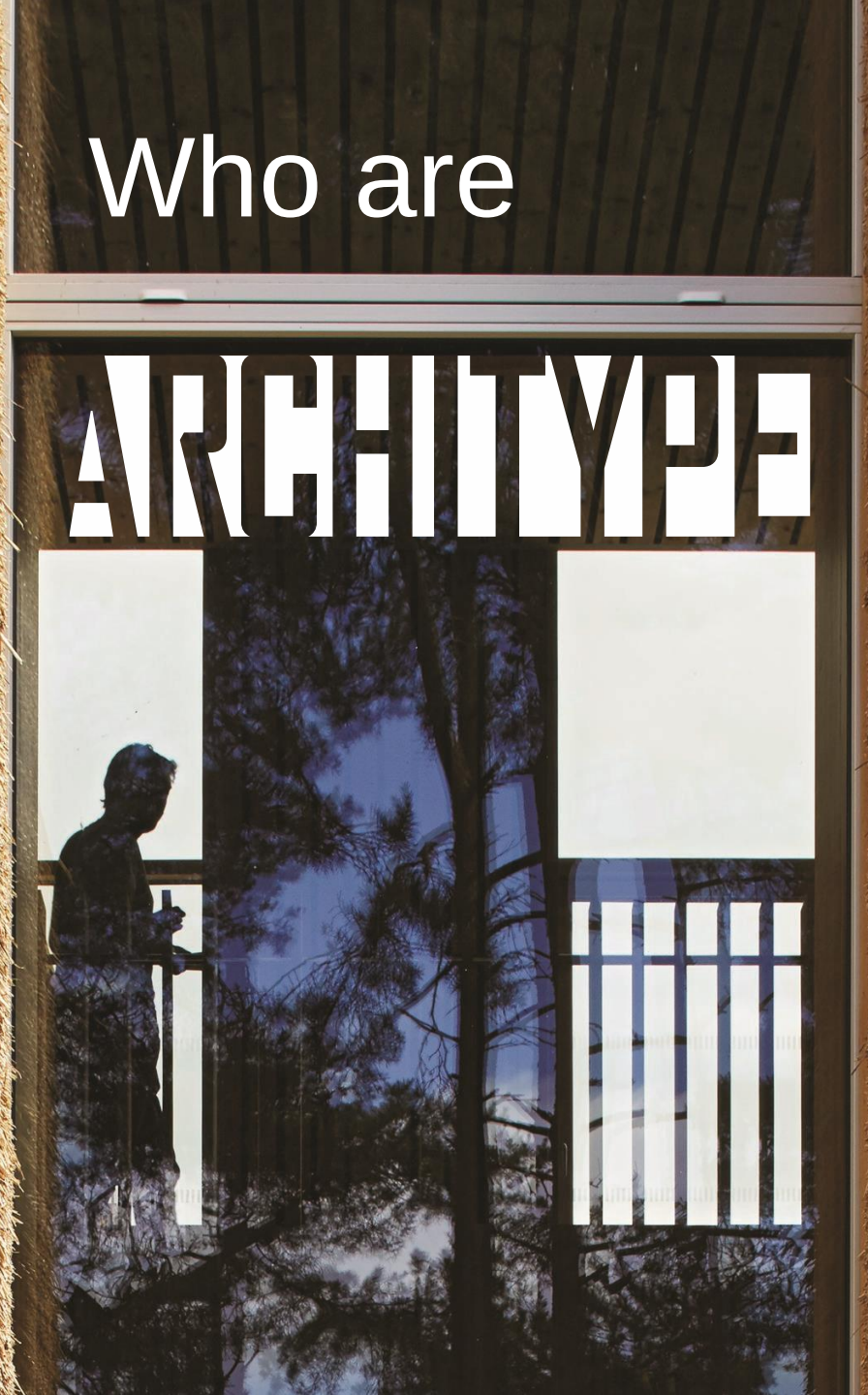
ARCHITYPE

London | Hereford | Edinburgh

# Regenerative Design Approaches: The Role of Whole Life Carbon Assessment Applied in School Buildings in the UK

Ann-Marie Fallon

# Who are



# Architype

Specialising in sustainable design for almost 40 years:

- Passivhaus
- natural materials
- low embodied carbon

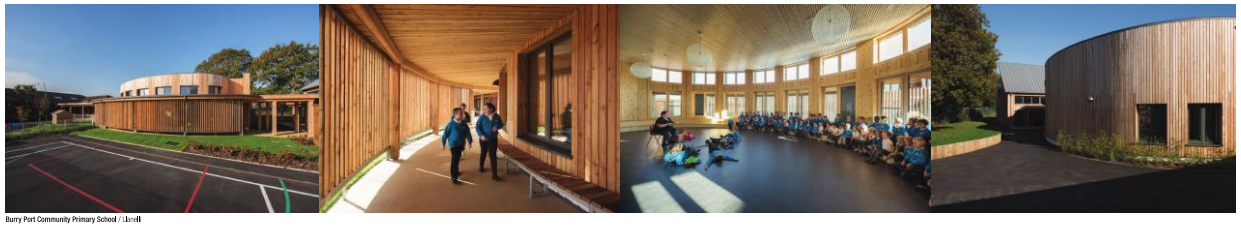
Working across all sectors:

- education and higher education
- private and social housing
- workplaces
- health and wellbeing
- archive and repositories
- cultural  and community buildings

Working throughout the UK from offices in:

- London
- Hereford
- opened Edinburgh office in 2018 in response to Scottish Government's ambitious climate policies

# Passivhaus Projects | Diversity in scale & sectors



Burry Port Community Primary School / Llanelli

Oak Meadow Primary School / Wolverhampton

Ysgol Bro Hyddgen / Machynlleth

Wilkinson Primary School / Wolverhampton

Ysgol Parc y Tywyn / Carmarthenshire

Ysgol Maes y Dre and Salop Road Primary School / Welshpool

London Dock Secondary School / London

Hackbridge Primary School / London

Swillington Primary School / Leeds

Christ Church Central / Sheffield

The Enterprise Centre - University of East Anglia / Norwich

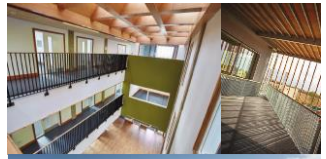
Hennerwood Farmhouse / Bromyard, Herefordshire

Callaughton Ash Housing / Much Wenlock, Shropshire

Imperial War Museum Paper Store / Duxford

Fishleys House / Colwall, Herefordshire

Herefordshire Archive and Records Centre / Hereford



Eco Business Centre / Bicester

Chester Balmore / Camden, London

Passivhaus Projects completed by ARCHITYPE

# Presentation overview | Key sections

- UK context for whole life carbon / life cycle assessment
- Architypes approach to regenerative design
- Early design stage assessment - process
- Key benchmark projects: upfront and whole life carbon assessment
- Beyond assessment – considerations for designers
- Regenerative design – a response

# Context

## UK Industry overview

- Impact of embodied carbon is significant
- 40-70% of whole life carbon in a new building (LETI 2020)

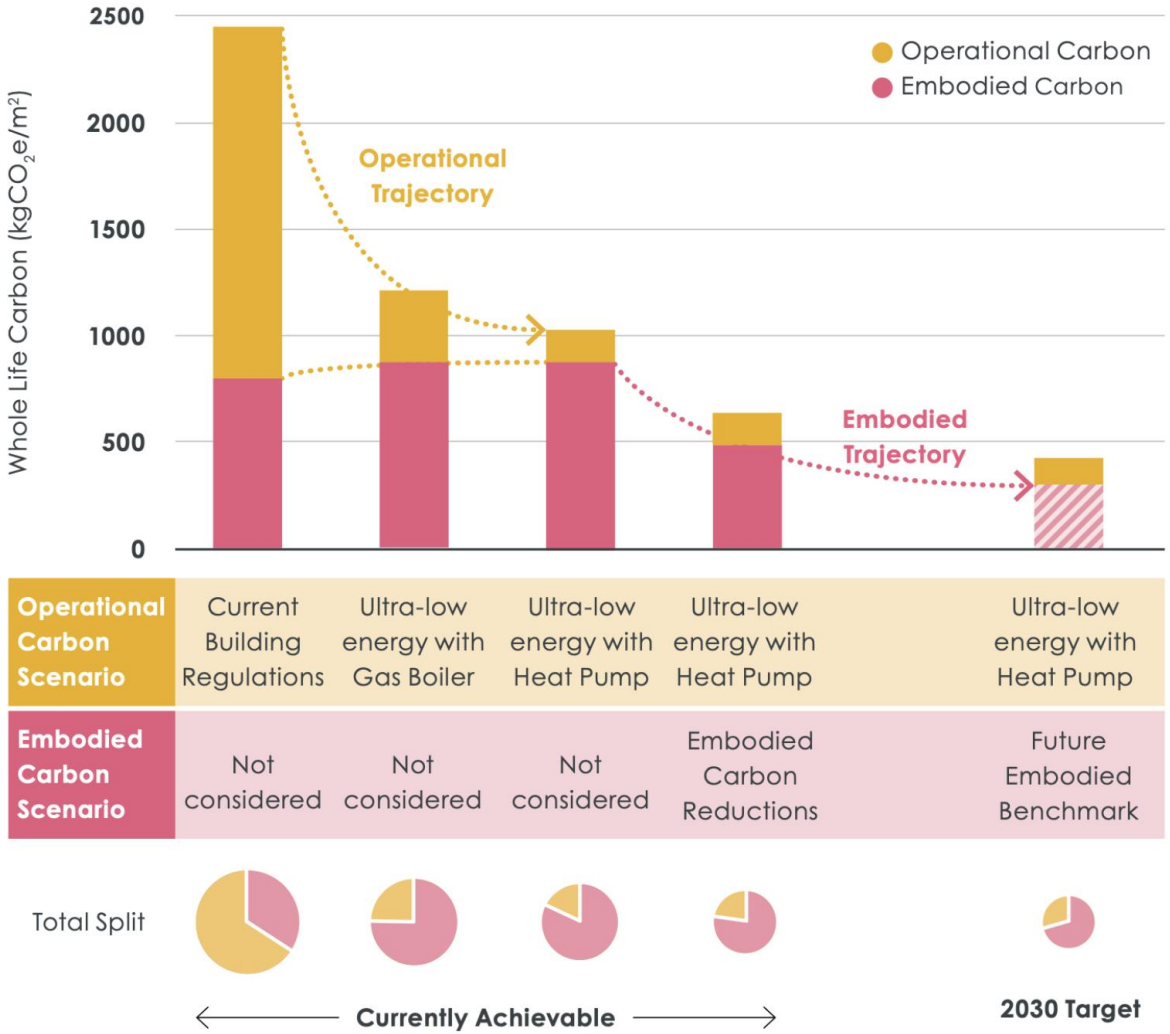
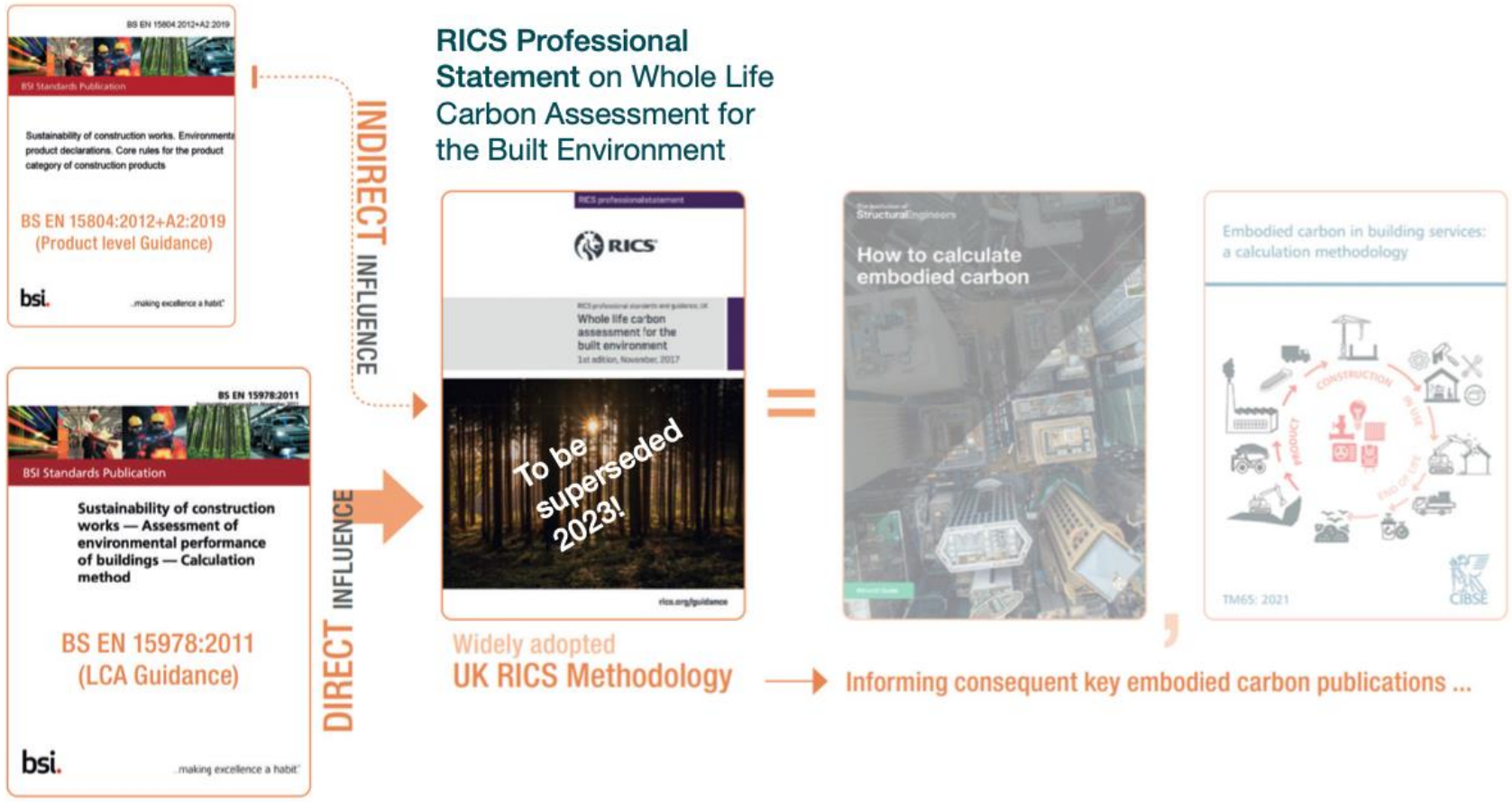



**Figure 5.1 -** Diagram showing operational and embodied carbon and trajectories

# Context

UK Industry overview

- Main documentation underpinning Life Cycle Analysis in UK
- No national mandated requirements
- Post Brexit adoption of EU requirements in UK?




https://www.leti.uk/_files/ugd/252d09_8ceffcbcafdb43cf8a19ab9af5073b92.pdf
https://www.architecture.com/about/policy/climate-action/2030-climate-challenge/resources

# Context

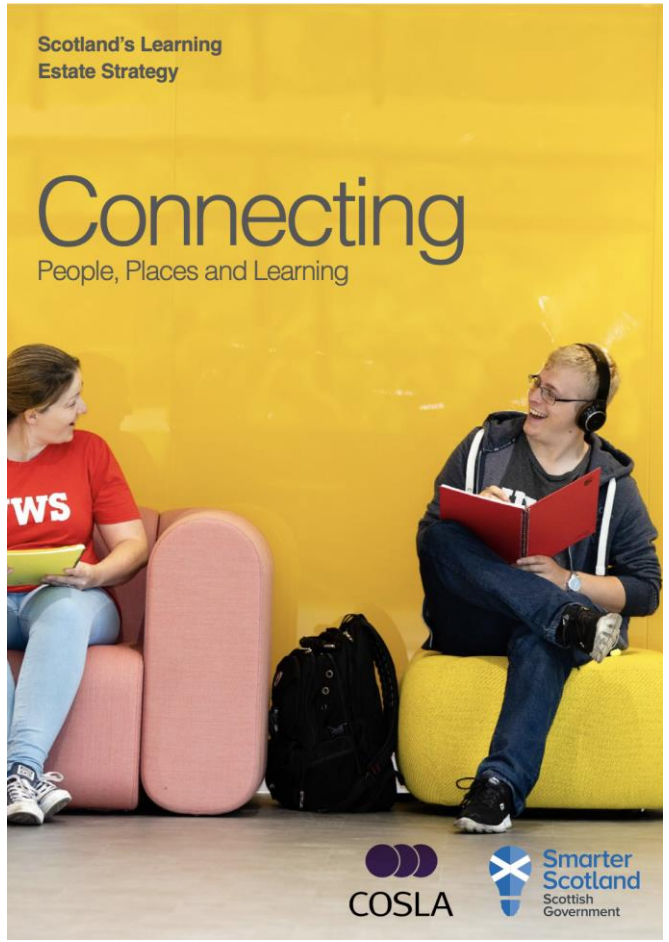
Regional exemplar

- Scotland Learning Estate Investment Programme 3
- Outcomes based funding over 25 years
- Operational energy target
- Upfront carbon target

SCOTTISH FUTURES TRUST

| Energy Consumption kWh/sqm/p.a. | Energy Funding % |
|---|---|
| A 67- 83 | 100% |
| B 84- 99 | 90% |
| C 100 - 115 | 60% |
| D 116 -130 | 30% |
| E 131+ | 0% |

| Embodied Carbon kgCO2e/m2 | Embodied Carbon Funding % |
|---|---|
| A <600 | 100% |
| B 601-666 | 90% |
| C 667-733 | 60% |
| D 734-800 | 30% |
| E 800+ | 0% |



# Regenerative Design – Challenges

Lack of knowledge/disconnect in:

