Zero Emission Buildings –
From definition to demonstration buildings

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Director The Research Centre on Zero Emission Buildings

The Research Centre on
Zero Emission Buildings

FME FORSKNINGS-SENTER FOR MILJØVENNLIG ENERGI

Outline

- Background
- ZEB Centre facts
- ZEB definition
- ZEB demonstration buildings
  - Virtual buildings
  - Real buildings
  - Pilot building outcomes
- The next step

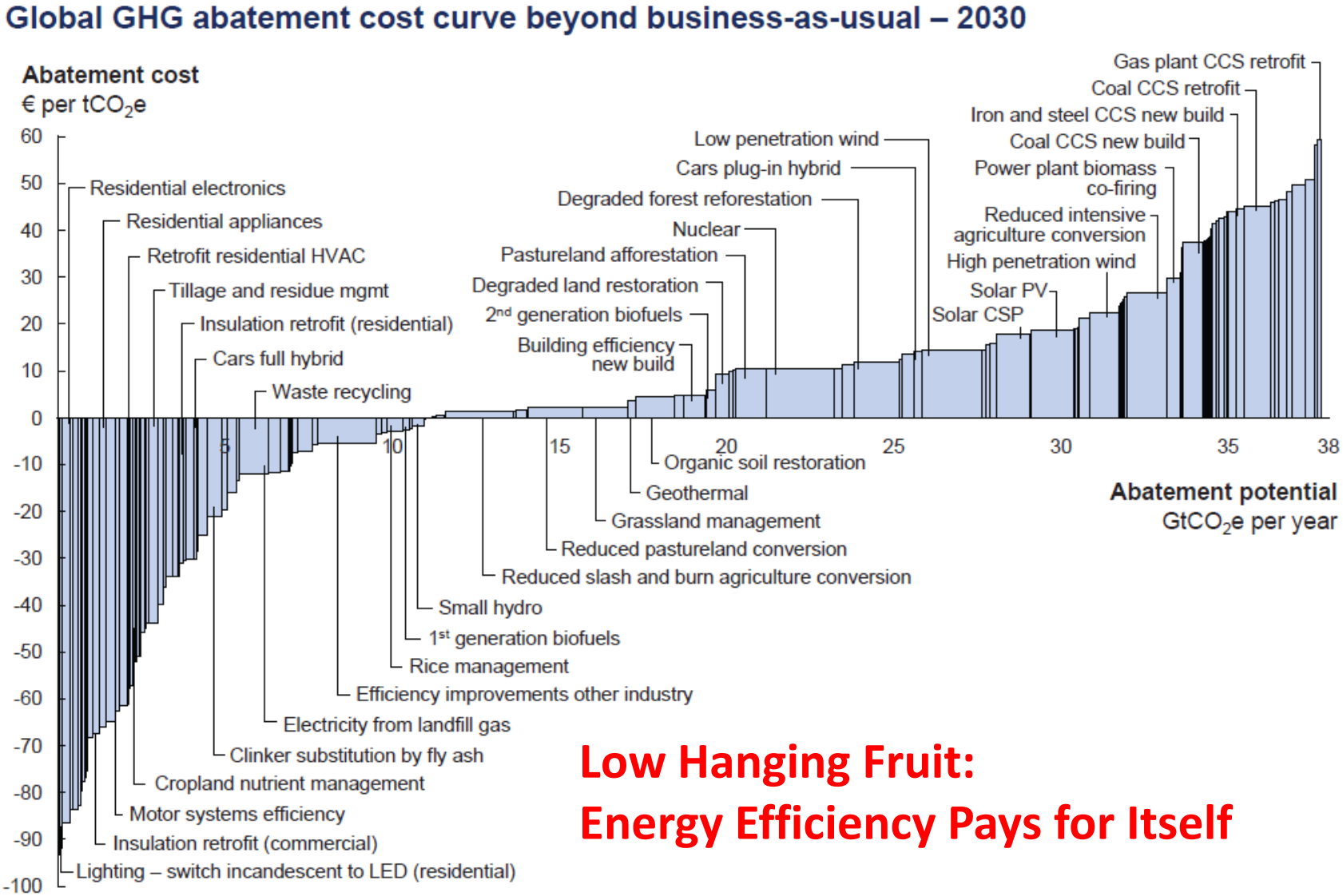
Roadmap to a resource efficient Europe, 2011

- Better construction and use of buildings in the EU would influence **42% of our final energy consumption**, about **35% of our greenhouse gas emissions** and more than **50% of all extracted materials**; it could also help us save up to 30% water.
- Existing policies for promoting energy efficiency and renewable energy use in buildings therefore need to be further strengthened and complemented with **policies for resource efficiency, which look at a wider range of environmental impacts across the life-cycle of buildings and infrastructure.**

- http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN

Why zero emission buildings?

McKinsey, ”Pathways to a Low Carbon Economy. Version 2 of the Global Greenhouse Gas Abatement Cost Curve”, McKinsey & Company, 2009.

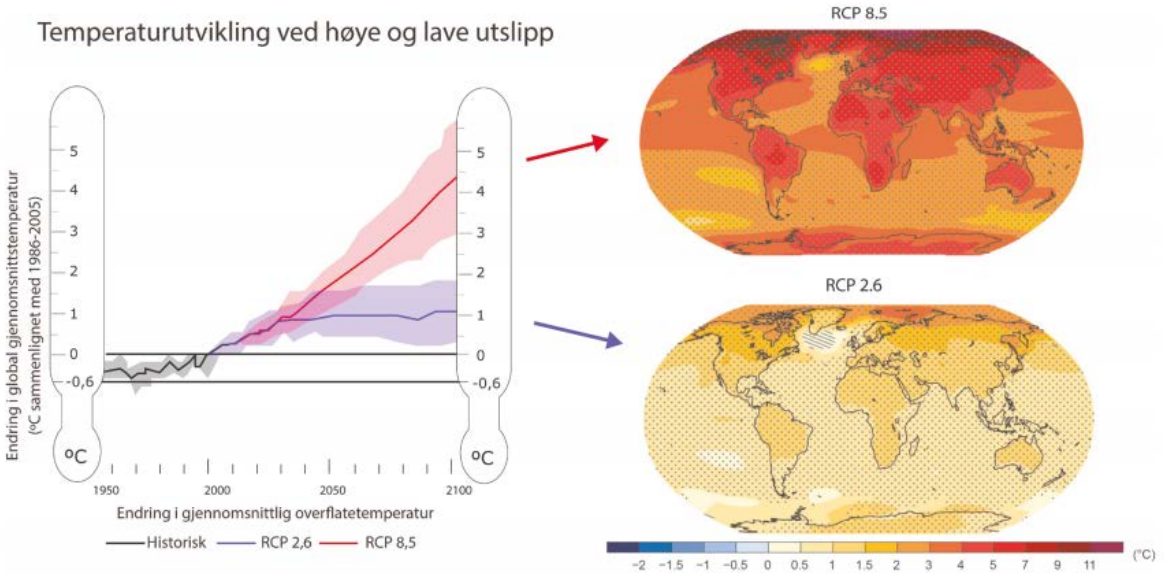


Low Hanging Fruit:
Energy Efficiency Pays for Itself

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.0

IPCC CLIMATE CHANGE 2014 SYNTHESIS REPORT, November 2014

- Human influence on the climate system is clear.
- There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to preindustrial levels. **These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO_2 and other long-lived GHGs by the end of the century**.



ZEB Centre's main objective

is to develop competitive products and solutions for existing and new buildings that will lead to market penetration of buildings with zero greenhouse gas emissions related to their production, operation, and demolition.


Illustration: Snøhetta/MIR

The centre encompass
both residential, commercial,
and public buildings.

www.zeb.no

ZEB Centre facts

- The ZEB Centre is a Centre for Environment-friendly Energy Research, funded by the Research Council of Norway and 25 partners

- Host institution:
  Norwegian University of Science and Technology – NTNU
- Research partners:
  SINTEF Building and Infrastructure and SINTEF Energy Research
- Industry and public partners: 22

- Start date: November 2009
- Total budget: Ca. 290 MNOK (+ additional to research infrastructure)

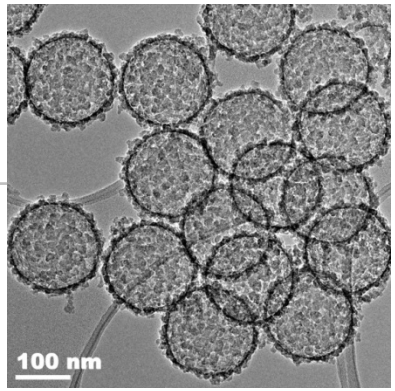
- Researchers associated with the Centre: about 25 (most part time)
- PhD candidates: 24
  - 16 is partly/directly funded by ZEB
- Post docs: 5

ZEB research activities

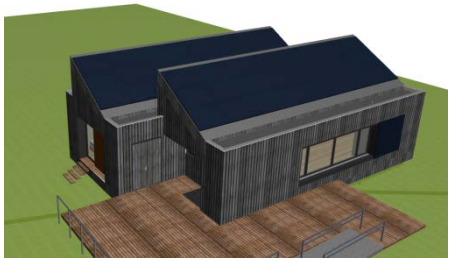
ZEB focuses its work in areas that interact and influence each other:

- **WP1** Advanced materials technologies
- **WP2** Climate-adapted low-energy envelope technologies
- **WP3** Energy supply systems and services
- **WP4** Use, operation, and implementation
- **WP5** Concepts, strategies and demonstration buildings
- **Laboratories**

