Cradle to Cradle & Whole-life Carbon assessment
–
Barriers and opportunities towards a circular economic building sector

Noemi Futás
Co-authors: Kartikeya Rajput, Rosa Schiano-Phan

UNIVERSITY OF WESTMINSTER
Chapman BDSP

SBE19 Brussels - BAMB-CIRCPATH
05-07 February 2019

BAMB BUILDING AS MATERIAL BANKS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

Presentation Outline

> From linear to circular

> Cradle to Cradle

> Whole-life Carbon assessment

> Case study LSE-CBR, London

> **Towards a circular economic building sector**

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From linear to circular

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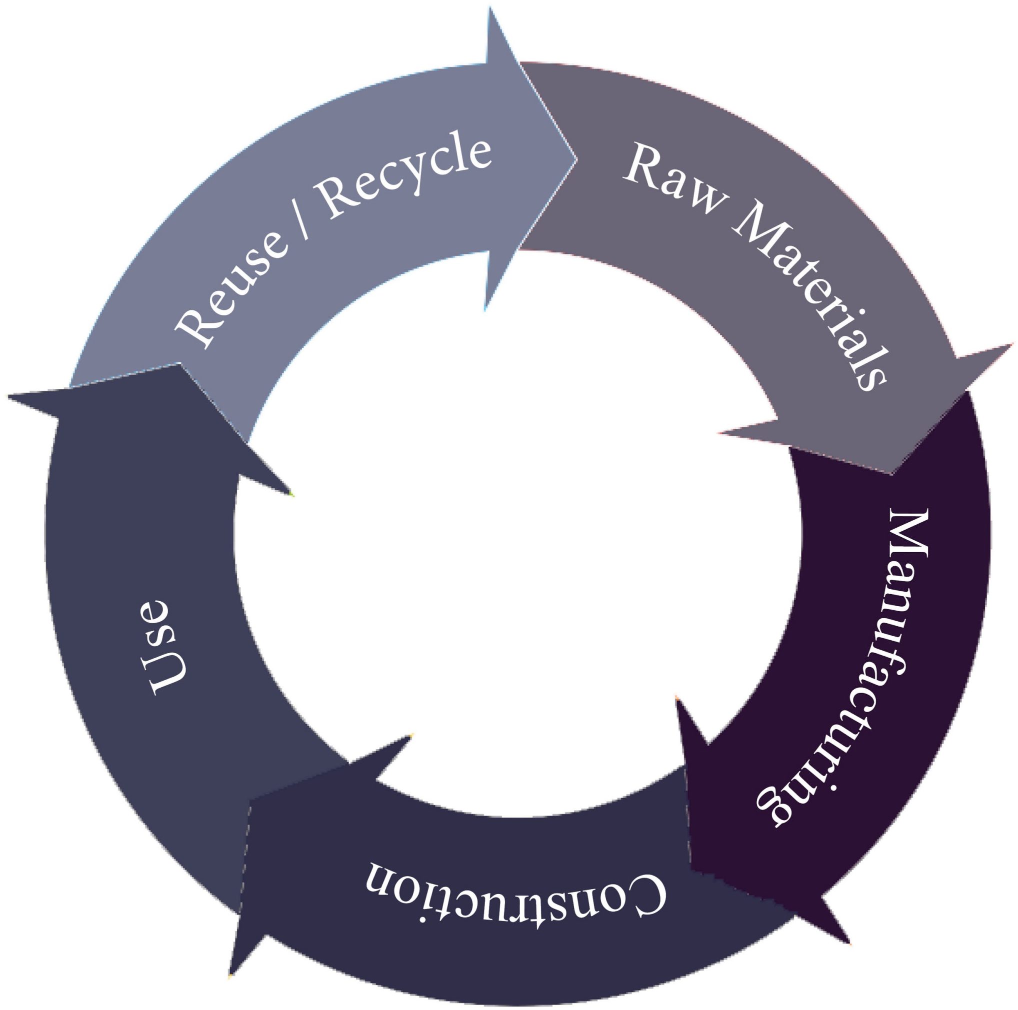
From linear to circular



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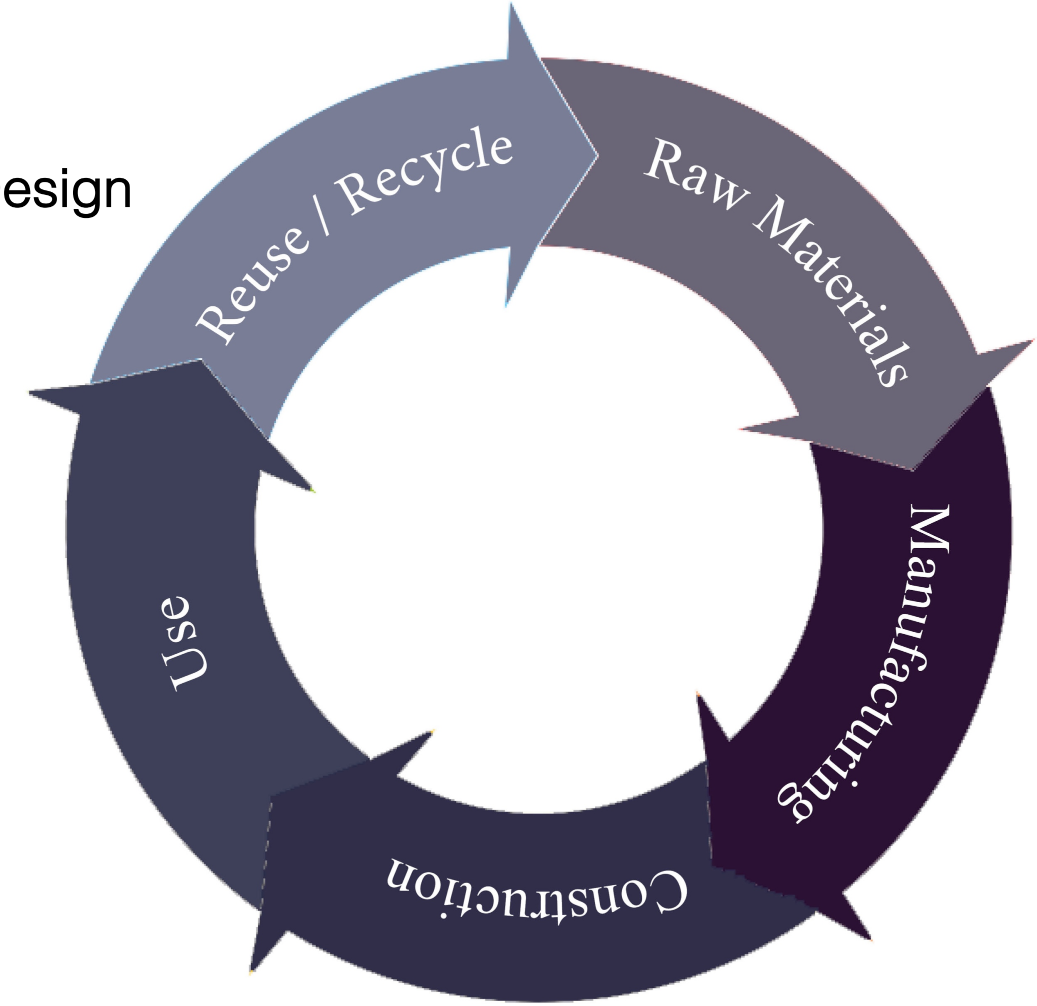
From linear to circular

Closed-loop

Reversible Design



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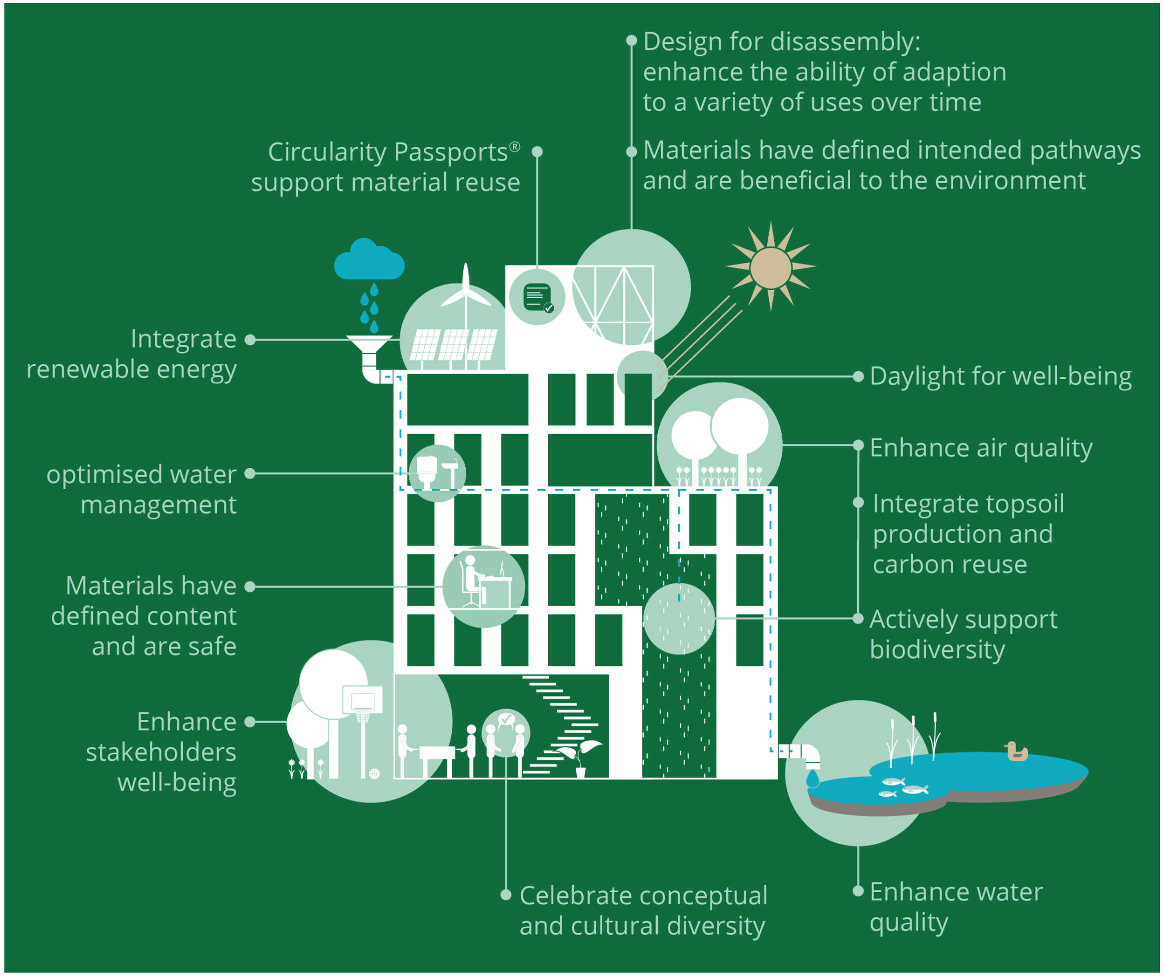
Cradle to Cradle

