LETI
Climate Emergency Design Guide & Embodied Carbon Primer

Webinar 26th January 2021
The Sustainability Series by Lancaster West Neighbourhood Team

@LETI_London

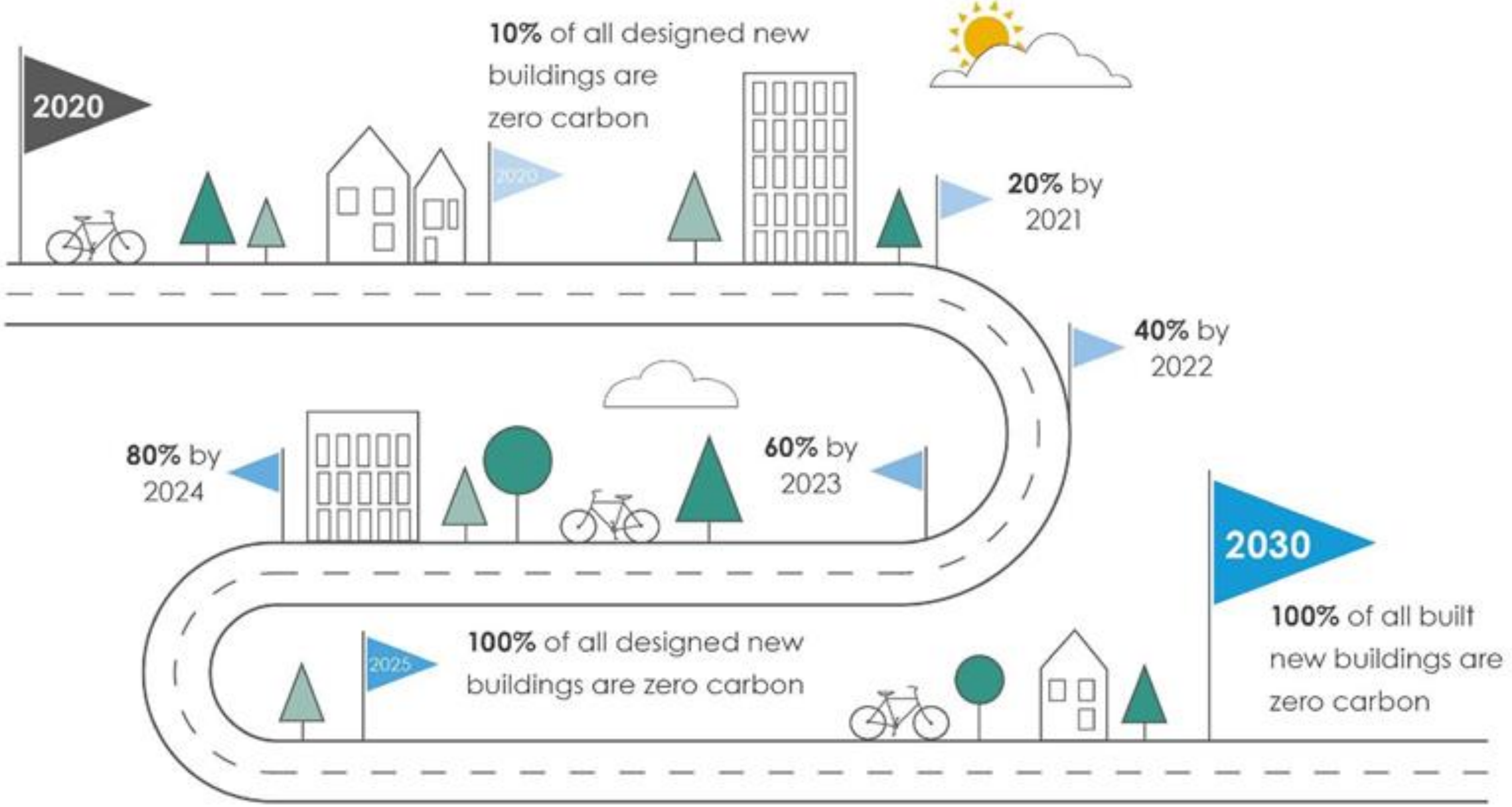
#BuildNetZero

www.leti.london

LONDON ENERGY TRANSFORMATION INITIATIVE

LONDON
ENERGY
TRANSFORMATION
INITIATIVE

www.leti.london @LETI_London #BuildNetZero



Path to zero carbon

LONDON
ENERGY
TRANSFORMATION
INITIATIVE

Low energy use

1. Total Energy Use Intensity (EUI) - Energy use measured at the meter should be equal to or less than:
   - **35 kWh/m²/yr** (GIA) for residential[1]

   For non-domestic buildings a minimum DEC B (40) rating should be achieved and/or an EUI equal or less than:
   - **65 kWh/m²/yr** (GIA) for schools[1]
   - **70 kWh/m²/yr** (NLA) or **55 kWh/m²/yr** (GIA) for commercial offices[1,2]

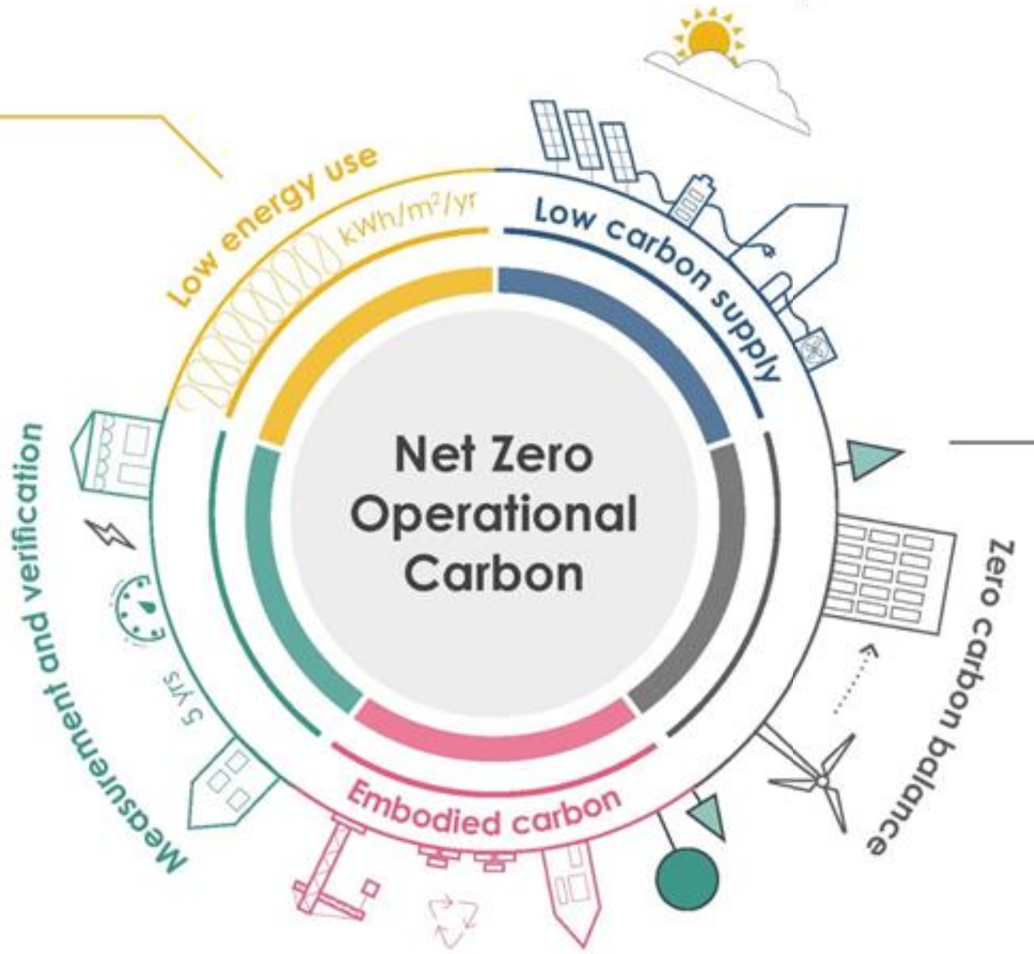
2. Building fabric is very important therefore space heating demand should be less than **15 kWh/m²/yr** for all building types.

Measurement and verification

3. Annual energy use and renewable energy generation on-site must be reported and independently verified in-use each year for the first 5 years. This can be done on an aggregated and anonymised basis for residential buildings.

Reducing construction impacts

4. Embodied carbon should be assessed, reduced and verified post-construction.[3]



Low carbon energy supply

5. **Heating and hot water should not be generated using fossil fuels.**

6. The average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.

7. On-site renewable electricity should be maximised.

8. Energy demand response and storage measures should be incorporated and the building annual peak energy demand should be reported.

