



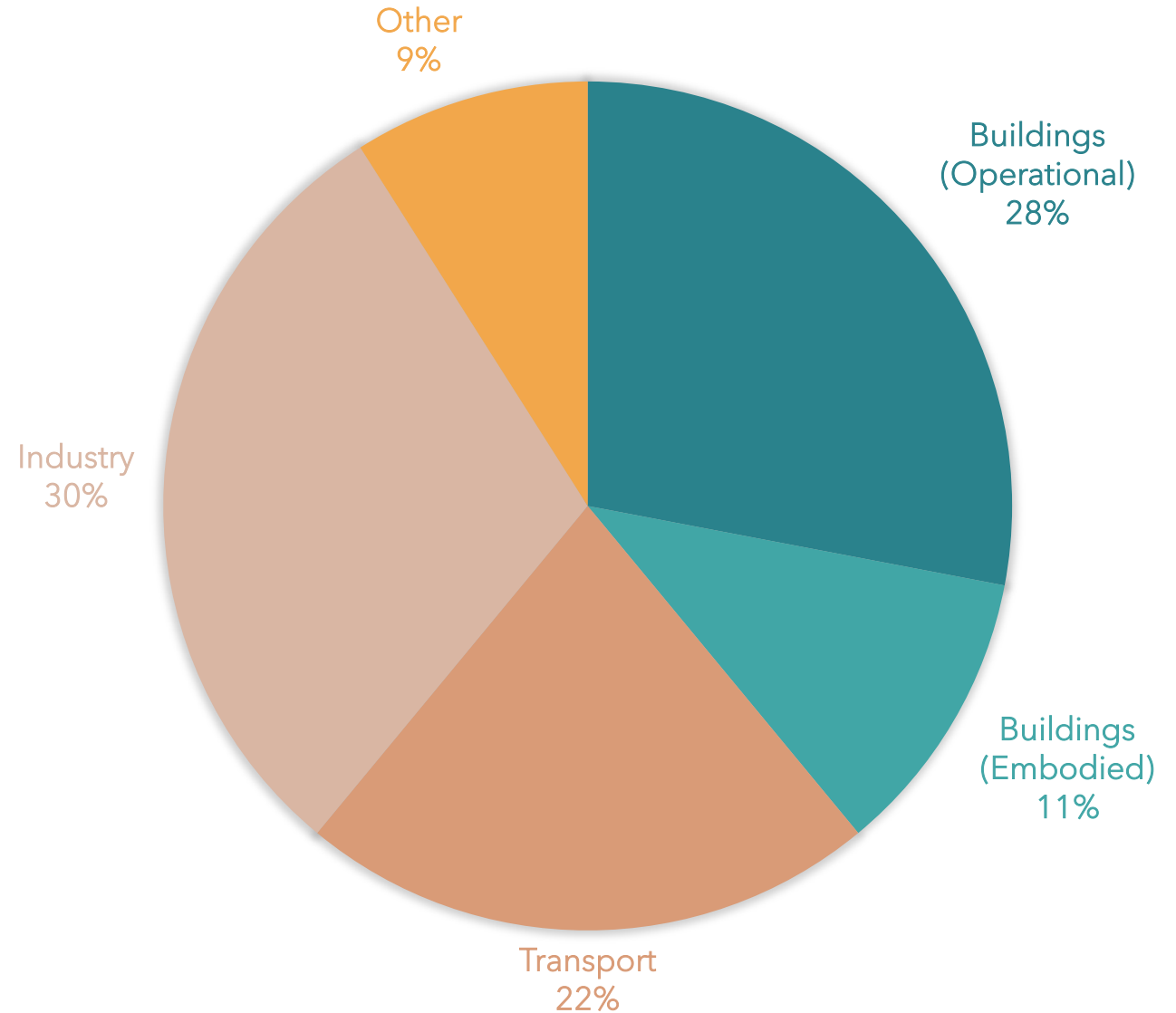
Whole Life Carbon Assessment

Carbon Emissions

- Climate change is the greatest environmental challenge of our time.
- Global warming due to human-generated greenhouse gas (GHG) emissions into the atmosphere, referred to as carbon emissions, will have severe adverse environmental, biodiversity, social and economic effects around the world if temperature levels continue to rise.