Waste Equals Food

Use Current Solar Income

Celebrate Diversity



Cradle to Cradle® in the Built Environment
Design for a Beneficial Footprint

EPEA The Cradle of Cradle to Cradle

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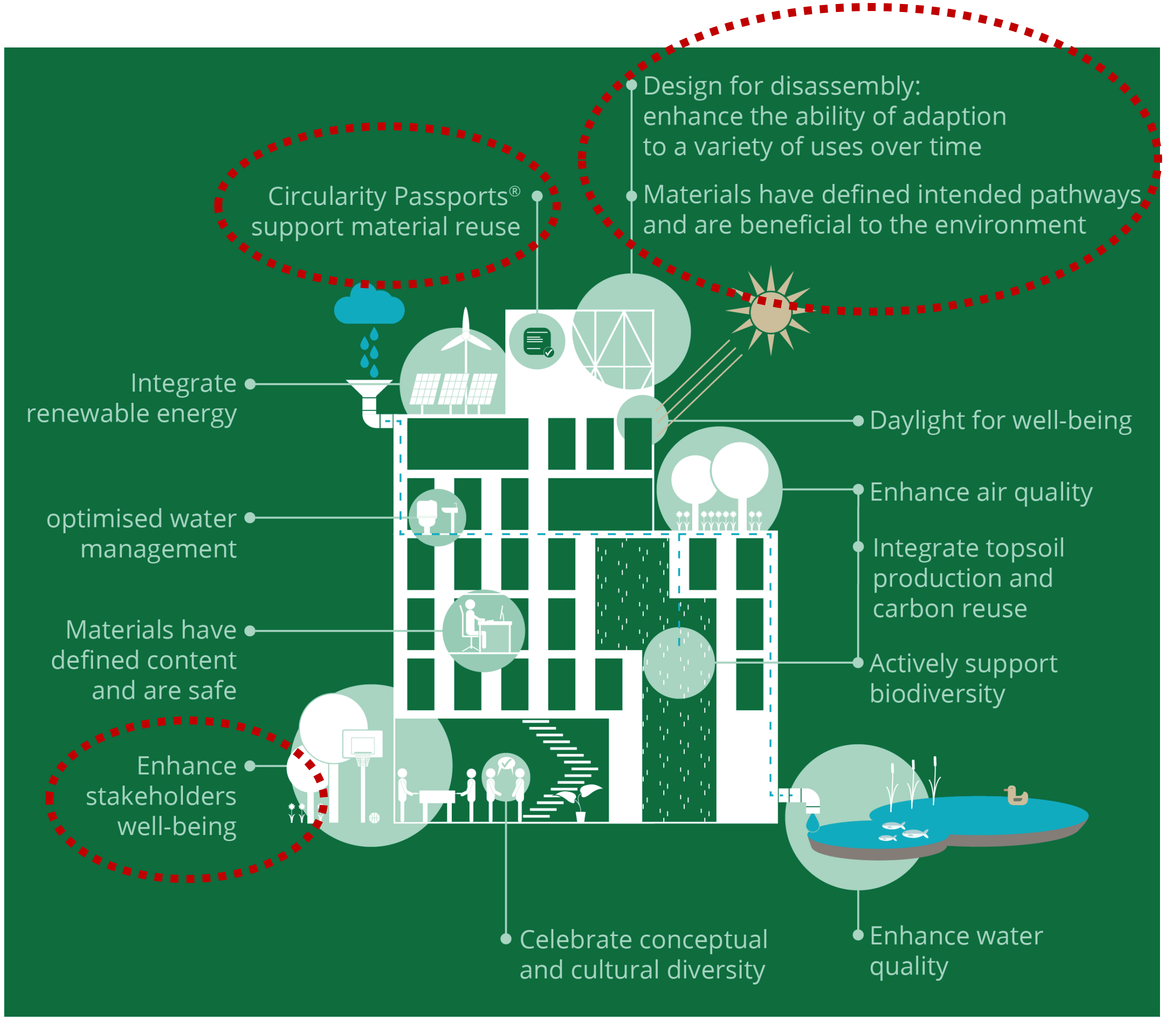

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Whole-life Carbon assessment

Building Assessment Information	Life Cycle Stages				Included in Assessment
Building Life Cycle Information	Product Stage		A1	Raw material supply	Yes
			A2	Transport	Yes
			A3	Manufacturing	Yes
	Construction Process Stage		A4	Transport	Yes
			A5	Construction Installation Process	Yes
	Use Stage (60 years)		B1	Use	Yes
			B2	Maintenance	Yes
			B3	Repair	Yes
			B4	Refurbishment	Yes
			B5	Replacement	No
			B6	Operational Energy Use	Yes
			B7	Operational Water Use	Yes
	End of Life Stage		C1	De-construction/Demolition	Yes
			C2	Transport	Yes
			C3	Waste Processing	Yes
			C4	Disposal	Yes
Beyond Building Life Cycle	Benefits and Loads		D	Reuse - Recovery - RecyclingPotential	No

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WLC Potential

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Cradle to Cradle & Whole-life Carbon assessment

Lack of

- unified and measurable framework
- detailed case studies
- post occupancy evaluation
- information on embodied carbon in buildings

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Case study LSE-CBR, London

Case Study to link theory with practice

- Short project introduction
- Embodied carbon study (LCA)
- Barriers to comprehensive, comparable LCA
- How the LCA informed the design

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Case study LSE-CBR, London

Rogers Stirk Harbour + Partners

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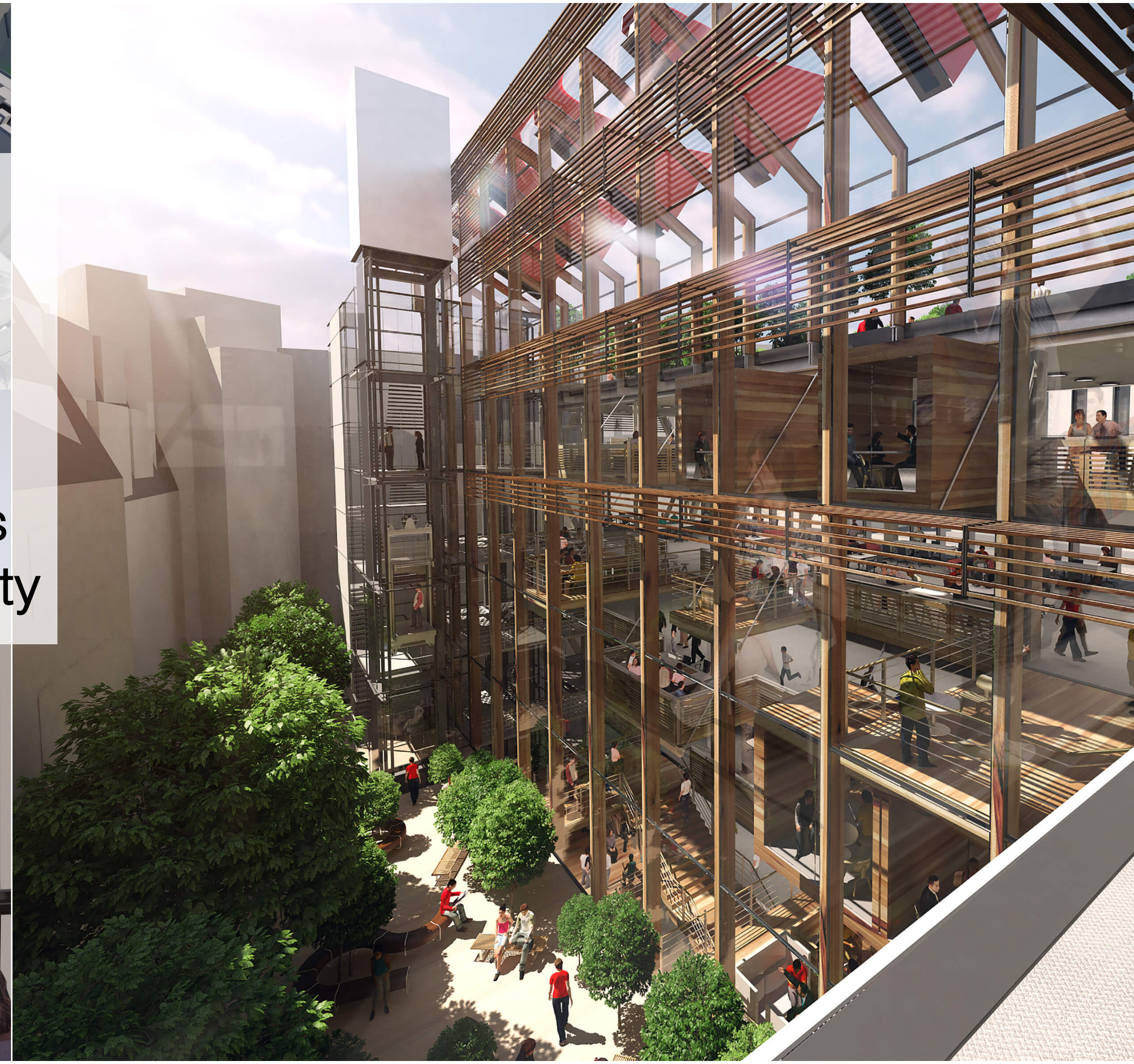
19,000 m²
£ 90 million
completion 2019

