Appendix A

Embodied Carbon Foot Printing associated with new construction of SBC assets and associated estates and recommendation to new developments – Full Report:

Minutes E&S Committee 10-05-2022:

As a result of the discussions during the presentation on climate change, it was suggested that any future developments of land owned by the Council or KGE Ltd should include a carbon calculation at application submission stage with a view to an appropriate recommendation being made to Council. It was also suggested that the information was requested from other developers.

The Committee agreed to add an item to their forward plan regarding

(i) Submission of a carbon calculation statement for any future developments owned by the Council or KGE

(ii) A request for a carbon calculation statement for developments submitted by other parties

Report:

The purpose of this report is to undertake an analysis into the viability of undertaking embodied carbon foot-printing of new Spelthorne Borough Council owned developments (through Knowle Green Estate) and request embodied carbon footprints for new private developments through the planning process.

Terms and Definitions:

Carbon budget	The maximum amount of cumulative equivalent carbon dioxide emissions that can be emitted without reaching a tipping point for climate catastrophe.
Carbon Footprint	The amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organization, or community.
Embodied Carbon	All carbon emissions emitted in producing a material or building. Estimated from energy use associated with extraction and manufacture.
Scope 1 Emissions	Emissions that occur directly on site as a result of organisational activity.
Scope 2 Emissions	Emissions that are associated with electricity production of electricity that is used on site.
Scope 3 Emissions	Associated emissions attributed to the upstream and downstream supply chain of an organisation.
Operational/In-use Carbon	All carbon emissions produced by the operation of the development.
LETI	London Energy Transformation Initiative

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RIBA	Royal Institute of British Architects
RICS	Royal Institute of Chartered Surveyors
BREEAM	Building Research Establishment Environmental Assessment Method
SPD	Supplementary Planning Document
tCO2e	Tonnes of Carbon Dioxide Equivalent
LCA	Life Cycle Assessment

Executive Summary:

In analysing approaches from other councils, it was found that no local authority at any level implements embodied carbon foot printing calculation into its developments or in planning applications. Therefore, it was not possible to implement known calculation methods into a form in which would be acceptable for Spelthorne Borough Council to utilise in its own assets, or in proposed developments within the borough.

Options from bodies such as LETI, RIBA and BREEAM were considered which included embodied carbon calculation guidelines. However, each method varied in scope and in their approach to analysing datasets and materials. Resulting in drastically different embodied carbon values, dependent upon a multitude of factors, for example the LETI document referenced specifically that 0.113kg of CO2e is released per kg of concrete used. However, the RIBA analysis says an an accurate calculation cannot be provided, stating that total emissions need to be calculated on a case-by-case basis as it is dependent on factors such as transportation distance etc. This discrepancy between these reputable bodies, coupled with the range in values found in other sources, throws doubt as to the viability of these quoted figures. Therefore, to recommend calculating in this way would not be accurate as finding true values would take considerable time and calculation.

Councils such as Cheltenham Borough Council have used LETI guides as examples of how reducing embodied carbon within developments can be conducted in their climate change Supplementary Planning Documents (SPDs).

Conversely to embodied carbon footprints, in-use operational carbon footprints of buildings are reliably calculated and recorded. Therefore, actions can be taken to reduce these footprints accurately and with a greater impact on life cycle carbon emissions than that of embodied carbon footprints.

Options for retrofitting and reusing exiting assets and materials were also considered.