Carbon Emissions

- Our buildings are responsible for around 40% of all global CO₂ emissions.

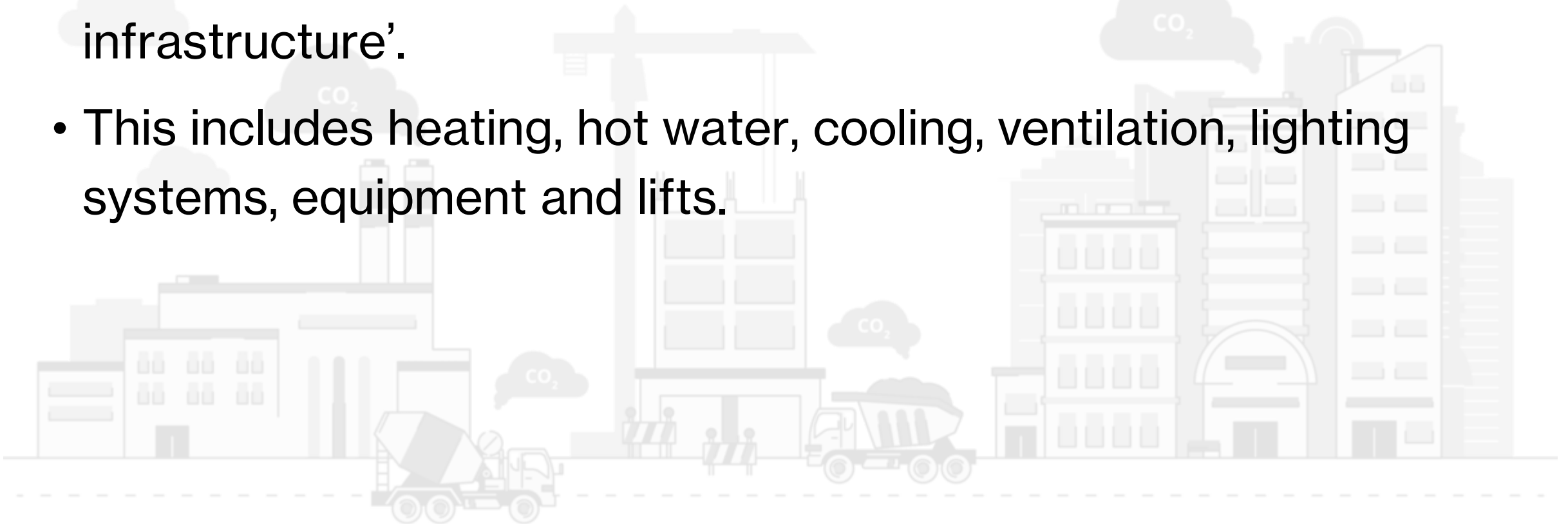


Carbon Emissions

“Professionals working in this industry have a responsibility to work together to reduce this figure and identify where reductions in carbon emissions can be made.” (RICS, 2023)