Zero carbon balance

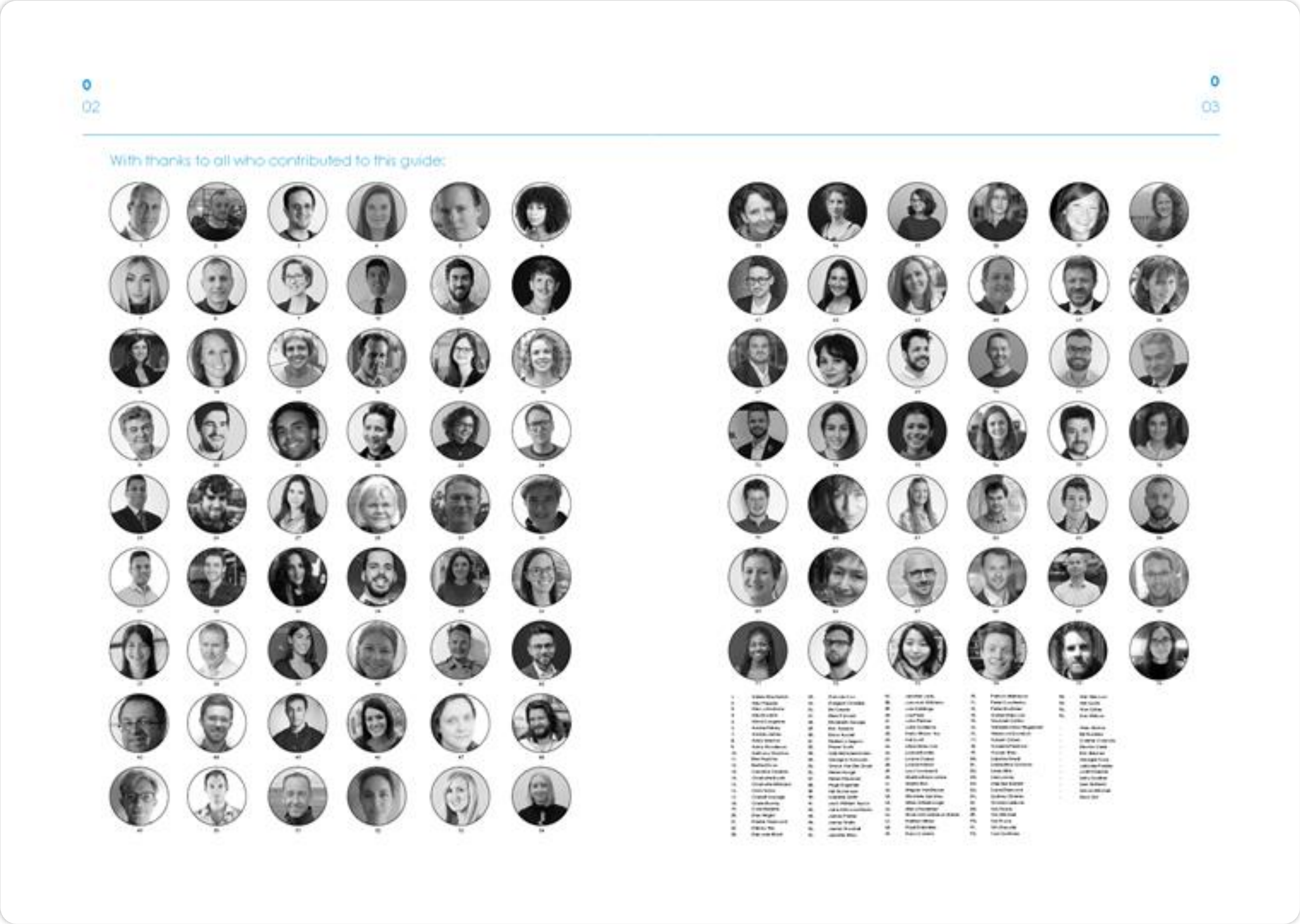
9. A carbon balance calculation (on an annual basis) should be undertaken and it should be demonstrated that the building achieves a net zero carbon balance.

10. Any energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site OR a minimum 15 year renewable energy power purchase agreement (PPA). A green tariff is not robust enough and does not provide 'additional' renewables.

Climate Emergency Design Guide

Hosted by NLA

100+ volunteers

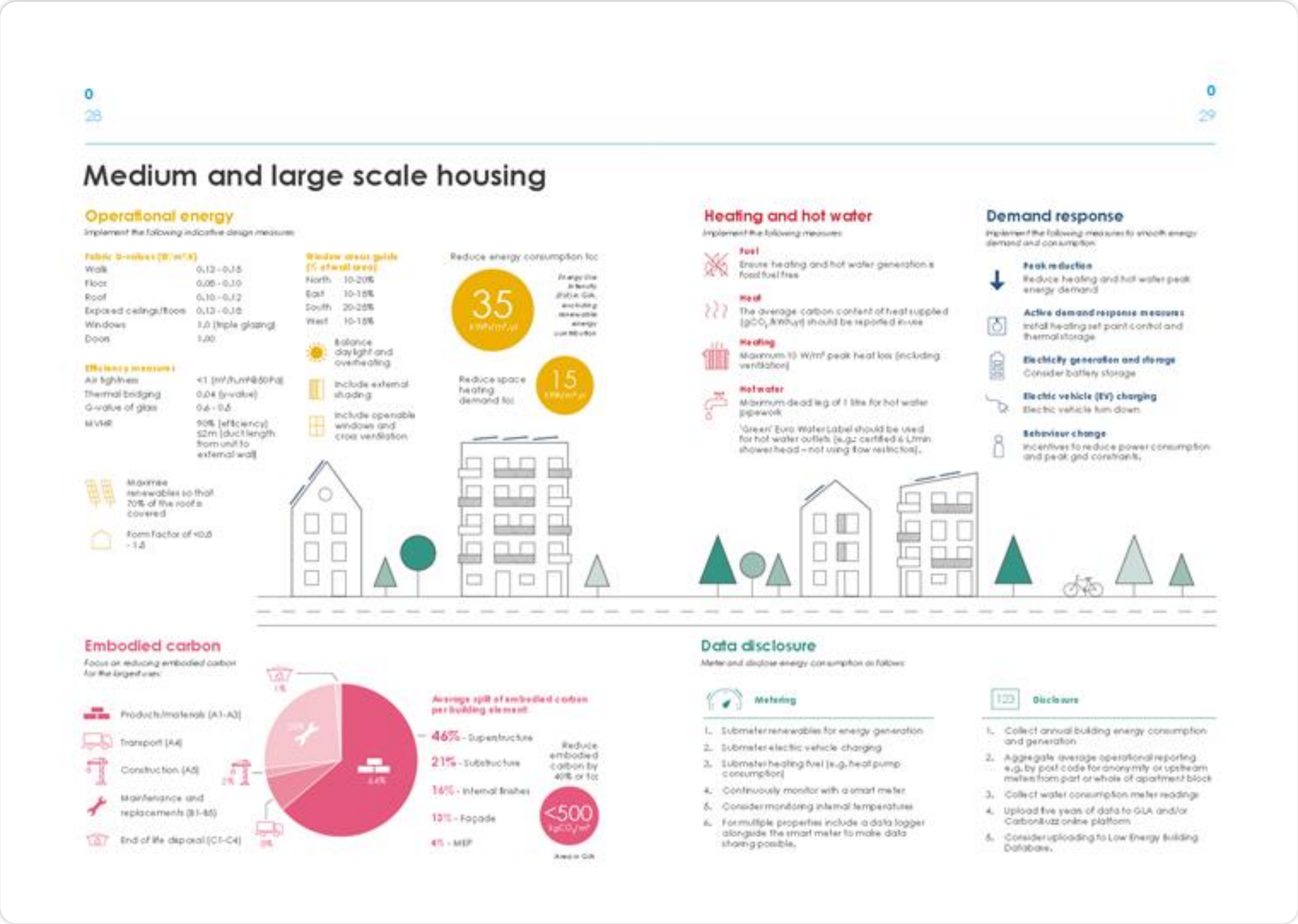


Chapter guide:

Elements of net zero carbon

- Operational energy
- Embodied carbon
- Future of heat
- Demand response
- Data disclosure

Archetypes



0
28

0
29

Medium and large scale housing

Operational energy

Implement the following indicative design measures

Walls	0.12 - 0.15
Floor	0.08 - 0.10
Roof	0.10 - 0.12
Exposed ceilings/floors	0.12 - 0.18
Windows	1.0 (triple glazing)
Doors	1.00

Air tightness	<1 ($m^3/h.m^2$@50Pa)
Thermal bridging	0.04 (y-value)
G-value of glass	0.6 - 0.8
MVHR	90% (efficiency) ≤2m (duct length from unit to external wall)

North	10-20%
East	10-15%
South	20-25%
West	10-15%

Balance daylight and overheating

Include external shading

Include openable windows and cross ventilation

Maximise renewables so that 70% of the roof is covered

Reduce energy consumption to:

35

Reduce space heating demand to:

15

Heating and hot water

Implement the following measures

Ensure heating and hot water generation is fossil fuel free

The average carbon content of heat supplied (gCO_2/kWh/yr) should be reported in-use

Maximum 10 W/m² peak heat loss (including ventilation)

Maximum dead leg of 1 litre for hot water pipework

'Green' Euro Water Label should be used for hot water outlets (e.g.: certified 6 L/min showerhead – not using flow restrictors).