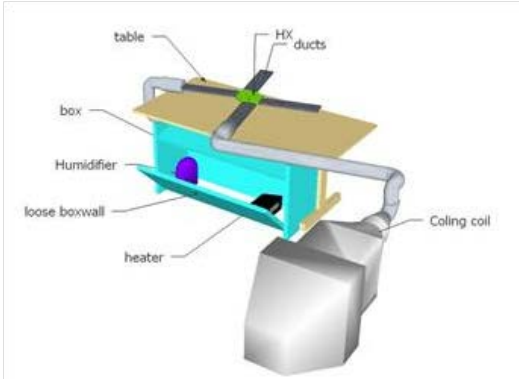
VIP Leca Isoblokk



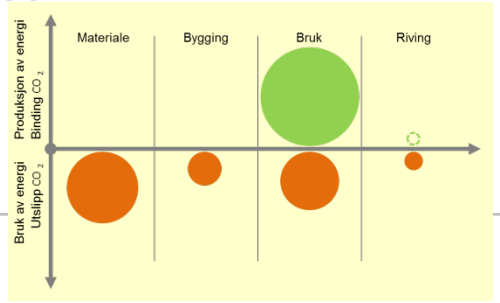
Nano insulation material



ZEB Living Lab



Membrane heat exchanger



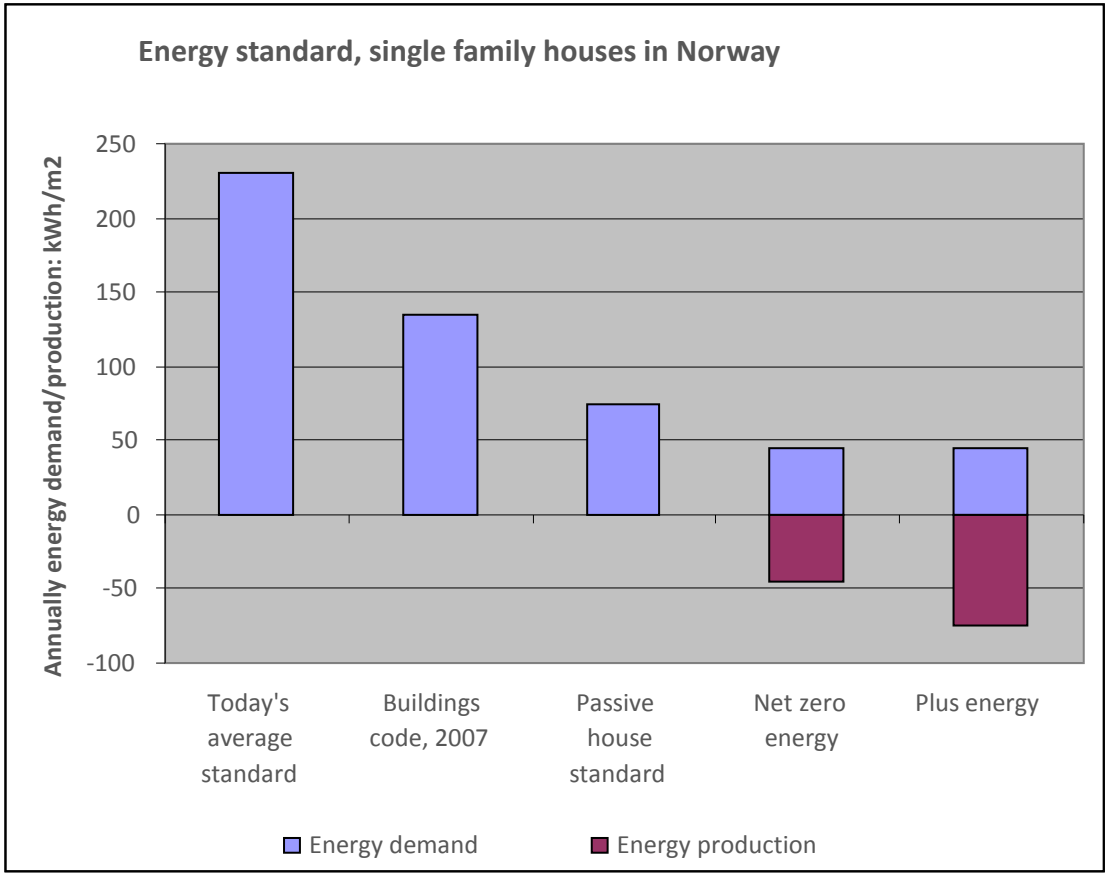
ZEB Definition

ZEB demonstration buildings

The Research Centre on Zero Emission Buildings

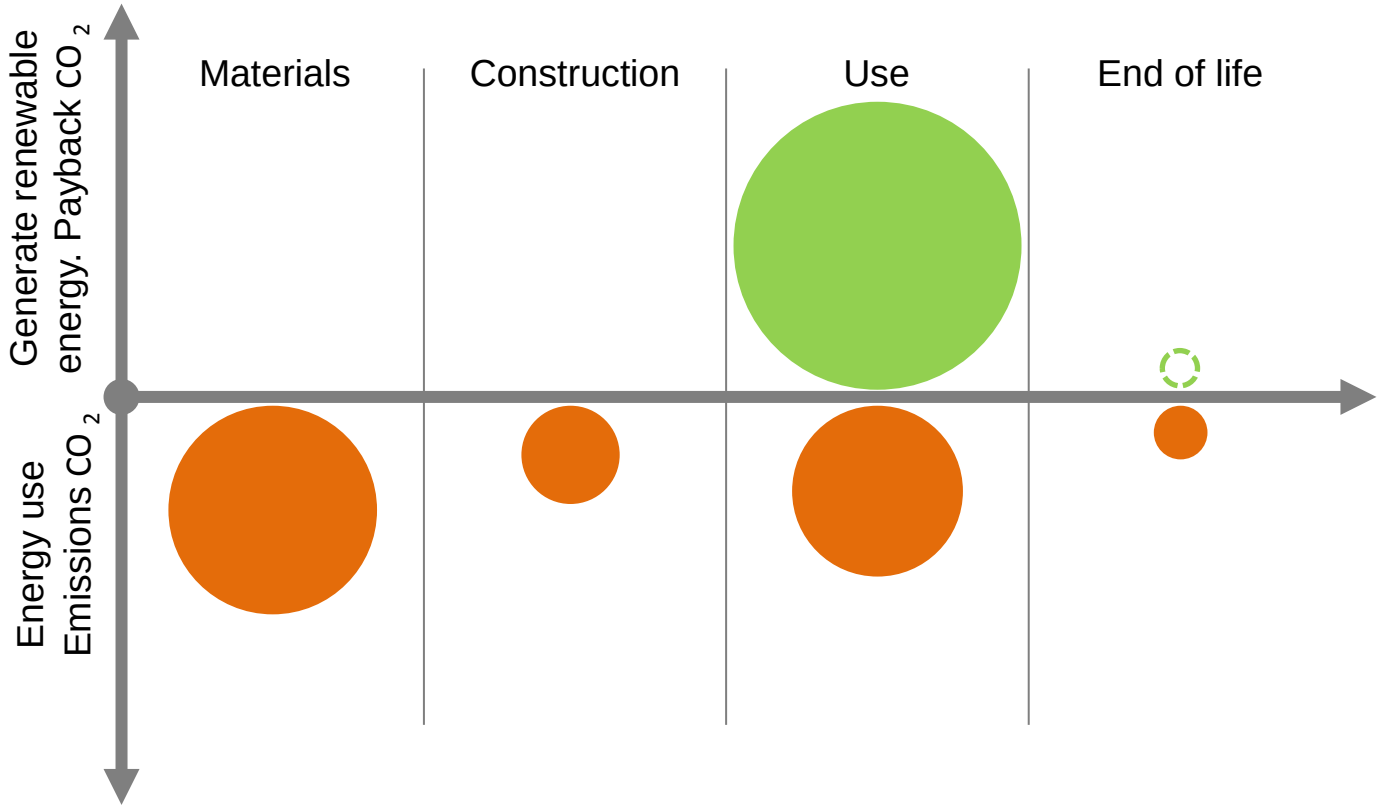
What is a zero emission building (ZEB)?

The main concept of a zero emission building is that renewable energy sources produced or transformed at the building site have to compensate for CO_2 emissions from operation of the building and for production, transport and demolition of all the building materials and components during the life cycle of the building.

