mesh.

Mesh's Guide to Whole Life Carbon

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www.mesh-energy.com

The Built Environment's Role

Our planet is in crisis. With global temperatures on track to rise by between 4-6°C by 2100, the chances of extreme weather events, food supply instabilities, and consequent mass migration, war, and famine are all looking increasingly likely.

The built environment has a critical role to play in addressing the climate crisis, and in responding to the temperature changes we're already facing.

In 2021, the built environment accounted for around

37%

of global emissions, 34% of energy demand and 50% of materials consumption. As reported by the Environmental Audit Committee (EAC) in 2022, The UK's Built Environment is responsible for

25%

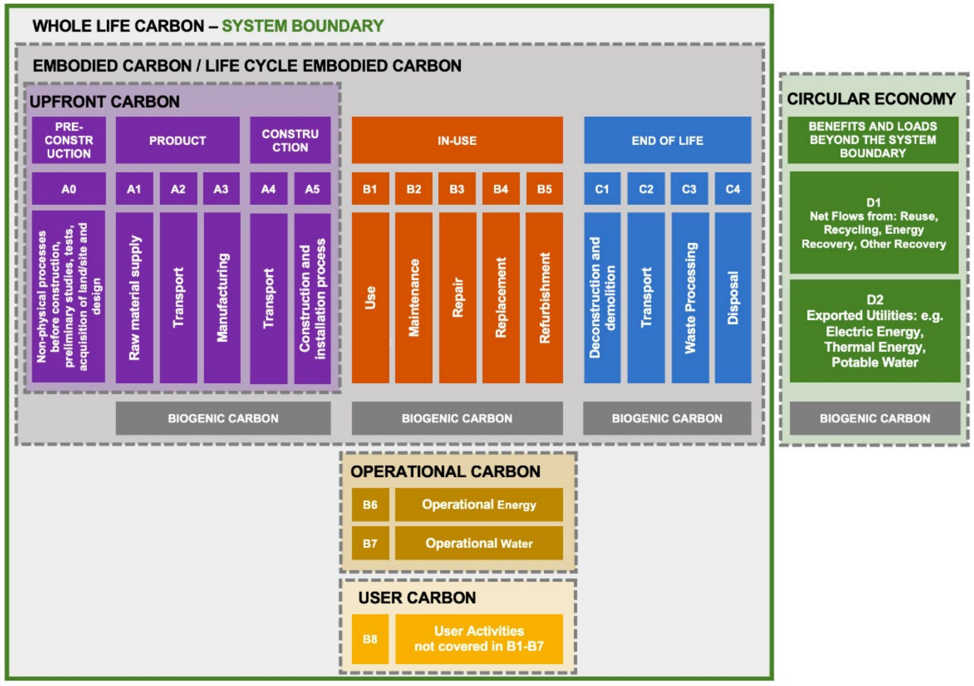
of the UK's greenhouse gas emissions. This is an incredibly high proportion.

The Essence of Carbon

A substantial amount of the emissions created by the built environment can be identified as coming from energy used in the construction process and the materials involved. It tends to be the usual suspects here, with fossil fuels being the main perpetrator (oil, coal, and gas). In 2022, the majority of the UK's primary energy was drawn from fossil fuels (78.4%), whereas the UK's primary consumption from 'low-carbon' (renewables and nuclear) sat at around one fifth (20.7%).

> Note - **Although renewable energy such as hydroelectric power can be used within the built environment and doesn't directly contribute to carbon emissions, the process of creating these sources will contribute towards built environment emissions, so renewable energy is not entirely free from giving off carbon emissions.**

While we can identify that these emissions come from construction, it's important we also identify the scope of these emissions to understand and pinpoint where they can arise during each stage of a building's life cycle. Let's take a look at the scope of emissions provided in RICS Whole Life Carbon Assessment (2nd edition). The table on the right illustrates how these are split into a few different modules.



Here we can see the different areas a building creates emissions over its entire life cycle:

Module A
covers emissions from all activities necessary to complete the construction of the building.

Module B
covers all emissions that occur over the 'use' stage of the building.

Module C
covers emissions during the 'end-of-life' stage of a building.

Finally, let's analyse the types of carbon emissions linked to these modules:

Carbon type: **Upfront carbon**

Modules A0-A5 - All impacts up to the completion of the project, but exclude any sequestered biogenic carbon stored within any construction products incorporated into the asset. E.g. Trees and soil.

