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LIFE CYCLE CARBON ANALYSIS OF BUILDINGS

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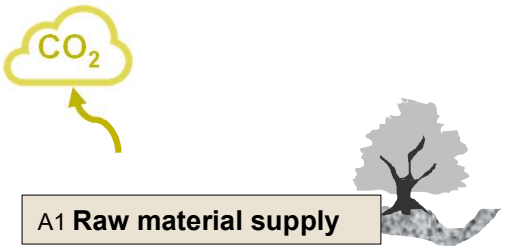
Lenum.

Carbon emissions along a building's life cycle

Building life cycle environmental information

According to DIN EN 15978



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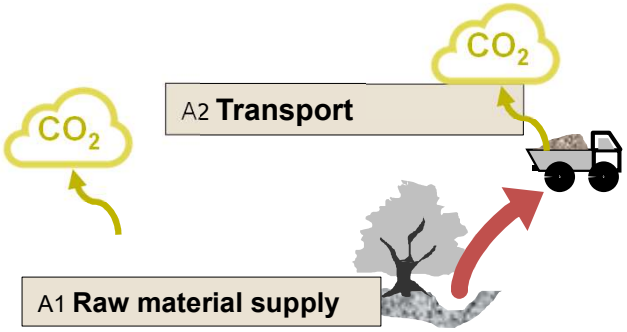

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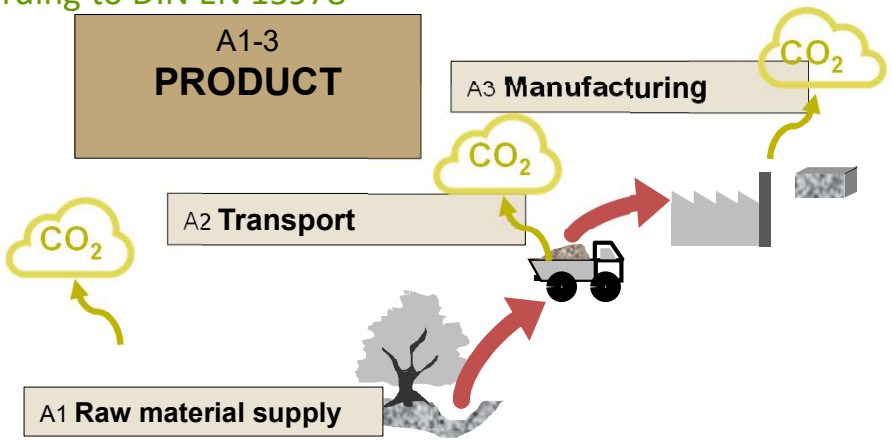

A3 Production of building materials / components

- emissions from factories

Source: www.cretaceousfossils.com

A3 Energy production ->embodied carbon

- emissions, primarily into air

Building life cycle environmental information

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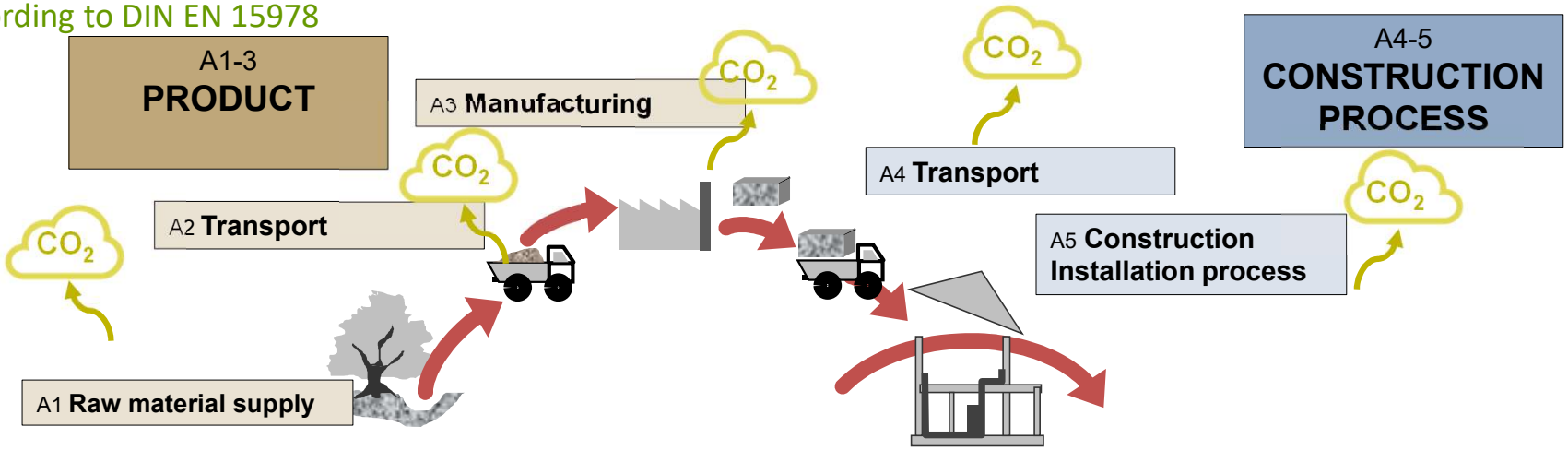