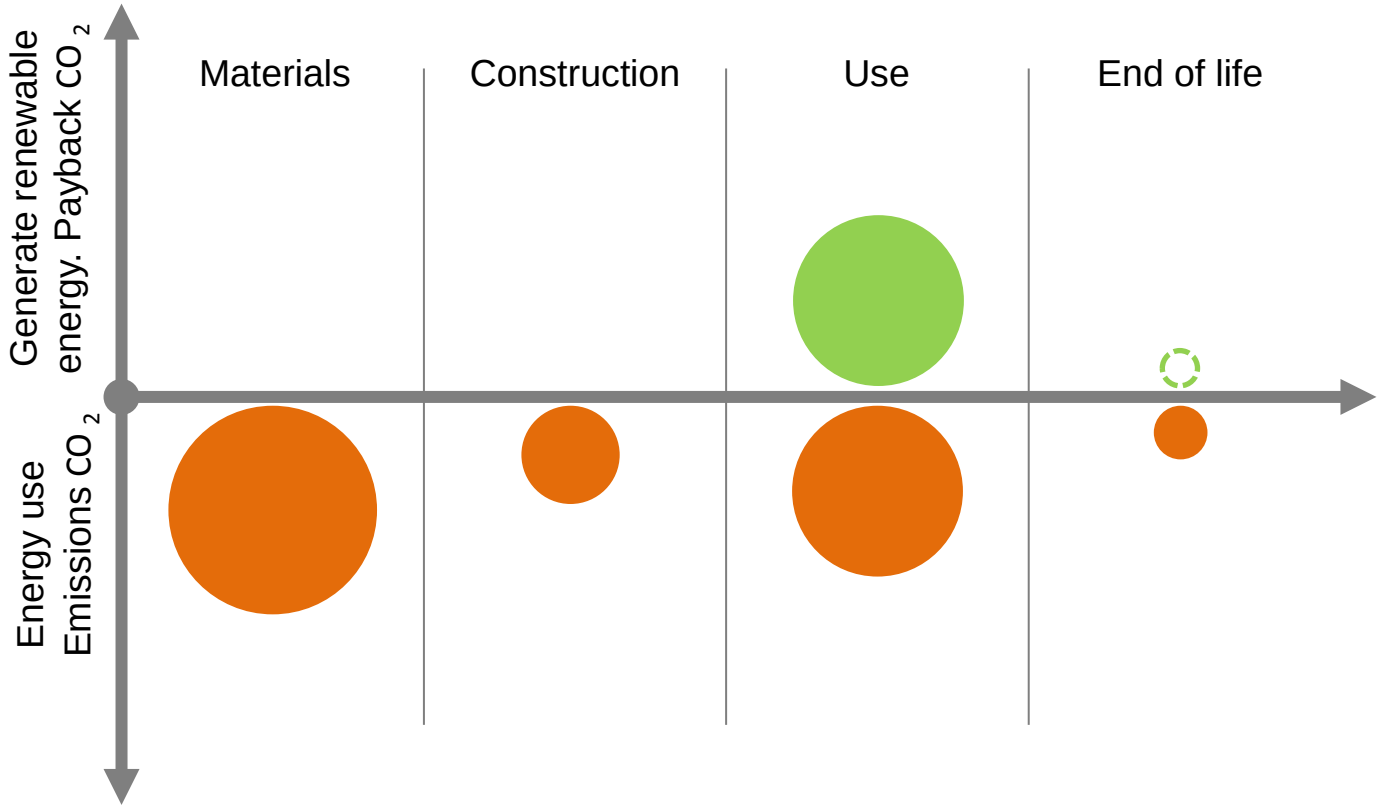


Source: SINTEF Byggforsk

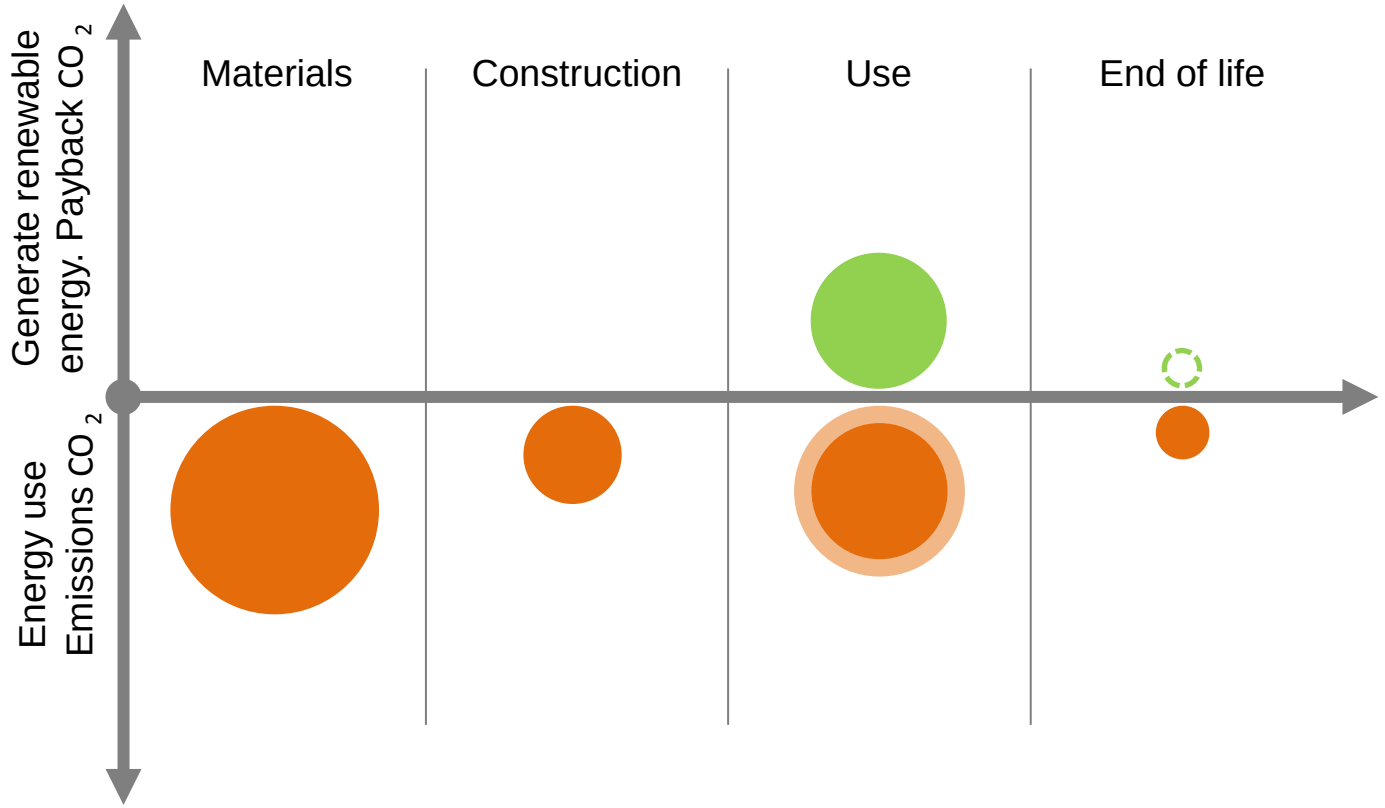
What is a zero emission building (ZEB)?



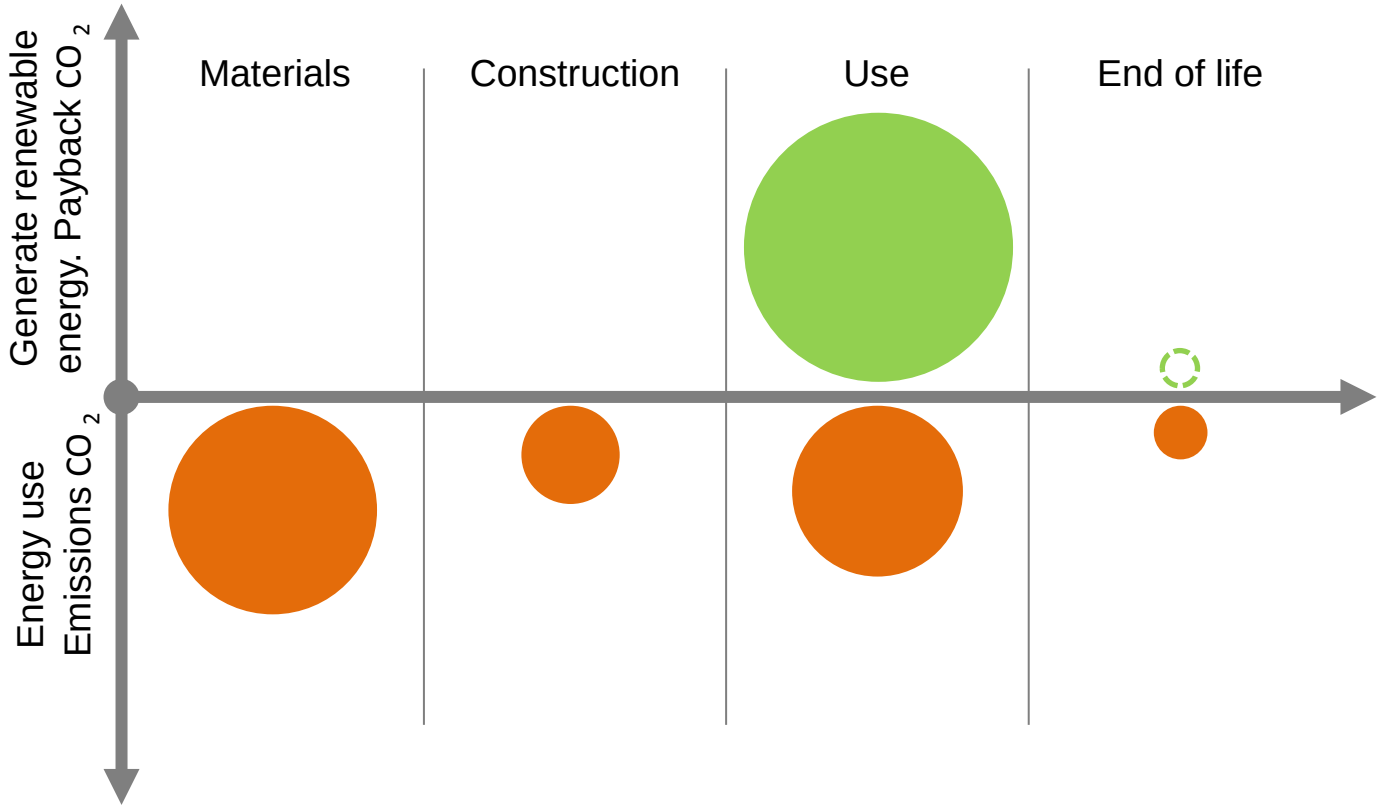
ZEB-O


Generate renewable energy. Payback CO_2
Energy use
Emissions CO_2
Materials
Construction
Use
End of life

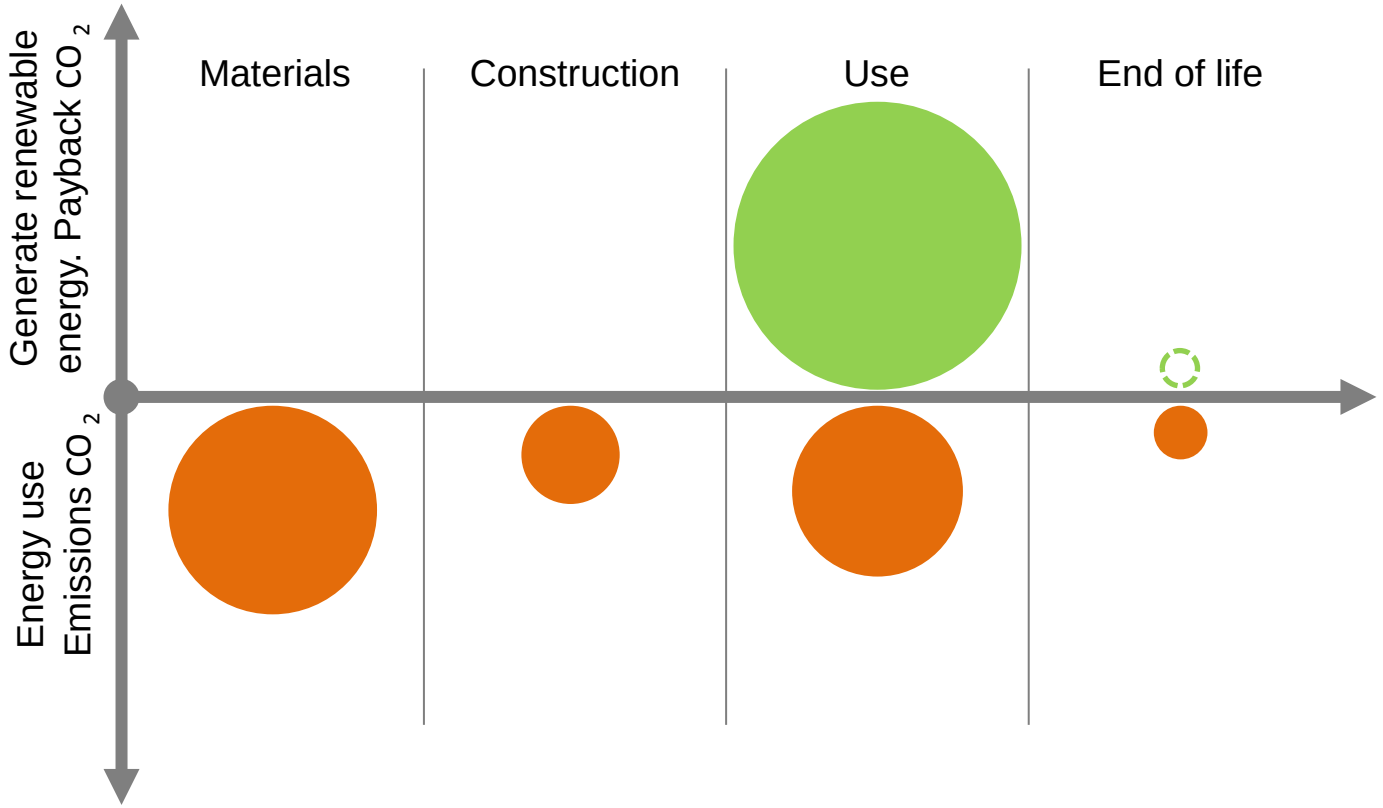
ZEB-O÷EQ


Generate renewable energy. Payback CO_2
Energy use
Emissions CO_2
Materials
Construction
Use
End of life

ZEB-OM


Materials
Construction
Use
End of life
Generate renewable energy. Payback CO_2
Energy use
Emissions CO_2

