

Bæredygtighed i bygningsreglementet

Energiforum Danmark

Webinar 2023-08-17

RAMBOLL

Bright ideas.
Sustainable change.



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Buildings Specialized Engineering

Agenda

1. Why sustainability and embodied carbon?
2. What is LCA?
3. LCA in Danish legislation
4. LCA in a building process

Why sustainability
and embodied
carbon?



According to the European
Commission the built environment
is responsible for...



...40% of society's resource
consumption



**...33% of society's water
consumption**



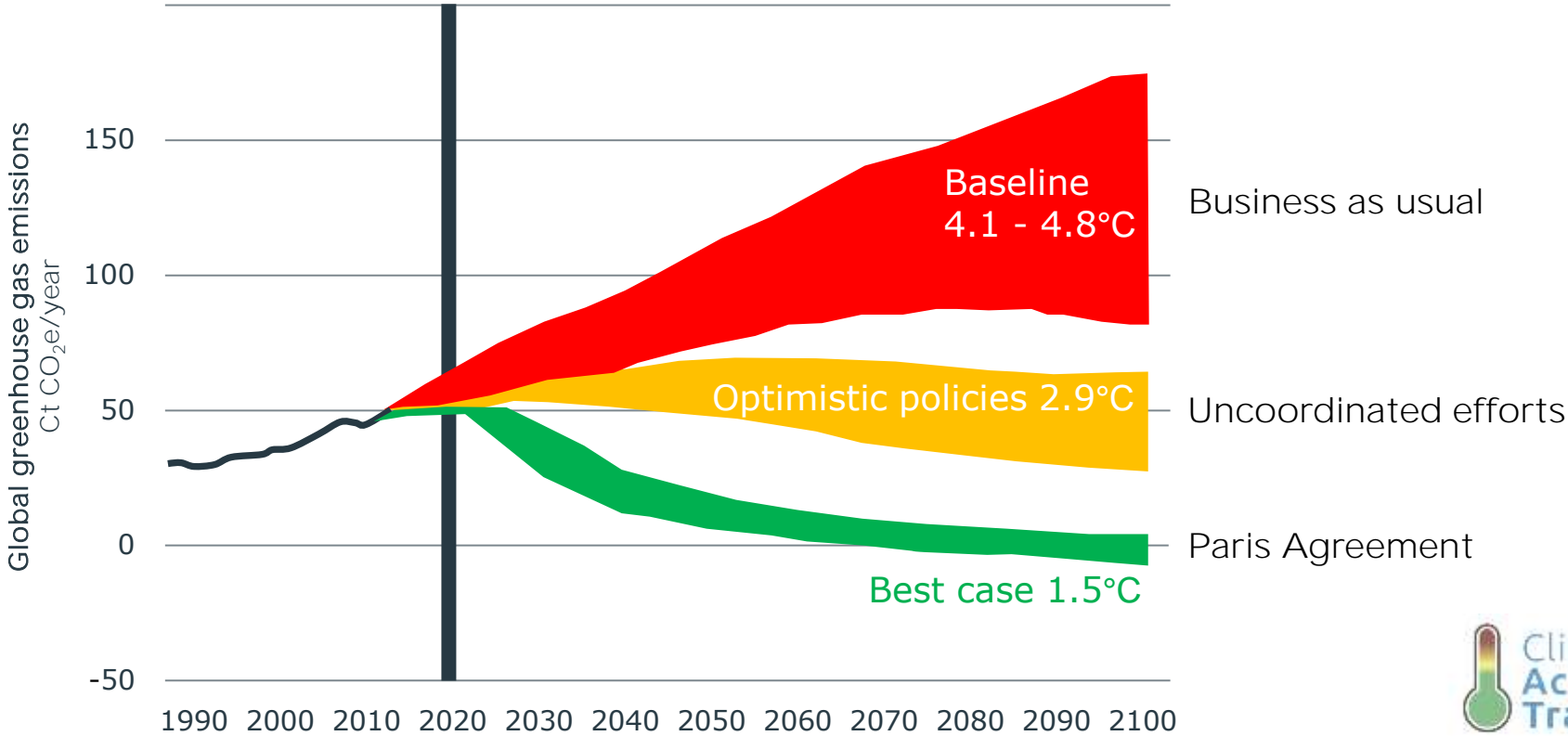
...40% of society's energy
consumption



**...39% of global energy related
carbon emissions**

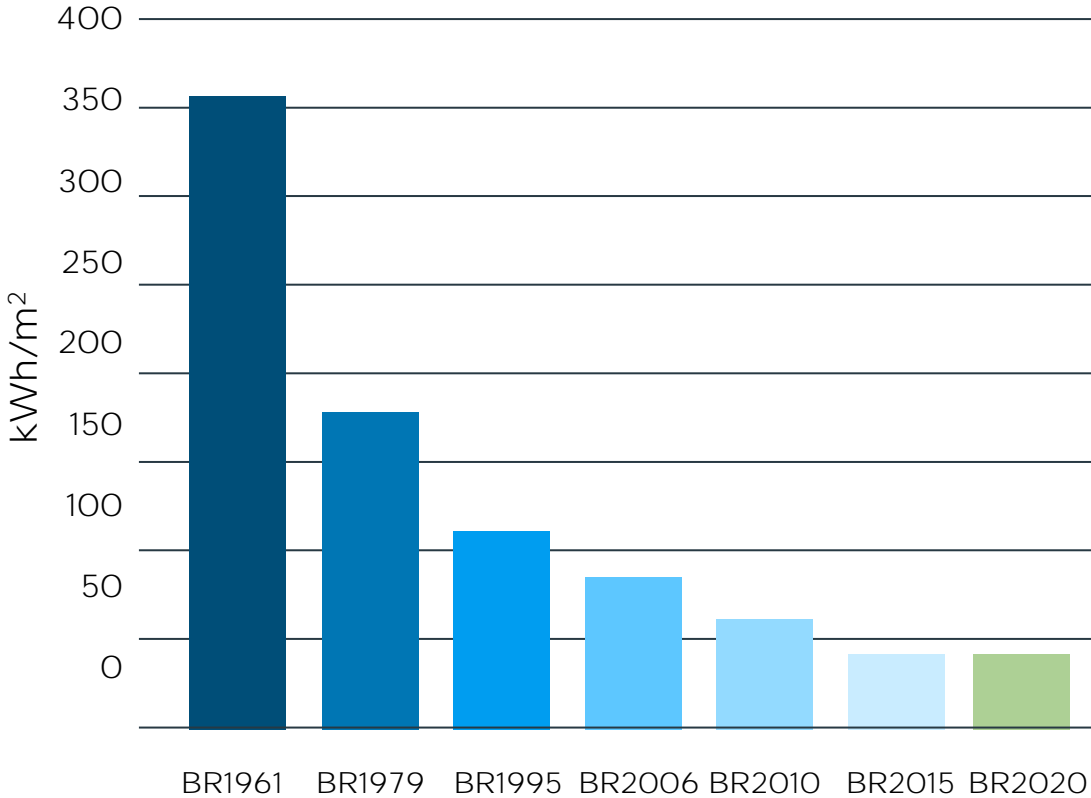
2100 warming projections

Emissions and expected warming based on pledges and current policies

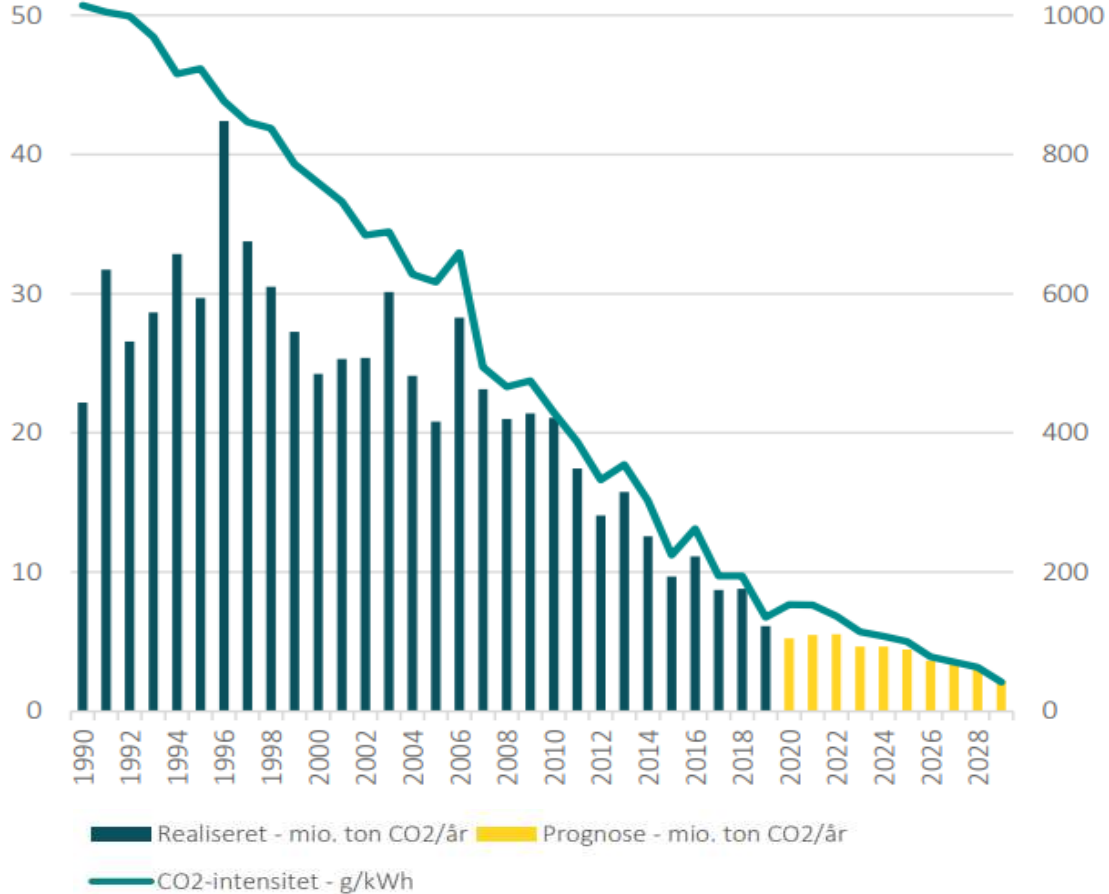


Historical focus

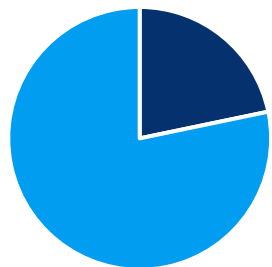
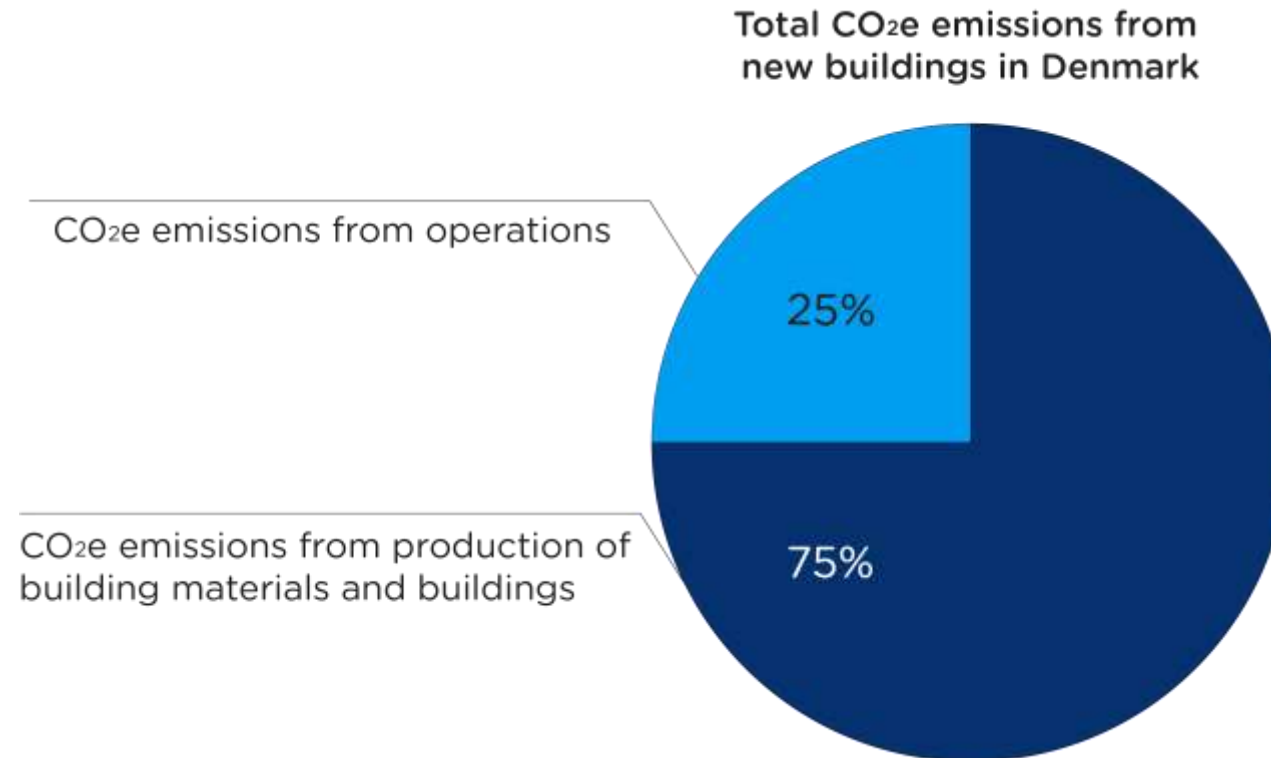
Legislation on energy consumption