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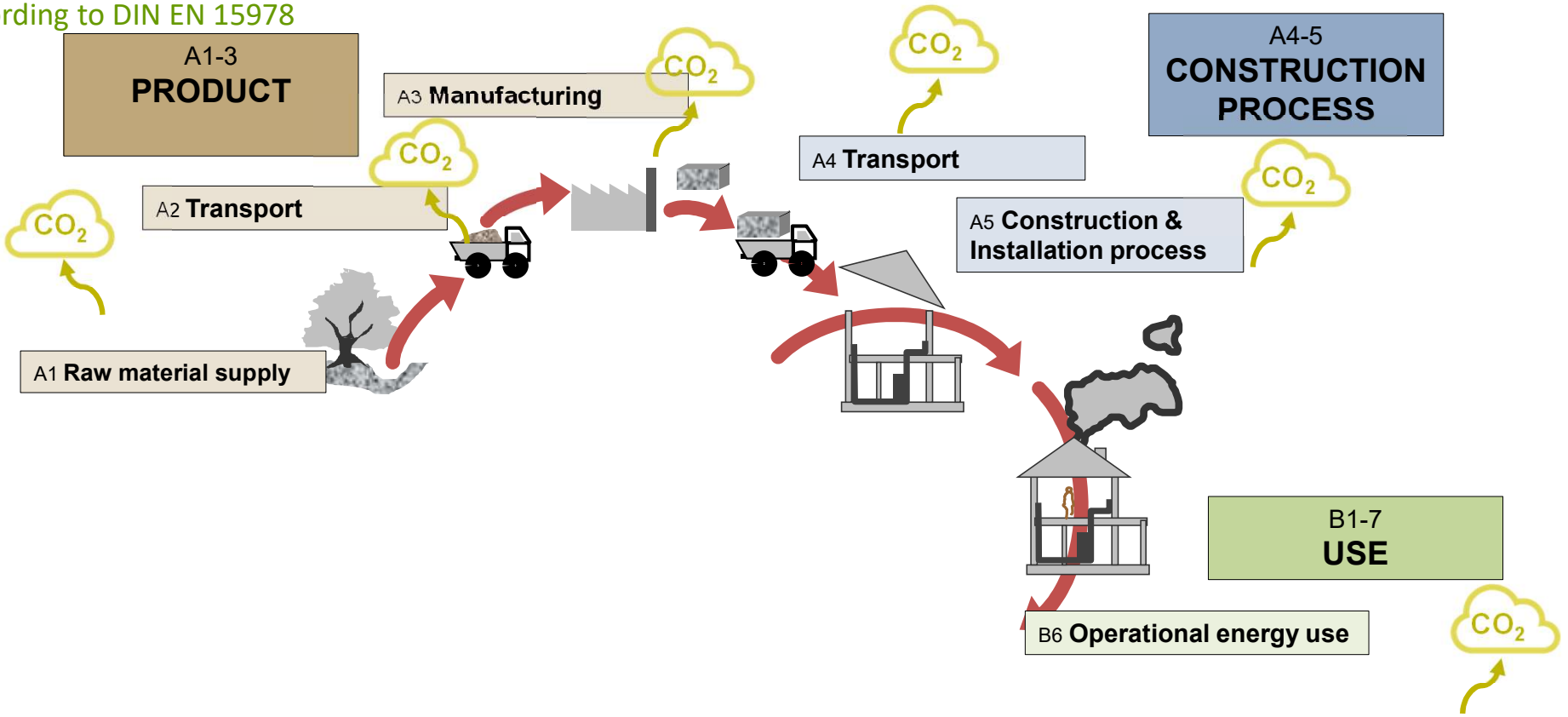

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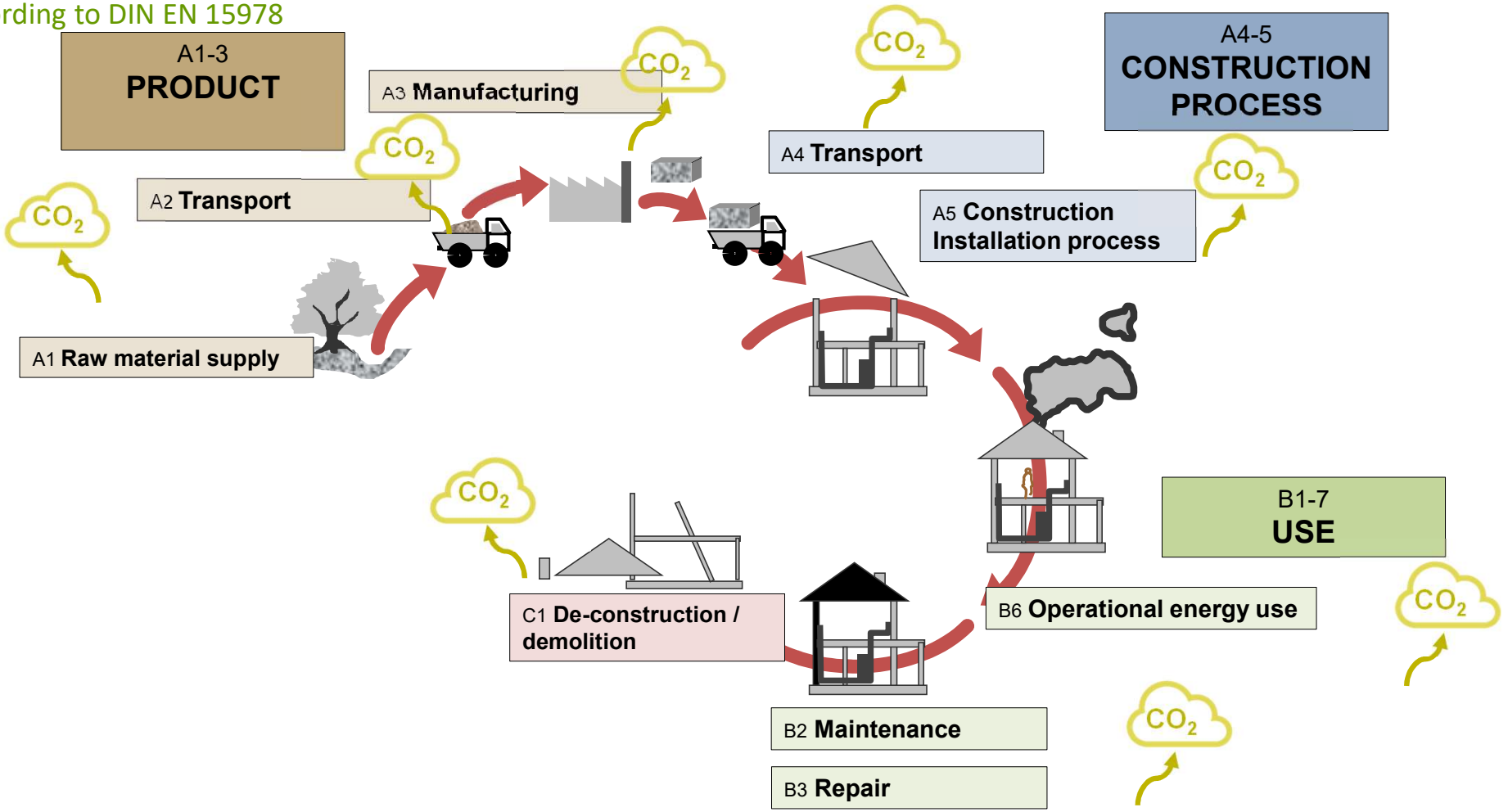