ZEB-COM


Materials
Construction
Use
End of life
Generate renewable energy. Payback CO_2
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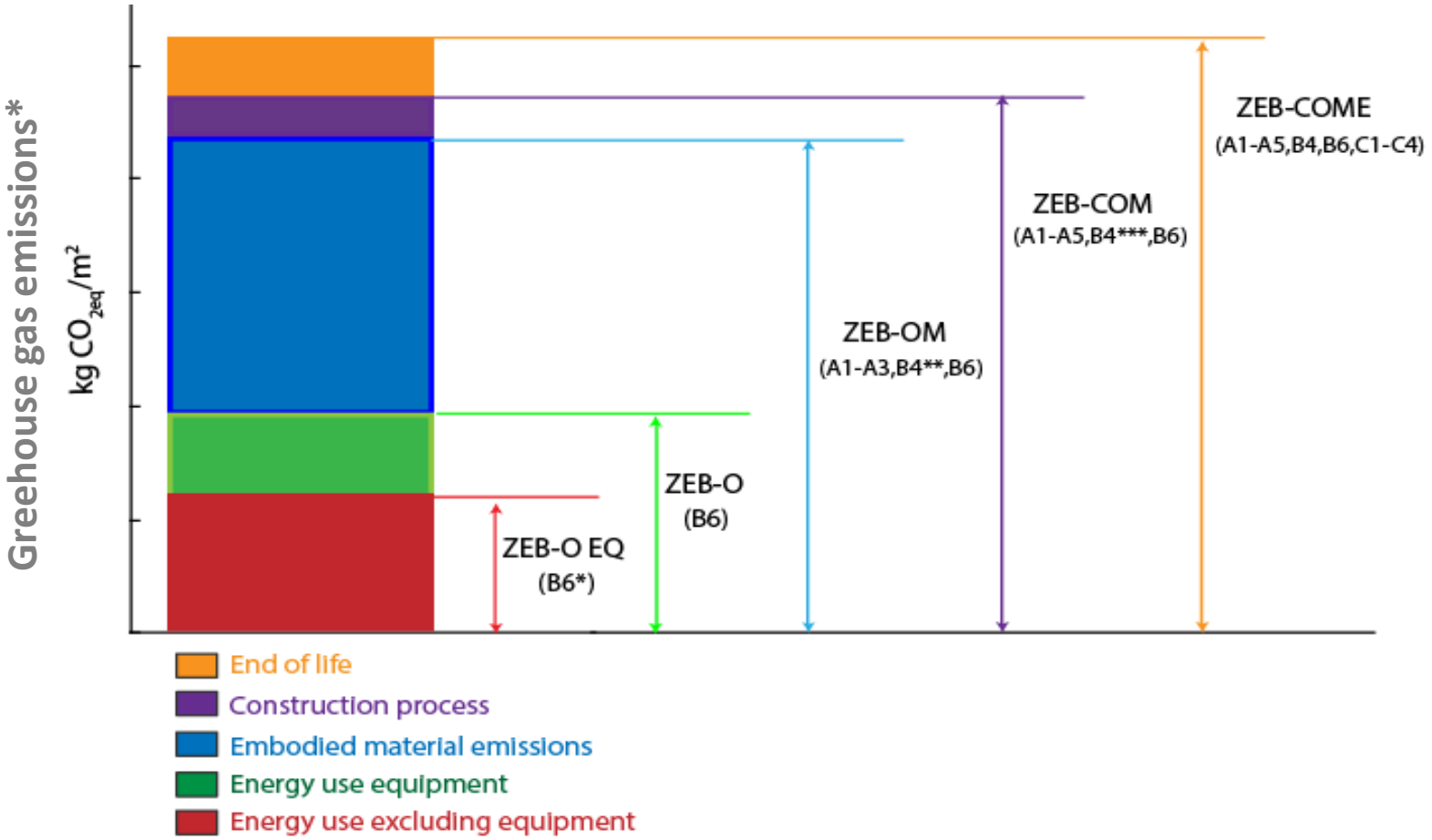
Emissions CO_2

Different levels of ambition for ZEB



* Greenhouse gas emissions are calculated as kg CO_2-equivalents per m^2 heated floor area per year (distributed over a 60 years life time)

ZEB demonstration buildings – example of strategies









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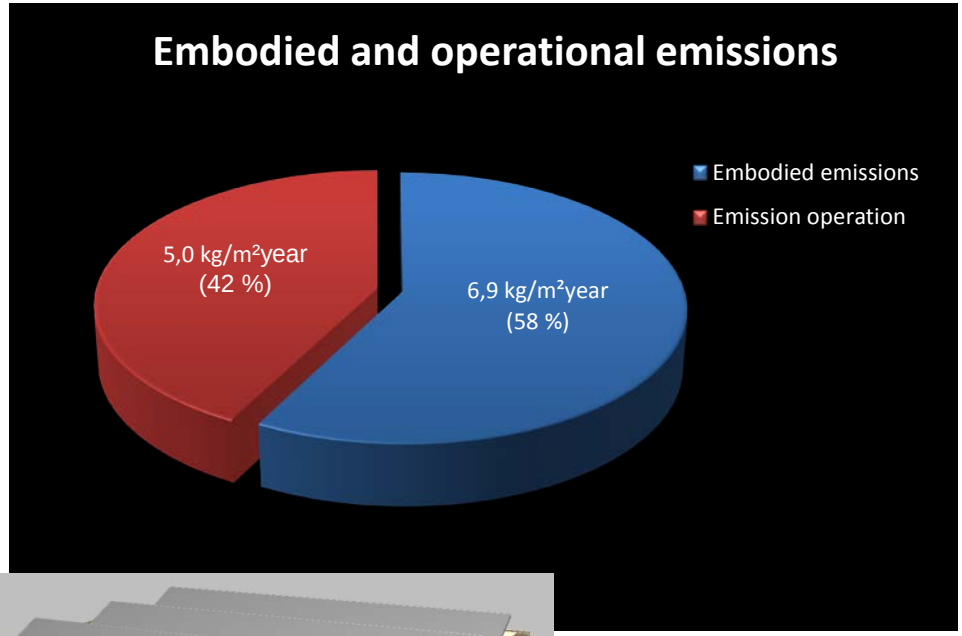
The first demonstration buildings were virtual ones – A large share of the emissions are related to materials

During the lifetime of a building, the material emissions can be as large as the emissions related to operating the building



ZEB demonstration buildings

Pilot Building	Type of Building	Built area
1. Skarpnes, Arendal	5 new detached houses	5 x 154 m^2
2. Powerhouse Kjørbo, Sandvika	Renovation of two office buildings	5 000 m^2
3. ZEB Pilot House, Larvik	New detached demonstration house	200 m^2
4. Ådland, Bergen	720 new dwellings	80 000 m^2
5. Visund, Haakonsvern Bergen	New office building	2 000 m^2
6. Powerhouse Brattøra, Trondheim	New office building	14 000 m^2
7. ZEB Living Lab, Trondheim	New research dwelling	100 m^2
8. Heimdal VGS, Trondheim	New upper secondary school	18 000 + 8 000 m^2
9. Campus Evenstad	New office building	1 100 m^2

Powerhouse Kjørbo, Sandvika

PowerHouse Alliance:

Skanska, Entra, Snøhetta, Zero, Asplan Viak, Hydro, SAPA

Illustrasjon: SNØHETTA / MIR

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Powerhouse Kjørbo

Ambition: ZEB – OM-EQ

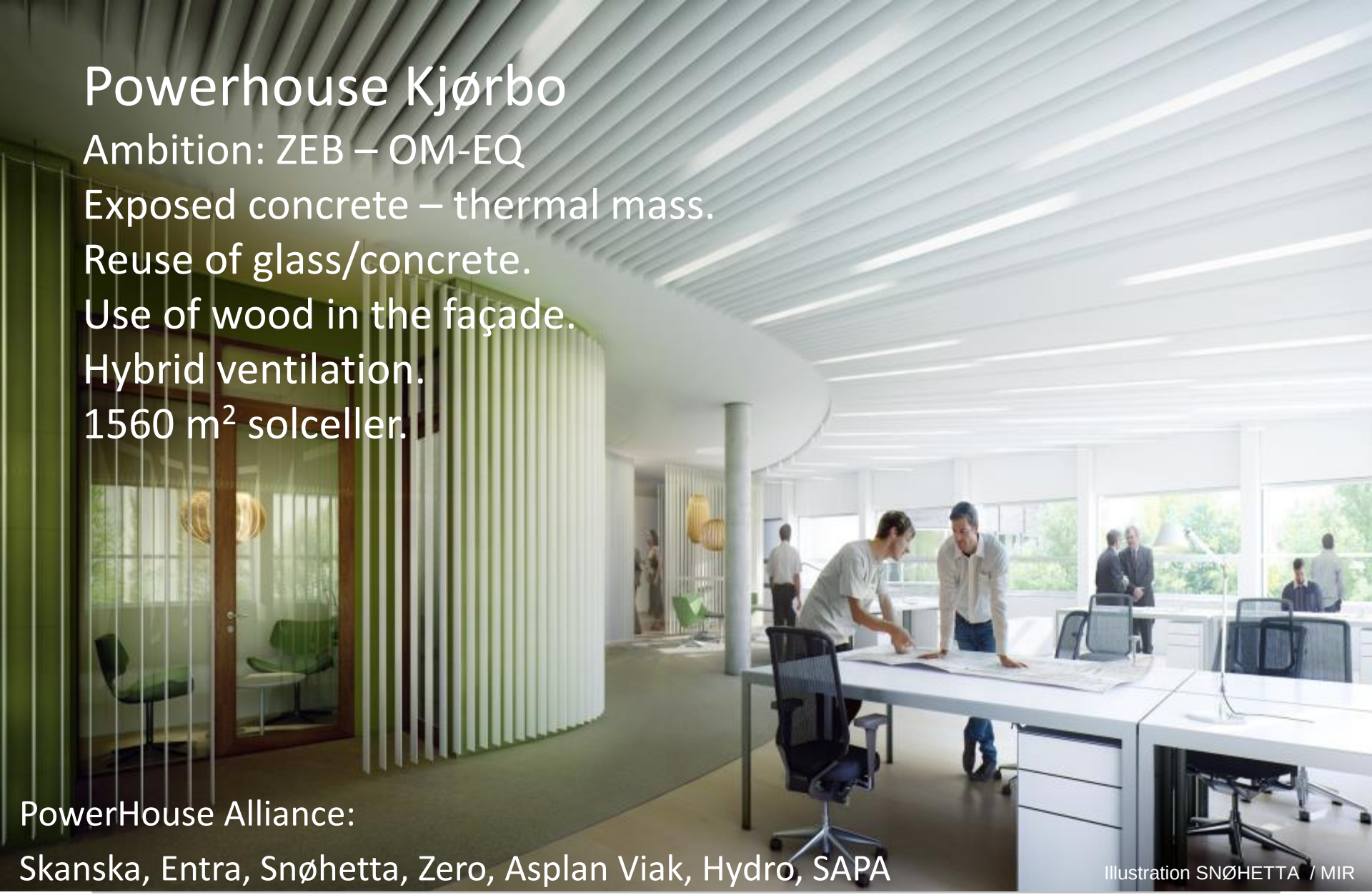
Exposed concrete – thermal mass.

Reuse of glass/concrete.

Use of wood in the façade.

Hybrid ventilation.

1560 m^2 solceller.



