Life Cycle GHG Emissions of Material Use in the Living Laboratory

Marianne Kjendseth Wiik, Aoife Houlihan Wiberg

marianne.wiik@sintef.no
aoife.houlihan.wiberg@ntnu.no

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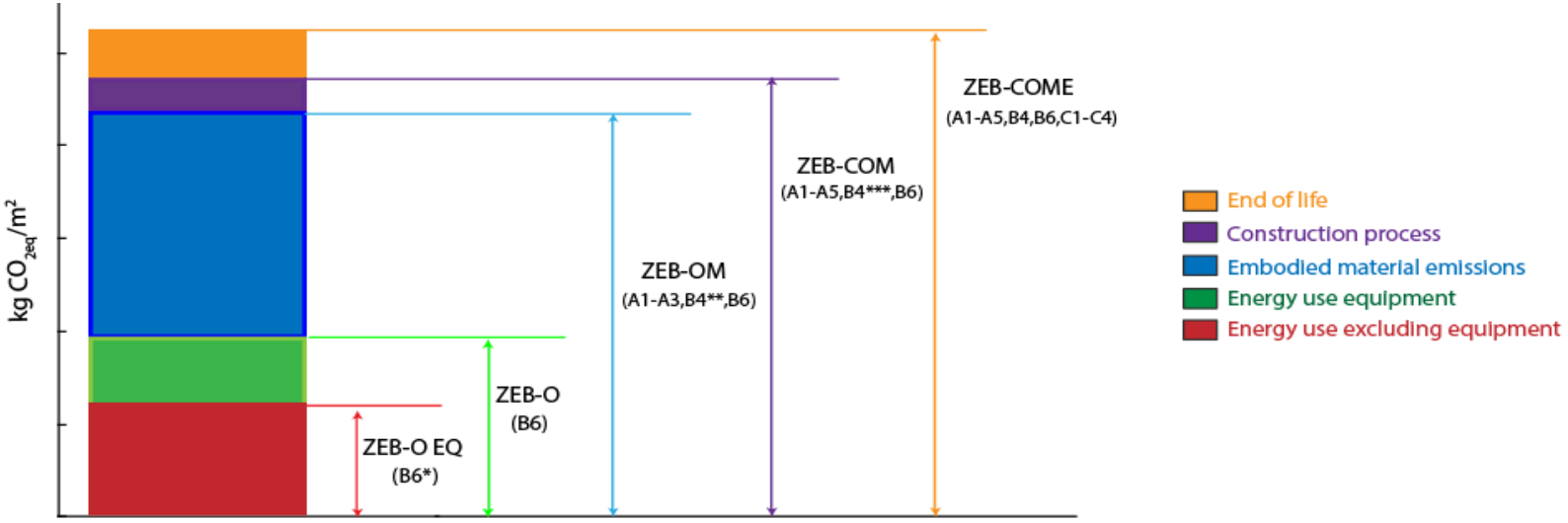
International Co-owners:
SBE SERIES
iiSBE
Sustainable Buildings and Climate Initiative
FIDIC
Global Alliance for Buildings and Construction

