LETI Opinion Piece

Circular economy and carbon in construction

Aim of this document

Reducing whole life carbon (WLC) and upfront and operational carbon, and supporting a circular economy (CE) are recognised as key considerations for the design, construction and operation of buildings.

This LETI Opinion Piece shines a light on the interconnectedness of the two concepts of CE and reducing upfront and WLC emissions and highlights interrelated issues, synergies and challenges when trying to meet the requirements of both.

This Opinion Piece is an exploratory document and is not intended to provide definitive solutions but rather provide a basis for discussion and development of further guidance.

Explanatory notes

Reuse*: To save on space in this document, the term '*Reuse**' *(italicised)*, is used to summarise the established CE hierarchy of reuse, refurbish, re-purpose, and recycle, in that order of decreasing prioritised.

Materials*: The term '*Materials**' *(italicised)*, is used to imply '(parts of) buildings, systems, components and materials', with the *Reuse** of whole or parts of buildings to be prioritised over the *Reuse** of just systems, which is to be prioritised over the *Reuse** of components, and finally, the *Reuse** of constituent materials.

'***Carbon***' is used in this piece as a generic term to represent all GHG emissions, set out in BS EN 15978 as Global Warming Potential (kg CO_2 equivalent). GHG emissions also include methane and many refrigerants which are hugely impactful as multipliers of atmospheric warming.

'***Minimising carbon***' in this piece is used to represent minimising either or both upfront carbon and whole life carbon. Distinction between the two is often important and has been made wherever needed.

The points raised in this Opinion Piece often hold in general but may vary in differing specific contexts. The nuances underlying the impacts of many design decisions means they should wherever possible be supported by the calculation of carbon and CE metrics.

Summary

Two concepts to address two global problems

The concepts of achieving CE, and minimising carbon are solutions to the global problems of resource scarcity and environmental degradation, and the climate emergency.

Global problem	Concept/solution
Resource scarcity and environmental degradation	Achieve circular economy
Climate emergency	Minimise whole life carbon and minimise upfront carbon[5]

Figure 1 - Two concepts to address two global problems

CE and minimising carbon support each other

Simply put, in construction minimising upfront and whole life carbon and achieving CE are generally related: *Reuse** and using less (CE) usually lowers carbon (upfront and whole life); and lowering carbon (upfront and whole life) usually requires using fewer *Materials** and/or *Reuse** (CE). The two concepts set out as solutions to resolving the two different problems but will have shared benefits.

Minimising upfront carbon is currently a priority to stave off multiple tipping points from climate change. Because CE strategies can reduce upfront and whole life carbon emissions from most *Materials** whilst embodied energy (which is the energy associated with materials and construction processes throughout the whole life cycle of an asset) is still carbon intensive, CE should be considered as augmenting upfront and whole life carbon reduction strategies.

In fact, cement, steel, and aluminium – which make up a significant part of embodied carbon emissions – have be shown to be 'hard to abate', meaning that they are very difficult to decarbonise – and are likely to remain so well into the future. For these materials achieving circularity is critical to reduce WLC, since, by implementing CE ideas it improves our ability to deliver the built environment we need whilst nevertheless reducing carbon emissions – by reducing the reliance on more new 'hard to abate' materials.

Definitions

Circular economy (CE): A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life[1].

Whole Life Carbon (WLC): 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[2]). Overall WLC asset performance includes separately reporting the potential benefit from future energy recovery, reuse, and recycling (Module D)[3].

Upfront [embodied] carbon: 'Upfront Carbon' emissions are the GHG emissions associated with materials and construction processes up to practical completion (Modules A1-A5). Upfront carbon excludes the benefits from biogenic carbon sequestered in the installed products at practical completion[4]. Minimising upfront [embodied] carbon plays a major role in short-term GHG emissions reductions needed to avoid global system tipping points being reached.

