ZEB Pilot house Larvik (Multikomfort)

As-built

ZEB - KLIMAX

October 12, 2016

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My presentation

- Introduction
- Building design
- Technical installations and energy system
- Performance
- Material emissions
- The ZEB balance
- Economy

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INTRODUCTION

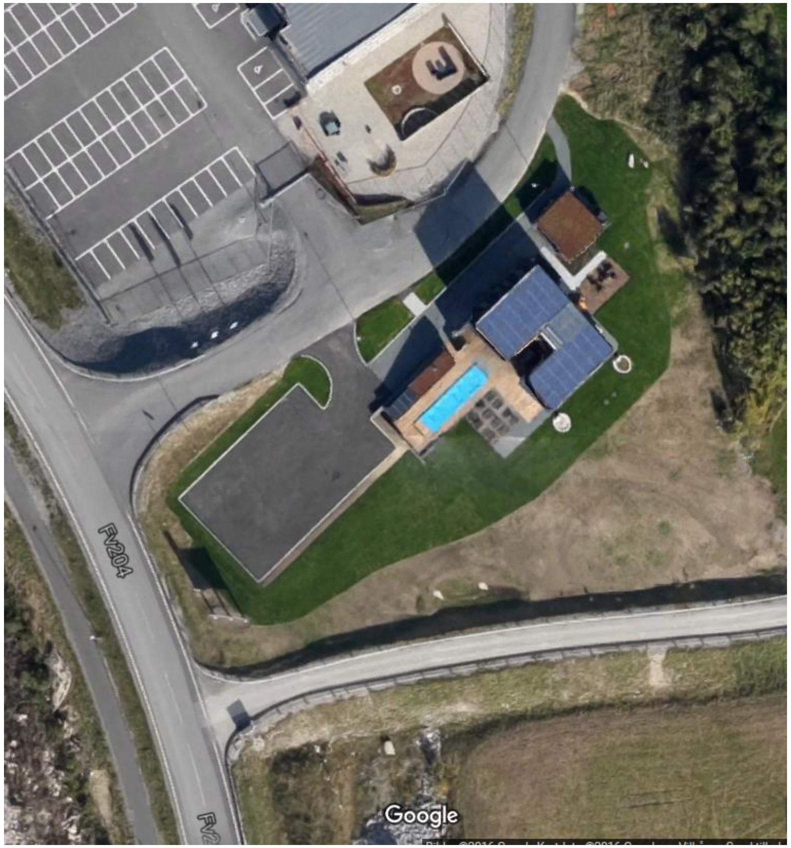
The ZEB pilot house Larvik ("Multikomfort-house")

- Two-storey single-family residential building
- Demonstration and exhibition house
- Heated floor area: 201.5 m^2
- Opening Autumn 2014

photo: Brødrene Dahl/Paal-André Schwital

Location

- Located near Larvik, by Brødrene Dahl warehouse

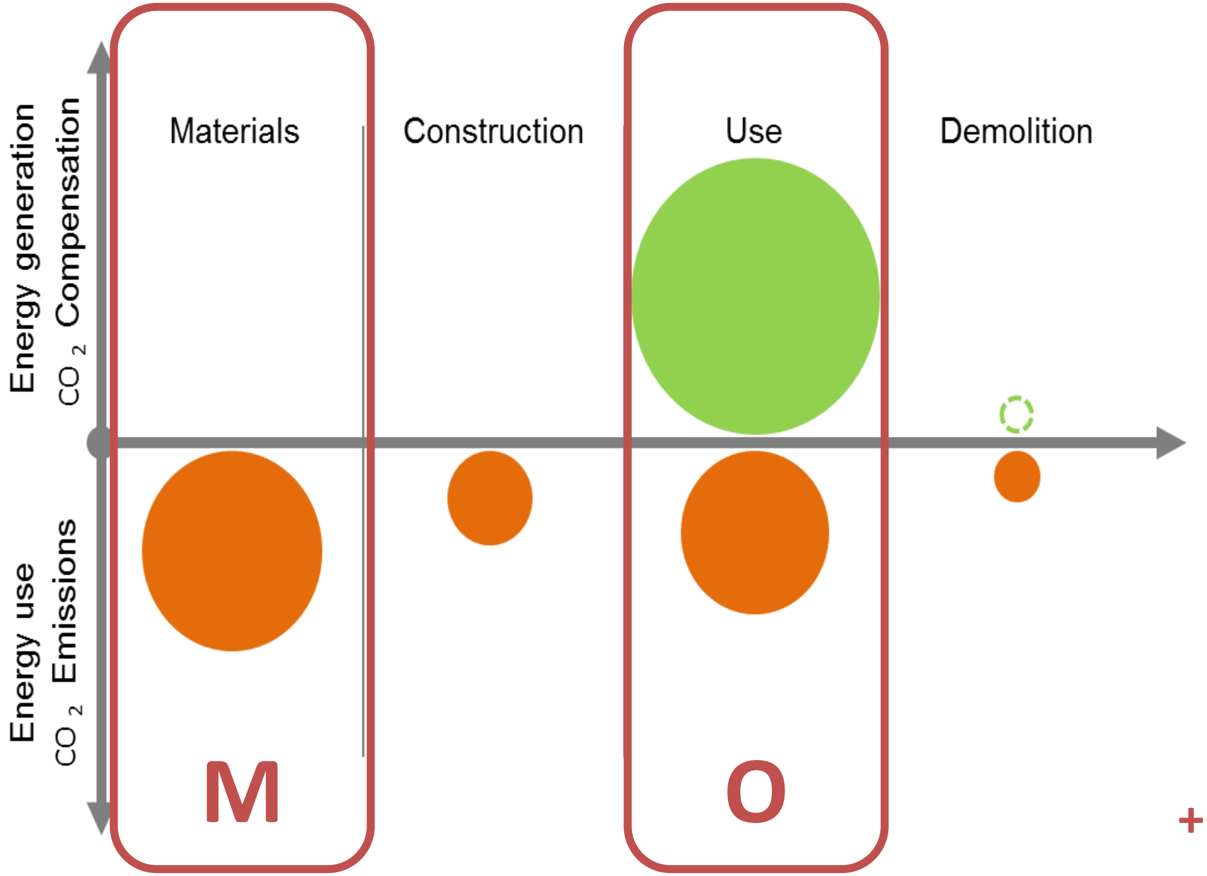


Pictures: Google maps

The team

Building owners	Brødrene Dahl AS and Optimera AS
Design team	**Brødrene Dahl** (energy concept), **Optimera** (building construction), **Snøhetta** (architect), and the **ZEB Research Centre** (energy and GHG emissions)
Construction	Espen Staer AS
Supporting	Bergersen Flis, Geberit, Glava, Grohe, Gustavsberg, Ifö, Porgrund, Intra, Lyngson, Nilan, Oras, Oso, Pipelife, Schneider Electric, Uponor, Villeroy&Boch, VPI, Grundfos, Lighthouse Company, Aubo, Barkevik, Bergene Holm, Boen, Elfa, Fischer, Gyproc, Isola, Moelven, Natre, Paslode, Velux and Weber