Demand response

Implement the following measures to smooth energy demand and consumption

Reduce heating and hot water peak energy demand

Install heating set point control and thermal storage

Consider battery storage

Electric vehicle turn down

Incentives to reduce power consumption and peak grid constraints.

Embodied carbon

Products/materials (A1-A3)

Transport (A4)

Construction (A5)

Maintenance and replacements (B1-B5)

End of life disposal (C1-C4)

46% - Superstructure

21% - Substructure

16% - Internal finishes

13% - Façade

4% - MEP

Reduce embodied carbon by 40% or to:

<500

Data disclosure

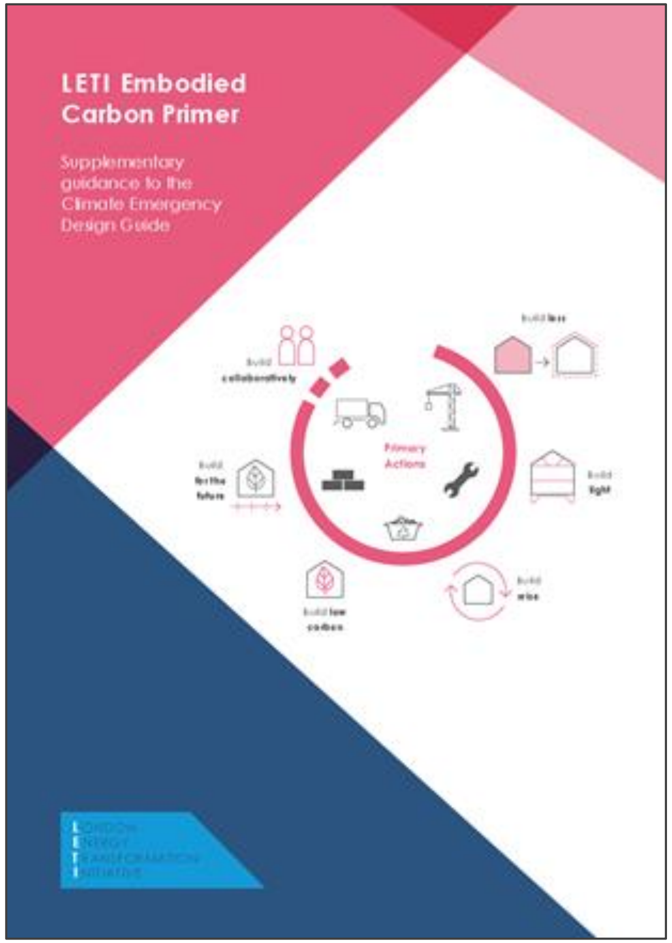
Metering

1. Submeter renewables for energy generation
2. Submeter electric vehicle charging
3. Submeter heating fuel (e.g. heat pump consumption)
4. Continuously monitor with a smart meter
5. Consider monitoring internal temperatures
6. For multiple properties include a data logger alongside the smart meter to make data sharing possible.

Disclosure

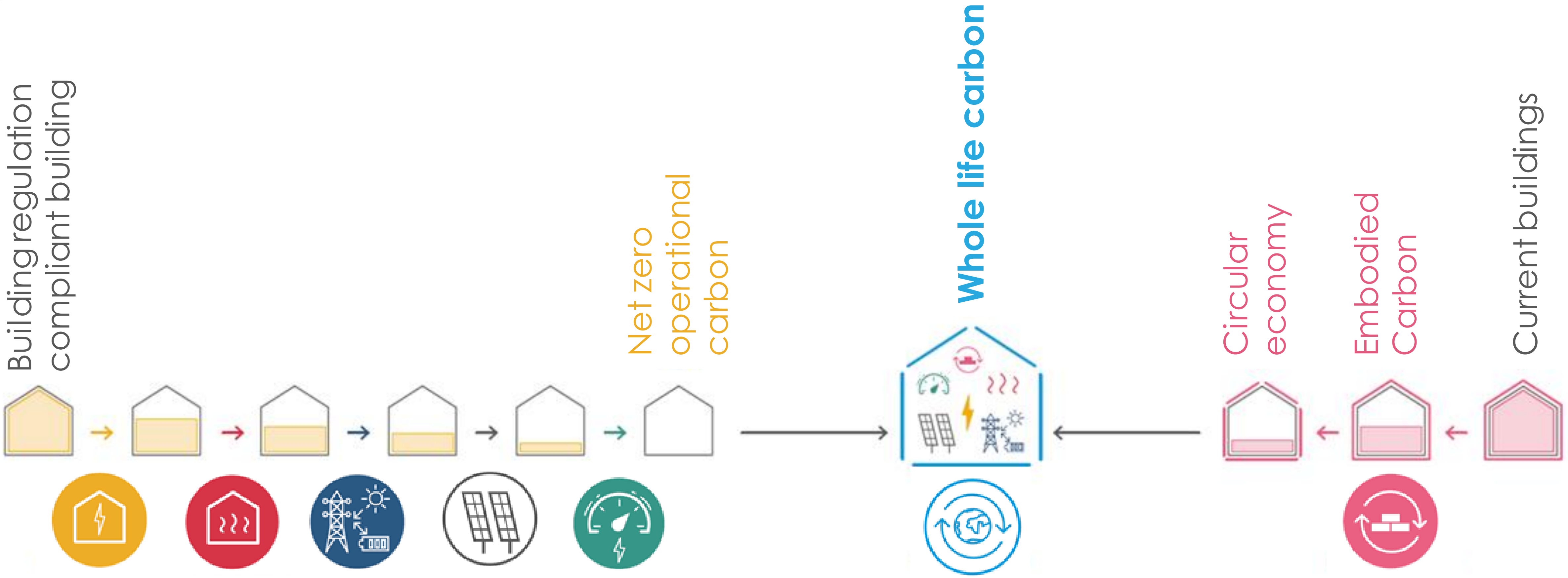
1. Collect annual building energy consumption and generation
2. Aggregate average operational reporting e.g. by post code for anonymity or upstream meters from part or whole of apartment block
3. Collect water consumption meter readings
4. Upload five years of data to GLA and/or CarbonBuzz online platform
5. Consider uploading to Low Energy Building Database.