PowerHouse Alliance:

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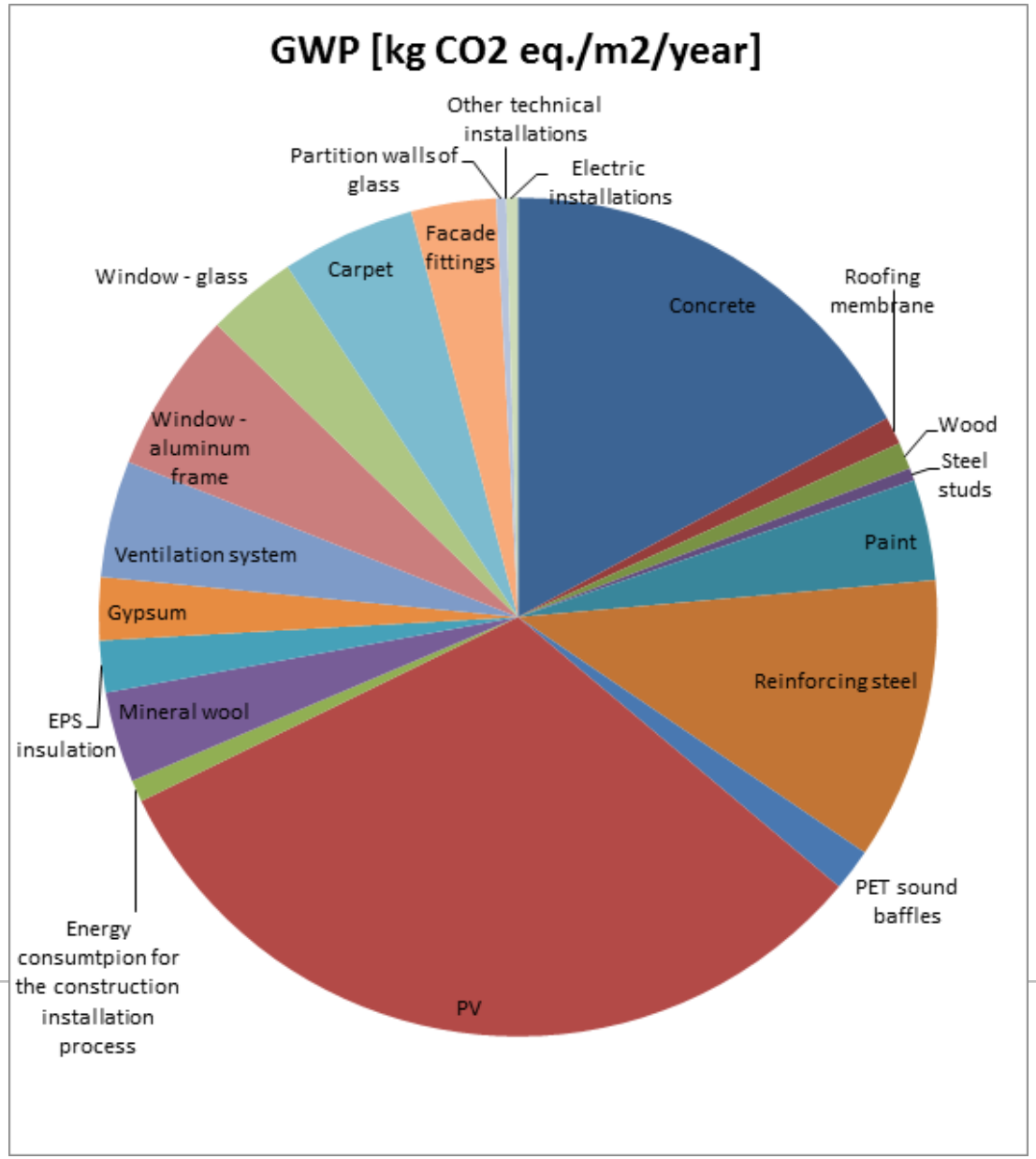
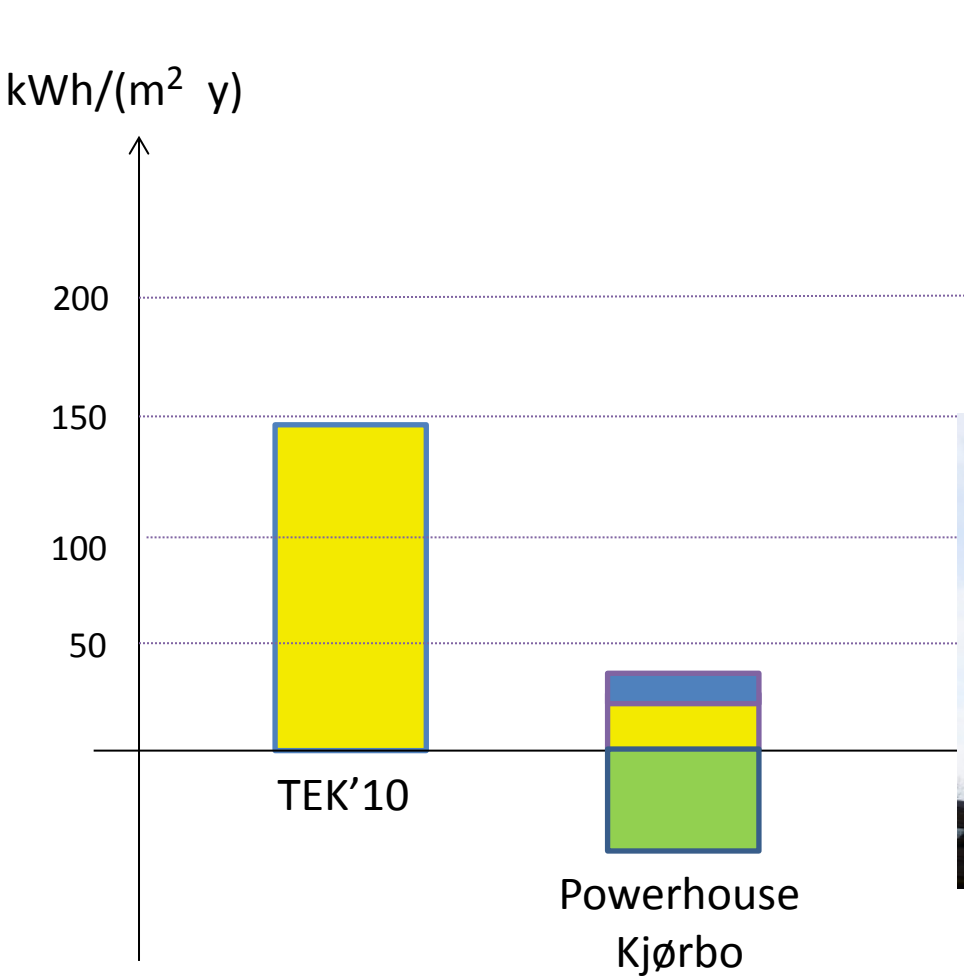
Illustration SNØHETTA / MIR

Powerhouse Kjørbo – Material emissions



Powerhouse Kjørbo



Energy use for operation*

Renewable energy production

Energy use for material production

* Not including plug loads

ZEB Pilot House Larvik - demonstration home

Owner: Brødrene Dahl and Optimera, Architects: Snøhetta, Illustration: MIR

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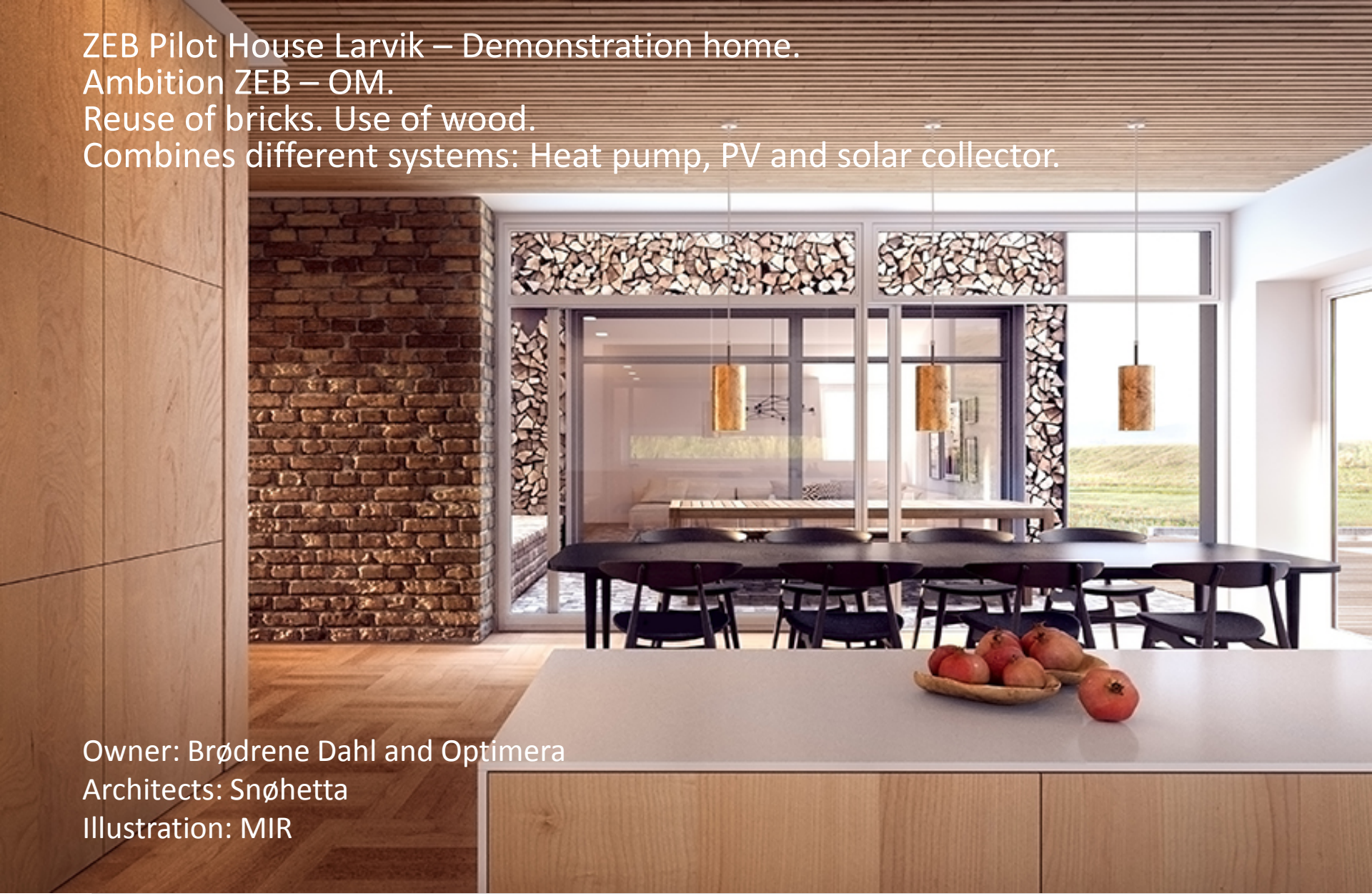
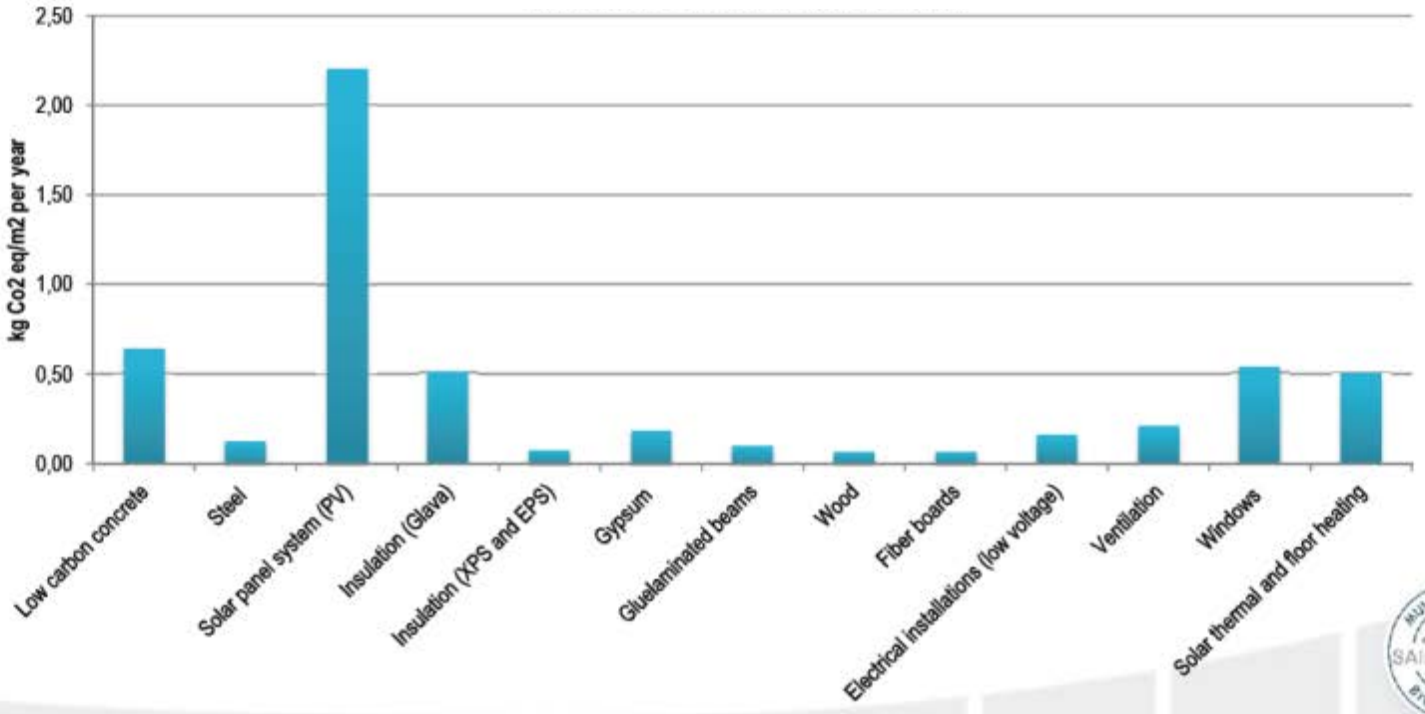
ZEB Pilot House Larvik – Demonstration home.
Ambition ZEB – OM.
Reuse of bricks. Use of wood.
Combines different systems: Heat pump, PV and solar collector.