Carbon type: **Embodied carbon**

Modules A0-A5, B1-B5 and C1-C4 - All emissions related to material.

Carbon type: **Operational carbon**

Modules B6 and B7 - Energy and water use.

Carbon type: **User carbon**

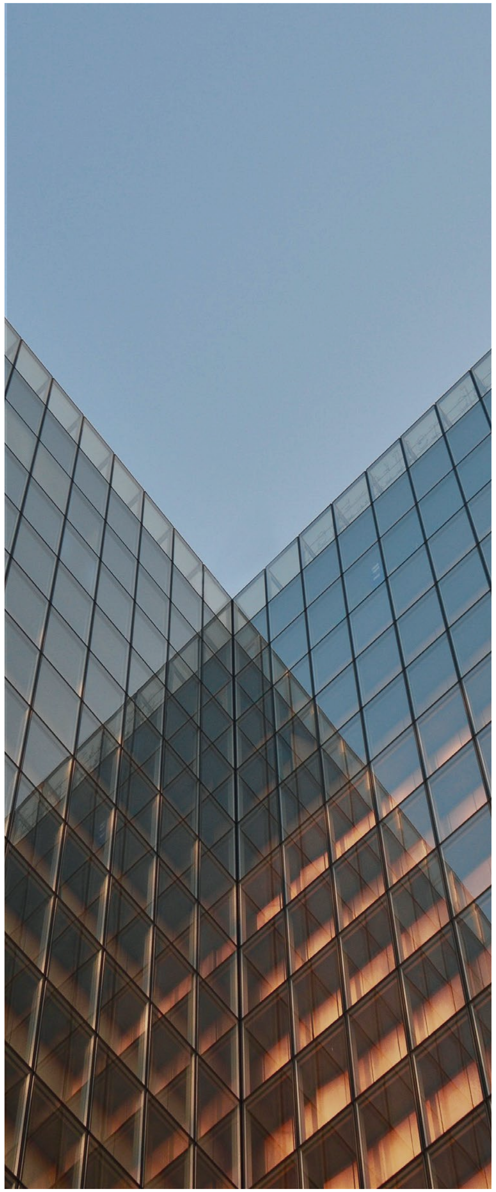
Module B8 - User activities.

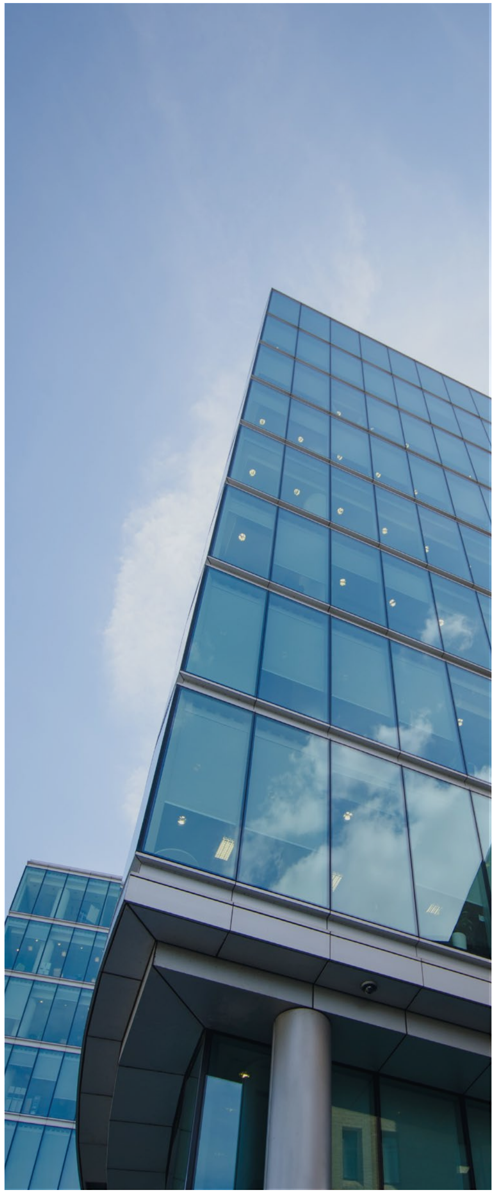
Carbon type: **Whole life carbon**

Modulces A, B, and C - This is the system boundary for a full carbon assessment over the building's life cycle. Whole life carbon does not include modules D1 and D2 as they are outside the boundary. While the RICS Whole Life Carbon Assessment 2nd edition will be able to give you a more in-depth look at each module and what they include, the key takeaway is that carbon impacts arise from multiple sources (not just from the act of constructing a building).