- Carbon invested in constructing a building vs carbon saved in operation
- Lifecycle cost and lifecycle carbon
- Consultants working in isolation & in a linear manner
- Lack of simple yet rigorous holistic early-stage modelling tools
- Lack of mandated verification methods
- Module C & D of whole life carbon – external factors

# Regenerative Design – Our Approach

# Architypes approach

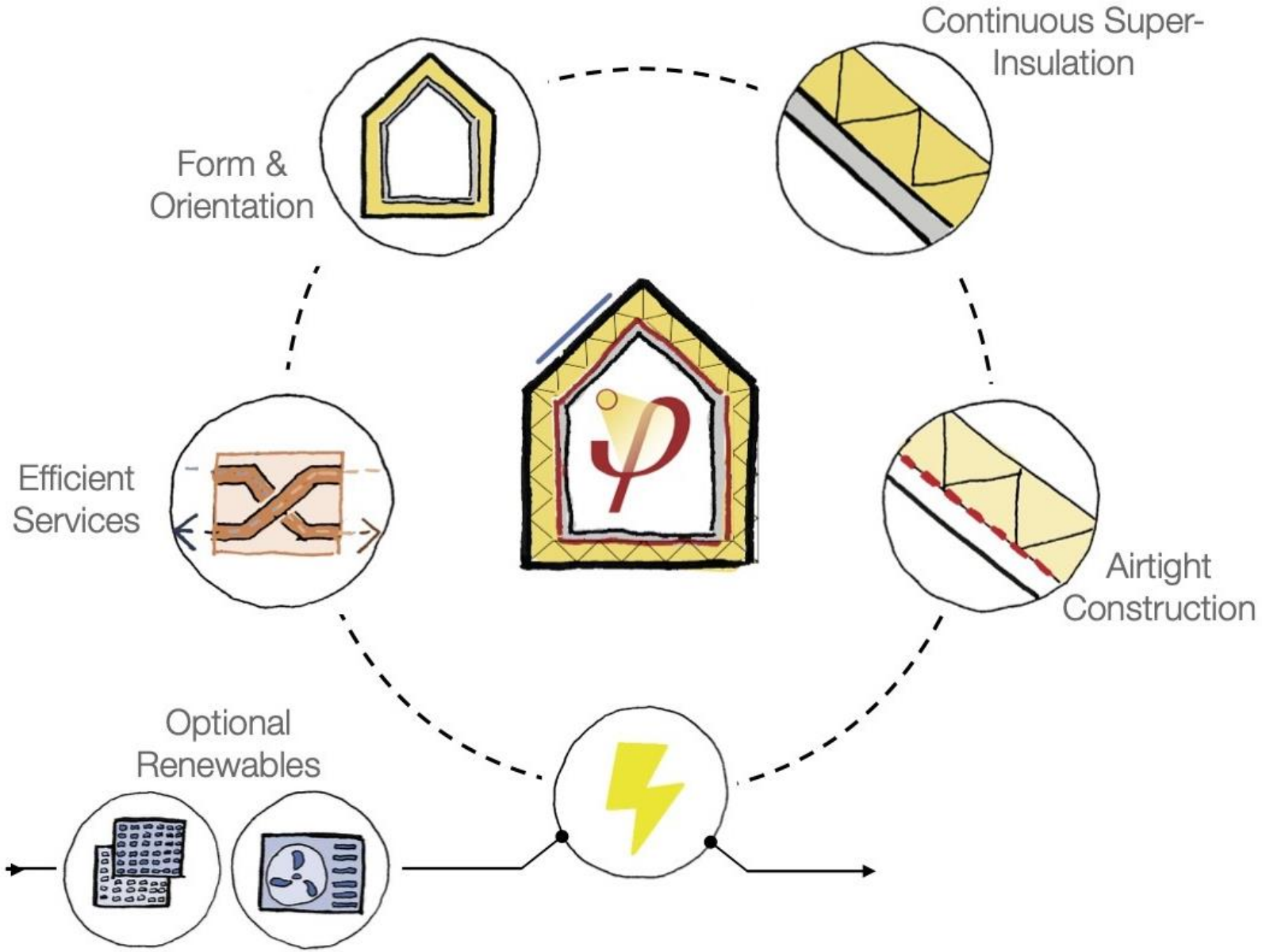
Passivhaus as design methodology

- Energy
- Comfort/health
- Design and site quality verification process

# Architypes approach

Passivhaus as design methodology

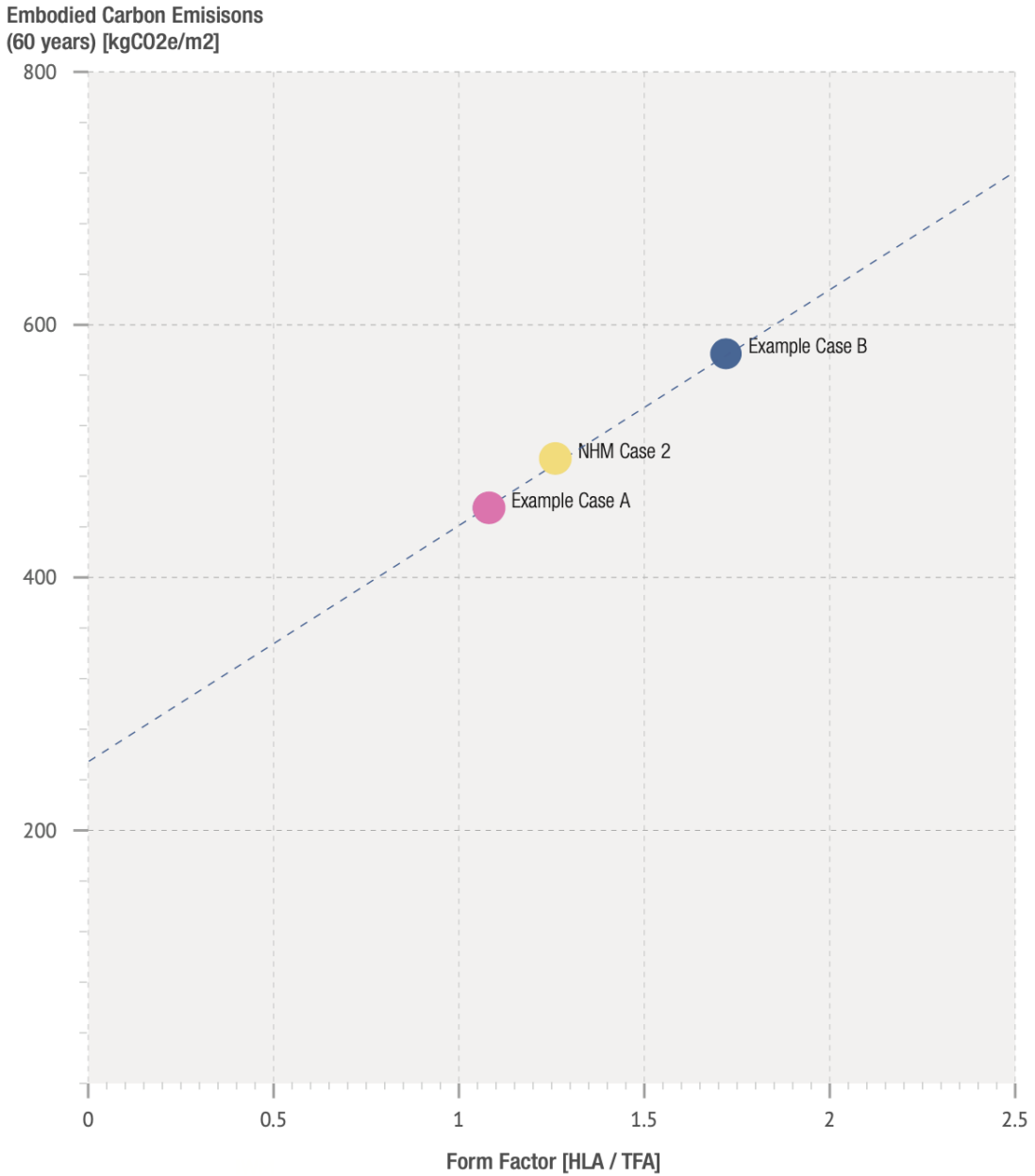
- Energy
- Comfort
- Iterative design approach
- Design & site quality verification process



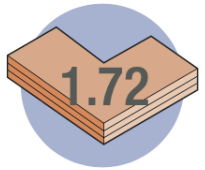
# Architypes approach

Passivhaus as design methodology

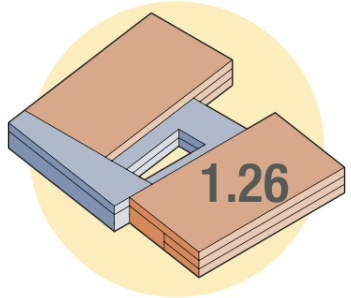
- Form factor is significant in whole life carbon assessment
- Design for spatial & material sufficiency




**Lower form factor is better:**




**Example Case B:** 3,000m² L-shaped plan



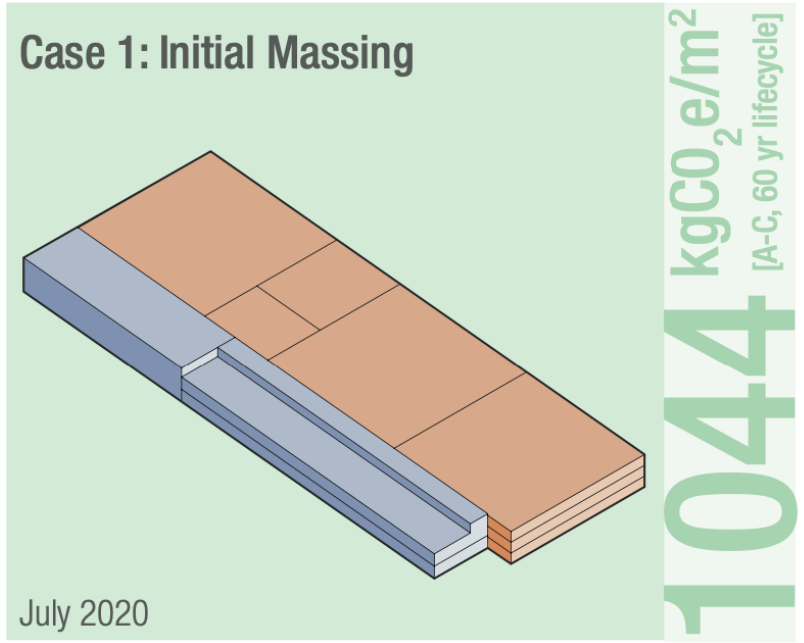

**NHM Case 2 [current]:** 30,000m² to current massing

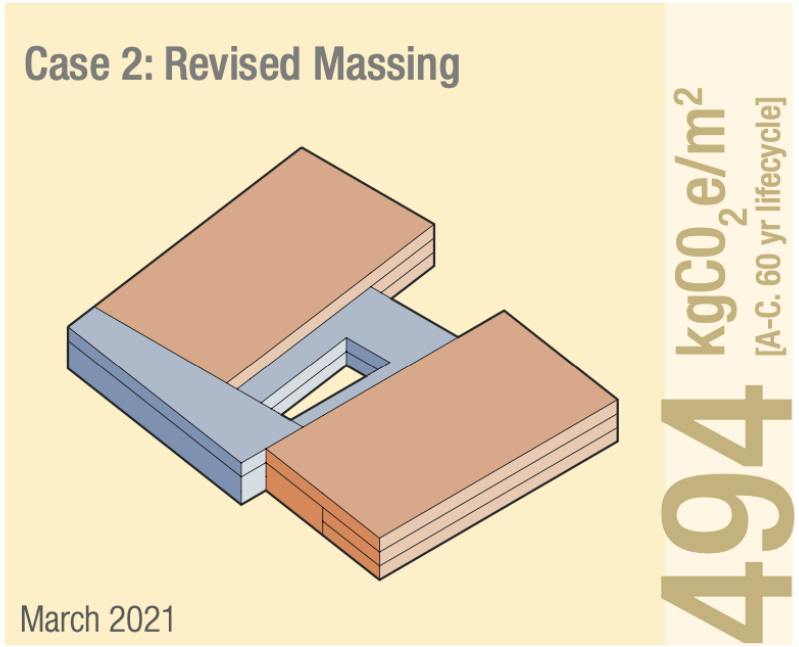

**Example Case A:** 30,000m² rectangular plan

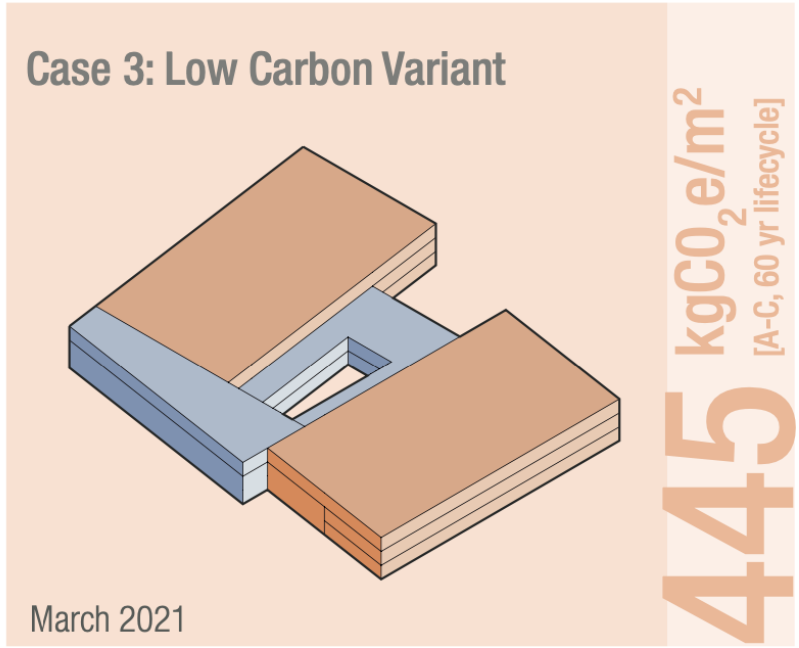
# Architypes approach

Passivhaus as design methodology

- Material choice & form factor combined can give significant results



# Architypes approach

Passivhaus as design methodology

- Demand reduction first
- Design for sufficiency in materials
- THEN offset remaining emissions

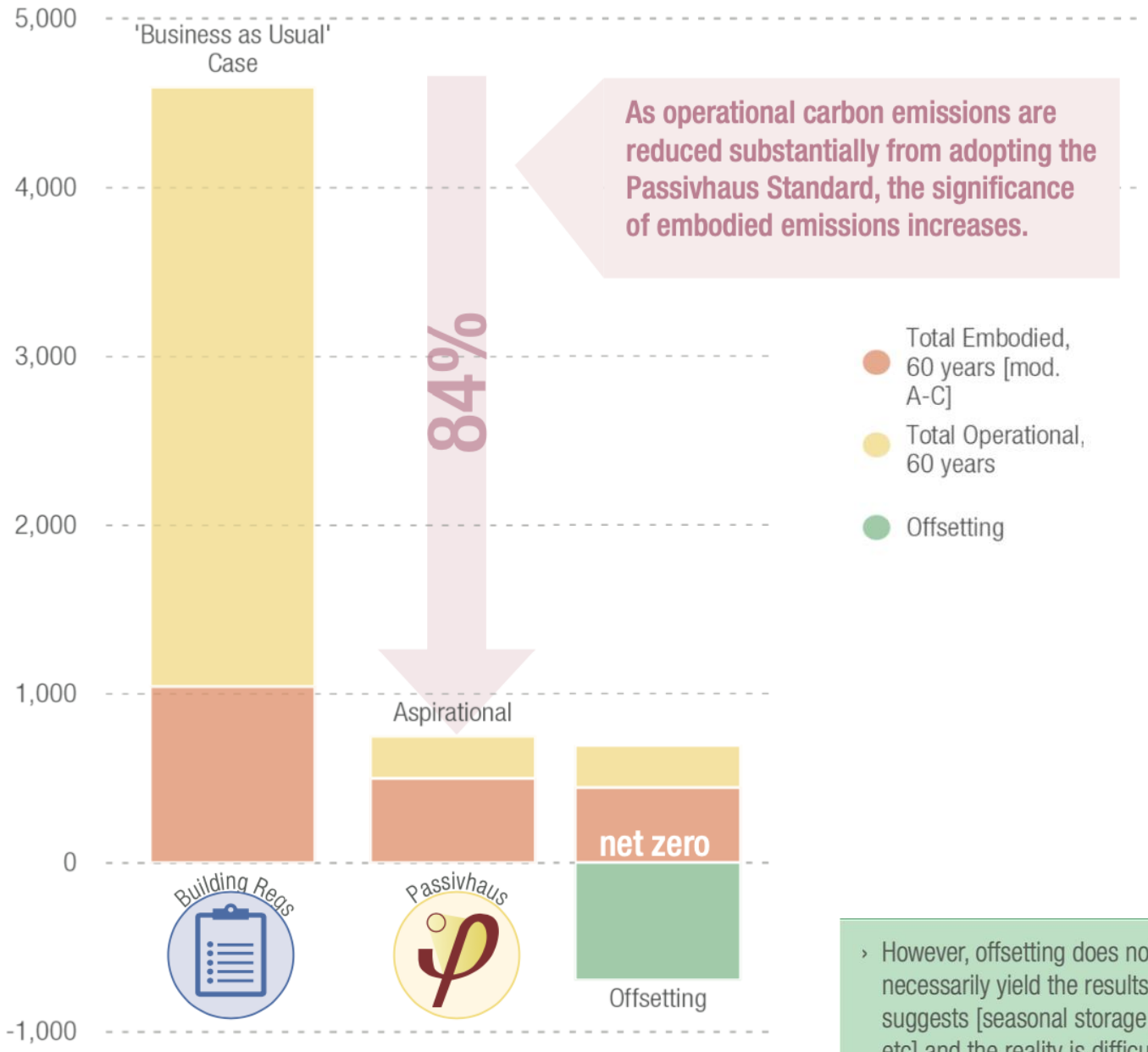



**Fig. 19 /** Lifecycle Emissions comparison

› However, offsetting does not necessarily yield the results it suggests [seasonal storage, etc] and the reality is difficult to quantify.