Owner: Brødrene Dahl and Optimera
Architects: Snøhetta
Illustration: MIR

ZEB Pilot House Larvik – Demonstration home

Material Emissions



BRØDRENE DAHL

www.dahl.no

Reused bricks for thermal mass

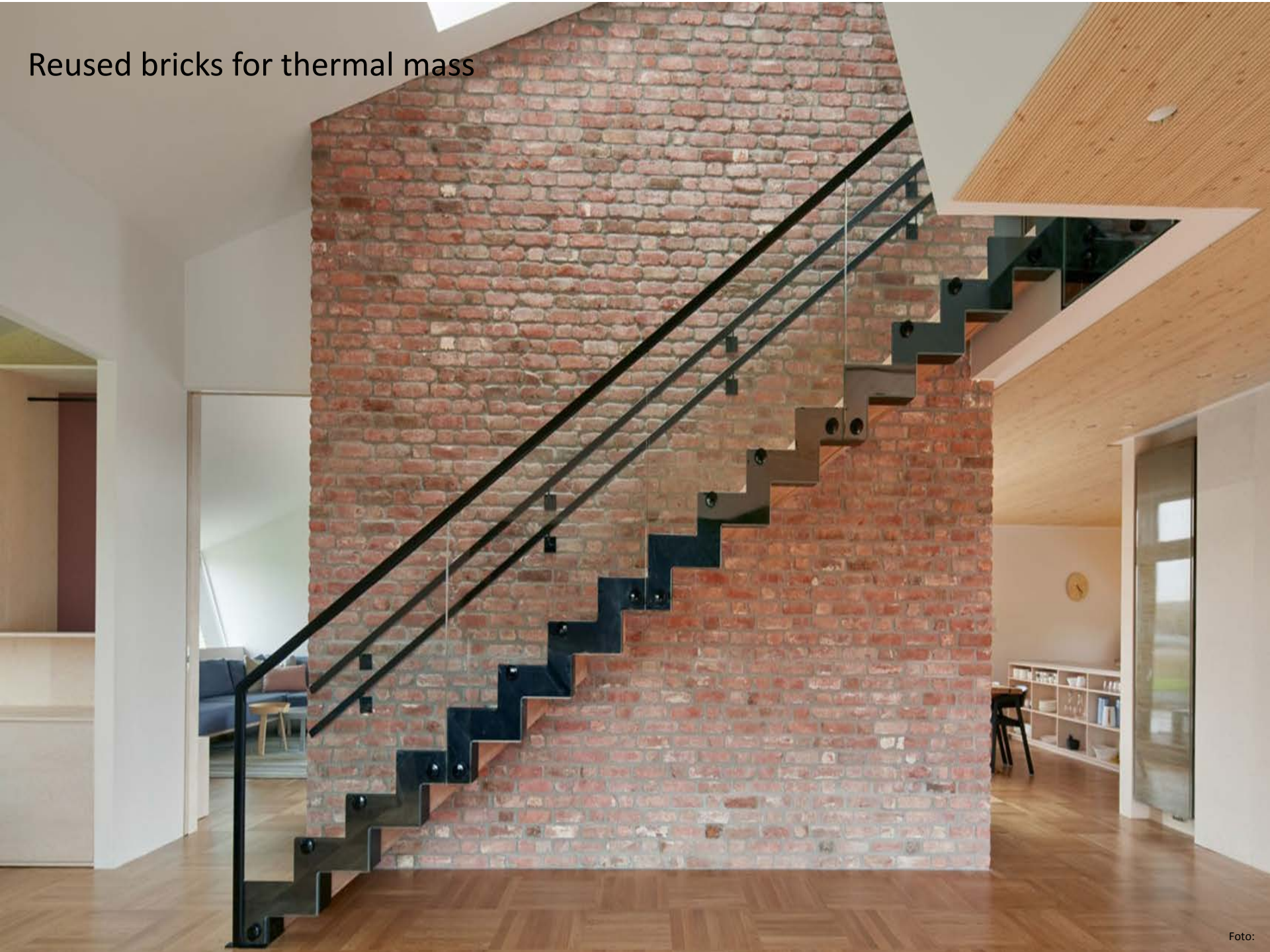


Foto:

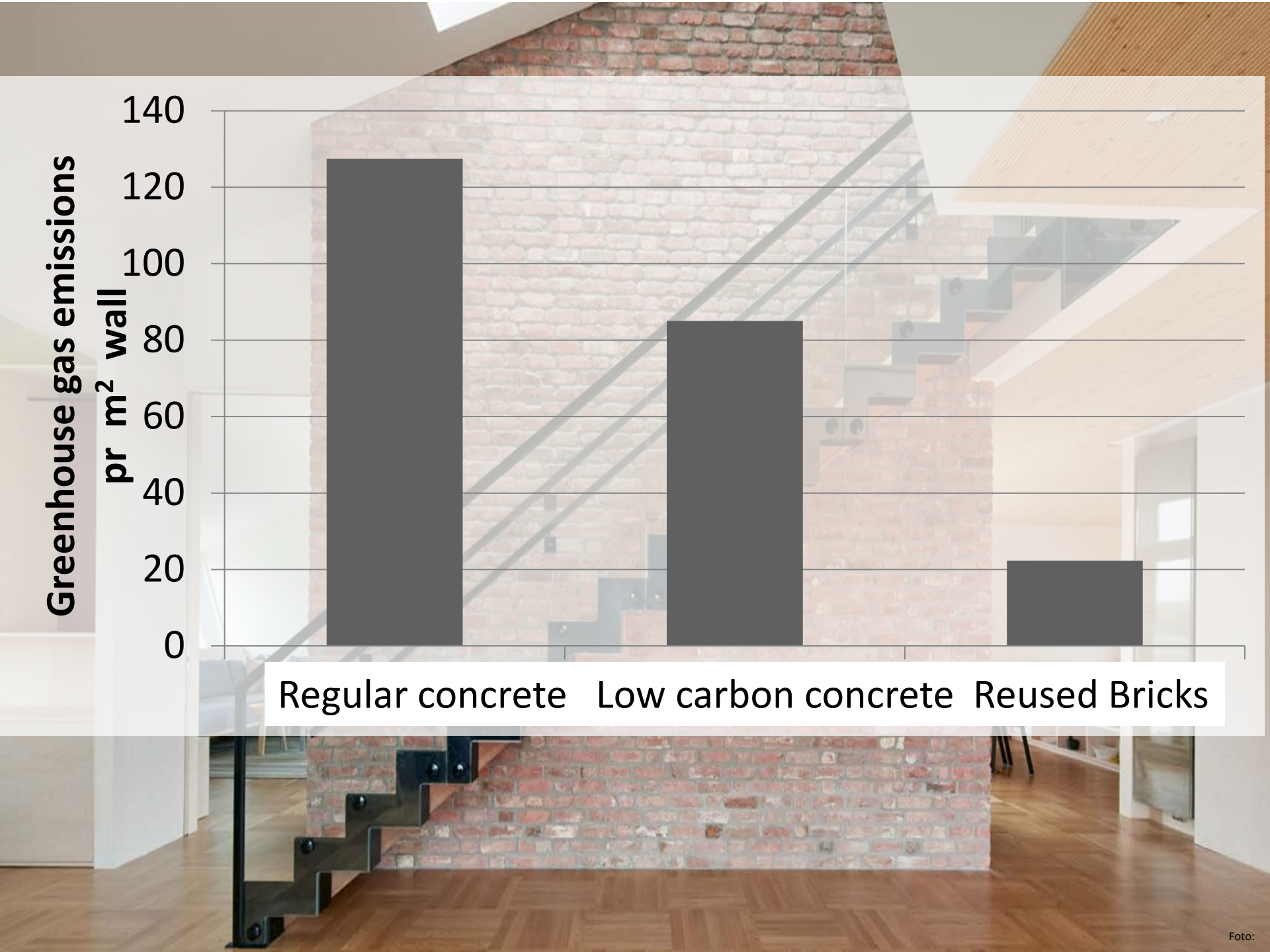

Greenhouse gas emissions pr m² wall
140
120
100
80
60
40
20
0
Regular concrete
Low carbon concrete
Reused Bricks