Considering emissions across all life cycle modules is known as a 'whole life carbon' approach; where we gain a comprehensive understanding of embodied, operational, and other carbon flows. This enables more targeted strategies to reduce carbon through material selection, energy efficiency, and other interventions across the design, construction and use phases.

Quantifying whole life carbon provides a crucial foundation for assessing and improving the climate impacts of the built environment.





What are Embodied, Operational, and User Carbon?

Embodied Carbon

Before we take a closer look at whole life carbon in its entirety, we need to take a look at embodied carbon (also known as 'embedded' or 'capital carbon' emissions). Embodied carbon emissions are the emissions that come about from acts involved in the creation and life cycle of a building, which means they can be allocated across Modules A, B, and C in Page 2. Things that create embodied carbon include:

1. Sourcing raw materials
2. The transportation of said raw materials to a factory
3. The fabrication of those raw materials into components or systems
4. The transportation of fabricated raw materials to the building site
5. Assembly of the building project using the fabricated raw materials

However, embodied carbon emissions don't just end at the completion of a building. Embodied carbon also refers to the emissions that come about through:

- The maintenance and replacement of a building over its 'building life expectancy'
- Final disassembly of the building once its life expectancy is over
- Disposal of materials after disassembly has occurred.
- For additional operational emissions, see RICS Whole Life Carbon Assessment 2nd edition.

'Disposal' in this instance also refers to the act of reusing and recycling building materials. Through these methods of disposal, redundant material from an old building can be used as raw material for another phase of use in a new building, instead of being sent to landfill.

Having an approach that embraces reuse and recycling is often referred to as the 'circular economy', an idea that optimises the reuse of already used and redundant materials so that they can be given a new lease of life. In turn, we can unlock disposal methods that are much less carbon intensive that traditional means, minimise the need for creating new material, and also help to set in stone design procedures that makes future acts of reuse easier to access.

Operational Carbon

Operational carbon includes emissions that occur during the use phase of a building and are allocated across modules B6 and B7. This includes emissions from:

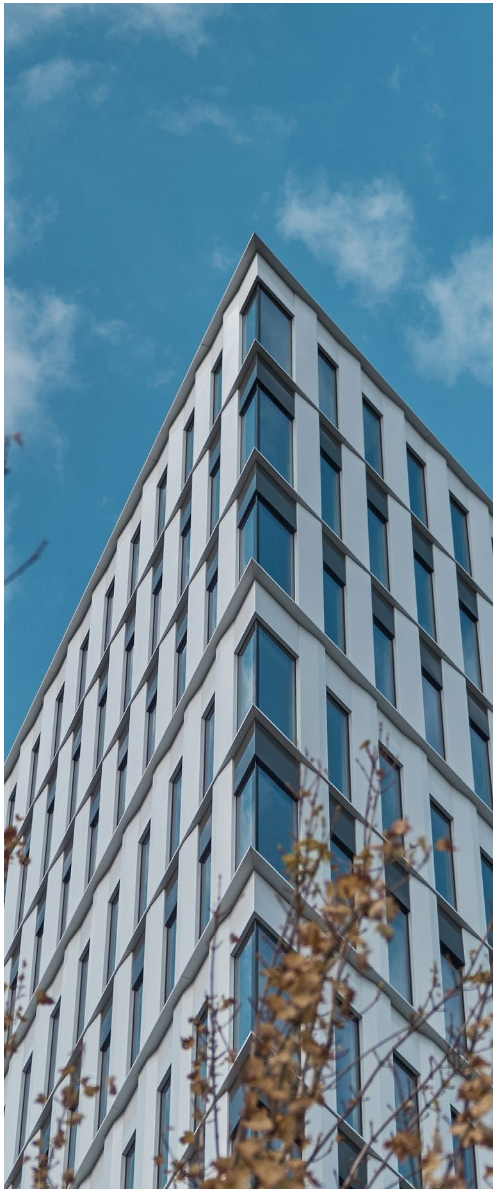
Energy use - The burning of fossil fuels to power heating, cooling, lighting, appliances, equipment, etc. This is usually the biggest source of operational carbon; and

Water use - Emissions associated with heating/treating water consumed in the building.

User Carbon

User carbon also included in the scope of whole life carbon is 'user carbon' under module B8. This module accounts for emissions arising from building user activities not covered under modules B6 and B7, such as:

- Transportation of occupants to and from the building site.
- Extraction, manufacturing, and transport of goods purchased by building users.
- Waste disposal and water treatment from user activities.
- Energy use by building occupants for cooking, appliances, etc.