Background



The Research Council of Norway

ZEB The Research Centre on Zero Emission Buildings

NTNU SINTEF

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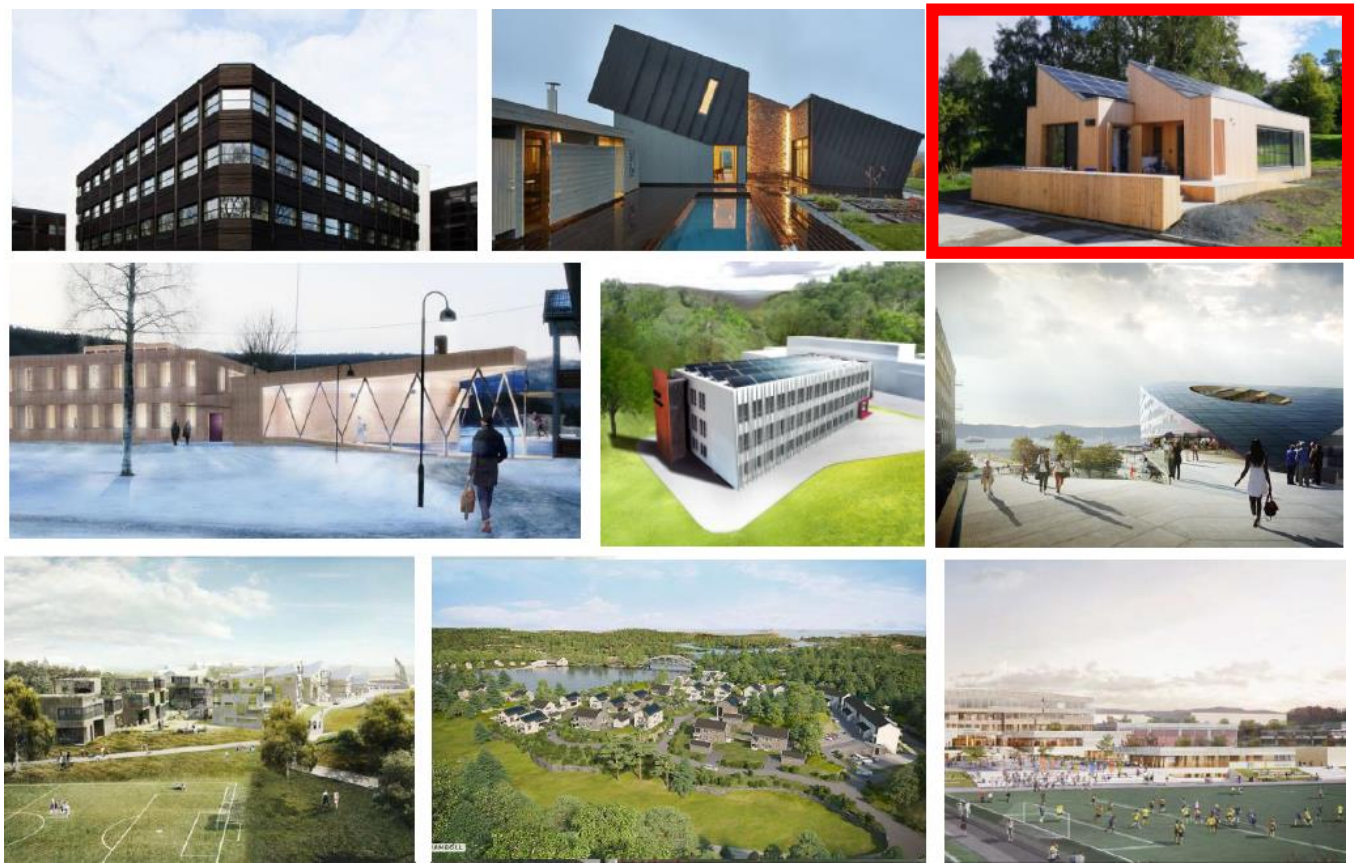
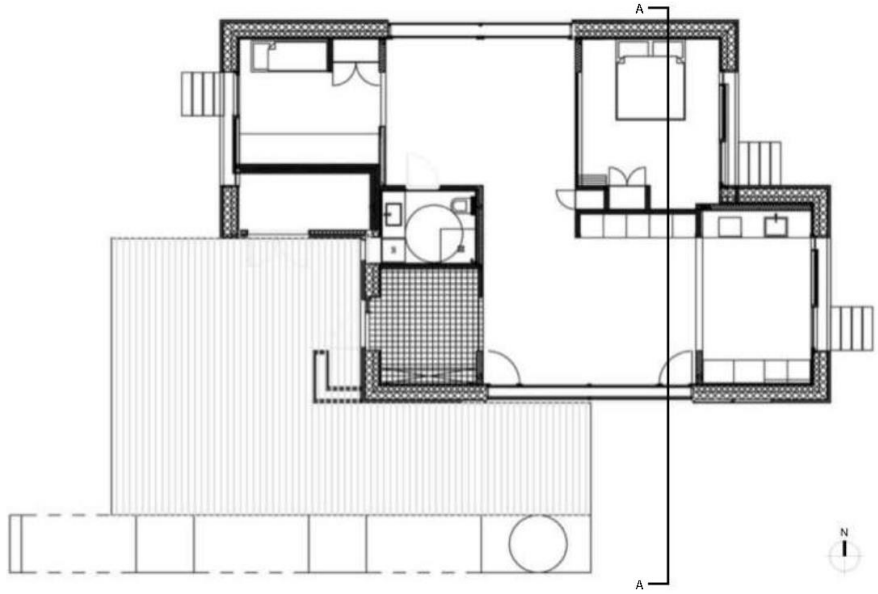
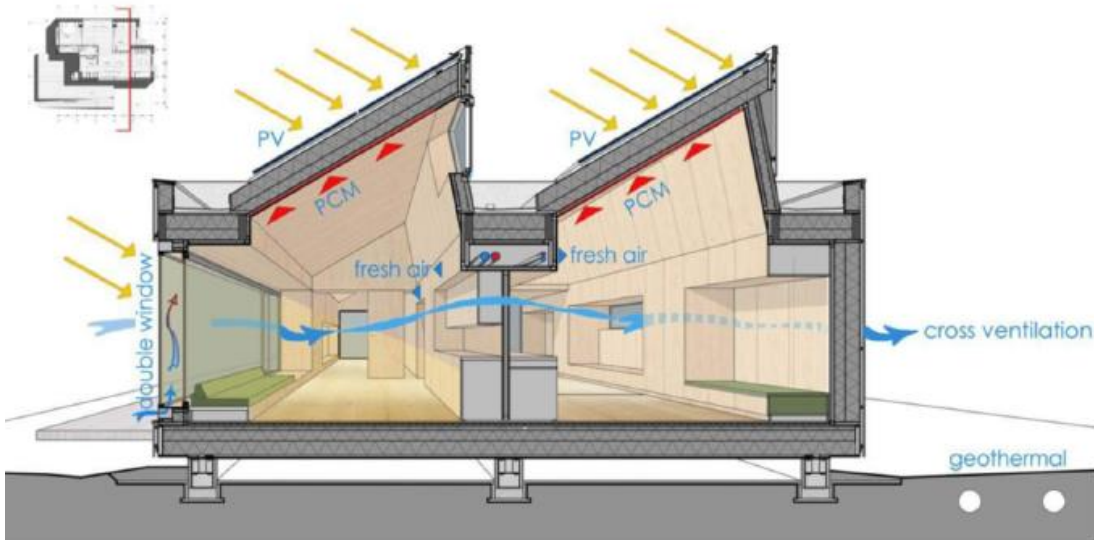
nZEB pilot projects