Design criteria: ZEB-OM + transport



+ Electrical car

Source: A Norwegian ZEB Definition Guideline

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BUILDING DESIGN

The design phase

- Focus on combining high aesthetic quality with comfort and energy efficiency
- Minimizing emissions from construction materials

Example workshop:
integrating spacial qualities and experiences

Picture: Snøhetta

The building envelope

Reduce the need for heating

- Well insulated
- Airtight

Avoid the need for cooling

- Solar protection (bedroom windows)
- Windows placed shaded from the sun

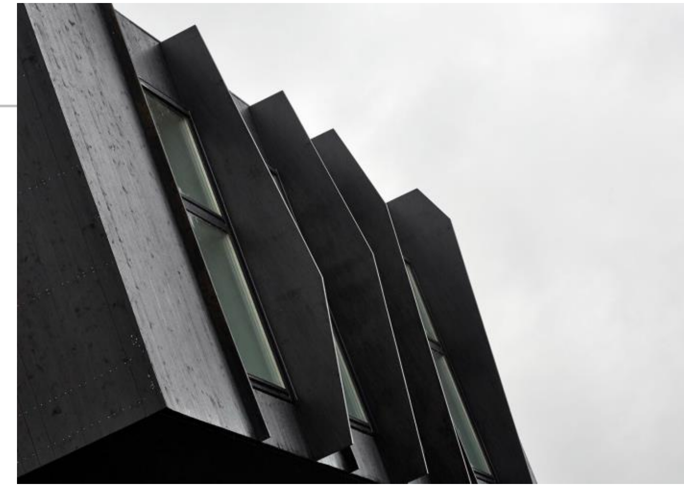
Construction materials

- **Reused bricks** are used in a wall inside - **Thermal mass** effect
- Stacks of **natural stone** and **timber** in the exterior facade
- Foundation slab based on **timber** and **fibre plate** construction
- **Strip foundation** to minimize the amounts of concrete
- **Low carbon concrete** was used
- **Timber based bearings** in light weight frames of outer walls
- Exterior walls are **well insulated**: 350mm glass wool insulation

U-values	Floor	Roof	Walls	Windows and doors
W / m^2K	0.080	0.084	0.111	0.75

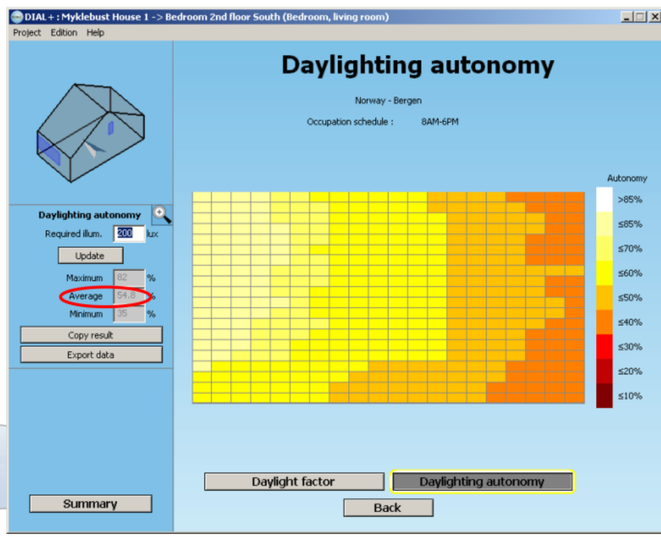
Illustration: Snøhetta

daylight distribution / solar shading



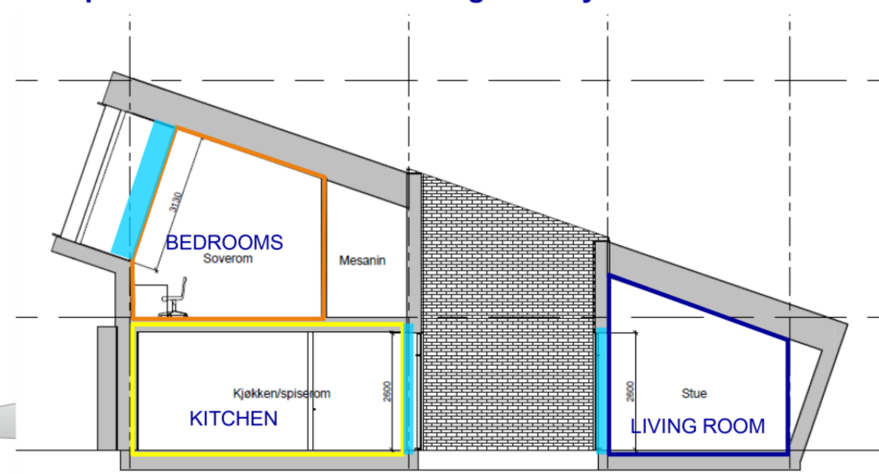
How to calculate DA ?

- As an example, DIAL+ software is able to calculate DA on one year based in different points in a room.
- The **average value** for the room is used