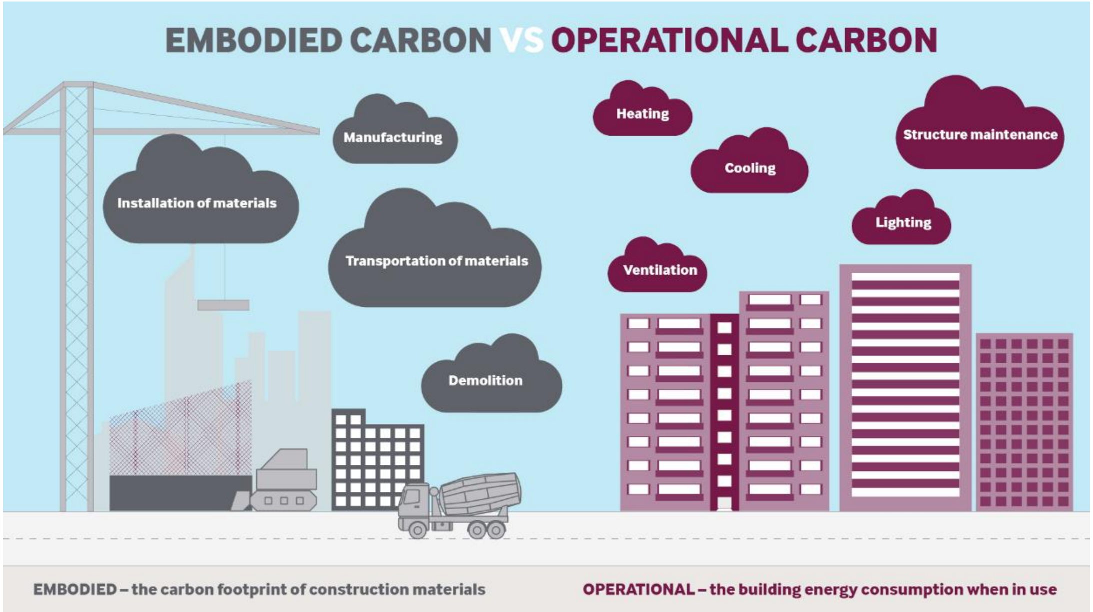
Taking actions to reduce in use carbon footprints and utilise existing assets and materials could be implemented in the form of an SPD or specific design guide for developers in future planning applications. This could be implemented as a policy for any council owned developments or future developer led developments.

The report recommends that a decision on a policy focus should be given which will on outline ways that will reduce embodied carbon, without requiring an outright embodied carbon calculation, through an SPD.

Appendix A

<u>Introduction</u>:

In the context of building developments and building operations, a carbon footprint is defined as being the total emissions of greenhouse gases produced throughout the lifecycle and operation of a building, measured in tonnes of carbon dioxide equivalent. Given this, the carbon footprint calculation can be calculated in two distinct ways, life cycle embodied carbon and in-use carbon emissions per annum. This is illustrated in the diagram below:



<u>Building life cycle (embodied carbon in the production stage):</u>

Building lifecycle within the context of embodied carbon emissions without considering end of life emissions consists of 'cradle to gate' or A1-A3 product stage emissions, in addition to the emissions associated with the construction process itself. A1-A3 can be seen in the picture below, and further explained in figure 2 within the appendix.

<u>Cradle to gate</u> (A1-A3 patrial product LCA, seen in figure 2 in Appendix), covers the impacts of a material or product <u>before use in construction</u>, covering raw material extraction, transport, and manufacturing emissions.

<u>Cradle to grave</u> (A1-C4 full product LCA) covers the entire lifecycle of a product, from resource extraction to construction, use phase and disposal. A diagram of all embodied carbon within the lifecycle of a building can be seen in figure 2 within the appendix.

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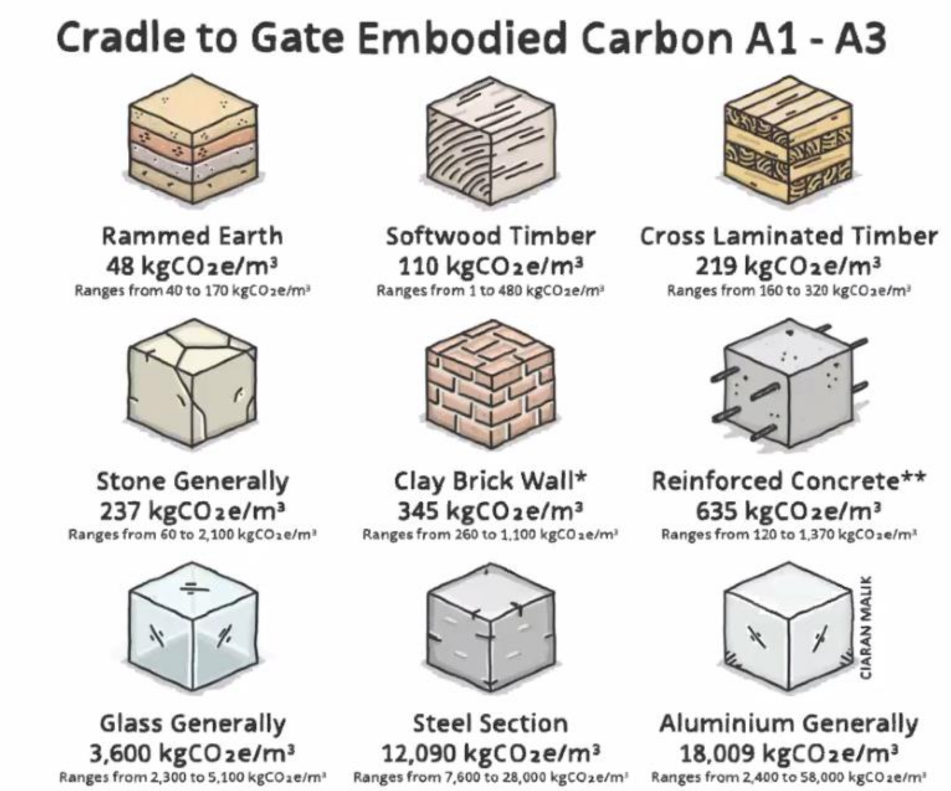
<u>Most common building materials in the UK:</u>