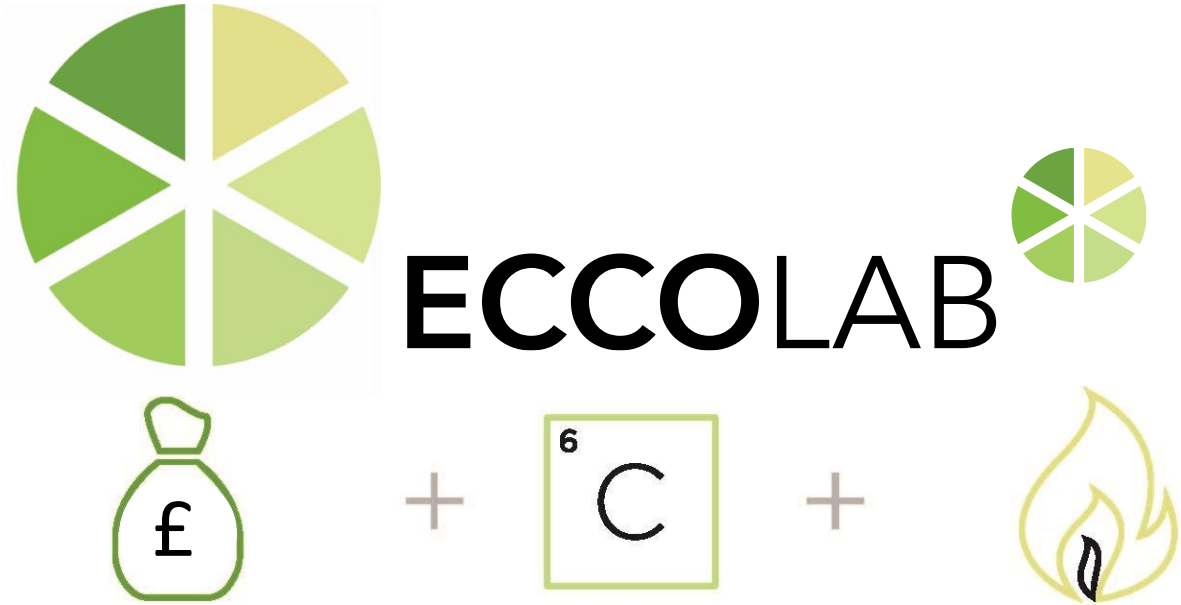
# Life cycle analysis


how much stuff

how bad stuff is
(be careful that units match)

how bad it is

# Life cycle analysis




Capital & Lifecycle Cost Model

£

Energy & Services Model

kWh

Embodied Carbon Model

$CO_2e$

Certification

✓

Materials Library

EPD

Optioneering

✓

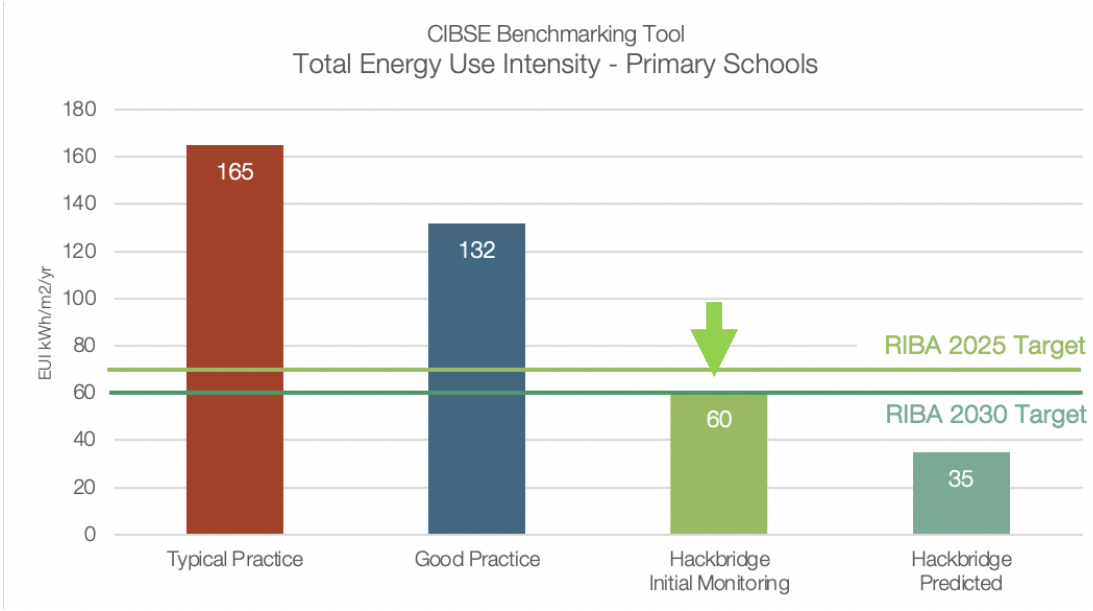
Rapidly and simultaneously optimise the Energy, Cost, and Carbon of a project's lifecycle

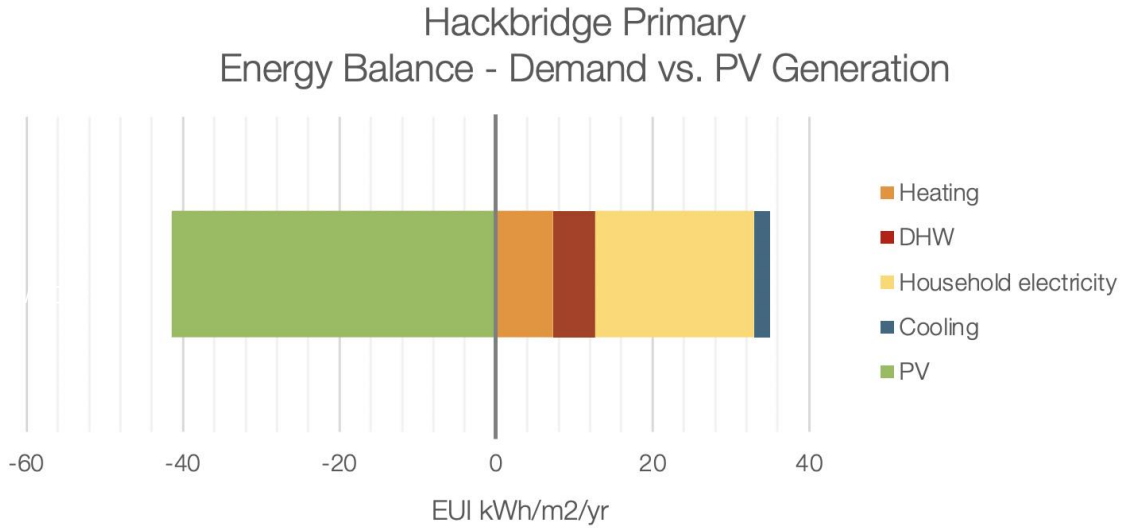
# Hackbridge Primary - Britain’s greenest school?

# Architypes approach

## Operational carbon exemplar

- Fabric first approach
- Meets and will exceed RIBA 2030 and RIBA 2025 targets
- Supplies energy back to the grid
- Operational net zero
- Verification due 2024



# Architypes approach

## Embodied carbon exemplar

- ECCOlab life-cycle carbon assessment
- Half the carbon use of ‘business as usual’
- Exceeds LETI 2020 Targets

**Embodied Energy Emissions**
Stages A1-A5 Only

Education sector

LETI ‘Business as usual’ [Benchmark]
**750-1000** $kgCO_2e/m^2$ [GIA]

London Plan [WLC Benchmark]
**700-800** $kgCO_2e/m^2$ [GIA]

LETI 2020
**500** $kgCO_2e/m^2$ [GIA]

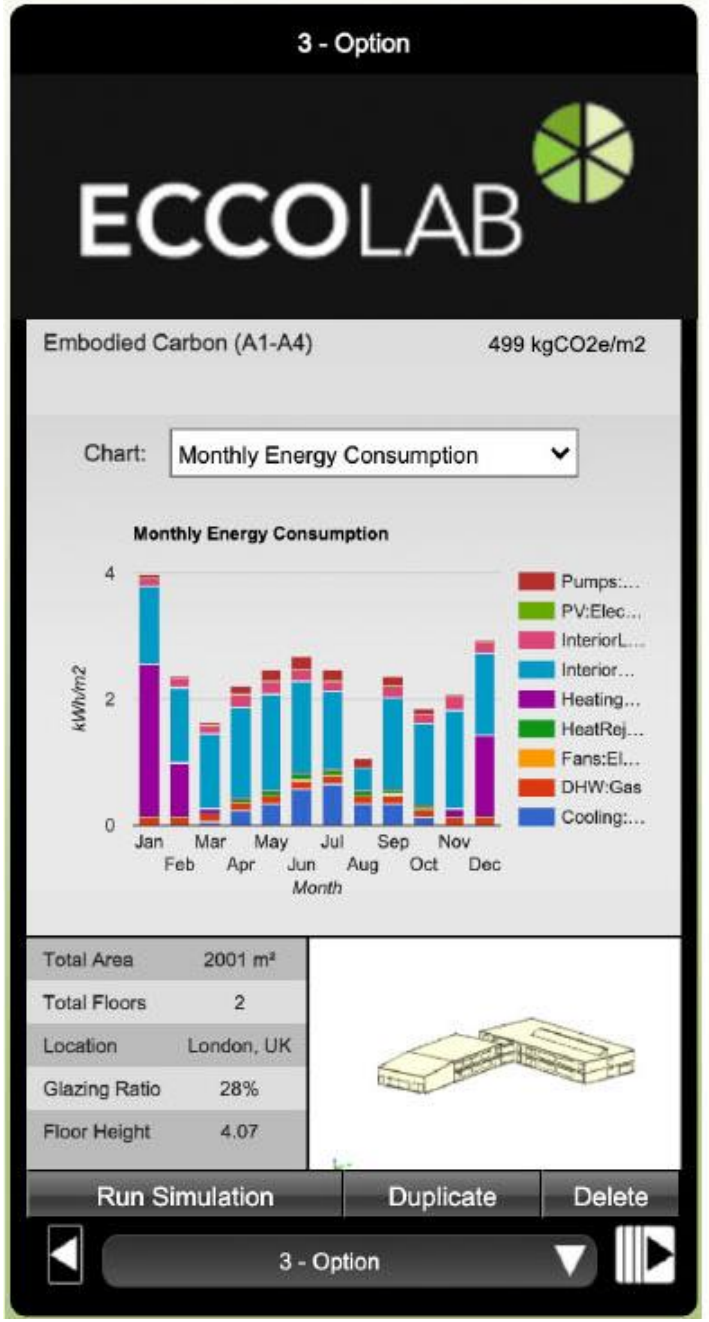
London Plan [Aspirational WLC benchmark]
**500** $kgCO_2e/m^2$ [GIA]

Hackbridge Primary excl. sequestration
**499** $kgCO_2e/m^2$ [GIA]

Hackbridge Primary incl. sequestration
**405** $kgCO_2e/m^2$ [GIA]

RIBA 2030 Target
**400** $kgCO_2e/m^2$ [GIA]

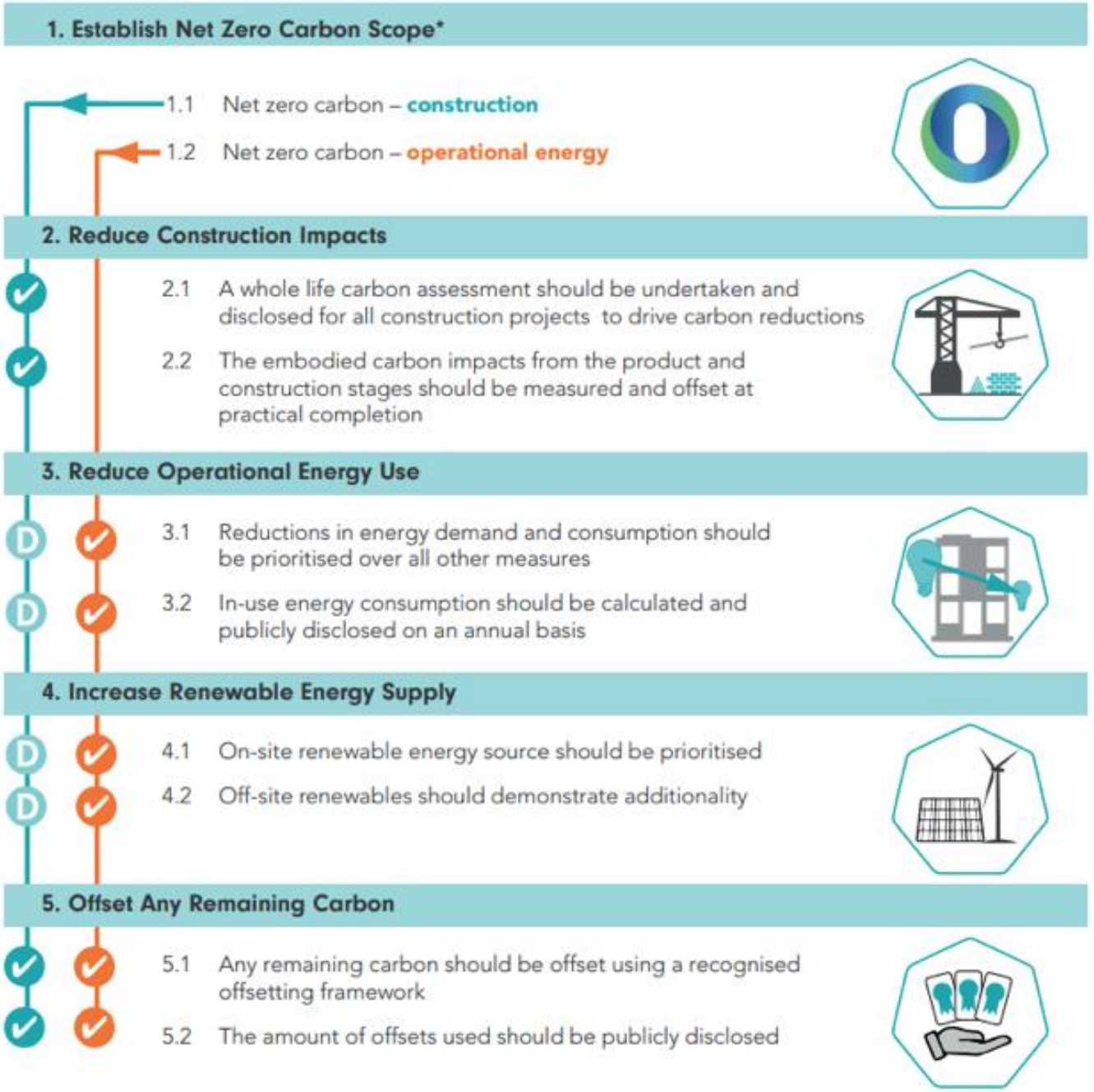
LETI 2030 Target
**300** $kgCO_2e/m^2$ [GIA]



# Architypes approach

## Why is verification important?

- Quality assurance
- UK Green Building Council Framework




Passivhaus

ECCOLAB

# Architypes approach

## Why is verification important?

- Quality assurance
- UK Green Building Council Framework
- One project verified in the UK by UKGBC

*Max Fordhams house London 1st verified net zero operational and embodied carbon building in the UK*
*https://www.maxfordham.com/news/max-fordham-house-becomes-the-uk's-first-net-zero-carbon-home*

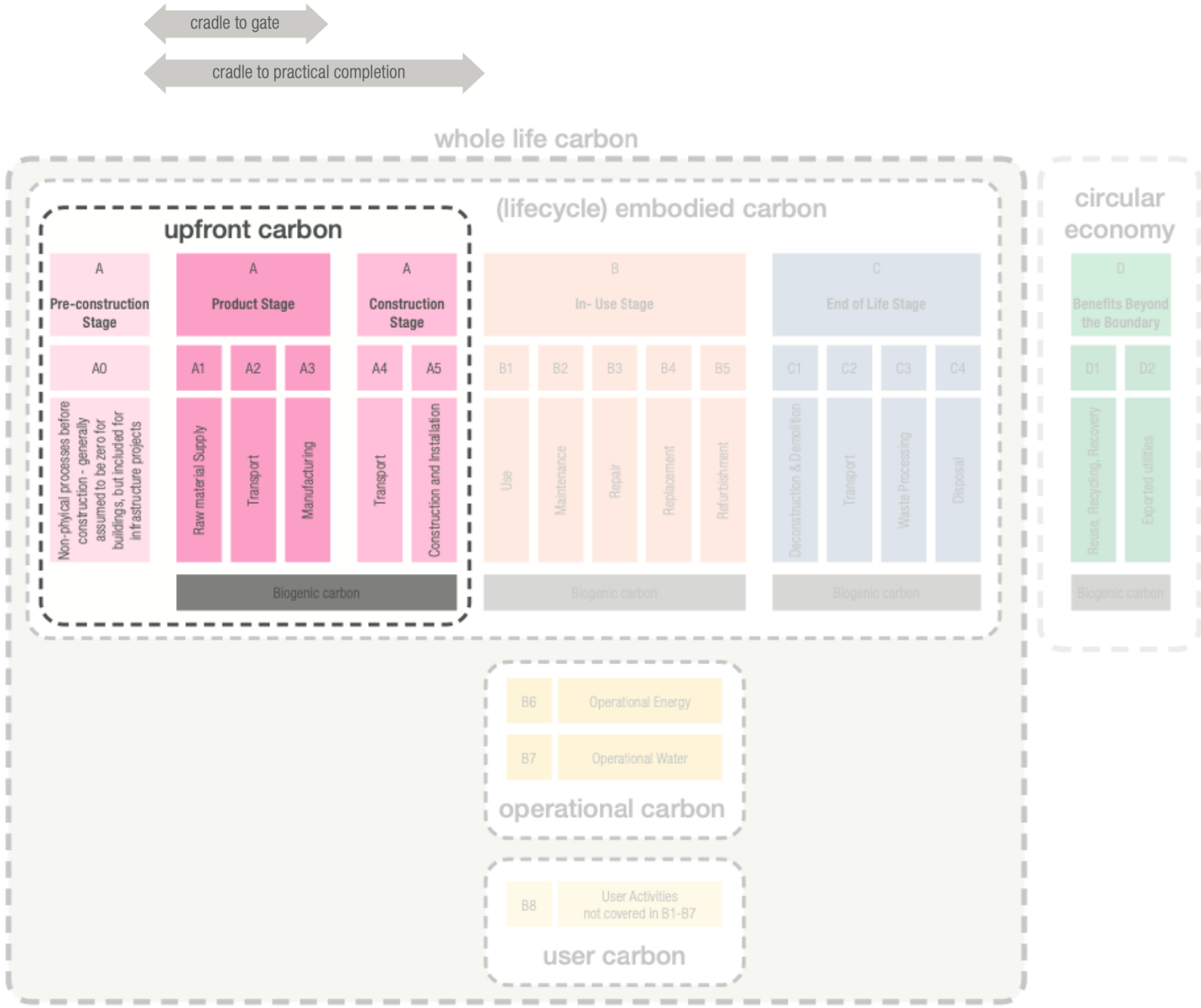
# Regenerative Design – early design stages