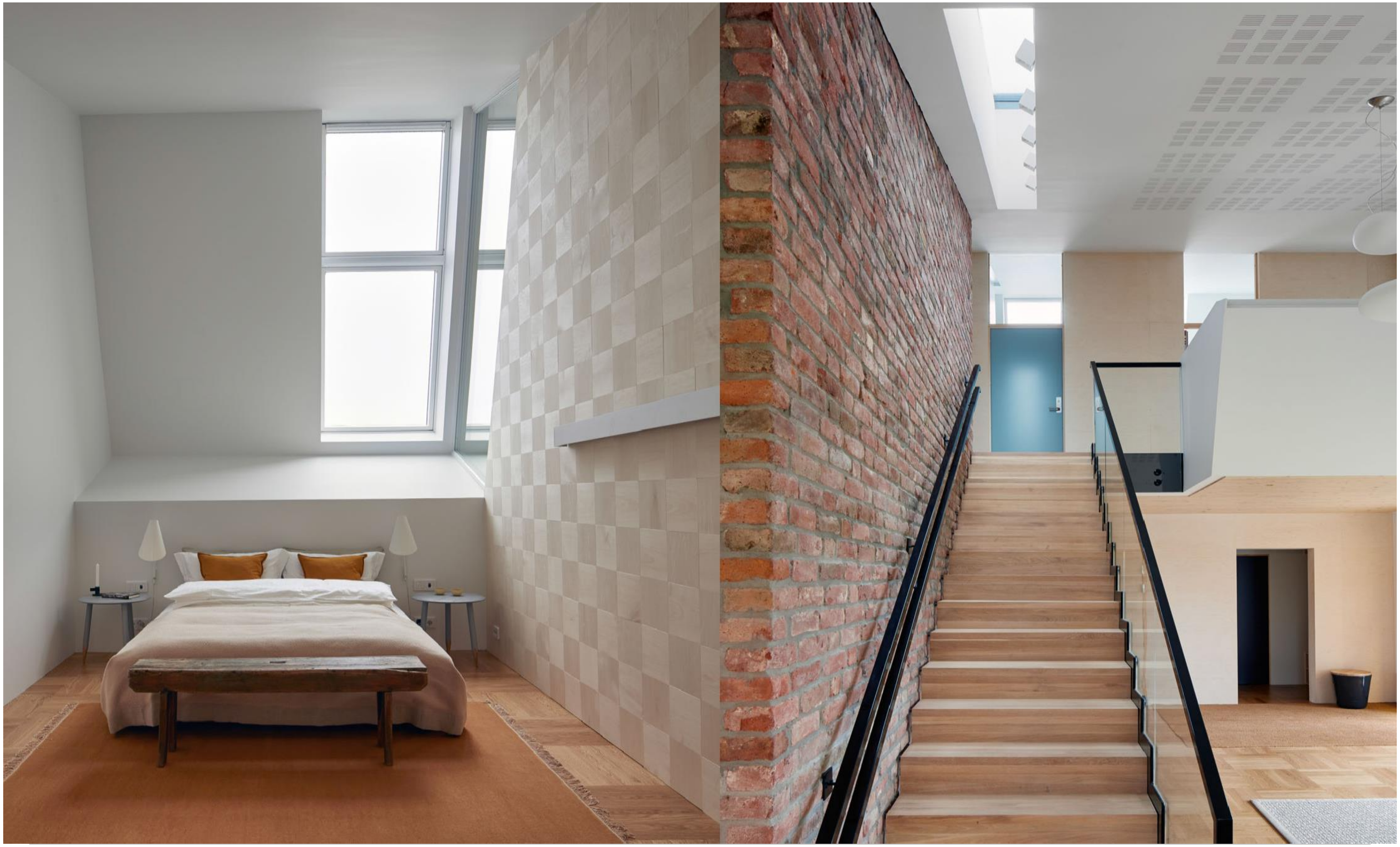


Main hypothesis for calculations

- **Simplifications made on rooms geometry**



Source: Snøhetta

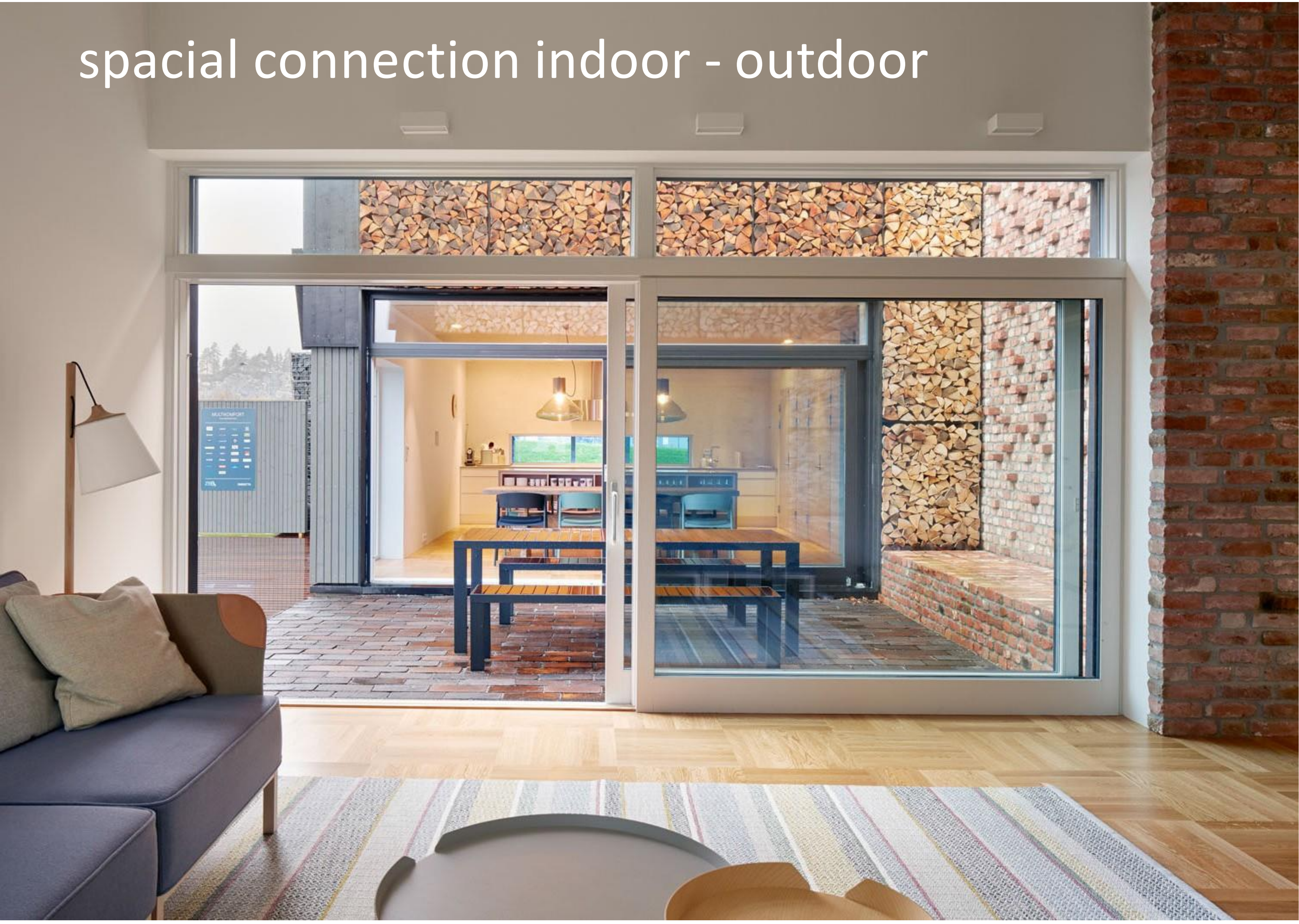


Pictures: Snøhetta

Re-used brick (old barn)