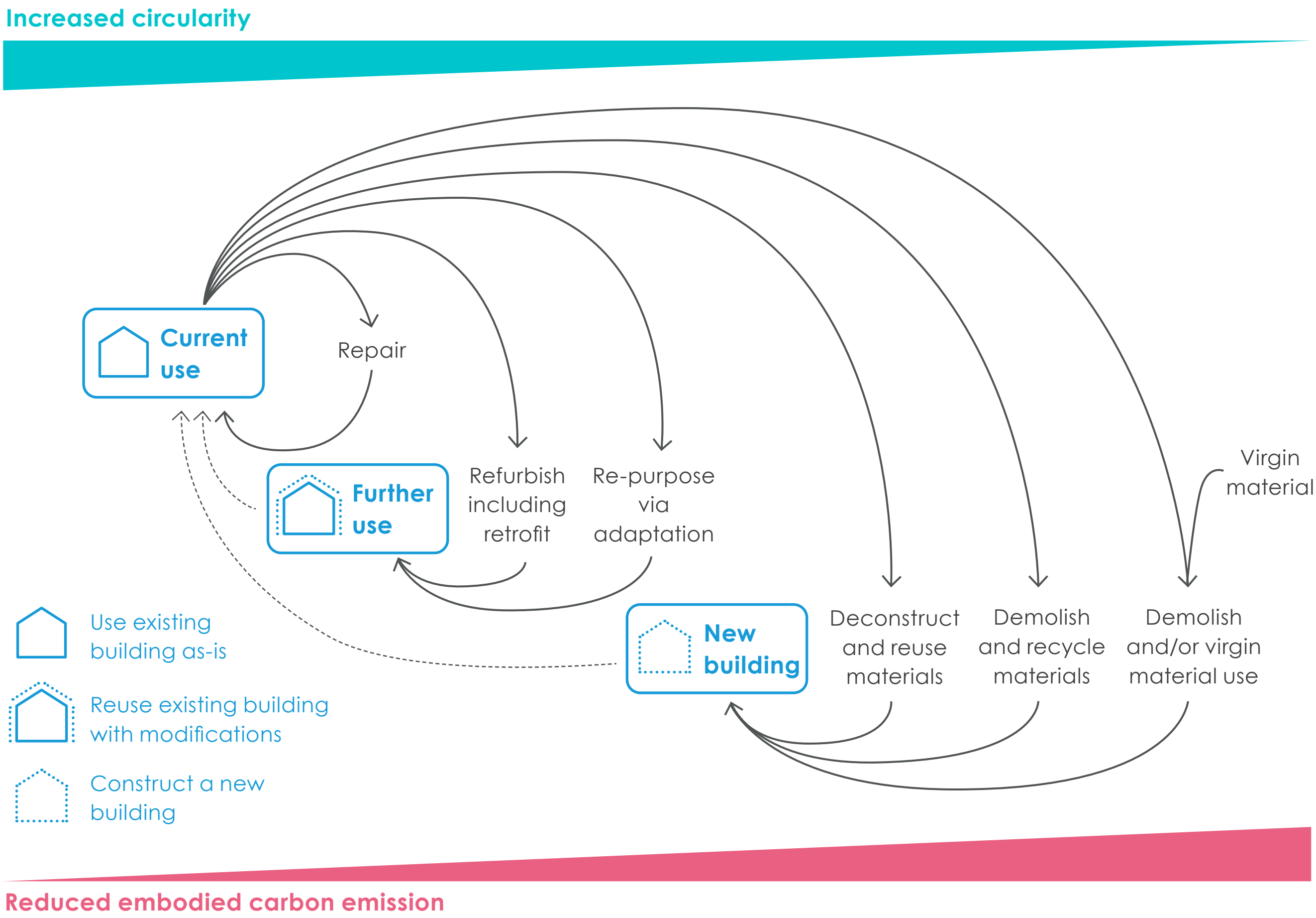

Figure 2 - Simplified diagram of the relationship between CE and embodied carbon in the built environment for different types of actions[6]

Differences / tension between CE and minimising (upfront and whole life) carbon

Situations may arise where there is a potential misalignment between minimising (upfront and whole life) carbon and achieving CE. This could result in different design solutions being judged as optimal under the two regimes. Focusing only on optimising CE metrics could result in a poorer carbon metric outcome, and vice versa.

For example, a highly circular building might require a higher carbon spend in the first 'lifetime' of the structure on the site, to give it optimal flexibility, adaptability, disassembly, and component replacement potential. This might be reflected in a higher upfront carbon or WLC assessment than another option which has lower circularity characteristics. This approach of a certain carbon spend now in exchange for uncertain carbon benefits in the future that may never be realised needs to be considered in the context of the urgent need to immediately reduce emissions to avoid global systems breaching tipping points.

It is advisable to clarify the motivation for design choices by reporting the impacts of these choices on CE, WLC and upfront carbon. For example, where upfront carbon has been prioritised, it is important to understand the impacts on CE and WLC, especially where there is a conflict.

Although CE and minimising carbon are largely mutually supportive, CE's benefits go beyond reducing carbon (biodiversity and ecosystem integrity). CE should therefore not just be pursued for the sake of generating carbon benefits.

Decarbonisation

The link between CE and minimising (upfront and whole life) carbon will reduce in time – the speed and extent of which depending on how well zero carbon energy demand can be met by supply[7] – as production processes[8] and the energy embodied in the manufacturing, transport, construction, and re-use becomes decarbonised. At that point, resource scarcity and environmental degradation will still need addressing, through CE principles.

Comparison: Supporting a circular economy vs. minimising carbon

The below table compares the two strategies by topic, and reveals differences and commonalities.