Faculty offices, teaching facilities, support spaces for Social Sciences faculty



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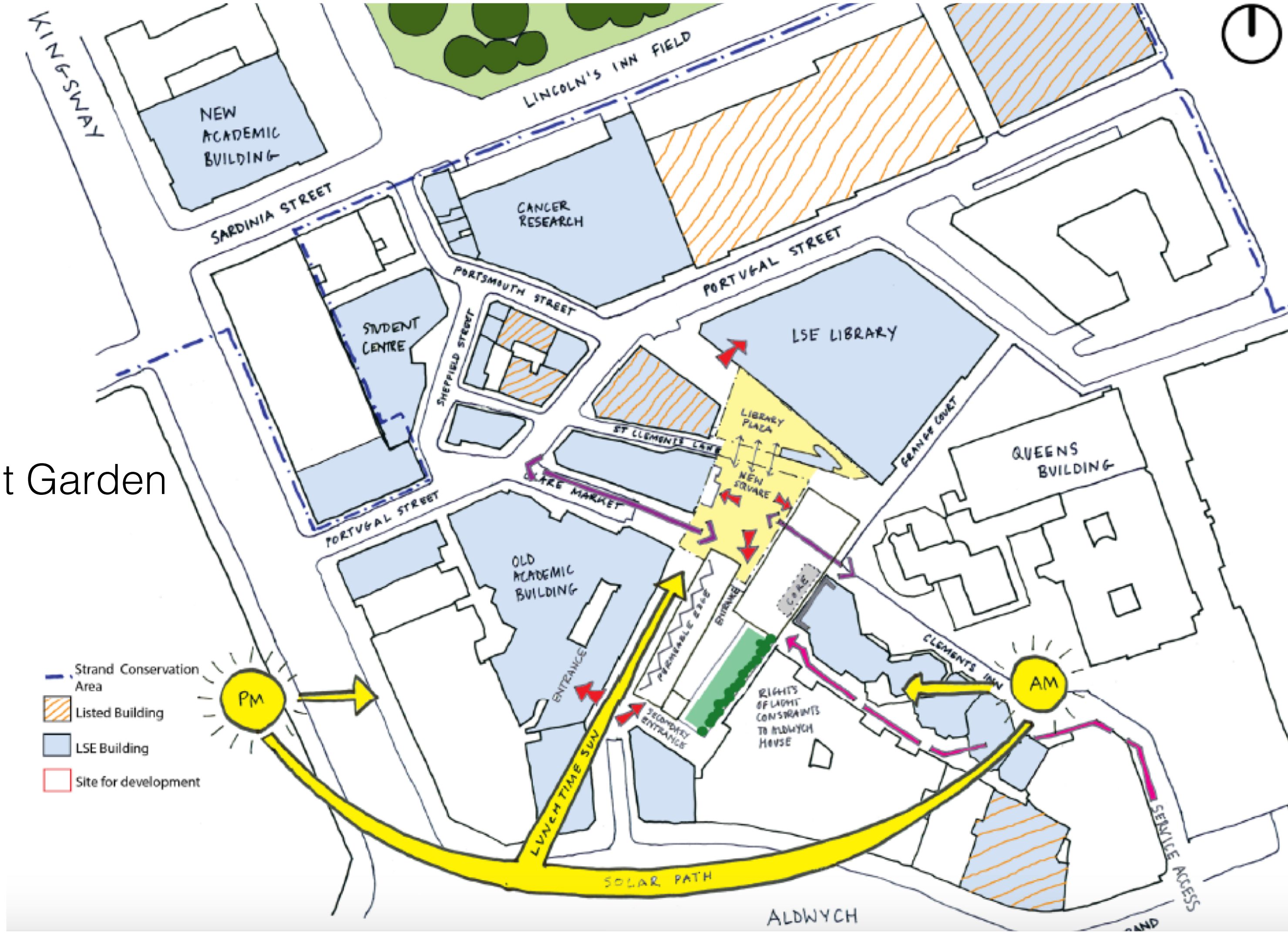

Covent Garden

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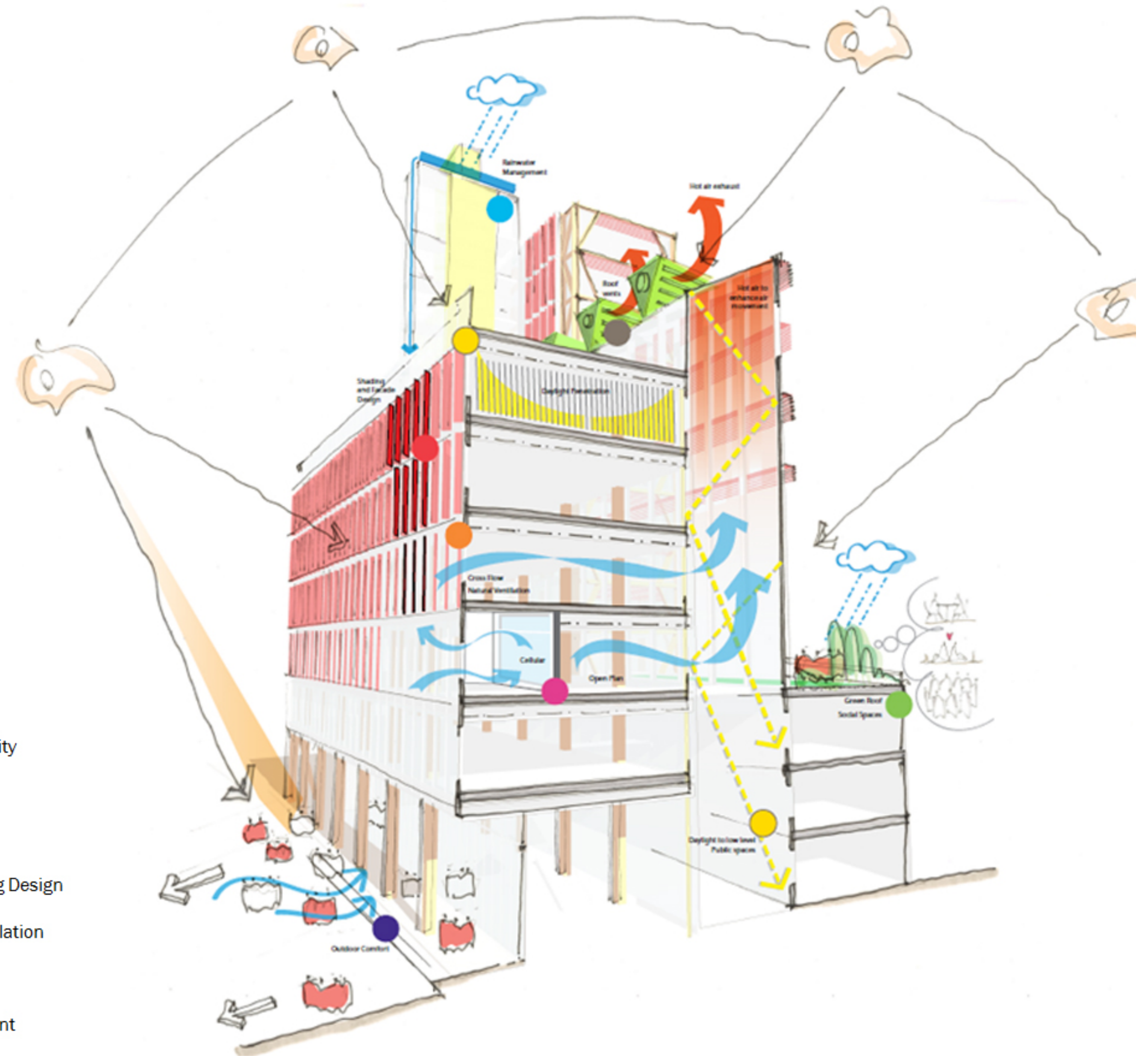

- Outdoor Comfort
- Flexibility & Adaptability
- Natural Ventilation
- Daylight Penetration
- Solar Control (Shading Design
- Atrium Design & Ventilation
- Green Roof
- Rainwater Management

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Collaboration: Client!