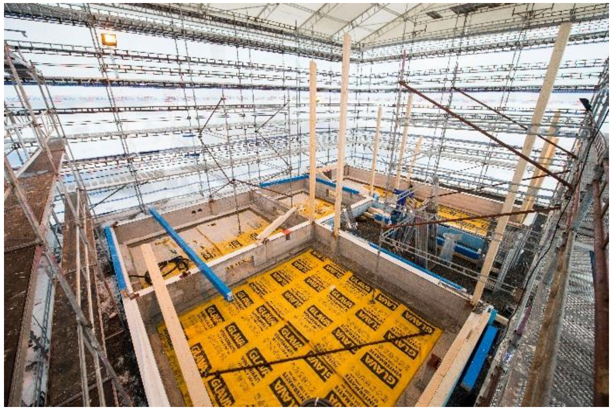
Picture: Snøhetta

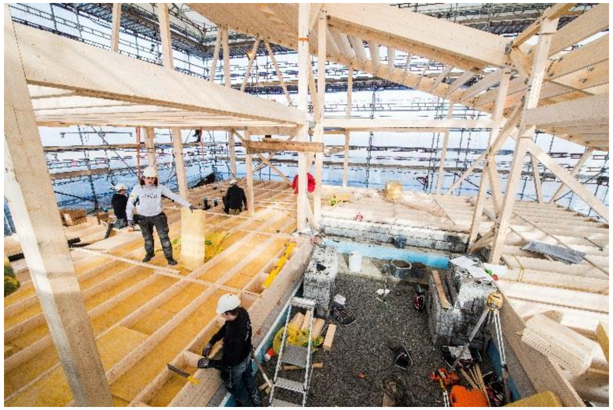
spacial connection indoor - outdoor



Picture: Snøhetta

The construction process





Pictures: Brødrene Dahl/Paal-André Schwital

The construction process

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The construction process

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The construction process

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The construction process

The Research Centre on Zero Emission Buildings

Pictures: Brødrene Dahl/Paal-André Schwital

FORSKNINGS-SENTER FOR MILJØVENNLIG ENERGI

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TECHNICAL INSTALLATIONS AND ENERGY SYSTEM

Conclusion: material optimization / technical optimization

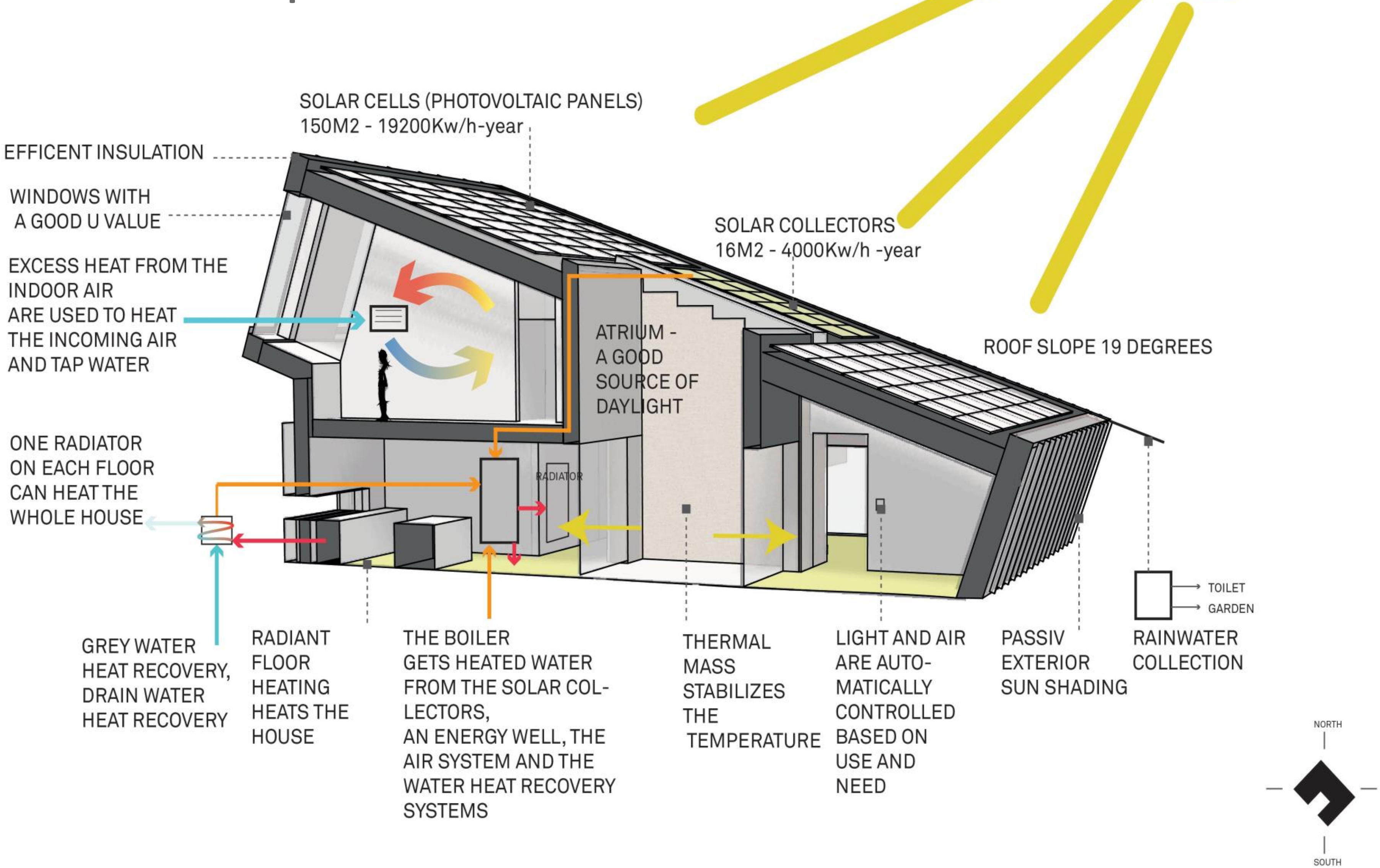


Illustration: Snøhetta

Overview of the energy system

- Electricity: Solar cells

  Battery bank

- Heat: Geothermal heat pump

  Solar thermal panels

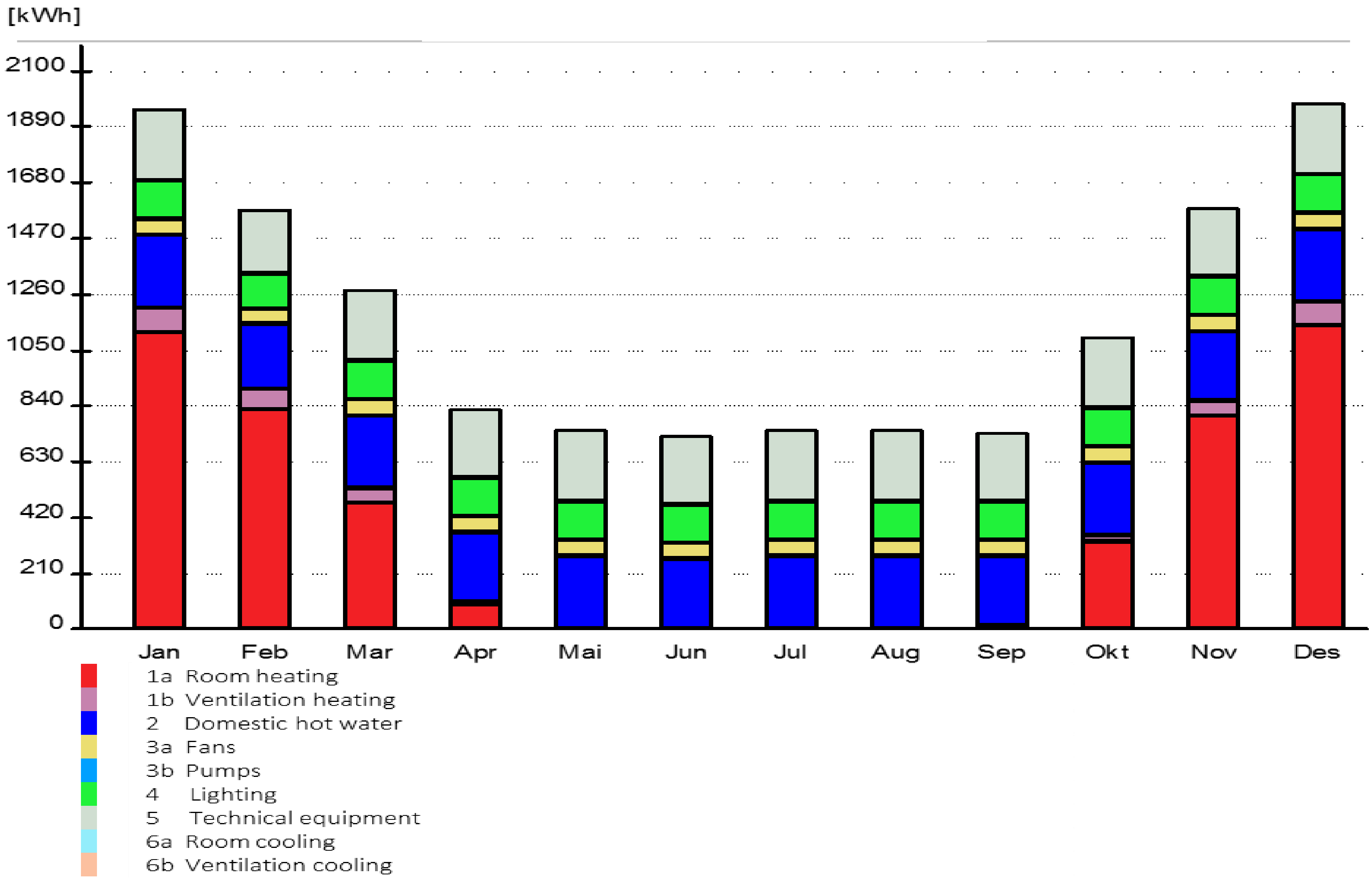
  Ventilation system: High efficiency heat recovery