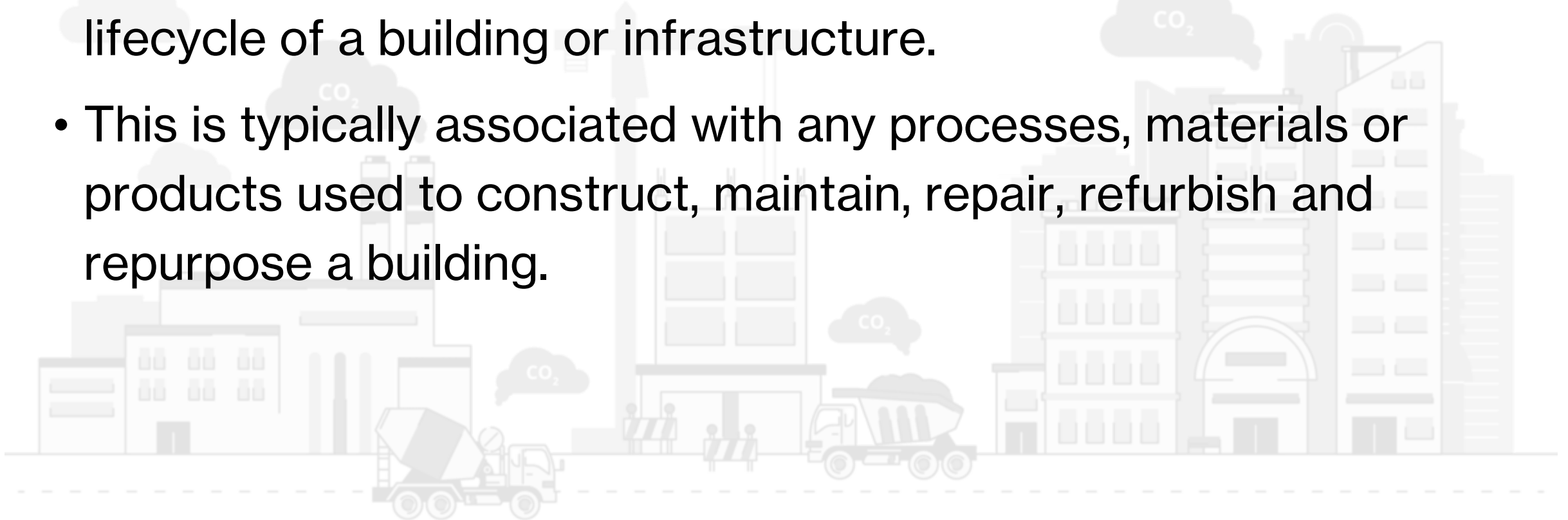
Operational Carbon

- Operational carbon refers to 'the emissions associated with energy used to operate the building or in the operation of infrastructure'.
- This includes heating, hot water, cooling, ventilation, lighting systems, equipment and lifts.



Embodied Carbon

- Embodied carbon refers to the emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure.
- This is typically associated with any processes, materials or products used to construct, maintain, repair, refurbish and repurpose a building.