Material	Cradle to Gate embodied carbon A1-A3 ($kgCO2e/m3$)
Brick	260 to 1,100
Concrete	120 to 1,370
Steel	7,600 to 28,000
Glass	2,300 to 5,100

Table 1: Cradle to gate embodied carbon emissions ~ carbon calculation varies note ranges depending on method of calculation used (circularecology.com)



Through calculating the embodied carbon of the largest material components of new builds against the above matrix, a comparison can be drawn to that of a standardised national average of materials for different building types and sizes. However, given the variation of values attributed to embodied carbon within materials, this is method contains complexity in that the calculation will be vastly different dependent upon the values chosen or calculated in each separate development.

<u>Life cycle analysis viability:</u>

For successful analysis of ‘cradle to gate’ or ‘cradle to grave’ life cycle analysis (Appendix 1 figure 2) of a building, a strict calculation must be undertaken that would be resource intensive, particularly for developers. This would require specialist knowledge and consultation to determine the true values of embodied carbon, which is a known difficulty given the varied complexity of different calculation methods.

Implementing design standards that consider embodied carbon/life cycle emissions:

Using existing standards on which buildings can be constructed to consider embodied carbon and life cycle analysis within them. BREEAM is one such sustainability assessment method on which buildings can be assessed, whereby a building can be awarded one of a number of levels of BREEAM achievement (Appendix 1 Figure 6). Additionally, the RIBA/RICS standard full life carbon assessment is another such design guide.

Potential solutions that could reduce the overall difficulty in calculating embodied carbon include:

1. Implementing standards that would need to include embodied carbon. Standards such as BREEAM Excellent or Outstanding, which include a degree of carbon calculation for embodied carbon through life cycle assessment (see Appendix 1 Figure 6)
2. Adopting methodologies in calculating embodied carbon within buildings in line with external bodies such as LETI or RIBA.
3. Generating a matrix based on known quantities of embodied carbon for commonly used building materials, on which to compare new buildings' materials against, seen in Table 1 above.

Different methods and guidelines around approaching full life/embodied carbon:

RIBA (Royal Institute of British Architects) standard full life carbon assessment:

RIBA's standard Full Life Carbon Assessment considers embodied life carbon along the lines of the British standard BS EN 15978:2011. RIBA suggest that the British standard is open to interpretation and lacks reliability and repeatability. Therefore, they created a professional statement document to supplement this standard and give further advice and guidance as to how embodied carbon calculations can be conducted and reported. This is an extensive guide that could be utilised to inform embodied carbon calculations worked in collaboration with RICS (Royal Institute of Chartered Surveyors). However, this guide must be used on every individual building to ensure accuracy, and, therefore, would require a degree of knowledge and understanding of embodied carbon calculations to implement.

The RIBA considers embodied carbon to be between 66% and 75% of a building's overall life cycle carbon emissions, as seen in Appendix 1 figure 4.

LETI (London Energy Transition Initiative) analysis into building decarbonisation:

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LETI have concluded that there are 4 building archetypes that comprise most of the new buildings within the UK as seen below (together make up 75% of new buildings to be built between now and 2050). Therefore, the analysis into decarbonisation of buildings can be conducted against these average building archetypes.