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
Core issue	The need for living within planetary boundaries[9]	Mitigate climate change and global system tipping points[10]
Priority	Minimise long term finite virgin resource use and waste	To mitigate climate change and global system tipping points, short term (upfront) GHG emissions must be minimised. This sits alongside the other priority of minimising long term GHG emissions, or WLC.
Metrics / indicators	There are two main groups of indicators: **First group: Indicators of material use circularity** include % of materials and elements reused and % of materials and elements expected to be reusable in future[11]. Aggregation in the indicators could be done by cost, mass or volume, weighted by relatively scarcity of the material/element, or by economic value of recirculated element[12] . There remains a lack of consensus on material use circularity metrics/indicators. *Further development* of these metrics would likely include differentiation of reuse into its five commonly used subcategories of reuse, refurbish, re-purpose, and recycle, with additional identification of downcycling and use of biogenic materials. *(continued overleaf)*	There are a number of metrics related to carbon and standards for its measurement[13]: → **WLC** = aggregation of Modules A1-A5, B1-B7, C1-C4 → **Upfront carbon** = aggregation of Modules A1-A5. Reducing this metric has the most immediate climate change mitigation potential → **Embodied carbon** = aggregation of Modules A1-A5, B1-B5, C1-C4 → **Module D** (usually reported separately). → **Whole life carbon asset performance** = WLC plus Module D These metrics are standardised as a rate per square metre, to facilitate comparison between buildings. *(continued overleaf)*

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
	Second group: Indicators of embodied carbon. These are a reasonably proxy for material circularity in the absence of other satisfactory metrics of material use circularity, and whilst embodied energy remains carbon-intensive. These include metrics on either side of the system boundary: → the *change in values* **of Modules A1-A5, B1-B7 and C1-C4** resulting from a design change to incorporate CE features; → **Module D** (referred to as the 'CE module' in RICS PS): benefit of passing material use from one use cycle to the next The impact on Modules A1-A5 of design changes to incorporate CE features has the most immediate climate change mitigation potential.	Incorporating Module D into the WLC evaluation provides the link between reducing 'next life' expected carbon beyond the system boundary and increasing *Materials** use circularity. Module D extends the projected carbon evaluation beyond the system boundary – to e.g., evaluate a temporary building with low EC yet non-reusable components versus one which has a greater EC outlay but is highly reusable. The latter might use less carbon and materials than the former, for the same amount of long-term square metre-years. *Further development:* A long term 'multiple uses over time on a site' view suggests exploring the utility of "WLC per square metre-years" as a metric. This should be defined in a way so as not to discourage increased use intensity – e.g., two shifts per day, which can reduce the overall area of buildings needed.
Consensus on metrics / indicators	There is no consensus on the preferred indicators for CE. Work on indicators is ongoing by the LETI Circular Economy workstream, as well as UKGBC and CIRCUIT.	There is a consensus on carbon metrics/ indicators, which are widely and consistently used when reporting (set out above). However, expressing carbon only as a rate per unit of area overlooks inefficiencies caused by under-use of building over time (e.g. only one 'shift' per day) or low per capita occupancy (e.g. oversized homes). *Further development:* Metrics should allow for such inefficiencies to be drawn out, e.g. by incorporating per capita and time elements.

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
Targets	Although the following general targets are often given for CE, they arguably represent idealised, hypothetical outcomes that may be difficult to attain: → 0% finite virgin resource use and 0% waste leakage from the system; → 100% reused *Materials**; → 100% reusable *Materials**; → 100% biodegradable materials	The following specific targets for project carbon emissions (described in the WLCN's carbon definitions document[14]) are generally considered to be achievable, even if obtaining all but the last of them involves a degree of offsetting. All targets work towards reducing the carbon emissions from the project to zero, although they operate over different time periods and include different emissions components. → Net zero WLC → Net zero Embodied Carbon → Net zero Upfront Carbon → Net Zero Carbon – Operational Energy → Net Zero Carbon – Operational Water → Net Zero In-Use Asset → Absolute Zero Carbon (for each of the above, but without reductions from offsets) Targets are expressed as a rate per square metre to standardise for building size. LETI and RIBA recommended targets are given in the document 'Embodied Carbon Target Alignment'[15].
Consensus on targets	The LETI Embodied Carbon Primer includes targets for reuse and reusability of systems, components and elements; however, these do not sufficiently describe other important CE design characteristics such as durability, flexibility, designing in layers and demountability. There are ongoing efforts to develop industry consensus on a definitive set of circularity indicators. See for example the work by CIRCUIT[16].	Consensus on targets for the embodied carbon component of WLC is improving, see for example LETI's proposed 'rating badge' based on industry consensus - from "Embodied Carbon Alignment", available at https://www.leti.london/carbonalignment. This guides clients wanting to incorporate carbon targets in project briefs. *Further development*: Per capita carbon allowances can address relative under-use of buildings due to under-timetabling or under-occupancy of space.