Living Laboratory




PV
PV
PCM
PCM
fresh air
fresh air
double window
cross ventilation
geothermal

Method

- Goal: To identify which materials and components contribute the most to embodied CO_{2eq} emissions in the Living Laboratory.
- Life Cycle Assessment (LCA) according to ISO 14044.
- Functional Unit: 'emissions per $1m^2$ of heated floor area per year of operational building lifetime.'
  - Heated floor area: $102m^2$
  - Building lifetime: 60 years
- Material inventory gathered from architect's drawings, product literature and through on-site observations.

Method

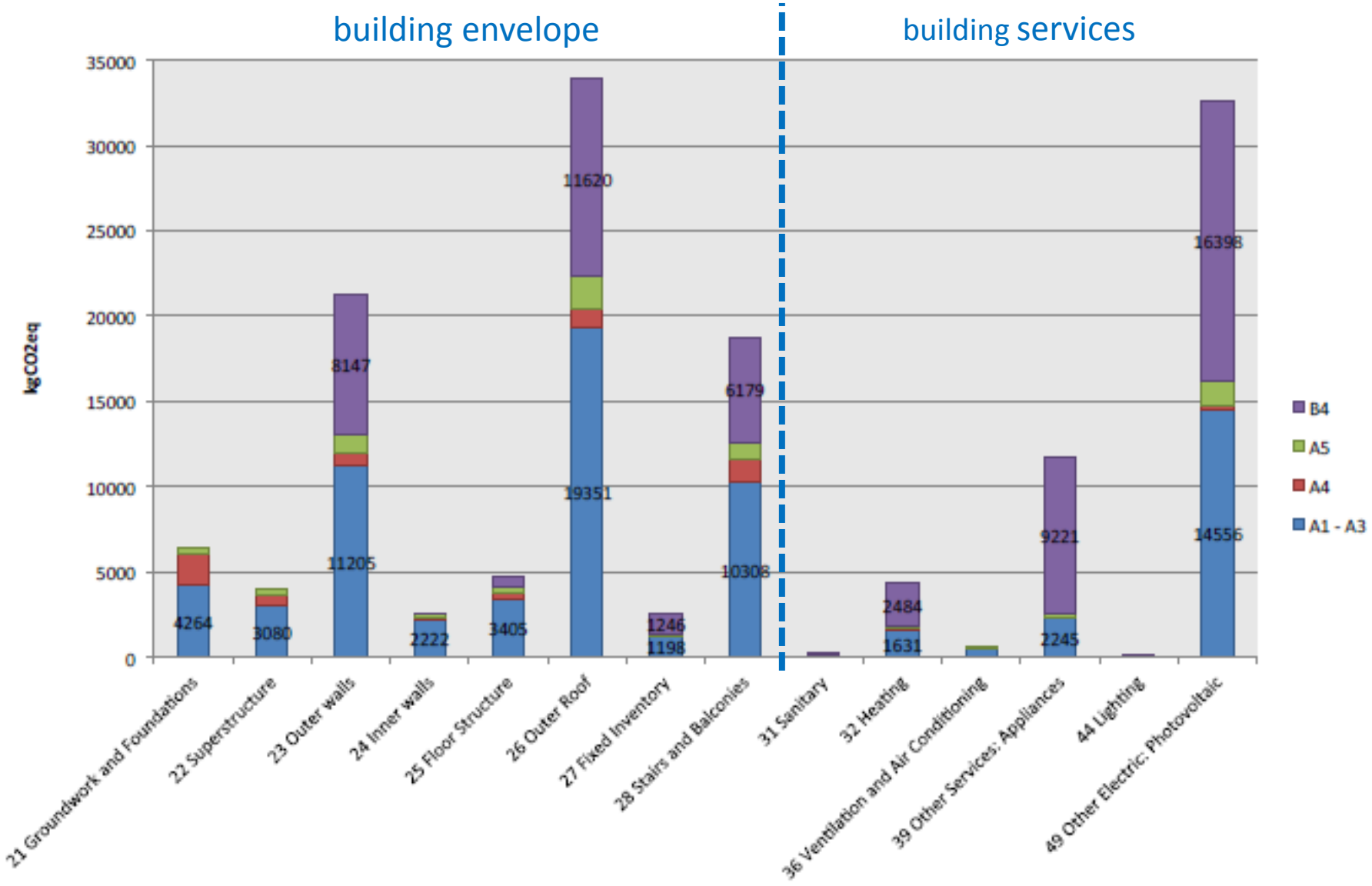
- System boundary defined according to EN 15978.
- NS 3451: 2009 Table of Building Elements.