What is 'Whole Life Carbon'?

> **In its simplest definition, whole life carbon is the total sum of the embodied and operational emissions expended over the whole life of a building.**

By 'whole life', we mean the entire life of a building mentioned in the RICS Whole Life Carbon Assessment (2nd edition). That means Modules A through to C.

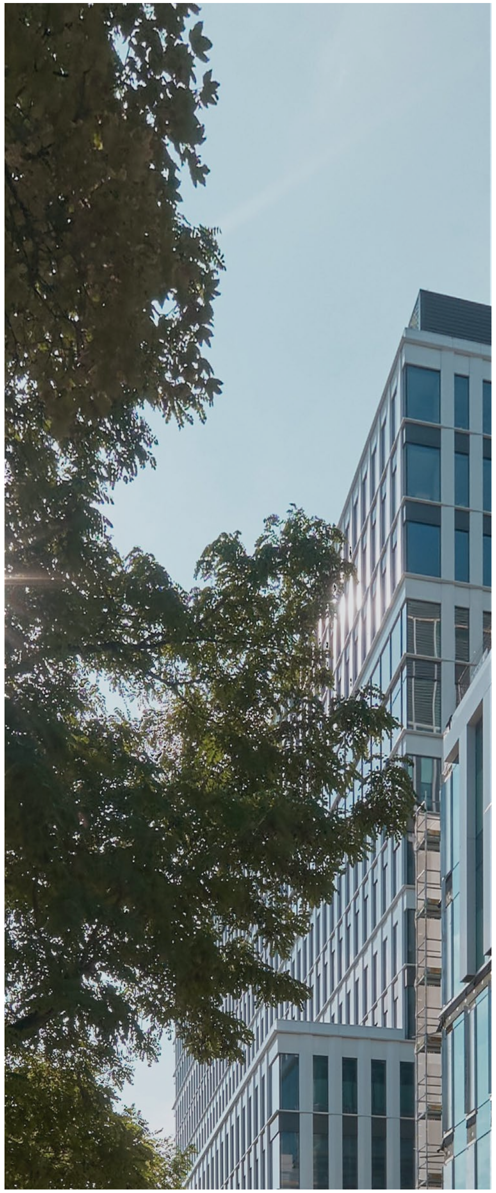
The key here is that we're combining both the embodied carbon and the operational carbon, which helps us optimise reductions to reach the lowest carbon footprint possible for the building.

Traditionally, operational carbon would get the most focus when it comes to making reductions, with areas such as heating, ventilation, and lighting being particular areas of importance for reducing carbon emissions through methods like incorporating renewable energy or utilising a fabric-first approach. Nowadays, operational impacts include all operational energy use, regulated and unregulated.

However, tackling operational emissions in isolation means that embodied carbon is not taken into account. Operational carbon emissions have the luxury of seeing possible reductions over time, where embodied carbon tends to be locked in place once the building has reached completion.

While work is ongoing to reduce operational carbon, without a comparable focus on reducing embodied carbon in construction materials, that work will not lead to the hoped-for mitigation of climate change. Embodied carbon is responsible for 11% of global emissions and by 2050, it is likely that embodied carbon will be responsible for 49% of the carbon footprint of new construction.

From 2020 to 2060, we expect to see 240 billion m^2 of new floor area added to the global building stock, the equivalent of adding an entire New York City to the world, every month, for 40 years.



How we can Assess Whole Life Carbon?

Like with most of Mesh's services, reducing whole life carbon is a job that's most effective when tackled early on (ideally in the early design stages). This is so we can get in there early, review the proposed building materials, and make any suggestions to help better optimise the footprint of the building.

The way Mesh does this is primarily through a process called a 'whole life carbon assessment.' An approach that manages carbon budgets, reduces emissions over the lifetime of a building, and contributes to the delivery of a net zero future for the built environment.

While we put emphasis on appointing a consultant from the early design stages, it is possible to tackle whole life carbon at every RIBA stage from the RIBA Plan of Work 2020. Let's review the RIBA stages and see how a whole life carbon assessment can provide assistance at each stage:

RIBA Stage 0 - Strategic Definition

The Strategic Definition stage is normally where the client would make that initial decision to set out whole life carbon aspirations. By starting the assessment here, whole life carbon accounting can be used as one of the key performance indicators of the project.