# Carbon Assessment

Typically, the scope can be:

## Upfront carbon

- Emissions from materials/construction processes up to practical completion
- Modules A1-A5
- Sequestration excluded and reported separately*

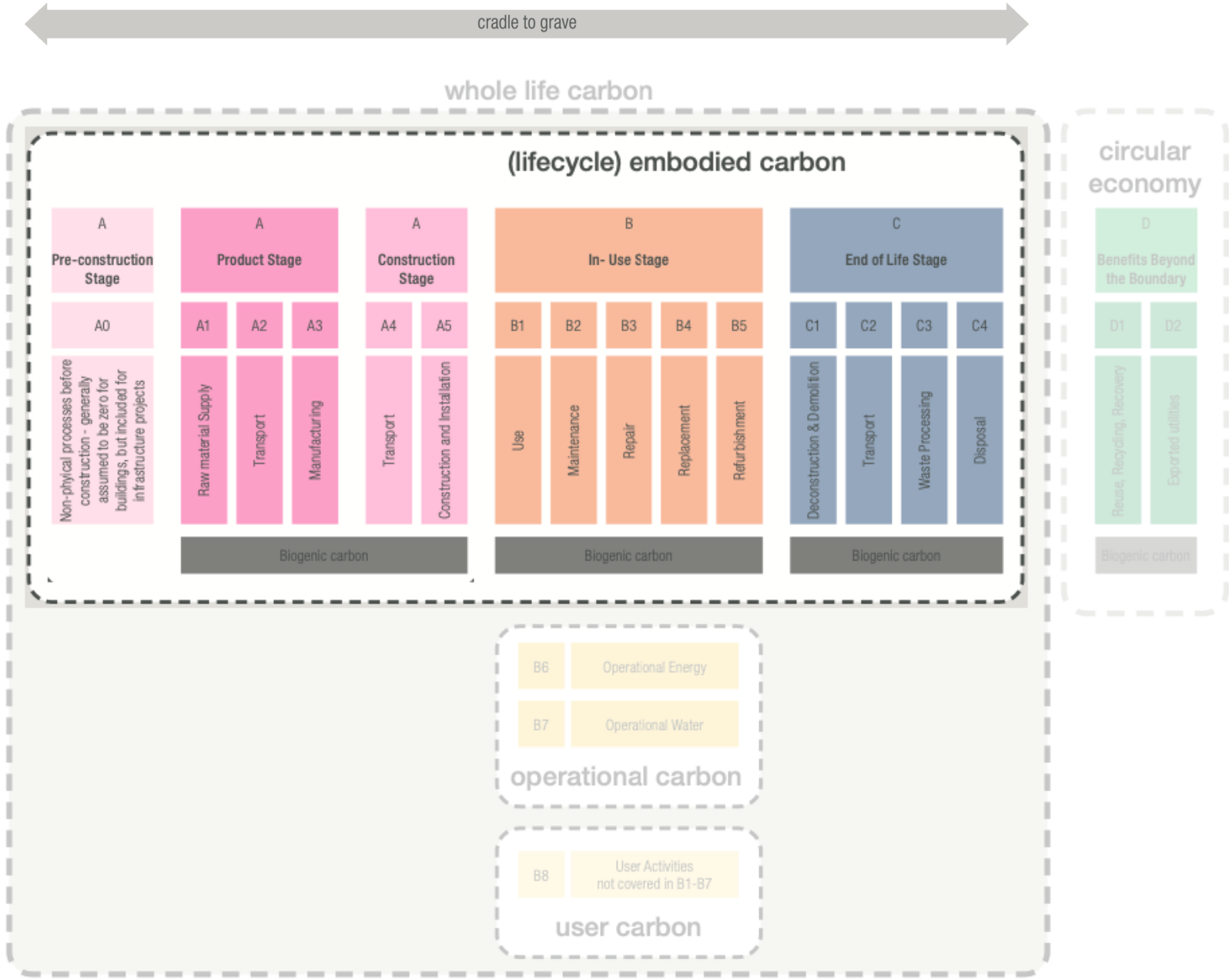


# Carbon Assessment

Or:

## Life cycle embodied carbon

- GHG emissions & removals from materials/processes throughout the whole life cycle of an asset
- Modules A1-A5, B1-5, C1-4
- Sequestration included only when fairly accounted in end of life emissions*

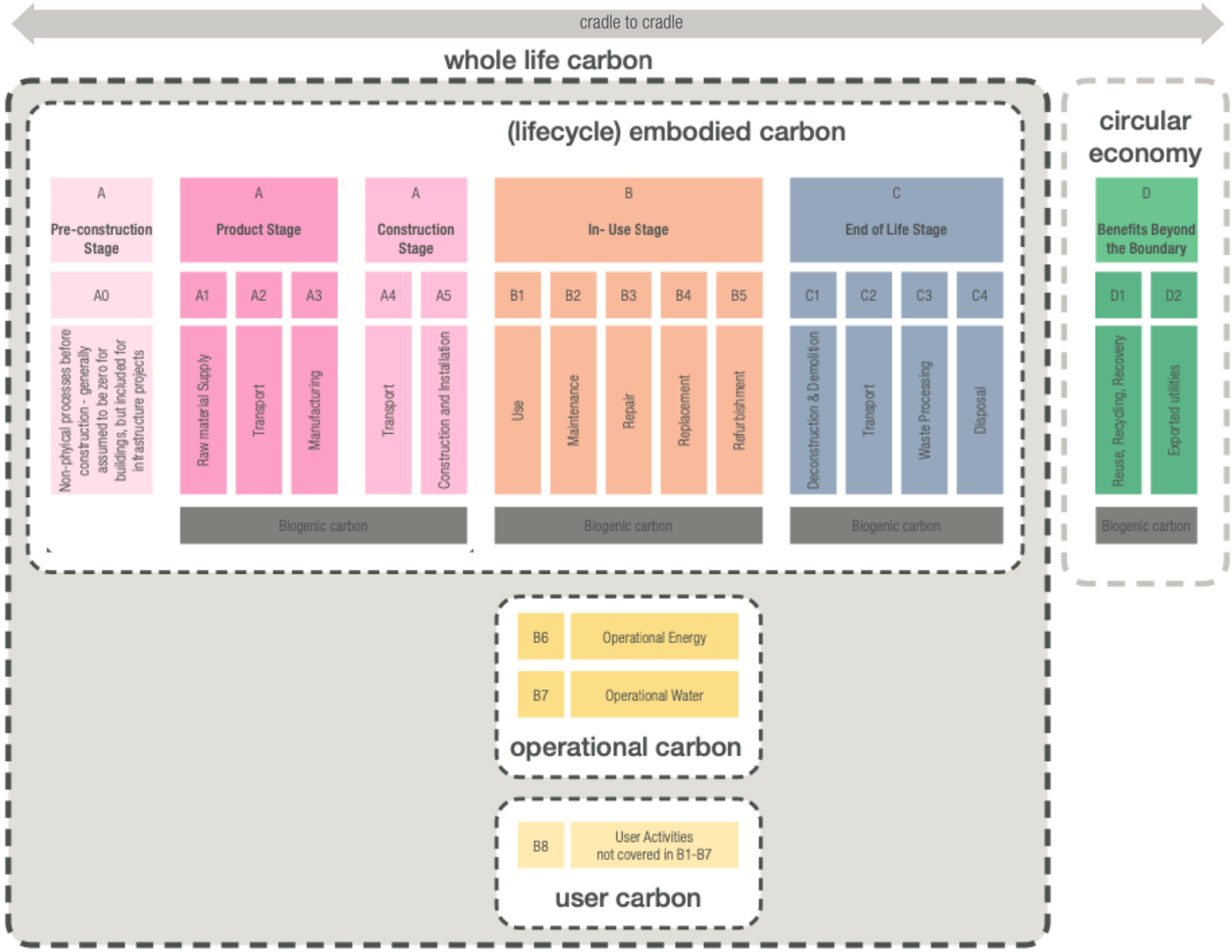


# Carbon Assessment

Or:

## Whole life carbon

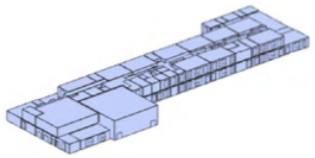
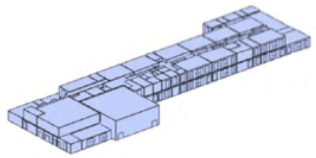
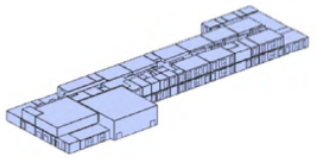
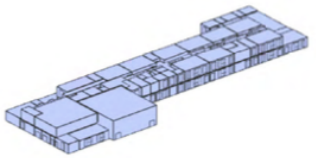
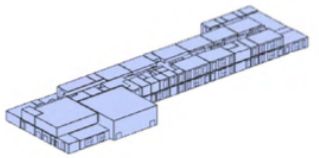
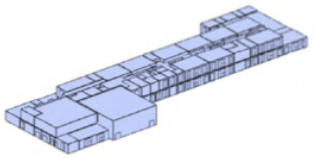
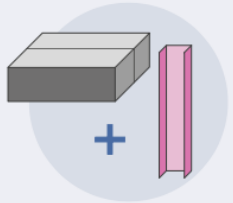
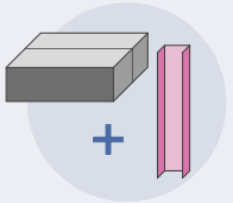
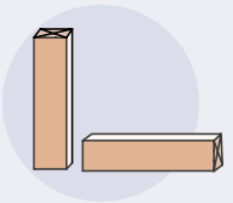
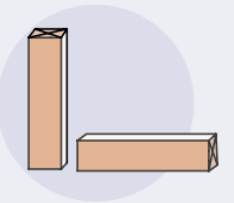
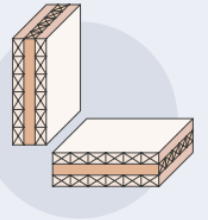
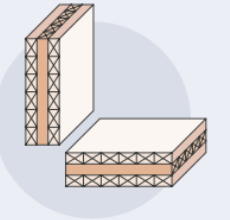
- Modules A0-5, B1-7, C1-4 including operational & biogenic carbon
- Separately report the benefits or loads from future energy/material recovery (D1,D2)



# Carbon Assessment

Bertha Park Primary school
Perth Scotland 2023

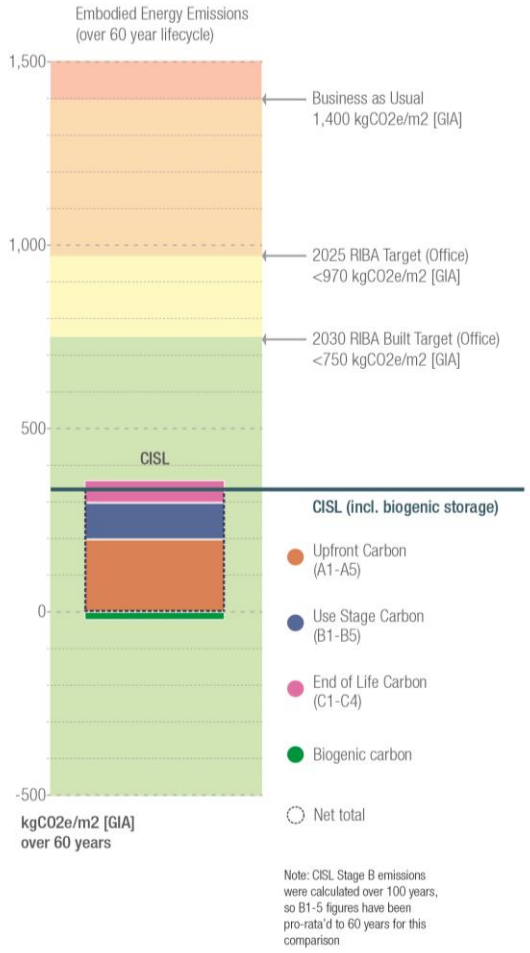
- Passivhaus
- Form factor fixed/compact: material exploration only
- LEIP 3 target for upfront carbon emissions A1-5 (< 600kgCO2/m2/yr)

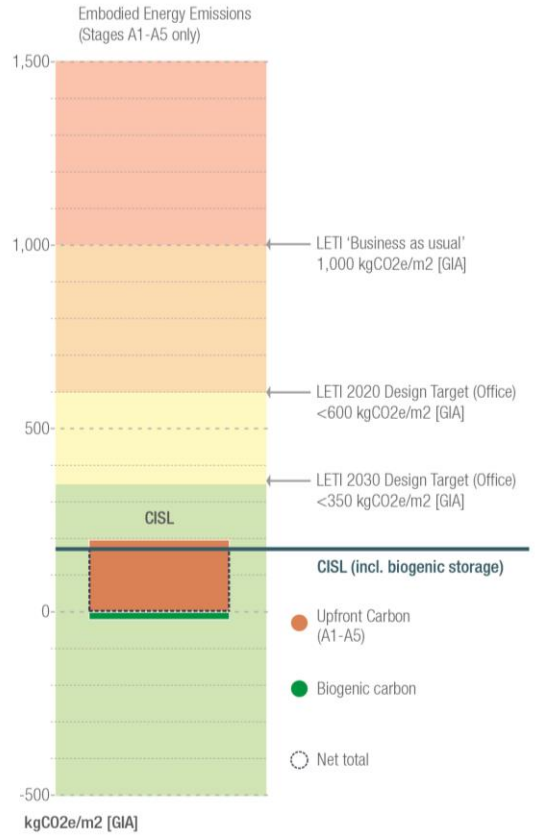
| | Option 1A: **Current Design*** Steel Frame & Metal Partitions | Option 1B: **Current Design** Steel Frame & Timber Partitions | Option 2A: **Current Design** Timber Frame & Metal Partitions | Option 2B: **Current Design** Timber Frame & Timber Partitions | Option 3A: **Current Design** Cross Laminated Timber Frame & Metal Partitions | Option 3A: **Current Design** Cross Laminated Timber Frame & Timber Partitions |
|---|---|---|---|---|---|---|
| **Geometry** |  |  |  |  |  |  |
| **Super Structure System** |  Steel Frame with Precast Concrete Floors & SFS Infill on Concrete Raft |  Steel Frame with Precast Concrete Floors & SFS Infill on Concrete Raft |  Timber Frame on Concrete Raft. |  Timber Frame on Concrete Raft. |  CLT Frame & Floors on Concrete Raft. |  CLT Frame & Floors on Concrete Raft. |
| **Upfront Carbon** | **440** $kgCO_2e/m^2$ [A1-A5] | **425** $kgCO_2e/m^2$ [A1-A5] | **362** $kgCO_2e/m^2$ [A1-A5] | **347** $kgCO_2e/m^2$ [A1-A5] | **489** $kgCO_2e/m^2$ [A1-A5] | **474** $kgCO_2e/m^2$ [A1-A5] |
| **Whole Life Carbon (excluding B6-B8)** | **751** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] | **693** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] | **670** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] | **613** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] | **825** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] | **767** $kgCO_2e/m^2$ [A-C. 60 yr lifecycle] |