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
Time horizon for measurement	There is no upper limit set for time horizon over which circularity is measured. The aim of circular design is that *Materials** remain in maximum utility for as long as possible (unconstrained by a time horizon).	Modules A-C are generally measured over 60 years[17], (to allow consistent comparisons) the so-called 'useful life' of a building, and not beyond. The time horizon cut-off for WLC separates it conceptually from CE. The metric whole life carbon asset performance[18] combines Module D with WLC (LCA Stages A, B and C), which is closer aligned with the even longer time horizon associated with the concept of CE. Module D reported separately shows carbon saved from reuse beyond useful life of building. Module D represents the carbon saved from a single *Reuse* of Materials**.
Ease of inclusion in briefs	Comprehensive client brief guidance is available e.g. in the UKGBC document 'Circular Economy guidance for construction clients'[19] . Lack of consensus on metrics/indicators and targets makes setting measurable targets in project briefs more difficult.	Consensus on metrics/indicators and targets makes it easier to brief for - and measure the design efficacy of - low carbon design than it is for CE in design. See also LETI Client Guide for NZC Buildings[20].
Role of the system boundary	The system boundary **separates** a current project's use in the original state from an anticipated future use action for the *Materials**. These actions include (in decreasing order of preference) 'reuse', 'refurbish', 'repurpose', 'deconstruct & reuse', and 'demolish and recycle'. Indicators like Module D and % reusable represent the predicted impact of actions beyond the system boundary. All actions, whether within or beyond the system boundary, need to be considered in a circular economy assessment.	The system boundary **forms a container around** the current building's carbon emissions during its lifetime (Modules A, B and C). Future expected avoided carbon emissions due to *Reuse** beyond the system boundary are represented within Module D, which is reported separately.

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
Future importance, and short to medium term alignment	Achieving material use circularity will always matter in the future **(short, medium, and long term)**. In fact, it is likely to become more prominent with the growing importance of resource scarcity and resource security. Where circular design increases *Materials** *Reuse** and improves materials use efficiency[21], it is likely to reduce embodied energy and carbon, which matters in the **short to medium term** whilst embodied energy is not yet decarbonised. Conversely, a focus on more durable Materials may increase upfront embodied energy and carbon in the **short to medium term,** whilst at the same time result in energy, carbon, and circularity benefits in the **long term**. Also, CE principles can reduce reliance on more new 'hard to abate' materials, thus reducing embodied carbon.	The importance of measuring and limiting WLC will recede in the **long term** as both operational and embodied energy are expected to decarbonise[22]. However, such decarbonisation is expected to be limited firstly by supply constraints with predicted zero carbon energy not meeting fast growing demand for such energy. Secondly, 'hard to abate' materials production will remain particularly difficult to decarbonise in the foreseeable future, as explained in the Summary section. Whilst embodied energy is not decarbonised (in the **short to medium term**), reducing EC can be achieved by reducing the amount of energy in the processing of materials and manufacturing of products, achieved by reducing finite virgin material use (which are generally energy intensive to extract, process and turn into products), and by *Reusing** *Materials**. I.e. material use circularity is an important strategy to reduce embodied carbon whilst embodied energy remains carbon intensive.
Uncertainty	Uncertainty plays a large part in CE given the difficulties around supply: sourcing used systems, components and materials remains difficult; the *Reuse** potential of *Materials** in the future remains difficult to predict. This *Reuse**/sourcing uncertainty applies to all CE indicators. Reducing this uncertainty by e.g. improving the reliability supply chains should improve the uptake of CE design. The acute shortage of circular *Materials** alternatives in supply chains that creates uncertainty for designers, specifiers and contractors is driven by continued overwhelming demand by clients for alternatives that represent the lowest financial cost and lowest financial risk. *(continued overleaf)*	For WLC metrics, uncertainty around assumptions, technologies, and carbon profiles grows the further into the future they apply. This means greater care should be taken when basing decisions and making comparisons on the values of Modules D, C and the '**medium to long term**' component of Module B. Module A provides the most 'reliable' component of WLC as its calculation does not rely on assumptions of future behaviour.

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
	As such there is little appetite for low planetary risk options (low resource depletion, carbon) to stimulate development of the circular supply chains for components and materials to deliver these. In addition, the extent of the accurate BIM record-keeping, reverse logistics and components and materials storage solutions required to implement CE at the required scale remains a formidable challenge. In such situations of market failure there is a strong case for legislators to act to adjust the imbalance, and reduce uncertainty.	
Life cycle	Built assets are made up of materials, components/products, and systems which each have different lifespans, often different to the design life of the whole building. This brings complication in the application of some CE principles in terms of what happens at the end of life and emphasises the importance of designing in layers and for maintenance so that a material or component with a longer lifespan is not damaged when trying to repair, renew, replace, or upgrade an adjacent material or component with a shorter life span. For example, where ceiling/services systems are not designed in layers the replacement of a shorter life-span worn-out suspended ceiling might trigger the premature replacement of the services in and above that ceiling with longer remaining service lives.	The reference study period (RSP)[23] represents the typical design life of an asset, which for buildings is assumed to be 60 years, and for infrastructure 120 years. When an asset's design life is expected to be less than the RSP, WLC is increased by emissions relating to the construction and operation of the next use of the asset/site. This impact is mitigated if circular economy principles can be deployed for the next use. Alternatively, when asset lives are expected to be "stretched" beyond the RSP then a sensible end of life scenario should be assumed at the end of the RSP[24] . *Further development*: Further investigation is needed into the carbon and circular economy impact of this fixed 60-year reference study period on design decisions, to explore e.g. whether it should be differentiated by typology.
Offsetting	'Offsetting' doesn't have a parallel to that in WLC when considering the materials circularity of a project[25].	All of the carbon targets listed in the row 'Targets' above – except for those termed 'absolute' – incorporate offsetting[26]. Offsetting operates outside the system boundary.
Sequestration	Biogenic materials, in particular timber, sequester carbon. Any end-of-use intervention that involves biodegradation must aim to limit carbon re-entering the atmosphere during that process. Any such emissions should be reported in WLC.	From the RICS Professional Statement: "Carbon sequestration figures should be identified separately but can be included within the total cradle-to-grave figures [A] to [C]."[27]