Clients can weigh up the benefits of undertaking a whole life carbon assessment here, with the notable benefits being:

- Unlocking optimised carbon reductions for both operational and embodied carbon
- Future-proofed design
- Marketing advantages
- A boost to corporate social responsibility (CSR)
- Added building value and reduced maintenance costs
- Design choices are made that are resource efficient
- Value engineering

RIBA Stage 1 - Preparation and Briefing

Once a project has reached the Preparation and Brief stage, the whole life carbon objective would be nestled within the project objectives, helping drive the strategic direction of the project as a sustainability aspiration.

Because of the need for the project team to understand the objectives and the need for the design team to understand optimal building fabric and performance post-completion, this stage is where making early contact with a consultant like Mesh usually happens to gain an expert level of advice on the matter.

RIBA Stage 2 - Concept

When it comes to the Concept Design stage, whole life carbon should be fully embedded into the design process, and whole life carbon considerations start to become a bit more relevant. This includes sufficient consideration of factors such as buildability, construction programme, climate resilience, durability, design for disassembly, and benefits beyond the end of life of the project.

In 2023, it's still common for building design teams to have limited experience in tackling whole life carbon, so this is a great opportunity for a consultant like Mesh to collaborate with design teams on concept development by offering advice on building fabric and the cost/benefit ratio of carbon-cutting operational strategies (such as mechanical vs natural ventilation, or the use of renewable energy solutions).

The design team can use a table comparing carbon impacts of different material and construction options. This allows choosing low-carbon designs with little to no cost increase. Sharing these lifetime carbon emission estimates with local government agencies can also help in planning approvals, as climate and whole life carbon awareness grows.

Product suppliers can be assessed for their ability to provide relevant information with respect to fabrication methodology, factory location, energy use type, treatment of waste etc. The carbon budget should be updated and included within the tender documentation. It is important that the tender documentation ensures that the competing contractors understand the WLC requirements, the goals and process of delivering and monitoring carbon reductions during construction. This process needs to be tailored to engage with, but not burden, the supply chain.

RIBA Stage 3 - Spatial Coordination

By the Spatial Coordination stage, a carbon assessment should be prepared using the cost plan's material descriptions and quantities that would have been established in Stage 1. This acts as a 'carbon budget' baseline. It should analyse emissions from materials and construction processes in as much detail as possible at this stage.

This analysis should estimate the project's full lifetime carbon emissions in as much detail as possible at this stage of design. It can be combined with projected maintenance and operating costs over the building's lifespan (part of the BREAAM Sustainability Rating criteria).

RIBA Stage 4 - Technical Design

Any choices that were previously made are now integrated into the detailed drawings, specifications, and tender documentation.

It's important to note here that any low carbon strategies that have been developed in stage 3 won't be realised unless they can actually be delivered during procurement.

Like with any tendering process, this can be sorted in a number of ways.

> **No matter the procurement route you take, it's incredibly important that the tender documentation includes whole life carbon information that is clearly set out and easy to understand.**

RIBA Stage 5 - Manufacturing and Construction

As the Manufacturing and Construction stage rolls around, the carbon impacts of the construction process need to be monitored against the carbon budget and any agreements made on completion of the tender process. There might be pressures at this stage to ease off carbon emission reductions because of programme and cost, so it's incredibly important to monitor the delivery of commitments made during the earlier stages so that we can deliver a low carbon building.

> **At this stage it is important to measure the carbon emissions arising from the construction process.**

Communication of intent with contractors and the supply chain is essential here, so that ideal cooperation and a positive outcome is ensured. If we get into the habit of reporting at regular intervals, as appropriate for the project size and scope, we can ensure a continuing focus and delivery against the initial objectives, and allow for whole life carbon impacts of variations to be brought to the team's attention.

The actual 'reporting' itself consists of interim updates to the carbon budget based on data from site activities, including transport movements and waste disposal.

RIBA Stage 6 - Handover

After the practical completion of the building, a final review of the 'as built' information should be undertaken and a final assessment of the whole life carbon impacts of the completed project produced.