Passive Design Strategies

Reversible Building Design

Adaptable, Human Design

Zero Carbon in operation

- Outdoor Comfort
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- Natural Ventilation
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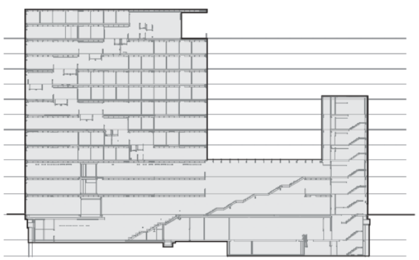
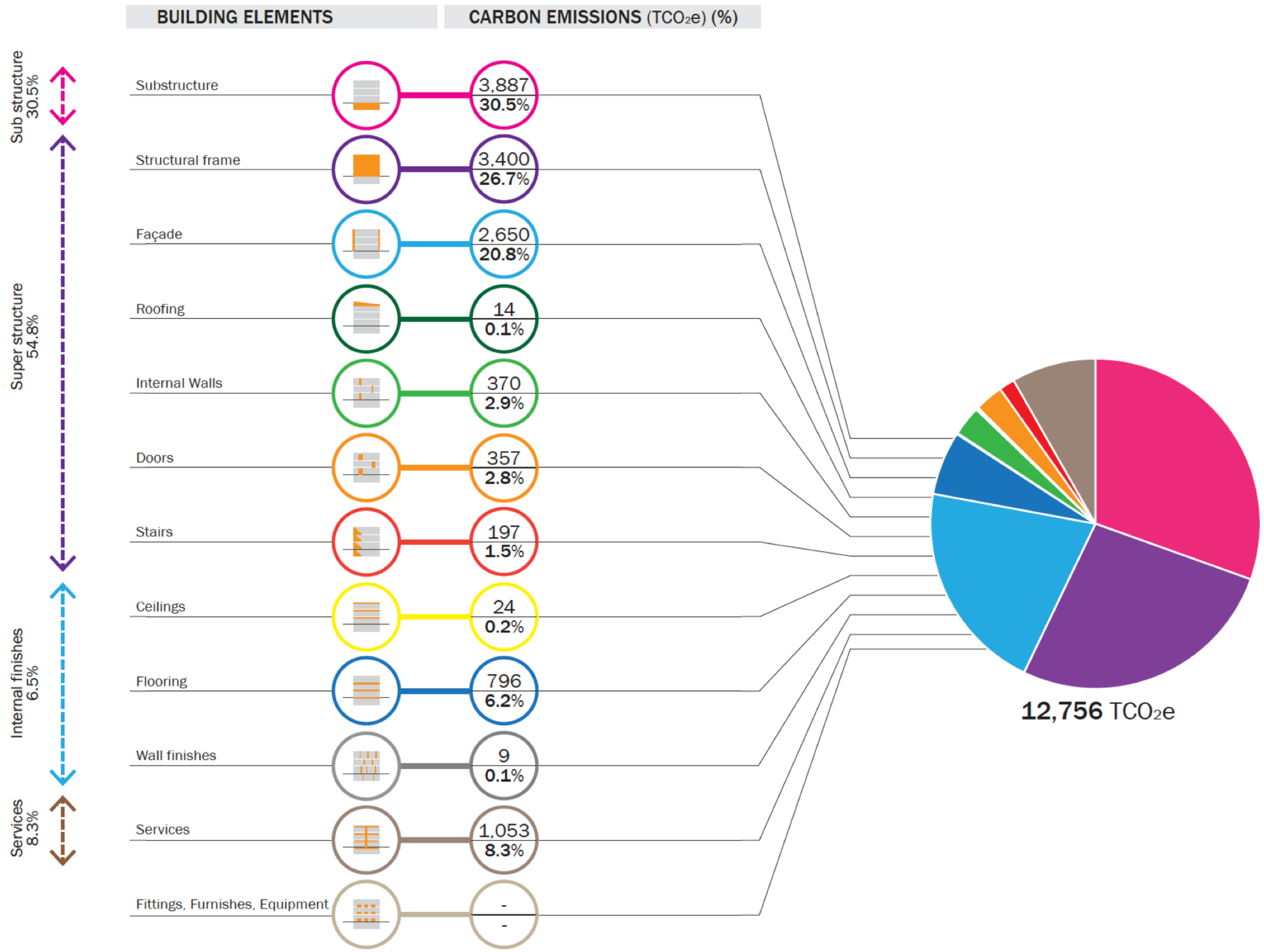
Embodied Carbon per Building Elements



Area: 15,507 m²



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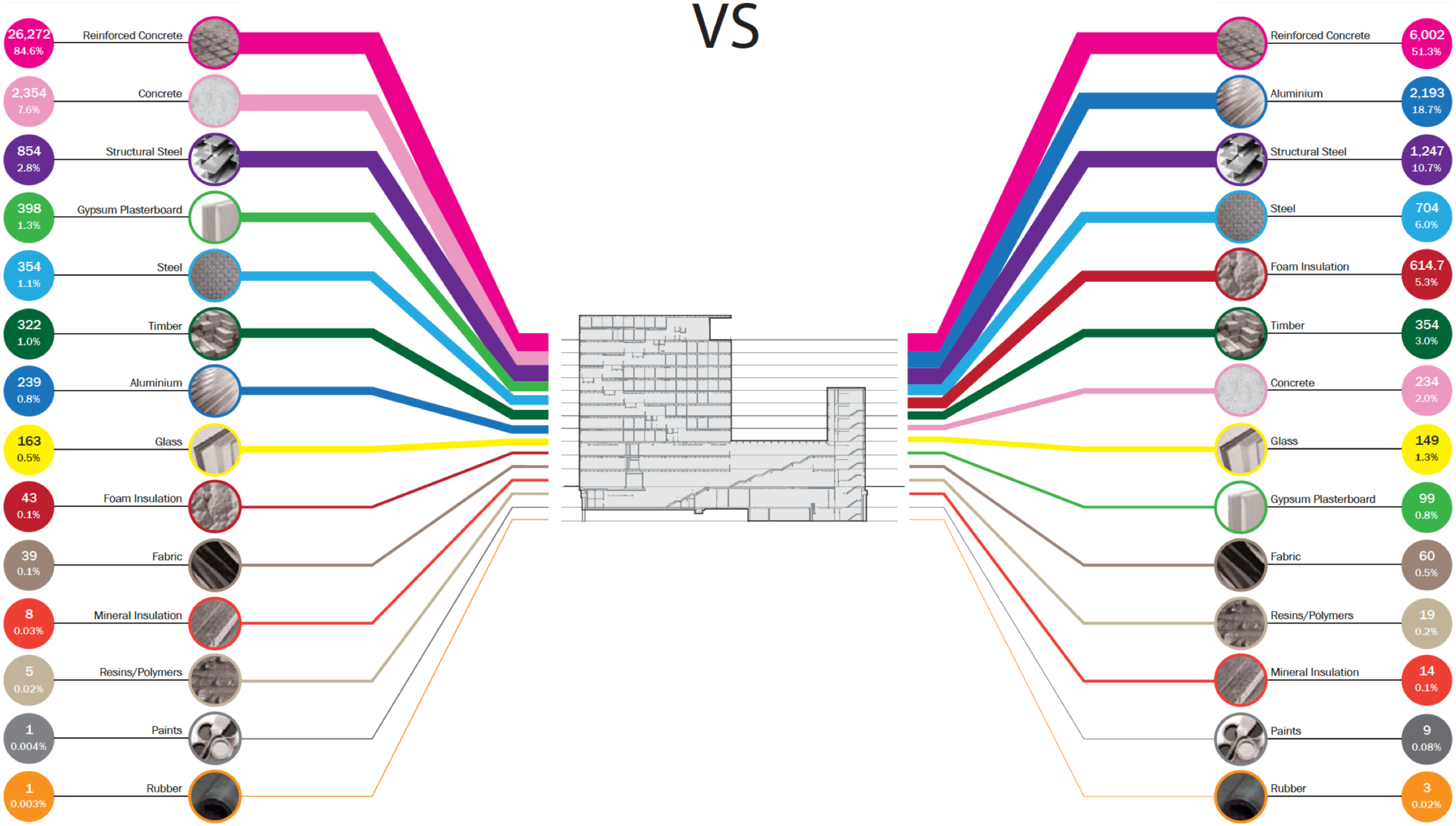
Material Quantity VS Embodied Carbon