Topic	Supporting a circular economy	Minimising (upfront and whole life) carbon
Future owner / occupant impact	As the environmental impact of materials use is expected to increase in the future, hence too will the circular economy impact of future decisions by owners and occupants. Therefore, circular economy guidance relating future operating and maintenance decisions must be included in the building user guide.	As embodied energy is expected to decarbonise in future, the carbon impact of future decisions by owners and occupants can be assumed to decrease. Still, closing the performance gap and reducing overall embodied and operational energy consumption should remain a priority as low carbon energy from renewables is likely to remain a finite resource.

Potential carbon impacts for different circular economy design approaches

The below table examines the rationale for each CE design approach, together with the accompanying carbon impacts / considerations.

CE design approach	Circular economy rationale	Upfront and whole life carbon considerations
Durability	Durability benefits the CE if it results in reduced finite virgin resource use in the long term, by enabling a material or component to remain in serviceable use for longer. There may be circularity benefits of matching a component's design life to that component's expected period of use. In that case, the component and the fabric to which it attached should be designed for it to be easily removed for reconditioning or recycling for next use. In other situations, there may be circularity benefits to designing highly durable components, no matter what their expected period of use, provided the component is de-constructable or re-configurable for re-use. Asset lifespans for fit-out, MEP systems and cladding are often aligned with long lease periods.	The WLC impact of durability is nuanced. Optimising component lifespans to expected replacement cycle durations (linked to expected lease length) and asset lifespans could reduce overall WLC. Maximising durability of components (or, more generally, *Materials**) could increase upfront embodied carbon and reduce in-use repair and replacement embodied carbon. The extent of next-life benefits reflected in Module D depends on the demountability and re-use potential of components, as well as there actually being a future use for that component for which a benefit is being claimed. Efforts to minimise the upfront carbon of building components could lead to lower component durability, and hence more frequent repair/replacement (possibly higher Modules B3 and B4) and lower reuse, refurbishment and repurposing potential (reduced benefit from Module D). On the other hand, it is possible that such components (lower upfront embodied carbon, less durable) are easier to replace (lower Module C) and refurbish/ re-manufacture (increased benefit from Module D) – which may have CE benefits. These nuances underscore the importance of carrying out WLC assessments.

CE design approach	Circular economy rationale	Upfront and whole life carbon considerations
*Reuse** (potential)	Reuse of whole or major parts of buildings (such as structure and envelope) is closest to the principle of full circularity[28]. For elements to be disassembled for reuse, they need to be assembled using removable fixings. It may be necessary to modify elements (e.g. structural elements) to improve *Reuse** potential[29]. More durable elements are likely to have greater potential for reuse by being more resilient to wear inflicted by disassembly, transport, and reassembly, but may involve more embodied carbon in manufacture. Standardising systems and product dimensions increases the likelihood of greater compatibility in future uses.	Reusing an existing building, system or component reduces WLC, primarily by reducing upfront carbon. Improved future *Reuse** potential of design elements could increase upfront carbon as explained under the heading "Durability" above.
Design in layers	Designing in layers reduces the unnecessary replacement of systems or components that are difficult to separate from those that do need replacing. Replacement cycles differ for internal finishes, internal fit-out, MEP systems and façades, and as such each of these must be easily separable from others and replaceable.	A design not containing layers that are easily separable and independently replaceable should attract a higher WLC by way of increased Module B4 (Replacement).
Disassembly and recoverability	Designing for disassembly and recoverability will matter for the future, but more from a materials impact on global ecosystems than carbon as embodied energy is expected to eventually decarbonise (less so for hard-to-abate materials).	Designing for disassembly and recoverability impacts Module C and increases the benefits contributed through Module D. The impact of different end of life scenarios (e.g. disassembly, recovery, demolition) on the separate component parts of LCA Stage C (Modules C1-C4) requires more study[30].