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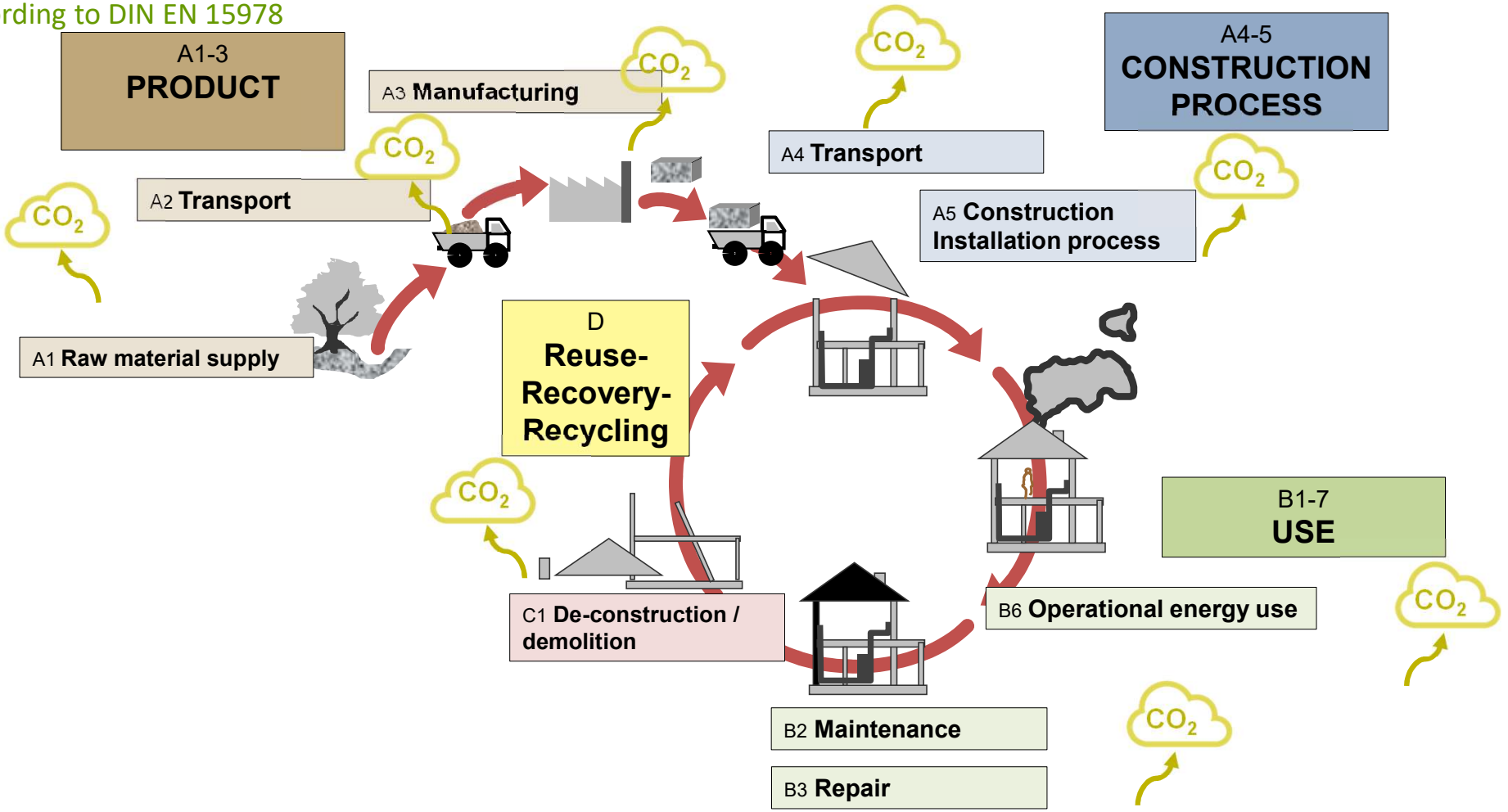
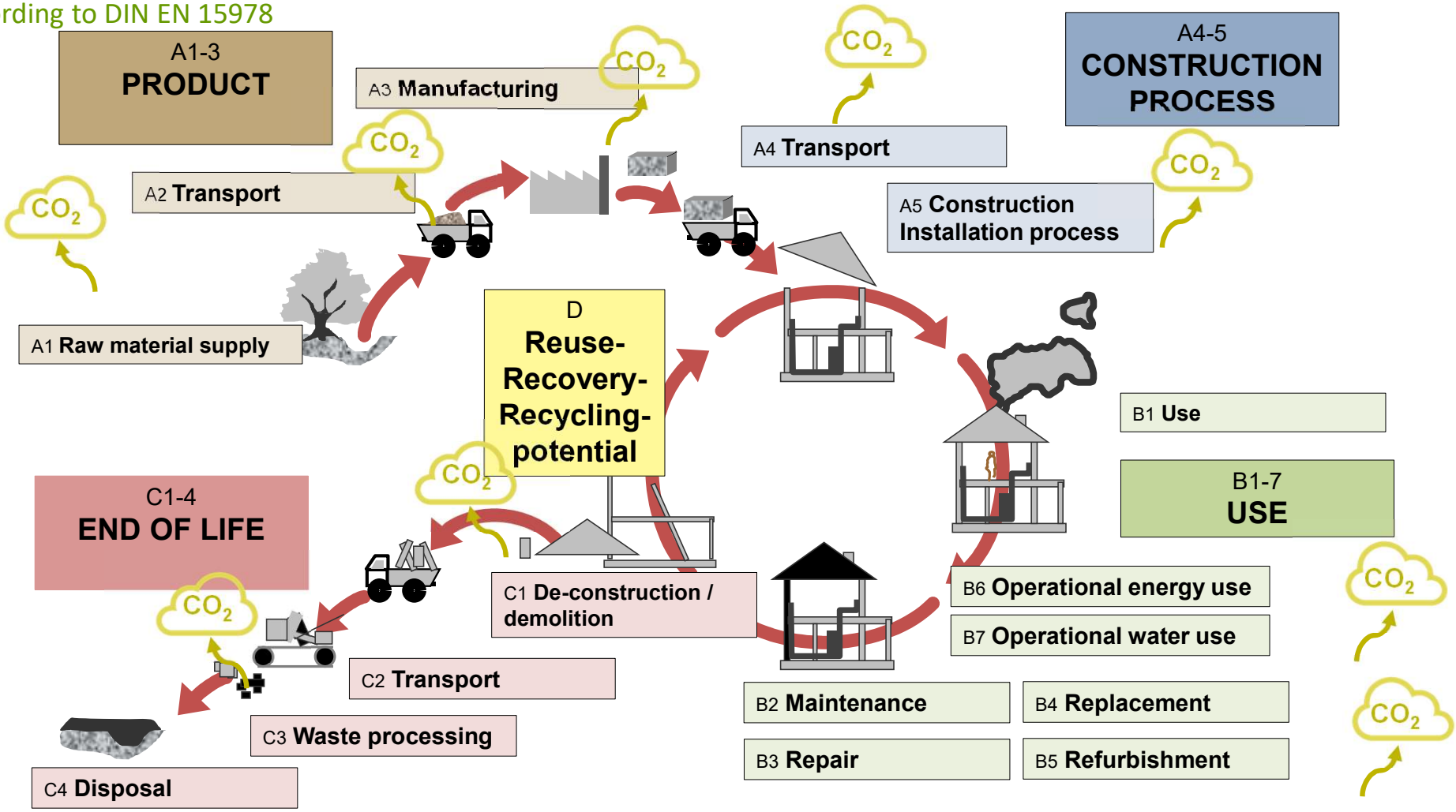