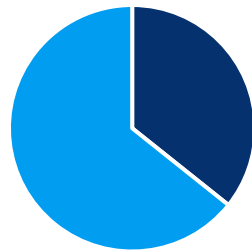
Electricity Production



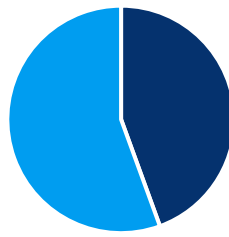
CO₂e emissions over time



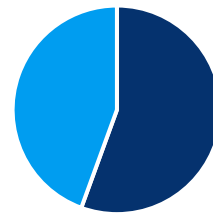
1961



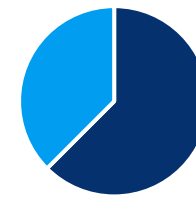
1979



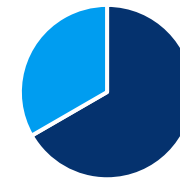
1995



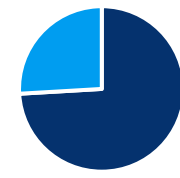
2006



2010



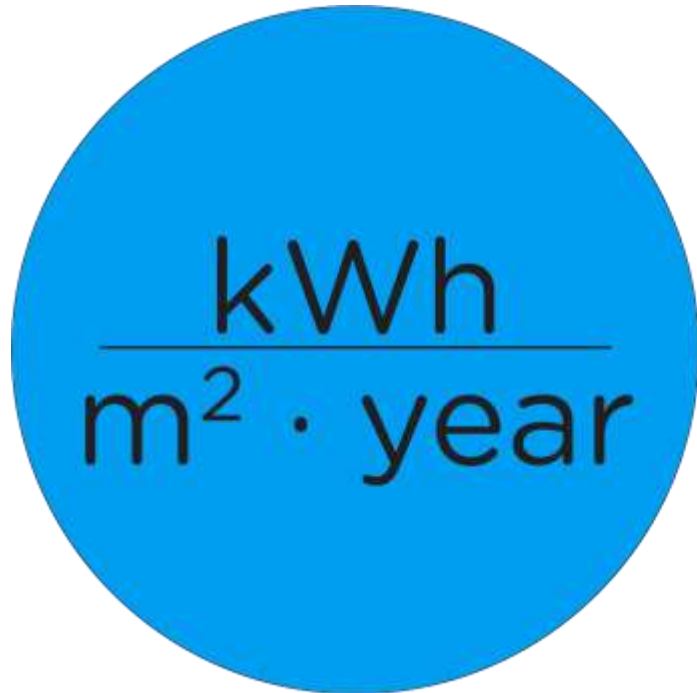
2015



2020

We must now shift focus

From energy focused ...



... to GHG focused



What is LCA?

Life Cycle Assessment

- Measurement of environmental impacts
- Objective
- Life cycle based

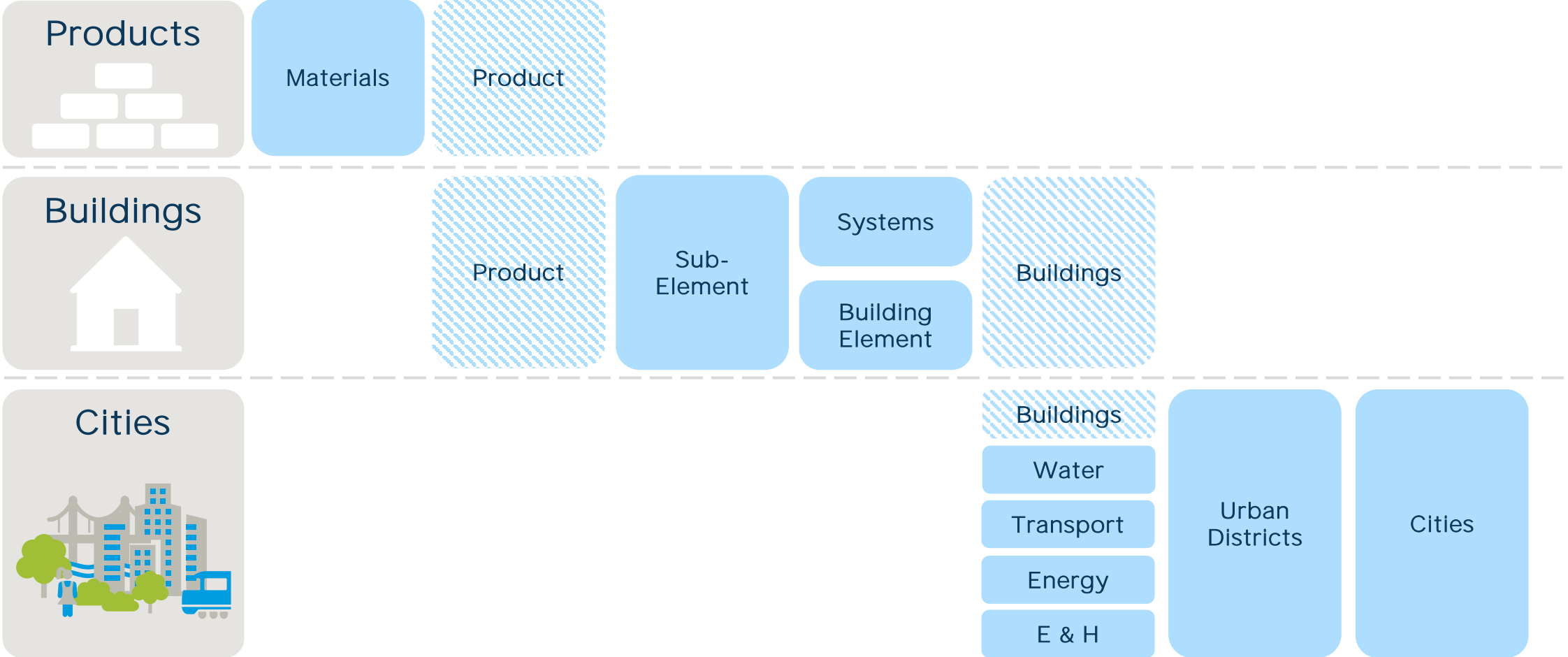
LCA is standardized in Europe ISO14040 and ISO14044

For the building industry:

- Building products → EN15804
- Buildings → EN15978



Life Cycle Assessment



Environmental impact indicators

Category:
Global Warming Potential

Unit:
Kg CO₂-equivalent

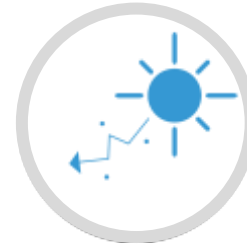
Impact:
Increase of GHG in the atmosphere, causing climate change and warming of the earth.



Category:
Ozone depletion potential

Unit:
Kg CFC-11-equivalent

Impact:
Gasses that deplete the stratospheric ozone layer, increasing penetration of harmful UV-light from the sun.



Category:
Photochemical ozone formation

Unit:
Kg ethene/NMVOC-equivalent

Impact:
Gasses that cause formation of smog in the lower atmosphere.



Category:
Eutrophication potential

Unit:
Kg Nitrogen/Phosphor-equivalent

Impact:
The enrichment of water ecosystems with nitrogen and phosphor, altering the ecosystems for the worse



Category:
Acidification potential

Unit:
Kg Sulfate/Mol H⁺-equivalent

Impact:
Increase in acidification of soils and water, affecting soil chemistry and nutrient balances



Category:
Depletion of abiotic resources – Fossil Fuels

Unit:
MJ

Impact:
Depletion of natural fossil fuel resources.



Category:
Depletion of abiotic resources – Minerals and metals

Unit:
Kg SB-equivalent

Impact:
Depletion of natural non fossil resources.



Category:
Primary Energy Use

Unit:
MJ

Impact:
Usage of primary energy resources, both materials and fuels, fossil and non-fossil.



Category:
Water Use

Unit:
M3 world equivalent deprived

Impact:
Water usage based on regional water scarcity factors.



[Link to read more](#)



Category:

Global Warming Potential

Unit:

kg CO₂-equivalent (kg CO₂e)

Impact:

Increase of greenhouse gas (GHG) in the atmosphere, causing climate change and warming of the Earth.

Equivalents:

Other similar substances that cause the same environmental impact.

1 kg CO₂ = 1 kg CO₂e

1 kg Methane = 36.8 kg CO₂e

1 kg Nitrogen Oxide = 298 kg CO₂e

Why Global Warming Potential?

Today in the building sector, our biggest focus is on our climate impact.