Embodied Carbon Primer



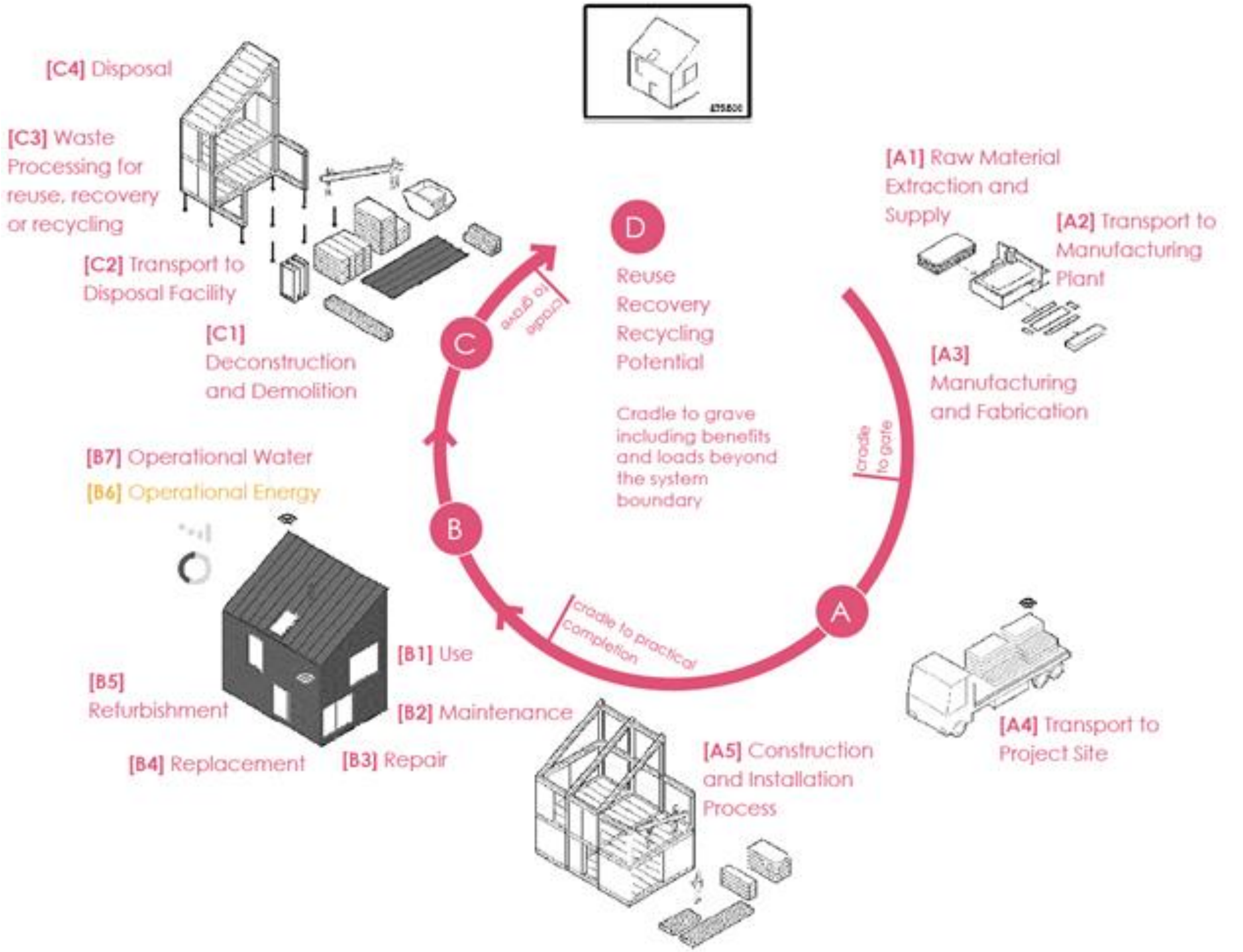
LONDON
ENERGY
TRANSFORMATION
INITIATIVE

Whole Life Carbon

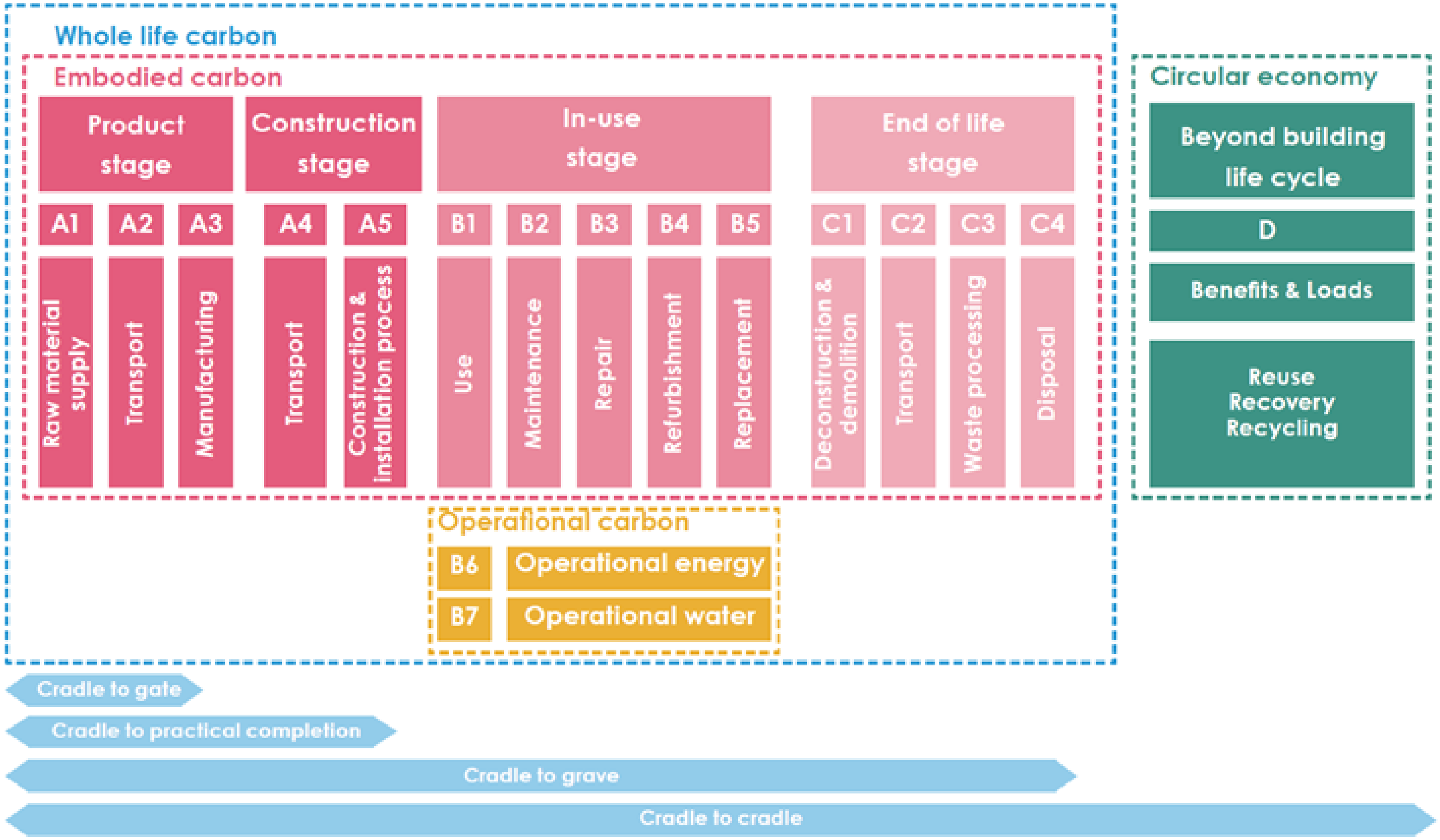


Whole Life Carbon = Operational Carbon + Embodied Carbon

Life Cycle Assessment & Whole life carbon



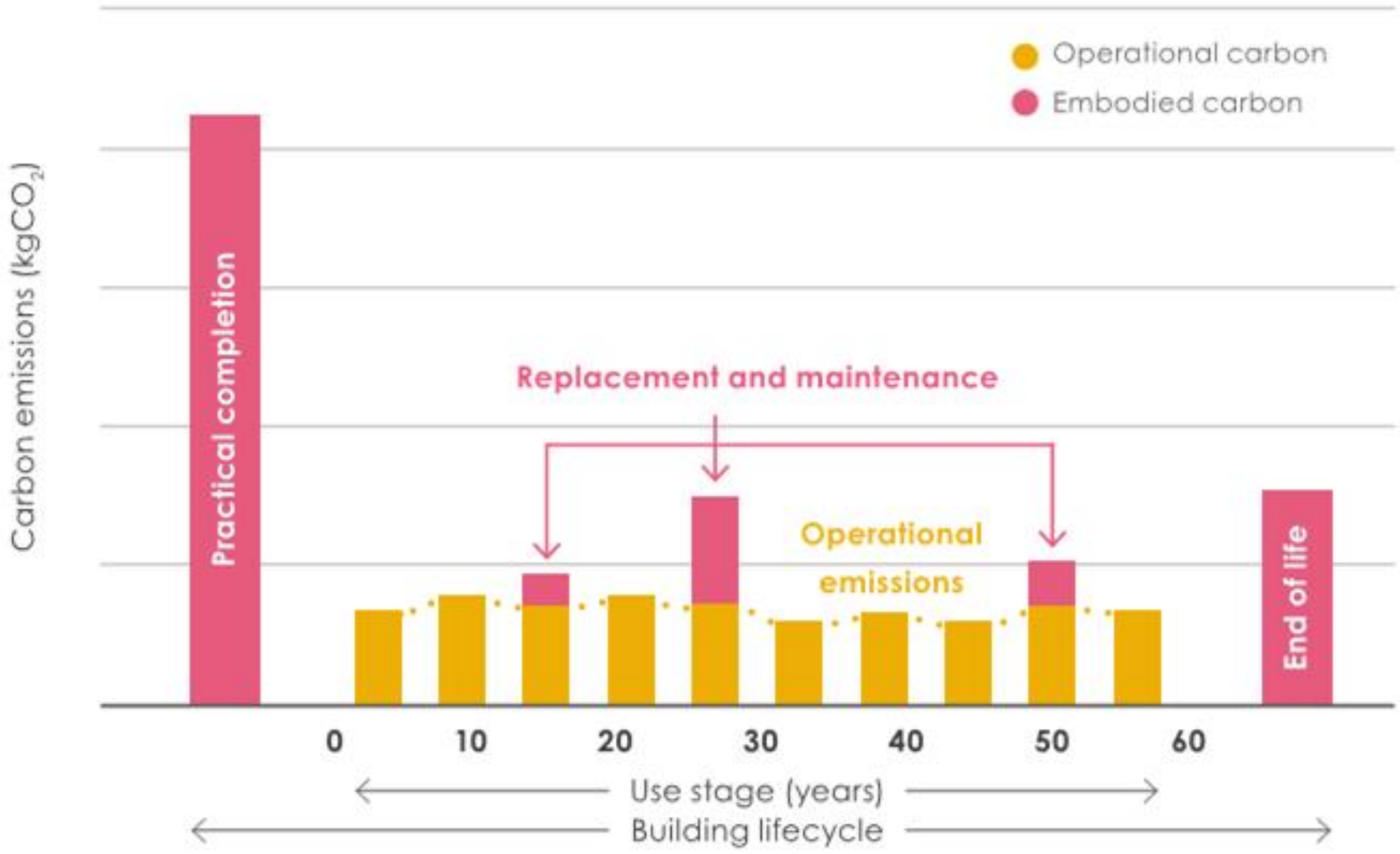
Life Cycle Assessment & Whole life carbon