- **Small scale residential:** terraced, semi-detached
  - or detached homes, up to three floors
- **Medium and large scale residential:** four floors
  - and above
- **Commercial office**
- **School:** Primary or secondary

In analysing these archetypes, LETI has concluded that in the case of embodied carbon emissions, it is more impactful to firstly reduce all operational carbon, and only making reductions of embodied carbon once this has been optimised. LETI life cycle assessments indicated that embodied carbon makes up between 25% and 33% of the overall carbon footprint of a building.

Upon reducing the operational carbon footprint of a building, using the principles of a circular economy, the embodied footprint can be reduced by including the maximum material from previous development into new development. This reduces the need for further resource extraction and prolongs the life of the original building materials. So reutilising materials from a previous development into a new development will reduce the embodied carbon on a project as it reduces the need for using further resources.

Baseline (business as usual) and reduction targets over baseline as seen in the first graph of Appendix 1 figure 5.

Although no authority requests calculation of embodied carbon, some (such as Cheltenham Borough Council) have utilised design guides written by LETI to inform a reduction in embodied carbon within development though SPDs. This could be a method in which embodied carbon can be reduced, without the need for a full calculation.

<u>Using embodied carbon footprints</u>

In analysing the general patterns around the ‘product’ and ‘construction’ stage (A1-A5, Appendix 1 figure 2) of the embodied carbon footprint of each typical building type, it has been demonstrated that this information can be utilised to support the reduction of carbon emissions for future assets and developments in the borough.

Additionally, a more complete picture as to the entire carbon outlay of all the council’s areas of influence can be realised. This can inform policy direction and allow a wider understanding of the impacts the council has upon the built environment and greenhouse gas emissions. From this information, estimations as to the whole embodied carbon footprint of the Borough can be made. Using this, a carbon budget can be determined to set realistic climate targets related to embodied carbon within Spelthorne's developments.

Limitations to embodied carbon foot printing:

In addition to the difficulty and complexity involved in conducting full embodied carbon foot printing, there remains limited opportunity for the footprint to be of use in reducing the overall climate impact of a development. Most sources indicate that the majority of emissions contained within a lifecycle of a building come from the in-use phase of the building. Therefore, a more meaningful analysis would be to focus attention onto scope 1, 2 and 3 emissions within the in-use phase of a building.

Conclusions in assessing embodied carbon:

In evaluating two prominent examples of embodied carbon calculation key conclusions can be realised.

Firstly, both RIBA and LETI have vastly different outlooks on what proportion of life cycle carbon is attributed to embodied carbon. RIBA suggest that embodied carbon makes up between 66% and 75% of the overall life cycle carbon footprint, whilst LETI outlines it to being only 25% to 33%.

This discrepancy between these highly reputable organisations is reason enough to suggest that there is no clear consensus, nor reliable and repeatable way to produce these statistics. Therefore, it is unwise to ask for embodied carbon calculations from developers given the inconsistency likely to be found within results.

Secondly, LETI discusses that in-use carbon footprints for Scope 1+2 emissions associated with developments can be accurately measured and recorded. Therefore, reducing these would result in a measurable reduction in carbon footprint of the life cycle of a building.

Therefore, it can be concluded in-use operational efficiency changes would be the most optimum, effective and measurable way to reduce the carbon footprint of developments.

Re-using existing assets and materials

Utilising the embodied carbon of existing developments is an element of design approach that can also be explored. Although the calculation methods are unreliable, pre-existing developments do contain embodied carbon. Therefore, by re-using materials or recycling associated with existing developments, a reduction of the embodied carbon can be made within new developments.

Where buildings already exist, there remains the potential to re-use/retrofit the entire, or parts of the building for a different purpose. In some cases, this may not be viable due to design standards or material efficiency concerns. However, a policy whereby new builds are required to utilise and incorporate, where possible, pre-existing materials from the previous building into their own design would be a unique way of ensuring a reduction of the overall embodied carbon of the new development.

A design guide or supplementary planning document is best placed to be an avenue whereby the council can implement a policy of maximining the re-use of buildings to preserve embodied carbon.