Legislation

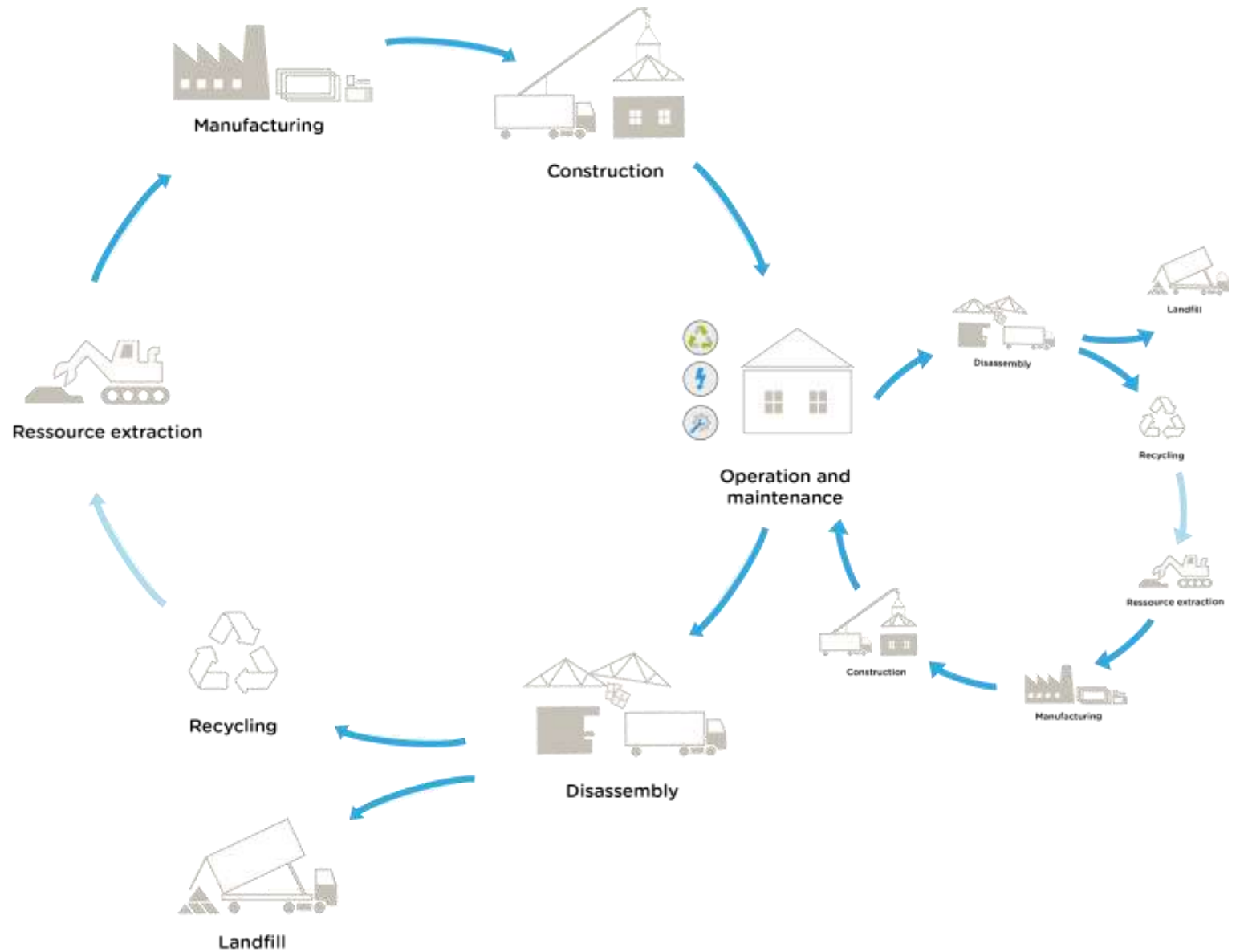
- Paris Agreement - limit global warming to 1.5°C
- National strategies
- Building regulations

Social tendencies

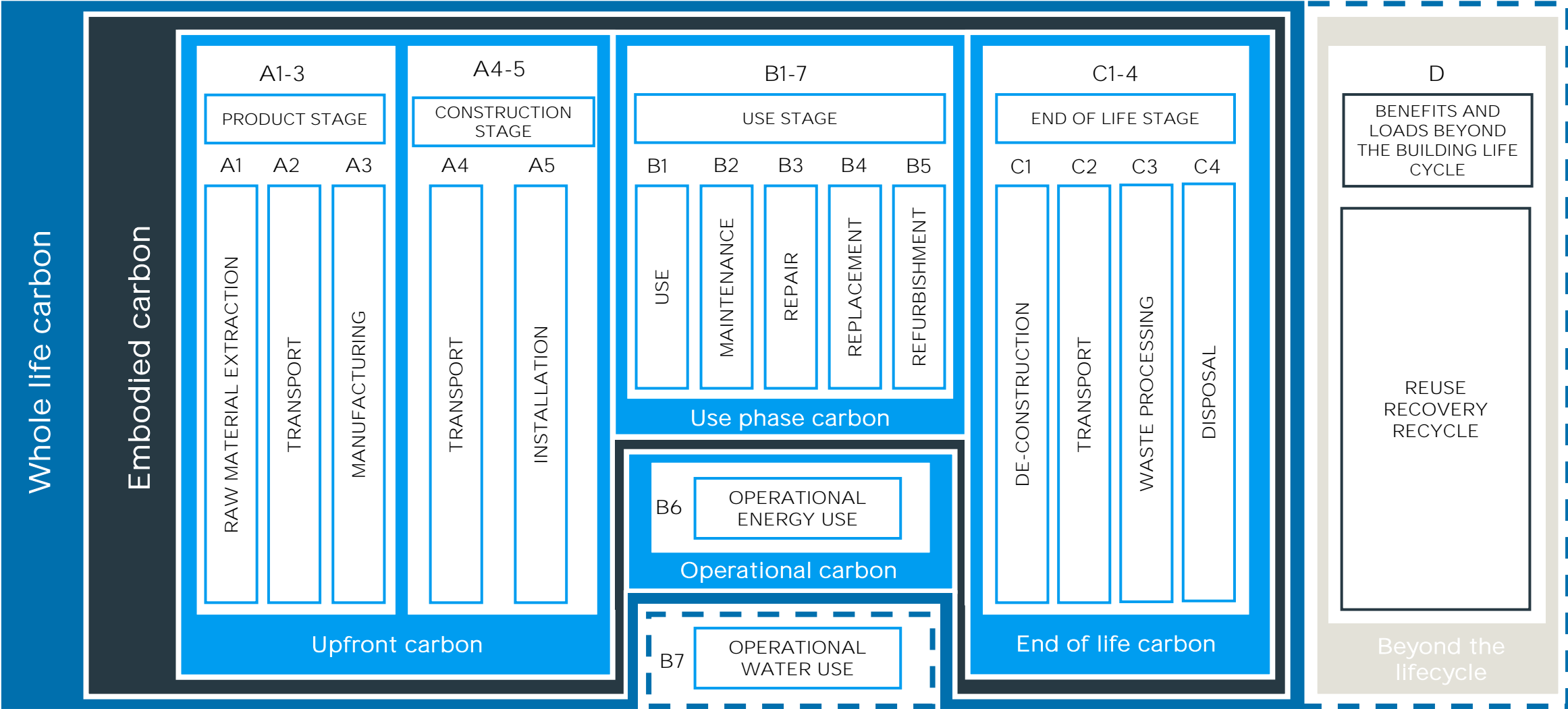
- More frequent extreme weather incidents
- CO₂ has become a buzzword

But...

Not all emissions occur at the same time!

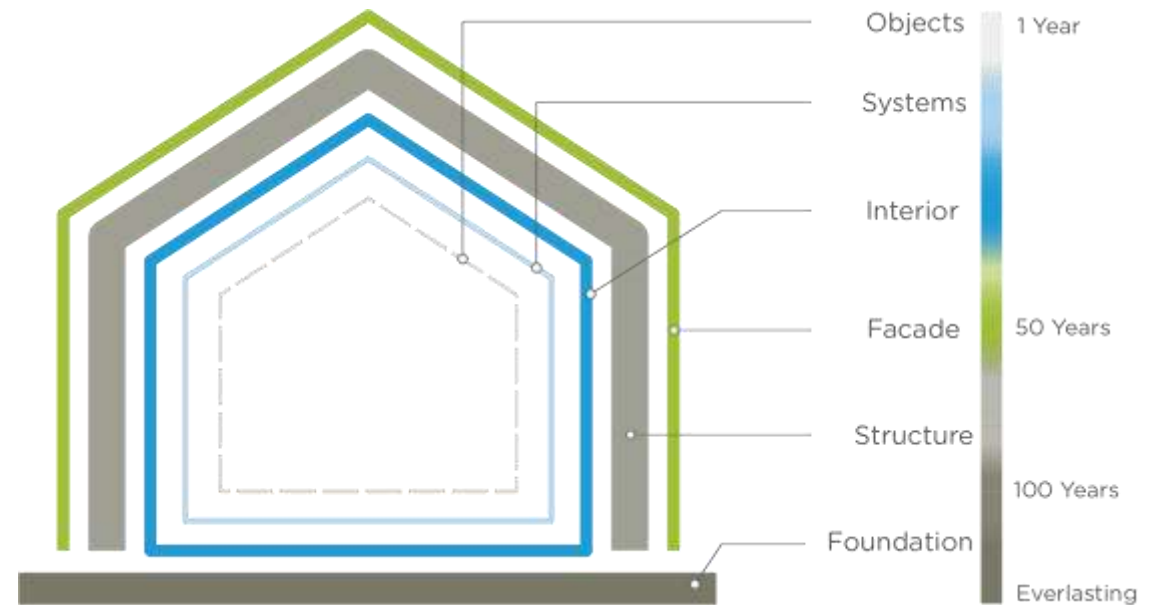


Life cycle stages



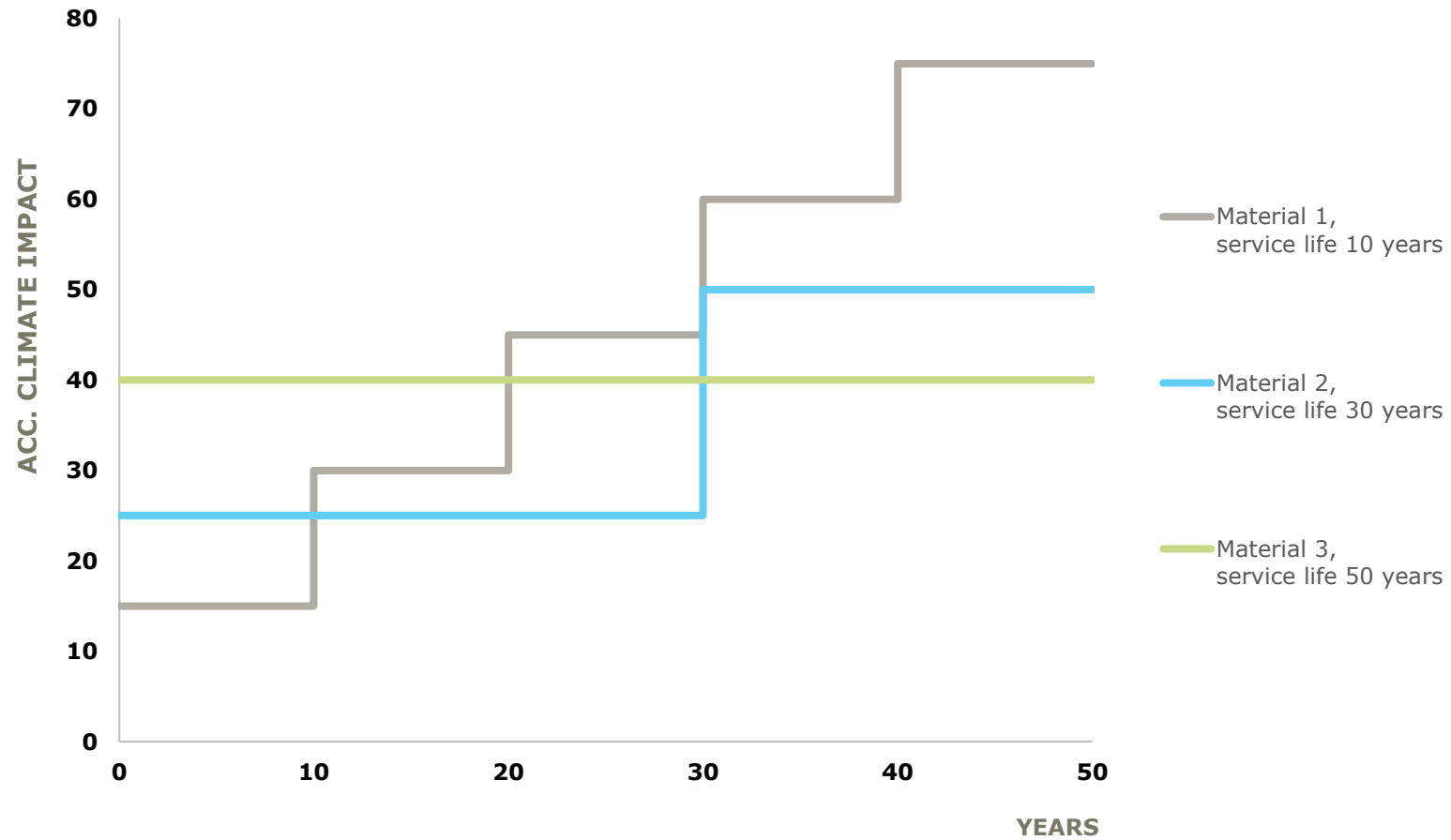
Assessment period

- The span of time over which the building is evaluated
- The assessment period brings the life cycle aspect to the calculation (Use Phase B1-B5)
- Not all materials have the same service life
- The longer we assess the building, the less the upfront emissions will impact the result
- Replacement of a material in the future, with the environmental performance of today