# Architype - Educational building benchmarking

# Whole life carbon | Benchmarking of projects

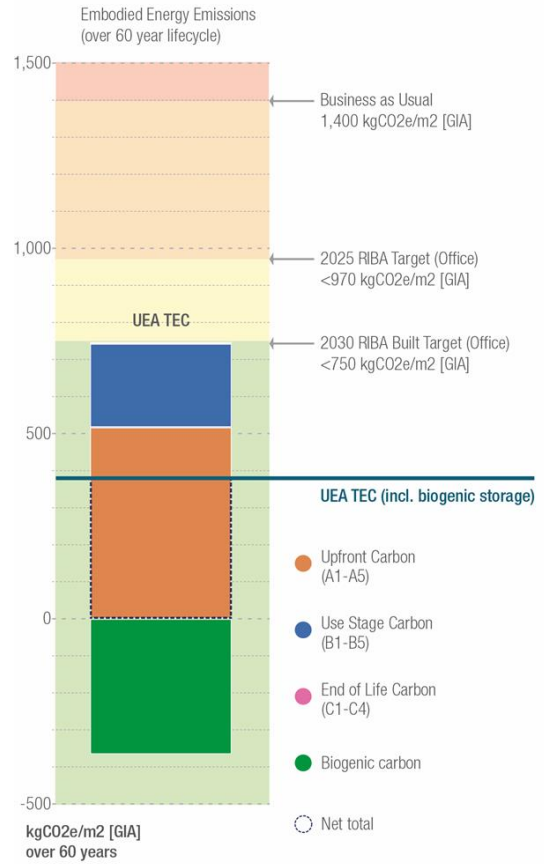
The Entopia Building
Cambridge institute of Sustainability Leadership
EnerPHit 2023

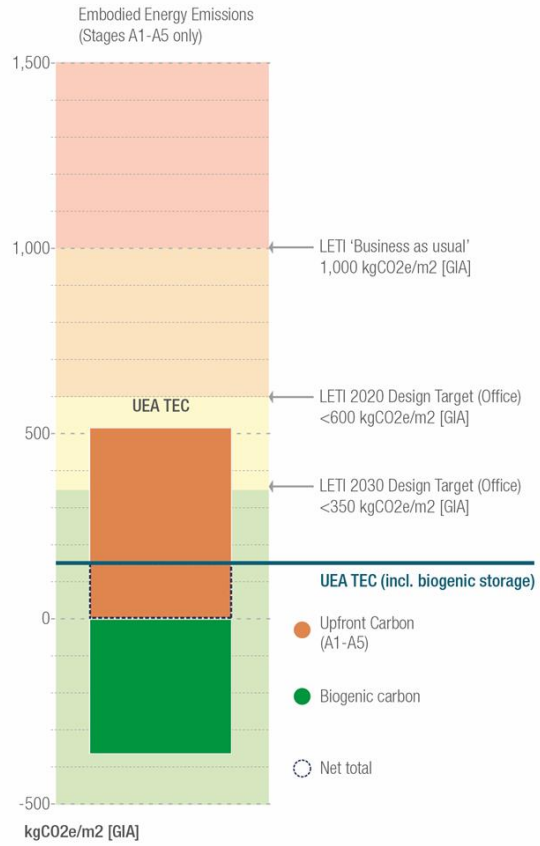


# Whole life carbon | Benchmarking of projects

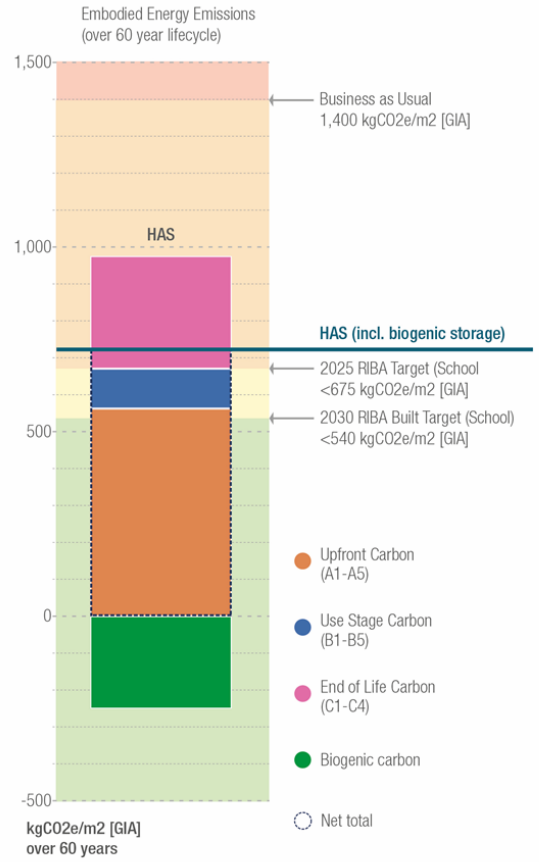
The Enterprise Centre
University of East Anglia
Passivhaus 2015

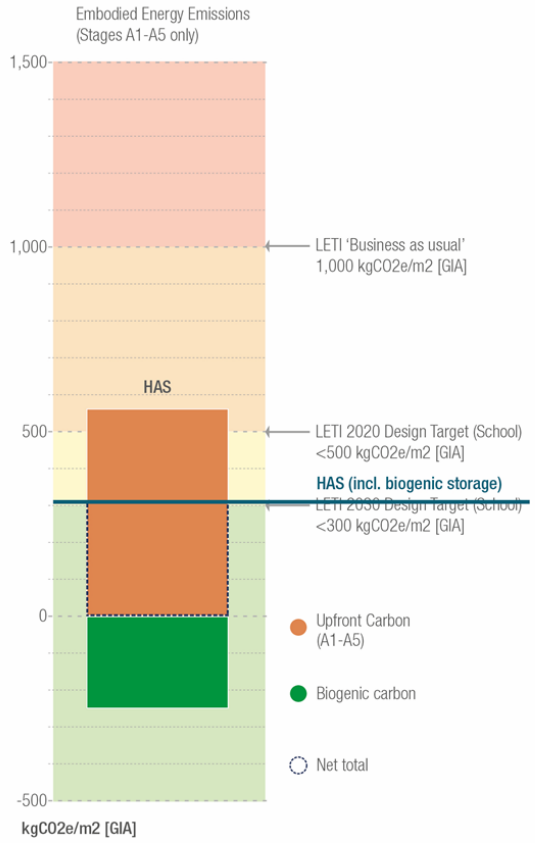


# Whole life carbon | Benchmarking of projects

Harris Academy Secondary School
London Borough of Sutton
Passivhaus



# Entopia

"The greenest building is the one that already exists"

Carl Elefante, former president of the American Institute of Architects

Entopia – world class retrofit for University of Cambridge Institute for Sustainability Leadership

# Entopia

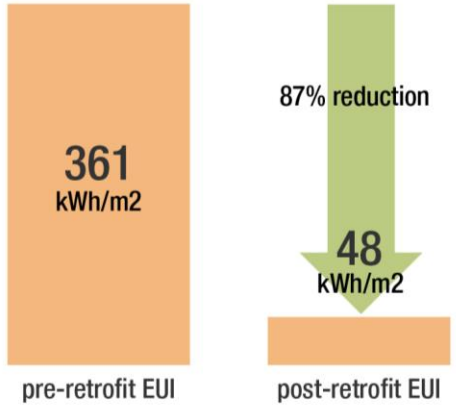
"The greenest building is the one that already exists"

Carl Elefante, former president of the American Institute of Architects

Entopia – world class retrofit for University of Cambridge Institute for Sustainability Leadership

# Entopia – Results

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |




BREEAM®
OUTSTANDING
★★★★★
90.0%
Design Stage

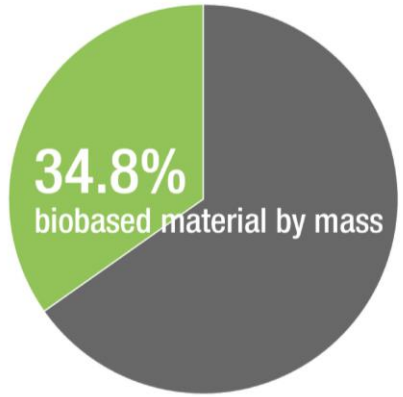
pending Post Construction Review

A+ 130 kgCO2e/m2
Upfront Carbon
A1-5 excl. sequestration

A 409 kgCO2e/m2
Embodied Carbon
A1-5, B1-5, C1-4

INTERNATIONAL WELL BUILDING INSTITUTE™
WELL
GOLD 2018

pending certification

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# Entopia - Before

- Originally built in 1939 as a telephone exchange
- Photo from BT Archives of a Cambridge telephone exchange


ARCHDUKE

# Entopia - Strategy

Internal wall insulation wrapped around building

Triple-glazed windows

Task-based lighting with intelligent lighting controls

Exposed ductwork distributes fresh air, tempered through heat recovery and peak-lop cooling

Suspended ceilings removed to increase height (+daylight) - absorbent finish proposed

Airtightness detailing

FF+E strategy being developed - aiming to reuse existing furniture where possible

Plants promote access to nature (effect on IAQ is minimal)

Low impact floor finishes proposed for functional reasons, and feature areas

Existing raised access floor retained, and exposed in lower traffic areas to reduce embodied carbon

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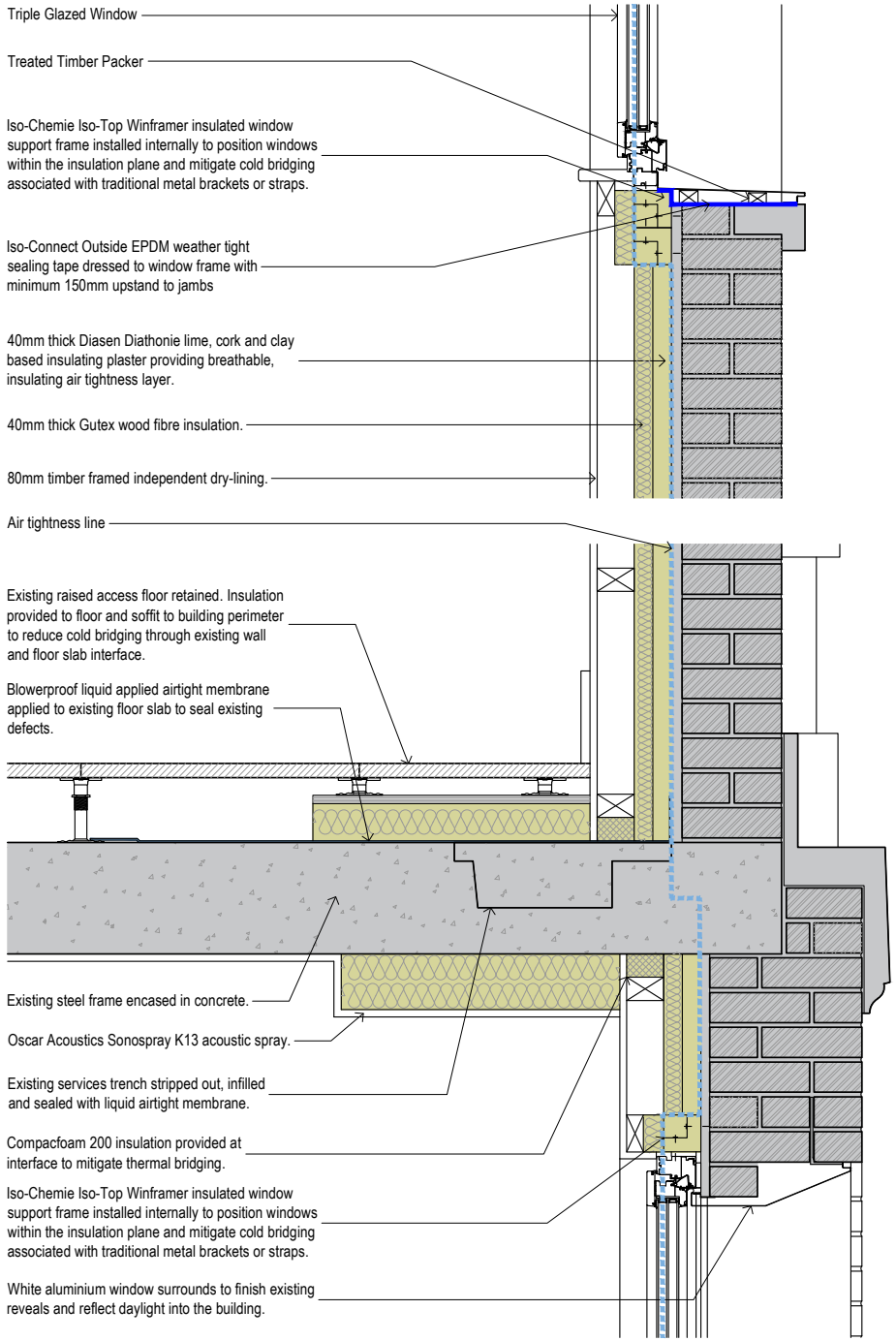
# Entopia - Detail development

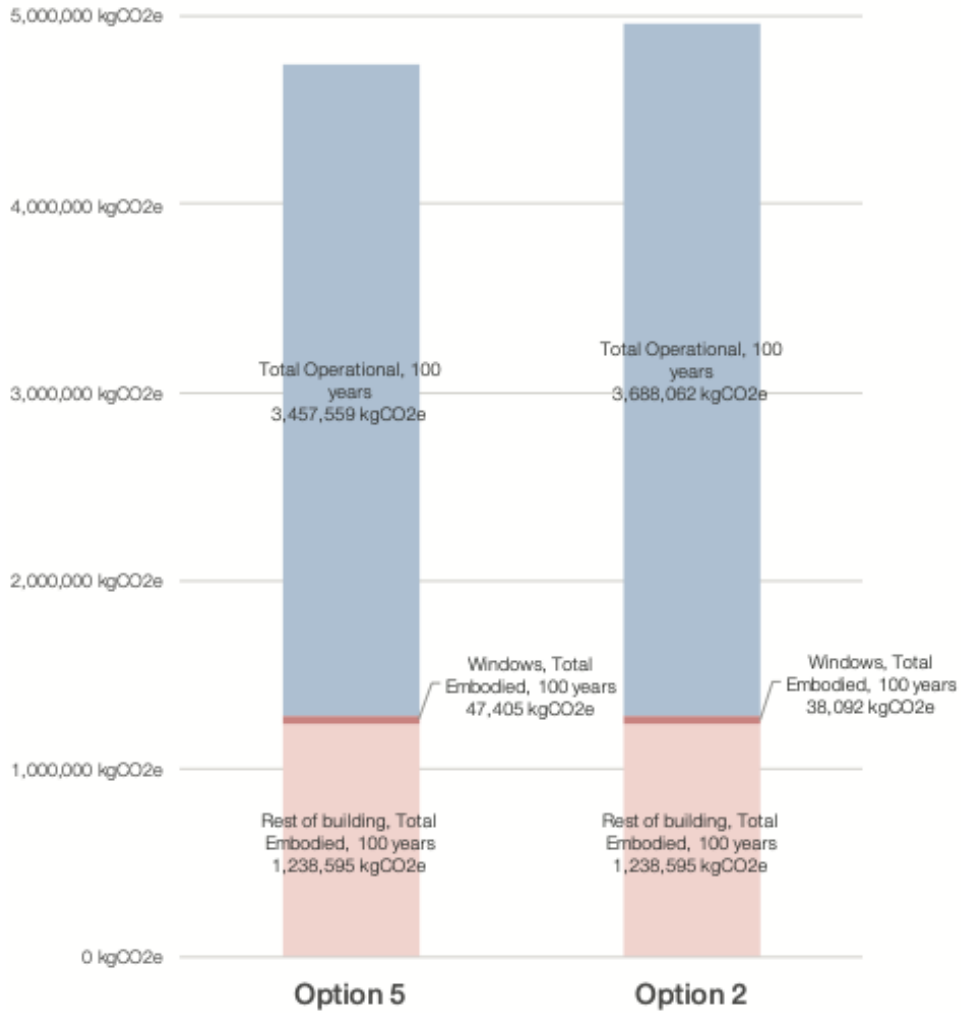
- Development of detail to include 40mm Diathonite insulating render and 40mm Gutex woodfibre board
- Bio based to minimise embodied carbon and manage moisture



# Total life cycle Carbon impact over 100 years

- Comparison between triple glazed mock sash & single triple pane
- 0.75% difference between total embodied carbon
- 4% increased life cycle carbon due to more glass & less frame (option 5)
- Offset by almost 10% operational energy betterment over 100 yrs & increased daylight benefit
- Lack of reliable embodied carbon data on windows – be careful as designers!