Originalgraphik mit allen Teilphasen

According to DIN EN 15978



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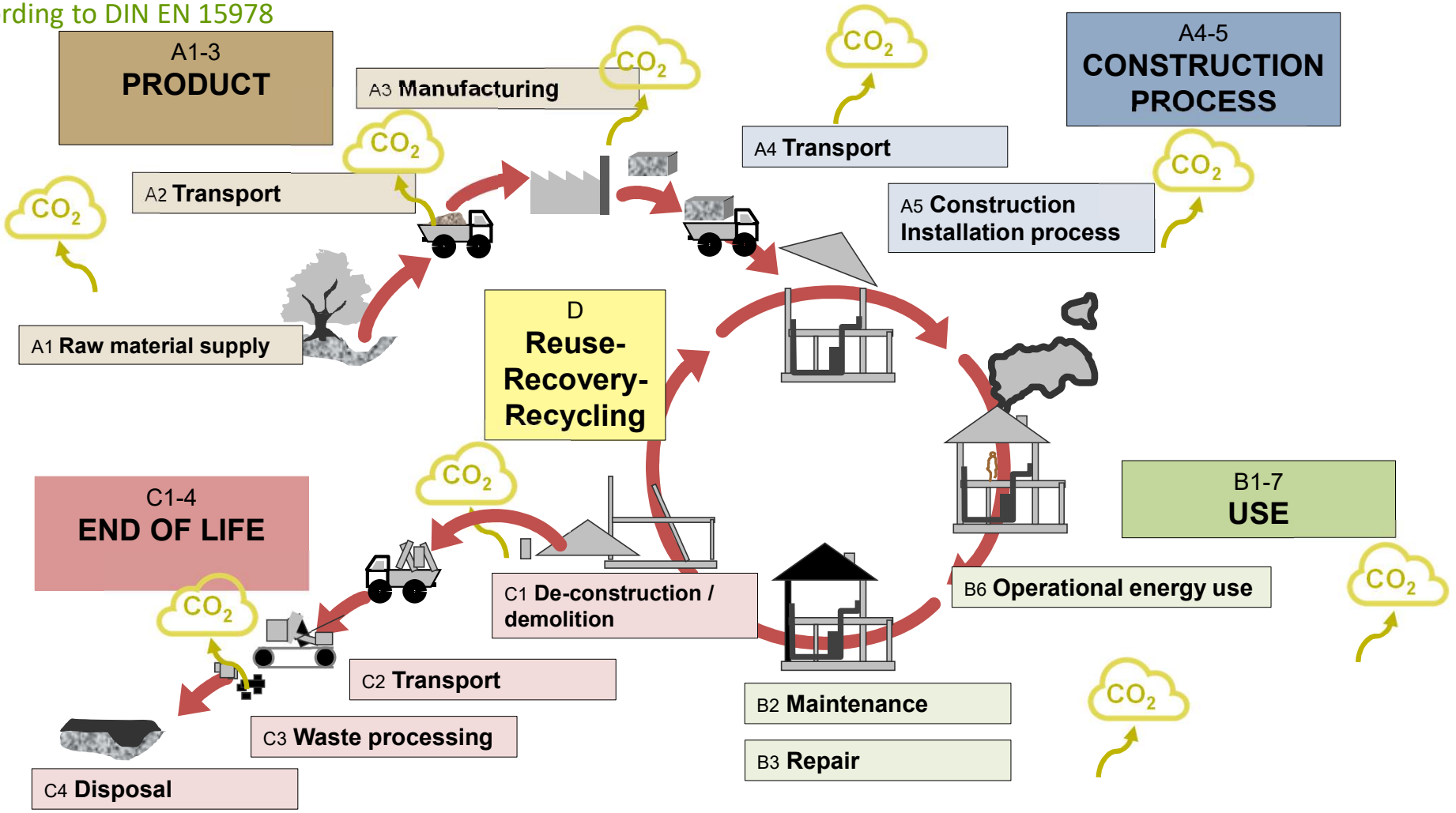