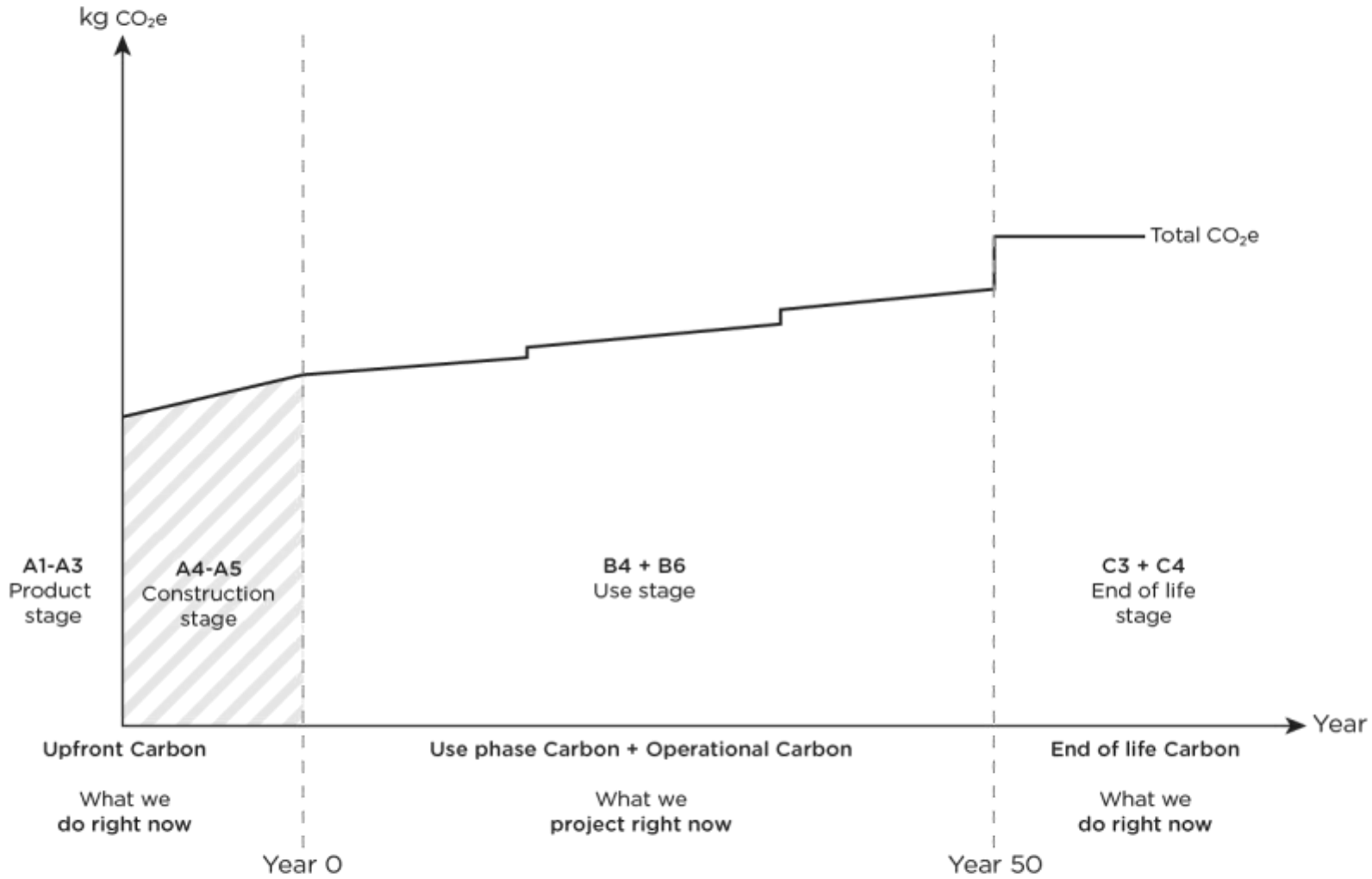


Assessment period

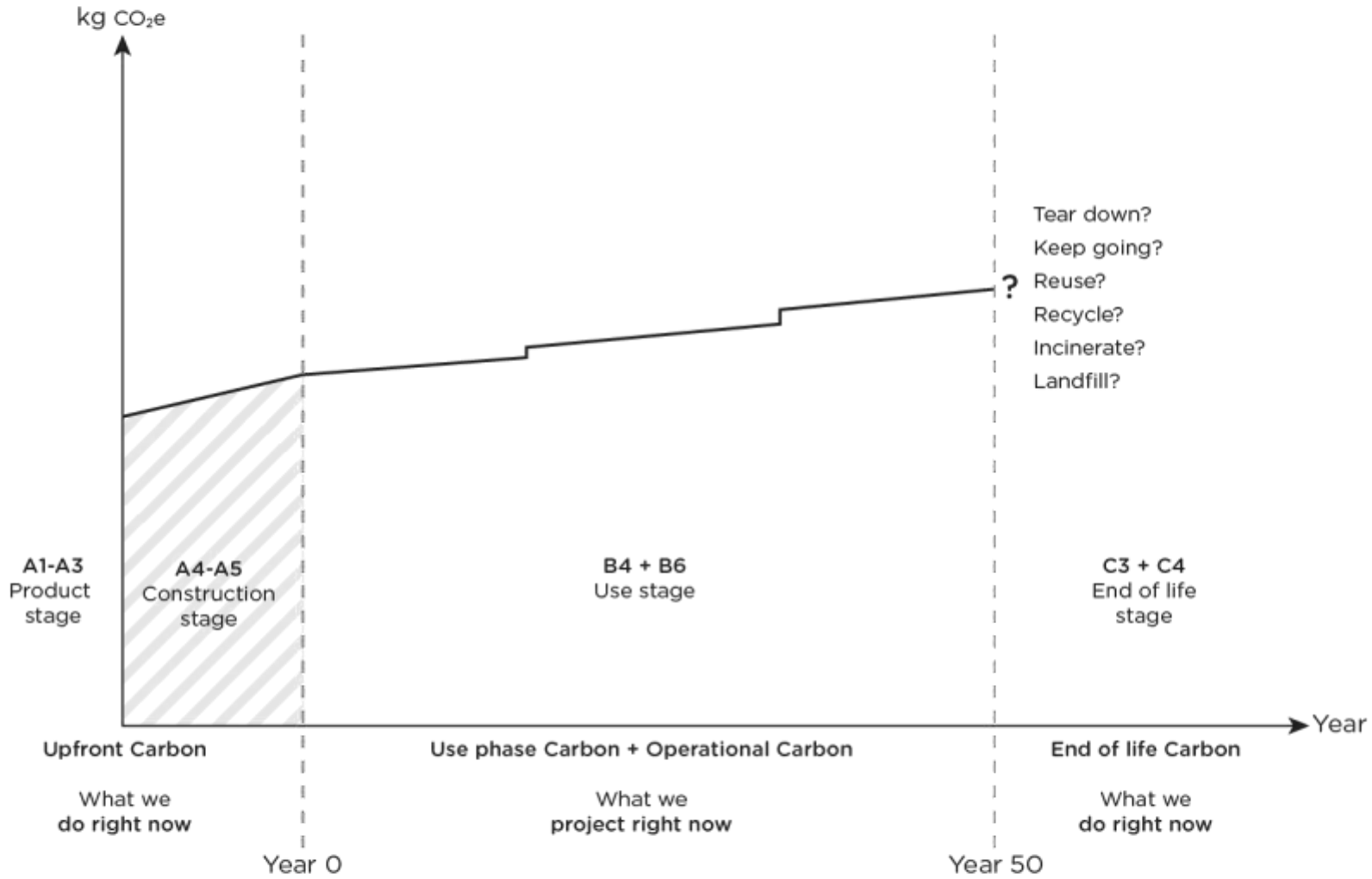
ACCUMULATED CLIMATE IMPACT



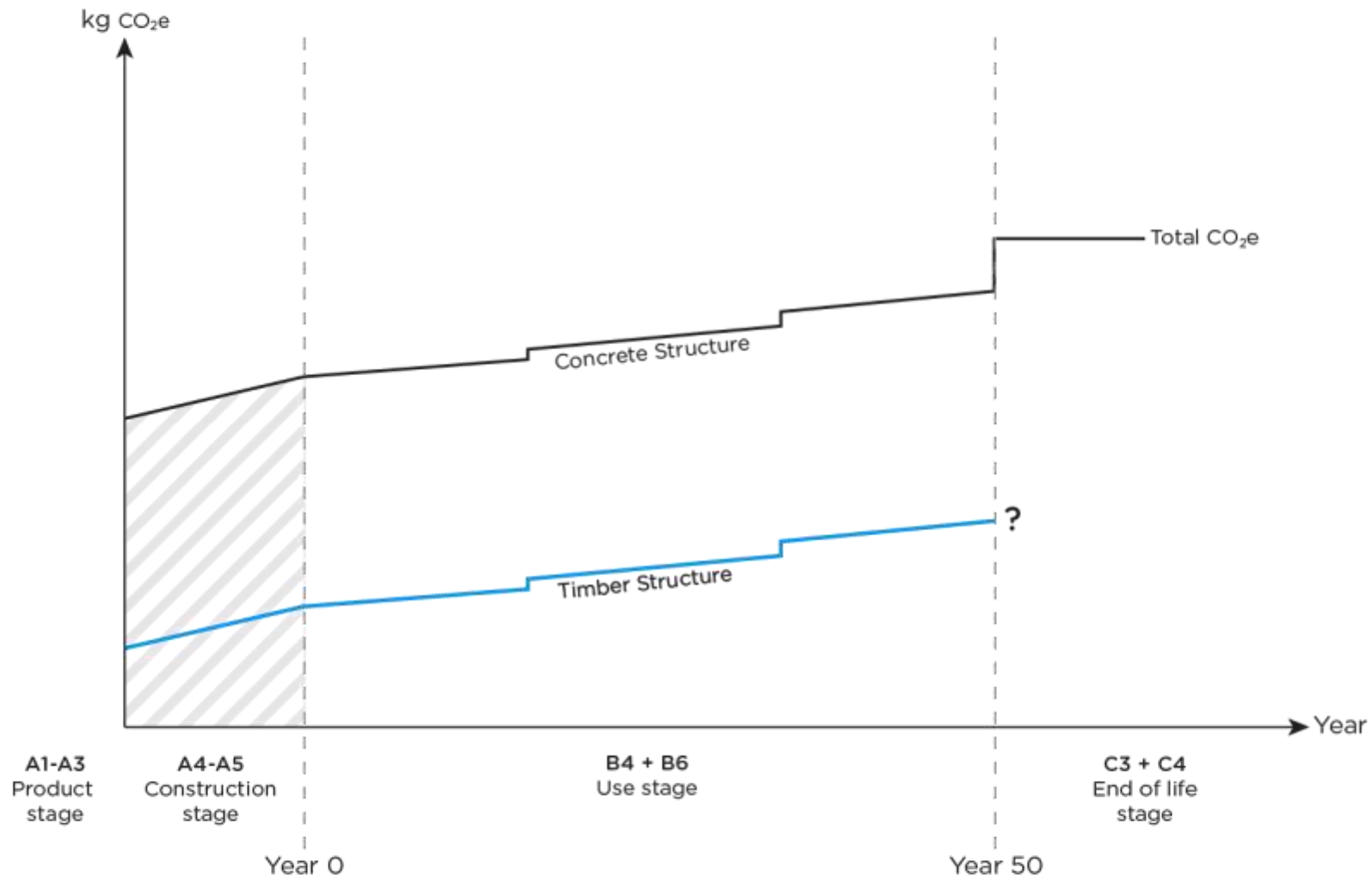
Building lifetime carbon profile



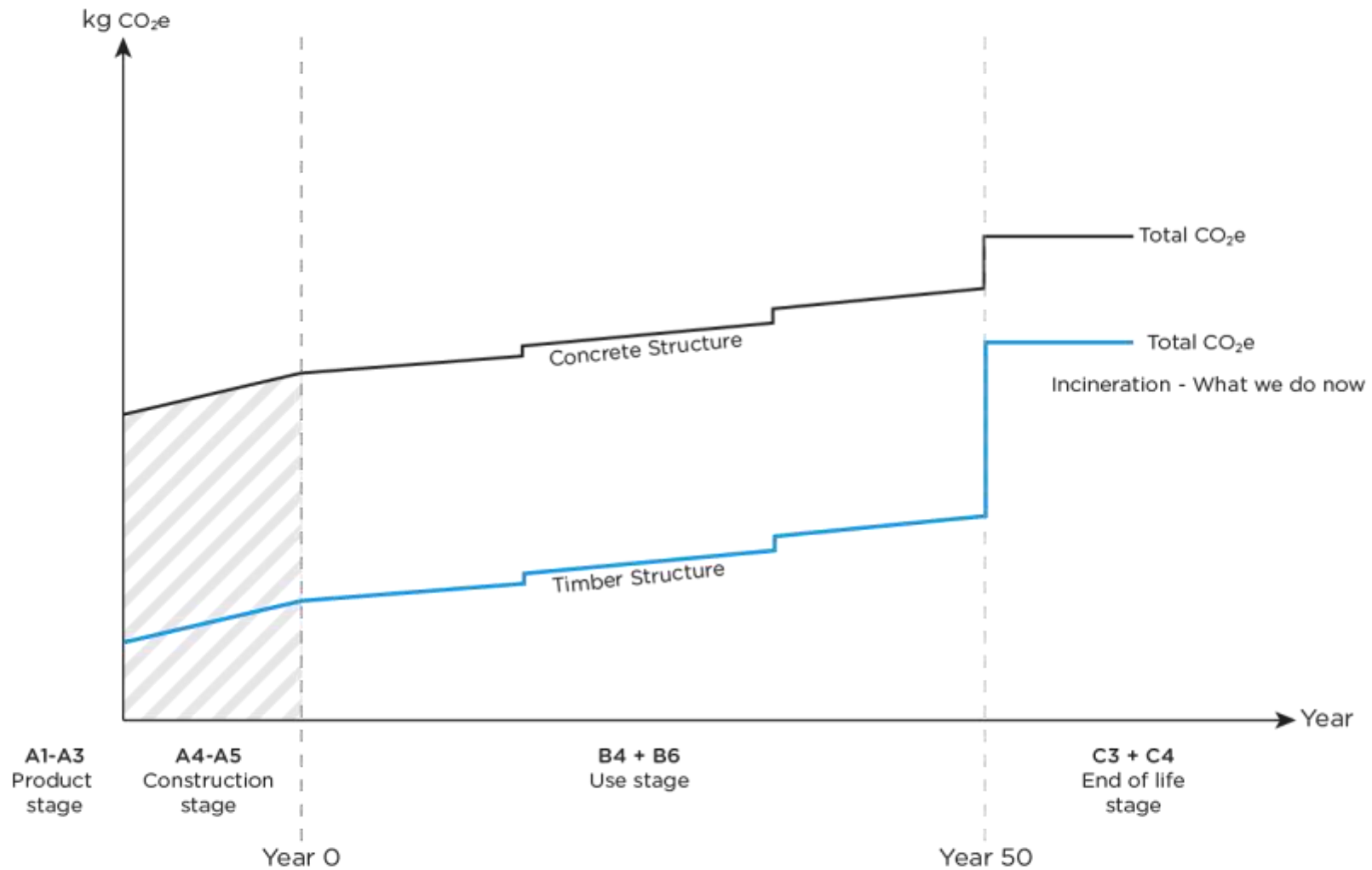
Building lifetime carbon profile



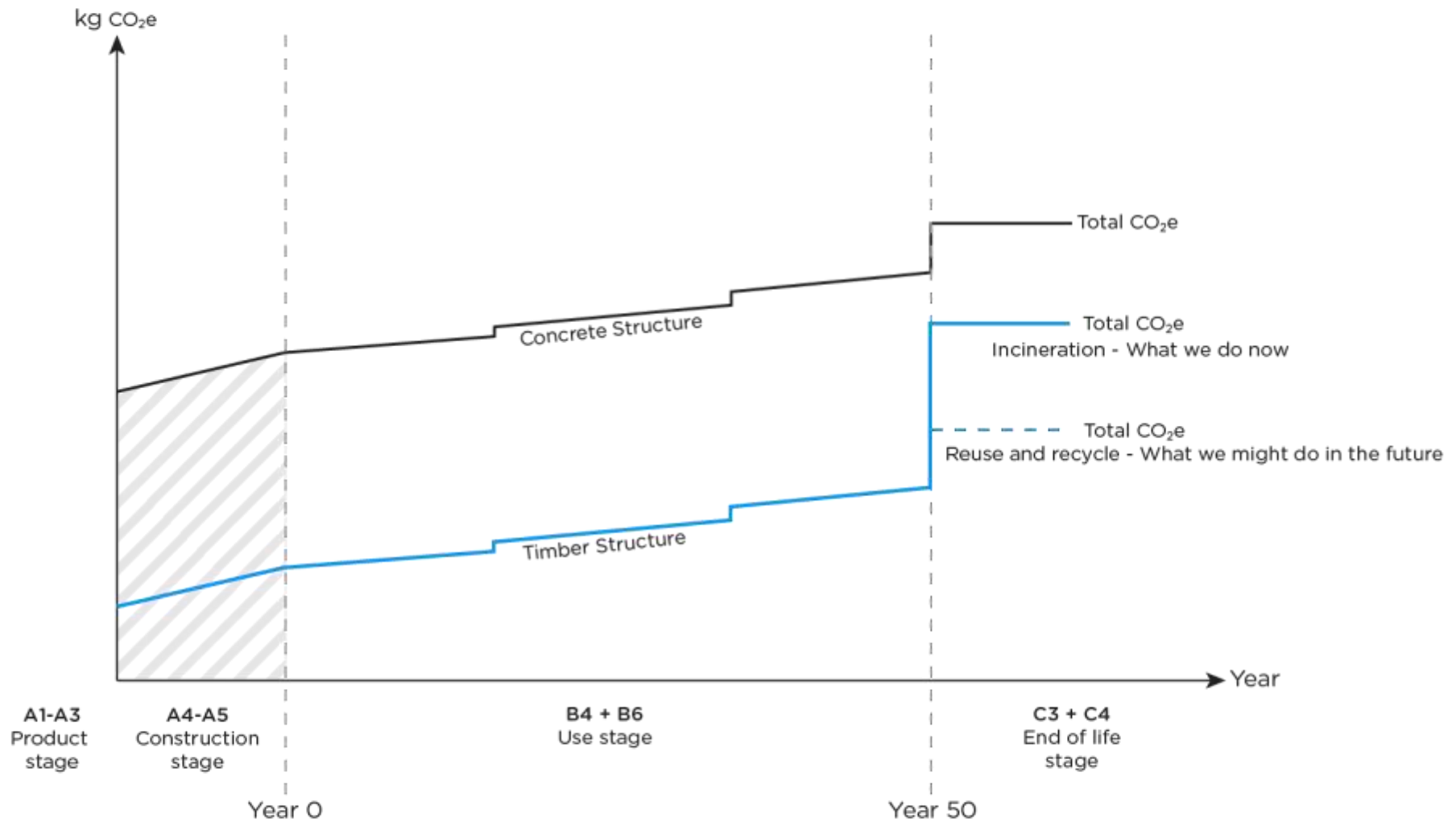