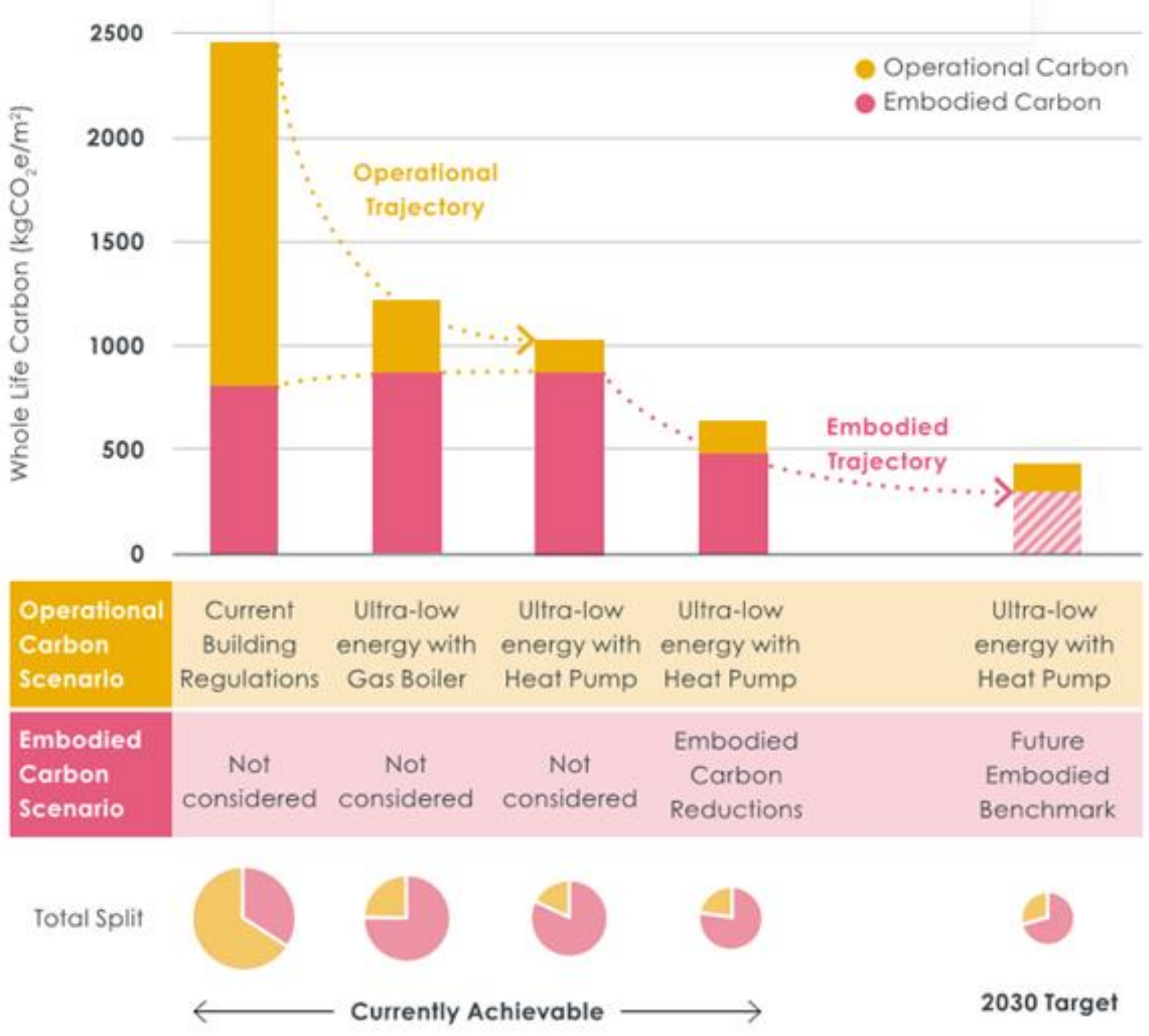
EN 15978:2011

Display of modular information for the different stages of the building assessment