A1-3 Product Stage			A4-5 Construction Process Stage		B1-7 Use Stage							C1-4 End of Life			
A1: Raw Material Supply	A2: Transport to Manufacturer	A3: Manufacturing	A4: Transport to building site	A5: Installation into building	B1: Use	B2: Maintenance (incl. transport)	B3: Repair (incl. transport)	B4: Replacement (incl. transport)	B5: Refurbishment (incl. transport)	B6: Operational energy use	B7: Operational water use	C1: Deconstruction / demolition	C2: Transport to end of life	C3: Waste Processing	C4: Disposal
x	x	x	x	x				x							

Results

Life Cycle Stage	$kgCO_{2eq}$	$kgCO_{2eq}/yr$	$kgCO_{2eq}/m^2$ 60 years	$kgCO_{2eq}/m^2/yr$
Production phase (A1-A3)	74,121	1,235	727	12.1
Transport to Site (A4)	6,188	103	61	1.0
Construction (A5)	7,412	124	72	1.2
Replacement (B4)	56,067	934	550	9.2
TOTAL	143,788	2,396	1,410	**23.5**

- 50% of total emissions from the production phase.
- 40% of total emissions from the replacement phase.
- 5% of total emissions from transport to site.
- 5% of total emissions from the construction phase.



Sensitivity of Functional Unit

AREA

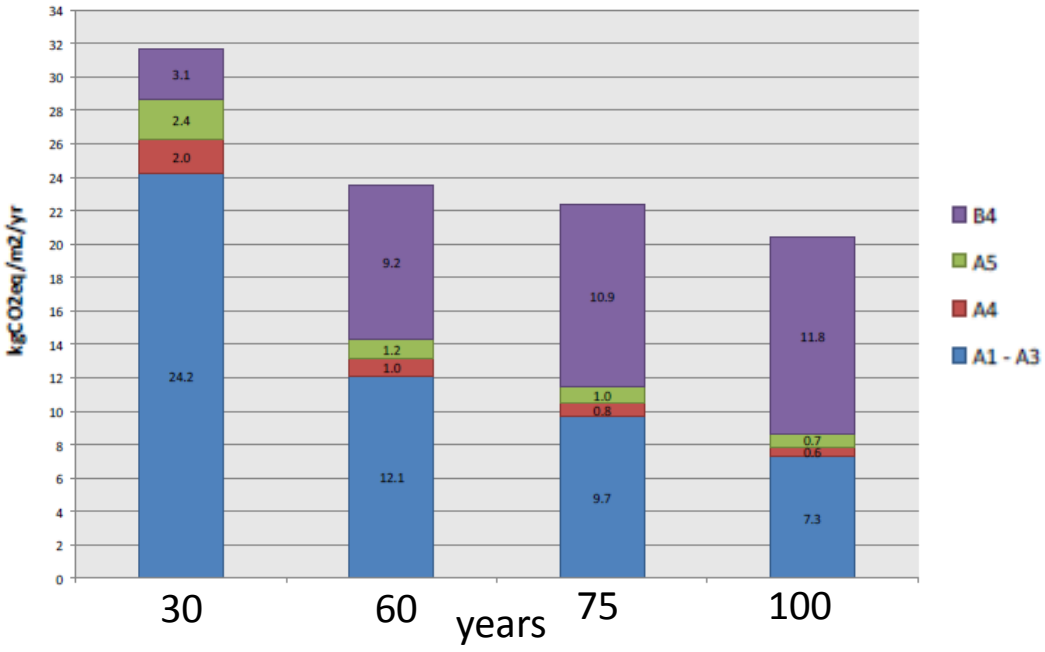
Heated floor area: 102m^2
23.5 kgCO_{2eq}/m^2/yr