Concrete vs timber structure




Concrete vs timber structure



Concrete vs timber structure





We must focus on both
whole life and *upfront* carbon
to provide the full picture

Data variation and EPD's

LCA data can vary greatly from product to product

This is a good thing!

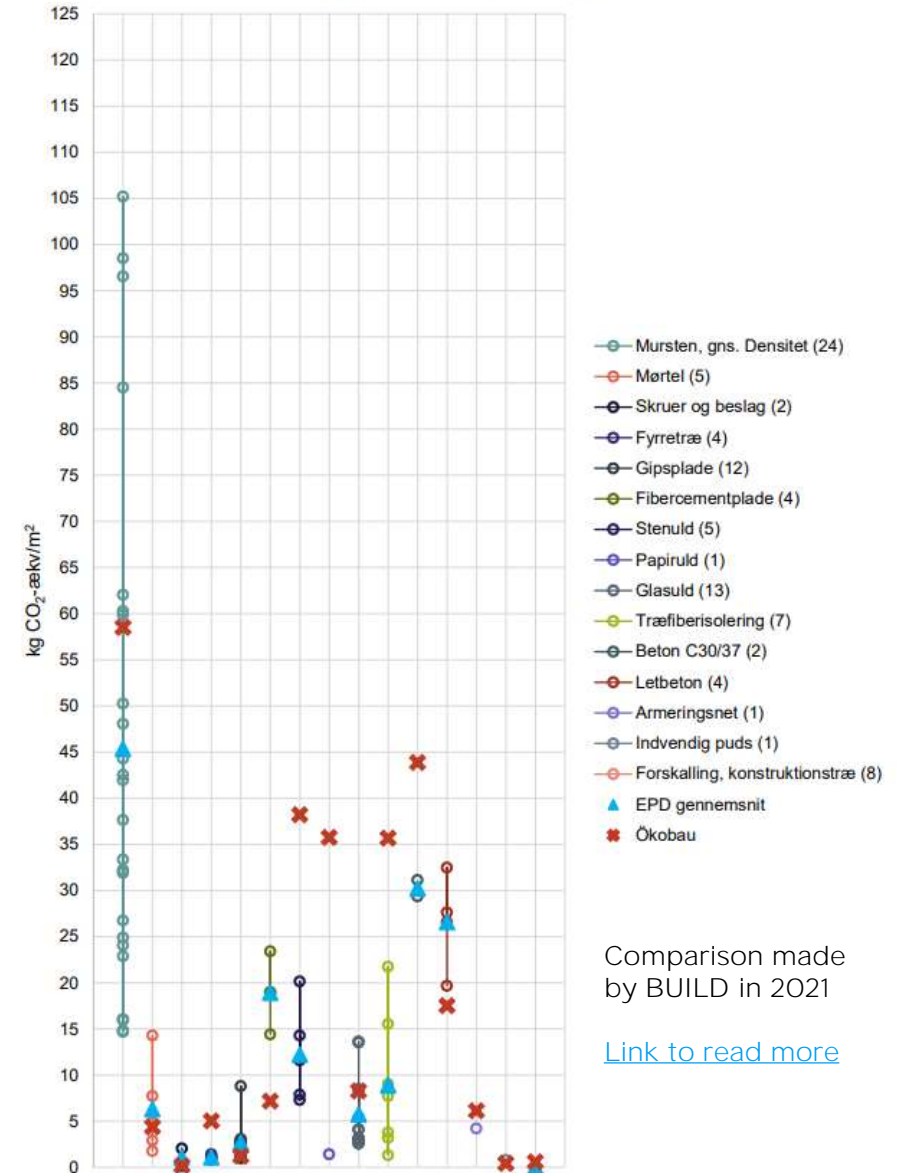
Because...