Foto:

PV and solar thermal system on the roof

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Photovoltaic panels

Kjørbo and Skarpnes

20,4 %

Sunpower E20

ZVB

18,3 %

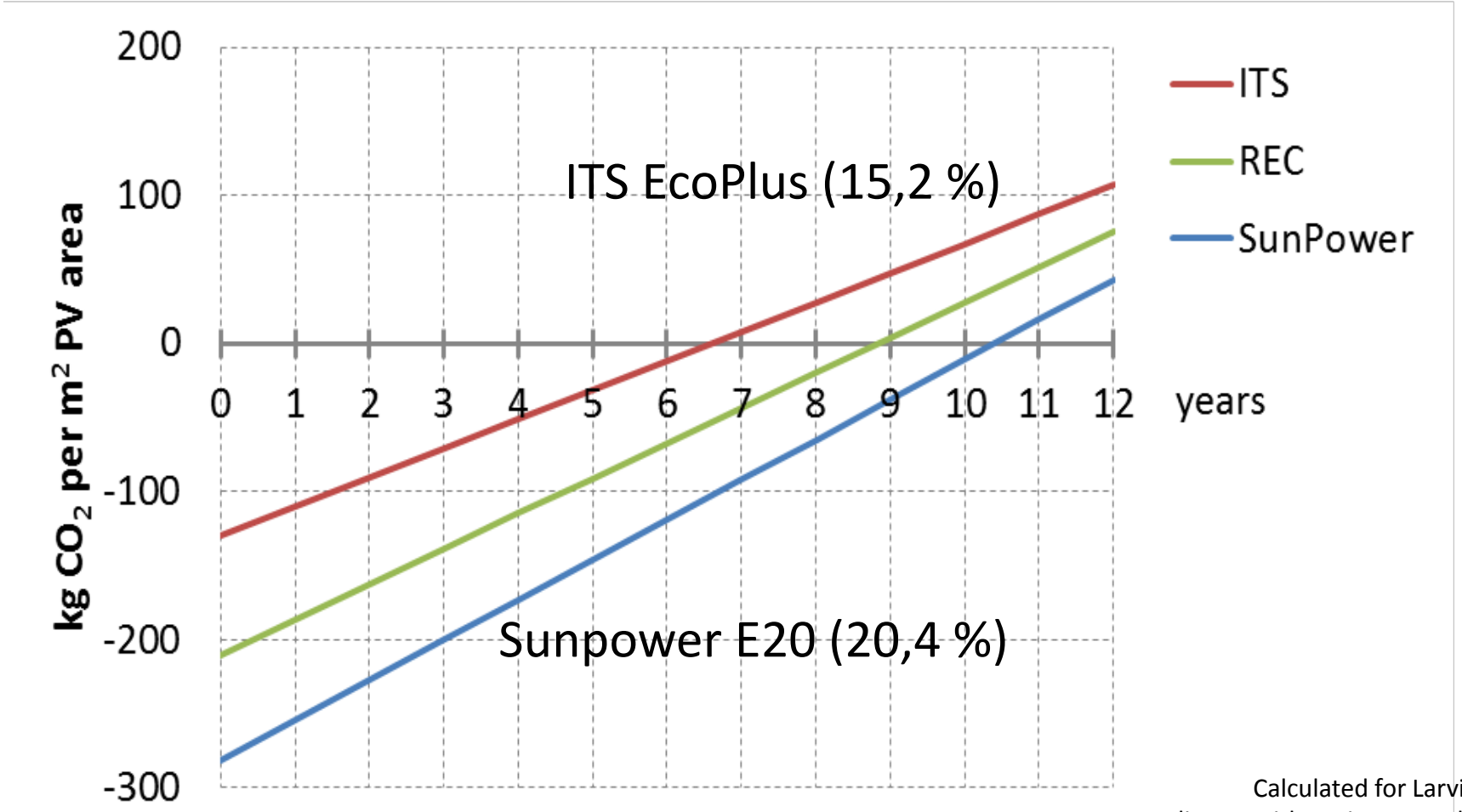
LG 300 N1

Larvik

15,2 %

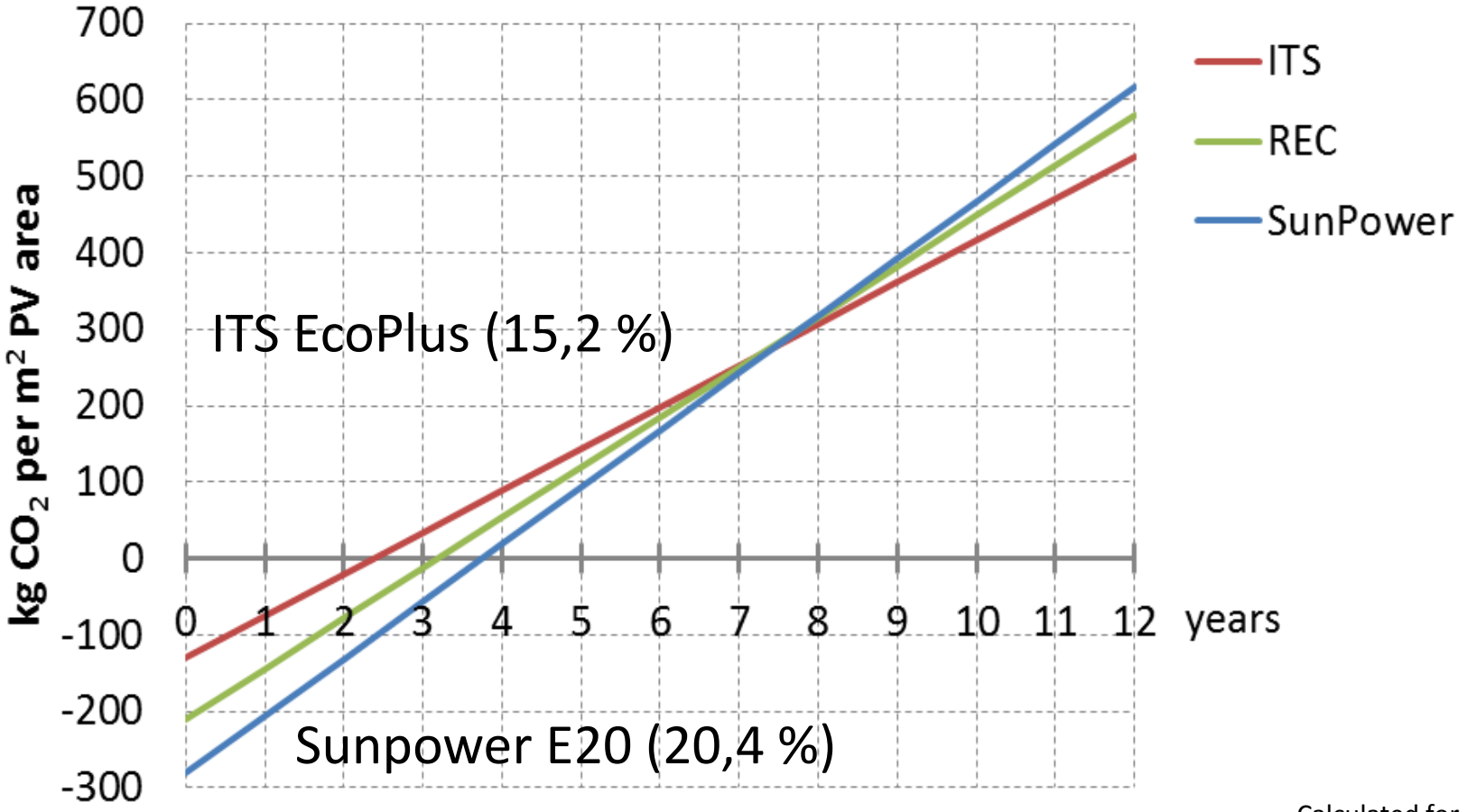
ITS EcoPlus

Payback time …… if we assume a grid factor of 130 g/kWh



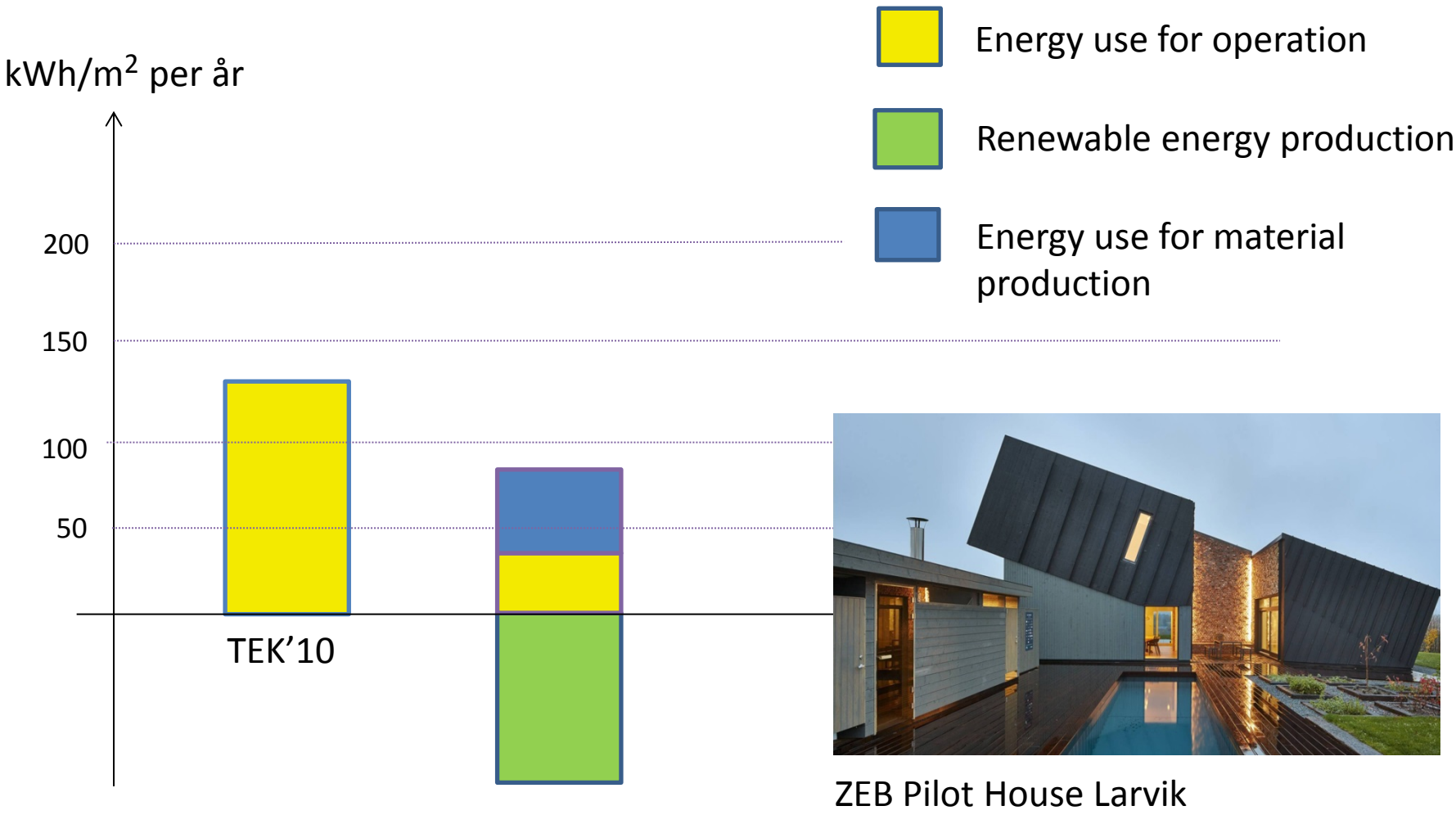
Calculated for Larvik climate with optimum angle