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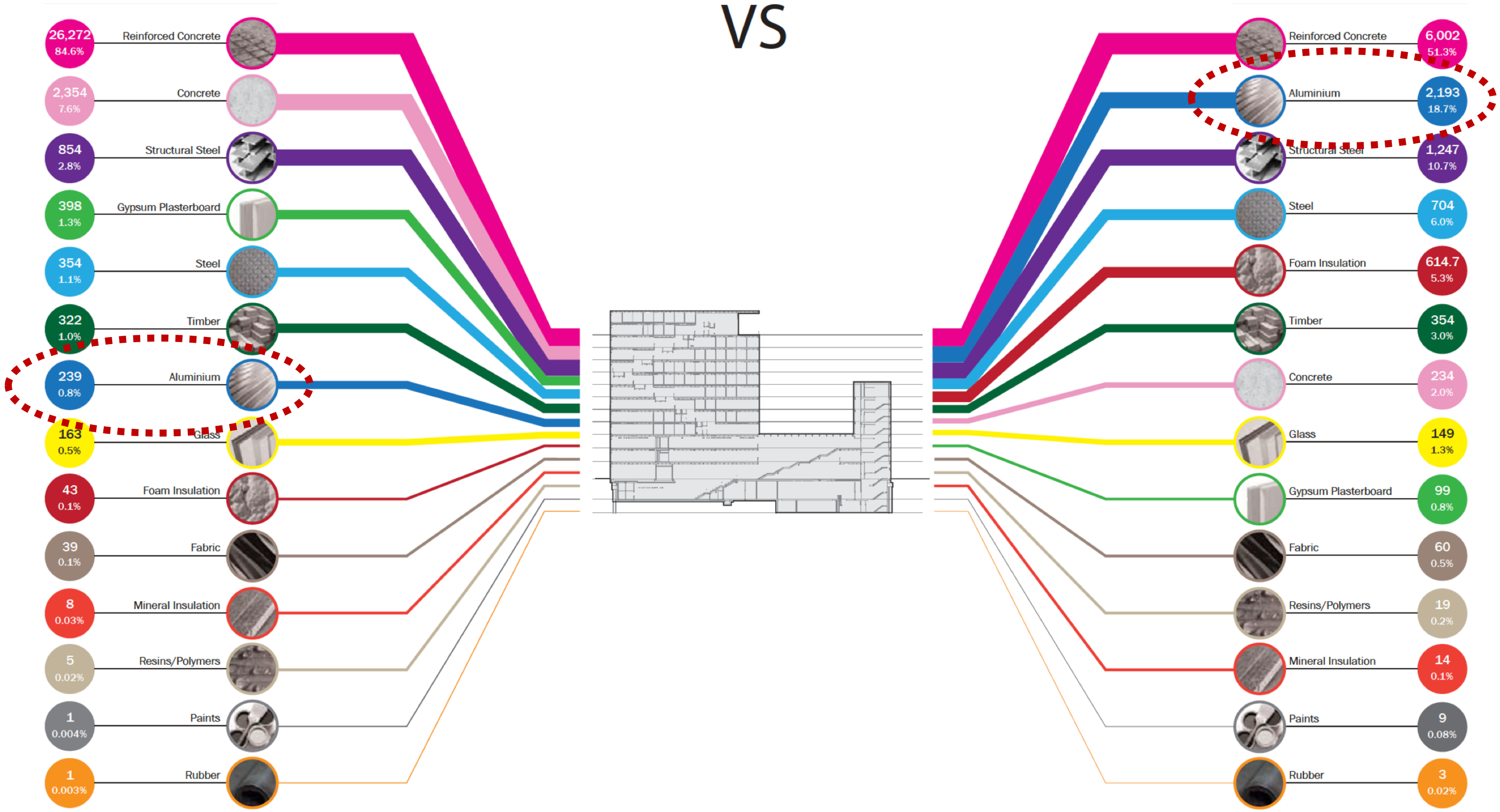

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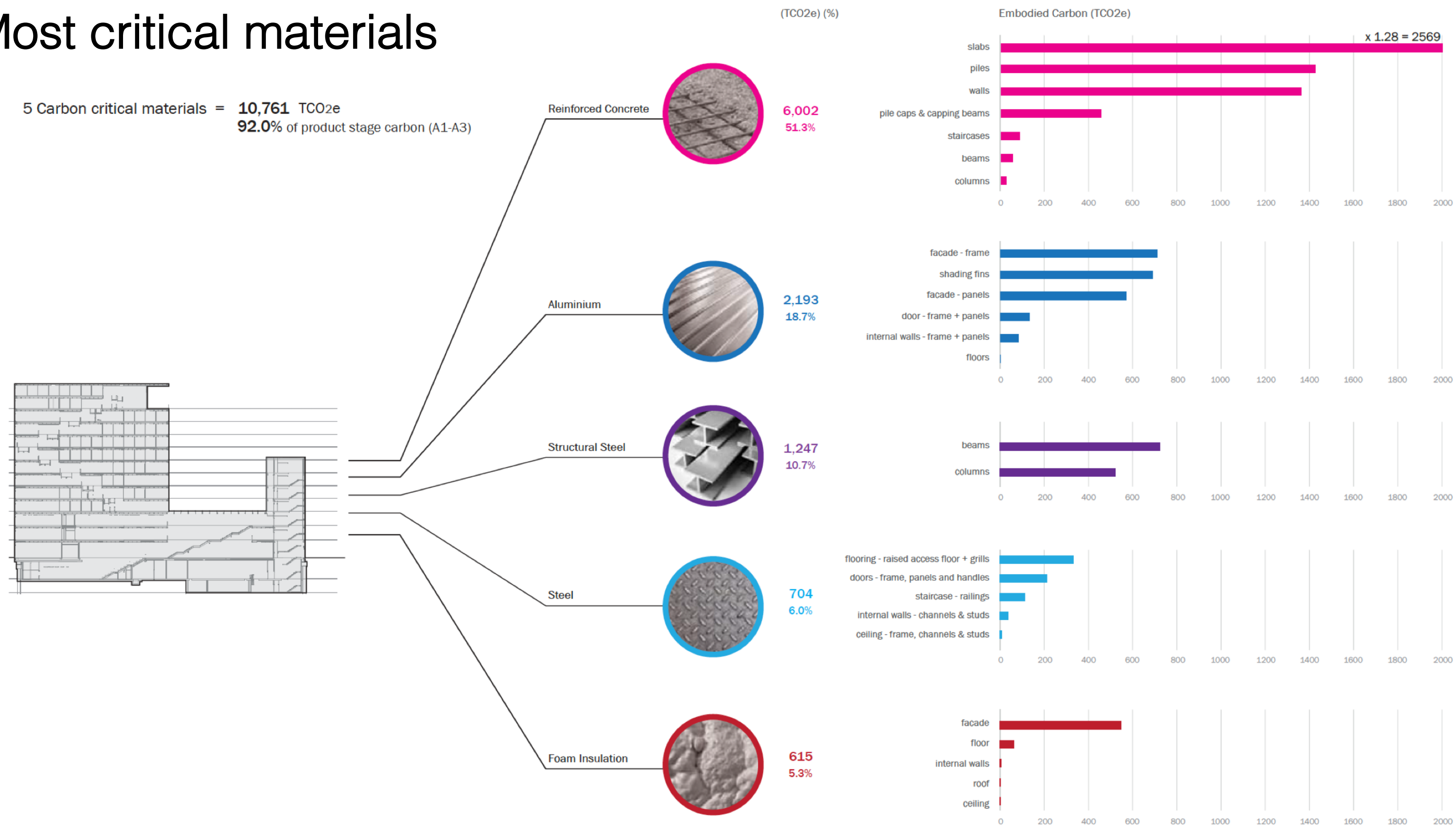
Embodied Carbon
Most critical materials

5 Carbon critical materials = **10,761** TCO2e
92.0% of product stage carbon (A1-A3)



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Case study LSE-CBR, London

Outcome of LCA varies depending on

- Benchmarks available

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Case study LSE-CBR, London

Outcome of LCA varies depending on

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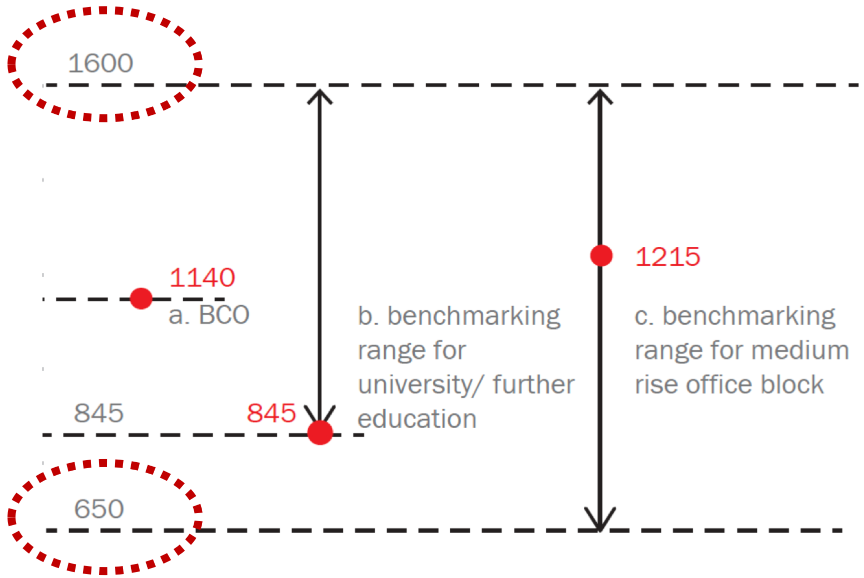
Atkins Carbon Critical Tool:

Medium rise office block

650 to 1600 $kgCO_{2e}/m^2$



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Outcome of LCA varies depending on

- Project stage (available information varies)

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Outcome of LCA varies depending on