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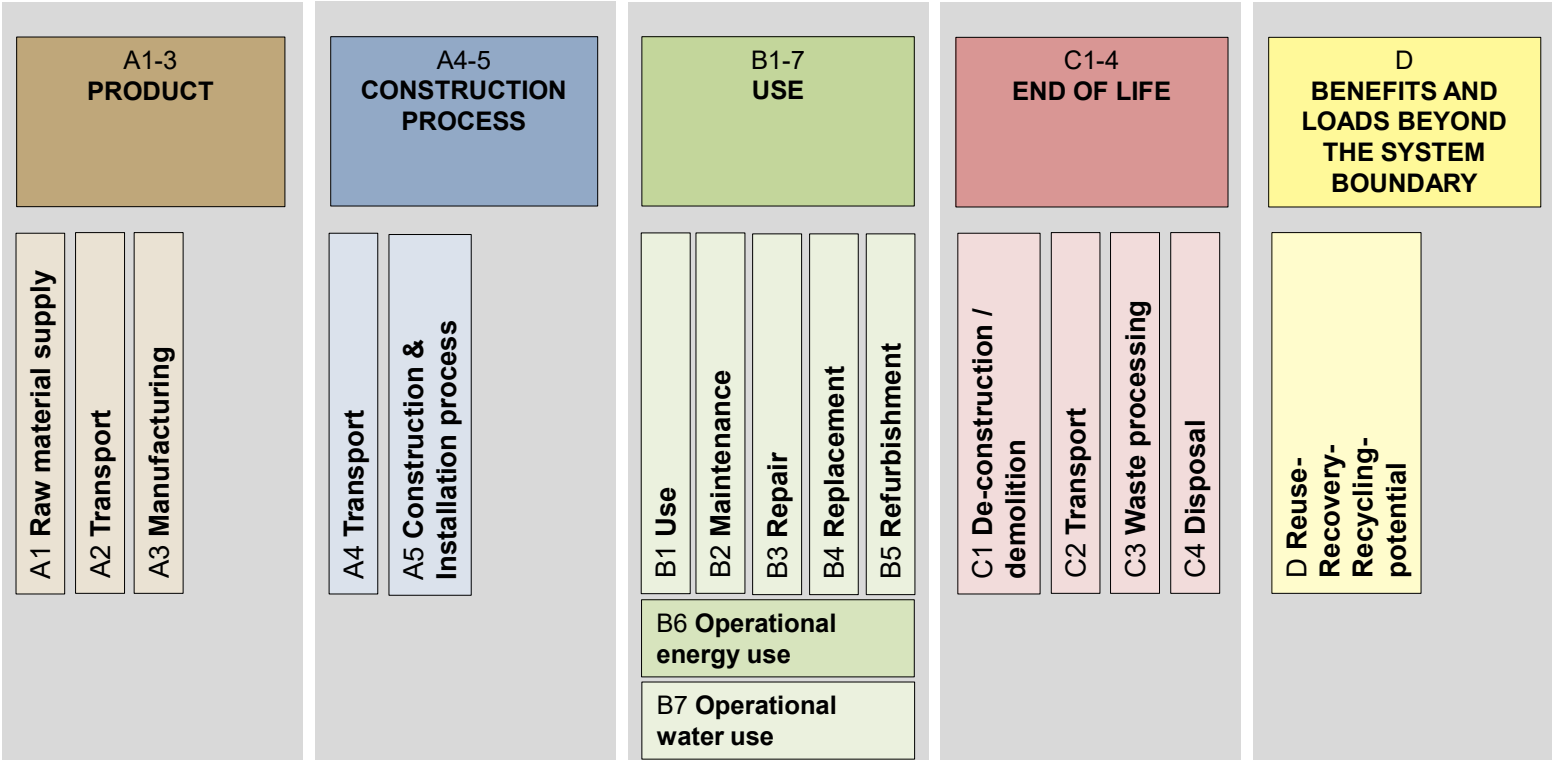
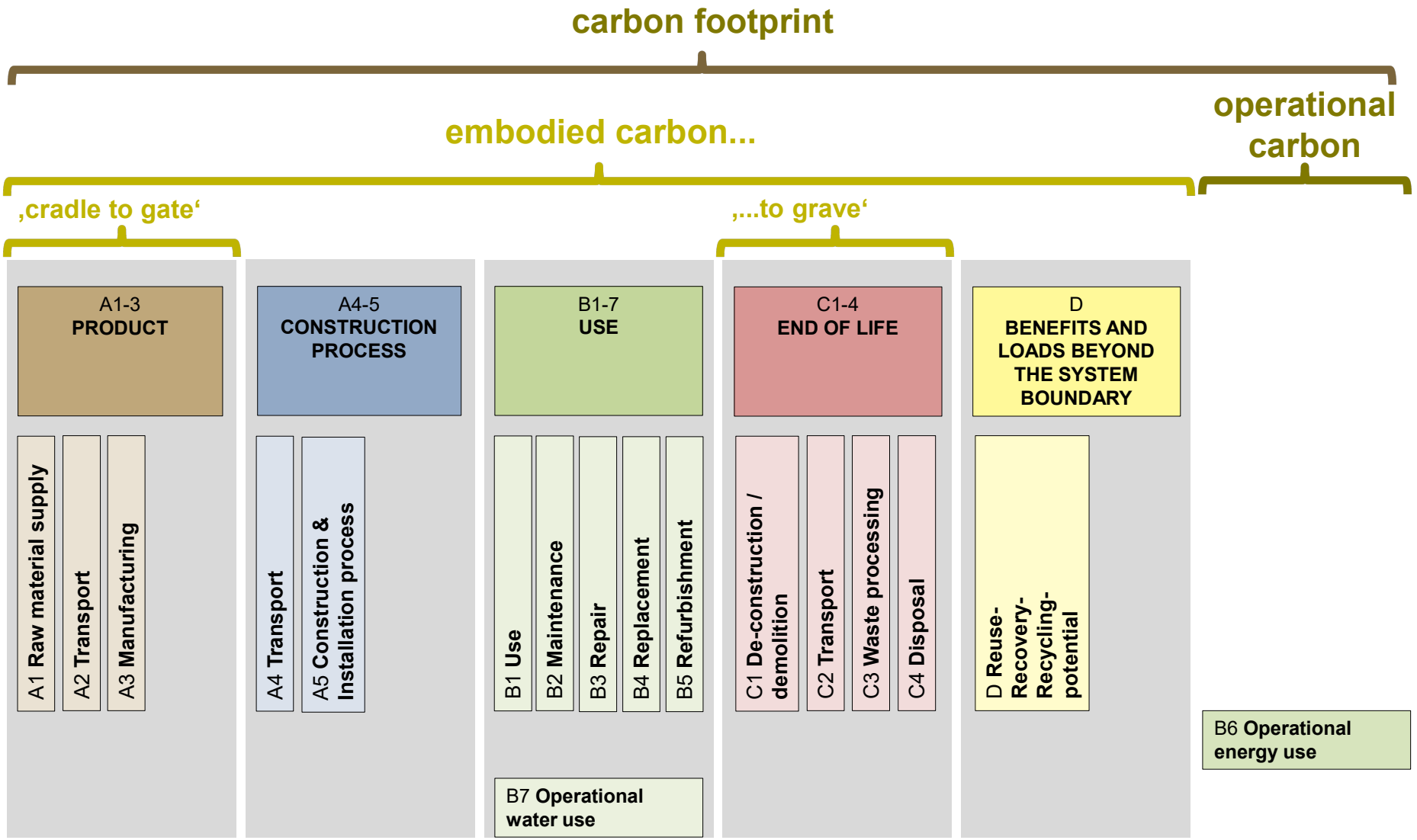



carbon footprint
embodied carbon...
operational carbon
‚cradle to gate‘
‚...to grave‘
A1-3
PRODUCT
A4-5
CONSTRUCTION PROCESS
B1-7
USE
C1-4
END OF LIFE
D
BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
A1 Raw material supply
A2 Transport
A3 Manufacturing
A4 Transport
A5 Construction & Installation process
B1 Use
B2 Maintenance
B3 Repair
B4 Replacement
B5 Refurbishment
C1 De-construction / demolition
C2 Transport
C3 Waste processing
C4 Disposal
D Reuse-Recovery-Recycling-potential
B7 Operational water use
B6 Operational energy use

The basic formula of Life Cycle Assessment (LCA)