Gross floor area: 132m^2
18.2 kgCO_{2eq}/m^2/yr

Net floor area: 97m^2
24.7 kgCO_{2eq}/m^2/yr

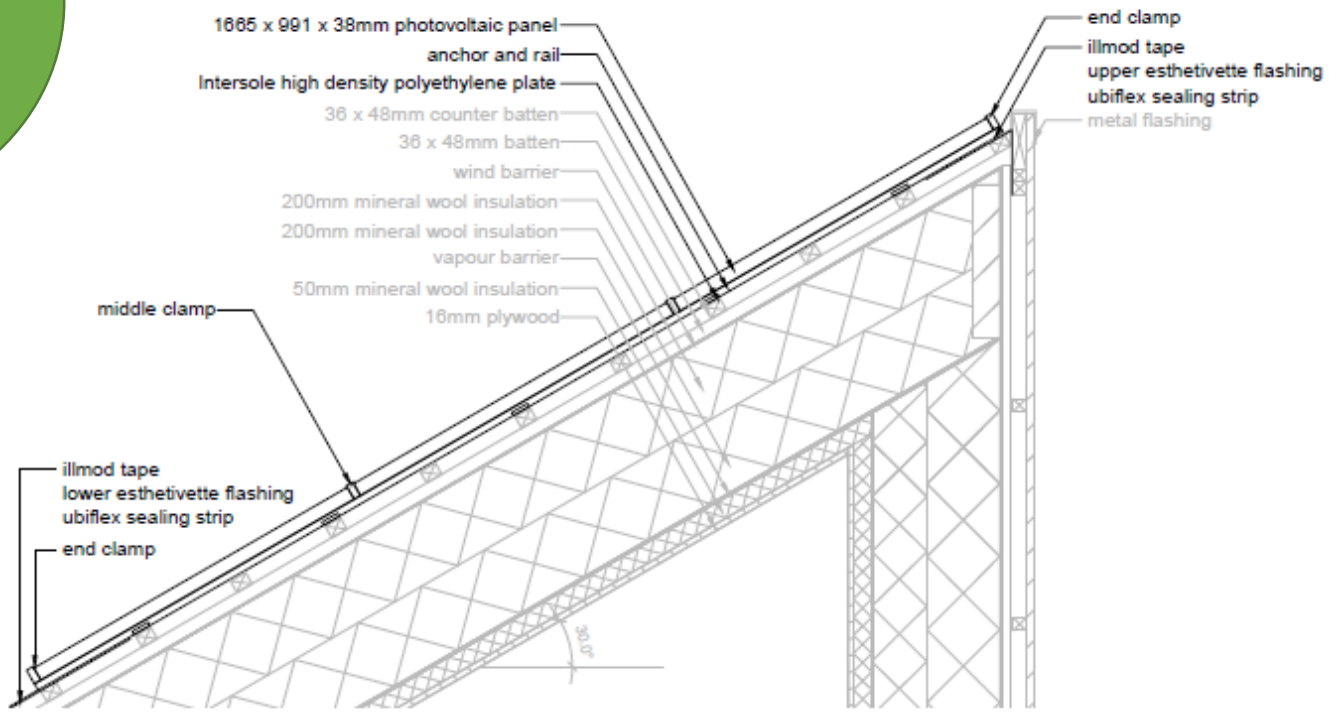
Built up area: 219m^2
10.9 kgCO_{2eq}/m^2/yr