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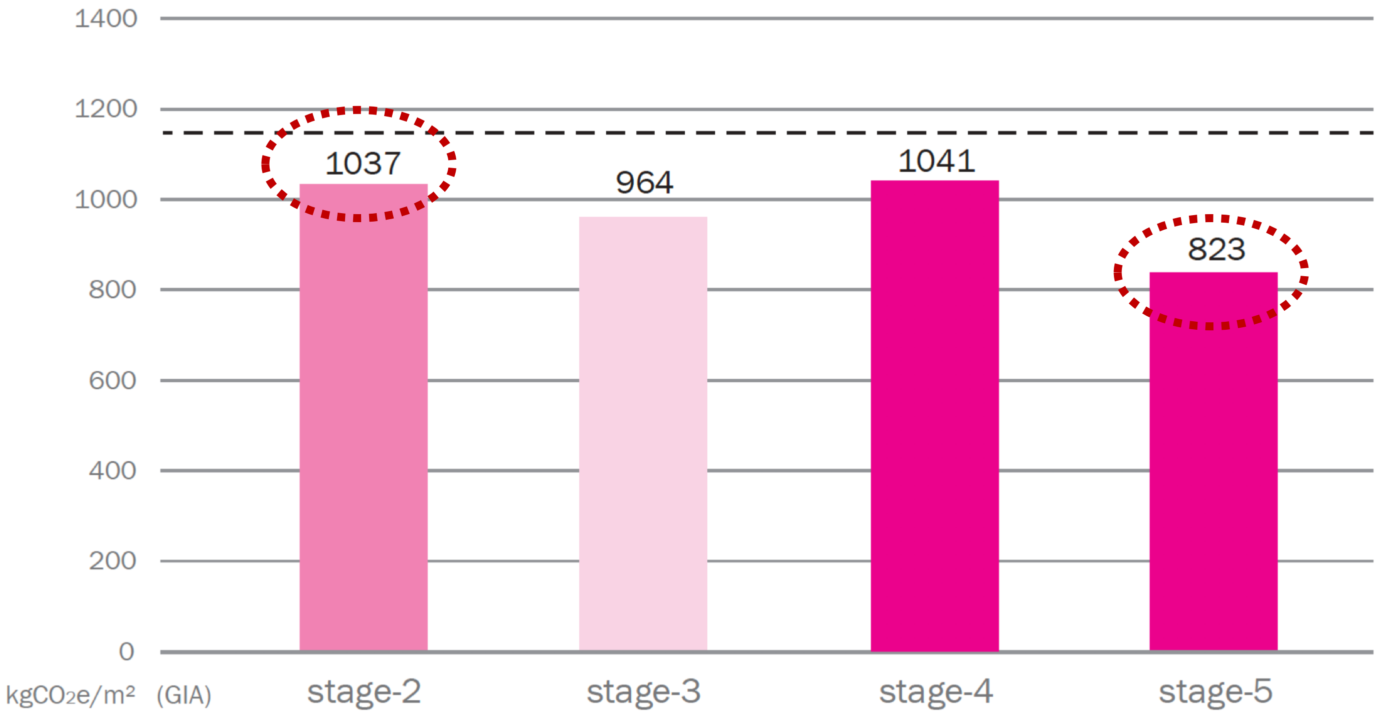

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How the LCA informed the design:

LSE-CBR measures to decrease embodied carbon

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How the LCA informed the design:

LSE-CBR measures to decrease embodied carbon

- Reduction in non-usable areas
- Improvements in material efficiency
- Sensible façade module design
- Improvement in piling design: volume reduction
- Increase of recycled steel in reinforced concrete

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LSE-CBR measures to decrease embodied carbon

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1kg **virgin** steel:	2.113 $kgCO_{2e}$
1kg **recycled** steel:	0.462 $kgCO_{2e}$

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Outcome of LCA varies depending on

- Information on materials (EPD etc lack info)

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Case study LSE-CBR, London

Outcome of LCA varies depending on

- Information on materials (EPD etc lack info)

  - Source of fabrication energy
  - Distance travelled
  - Production method
  - Maintenance and refurbishment effort
  - Lifespan
  - Ease of disassembly

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Case study LSE-CBR, London

Outcome of LCA varies depending on

- Time span considered (60 vs 100 years)

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Outcome of LCA varies depending on

- Time span considered (60 vs 100 years)

Low initial embodied energy ≠ Low whole-life embodied energy

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Outcome of LCA varies depending on

- **Time span considered (60 vs 100 years)**

Low initial embodied energy ≠ Low whole-life embodied energy

Embodied Carbon at Product Stage (A1-A3)	**823**	$kgCO_{2e}/m^2$
Operational Carbon at Use Stage (B1)	**2282**	$kgCO_{2e}/m^2$

Embodied Carbon = **21.6 years** of Operational Carbon

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Case study LSE-CBR, London

Predicted Total Carbon Footprint (60 years)

In $kgCO_{2e}/m^2$	3,291
In $kgCO_{2e}$	51,031,969

Life Cycle Stages split (in %)

Product stage	(A1-A3)	25.0%
Construction stage	(A4-A5)	1.4%
Use stage	(B1-B6)	72.5%
End of Life stage	(C1-C4)	1.1%
Beyond Life cycle	(D)	n/a

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Case study LSE-CBR, London

Project Study lacks

Beyond building lifecycle (Reuse, Recovery, Recycling Potential)

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Towards a circular economic building sector

BAMB
BUILDING AS MATERIAL BANKS

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Towards a circular economic building sector

Combine Cradle to Cradle & Whole-life Carbon assessment

C2C + Criteria of other Certification Systems	Operational Carbon (as in LCA) + Embodied Carbon

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Combine Cradle to Cradle & Whole-life Carbon assessment

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Operational Carbon (as in LCA) + Embodied Carbon

Enhanced C2C Criteria + **Whole-life Carbon (WLC)**

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Optimized Assessment Framework towards a **Circular Economic Building Sector**

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Towards a circular economic building sector

Combination of C2C & WLC indicators

-> Potential to improve

-> Opportunity of a comprehensive, unified assessment framework for a circular building sector

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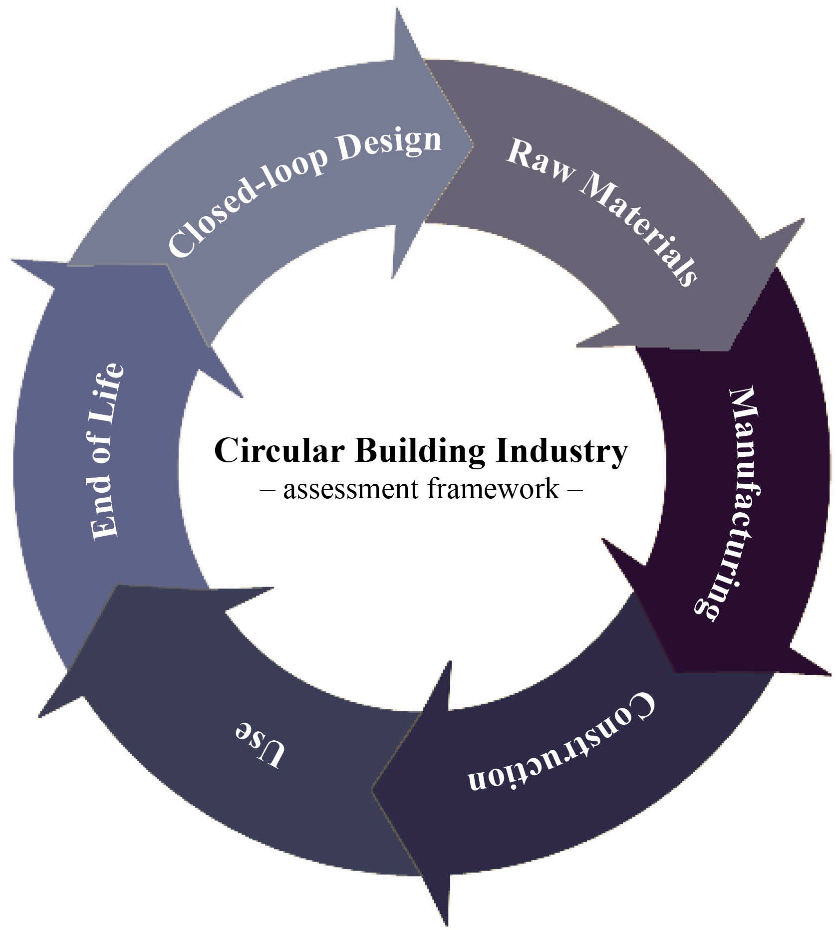
Towards a circular economic building sector



1. Closed-loop Design
- Design for Well-Being (daylight, air & water quality, (bio-) diversity, water management, renewable energies) ○
- Design for Disassembly ○
- Collaboration w. Steakholders ○
-> Integrated Design: BIM ■

2. Raw Materials
- Extract △
- Process △
- Transport □△
-> Resource Management ■
-> Resource Locator on site ■

3. Manufacturing
- Fabrication Energy used △
-> Precast / In-situ? ■
- Carbon Management □○
- Water Stewardship □○
- Material Health ○
- Social Fairness ○
-> Material Passports ○
-> Circularity Passports ○

4. Construction
- Transport □△
- Installation Process □△
-> Material Application (Quantity: Embodied Carbon) ■

5. Use
- Maintenance □△
- Repair / Refurbishment □△
- Replacement: Leasing? ■
- Operational Energy Use □△
- Operational Water Use □△
-> Lifespan? ■
-> BMS + Resource Locator ■

6. End of Life
- De-Construction (Instructions □△ & Take-Back Services) ■
- Biological Degradation ○
- Reuse / Recover / Recycle ■
-> "Material Bank" ■
-> Avoid Demolition (Waste Processing, Transport, Disposal) □△
-> Circularity Passports ○
-> Post-Occupancy Evaluation ■

○ C2C □ LCA △ WLC ■ Potential to improve

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Towards a circular economic building sector

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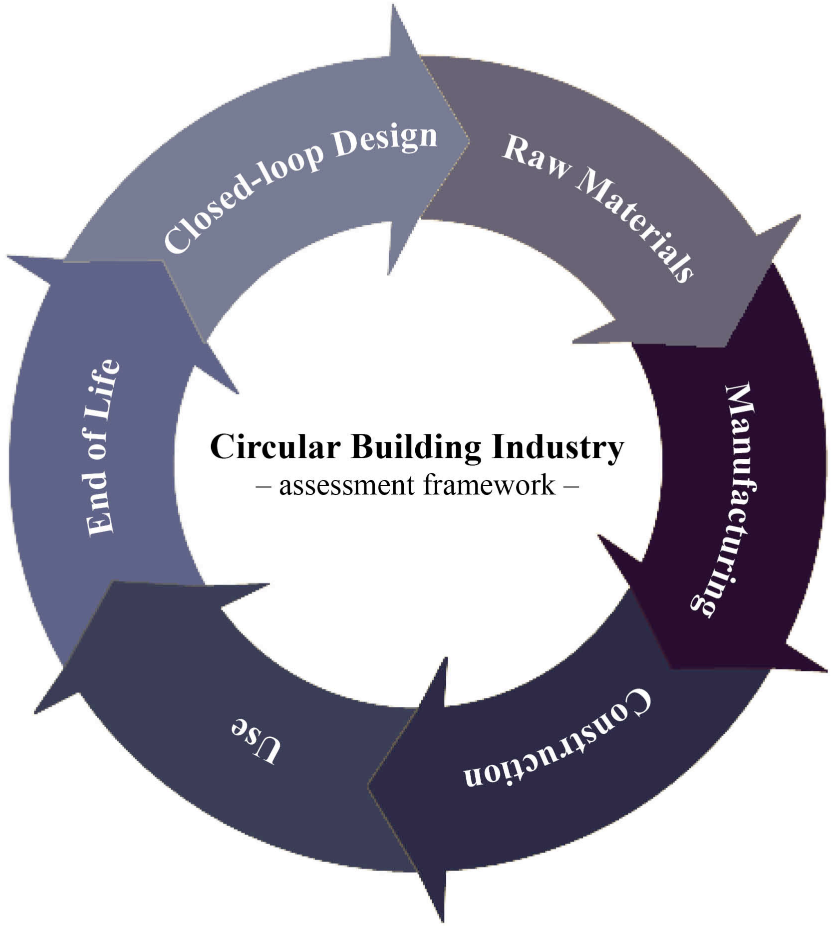

