callaghan
Graham Edgell – Morgan Sindall Group
Hayley Cormick – KLH Sustainability
Ian Heasman – Taylor Wimpey
Jamie Bell – GreenSpec/Baringa
Jonathan Brunette – Guardian Glass
John Renshaw – Wienerberger
Jono Ayton – Wilmott Dixon
Katharina Lehmann – Blumer Lehmann
Margarita Gonzalez-Calvo – Wienerberger
Mary Halpenny – Wicona
Nadia Bidzinska – Laing O'Rourke
Nick Coleman – Tata Steel
Olcay Parikka – Guardian Glass
Rob Wheaton – Stride Treglown
Robert Osborne – Gypsum Products Development Association
Sara Halliday – Severfield
Sila Danik Dirihan – Saint Gobain
Simon Sturgis – Targeting Zero
Stephanie Palmer – Weinerberger
Steve Paterson – Cleveland Steel & Tubes Ltd
Victoria Thorns – LLDC
Wayne Zaker – DBG Holdings

Technical review

Clara Bagenal George – Introba
Joe Jack Williams – Feilden Clegg Bradley Studios
Louisa Bowles – Hawkins Brown
Mirko Farnetani – Skidmore, Owings & Merrill (Europe)
Nuno Correia – Wilkinson Eyre

Proof reading

Brooke Penman – UKGBC
Elaine Toogood – MPA The Concrete Centre
Erica Russell – University of Surrey
Francesca De Petris – Tony Gee and Partners LLP
Kallum Desai – AECOM
Sidonie Immler – Foster + Partners

Graphics team

Alex Johnstone – Architype
Clare Murray – Levitt Bernstein
Ramone Sanchez – Ryder Architecture
Sukriye (Rae) Robinson – Skidmore, Owings & Merrill

A3: Survey Feedback

This guide has been supported by thoughts and ideas from across the value chain. Over 140 people responded to a LETI survey, and gave their views on how they are experiencing embodied carbon and procurement in the construction sector. Involved in both buildings and infrastructure, many of them had expertise in carbon, with over 50% being sustainability or low carbon professionals. They represent all levels of the industry value chain, from developers/owners to architects/designers, contractors, consultants and manufacturers. The responses provided in the survey, and in a number of subsequent detailed interviews, provide a snapshot of current activity related to embodied carbon reduction in construction. The comments, ideas and practices shared formed the basis of the practical approach to low embodied carbon specification and procurement developed in this document.

Importantly, procurement requirements are increasingly including declarations of carbon measurement. This takes many forms and is dependent on where in the value chain you work. Being asked to provide or work with Environmental Product Declarations (EPDs) is the most likely activity for manufacturers and architects, but assessment of operational and embodied carbon trade-offs is being seen across the procurement process. Many clients are also looking at non-traditional construction and circular economy approaches as a method to reduce embodied carbon.

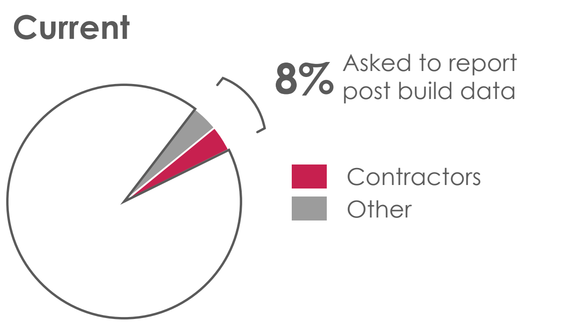
Whilst architects are increasingly being asked to undertake carbon analysis as part of the project development, many contractors are only asked to monitor carbon during the build (a not inconsiderable activity). This typically comes from a client expectation but regulation is starting to follow suit, such as the GLA's whole life-cycle carbon assessments and the proposed Part Z. Only 8% of all those who responded to the survey had been asked to report post build data, of which half were contractors. Encouragingly there is a strong indication that $kgCO_2e/m^2$ (GIA) is becoming a standard metric in design specifications. Benchmarks, however, remain rare and contractors still find they are being asked to work to more arbitrary baselines or targets than other parts of the value chain.

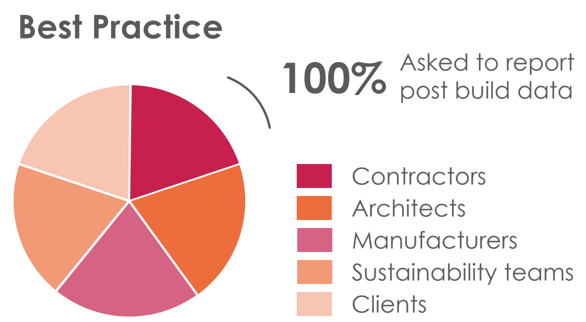
"We've overcome barriers by ensuring the briefing on a project is clearly defined. Educating clients in allowing time to propose design options, educating design team to deliver low carbon options quickly, and ensure that our arguments for change are positively presented."
- Architect

Manufacturers are increasingly seeing carbon requirements within specifications and are most likely to have worked on projects where embodied carbon procurement has been addressed successfully: contractors and architects identified fewer examples. Responsibility for embodied carbon reduction is seen by most respondents as the role of designers/ architects and sustainability teams. Few suggest that the procurement team or those managing specifications are key to this work.

Clients continue to be seen as key to driving action and setting targets or supporting the targets set by the design team, but architects are increasingly being identified as important leaders.

There is also a positive feeling that embodied carbon reduction is being driven at the company level, with businesses setting their own targets , a point most strongly felt by contractors.





Despite changing practice there appears to be little appetite for new procurement approaches to support carbon reduction, such as financial incentives or shared risk. Rather, regulation or policy is perceived as the most important driver for all parts of the value chain, most especially for architects. In contrast however, Government is not seen as stepping up, with regulation identified as weak and planning requirements and public procurement lagging.

For visualised results and more detailed analysis please read our LETI blog.

SIGNPOST *21.06.21 Embodied Carbon: Specification & procurement survey analysis*

Key points

- → Manufacturers, contractors and clients highlight the importance of including carbon in specifications
- → The industry is coalescing on a common embodied carbon metric: $kgCO_2e/m^2$
- → Only 16% of respondents see cost as a barrier to embodied carbon reduction
- → Manufacturers and architects are seen as key to embodied carbon reductions BUT clients, procurement teams and legislation play important roles
- → There continues to be a need for performance standards and data to support decision making.

Specification and Procurement Guide

This Specification and Procurement Guide offers supplementary guidance to those interested in exploring material specification and procurement in more detail. Due to the lack of knowledge in the built environment surrounding specification and procurement strategies, LETI has produced this document to support project teams to design buildings that deliver ambitious embodied carbon reductions.

www.leti.uk

@LETI_UK

admin@leti.uk

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