  Grey water heat recovery systems

Energy budget: Energy demand

Energy budget	Energy demand (kWh/year)	Specific energy demand (kWh/m^2/year)
Room heating	4,799	23.8
Ventilation heating	418	2.1
Domestic hot water	3,212 (6,424)*	15.9 (31.8)*
Fans	765	3.8
Lighting	1,765	8.8
Technical equipment	3,177	15.8
Total net energy demand	14,136 (17,348)*	70.2 (86.1)*

* Assumption: Recover 50% of the energy in the grey water in heat recovery system


[kWh]
2100
1890
1680
1470
1260
1050
840
630
420
210
0
Jan
Feb
Mar
Apr
Mai
Jun
Jul
Aug
Sep
Okt
Nov
Des
1a Room heating
1b Ventilation heating
2 Domestic hot water
3a Fans
3b Pumps
4 Lighting
5 Technical equipment
6a Room cooling
6b Ventilation cooling

Energy budget: Delivered energy

Energy budget	Delivered energy (kWh/year)	Specific delivered energy (kWh/m²/year)
Direct electricity	5,707	28.3
Electricity heat pump (ground-source HP)	1,014	5.0
Electricity solar energy	144	0.7
Other energy sources (HP in ventilation)	276	1.4
Total delivered energy	7,142	35.4

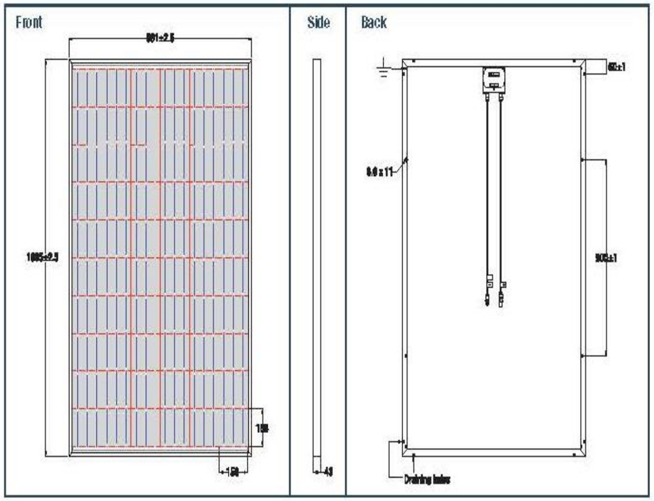
Total energy balance

Energy balance (kWh/year)	Energy demand	Delivered energy		
		Electricity	Heat from ground-source HP,exhaust air HP and solar collectors	Heat from grey water system
Room heating and ventilation	5 217	1 025	4 192	
Domestic hot water	6 424	409	2 803	3212
Fans, lighting, technical equipment	5 707	5 707		
		7 142	6 995	3 212
Total	**17 348**			**17 348**

Solar cells and battery bank

- 22.75 kW_p PV system, 150 m^2, 91 modules (Innotech Solar)
- Each module: 15.5% efficiency, peak power 250 W_p
- Calculated: 19,200 kWh per year
- Connected to the utility grid
- Battery bank with 24 batteries: 48V at 600Ah in total