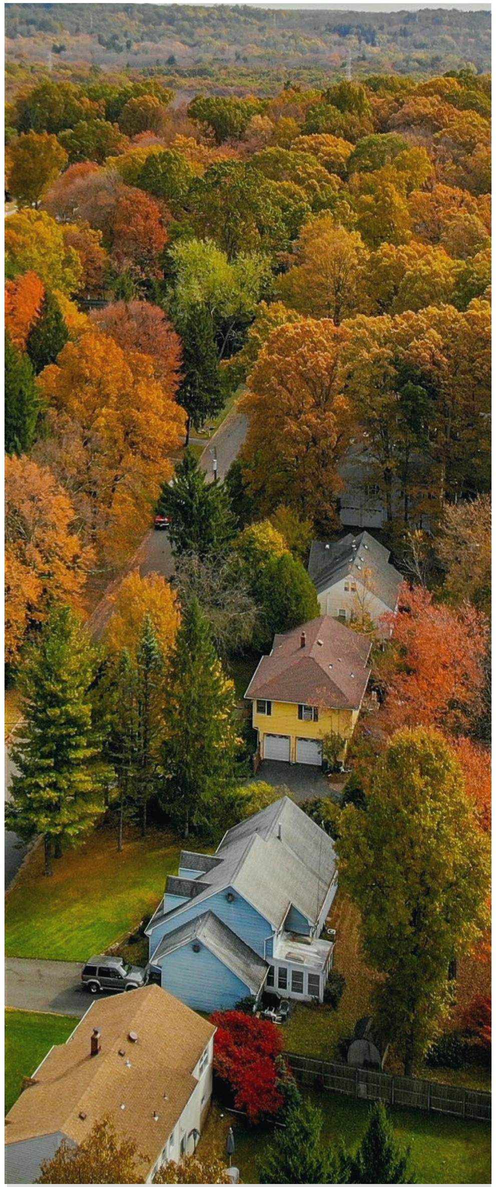
The final version of the whole life carbon assessment should be included within the O&M manuals, and the final assessment should be compared to the initial budgets as an opportunity for lessons to be learned.

Like any process that requires positive action, verification and assessment of the completed project is vital. Knowledge of the post-completion assessment requirement helps ensure compliance, and the completion assessment can include certification that a certain embodied carbon footprint has been achieved.

RIBA Stage 7 - Use

By the time a building is in use, any post-occupancy evaluation (POE) process should take account of all whole life carbon impacts, including the actual performance of the building's environmental systems, together with the fabric's physical performance with respect to durability and fitness for purpose from the occupant's POV. It should include an assessment of maintenance regimes for both.

Through action/interaction with occupants and the effects of a changing climate, buildings can evolve over time, positively and negatively, and the scope and severity of these changes tend to be decided early in the design stages. For example, if a building requires maintenance or refurbishment, the carbon intensity of those actions are determined by early design decisions and the maintenance regimes put in place, so running costs might start stacking up if good design isn't established in the first instance!



> A big question on our minds is how can we actually start going about improving our carbon footprint when it comes to new developments?

So, what's the best place to start?

0.1 Prioritise Reuse

Ideally, resource-efficient low carbon design should always start on site, using whatever material, structure, and fabric is already available and suitable for reuse.

Retention is the first port of call with reuse and involves keeping structures and major components on site to be used in the next project. Retention removes the need for any demolition, disposal, and transportation of waste, while also removes the need for any new fabrication and the transportation and construction required by the replacement materials.

The second-best method is recycling, however, only if the process results in lower overall carbon emissions than if we were to choose new fabrication methods.

Lastly, if we can't retain or recycle due to the material having no further use, disposal using a 'zero waste to landfill' service is still an option. This way we can ensure that we're still being as efficient as possible, even if we can't use the material.

When making these choices, it's a good idea to ask yourself the question 'if another architect came along to refurbish my building, could they:

- Fully dismantle all components and recycle them?
- Reuse components at the same level of use (and not at a lower level)?
- Avoid substantial levels of waste?

If we can answer all three of those questions with a 'yes', we'll be successfully designing for flexibility and making it easier for future architects to reuse the building.

0.2 Fabric first

When it comes to mitigating operational and embodied carbon, the topic of mechanical vs passive solutions comes into play. While mechanical systems can provide effective solutions to things like heating and ventilation, they can often end up being incredibly costly, energy-intensive, and carbon-intensive when compared to a passive design approach, which in comparison, have much longer lifespans, require less maintenance, and have lower operational costs, and more effective occupant comfort.

At Mesh, we often talk about the fabric-first approach and its importance in building design, and you can find more information about this approach in our blog.

0.3 Structural systems

The structural systems of any building will always have a carbon cost because of sourcing and assembly, though that cost can be reduced if a system is chosen that has flexibility for future reuse. This is incredibly important, as the majority of possible carbon reductions in a project tend to be structure, building envelope, and building services-related.