Brief overview of operational (in-use) carbon footprints in buildings:

A building's carbon footprint can be broken down into the 3 scope of emissions. Scope 1 is defined as all combustion that occurs on the site of the building, primarily through gas cookers and gas boilers. Scope 2 is defined as all emissions associated with the use of electricity in the building, and the greenhouse gases emitted through the generation of this electricity. Scope 3 is all associated emissions within the supply chain of the building in use, which is broken down below:

2023 will see the introduction of newly updated building regulations.

Scope 1 – Emissions that occurs directly on site.

Examples include:

- Gas Boilers
- Cooking with gas
- Furnaces
- Fireplaces
- Leaking refrigerant
- Firefighting foams

Scope 2 - electricity usage associated emissions.

Scope 3 - associated emissions along the supply chains:

Upstream:

All the materials that are created and transported to the building for use in its operation. Including gas/maintenance etc.

Downstream:

All associated carbon that occurs after the point of use within the building. This could include waste disposal, recycling of used materials and associated carbon emissions.

Examples of areas in which operational carbon footprints can be reduced:

The design of a development has a significant impact on the overall operational carbon footprint over a building's life cycle. Through strengthened design, such as that proposed by the newly proposed building regulations for 2023, a greater degree of carbon efficiency will be achieved in new buildings. This can be taken further through local planning policies to strengthen the local plan's climate change commitment and reduce operational carbon emissions in the borough.

Elements of building design, such as location/orientation, material efficiency design, heat sources and electricity production and consumption can all be utilised and strengthened to reduce the operational carbon footprint of building. Therefore, having significant impacts on the life cycle carbon of a development.

Conclusions:

Due to the overall unreliability of the core data, embodied carbon calculations for council owned developments and as a condition of planning are not effective measures of reducing overall carbon emissions in the borough.

It is the recommendation of this report that instead of focusing efforts on calculating and reducing operational carbon footprints of council owned assets planning policies are strengthened too. This is because operational carbon footprints are more easily calculated and are known to have a significant impact on the overall lifecycle carbon of a development.

To implement these recommendations, options such as further strengthening council policy over owned assets should also be considered. The Council can therefore consider producing supplementary planning documents which sit alongside the local plan to provide strengthened design guides for developers to follow, allowing them to calculate and reduce operational carbon footprints in all new developments in the Borough. Additionally, this can be conducted through the development of a design guide to encompass low embodied carbon building practices.

The report advises a decision on the implementation of embodied carbon policy:

Although no authority has mandated the calculation of embodied carbon foot printing, some have utilised LETI or RIBA advice documents in directing SPDs for new developments to consider. Given this, the focus should be on outlining methods to reduce embodied carbon, without requiring an outright embodied carbon calculation.

Appendix A

Appendix:

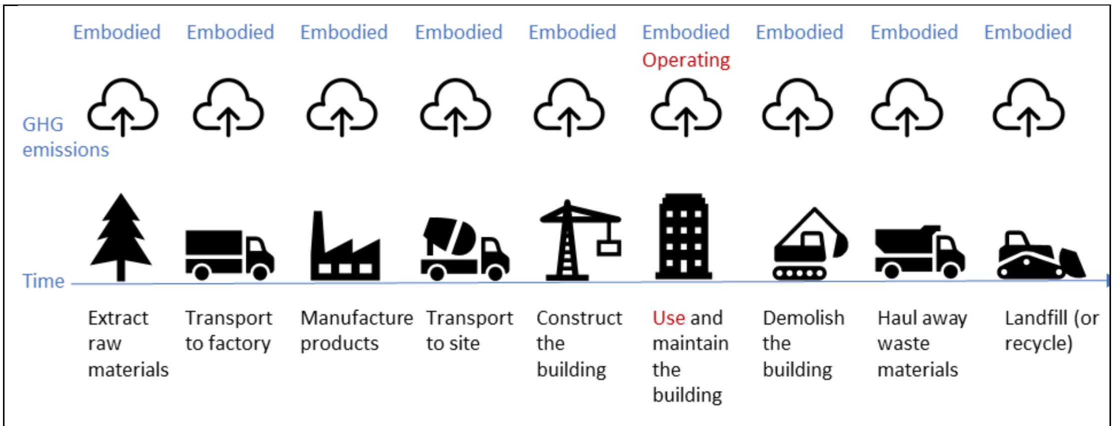


Figure 1: Diagram of embodied carbon within a building lifecycle

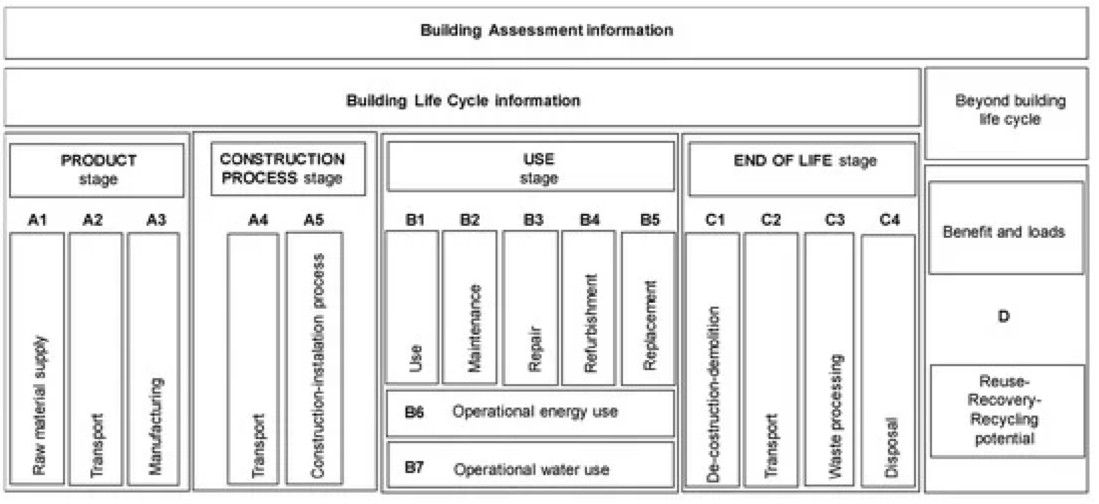


Figure 2: Building Assessment Information