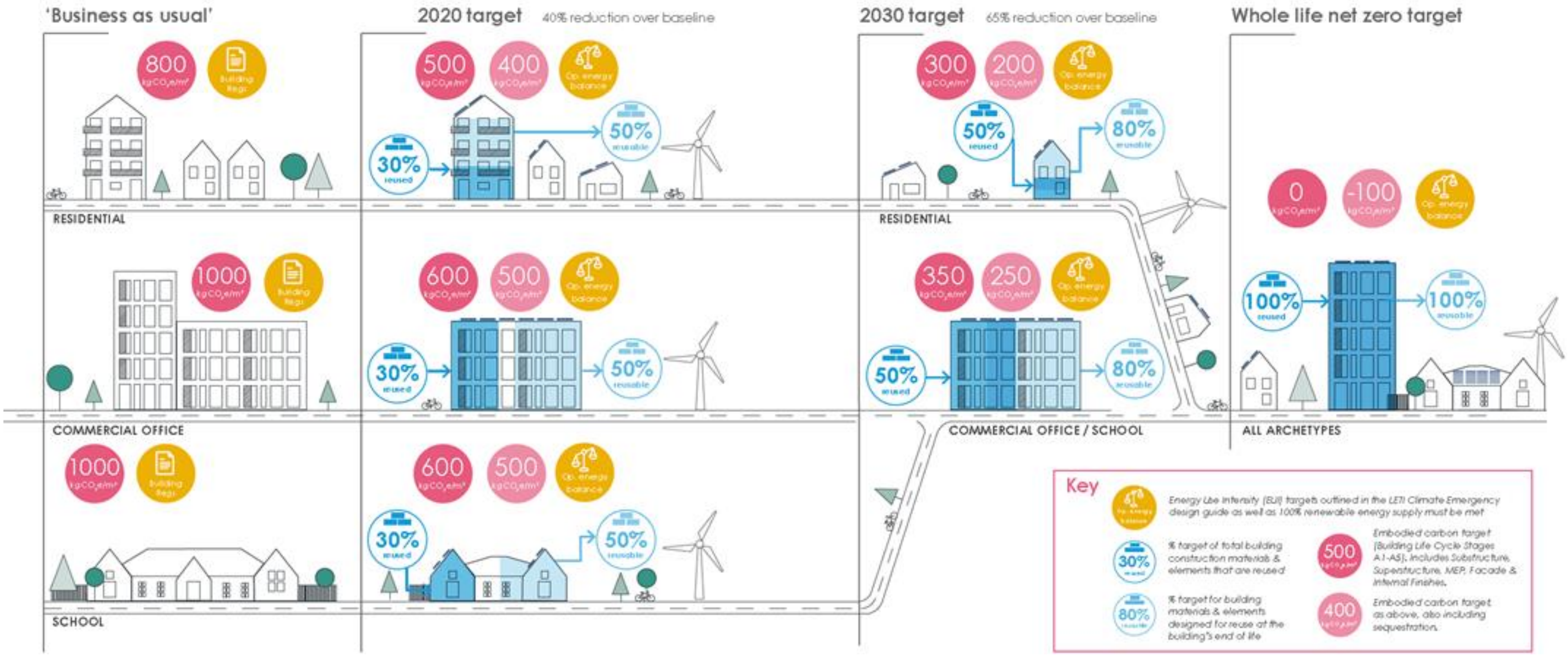
Lifecycle emissions



Trajectories

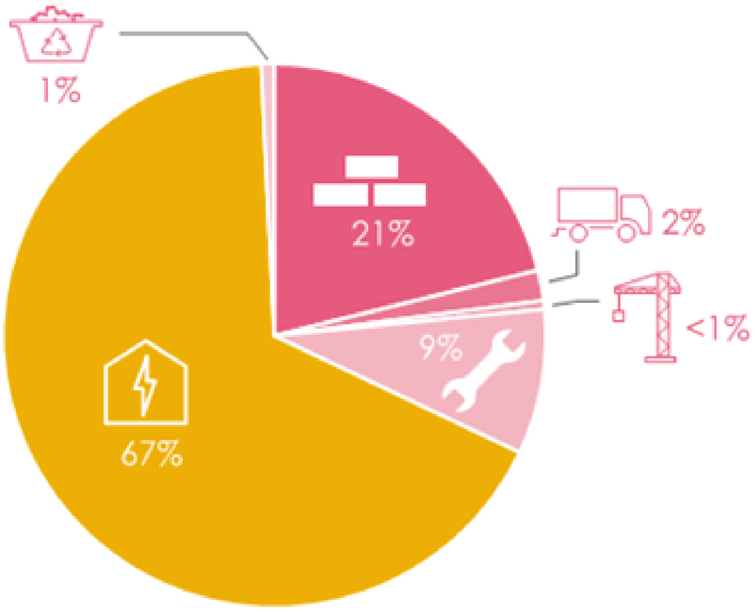


Whole life carbon targets

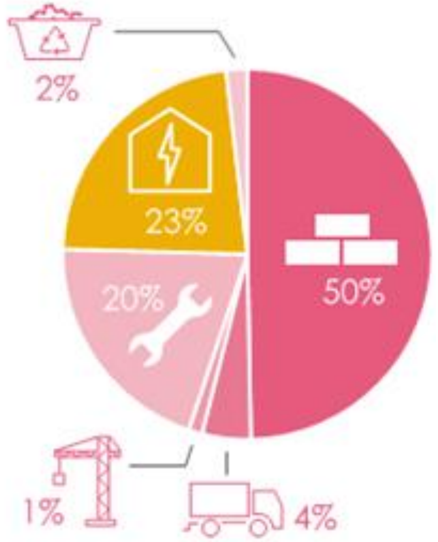


Breakdowns

Medium scale residential



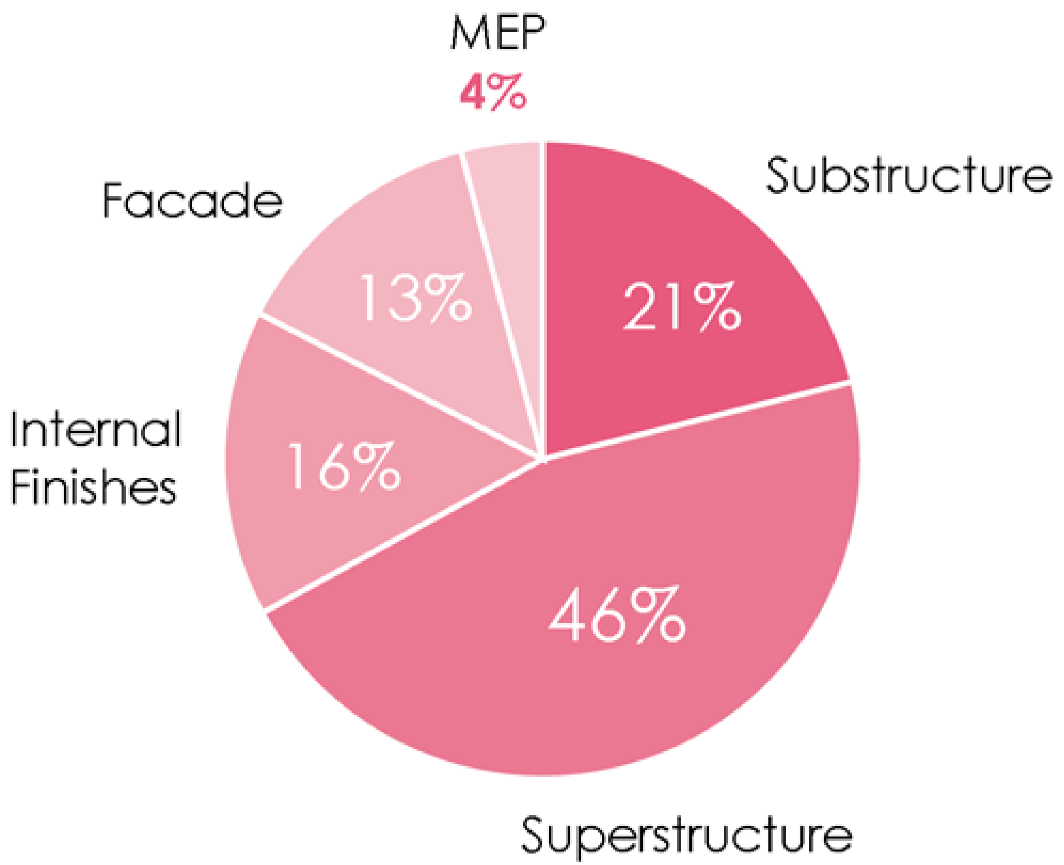
Building Regulations compliant building



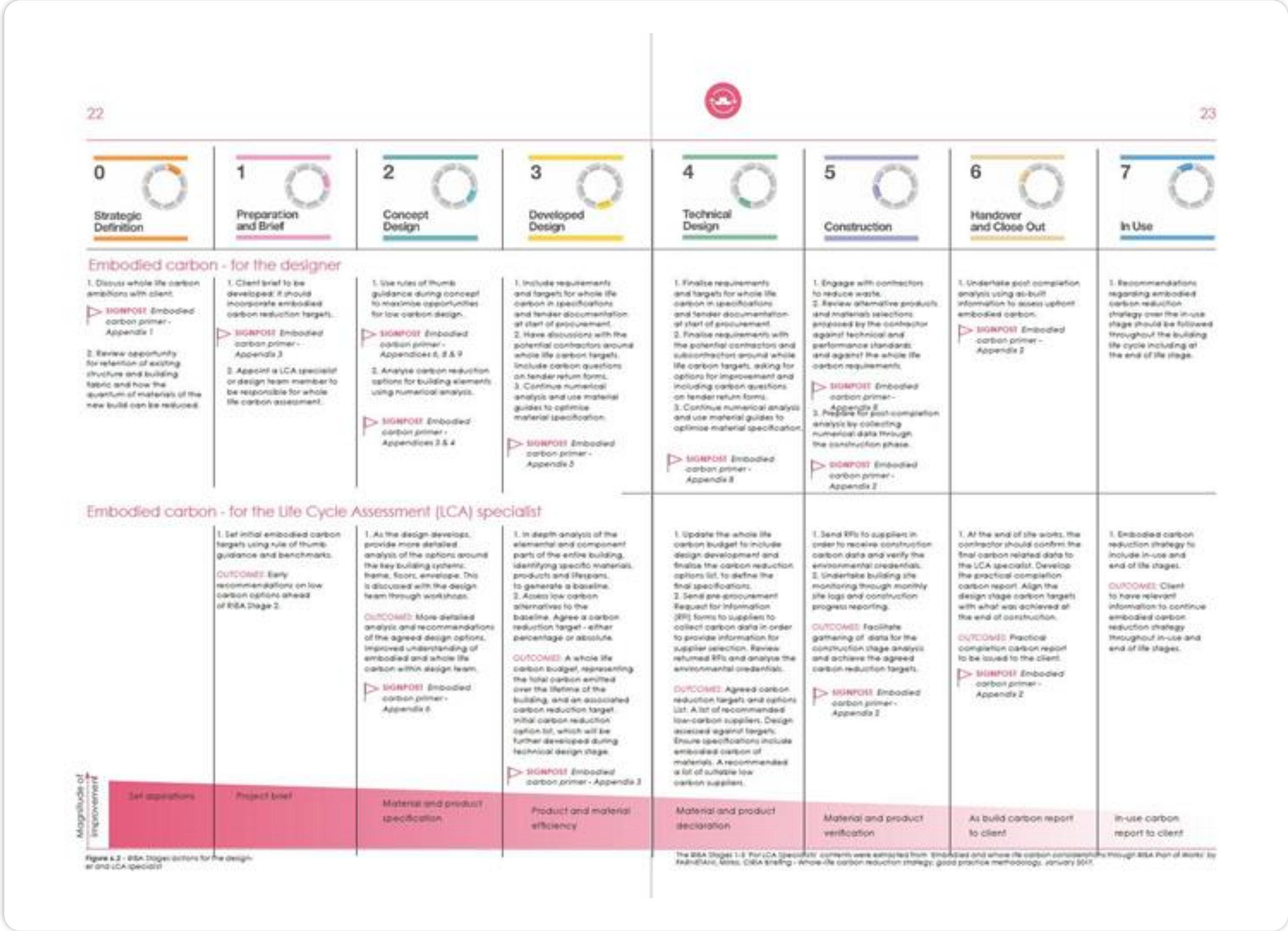
Ultra-low energy building

Embodied carbon per element

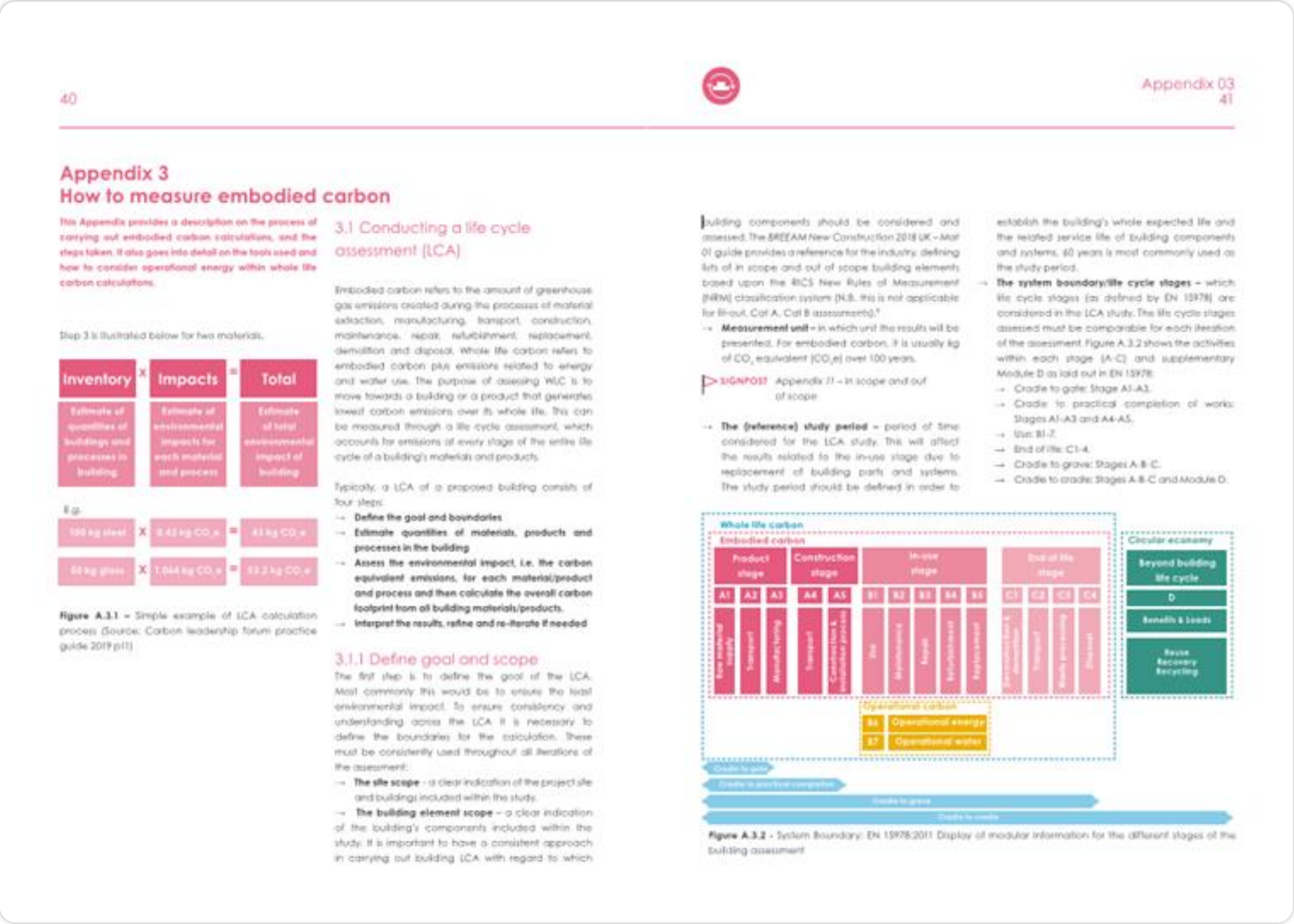
Medium scale residential



Actions by RIBA Stage



Appendices – How to measure



40

Appendix 03
41

Appendix 3
How to measure embodied carbon

This Appendix provides a description on the process of carrying out embodied carbon calculations, and the steps taken. It also goes into detail on the tools used and how to consider operational energy within whole life carbon calculations.

Step 3 is illustrated below for two materials.

Figure A.3.1 – Simple example of LCA calculation process (Source: Carbon leadership forum practice guide 2019 p11)

3.1 Conducting a life cycle assessment (LCA)

Embodied carbon refers to the amount of greenhouse gas emissions created during the processes of material extraction, manufacturing, transport, construction, maintenance, repair, refurbishment, replacement, demolition and disposal. Whole life carbon refers to embodied carbon plus emissions related to energy and water use. The purpose of assessing WLC is to move towards a building or a product that generates lowest carbon emissions over its whole life. This can be measured through a life cycle assessment, which accounts for emissions at every stage of the entire life cycle of a building's materials and products.

Typically, a LCA of a proposed building consists of four steps:

→ **Define the goal and boundaries**
→ **Estimate quantities of materials, products and processes in the building**
→ **Assess the environmental impact, i.e. the carbon equivalent emissions, for each material/product and process and then calculate the overall carbon footprint from all building materials/products.**
→ **Interpret the results, refine and re-iterate if needed**

3.1.1 Define goal and scope

The first step is to define the goal of the LCA. Most commonly this would be to ensure the least environmental impact. To ensure consistency and understanding across the LCA it is necessary to define the boundaries for the calculation. These must be consistently used throughout all iterations of the assessment:

→ **The site scope** – a clear indication of the project site and buildings included within the study.
→ **The building element scope** – a clear indication of the building's components included within the study. It is important to have a consistent approach in carrying out building LCA with regard to which building components should be considered and assessed. The *BREEAM New Construction 2018 UK – Mat 01* guide provides a reference for the industry, defining lists of in scope and out of scope building elements based upon the RICS New Rules of Measurement (NRM) classification system (N.B. this is not applicable for fit-out, Cat A, Cat B assessments).[9]
→ **Measurement unit** – in which unit the results will be presented. For embodied carbon, it is usually kg of CO_2 equivalent (CO_2e) over 100 years.

SIGNPOST Appendix 11 – In scope and out of scope

→ **The (reference) study period** – period of time considered for the LCA study. This will affect the results related to the in-use stage due to replacement of building parts and systems. The study period should be defined in order to establish the building's whole expected life and the related service life of building components and systems. 60 years is most commonly used as the study period.
→ **The system boundary/life cycle stages** – which life cycle stages (as defined by EN 15978) are considered in the LCA study. The life cycle stages assessed must be comparable for each iteration of the assessment. Figure A.3.2 shows the activities within each stage (A-C) and supplementary Module D as laid out in EN 15978:
  → Cradle to gate: Stage A1-A3.
  → Cradle to practical completion of works: Stages A1-A3 and A4-A5.
  → Use: B1-7.
  → End of life: C1-4.
  → Cradle to grave: Stages A-B-C.
  → Cradle to cradle: Stages A-B-C and Module D.

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

Appendices – Rules of Thumb

6.7 The site

Analysing a site is a standard procedure for designers to best assess what is viable to construct. Designers carry out studies analysing a site in terms of it neighbourhood context, planning restrictions, physical features and microclimate to name but a few but embodied carbon, until now, has rarely been a specific consideration.