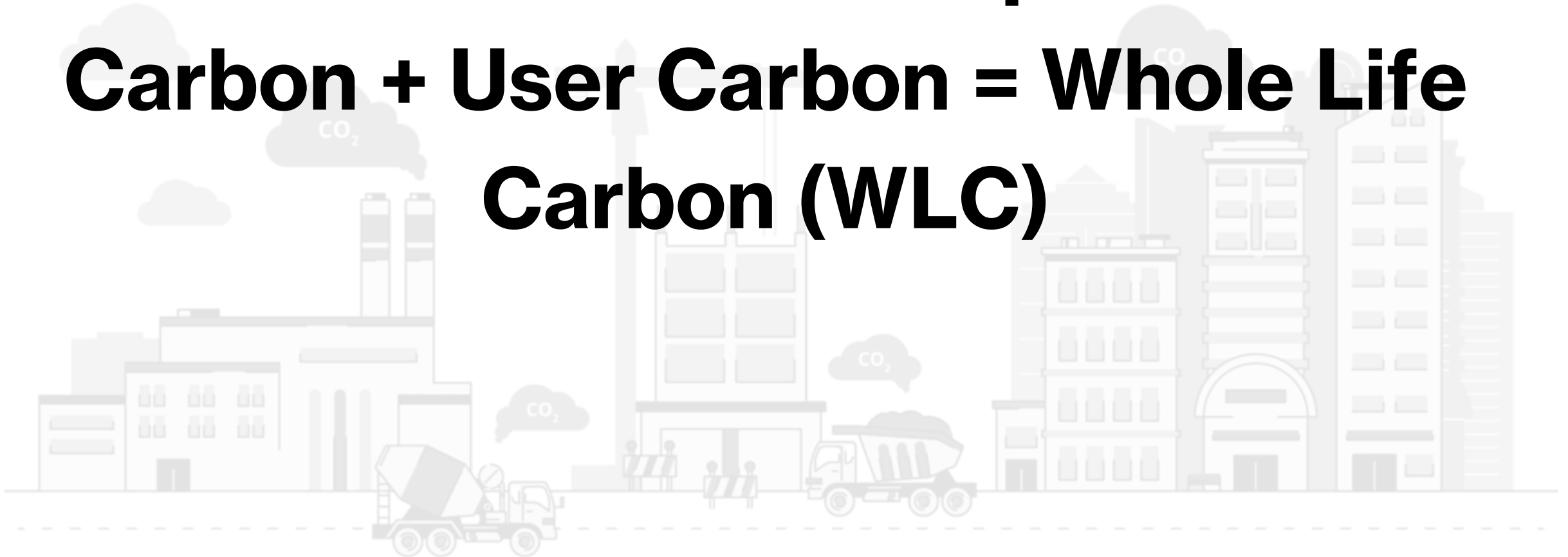
User Carbon

- User Carbon impacts are from the activities of the users of a built asset, outside of the use of energy and water used to operate the asset.
- i.e. commuting to an office building or the impact of vehicles using a road, which produce further user-related emissions.



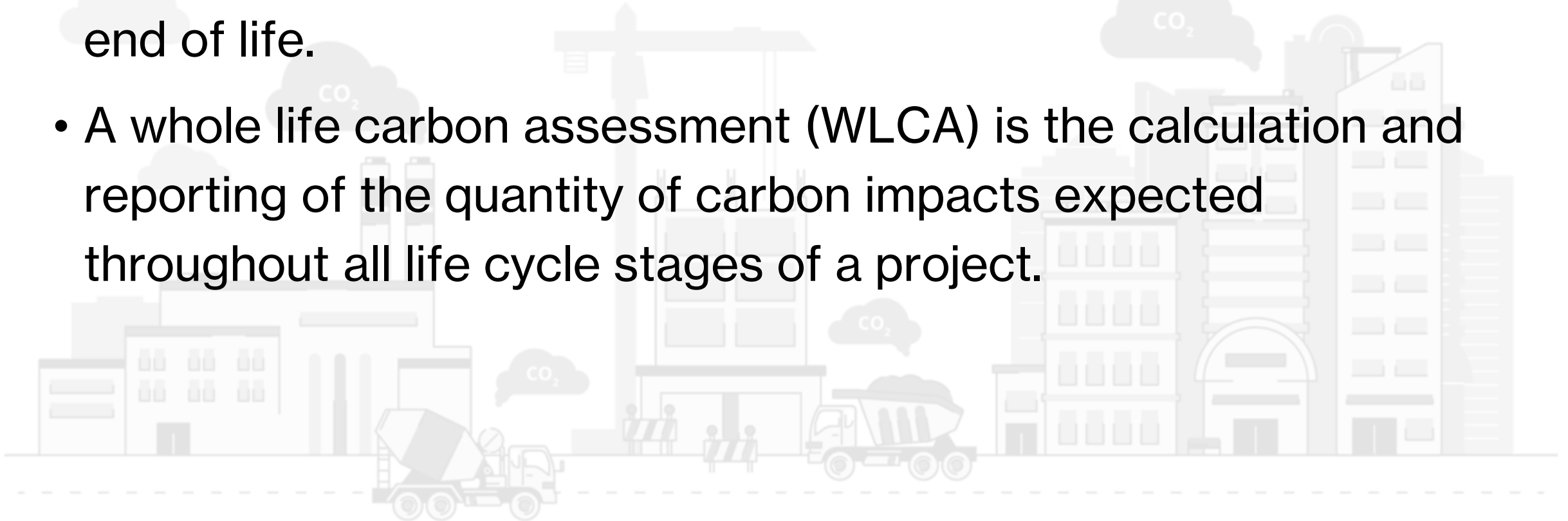
Whole Life Carbon

**Embodied Carbon + Operational
Carbon + User Carbon = Whole Life
Carbon (WLC)**



Whole Life Carbon Assessment

- Whole life carbon refers to the carbon impacts over the entire life cycle of a built asset, from its construction through to its end of life.
- A whole life carbon assessment (WLCA) is the calculation and reporting of the quantity of carbon impacts expected throughout all life cycle stages of a project.



