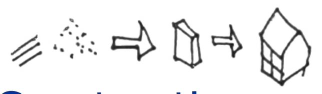
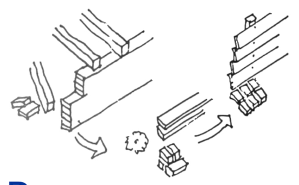
AAR4532 Climate and built form, Solar Decathlon design project

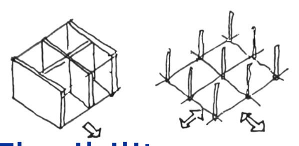
Ideas


Production

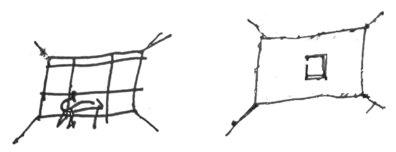

Construction

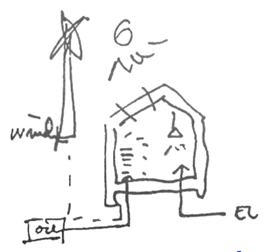

Reuse

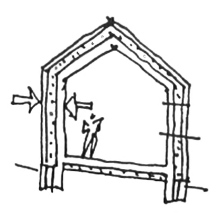

Form

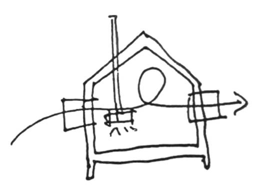