The following is a selection of criteria often identified during site analysis which could offer alternative, low embodied carbon approaches compared with conventional solutions.

6.7.1 Site selection

When presented with a site, it is important to consider the existing ecosystem which may already be acting to absorb and store carbon. From a policy perspective this is important to consider when deciding on whether the site is appropriate for redevelopment or not.

Wherever possible, minimise disruption to existing natural features acting as a carbon sink e.g mature trees, grasslands, wetlands.

6.7.2 Reducing impact on the site

Exploring opportunities where existing buildings and foundations can be retained is possibly the greatest saving of embodied carbon a project site can offer. Consider:

- Recladding an existing structural frame – this can give the appearance of a completely new building.
- Opportunities to add additional storeys to an existing frame to increase financial viability of the development.
- If the frame is deemed unusable/unsuitable for the purpose of the proposed (re)development then look to the foundations for potential re-use. Particularly if there are opportunities to use a less carbon intensive superstructure than was deployed in the original building.

6.7.3 Use low carbon materials

Guidance on specific low carbon materials can be found in the rest of Appendix 6 however, as designers of any building project, it is standard practice to look at the immediate surroundings for inspiration and the local vernacular may be heavily influenced by particular design features and materials.

Using locally sourced materials to reduce transport emissions, particularly for high mass materials, should be considered.

Use materials with a high recycled content, such as crushed concrete as base or reclaimed materials

6.7.4 How to reduce waste

Working with the existing 'lay of the land' will minimise the amount of cutting required and subsequently the embodied energy associated with the plant and machinery required for the groundworks as well as carting away the spoil from the site.

There may be opportunities to re-use man-made materials in some way. Steel can be recycled but it can also be re-used on or off site. Recycled steel still needs to be melted down at high temperatures and manufactured into a new product which has much higher impacts than simply re-using the same piece of steel in a new application.

Depending on the quality and mix of any unwanted concrete on site, there may also be some scope to either re-use it, or crush it so that it can be added to new concrete as a recycled aggregate or used elsewhere in construction.

6.7.5 Pitfalls

As identified under site selection, allowing existing natural features to be retained may be challenging for clients looking to maximise returns for their investors.

6.7.8 Case studies

100 Liverpool Street, Hopkins Architects, AKT II

The project involves the refurbishment and extension of 100 Liverpool Street for British Land in Broadgate, London. The project will reinvigorate the existing outdated building, stripping it back to its structural frame and providing it with a dynamic new identity thanks to a new curving façade and revamped public realm.

100 Liverpool Street, Hopkins Architects, AKT II
External view
https://www.akt-uk.com/projects/100%20liverpool%20street

Appendices – Materials Guide

8.5 Aluminium

The production of primary aluminium requires a very high consumption of electricity, almost 10 times that of steel. Due to the energy intensive process, the EC is very high, especially if aluminium is used in large volumes. In order to reduce the embodied carbon as much as possible, electricity from renewable sources shall be used; therefore, if the use of aluminium is unavoidable, it should be specified from a country with largely renewable energy infrastructure (i.e. Norway, Iceland).

By contrast, aluminium is highly recyclable, with properties that do not deteriorate as the material is re-used. Worldwide, around 75% of all aluminium produced is still in use. Recycling uses only around 5% of the energy needed to produce primary aluminium. The recycled material supply chain is however not enough to cover the current demand; it is therefore imperative to reclaim as much aluminium as possible at the end-of-life of each product. Inventories of all aluminium components should be kept to ensure the material is tracked and can be recycled.