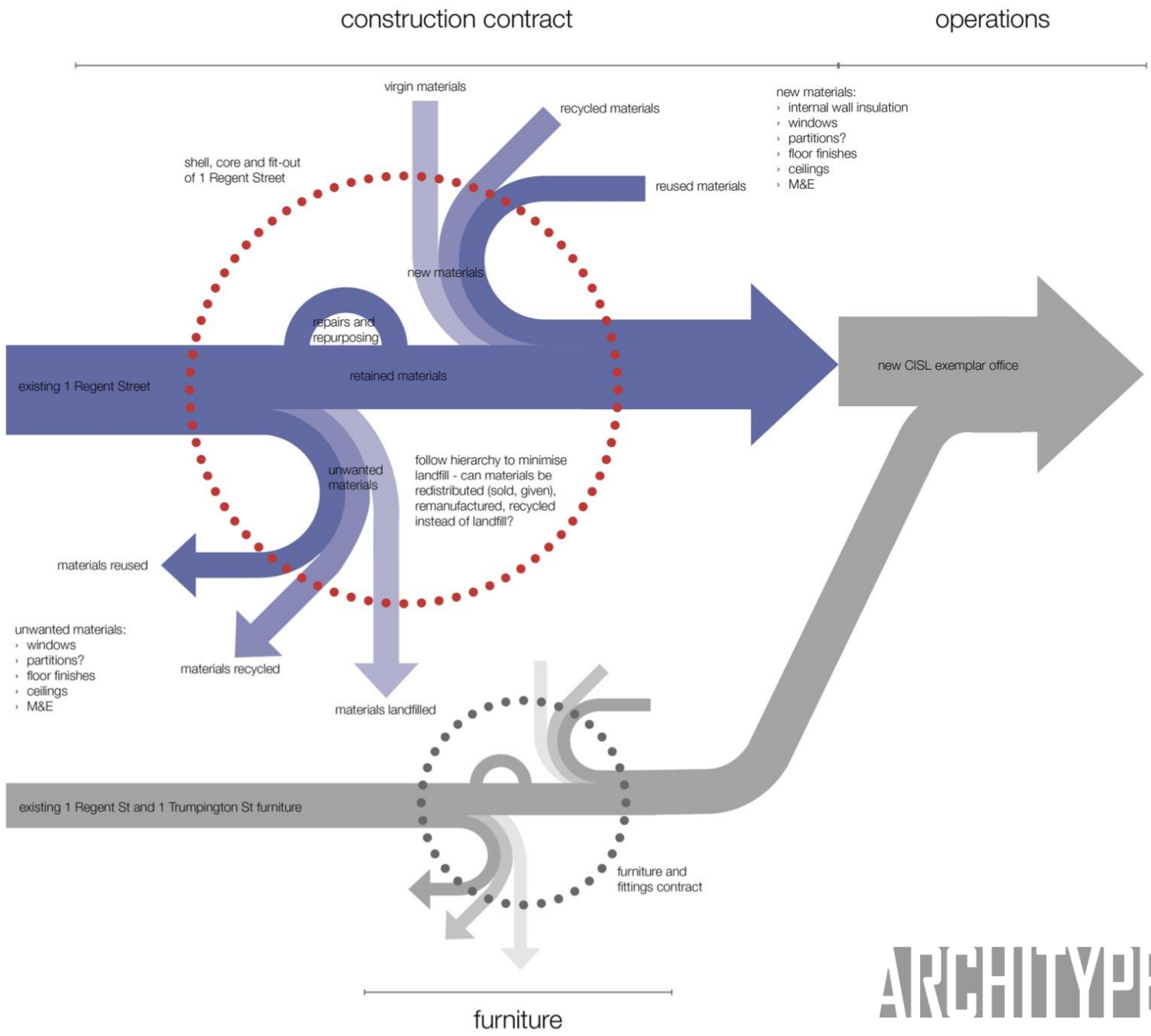
3D view - Option 2: Recessed mock sash window (with additional glazing bars)




3D view - Option 5: Proposed recessed window with recessed frame

Calculated using Eccolab software stages A1-A5, B and C

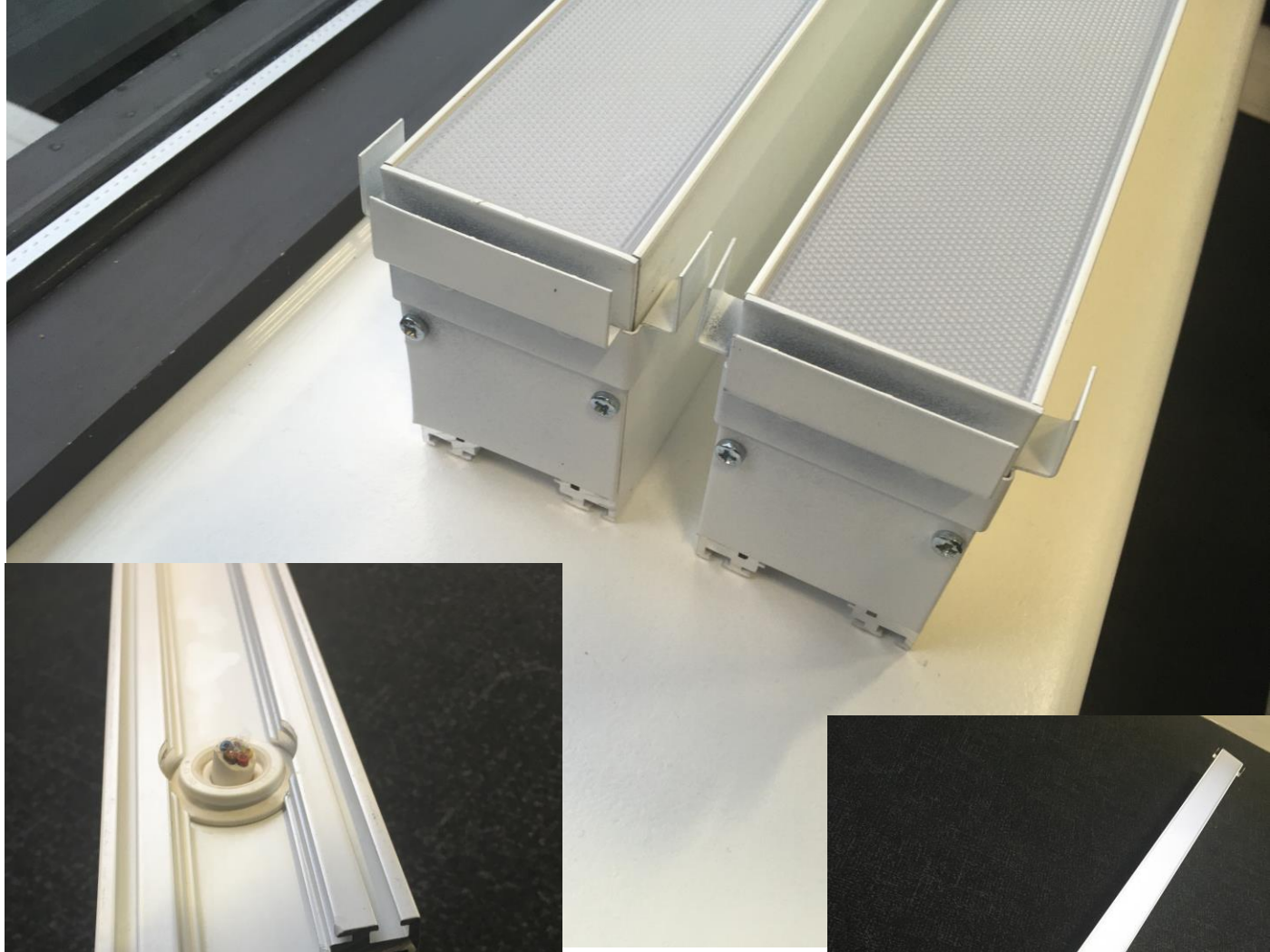
# Circular economy




ARCHITYPE

# Reused lights

- Contractor sourced from CAT A fit out in London
- Persuaded the original manufacturer to test and honour the remaining warranty period
- Lights adapted to be hung suspended, with additional LED strip for uplight



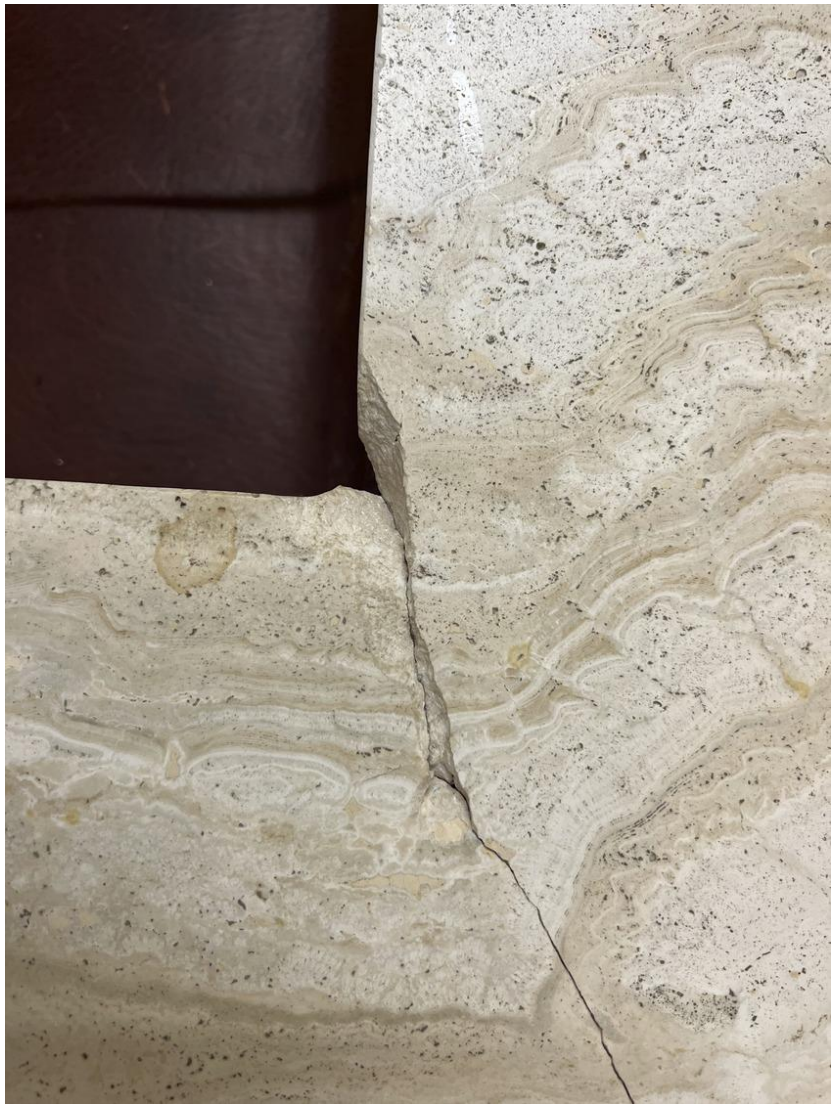


# Reused reception desk

- Sourced by contractor from the Copyright Building, London
- Removed in 2021 and taken back to original manufacturer's workshop to be stored and adjusted
- Some modifications for accessibility

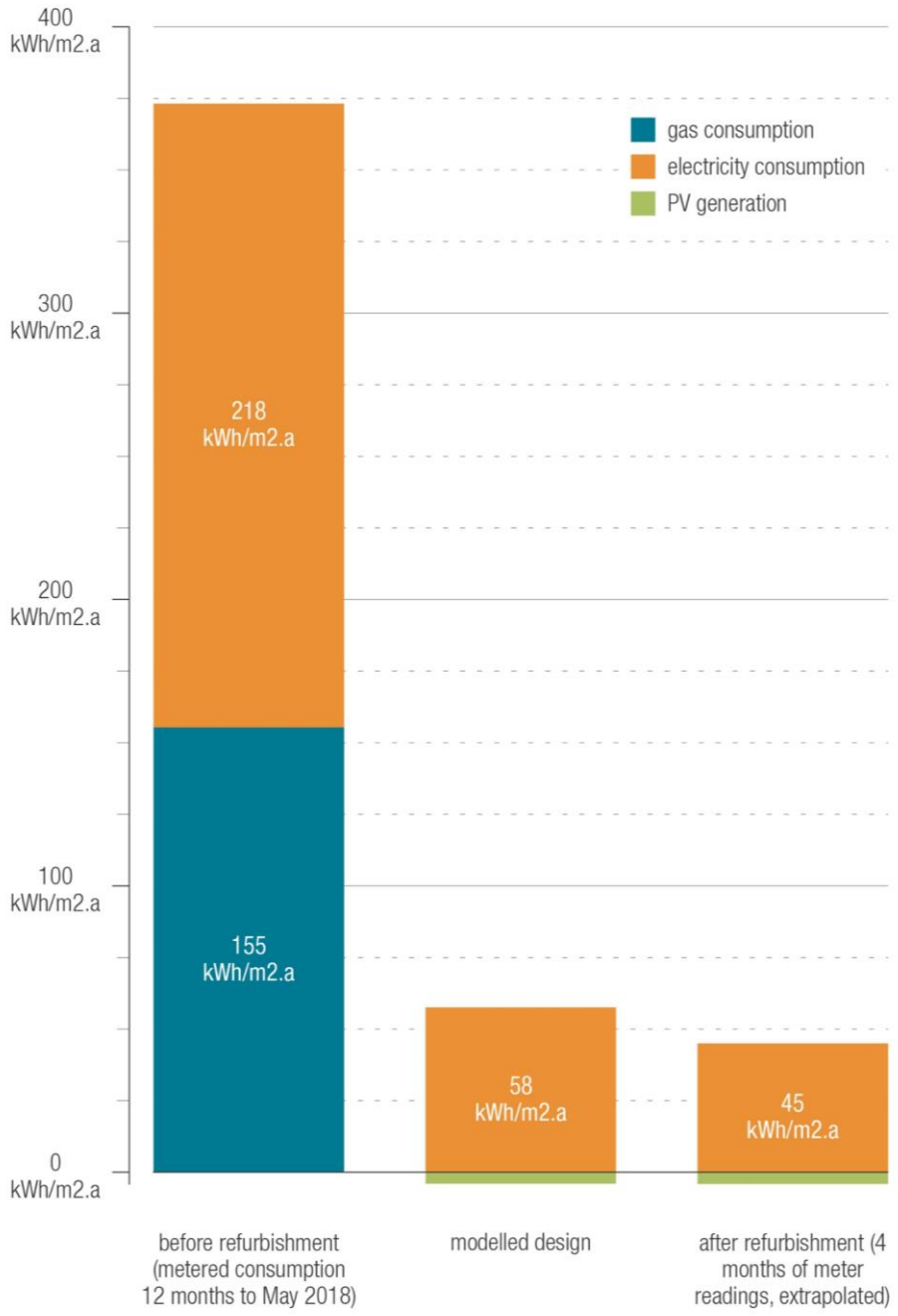
# Kintsugi Repair

- Travertine stone top cracked during removal: repaired in the spirit of Japanese Kintsugi technique
- Breakage and repair treated as part of the history of the object
- Manufacturer now designing for disassembly



# Metered energy usage

- University of Cambridge current data before & after
- Performing better than designed
- Energy Use Intensity of 45 kWh/m2 a
- Saving £100,000 a year in energy costs




THIS IS NOT AN ORDINARY PROJECT.
BUT IT NEEDS TO BE.
The time is now.
Together we can be extraordinary. Together we can build a better world.
#BuildingChange | #Entopia | @CISL_Cambridge

# Beyond assessment – considerations for designers

# Considerations for designers

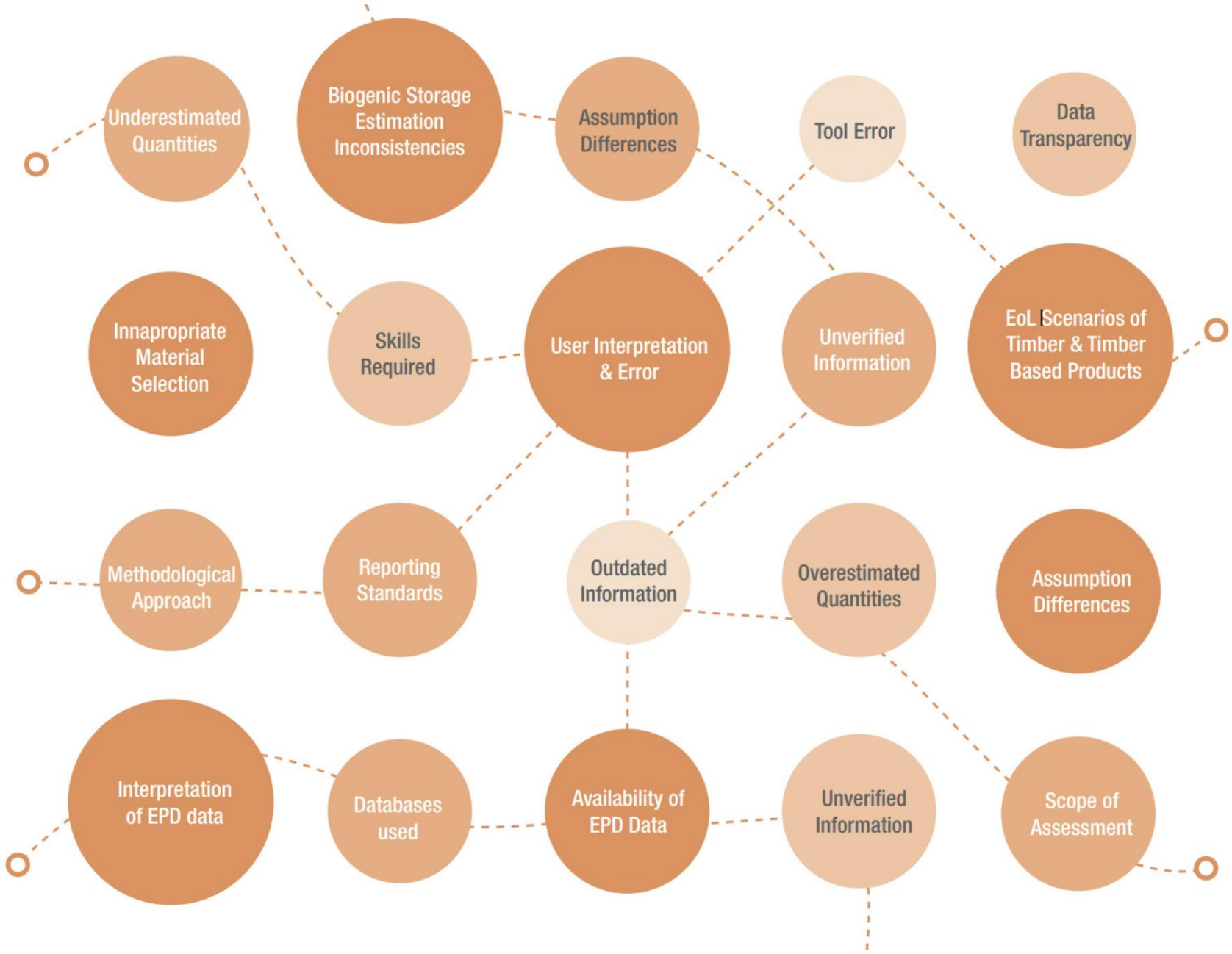
Some factors outside of assessment control:

- Assessment tools and their availability
- Structural material choice
- Services over a building life
- Renewables end of life of physical components
- Materials scarcity - example
- Fitted furniture FFE and finishes

# Assessment tools and availability

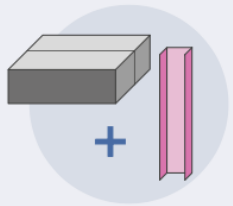
Requires expert Knowledge to navigate well