Flexibility


Orientation


Daylight


Heating and cooling


Layering/insulation


Ventilation

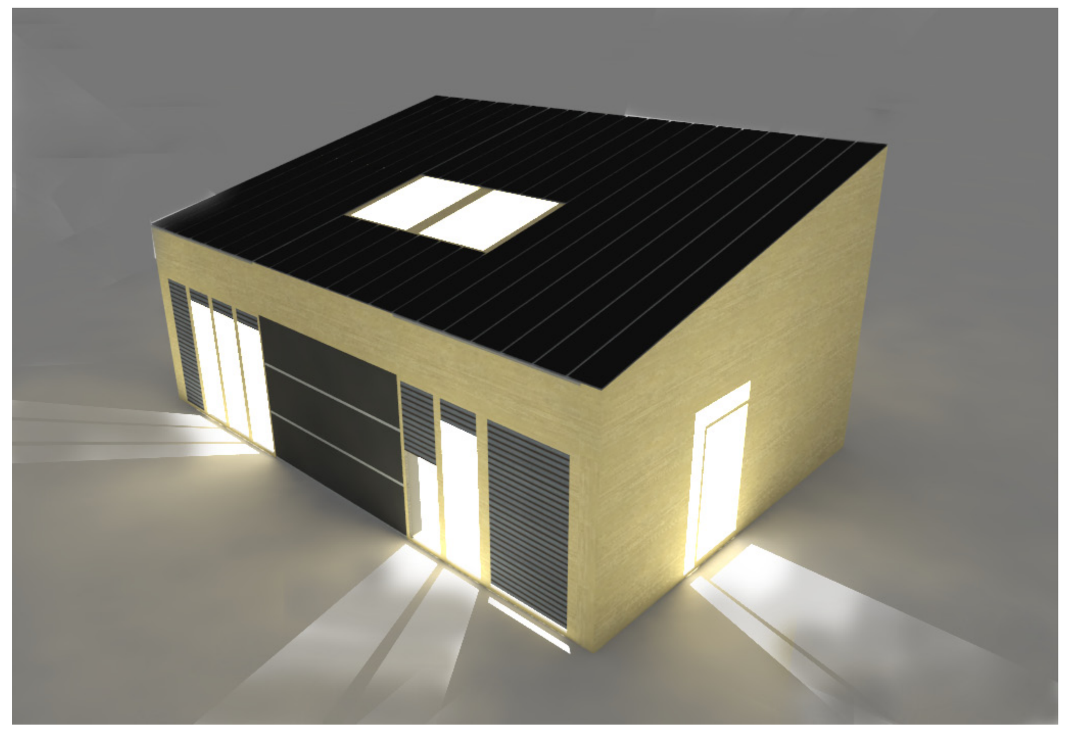
Concept

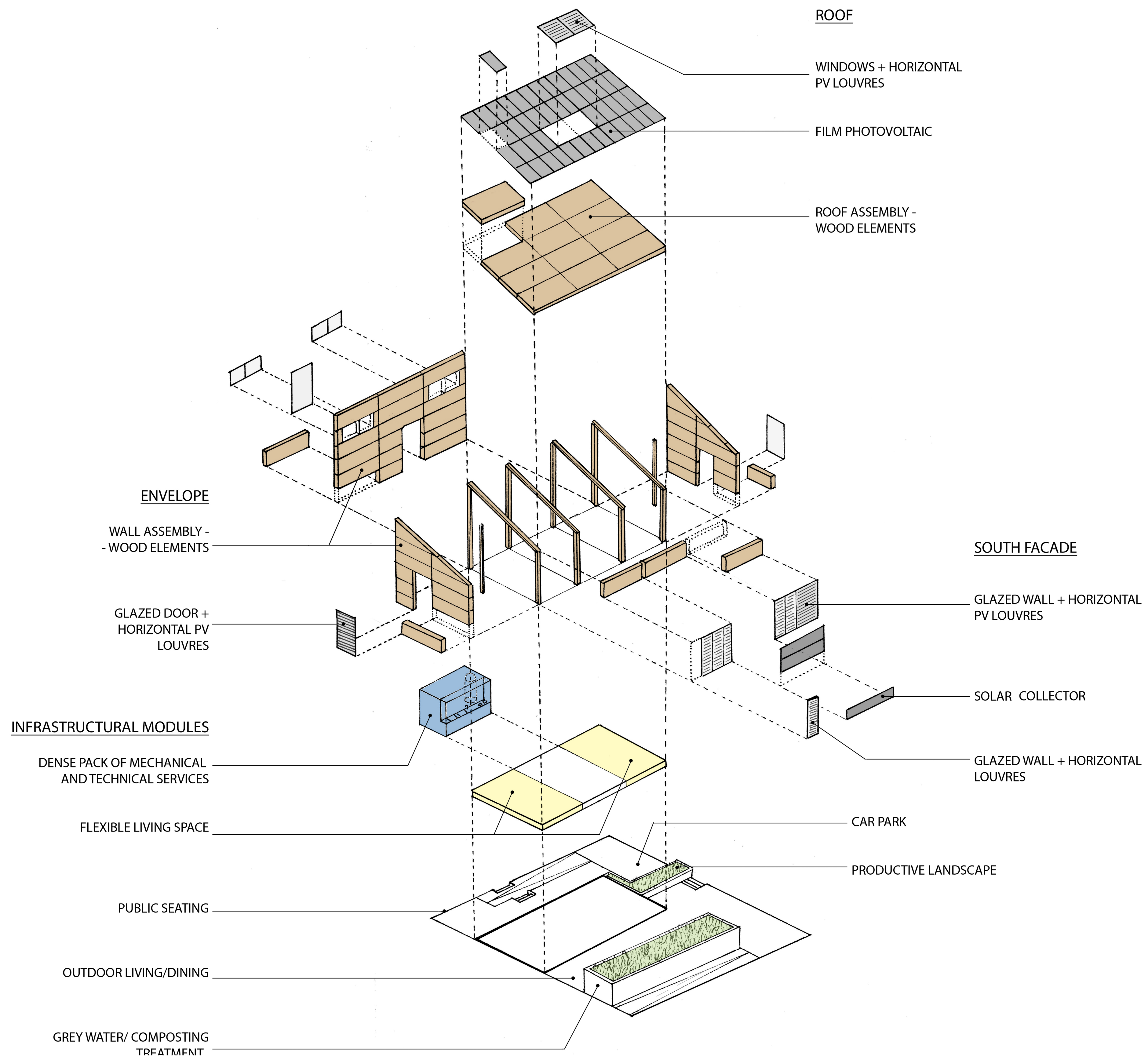
The Solar Decathlon is a competition in which universities meet to design an energetically self – sufficient house that runs only on solar energy and incorporates technologies that maximize its energy efficiency.