Whole Life Carbon Assessment

- WLCAs should be integrated into project planning and cost planning from the outset, developed in collaboration with the wider project team and updated as the project evolves.
- WLCAs can be carried out during any project phase, using generic information in the early design phases before evolving to more specific data as the design becomes more developed.



Whole life carbon assessment information

Whole life carbon – system boundary

Embodied carbon/life cycle embodied carbon

Upfront carbon

Pre-construction	Product			Construction	
A0	A1	A2	A3	A4	A5
Nonphysical process before construction, preliminary studies, tests and design	Raw material supply	Transport	Manufacturing	Transport	Construction and installation

Upfront biogenic carbon

In use

B1	B2	B3	B4	B5
Use	Maintenance	Repair	Replacement	Refurbishment

Biogenic carbon

End of life

C1	C2	C3	C4
Deconstruction and demolition	Transport	Waste processing	Disposal

Biogenic carbon

Operational carbon

B6 Operational energy

B7 Operational water

User carbon

B8 User activities not covered in B1–B7

Information beyond the construction works life cycle

Benefits and loads beyond the system boundary

D1
Net output flows from reuse
recycling
energy recovery
other recovery

D2
Exported utilities,
e.g. electric energy
thermal energy
potable water

Biogenic carbon

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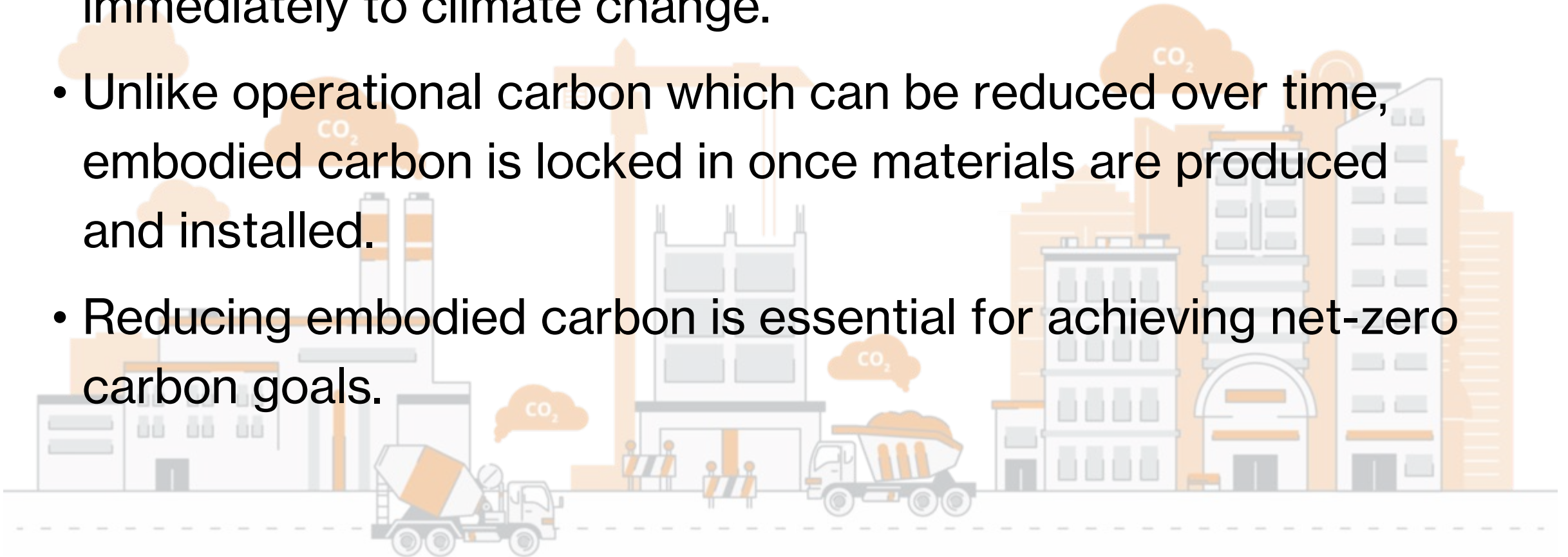
Embodied Carbon

Overall, Greenhouse gas emissions are predicted to follow a downward trend, largely due to the implementation of energy efficiency standards for new buildings, but embodied emissions are forecasted to **increase**.