BUILDING LIFETIME



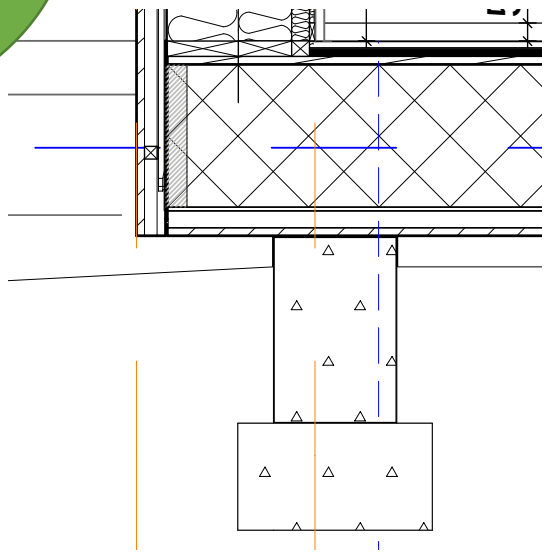
Design Driver: High Emissions

25% total emissions from roof
20% from BAPV



Design Driver: Low Emissions

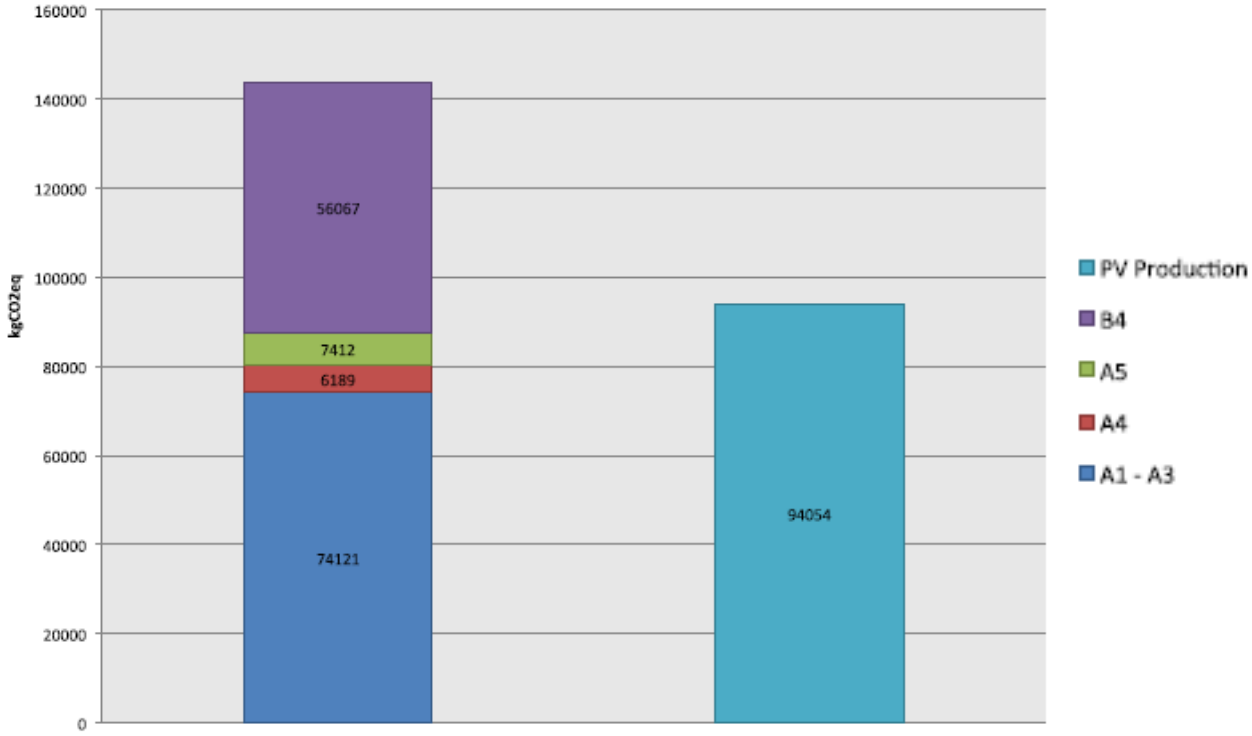
40% reduction
in material use
20% reduction
in emissions



Design

As-built

Material Emission Balance



- 65% of total embodied material emissions are compensated for by local PV energy production.

Discussion

- The foundations experience a 40% material reduction and 20% emission reduction. This may be reduced with low carbon concrete.
- Materials with long reference service lives (RSLs) have high emissions during the production phase, whilst materials with short RSLs, have high emissions during the replacement phase.
- The emission balance shows that further measures are required to reduce material emissions and increase local energy production.
- The roof and BAPV contribute to almost half of emissions. Further research could investigate a BIPV solution instead, which uses a less elaborate roof form.
- The Living Laboratory is a temporary building with a short building lifetime. Thus, focus on recyclability and demountability.

Conclusion

- This study has identified which materials and components contribute the most to embodied emissions in the Living Lab.
- It highlights methodological and design considerations:
  - The functional unit is sensitive to definition of area and lifetime.
  - A complex roof form and PV led to high embodied emissions.
  - An concrete omission in the foundations led to a reduction in embodied emissions.
- It also provides alternative solutions for low carbon design.
  - For example, the sensitive use of PCM and VIP.
- Material optimisation should be considered at an early stage in the design process to reduce embodied material emissions.

Thank you