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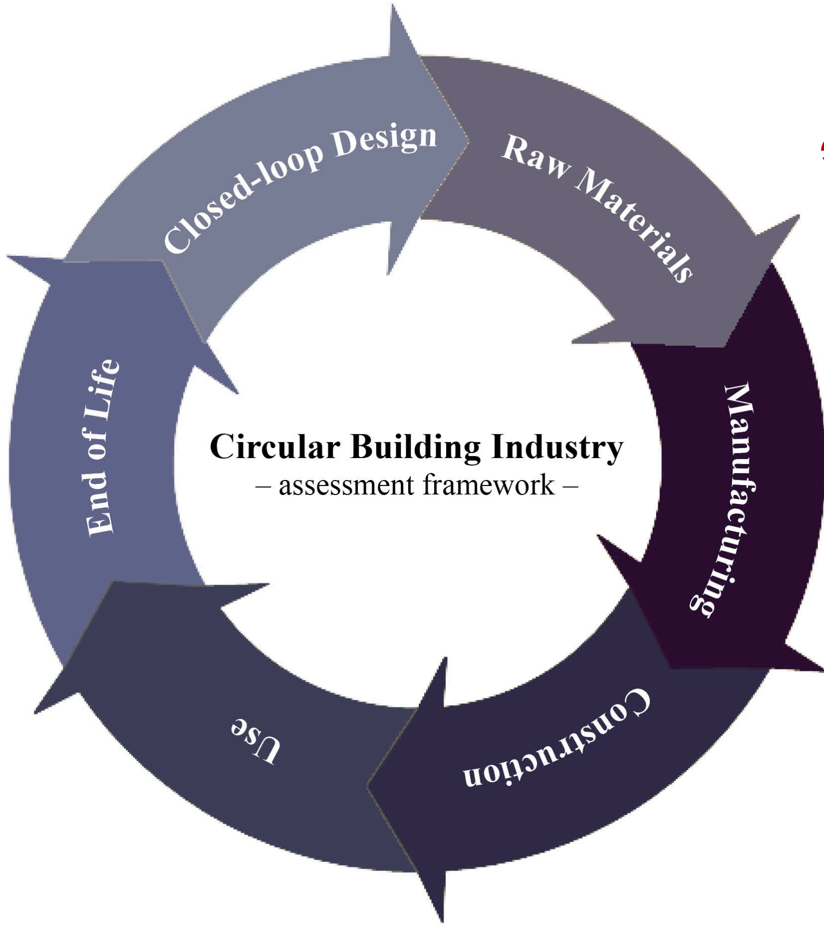

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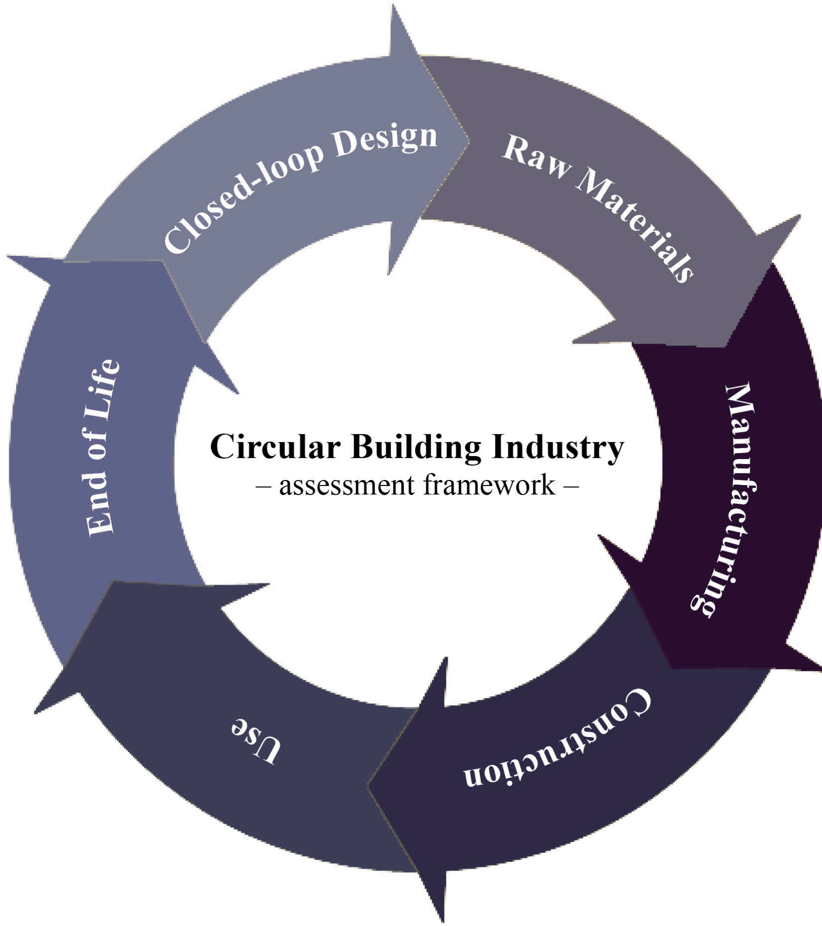

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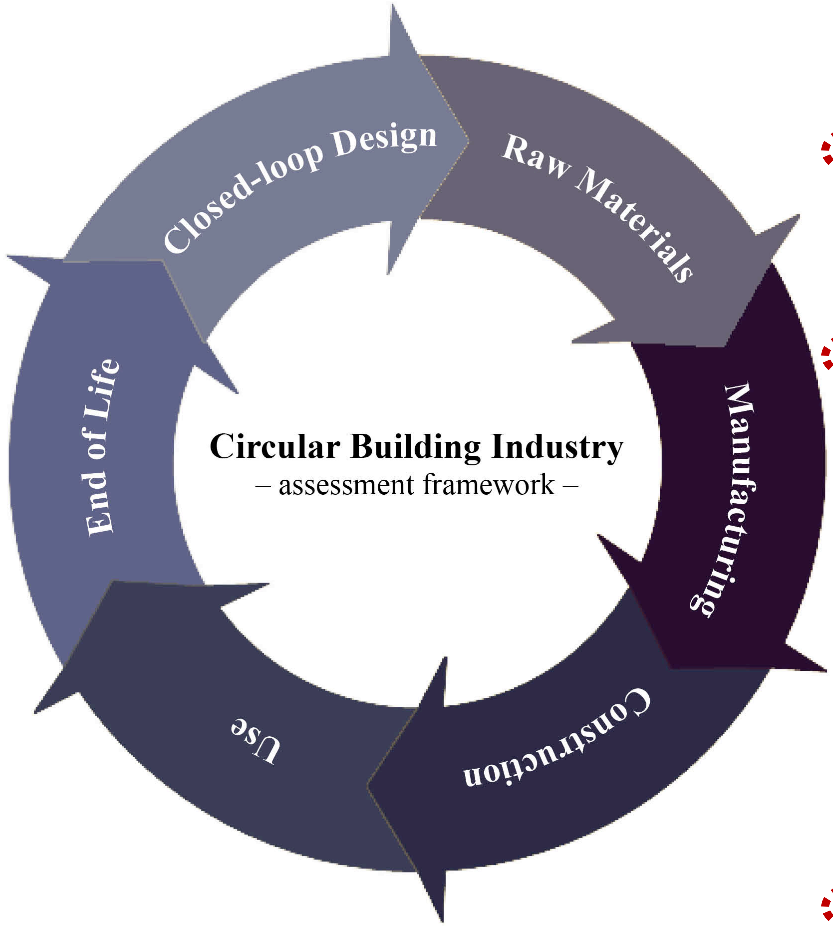

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-> Material Application (Quantity: Embodied Carbon) ■

○ C2C □ LCA △ WLC ■ Potential to improve

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Towards a circular economic building sector