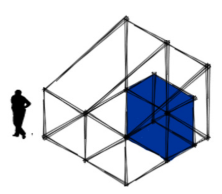
The main challenge of this project was to design a house that has to be adapted to two completely different cities across Europe: Madrid and Trondheim. Start from Norway, we know that is a country with extreme climatic conditions that pose significant challenges to the traditional approaches to passive solar design. From the very beginning the traditional approaches were extremely important in our design process. So the use of wood as a construction material came out as a natural choice.

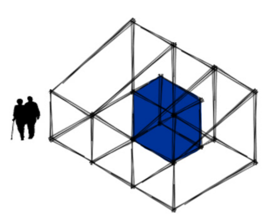
As we went further we decided that great care has also to be taken to design a flexible house: a home for a couple or for a family that could be incorporated in the Brøset project, but at the same time a house easy to transport, with rapid assembly and disassembly times.

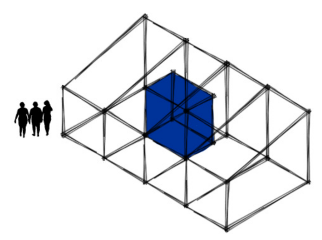
All these main ideas had to be integrated with the concept of a green house. At the end the combination of passive and active solar design, energy production, flexibility and traditional materials produces the “IKEA HOUSE” that sets a new standard for prefabricated solar design in Norway’s northern climate.

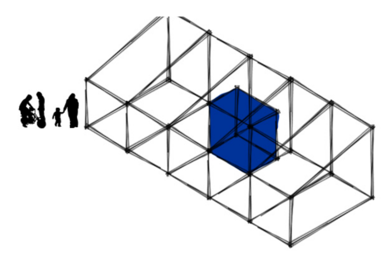




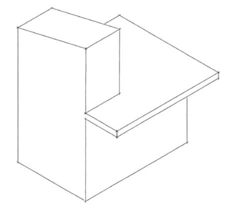








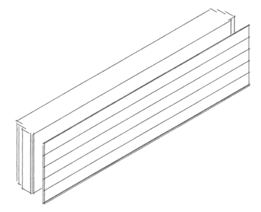
Catalogue

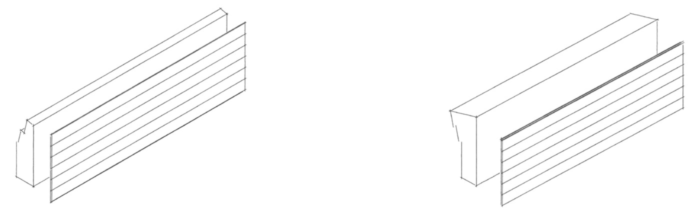

Technical core (1)

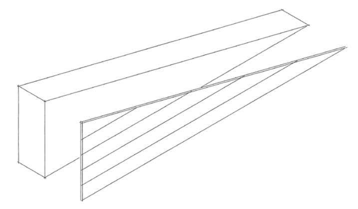

Posts south/north elevation (4/4)

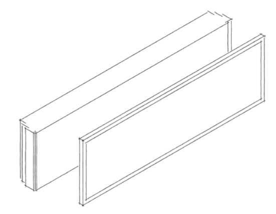
Roof beam (4)

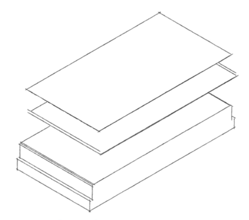
Corner element (4)

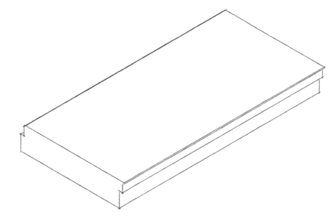

Wall element (30)

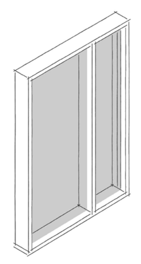

Special corner element south/north elevation (3/3)