Payback time …… if we assume a grid factor of 360 g/kWh



Calculated for Larvik climate with optimum angle

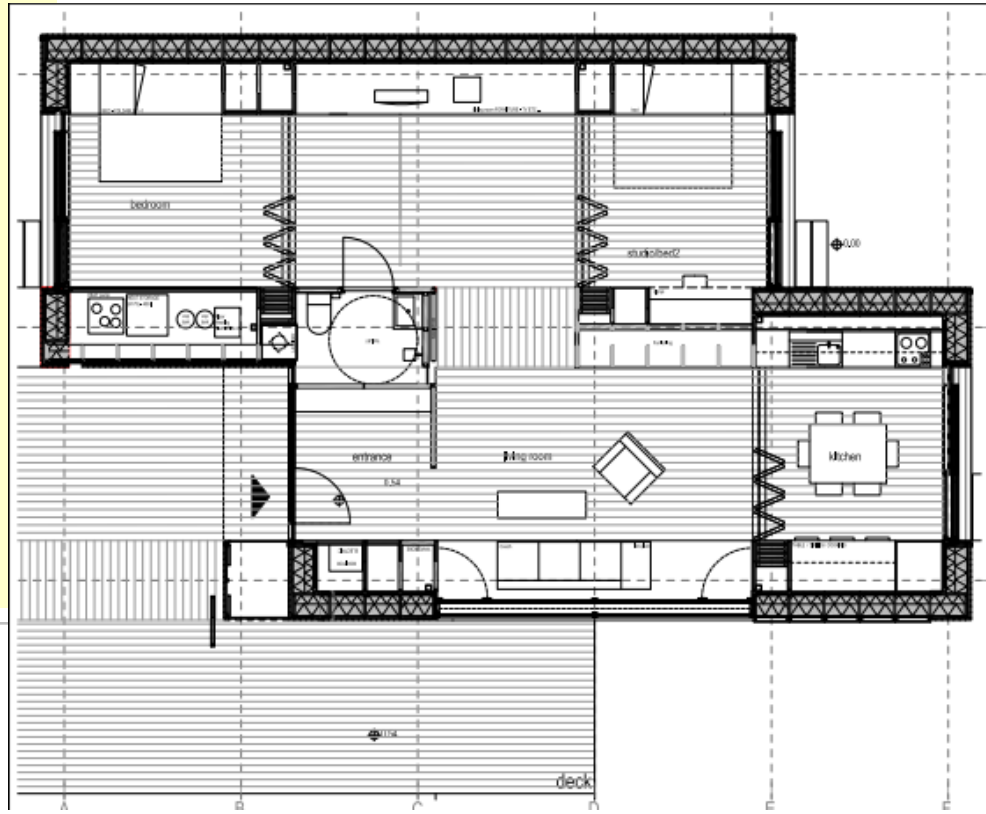
ZEB Pilot House Larvik – Demonstration home



ZEB Pilot House Larvik

ZEB Living Lab

- 100 m² living area
- ZEB-OM (Operation and Materials)
- Building Integrated Photovoltaics: 80 m²
- Solar panel in the facade
- Ground to water heat pump
- Heat recovery system (Flexit)
- PCM in the roof (DuPont)
- VIP in sliding doors (NorDan)
- Reflective vapor barrier (Isola)
- Mixed mode ventilation (Sapa, VELUX, and Caverion)
- LED Lights (NorDesign)



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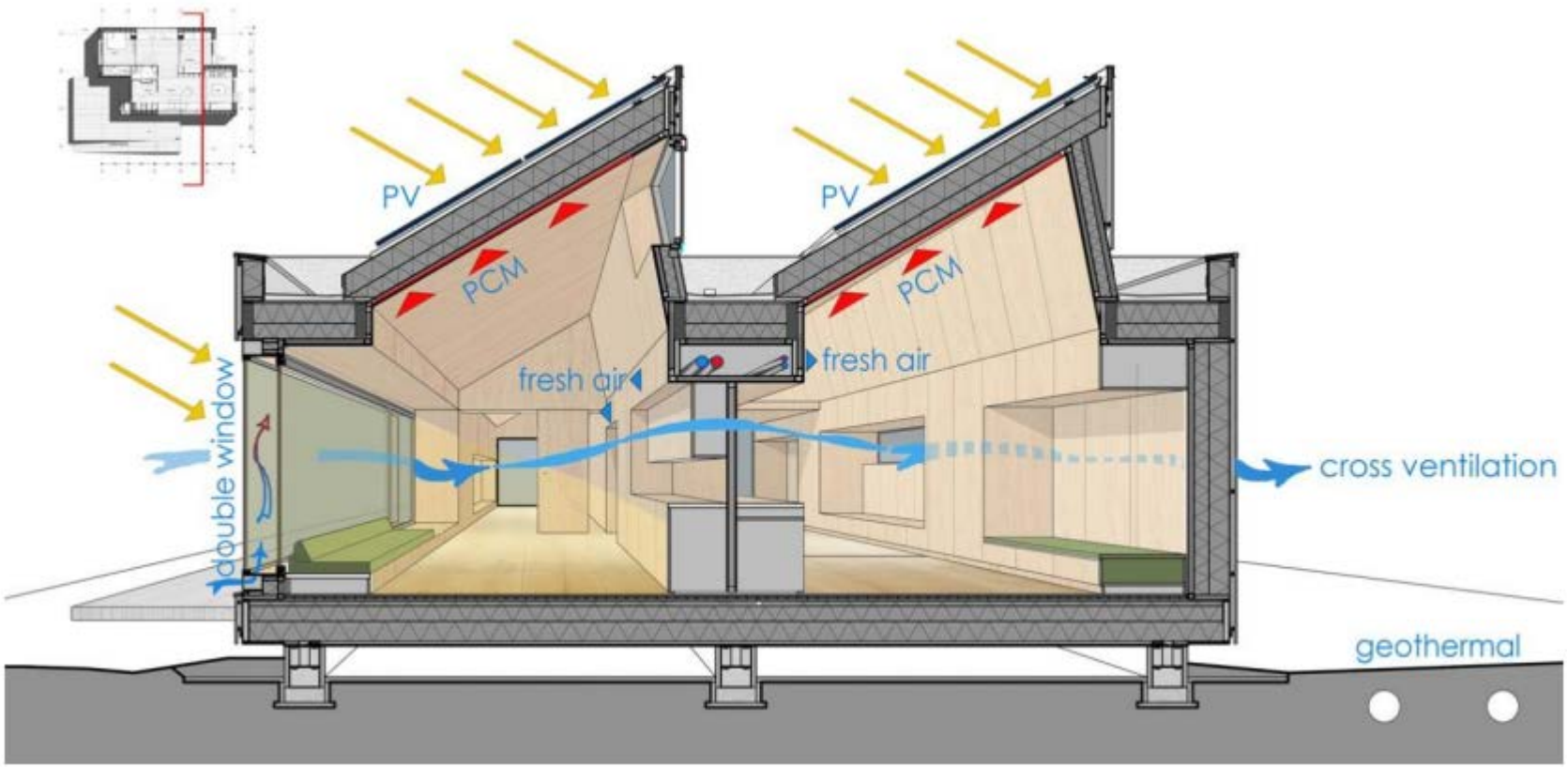
ZEB Living Lab – Interior view

ZEB Living Lab



Important Outcome of Pilot Buildings

- Verification of calculation procedures (indoor climate, energy, emissions)
  - All pilot buildings will be instrumented and measured
  - Do the buildings perform as planned?
- Testing of new materials/building assemblies/façade solutions
- Verification of technical installations
  - Heating, ventilation, lighting, control
  - Energy supply (e.g. solar cells, solar thermal)
- Demonstration and testing of integrated solutions/the entire building
- Transfer of knowledge to the Norwegian building industry

The next step –
New centre for environment-friendly energy research

Main research question

How should the sustainable neighbourhoods of the future be designed, built, transformed and managed to reduce their greenhouse gas emissions towards zero?

Zero Village Bergen: Development of a zero emission neighborhood at Ådland, Bergen.

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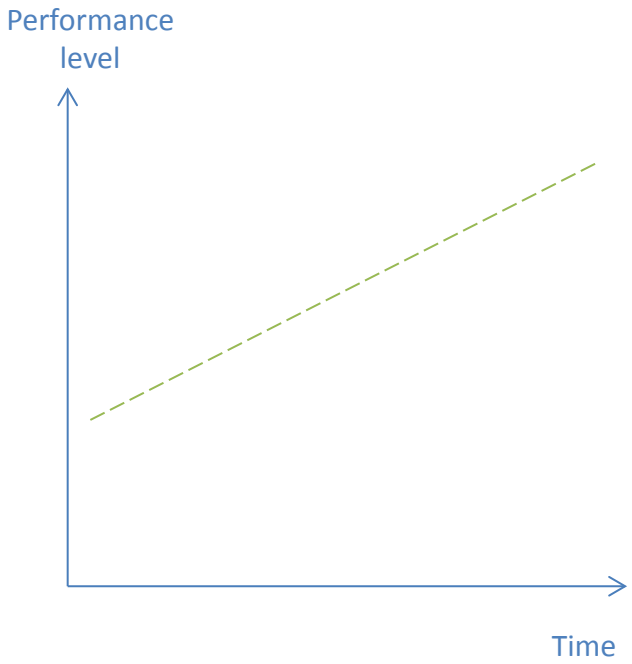
ZEB challanges for Zero Village Bergen

- Project under development
- Setting more and more ambitious energy performance goals for each construction phase
- Exchange of energy between buildings, to/from grid, storage, and with electro-mobility
- Business models: Cooperation with local utility company (BKK)
- ZEB ambition area : ZEB – O
- ZEB ambition building: ZEB – OM



Thank you for your attention!

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