Climate Change

- Embodied carbon is released upfront, contributing immediately to climate change.
- Unlike operational carbon which can be reduced over time, embodied carbon is locked in once materials are produced and installed.
- Reducing embodied carbon is essential for achieving net-zero carbon goals.



Decarbonisation

Avoid

- The extraction and production of raw materials

Shift

- To low carbon earth- and bio-based building materials

Improve

- Methods to decarbonise conventional materials.

Resource Depletion

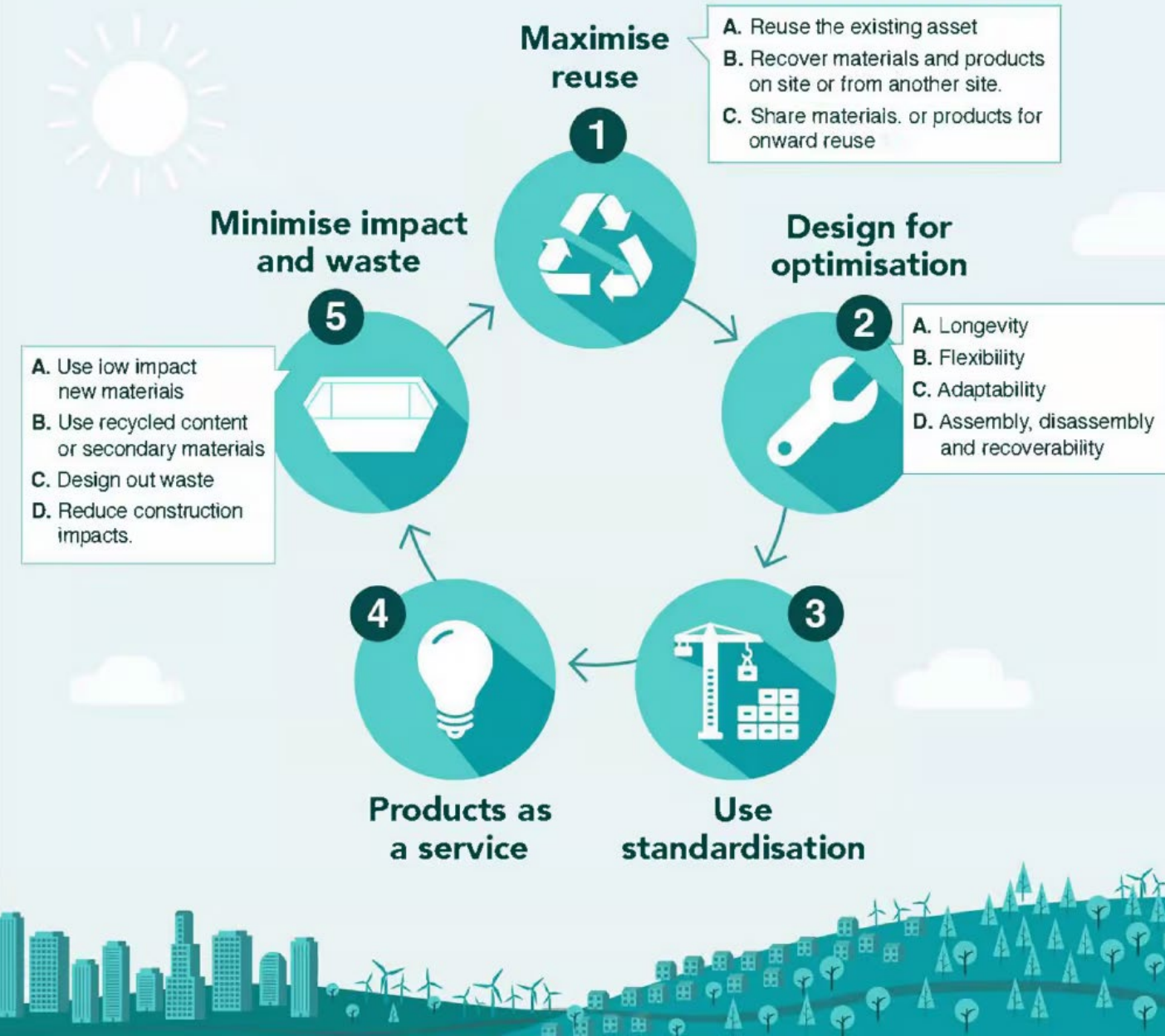
- The construction industry is responsible for 50% of global raw material extraction.
- Building materials account for half of the solid waste generated every year worldwide.