It creates competition between different product types e.g., stone wool, glass wool, PIR, paper, woodfibre

It creates competition between manufacturers of the same product e.g., bricks

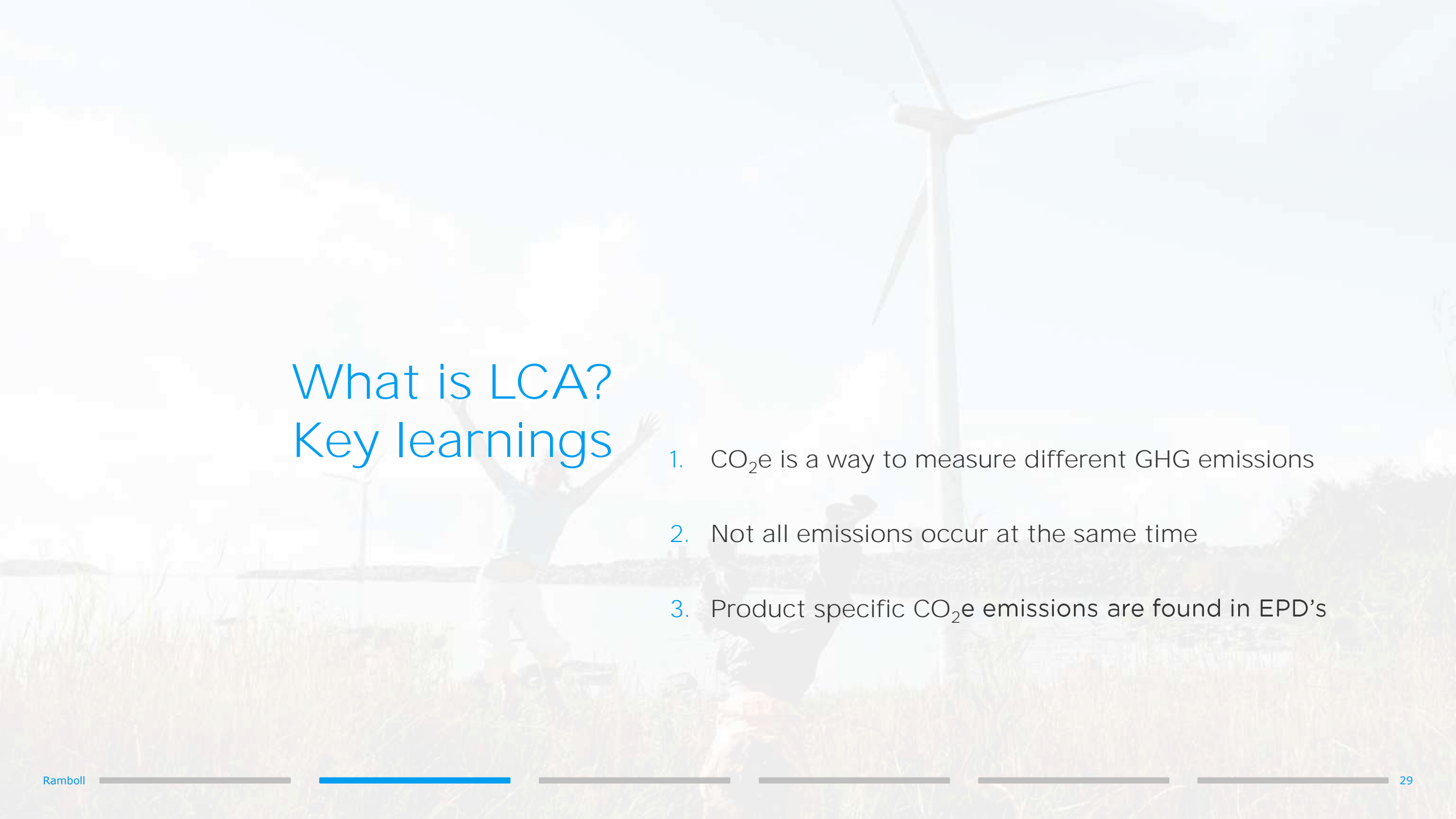
...Market mechanisms create more sustainable products

Ydervæg B, U-værdi = 0,16 W/(m²K)



Comparison made by BUILD in 2021

[Link to read more](#)

The background of the slide features a large, semi-transparent image. On the right side, a tall wind turbine stands against a bright, hazy sky. In the foreground, two people are captured in a moment of joy, jumping or dancing in a field of tall grass. The overall scene is bright and positive, suggesting a clean energy or sustainable future theme.

What is LCA? Key learnings

1. CO₂e is a way to measure different GHG emissions
2. Not all emissions occur at the same time
3. Product specific CO₂e emissions are found in EPD's

LCA in Danish legislation

LCA in legislation

Globally



Paris Agreement:
Substantially reduce global greenhouse gas emissions to limit the global temperature rise to below 1.5°C compared to pre-industrial levels

European



European Green Deal:
No net emissions of greenhouse gases by 2050
Economic growth decoupled from resource use
No person and no place left behind

National

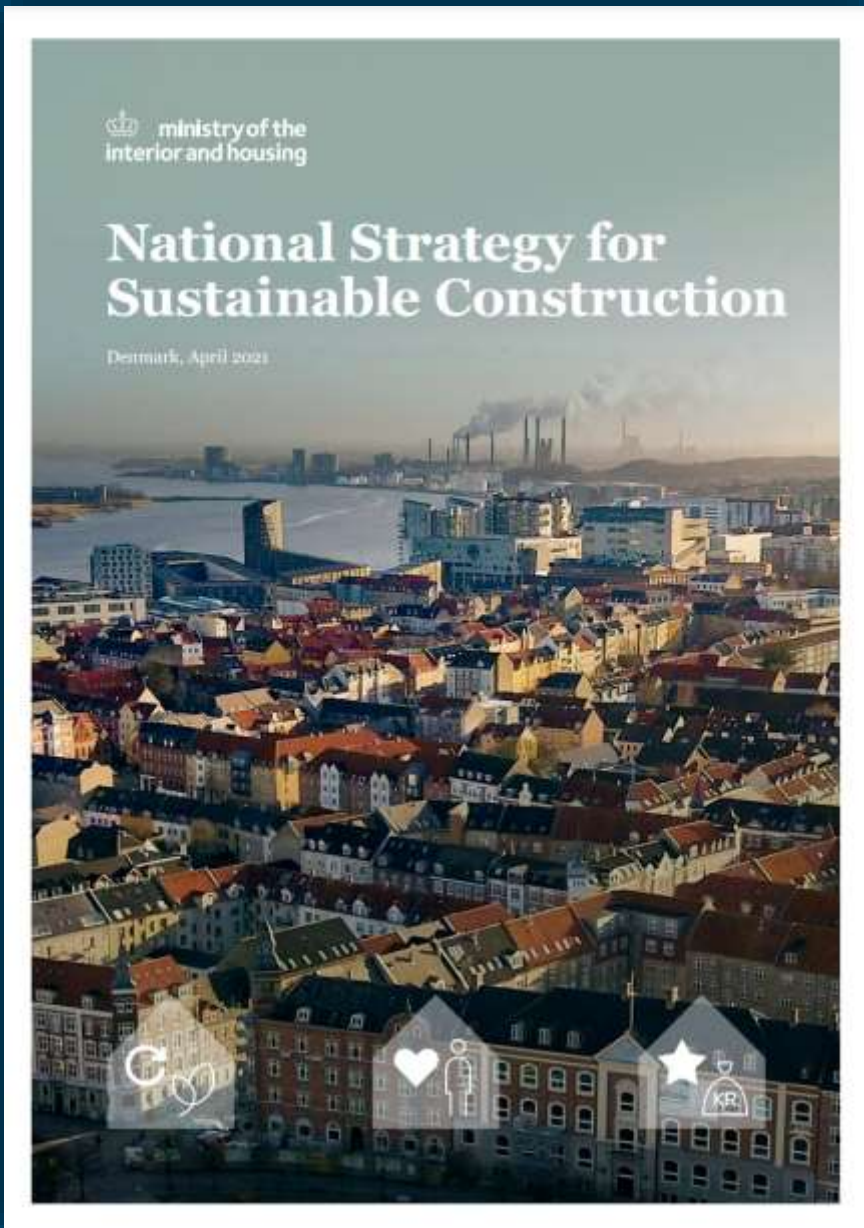


National strategy for sustainable construction

Company



Company Strategies



DK National strategy for sustainable construction

5 focus areas and 21 initiatives must support the construction's green transformation

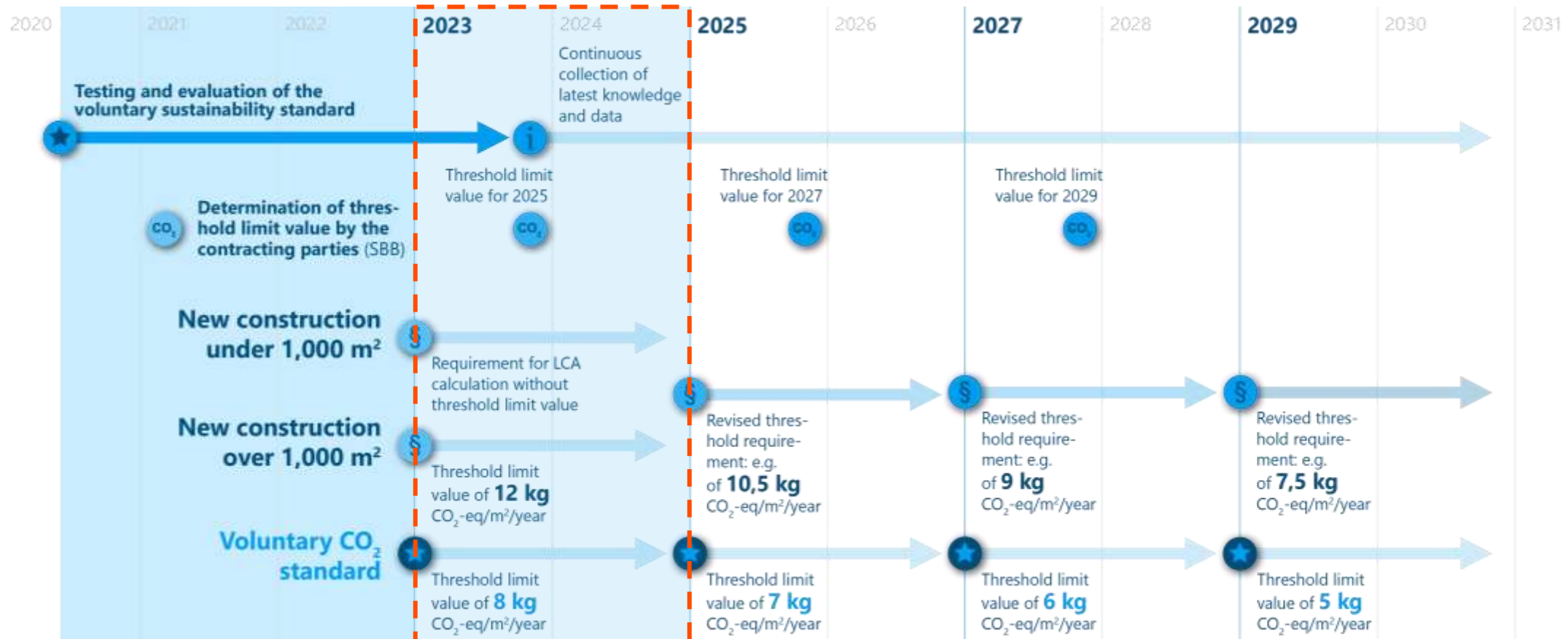


- More climate friendly building and construction
- Durable, high-quality buildings
- Resource efficient buildings
- Energy efficient, healthy buildings
- Digitally-supported construction

Source: [National strategy for sustainable construction, 2021, Ministry of the Interior and Housing](#)

Phasing in a threshold limit value

- LCA required for all new buildings from 2023
- Limit of 12.0 kg CO₂e/m²/year for new buildings with heated floor area > 1,000 m²
- Lower limit value over time to reduce the carbon footprint from buildings