Solar cells from Innotech solar



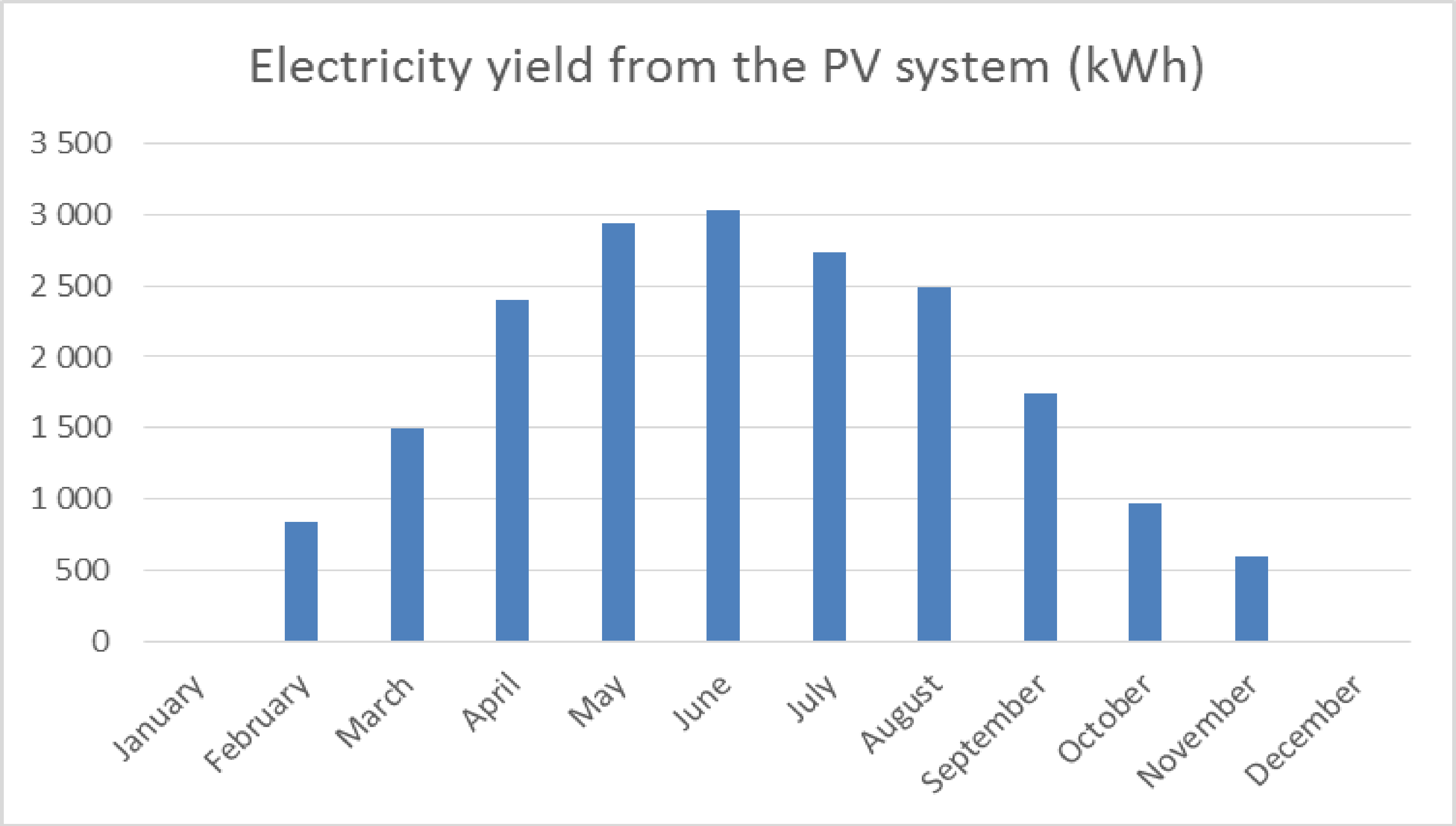
DesignBlack – Poly

STC*

Pmax	Wp	240	250	260
Vmpp	V	30.2	31.0	31.2
Impp	A	8.11	8.22	8.49
Uoc	V	37.1	37.6	37.8
Isc	A	8.66	8.79	8.98
IR****	A	20	20	20
η	%	14.6 – 15.2	15.2 – 15.8	15.8 – 16.4


Tak&Beslag
alt i tak-/blikkenslagerarbeide

Calculated electricity production



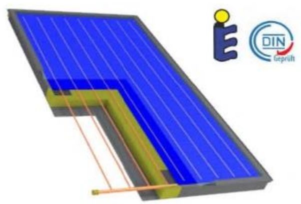
Geothermal heat pump and Solar thermal panels

- Ground-source-to-water heat pump, 3 kW
  - Cover 80% of the heating load
- Solar thermal collector system, 16.8 m^2
  - Cover 20% of the heating load
- Hot water is collected in a 400 liter tank
- Low temperature distribution system

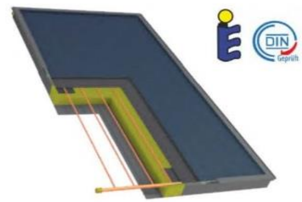
HEWALEX

COMPONENTS OF SOLAR SYSTEMS

FLAT PLATE SOLAR COLLECTORS:



HEWALEX KS2000 TLP



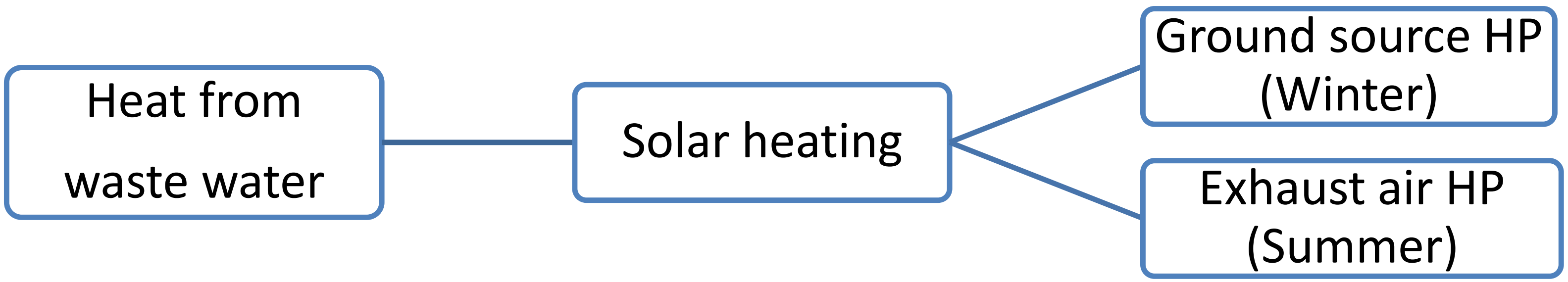
HEWALEX KS2000 SLP

SOLAR COLLECTOR:	KS2000 TLP (KS2000 TP)	KS2000 SLP (KS2000 SP)	KS2000 TLP AC (KS2000 TP AC)
Article number	14.22.00 (14.21.00)	11.22.00 (11.21.00)	14.41.00 (14.40.00)
Solar Keymark certificate (PN-EN12975-1,2:2007)	011-7S181 F	011-7S180 F	011-7S1693 F
Active (aperture) area, m²	1,818	1,817	1,827
Gross area (total), m²	2,095	2,094	2,091

Optima Twin Coil - EPTC - gir varme og varmtvann

Radiators

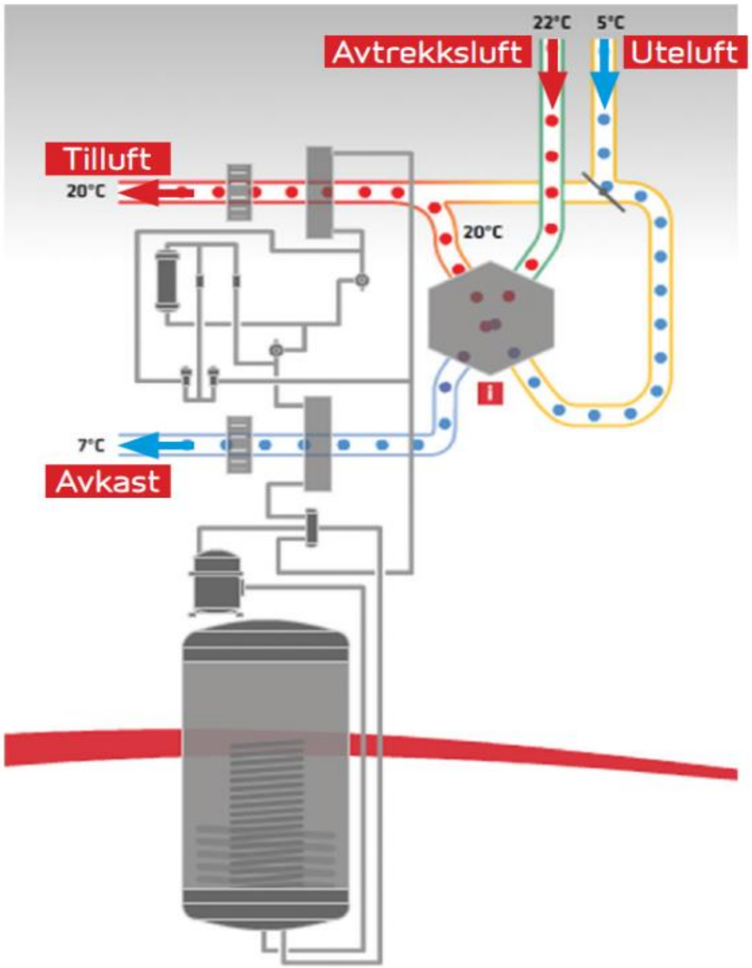
Domestic hot water



Grey water heat recovery systems

Ventilation system

- Balanced, mechanical ventilation system with constant air flows
- Exhaust air heat pump
- Heat exchanger (87% efficiency)