CE design approach	Circular economy rationale	Upfront and whole life carbon considerations
Reduce energy use	Drawing on finite energy resources contributes to resource depletion and is counter to CE principles. To preserve natural ecosystems, the CE requires reduced energy use, and sourcing energy from renewables.	To reduce carbon emissions requires reduced energy use, and sourcing energy from renewables. A better understanding is needed of the embodied carbon per unit of in-use operational energy from different sources of renewable energy. How best to include the carbon impact of operational energy sourcing is currently under review. The benefit from exporting renewable energy generated on-site is reported in Module D. Reducing operational energy use, and its carbon emissions Module B6 is likely to contribute to a CE. This is true even for 'so-called'[31] 'decarbonised' energy: For example, reducing use of lithium batteries[32] and solar panels will not just reduce finite virgin material consumption, but also reduce the negative environmental impacts of lithium, cadmium and lead mining.
Reduce water use	Drawing on finite natural water resources contributes to depletion of resources — clean water in this case. To preserve natural ecosystems, the CE requires reduced water use, and sourcing water from closed-loop recycling systems.	Although municipal water supplies still generally have low operational carbon Module B7, a better understanding of the embodied carbon LCA Stages A, B, C impact of different sources and recycling of water is needed as climate change places stress on water supplies[33]. Reducing operational water use, and its associated carbon emissions Module B7 is likely to contribute to a CE[34].
Standardisation	Standardisation of components can minimise wastage through off-site manufacture and reducing on-site derived waste. Easily demountable standardised components may improve reuse[35] and the likelihood of back-in-factory reconditioning.	Standardisation does not necessarily mean lower WLC, as it may result in oversized components in places. Bulky, pre-assembled volumetric modular components (e.g. Type 1 MMC) are likely to be more carbon efficient to manufacture off-site (Module A3) and install on-site (Module A5) but may have higher transport emissions Module A4 as more vehicle journeys may be required to transport the same weight of building materials.

CE design approach	Circular economy rationale	Upfront and whole life carbon considerations
Flexibility, adaptability	A flexible design that is easily adaptable for anticipated future uses reduces the likelihood and amount of building elements being replaced at the end of a use cycle. Designing by flexibility and adaptability today will obviously matter for the future, but more from a materials impact on global ecosystems than carbon as embodied energy is expected to eventually decarbonise (less so for hard-to-abate materials). It is important to assess the long-term material use impact of flexible and adaptable designs. 'Over-designing' to accommodate all possible future uses may be detrimental to long-term material use circularity. The theory of adaptation pathways[36] can be useful to have designs achieve realistic compromises between the 'known' present and the 'unknown' future. An expected future upside or downside may never materialise: any trade-off between the present and the future must be carefully evaluated.	A design containing inherent flexibility for possible future change in use may carry a higher upfront carbon cost in exchange for a lower expected WLC. Conversely, embodied carbon can be reduced in a building by reducing the amount of material used, at the cost of limiting potential flexibility e.g. design load restrictions for structures. Just as flexibility and adaptability can result in improved material use circularity, so can such 'over-designing' result in higher WLC. Adaptation pathways theory also has potential uses in designing for reduced WLC.
Recycling / use of recycled content	Recycled content avoids finite virgin resource extraction and processing, which also usually entails higher embodied energy and carbon.	*Materials** with high recycled content usually reduce WLC, primarily by reducing upfront carbon.
Leasing arrangements	The lease of installed building components[37] to the building owner can incentivise the manufacturer/supplier which leases them to improve durability, to reduce maintenance, repair and replacement costs, to design in layers (so faulty components can be individually replaced as needed) and develop improved reverse logistics infrastructure.	The expected WLC impact of any leasing arrangements needs careful review. Suppliers have an interest to reduce maintenance, repair and replacement costs which should reduce Modules B2, B3 and B4. These benefits may be negated by higher transport emissions generated by supplier site attendances and the moral hazard of mistreatment by building owners.

Design actions

Design actions can be represented by the following Venn diagram, which is an alternative illustration of the interdependency between minimising (upfront and whole life) carbon and achieving a CE. Design actions achieve either a CE, minimise carbon, or do both.

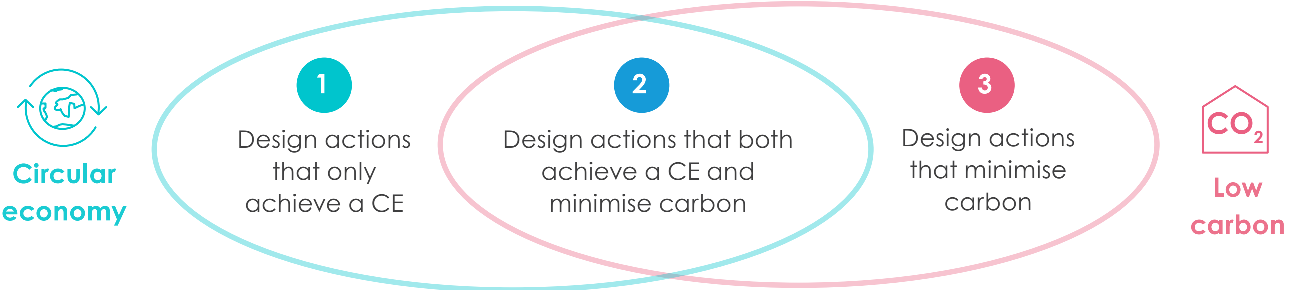

Figure 3 - Overlapping sets of CE and low carbon design actions

1 'CE only' design actions

The following design actions have an unclear impact on carbon:

→ Specify certain suppliers and/or systems, components and materials that (and therefore stimulate demand for suppliers and/or systems, components and materials that):

  → Eliminate eutrophication, toxic chemical release, ozone depletion, acidification
  → Preserve biodiversity (e.g. C2C or FSC certification)

2 Low carbon and CE design actions

The following design actions are likely to result in both low carbon and positive CE impact(#):

→ Avoid demolition in favour of retention, often with the required retrofit to reduce WLC
→ Avoid finite virgin resource extraction
→ Build less, *Reuse** buildings
→ *Reuse** and recycle *Materials**
→ Use low carbon systems, components and materials that are durable and low maintenance
→ Use systems, components and materials with high recycled content
→ Use biogenic materials
→ Reduce transport of components and materials by using local supply chains
→ Specify certain suppliers and/or systems, components and materials that (and therefore stimulate demand for suppliers and/or systems, components and materials that):
  → Decarbonise reprocessing and re-manufacture
  → Decarbonise recycling
  → Decarbonise reverse logistics networks (#)

3 'Low carbon only' design actions

The following design actions are likely to have negative CE impact:

→ Decarbonise demolition (assuming the alternative of 'no demolition' is rejected as an option)
→ Specify certain suppliers and/or systems, components and materials that (and therefore stimulate demand for suppliers and/or systems, components and materials that):
  → Decarbonise finite virgin resource extraction, transport, and processing (assuming the alternative of 'no further finite virgin resource extraction' is rejected as an option)

(#): Whilst embodied energy is not decarbonised, reducing EC is aligned with reducing the amount of energy in the processing of materials and manufacturing of products. This is best done by reducing finite virgin material use (energy intensive to extract, process and turn into products) and *Reuse** of *Materials**.

Figure 4 - Design actions comparison table

Next steps

To provide evidence to back up the various statements made in this thought piece, a series of case studies is needed. Each would ideally contain detailed, verified CE and upfront and whole life carbon metrics calculated during design and at completion to understand the nuances and potential contradictions in key relevant design components.

LETI is planning to publish detailed discussions on individual topics touched upon in this document and therefore specific feedback on the content of this document is welcomed via the LETI website.

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Notes and references

[1] This definition of CE is taken from WRAP, at www.wrap.org.uk/about-us/our-vision/wrap-and-circular-economy

[2] The WLC life cycle stages and modules are defined in BS EN 15978

[3] For further detail on the definition of WLC, refer to the LETI Embodied carbon primer, WLC one pager, and the WLCN document "Improving Consistency in Whole Life Carbon Assessment and Reporting" (May 2021)

[4] This definition of upfront carbon is taken from the WLCN document "Improving Consistency in Whole Life Carbon Assessment and Reporting" (May 2021), available at https://www.leti.london/carbonalignment

[5] Guidance on achieving the optimal balance between minimising upfront carbon and WLC needs further development given the immediate and long-term global carbon reduction needs.

[6] Definitions (in decreasing order of circularity)

Reuse: Products or components are used again for the same purpose for which they were conceived, either as they are or by being checked, cleaned or repaired. Typically no other processing would be required.

Refurbish: Redevelop through restoring, refinishing and future proofing while minimising changes and avoiding major replacement of any parts.

Repurpose: Redevelop with significant major changes and replacement of shorter-life parts to accommodate different needs and/or uses (e.g. from industrial use to mixed use).

Recycle: Recycling is then waste materials are reprocessed into products, materials or substances whether for the original or other purposes. Often terms such as down-cycling are used where the product is considered to fulfil a lower quality function that the original.

For completeness, we include in the definition of recycling the biodegrading of natural building materials at end of life in natural environmental conditions, but in a way that limits GHG emissions (e.g. composting with biomethane capture).

[7] Decarbonisation of embodied energy is likely to be constrained by accelerating across-the-board demand for zero carbon energy not being matched by supply. Peak demand spikes will exacerbate this overall supply/demand mismatch. See for example https://www.iea.org/news/clean-energy-demand-for-critical-minerals-set-to-soar-as-the-world-pursues-net-zero-goals

[8] For many materials, including cement and steel, emissions result not just from the energy used in the production process, but also from the chemical reactions associated with the production process itself.

[9] From: https://ec.europa.eu/environment/action-programme/pdf/Position%20Papers%20received/Environmental%20Pillar.pdf

[10] See: https://www.carbonbrief.org/explainer-nine-tipping-points-that-could-be-triggered-by-climate-change

[11] These CE metrics are set out in the LETI Embodied Carbon Primer

[12] For a discussion on aggregation in CE metrics, see Marcus Linder, Steven Sarasini, Patricia van Loon, "A Metric for Quantifying Product-Level Circularity", Journal of Industrial Ecology, Volume21, Issue3, Special Issue: Exploring the Circular Economy, June 2017, Pages 545-558.