https://greenbuildingencyclopaedia.uk/wp-content/uploads/2014/07/Full-BSRIA-ICE-guide.pdf

Appendix A

RIBA embodied carbon assessment: comparison between building types

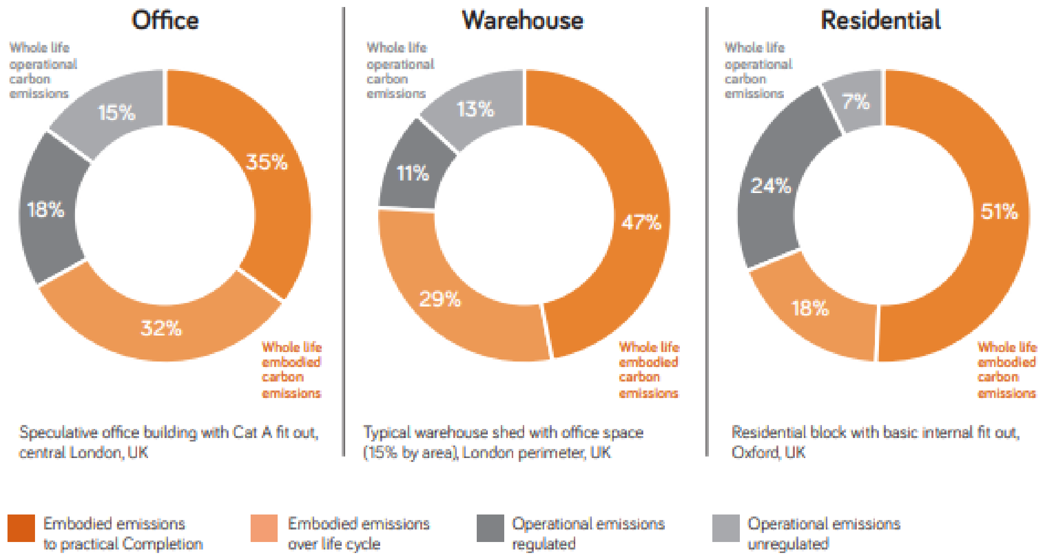
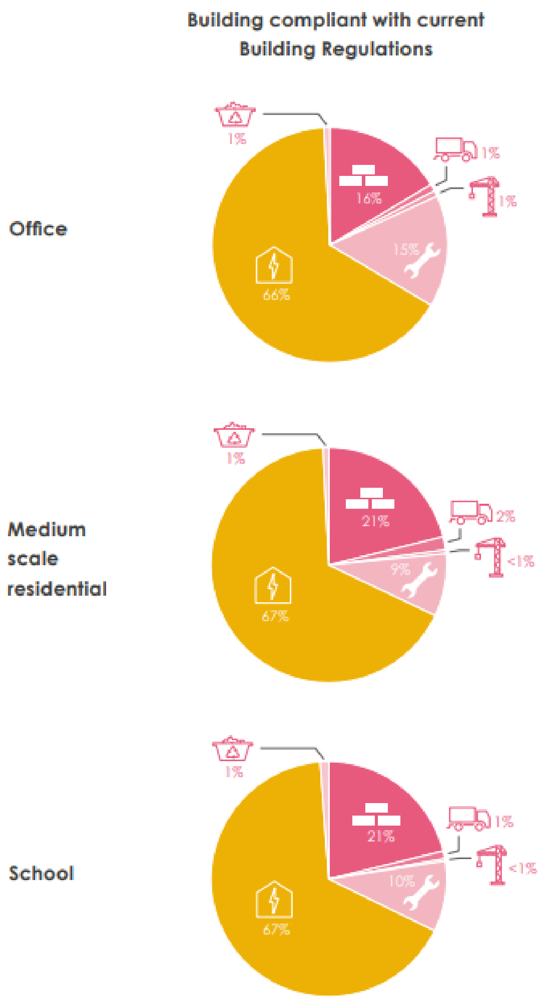