Water system

- Rain water is reused in toilets and for watering the garden
- Rain water from the roof is harvested, mechanically cleaned, and stored in a 6000 litre tank

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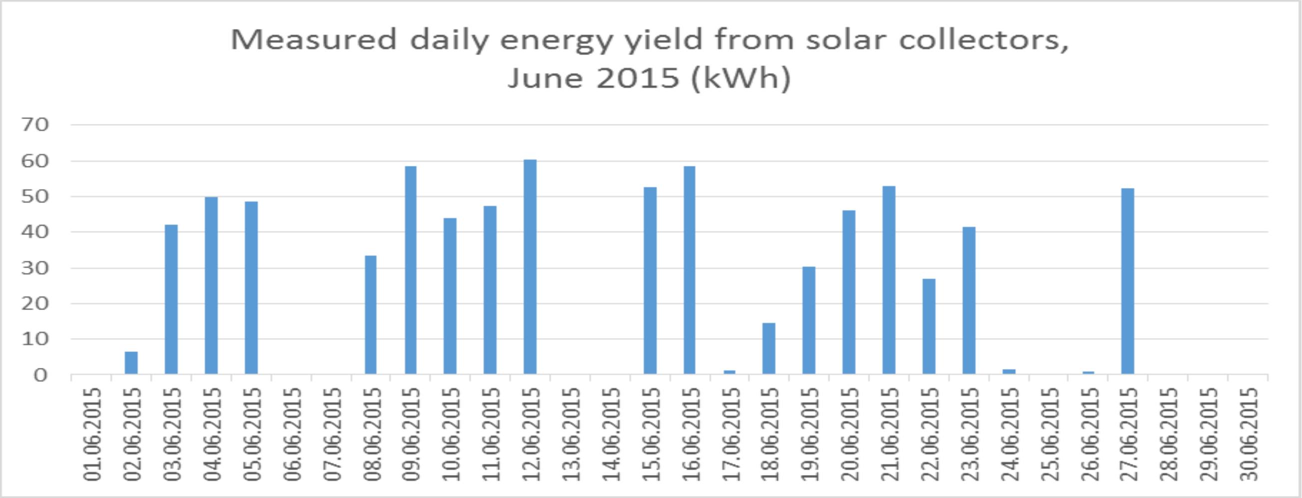
PERFORMANCE

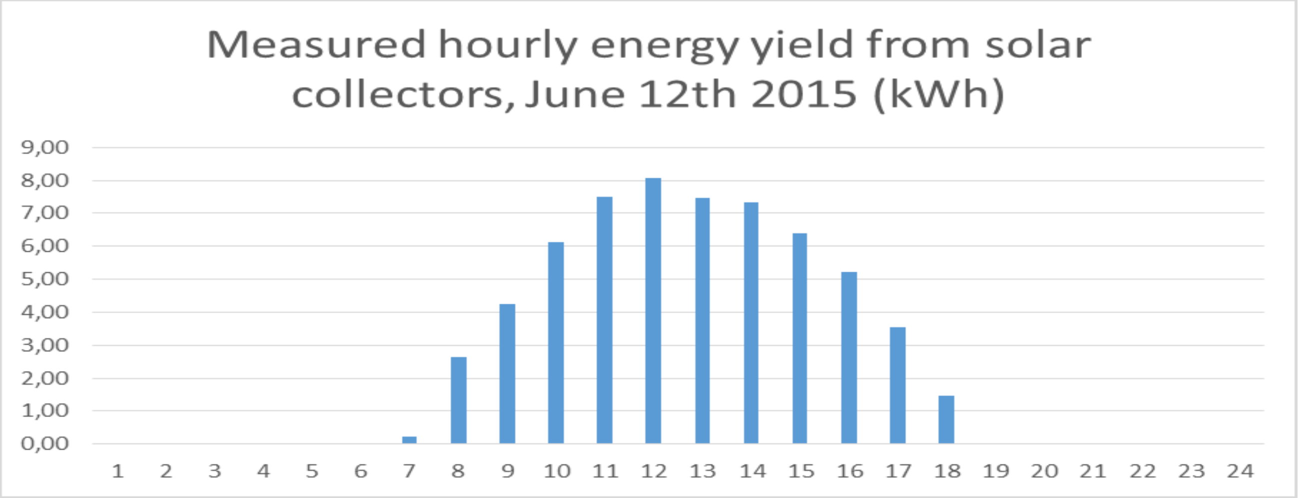
Measurements

- Air leakage number: 0.60 air changes per hour

- Energy metering:
  - Electrical consumption, electricity production, thermal energy production and consumption for heating and hot water
  - No-one living in the building
  - Few measurements available yet

Measurements solar collectors





Example sunny day:
60 kWh heat from solar collectors

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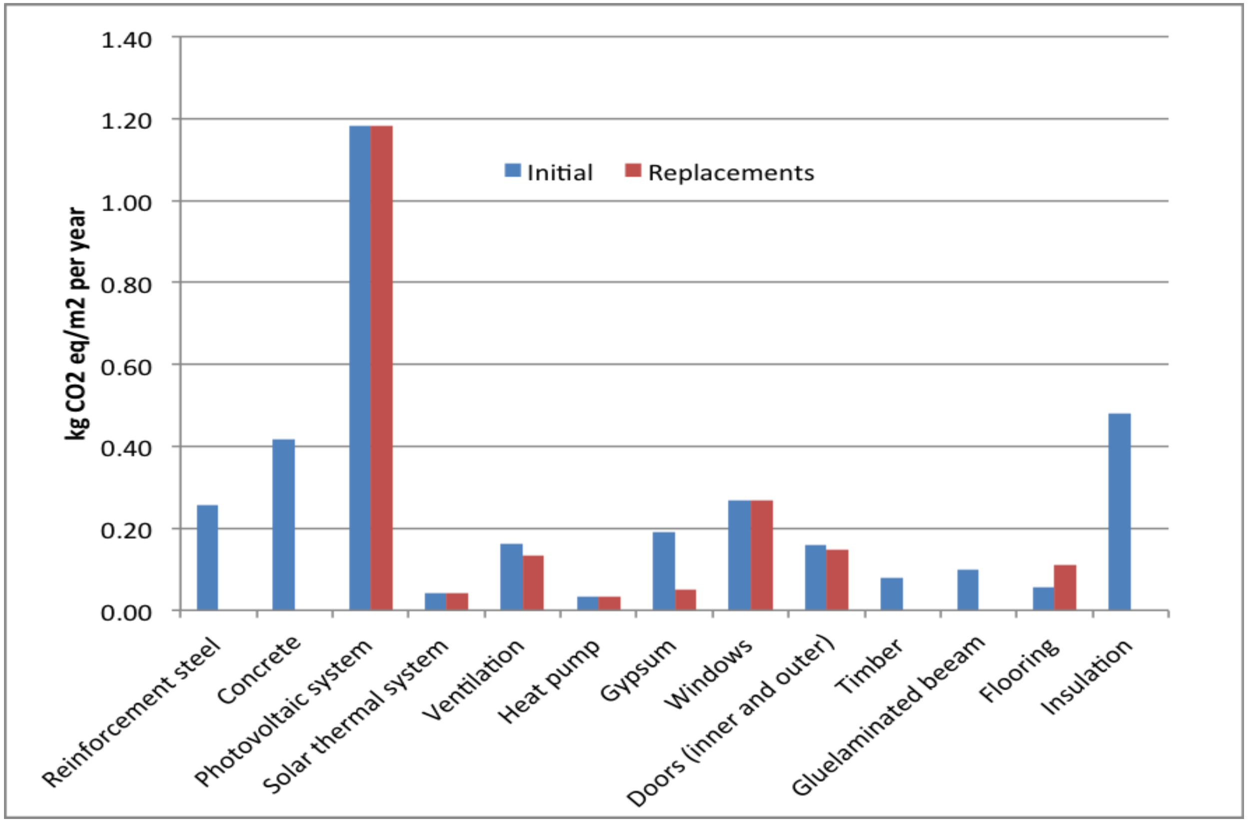
THE ZEB BALANCE