[13] For more detailed definitions of these and other concepts, refer to the WLCN document "Improving Consistency in Whole Life Carbon Assessment and Reporting" (May 2021), available at https://www.leti.london/carbonalignment

[14] See note 13

[15] The LETI document "Embodied Carbon Target Alignment" is available at https://www.leti.london/carbonalignment

[16] CIRCUIT's work on circular economy metrics is at https://www.circuit-project.eu/post/report-recommendations-on-circularity-indicators-for-a-circularity-dashboard

[17] RICS professional statement, Whole life carbon assessment for the built environment, 1st edition, p11

[18] See note 13

[19] UKGBC's "Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage" (April 2019), is available at https://www.ukgbc.org/ukgbc-work/circular-economy-guidance-for-construction-clients-how-to-practically-apply-circular-economy-principles-at-the-project-brief-stage/

On page 22, it sets out briefing guidance for achieving a CE in terms of WLC: "Ensure a presumption in favour of retaining most, if not all, of the asset (structure, facade, building services, fixtures and fittings) based on whole life cost modelling [/] Aim for a percentage reduction in embodied carbon against the total for a notional reference building, deemed to be typical of that building class, see the RICS Embodied Carbon database. Otherwise, where possible, set a whole life carbon target for an assumed design life based on comparison with benchmark data, see the RICS professional statement Whole life carbon assessment for the built environment"

[20] THe LETI Client Guide for Net Zero Carbon Buildings is available at https://www.leti.london/clientguide

[21] In this case, the design falls in both Category A (Reuse in design and construction now) and Category B (Design for reuse at end of Material use cycle) as defined on p21 of UKGBC's "Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage" (April 2019), available at https://www.ukgbc.org/ukgbc-work/circular-economy-guidance-for-construction-clients-how-to-practically-apply-circular-economy-principles-at-the-project-brief-stage/

[22] For more on projected decarbonisation of embodied energy, see DECC and BEIS, Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050 (March 2015).

[23] The Reference Study Period is defined on p18 of BS EN 15978

[24] The relationship between asset life and the Reference Study Period is addressed on p11 of RICS professional statement, Whole life carbon assessment for the built environment, 1st edition

[25] In theory it might be possible to for example secure efforts to enhance biodiversity in one place to counter the destruction a project has caused in another place. However, given the general failure of carbon offsetting markets to achieve meaningful emission reductions, the expectation for any circular economy offsetting to have a positive impact is low.

[26] See note 13

[27] It is worth noting that this treatment of sequestration can create double accounting at the national level. For example, under UN rules on land use a country exporting grown timber for construction can claim the carbon sequestration benefit, whereas the importing country uses the same in its constriction carbon balance. This is a topic for further investigation.

[28] This is embodied in the statement, "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times", from "Towards a circular economy: business rationale for an accelerated transition", Ellen McArthur Foundation, p2.

[29] For example, timber structural members at Brummen Town hall are oversized to improve the likelihood of reuse. See https://constructionmanagermagazine.com/circular-economy-world-keeps-turning/

[30] For more on impacts of end of life scenarios on Stage C, refer to the table in "End of life LCA and embodied carbon data for common framing materials" available at SteelConstruction.info https://www.steelconstruction.info/End_of_life_LCA_and_embodied_carbon_data_for_common_framing_materials

[31] We refer to this decarbonised energy as 'so-called' because embodied carbon is still required to manufacture, transport, maintain and reuse/recycle/dispose of the components (photovoltaics, wind turbines, etc.) that generate this 'decarbonised' energy.

[32] Note that emerging battery technology, although a way from mainstream production, does not require lithium or elements with similar environmental impact.

[33] In fact, London opened its first desalination plant in 2010. Desalination plants are a highly energy intensive way of producing drinking water. See: https://en.wikipedia.org/wiki/Thames_Water_Desalination_Plant

[34] Reductions in operational water use need not necessarily reduce performance. For example, high performance low flow shower head can deliver the same performance as a traditional high flow shower head.

[35] A note on standardisation for steel: The use of the most common standard sections improves reuse potential, as they will be most identifiable and most likely to be specified in future designs incorporating reused sections. Use of extendable beam-to-column connections also improves the likelihood of unmodified reuse in future onward uses.

[36] A definition of adaptation pathways, from http://www.coastalwiki.org/wiki/Climate_adaptation_policies_for_the_coastal_zone#Adaptation_pathways is as follows: "A static plan is inadequate, as the future can unfold differently from what is anticipated. Actions that are appropriate for the foreseeable future can [be revealed to be] inadequate for the long term and even hinder actions that may become necessary later. One way to deal with this problem of "robust decision making" is the strategy of adaptive pathways. [These] consist of different sets of successive adaptation actions. Each step of such a pathway should ultimately lead to successful long term adaptation within a particular scenario of climate change and socio-economic development. The analysis of the different pathways enables the selection of short term actions that are suitable (no adverse lock-in effects) within different scenarios. The most promising actions are those with the best performance in terms of societal benefits and costs."

[37] Leasing of building components is currently possible for e.g. lifts and lighting installations.