8.5.1 Embodied carbon

The embodied carbon of aluminium depends on where it was produced and the proportion of recycled material used. For example:

→ Produced in Europe and assuming a recycle rate of 83% based on worldwide flow model of the construction sector = **5.58kg CO_2e/kg**
→ General mix in Europe, including imports and assuming a recycle rate of 95% = **6.67kg CO_2e/kg**

8.5.2 Benefits

→ High durability
→ Strong and light
→ Low maintenance

8.5.3 Considerations

→ Aluminium is one of the most energy-intensive materials to produce, the largest consumer of energy on a per-weight basis and, because it is produced on such a large scale, one of the largest contributors to carbon dioxide emissions of all industries (Robinson, 2004).
→ As it is produced in countries around the equator (i.e. Australia, China, Brazil, India, Guinea, Indonesia, Jamaica, Russia and Suriname), the EC increases due to the long transportation routes between extraction, processing and fabrication.
→ In addition to being very energy intensive, the most common method of refining aluminium from bauxite – the Bayer process – consumes large amounts of water.
→ The unwanted residue of the process is in the order of 120 million tonnes per year. Most of it is stored in holding ponds, as there are virtually no further suitable applications. As this is a toxic material that could cause harm to animals and plant life, its impact should be taken into consideration in a life cycle analysis approach.
→ As a result of its high environmental impact, aluminium should be treated as a high-value material and used sparingly, with re-use in mind.
→ Coatings should be avoided when unnecessary; environmental product declaration (EPD) coatings should be used wherever possible.

8.5.4 Further readings

Many case studies can be found in the Aluminium Recyclability and Recycling Report published by the International Aluminium Institute available at
http://www.world-aluminium.org/media/filer_public/2016/10/03/tsc_report2_am_72dpi_release_locked_1016.pdf
http://www.world-aluminium.org/media/filer_public/2016/10/03/tsc_report2_am_72dpi_release_locked_1016.pdf

International Aluminium Institute publications including Sustainable Mining and LCA information
http://www.world-aluminium.org/publications/

Aluminium and sustainability
http://recycling.world-aluminium.org/review/sustainability/

Robinson, T. Lowering energy intensity and emissions in the aluminum industry with government/ industry/ academia partnership. In Light Metals; TMS: Warrendale, PA, USA, 2004; pp. 277–281.

8.5.5 Case studies

Weston Library, University of Oxford, Wilkinson Eyre

The refurbishment of the New Bodleian Library, a Grade II listed building extends over 11 floors. All of the major features of Gilbert Scott's original architecture were retained during refurbishment, including the 77 year old anodised aluminium windows.

Weston Library
External view

https://www.wilkinsoneyre.com/projects/weston-library

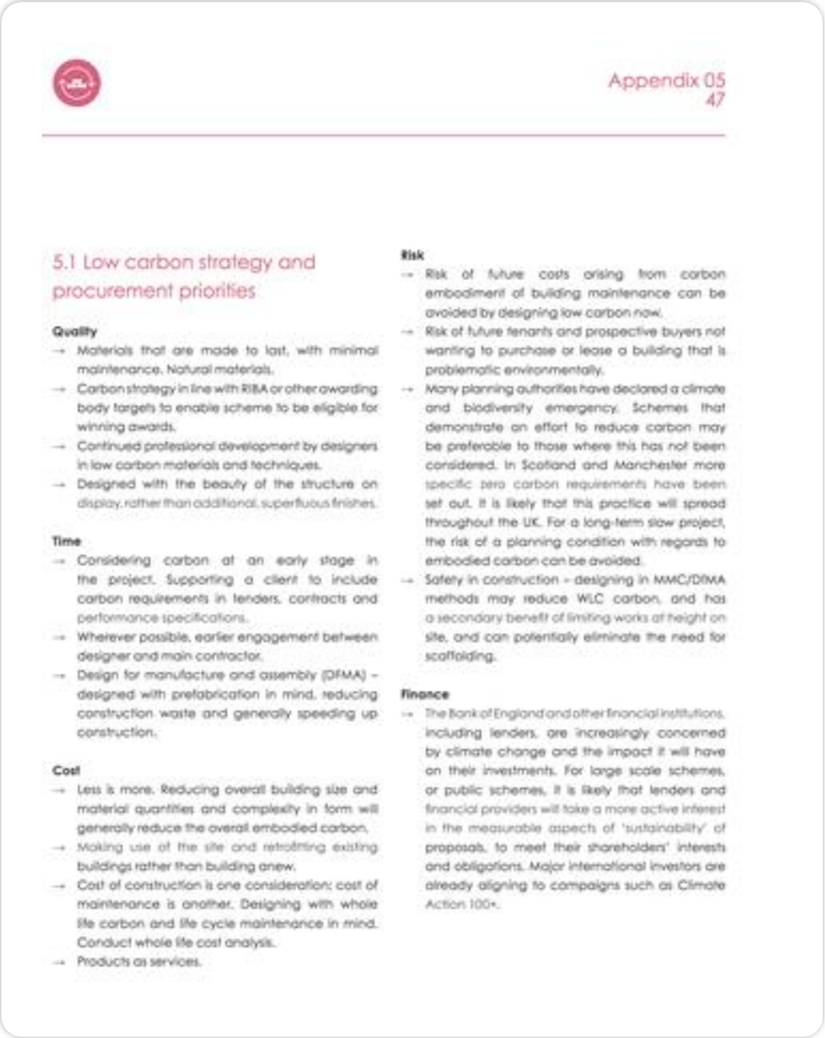
Next steps…

Policy & procurement

Recommendations for policymakers

→ Adopt a policy hierarchy that advocates circular economy principles: reuse and refurbishment in preference to demolition and new construction.
→ Adopt a policy that mandates embodied carbon reduction strategies based on embodied carbon and whole life carbon analysis on all projects.
→ Adopt embodied carbon targets.
→ Recognise a consistent methodology and dataset for embodied and whole life carbon analysis e.g. RICS Professional Statement WLC, reporting embodied carbon across the chosen life cycle stages of EN 15978, as explained in Appendix 3 - How to measure embodied carbon.
→ Phasing in the mandatory requirement of EPDs for at least all building parts forming Substructure, Frame and Upper Floors.

Page 20 of the E.C. Primer


Appendix 05
47

5.1 Low carbon strategy and procurement priorities

Quality

- → Materials that are made to last, with minimal maintenance. Natural materials.
- → Carbon strategy in line with RIBA or other awarding body targets to enable scheme to be eligible for winning awards.
- → Continued professional development by designers in low carbon materials and techniques.
- → Designed with the beauty of the structure on display, rather than additional, superfluous finishes.

Time

- → Considering carbon at an early stage in the project. Supporting a client to include carbon requirements in tenders, contracts and performance specifications.
- → Wherever possible, earlier engagement between designer and main contractor.
- → Design for manufacture and assembly (DFMA) – designed with prefabrication in mind, reducing construction waste and generally speeding up construction.

Cost

- → Less is more. Reducing overall building size and material quantities and complexity in form will generally reduce the overall embodied carbon.
- → Making use of the site and retrofitting existing buildings rather than building anew.
- → Cost of construction is one consideration: cost of maintenance is another. Designing with whole life carbon and life cycle maintenance in mind. Conduct whole life cost analysis.
- → Products as services.

Risk

- → Risk of future costs arising from carbon embodiment of building maintenance can be avoided by designing low carbon now.
- → Risk of future tenants and prospective buyers not wanting to purchase or lease a building that is problematic environmentally.
- → Many planning authorities have declared a climate and biodiversity emergency. Schemes that demonstrate an effort to reduce carbon may be preferable to those where this has not been considered. In Scotland and Manchester more specific zero carbon requirements have been set out. It is likely that this practice will spread throughout the UK. For a long-term slow project, the risk of a planning condition with regards to embodied carbon can be avoided.
- → Safety in construction – designing in MMC/DfMA methods may reduce WLC carbon, and has a secondary benefit of limiting works at height on site, and can potentially eliminate the need for scaffolding.

Finance

- → The Bank of England and other financial institutions, including lenders, are increasingly concerned by climate change and the impact it will have on their investments. For large scale schemes, or public schemes, it is likely that lenders and financial providers will take a more active interest in the measurable aspects of 'sustainability' of proposals, to meet their shareholders' interests and obligations. Major international investors are already aligning to campaigns such as Climate Action 100+.

LETI pioneer projects

- Energy Use Intensity (EUI) targets
- Embodied carbon targets
- Fossil free heating and hot water
- Demand Response key performance indicators
- In-use monitoring and publication of energy data
- On-site and off-site renewable energy to achieve a zero carbon balance

Email pioneers@leti.london

LETI 2020 workstreams

- ***Retrofit***
- ***Embodied Carbon***
- ***Part L***
- ***Clients Guide***
- ***Hydrogen – myth or reality***
- ***Development Industry Forum***
- ***Local Authority Guides***
- ***Modelling (how do we do it)***
- ***Additional typologies***
- ***Demand response and energy storage KPI's***