Material emissions – from design phase (60 y)



Product phase: 3.6 kg CO_2 eq/m^2 per year + Material replacement 2.2 kg CO_2 eq/m^2 per year = 5.8 kg CO_2 eq/m^2

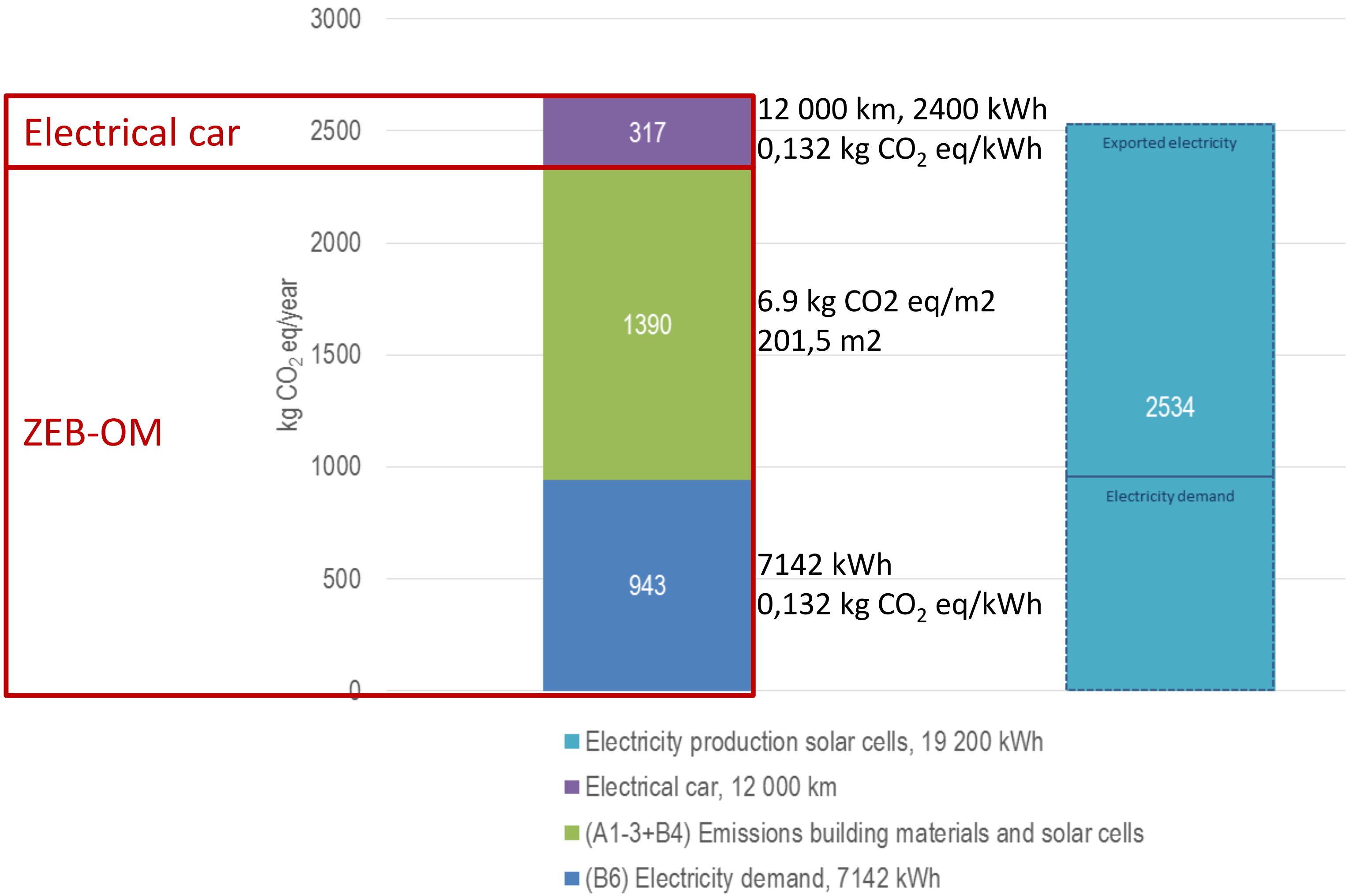
As-built estimations, material emissions

- Rough design phase estimations 5.8 kg CO_2 eq/m^2/y
- Assumed less emissions replaced PV -0.6 kg CO_2 eq/m^2/y
- CO_2 emissions from batteries +0.6 kg CO_2 eq/m^2/y
- Estimated increase, rough calculations +1.16 kg CO_2 eq/m^2/y

- New total annual material emissions 6.9 kg CO_2 eq/m^2/y

The ZEB balance

Balance: ZEB-OM + 7,600 km



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ECONOMY

Economy

		A future building similar to the pilot building	
Investment, inclusive tax		5.8 million NOK *	
Delivered energy to building and el. car		7,142 kWh + 2,400 kWh	
Annual energy cost, if 1 NOK/kWh		0 kr **	
Income from plus-energy house, if 0.5 NOK/kWh		4,829 NOK (kWh: 19,200 -(7,142+2,400))	

* Ambitious buildings and technology choices may qualify for support from Enova. Such support varies, and is not included in the cost efficiency calculation.
** Assume 100 % self-consumption or similar energy price for selling and buying electricity.

Summary ZEB Pilot house Larvik

- An interdisciplinary project team has been involved in the design and construction process
- A number of untraditional passive energy measures are demonstrated
- The demonstration house has gained a lot of attention

- Calculated ZEB balance: ZEB-OM ambition + 7,600 km el car

- Approach is sensitive to material emission accounting and electricity emission factors for import and export of electricity

Takk for meg!

ZEB The Research Centre on Zero Emission Buildings

FME FORSKNINGS-SENTER FOR MILJØVENNLIG ENERGI