Circular Economy

The circular economy in the construction industry focuses on minimising waste, maximising resource efficiency, and promoting sustainability by designing buildings and infrastructure with materials that can be reused, recycled, or repurposed.

Circular economy principles for construction



Reuse, Refurbish and Repurpose

Aim:

Reusing an entire asset or reusing a significant proportion of the existing asset.



Reuse, Refurbish and Repurpose

Aim:

Incorporating reuse elements and materials that have been recovered from the existing site, or from another site, into the new development



Design Buildings for Optimisation

Aim:

To create a built asset with well-defined long-term needs, while being durable, resilient or able to cope with societal and environmental change.

It will require little modification/no replacement of parts, due to its 'loose fit', generous proportions and readiness for alternative technologies

Design Buildings for Optimisation

Aim:

To balance the needs of the present with how those needs will change in the future and to enable change through frequent reconfiguring including reconfiguration of non-structural parts



Design Buildings for Optimisation

Aim:

Products and services are designed to be assembled, deconstructed and reused or recycled on a part-by-part basis.



Standardisation

Aim:

Designing and constructing buildings that apply standardised elements or modular designs for materials and products that enable a reduction in construction waste and easier reuse in next life



Products as a Service

Aim:

Establish and promote a payment structure through which customers have unlimited access to resources but only pay for what is used, or for the result linked to their use.

This represents a transition from selling products to selling services

Design and Construct Responsibly

Aim:

Any new materials specified in the development are low impact materials with little or no adverse effect on either the environment or on human health throughout its lifecycle.



Design and Construct Responsibly

Aim:

To recognise and encourage the use of recycled content and secondary aggregates, thereby reducing the demand for virgin material and optimising material efficiency in construction.



Design and Construct Responsibly

Aim:

To design out waste over the whole life cycle of the building, so there is minimal waste during the design, construction, deconstruction and next life of the built asset.



Design and Construct Responsibly

Aim:

Ensure construction sites
reduce on-site waste,
including packaging.



Timber

- The built environment uses 38 per cent of the world's wood products.
- Increasingly, mass timber is becoming an attractive alternative to carbon-intensive concrete and steel due to its potential for scalability, sustainability, strength and flexibility in mid-rise urban buildings.
- Advances in timber building material technologies are making it possible to shift towards large-scale structural timber products, provided that the timber industries continue to innovate and are regulated for sustainable practices.



Bamboo

- Bamboo is a fast-growing renewable resource that has witnessed significant advances as a scalable building material in the last two decades.
- Progress in engineered bamboo has demonstrated structural performance like that of cross-laminated timber and steel.
- However, the variability in species across regions requires investments in further development of low-cost and low-carbon construction methods, standards and certifications.

Improve

- Cement can be decarbonised by reducing the clinker-to-cement ratio, increasing the share of cement alternatives
- Shifting to electric kilns powered by a decarbonised electric grid supplied with renewable energy
- Potentially strengthening concrete through carbon capture and utilisation during manufacturing.