1. Closed-loop Design

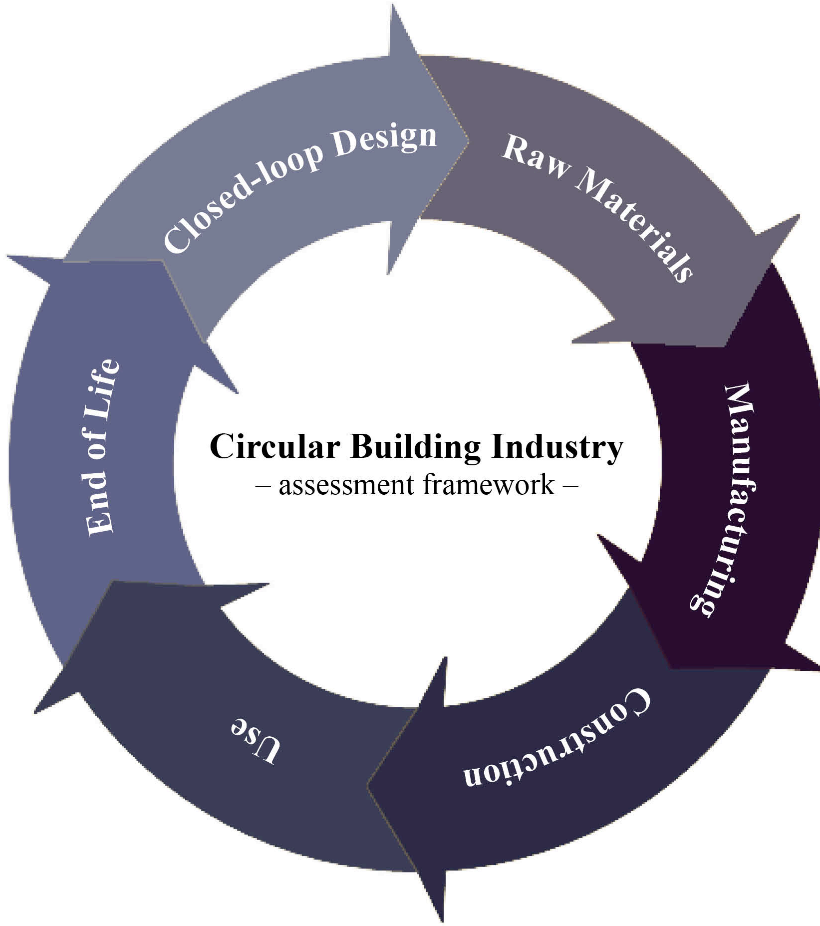
- Design for Well-Being (daylight, air & water quality, (bio-) diversity, water management, renewable energies) ○
- Design for Disassembly ○
- Collaboration w. Steakholders ○
- -> Integrated Design: BIM ■

6. End of Life

- De-Construction (Instructions & Take-Back Services) □△ ■
- Biological Degradation ○
- Reuse / Recover / Recycle ■
- -> "Material Bank" ■
- -> Avoid Demolition (Waste Processing, Transport, Disposal) □△
- -> Circularity Passports ○
- -> Post-Occupancy Evaluation ■

5. Use

- Maintenance □△
- Repair / Refurbishment □△
- Replacement: Leasing? ■
- Operational Energy Use □△
- Operational Water Use □△
- -> Lifespan? ■
- -> BMS + Resource Locator ■



2. Raw Materials

- Extract △
- Process △
- Transport □△
- -> Resource Management ■
- -> Resource Locator on site ■

3. Manufacturing

- Fabrication Energy used △
- -> Precast / In-situ? ■
- Carbon Management □○
- Water Stewardship □○
- Material Health ○
- Social Fairness ○
- -> Material Passports ○
- -> Circularity Passports ○

4. Construction

- Transport □△
- Installation Process □△
- -> Material Application (Quantity: Embodied Carbon) ■

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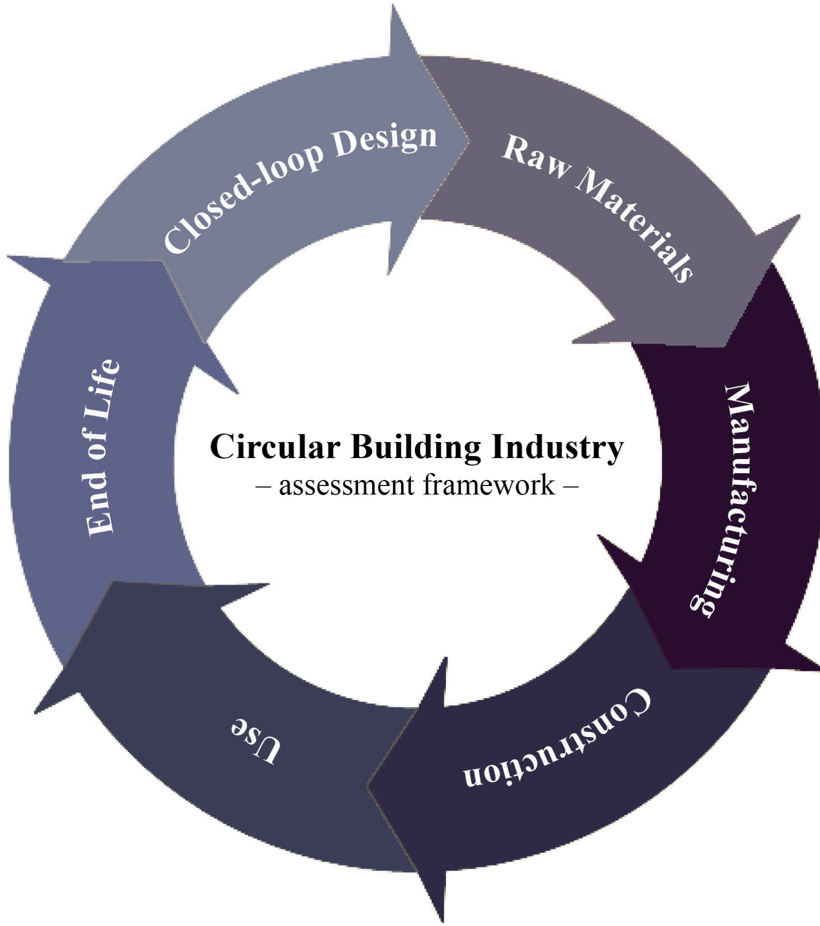

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BAMB BUILDING AS MATERIAL BANKS
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Another case study… ECOLAR

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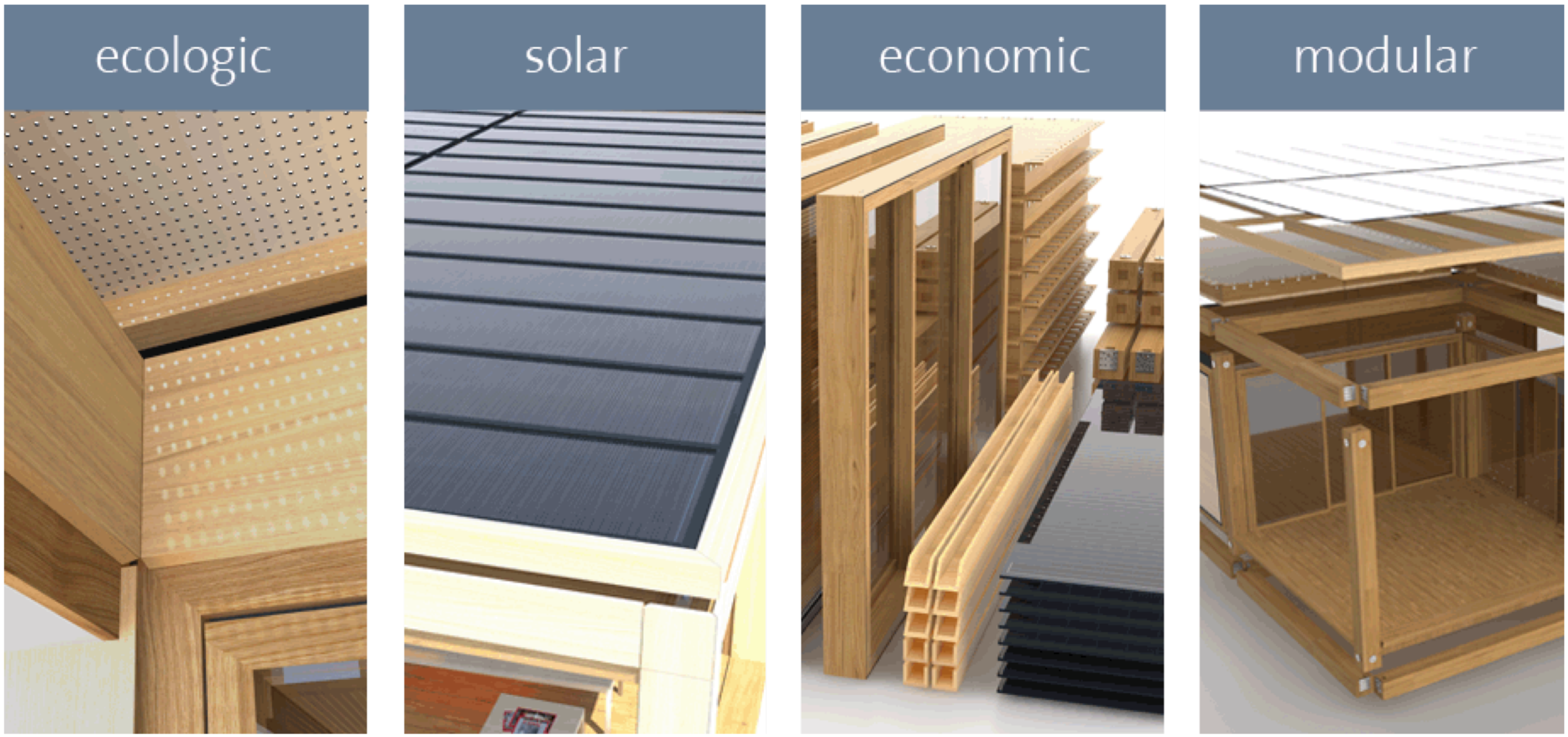
http://sde2012.htwg-konstanz.de



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Thank you!

Noemi Futás

University of Westminster / Urban Systems Design

noemi.futas@gmail.com

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