Figure 3: RIBA Embodied Carbon Graphic

Appendix A

LETI embodied carbon assessment: comparison between building types



LETI estimates regarding oerational carbon (yellow versus embodied carbon (pink).

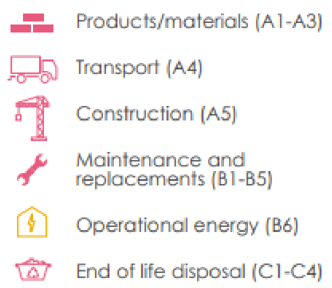


Figure 4: LETI comparison of embodied carbon within different building types

Appendix A

LETI Analysis of decarbonisation within buildings and life cycle analysis

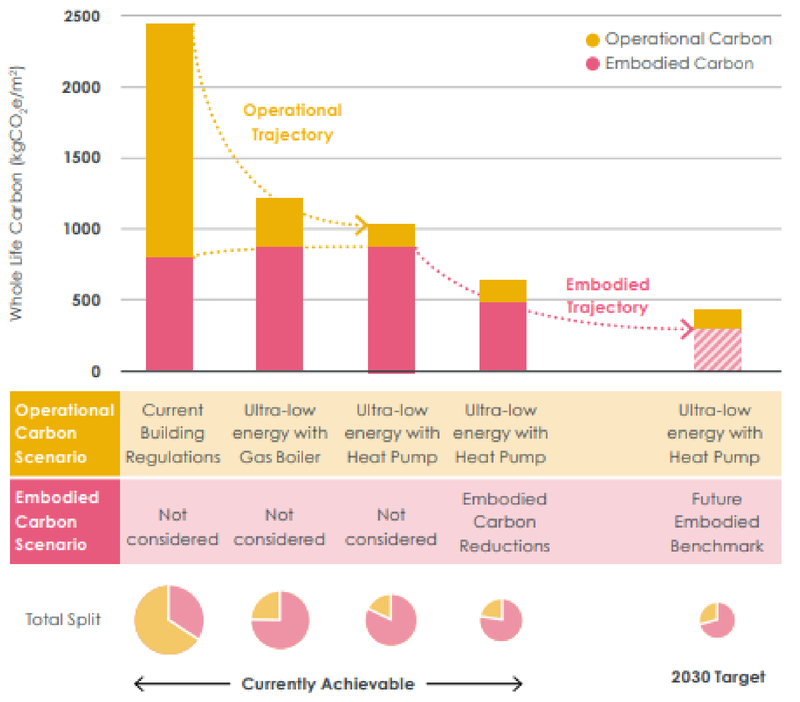


Figure 5.1 - Diagram showing operational and embodied carbon and trajectories

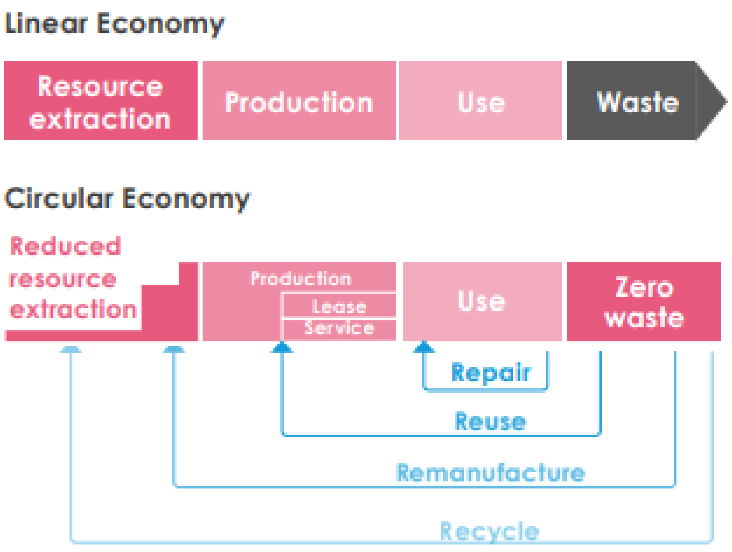


Figure 3.1 - Circular Economy Principles, compared to existing Linear Economy

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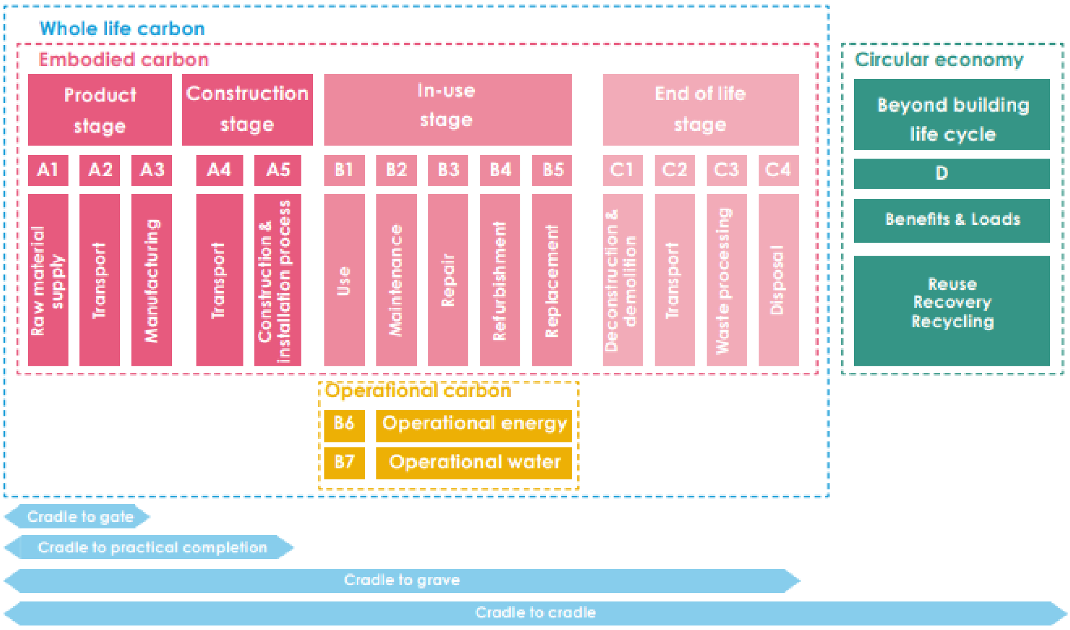

Figure A.3.2 - System Boundary: EN 15978:2011 Display of modular information for the different stages of the building assessment

Figure 5:LETI Analysis of Decarbonisation graphics

BREEAM rating		% score
Outstanding	★★★★★	≥85
Excellent	☆★★★★	≥70
Very good	☆☆★★★	≥55
Good	☆☆☆★★	≥45
Pass	☆☆☆☆★	≥30
Unclassified	☆☆☆☆☆	<30

Figure 6: Table of BREEAM ratings