There's a few different options for structural systems used by structural engineers that satisfy immediate need while also allowing for future flexibility, as the process for dismantling and reusing these systems is much simpler than their alternatives. These systems include:

- Concrete that uses the existing structure, or alternatives to cements such as cemfree or recycles aggregates
- Timber (though this may come from an overseas source)
- Steel with recycled content
- Recycled aggregate i.e. gravel and sand

The choice for structural systems is going to be made early on during the initial construction stage and not as a post-completion consideration, so structural choices tend to be limited by the cost and procurement options that exist at this stage. This again puts emphasis on the importance for developers to take a step back and consider the long-term with their projects so that these choices aren't considered once it's too late.

0.4 Exterior and Interior Design Choices

Designing a building's exterior involves many factors - namely its environmental impact, aesthetics, and cost. These choices directly affect how comfortable and efficient the building's interior space will be. The main considerations for the lowest carbon impact are:

1. Initial carbon costs of construction
2. Lifetime embodied carbon costs for upkeep and replacement
3. Ability to eventually disassemble parts for reuse
4. Lifetime operational performance costs
5. Fire strategy

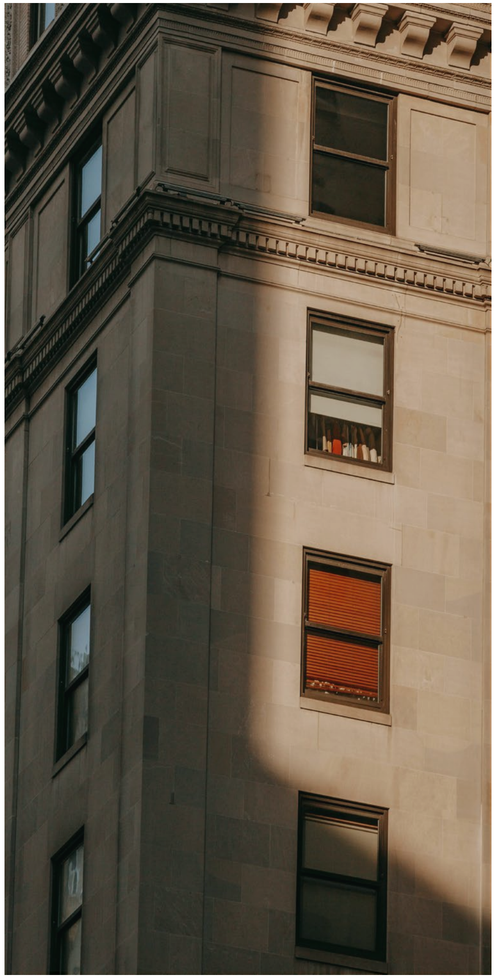
The balance between these factors depends partly on how long the building is intended to last and perform. Making poor exterior design decisions such as unoptimised cladding systems with short life spans will introduce unnecessary carbon costs further down the line (dismantling, disposing, and replacing).

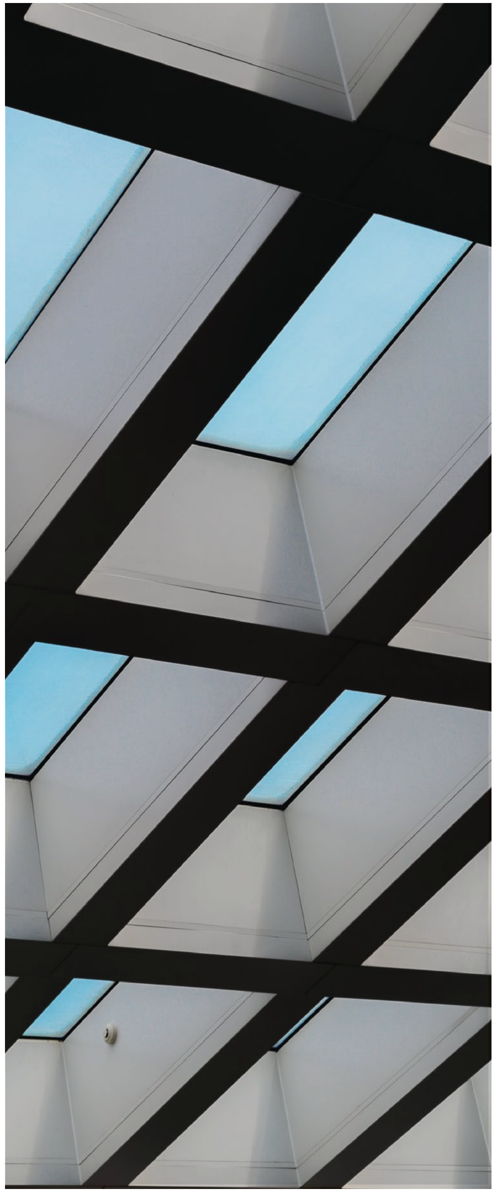
The choices for the interior of the building matter just as much as the exterior. The interiors of a building get changed more often than the building structure itself. So even though putting in new furniture or flooring might not seem like it impacts the environment much at first, over the life of a building those small changes can add up. For public buildings or offices that get heavy use, redecorating or renovating many times can end up having a bigger total carbon footprint than even building the structure in the first place.