Calculation of embodied carbon of buildings

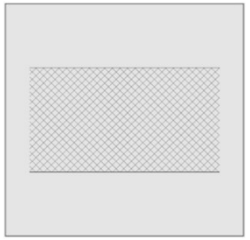
Use less material

$$\text{Total embodied carbon of a building per year} = \frac{\text{mass} \times \text{embodied carbon / kg of materials}}{\text{lifetime}}$$

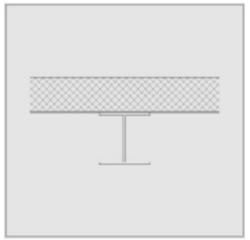
Using less material

Source: Stücheli Architekten / Lenum AG

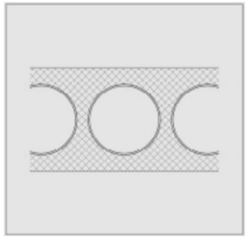
More examples



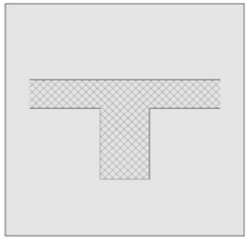
Massive concrete slab: 34 MJ/m²



Steel-concrete slab: 26 MJ/m²



Bubble Deck slab: 33 MJ/m²



Ribbed concrete slab: 20 MJ/m²

Europaallee, Zürich, Switzerland

Architects: Stücheli Architekten

Europaallee, Zürich, Switzerland

Source: Stücheli Architekten / Lenum AG

Calculation of embodied energy of buildings

Use materials with less embodied carbon

$$\text{Total embodied carbon of a building per year} = \frac{\text{mass} \times \text{embodied carbon / kg of materials}}{\text{lifetime}}$$

Embodied energy / carbon for different bricks and blocks

	Embodied Energy (MJ/m3)
Autoclaved aerated concrete blocks	1506
Cellular light weight concrete	1131
Pulverized fuel ash-lime bricks	1682
Pulverized fuel ash-cement bricks	1217
Solid concrete blocks	1065
Hollow concrete blocks	799
Compressed stabilized earth blocks	803
C&D waste bricks	1751
Perforated burnt clay bricks	1950
Hollow burnt clay block	1219
Solid burnt clay bricks	2570 - 4747

x 6

Data Source: Sameer Maithel et. al, Greentech Knowledge Solutions Pvt. Ltd., New Delhi
EMBODIED ENERGY DATABASE FOR BRICKS & BLOCKS IN INDIA USING PROCESS ANALYSIS METHODOLOGY
Inspire 2017

Calculation of embodied carbon of buildings

$$\text{Total embodied carbon of a building per year} = \frac{\text{mass} \times \text{embodied carbon / kg of materials}}{\text{lifetime}}$$

Extend lifetime: doubling the lifetime of your building halves the embodied carbon spent per year

Building and building material lifetime

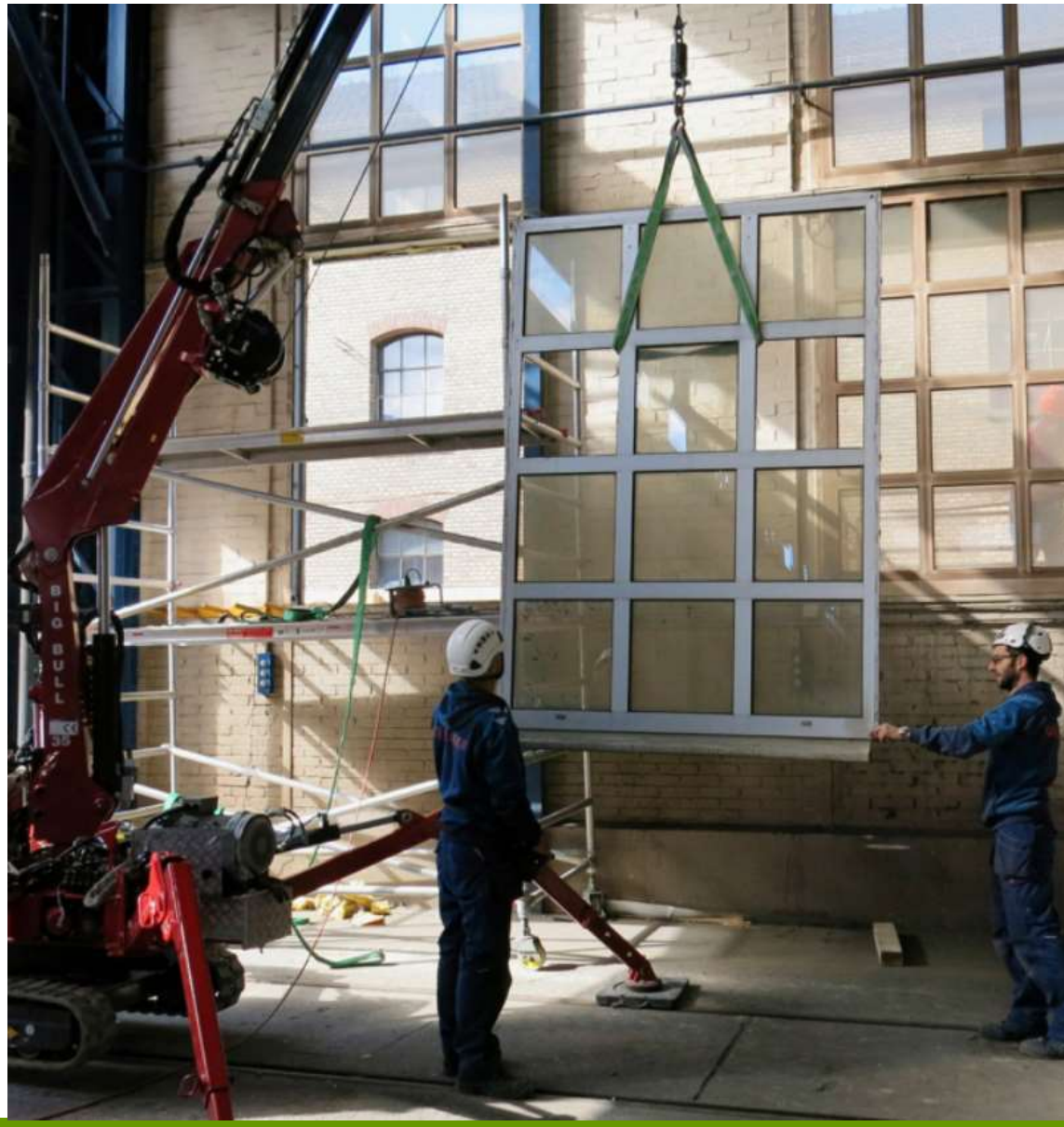
Layers of durability:

- Urban design
- Building design
- Material qualities

Material Reuse

Salvation of building materials from decommissioned buildings

https://www.insitu.ch/projekte/196-k118-kopfbau-halle-118



Material Reuse

Project: K.118 Kopfbau Halle 118 Winterthur, Switzerland

Reuse of materials can be considered as an extension of the liftime on the level of building elements or as ‘zero embodied carbon’ material.

60% of carbon emissions und 500 tons of primary materials avoided compared to new construction

$$\text{Total embodied carbon of a building per year} = \frac{\text{mass} \times \text{embodied carbon / kg of materials}}{\text{lifetime}}$$

https://www.insitu.ch/projekte/196-k118-kopfbau-halle-118

Cradle to Cradle ®

Building for recyclability - Buildings as a resource depot

Foto Jens Kirchner

Administrative building for the RAG-Stiftung und RAG Aktiengesellschaft, in Essen, Germany

Foto Nikolai Benner

$$\text{Total embodied carbon of a building per year} = \frac{\text{mass} \times \text{embodied carbon / kg of materials}}{\text{lifetime}}$$

Refurbishment of Secondary School, Balzers, Liechtenstein

BEFORE

Year of Construction: 1970

Fossil fuel (heating oil)

Construction:

- Frame construction in concrete

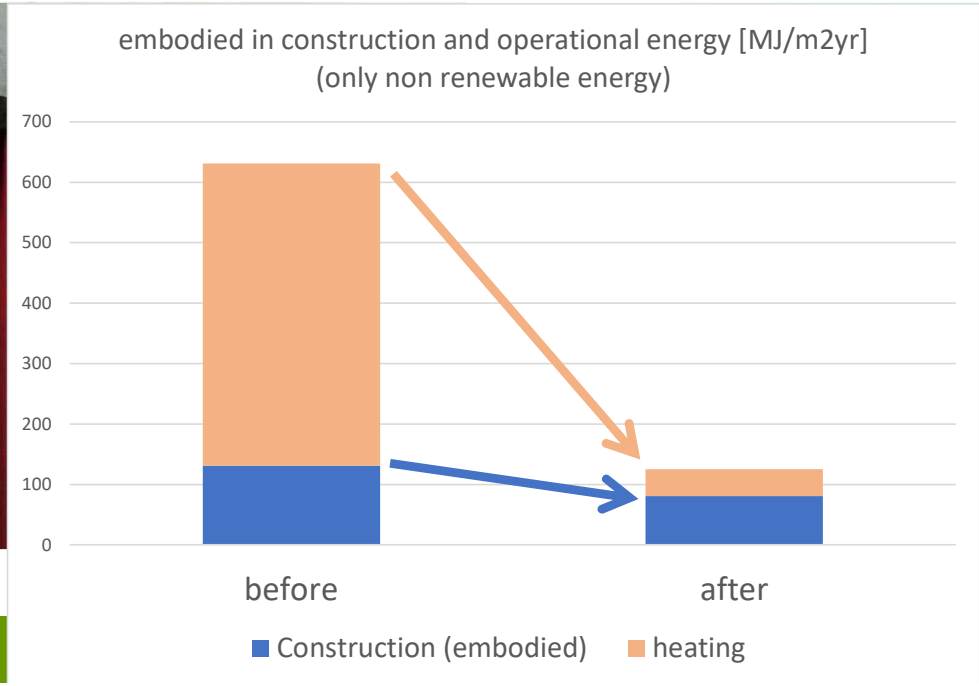
-Prefab concrete facade elements
poor insulation

AFTER

Renewable heating system (wood chip boiler)

Construction:

- Frame construction in concrete (reuse of existing)
- facade in timber-construction (new)
highly insulated, flexible external shading



Summary on embodied carbon parameters

Use materials with less embodied carbon

Use less material

Total embodied carbon of a building per year = (mass x embodied carbon / kg of materials) / lifetime

Extend lifetime: doubling the lifetime of your building halves the embodied carbon spent per year

Reduce the embodied carbon of material [CO2 / kg]

- Produce building materials more energy efficient
- Use alternative materials

Reduce mass [kg]

- Material efficient structures
- Lightweight materials

Increase lifetime [t]

- Good design from construction detail to urban level

Don't forget about m²/person

- How can we avoid emerging countries going the same way as Europe and America, where m2/person keep increasing?