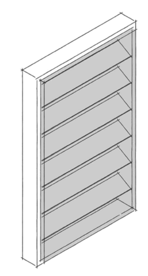

Special wall element east/west elevation (2/2)

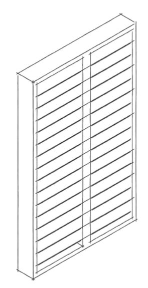

Wall element with solar collector (3)

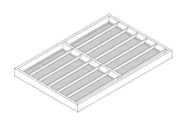

Roof element with steel cladding and PV (12)

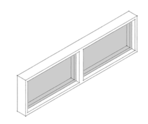

Floor element (12)


Glazed door (2)


Glazed wall with PV louvres (2)


Windows with louvres (3)


Skylight with PV louvres (1)


Windows north elevation (2)

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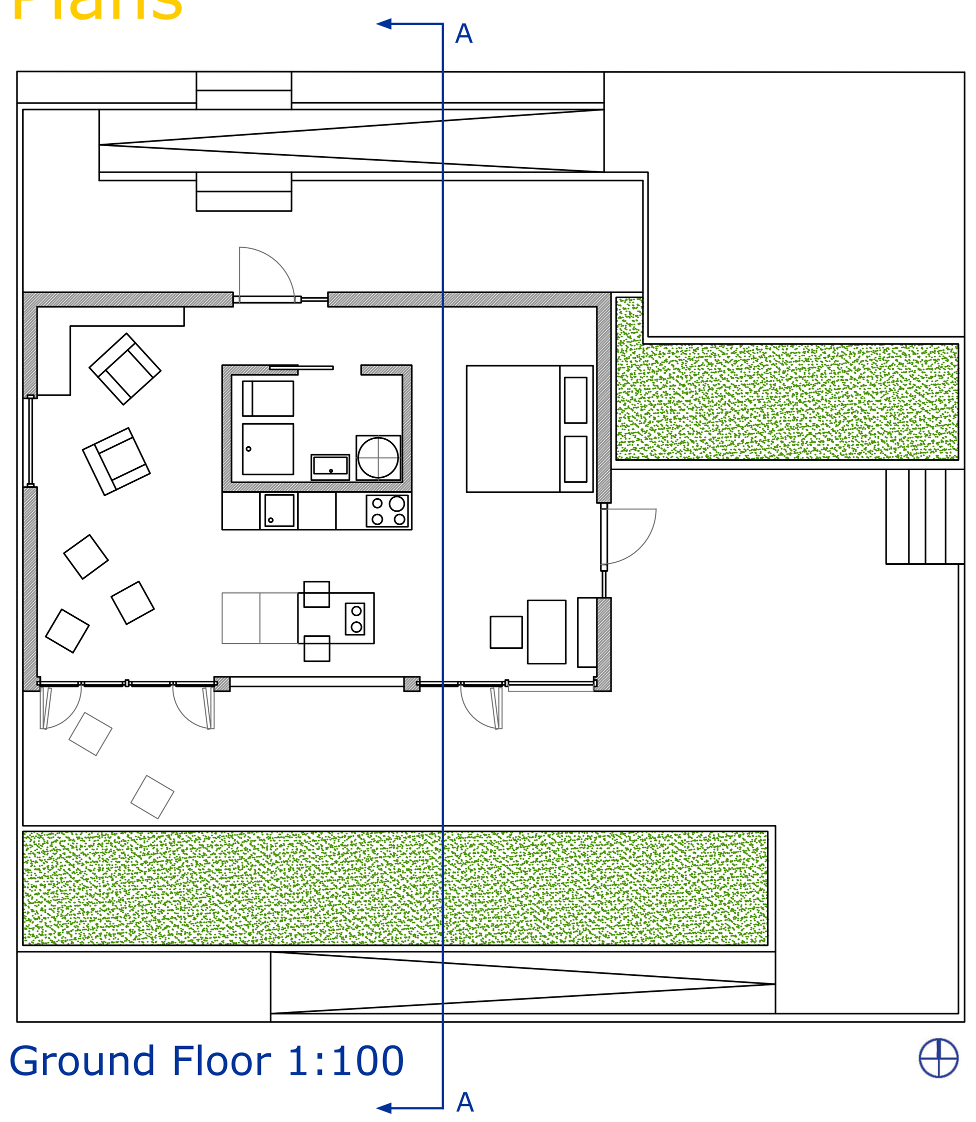
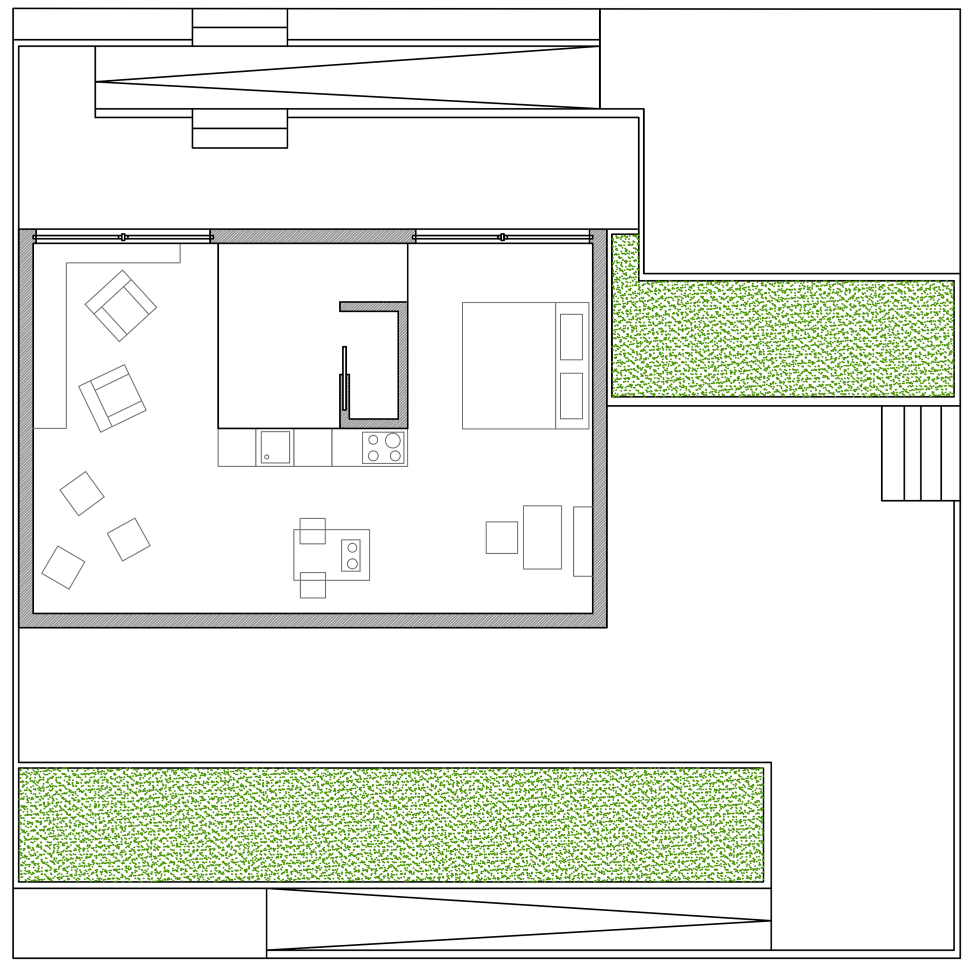
Pablo Alarco' Mila Shrestha Elisabetta Caharija Vegard Heide Ole Kristian Kråkmo

A A R 4 5 3 2   C l i m a t e   a n d   b u i l t   f o r m ,   S o l a r   D e c a t h l o n   d e s i g n   p r o j e c t