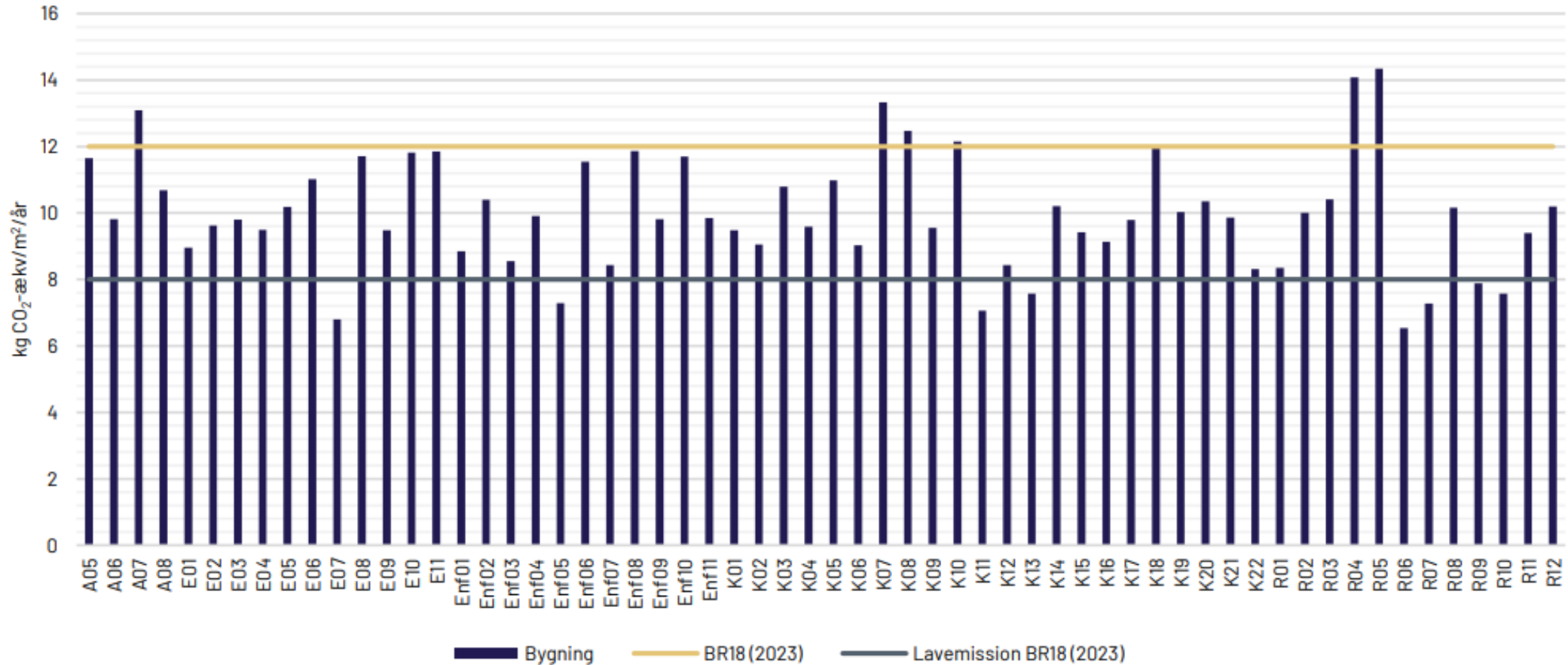
A background image showing a wind farm with several wind turbines. In the foreground, two people are celebrating in a field of tall grass. One person is jumping with their arms raised, and the other is performing a handstand. The scene is bright and sunny, suggesting a positive and sustainable environment.

Why 12 kg CO₂e/m²/year?

Limit value

$$\frac{\text{Total climate impact, building components}}{\text{Reference area} \cdot 50 \text{ years}} + \frac{\text{Total climate impact, operations}}{\text{Heated floor area} \cdot 50 \text{ years}} = \frac{\text{kg CO}_2\text{e}}{\text{m}^2 \cdot \text{year}}$$

Why 12 kg CO₂e/m²/year?



Source: [BUILD Rapport 2021:13 - Klimapåvirkning fra 60 bygninger, 2021, BUILD, AAU](#)

A faded background image showing a wind farm with several wind turbines. In the foreground, two people are celebrating in a field of tall grass. One person is jumping with their arms raised, and the other is performing a backflip. The scene is set near a body of water under a bright sky.

Is it ambitious?

Ramboll examples



Kongebrohuset

- 7-storey apartment building, 4,080 m²
- 1-storey basement, 420 m²
- Traditional concrete structure, pile foundations
- Heavy balcony construction
- Embodied: 6.9 kg CO₂e/m²/yr
- Operational: 1.9 kg CO₂e/m²/yr

Total: 8.5 kg CO₂e/m²/yr



Tankefuld

- 2-storey townhouses, 2,855 m²
- Pre-fab timber wall-elements and deck
- Concrete foundation
- Embodied: 5.1 kg CO₂e/m²/yr
- Operational: 0.9 kg CO₂e/m²/yr

Total: 6.0 kg CO₂e/m²/yr

Ramboll examples



Marmormolen

- 8-storey office building, 28,300 m²
- 3-storey parking basement, 10,000 m²

- CLT-Structure, heatpumps, PVs
- Heavy foundation, 3-storey basement

- Embodied: 8.5 kg CO₂e/m²/yr
- Operational: 0.7 kg CO₂e/m²/yr

Total: 9.2 kg CO₂e/m²/yr



Resource Danmark FTP

- 1-storey industrial production, 11,100 m²
- 3-storey office, 1,400 m²

- Traditional steel frame structure
- Unheated production building, office heated

- Embodied: 8.6 kg CO₂e/m²/yr
- Operational: 3.3 kg CO₂e/m²/yr

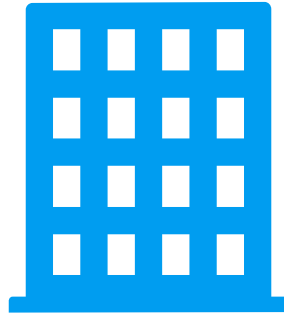
Total: 11.9 kg CO₂e/m²/yr

Different buildings, different challenges



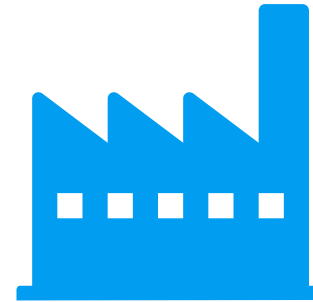
1-2 storey buildings

- Foundation
- Ground slab
- Roof



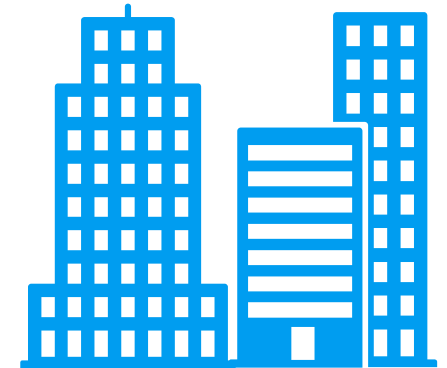
Multi-storey buildings

- Structural system
- Deck slabs
- Exterior walls



Industry

- Structural system
- Ground slab
- Roof
- Exterior walls



Complex buildings

- Foundation
- Ground slab
- Roof
- Exterior walls
- Structural system
- Deck slabs
- Basements
- ?

Who are affected by it?

Buildings affected

- New construction covered by requirements for energy performance calculations (§259 and §260)
- Building permit applications after 1 January 2023
- Limit of 12 kg CO₂e/m²/yr applies to buildings with a heated floor area > 1,000 m²

Who is responsible?

- No requirements to who conducts the LCA
- In Ramboll, the LCA Manager is responsible for the final LCA

Who are affected by it?

What happens if the LCA does not comply with the limit value?

- Cannot obtain occupation permit
- Initiatives to bring the building below the limit value
- Dispensation through §22
- Potential police reporting / fine according to §564

Special conditions

Certain prerequisites can allow an exceedance of the limit value to ensure we are still able to build certain typologies or in certain areas. Special conditions are assessed by the municipality for each individual case.

Potential special conditions:

- Hospital/lab equipment sensitive to vibrations in the building
- High-payload structures
- Consequence Class CC3
- Challenging soil conditions
- Buildings with high cleanliness requirements
- Buildings with high security requirements

Non-special conditions:

- Architectural design choices
- Unusually large volume of rooms
- Multi-storey cellar in the soil
- Many room separations

LCA in Danish legislation

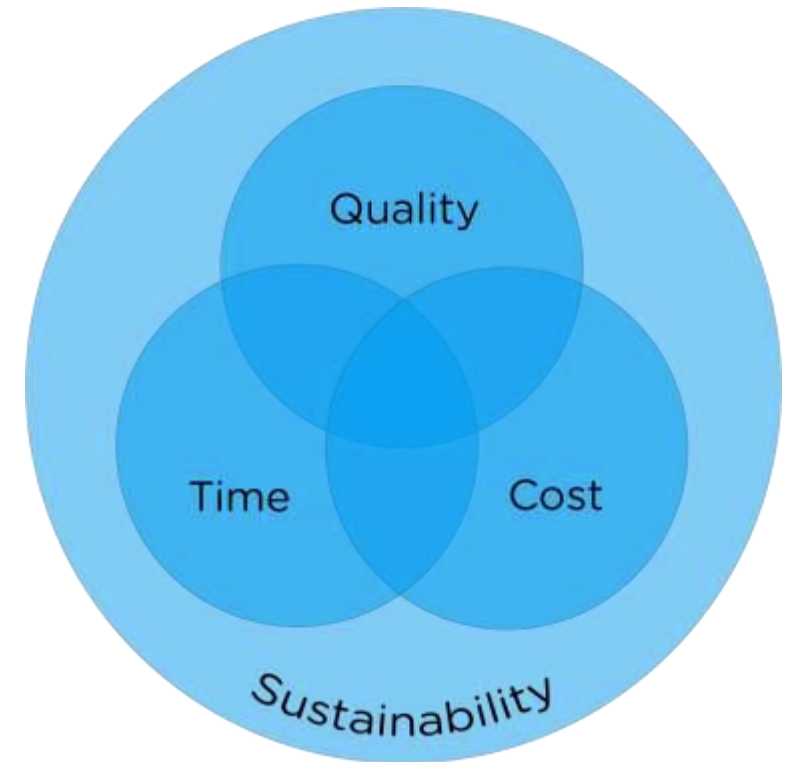
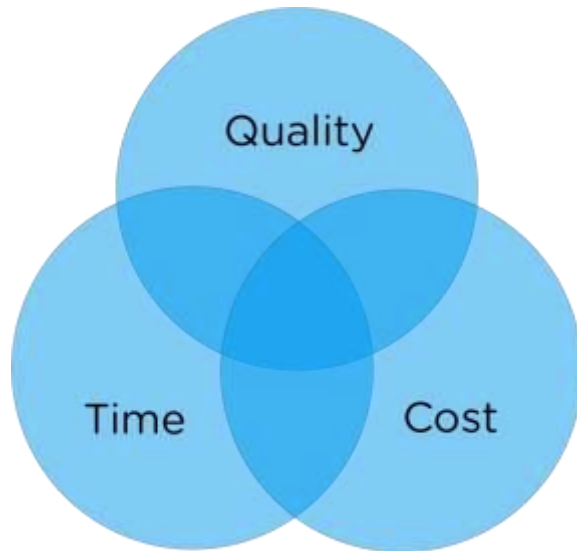
Key learnings

1. LCA on all new buildings from 1 January 2023
2. Heated floor area above 1,000 m²
→ limit value 12 kg CO₂e/m²/yr
3. Dare to be ambitious