Improve

- In primary steel production, a shift from blast furnace to direct reduced iron technology
- Coupled with electric arc furnaces powered by renewable energy sources, offers the greatest emission reduction potential
- Increasing recycling efficiencies and carbon capture and storage



Improve

- Plastics are used in applications from plumbing pipes to window frames, insulation, lining, building textiles and packaging.
- A shift towards improved methods of plastics recycling, complemented by novel bio-based and biodegradable plastics wherever possible, requires major support for advances in plastics production and recycling.



Improve

- Options for decarbonising glass production include switching the energy source, electrification of all processes, process intensification and waste heat recovery.
- In renovation and deconstruction, off-site window disassembly avoids contamination and allows for glass recycling.



Improve

- High quality earth-based masonry has potential to replace concrete in many low-rise applications but needs development and regulation.
- Diverse earth masonry materials made from clay-rich soil and natural fibres, that are dried in the sun or fired, have been used for much of human history and are often re-used.
- Increasingly masonry bricks have adopted the use of high carbon cement binders and high temperature firing to address mechanical and moisture performance.
- If locally made with low-carbon binders, additives and processing methods, earth masonry can regain its role as a viable building material.



Embodied Carbon Calculations

- Allows a direct comparison between different materials to choose those with lower carbon footprints.
- Highlights high emission materials, guiding designers towards more sustainable alternatives.
- The most important time to calculate embodied carbon is in the early design stages.

Embodied Carbon Calculations

- The unit used to measure the total greenhouse gas (GHG) emissions of a particular activity, product or process in terms of the amount of CO₂ that would have the same global warming potential is called kilograms of carbon dioxide equivalent (kgCO₂e).

Embodied Carbon Calculations

The fundamental principle of an embodied carbon calculation is to multiply the quantity of each material by a carbon factor for the life cycle modules being considered:

material quantity (kg) x carbon factor (kgCO₂e/kg) = embodied carbon (kgCO₂e)

Material quantity (kg) = Volume (m³) x Density (kg/m³)

Material Quantities

The first step is to determine the quantities of materials used in the project.

Project phase	Material quantity source
Early design phase – predicted or estimated quantities	• Estimation from drawings and 3D models/BIM • QTOs from 3D/BIM/BoQs/cost plan, where available • Industry guidance (see 4.5.1) • Assumptions from other buildings (see 4.5.2) • For MEP, see also Appendix F
Technical design and construction phases – measured or calculated quantities	• QTOs from 3D/BIM/BoQs/cost plan • BIM model and drawings data • Project technical information: specifications, construction methodologies, etc. • Industry guidance (see 4.5.1)
Post-completion phase – actual quantities	• As-built BIM model • As-built cost record of material quantities procured • Cross-reference with as-built records where practical, including material delivery records, concrete pours, etc.

Building Elements

01 Demolition, site preparation and formation

02 Substructure

03 Structure

04 Non-structural works

05 Services and equipment

06 Surface and underground drainage

07 External and ancillary works

08 Preliminaries/constructors' site overheads/temporary works

12 Production and loose furniture, fittings and equipment

Carbon Factors

Embodied Carbon Calculations

Calculate the total embodied carbon (kgCO_2e) for the asphalt layer of a 1 km road section, given the following data:

Road width: 10 metres

Asphalt layer thickness: 0.15 metres

Asphalt density: $2,400 \text{ kg/m}^3$

Embodied Carbon Calculations

Calculate the total embodied carbon (kgCO_2e) for the concrete structure of a building, given the following data:

Total concrete volume: $2,000 \text{ m}^3$

Concrete density: $2,400 \text{ kg/m}^3$

Embodied Carbon Calculations

Calculate the total embodied carbon (kgCO_2e) for the steel structure of a building, given the following data:

Total steel volume: 7.5 m^3

Steel density: $7,850 \text{ kg/m}^3$

Embodied Carbon Calculations

Calculate the total embodied carbon (kgCO_2e) for the equivalent timber structure of a building, given the following data:

Total timber volume: 22.5 m^3

Timber density: 750 kg/m^3