When designing building interiors, developers should give consideration to how easy the materials will be to keep maintained or recycled in the future, on top of aesthetics and the costs involved. For example, bare brick and other natural finishes don't need frequent repainting or other maintenance, which will help lower carbon emissions over the life of the building.

0.5 Good design matters

It's important to also remember that buildings that have a low level of durability and low level of architectural design quality can have drastic economic and sociological effects for the local community and the building occupants. Well made buildings with good architectural design retain their value, whereas buildings with poor durability and are seen as an eyesore sadly risk the chance of an early demolition. This is not an ideal outcome considering the carbon emissions involved with such a process.





Looking Forward

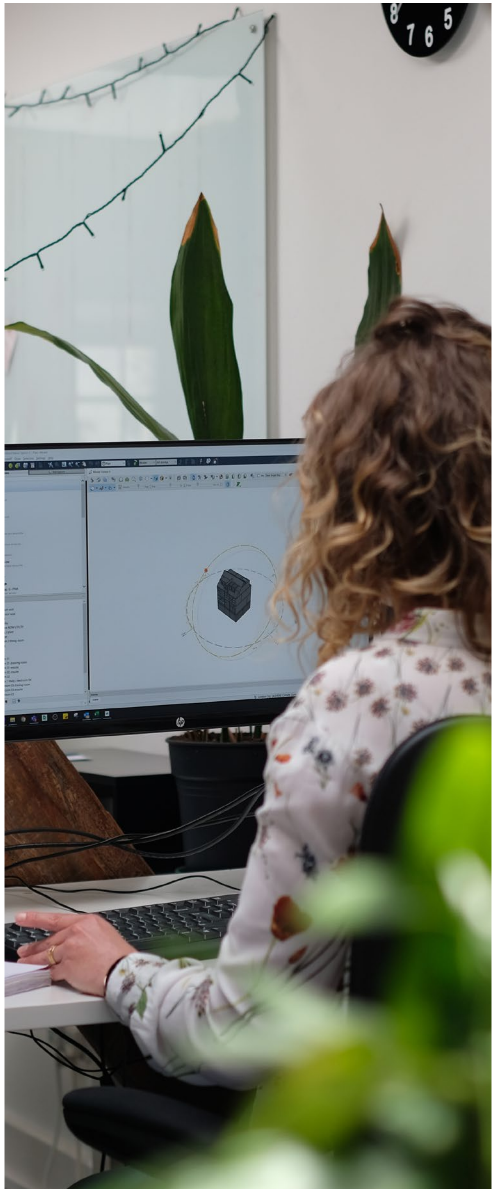
So, what is the future of whole life carbon?

As of this guide's publication date, there is sadly no government policy in the UK requiring whole life carbon reporting. However, there is an industry-proposed 'Part Z' amendment to UK Building Regulations 2010 that would introduce mandatory reporting of carbon emissions in the built environment, which would also come with limits to embodied carbon emissions on projects.

While Part Z is still just a proposal, that doesn't mean whole life carbon reporting isn't being carried out as best practice in response to local planning policy. LETI, a voluntary network of over 1,000 built environment professionals has made great strides in advocating for Net Zero in the built environment through its many different publications, such as the Climate Emergency Design Guide and Embodied Carbon Primer. Many of LETI's recommendations have been included in emerging London policy and Energy Assessment Guidance.

We recently drew upon LETI's findings in a whole life carbon webinar on Meshwork, our unique network that brings together architects, developers, installers, and students.

At Mesh, we understand the importance of reducing the embodied and operational carbon emissions over the whole life of the building, and that's why assisting developers with their whole life carbon assessments is one of our key services.



If you're looking for a consultant to help with your next project, don't hesitate to get in touch with us at

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