LCA in a building project

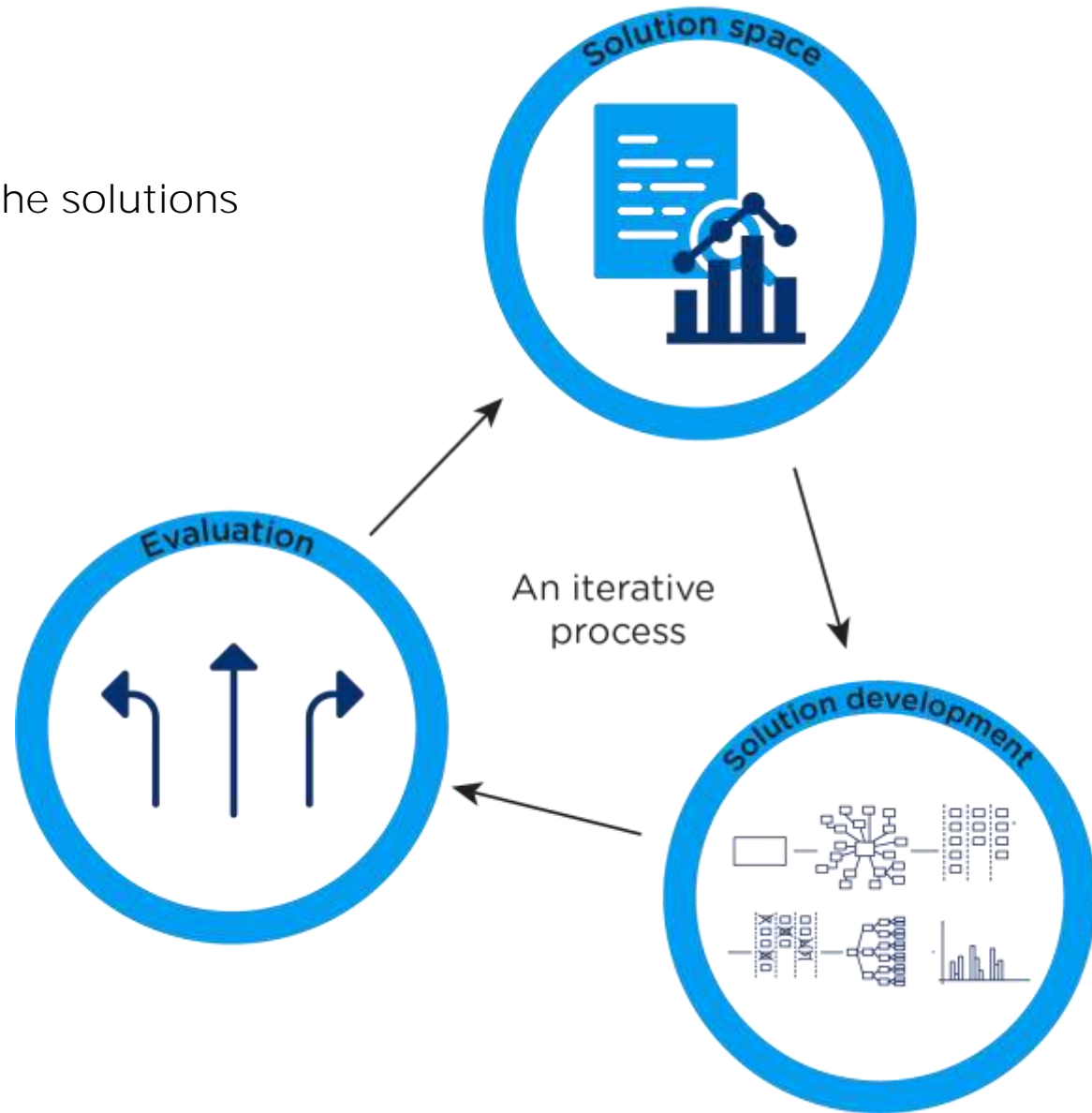
Sustainable buildings require additional ways of thinking

- Designing a building entails many different parameters
- Sustainability is a new factor and adds additional design parameters



An iterative process

Develop answers and use them to enhance the solutions



The Design Pyramid

1. Challenge the brief
 - Are the set requirements necessary?
 - How can we obtain the same result and reduce our impact?
2. Use less material
 - E.g., hollow core slab instead of cast concrete deck
 - 3D printed hollow columns instead of solid columns
 - Less simultaneous loads to avoid 100% - can it be done with 70%?
3. Use better material
 - Optimize concrete: e.g., recycled aggregate, Futurecem, fly ash, strength class, Unigreen
 - Windows with recycled glass
 - Solar panels with lower climate impact
 - Pex pipes made from recycled plastic



Evaluate and choose materials and products

Classic design parameters

- Performance (weight, efficiency, strength, fire resistance, acoustical performance, loads etc.)
- Quality (lifetime, material, design, health and toxicity)
- Cost (initial cost, service costs, replacement costs)

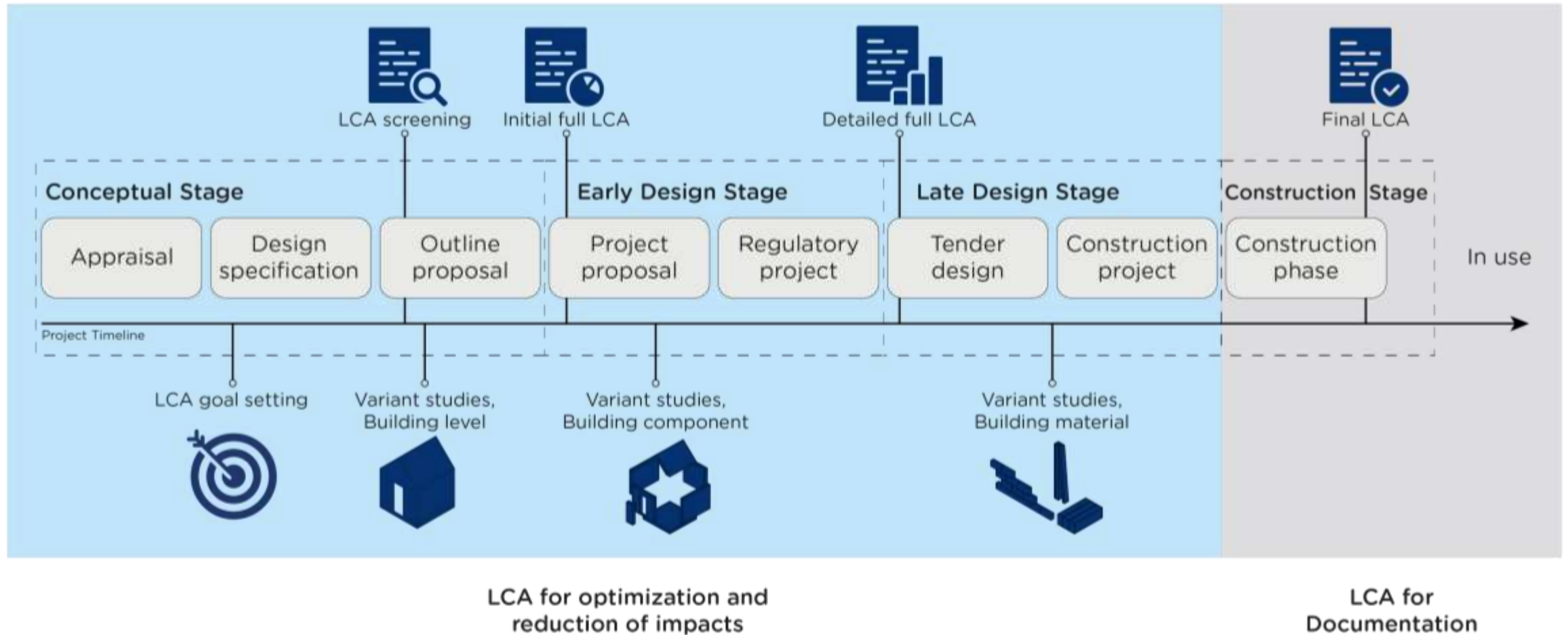
The LCA approach adds additional parameters we should keep in mind besides the direct CO₂e footprint:

- Potential for disassembly
- Potential for reuse
- Recycle potential
- Future CO₂e improvement potential
- When in time does the CO₂e emission occur

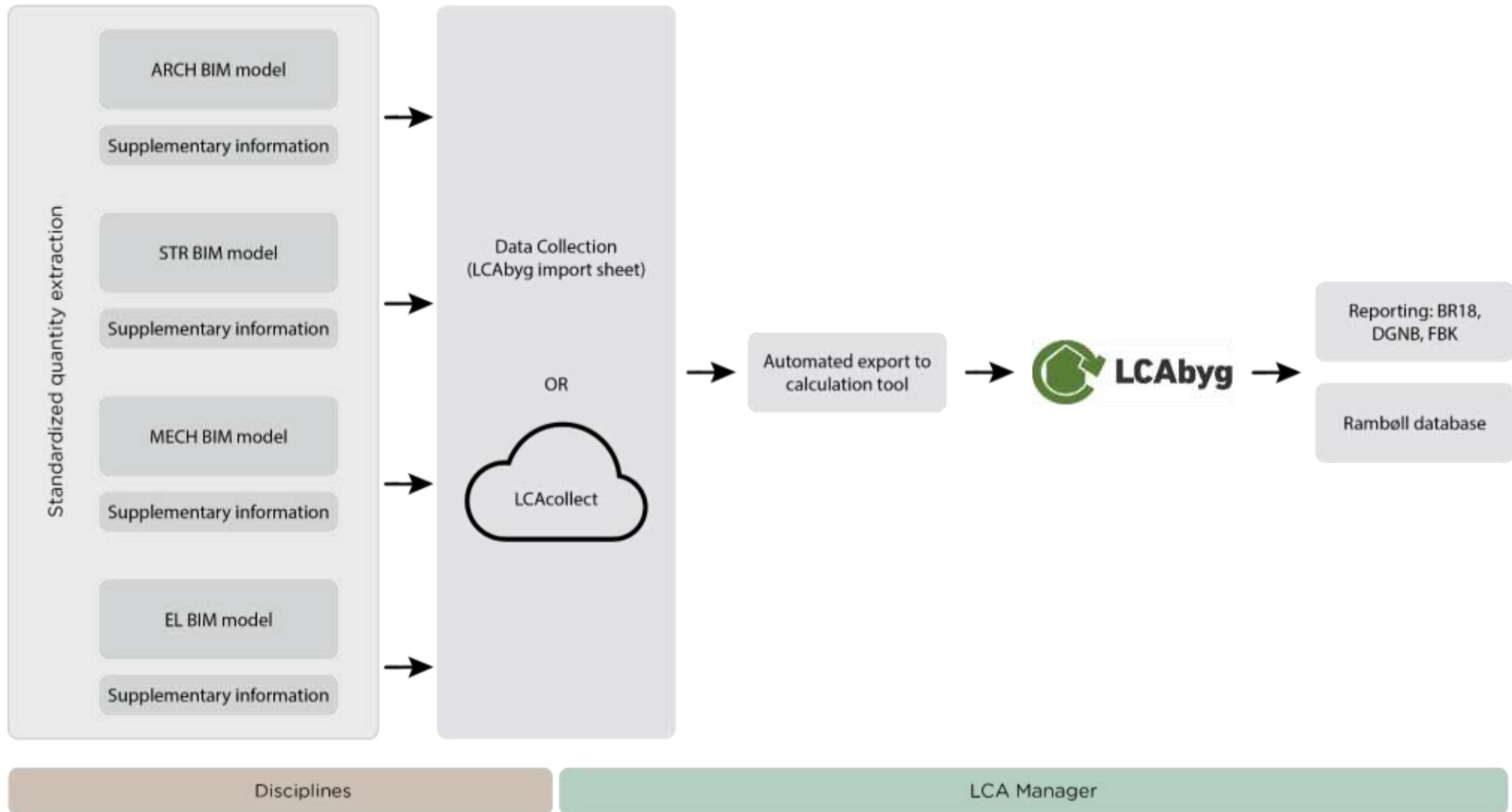


Project model for LCA

LCA in project stages



Data collection - tool level



The background of the slide features a large, semi-transparent image. On the right side, a tall wind turbine stands against a bright, hazy sky. In the foreground, a person is seen from behind, standing in a field of tall grass with their arms raised in a gesture of triumph or joy. The overall scene is bright and airy, suggesting a clean, sustainable environment.

LCA in a building process

Key learnings

1. LCA opens new relevant design parameters
2. Develop alternative solutions, evaluate, enhance
3. Use the Design Pyramid
4. Address circularity

Better
engineering.
Less CO₂

RAMBOLL