- Interpretation
- Data availability
- Verified information
- Biogenic storage inconsistencies



# Material choice

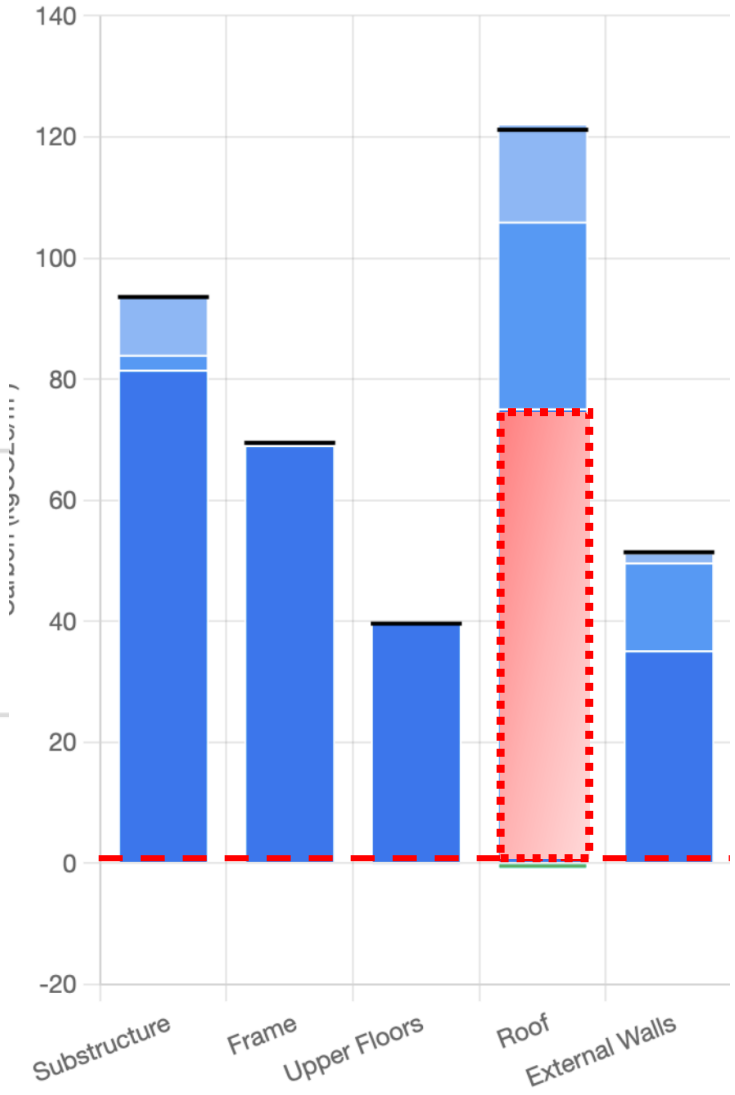
**Option 1A:**
**Current Design***
Steel Frame & Metal Partitions



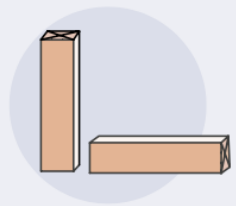
Steel Frame with Precast Concrete Floors & SFS Infill on Concrete Raft

**440**
**kgCO₂e/m²**
**[A1-A5]**

**751**
**kgCO₂e/m²**
**[A-C. 60 yr lifecycle]**



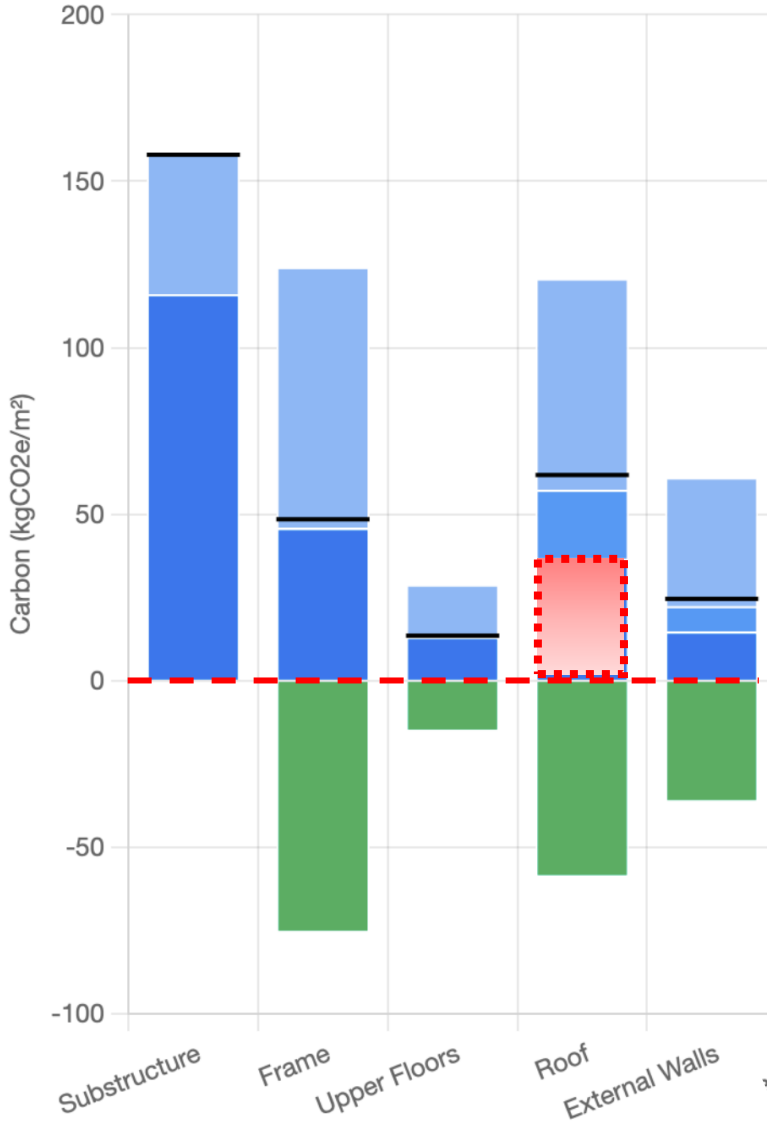

**Option 2A:**
**Current Design**
Timber Frame & Metal Partitions



Timber Frame on Concrete Raft.

**362**
**kgCO₂e/m²**
**[A1-A5]**

**670**
**kgCO₂e/m²**
**[A-C. 60 yr lifecycle]**




A1-5 Upfront Carbon
B1-5 Use Embodied Carbon
C1-4 End-of-Life
A1-3 Product (Sequestered)
NET (Including sequestration)

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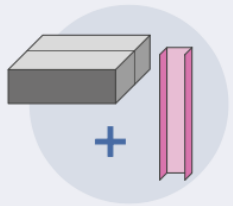
**Current Design***
Steel Frame & Metal Partitions



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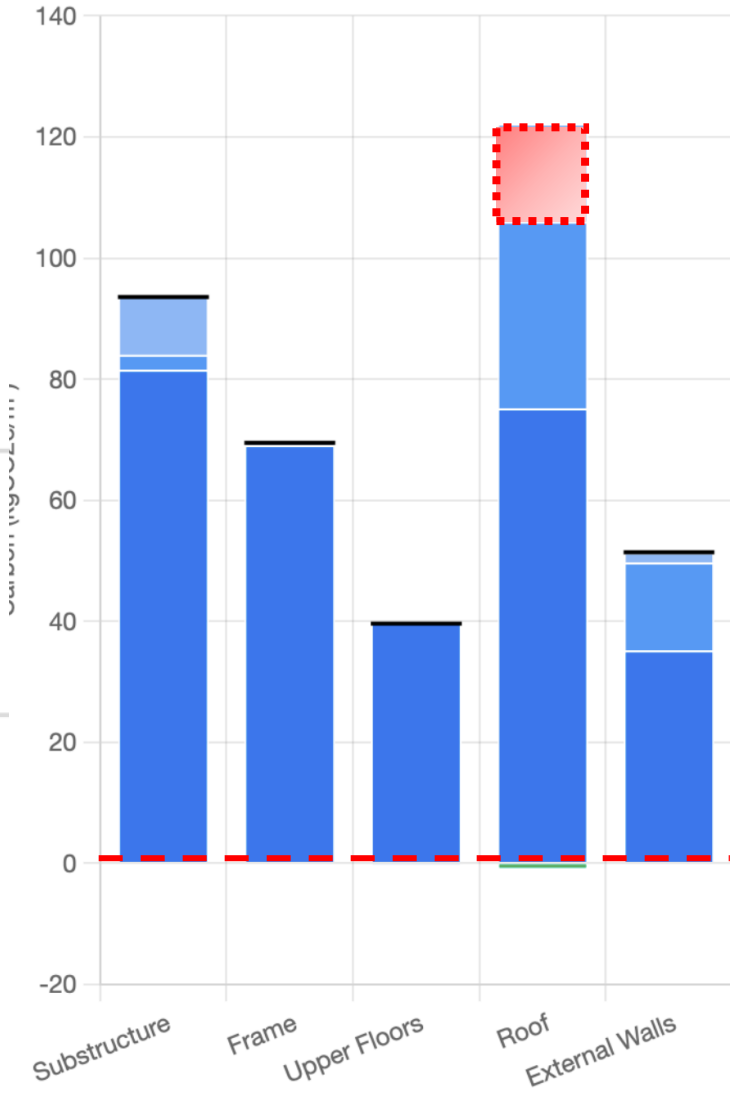


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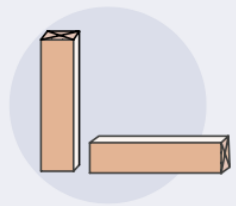

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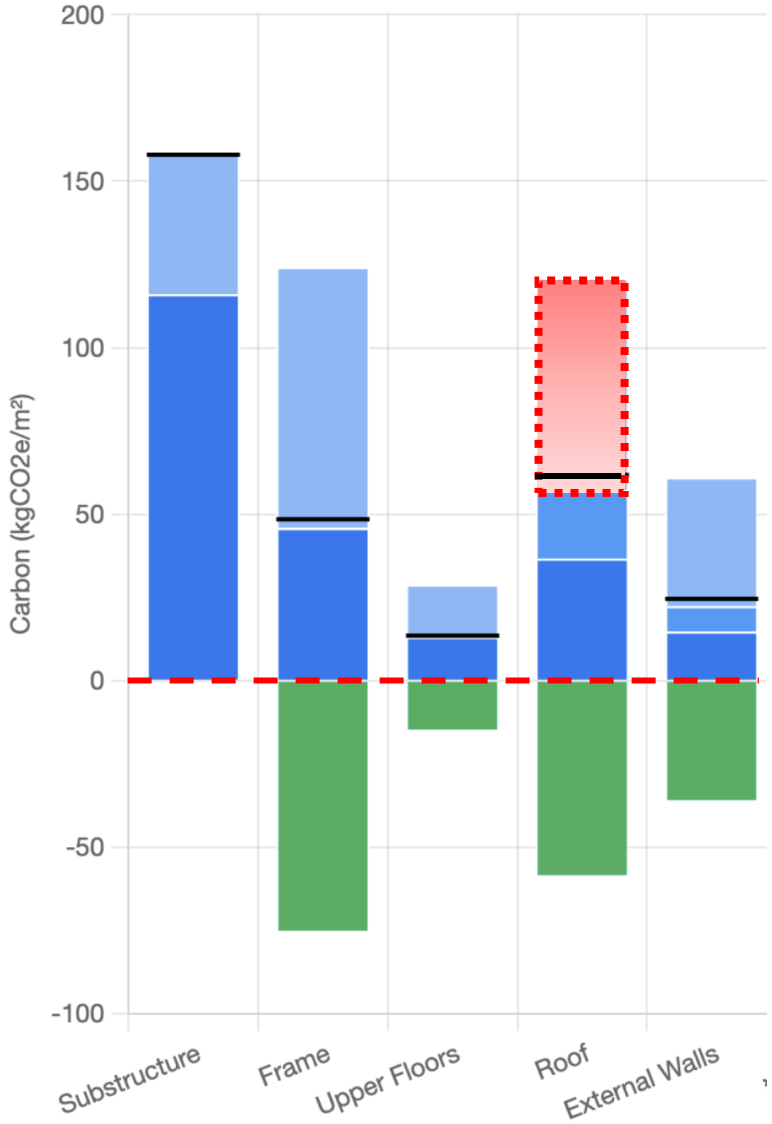


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B1-5 Use Embodied Carbon
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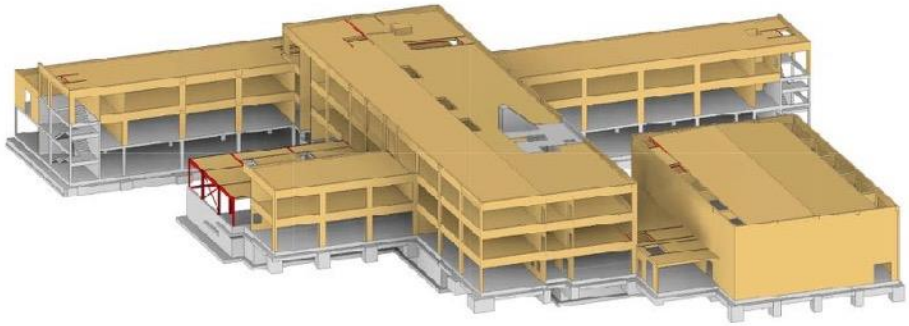
A1-3 Product (Sequestered)
NET (Including sequestration)

# Material choice



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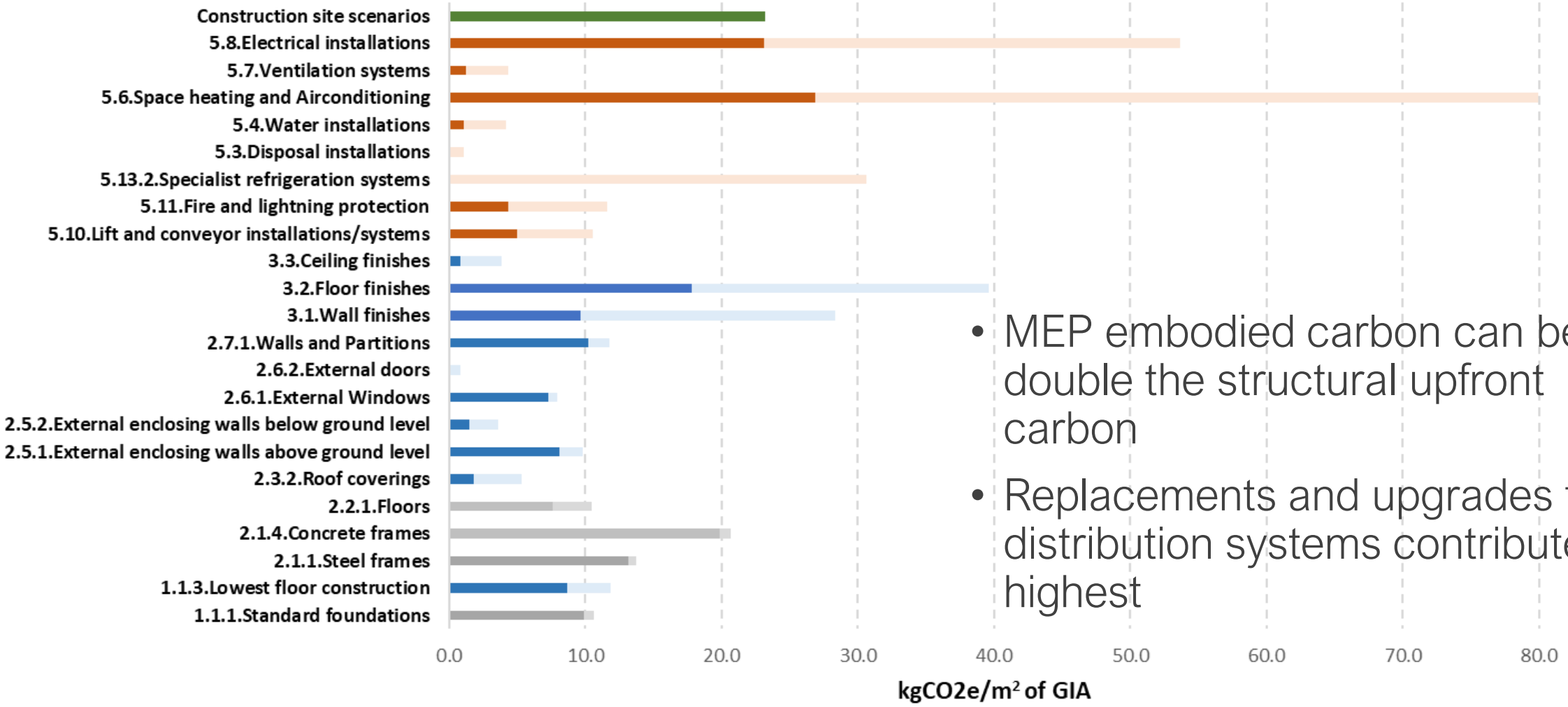
CONSTRUCTION

DE-CONSTRUCTION

# Services

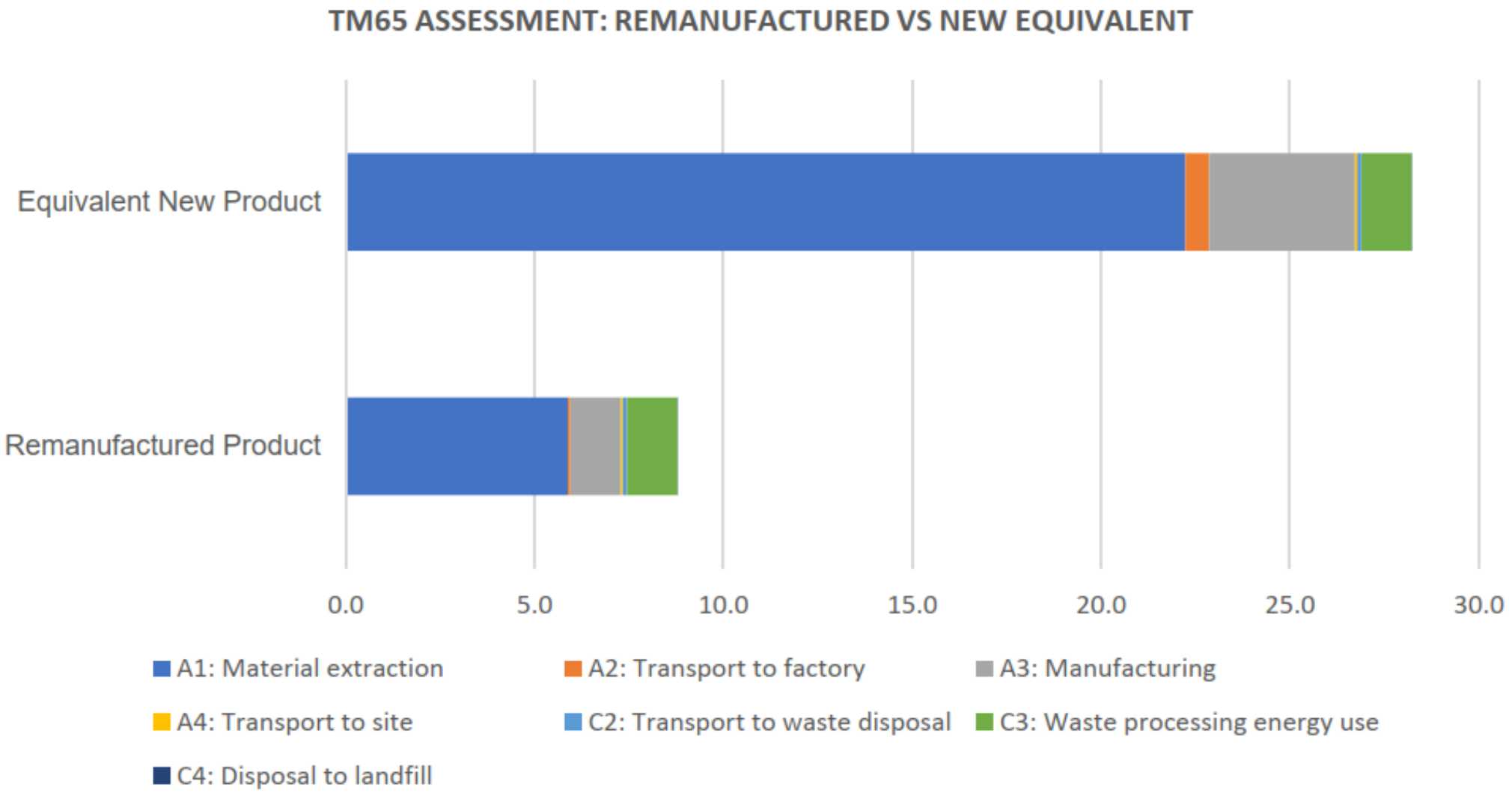
# Services




- MEP embodied carbon can be double the structural upfront carbon
- Replacements and upgrades to distribution systems contribute the highest

MAX FORDHAM

Global resource consumption has tripled in the last 50 years
Resource efficiency of what we have in the system is key




MAX FORDHAM

# Renewables at end of life

No global solutions for end of life of renewable components

- 1st PV recycling plant in 2023 Grenoble France globally
- Wind nacelles re-use/ recycle potential
- Race to ‘net zero’ must consider these issues

## Solar panels - an eco-disaster waiting to happen?

3 days ago

Climate change


LAURENT JULLIAND

**By Daniel Gordon**

The Climate Question podcast, BBC Sounds

LAURENT JULLIAND

Solar panels are delaminated in order to recover precious materials

At ROSI's high-tech plant in Grenoble, the solar panels are painstakingly taken apart to recover the precious materials inside - such as copper, silicon and silver.

# Materials scarcity


https://www.unep.org/news-and-stories/story/problem-our-dwindling-sand-reserves#:~:text=Sand%20is%20the%20foundation%20of,the%20collapse%20of%20coastal%20defences.

# Material scarcity

Glass & components within frames for performance

- Replacement rates
- Industry incentives to refurbish components
- Future of components as hire purchase items?
  (Zero waste Scotland)

# FF & E

Fittings furniture & equipment

- Generally, not modelled in whole life carbon assessments
- Major impact
- Entopia EnerPHit – Up to 40% of whole life carbon over 100 years even with re-used elements

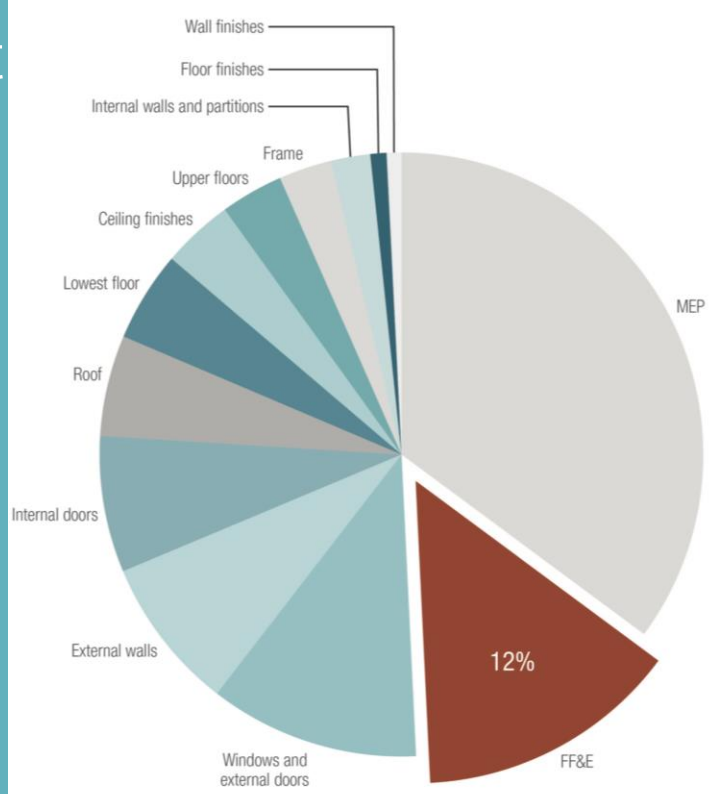



**Fig. 11 /** FF&E upfront carbon (A1-5) in red, compared with different elements of the building fabric

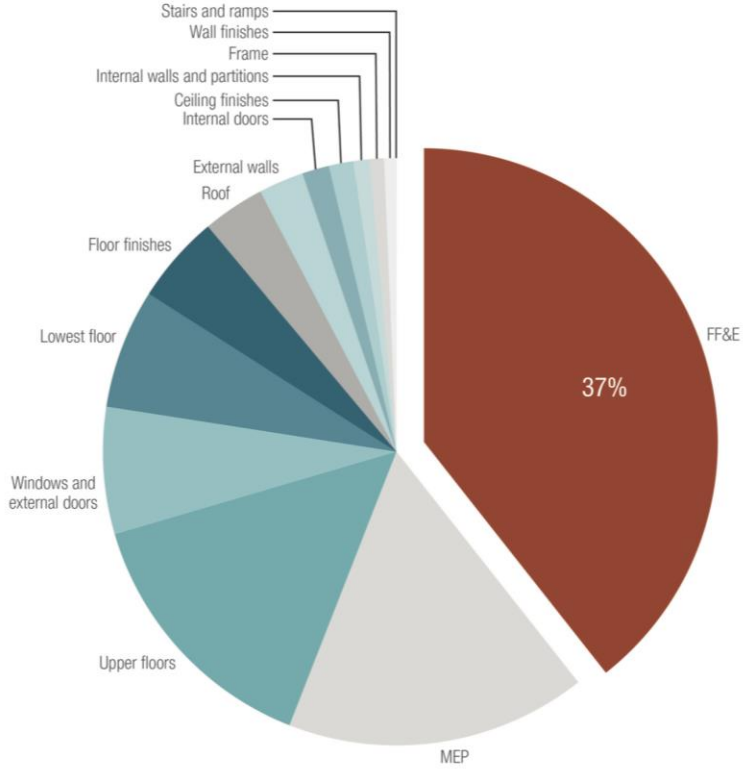



**Fig. 12 /** FF&E embodied carbon (A1-5, B1-5 and C1-4 over 100 years) in red, compared with different elements of the building fabric

# Finishes

Floor finishes example

The Enterprise Centre
University of East Anglia UK

- Concrete floor chosen for longevity over timber floor

# Finishes

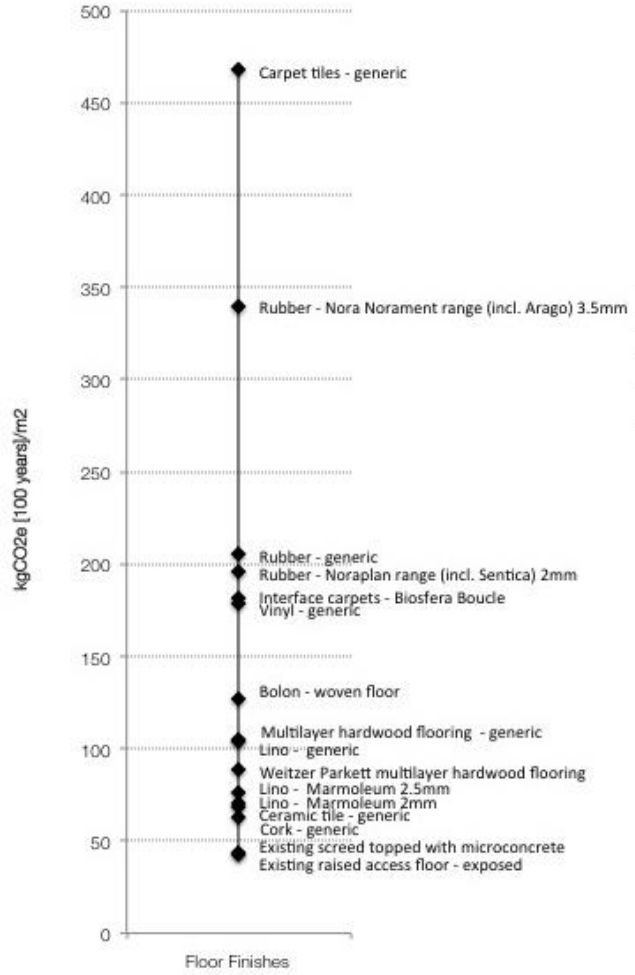
Floor finishes example

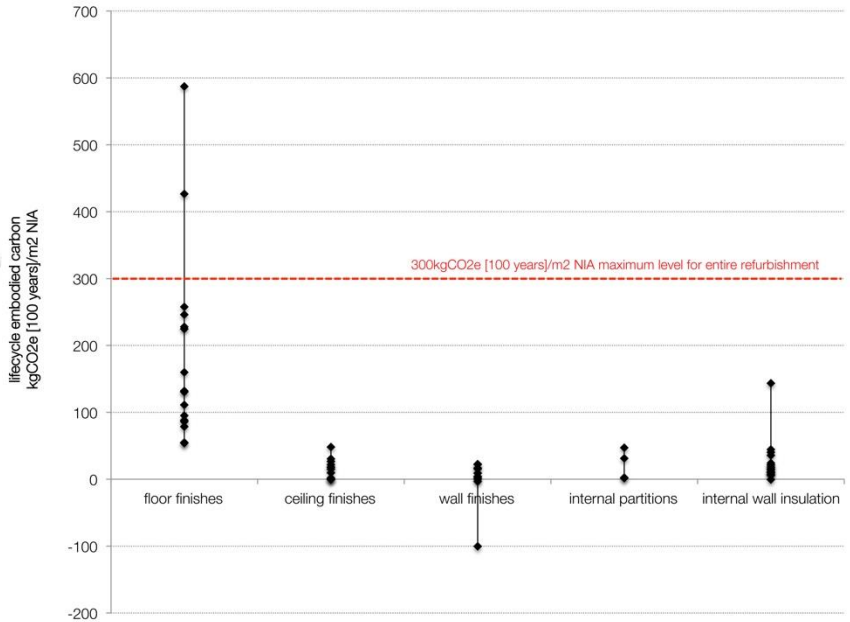
The Enterprise Centre
University of East Anglia UK

- Concrete floor chosen for longevity over timber floor
- Timber assessment excluded biogenic storage on a 15-year replacement rate for heavy trafficked area

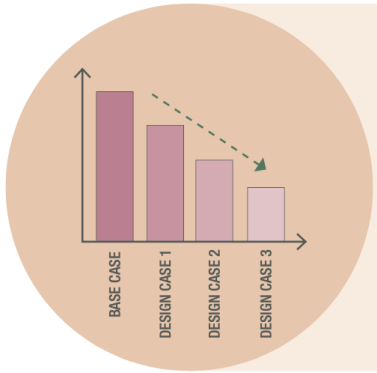
# Finishes

## Entopia example



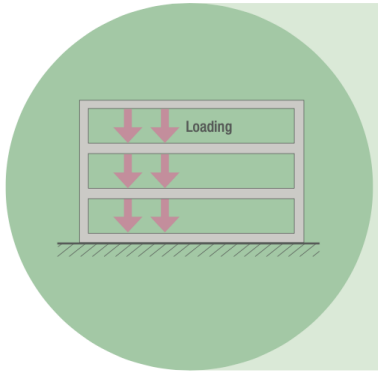




# Regenerative design – a response



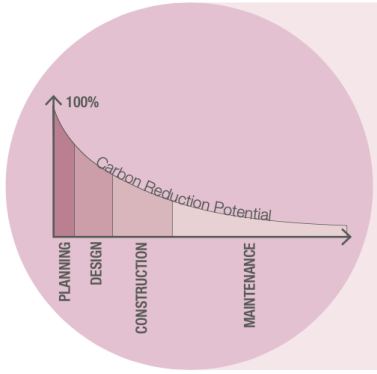

## 1. Use LCA Analysis as a Design Tool

- Appoint a Lifecycle Carbon Assessment [LCA] specialist or design team member for whole life carbon assessments moving forward. This should be in the form of iterative assessments at key design stages.
- Avoid seeing the analysis as a 'tick-box' exercise, instead use the tool to inform key design decisions.
- There are several standards which should be met when carrying out LCA analysis, this includes the RICS Professional Statement on Whole Life Carbon.



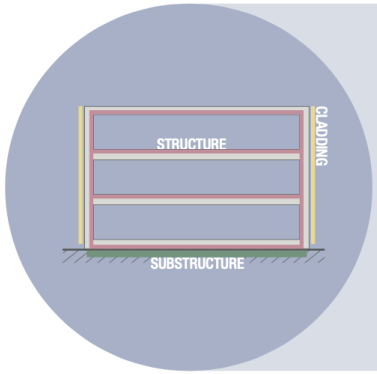

## 2. Build Light and Wise

- Whilst we can track and reduce the impacts of Embodied Carbon, the best principle is to only build what is necessary, with as little material as possible.
- Optimising structure at very early stage is essential for understanding where the greatest reductions can be achieved in structural design optimisation.



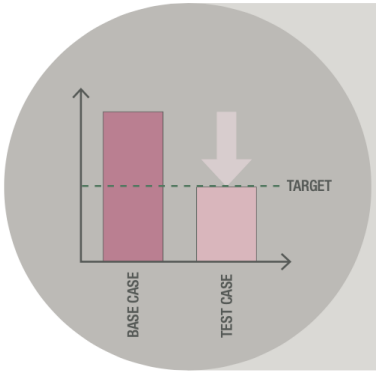

## 3. Early Assessment = Greater Reduction Potential

- The earlier embodied carbon is considered, the greater the ability to reduce it.
- Whilst many design elements have not been developed yet, it is important to assess the impact of these elements at early stage to understand the 'carbon consequences'.
- A carbon policy including Embodied and Operational Carbon for C&BRP should be agreed, with requirements for reducing Upfront and Embodied Carbon included in project briefs.



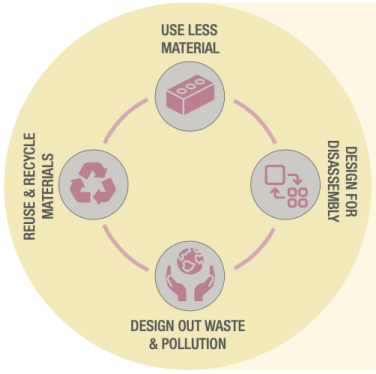

## 4. Focus on Carbon Hotspots

- Approximately 50% of main carbon impacts will be typically down to a small number of key elements.
- Elements such as foundations and structure will represent the biggest contribution to Embodied Carbon, largely due to the 'quantity' of material required.
- Therefore, focus on these main elements for replacements with lower carbon materials or further optimisation, to achieve significant reductions.




## 5. Set Achievable Reduction Targets

- Benchmarks are a useful way to check performance, however careful targets should be used to ensure useful and comparable data.
- We recommend that each new iteration of the model should be compared to the previous carbon studies for this project, with the aim of reducing where possible, and accounting for any increases (eg from increased scope, or greater detail).




## 6. Aim for a Circular Economy Principles

- Design for disassembly where possible, so that elements could be reused or recycled in the future, supporting a circular economy.
- Assess whether existing or recycled materials local to the site could be used, in full or in part, in the design.

# Regenerative design – a response

Carbon is just one metric of sustainability

Invest in knowledge sharing and lessons learnt – we are all still learning

A lot done, even more to do!

ARCHITYPE

London | Hereford | Edinburgh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