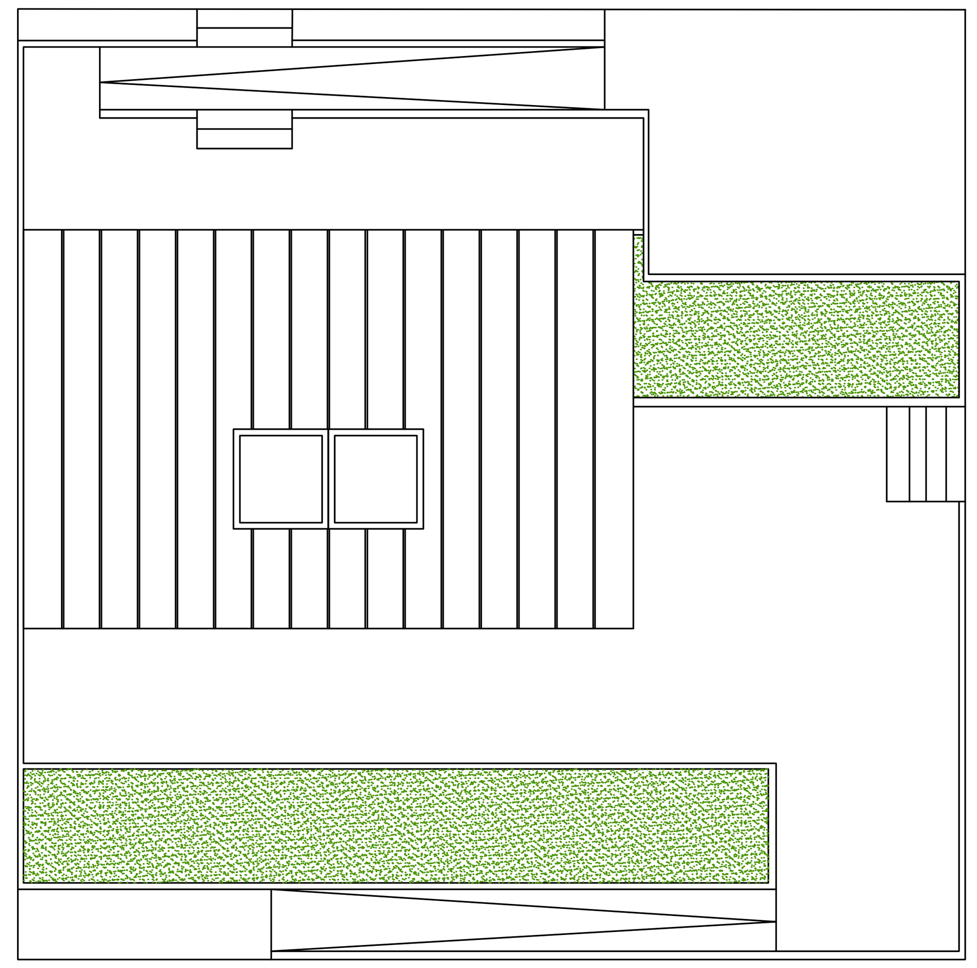
Plans



Ground Floor 1:100

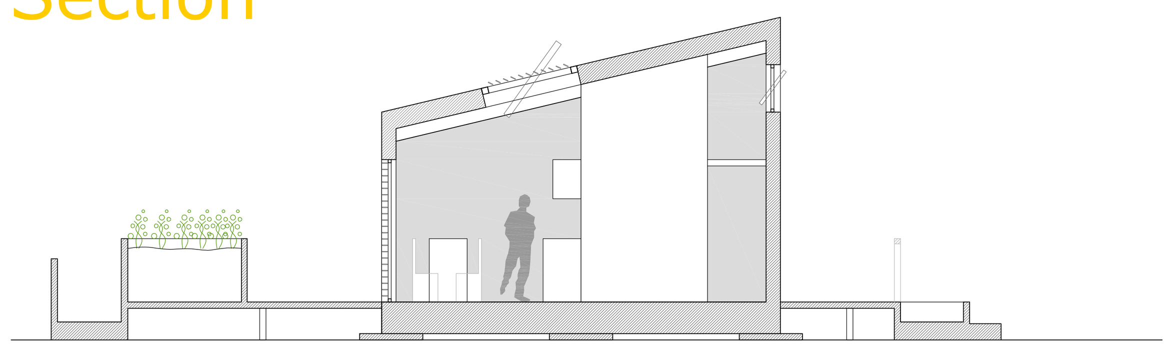


First Floor 1:100



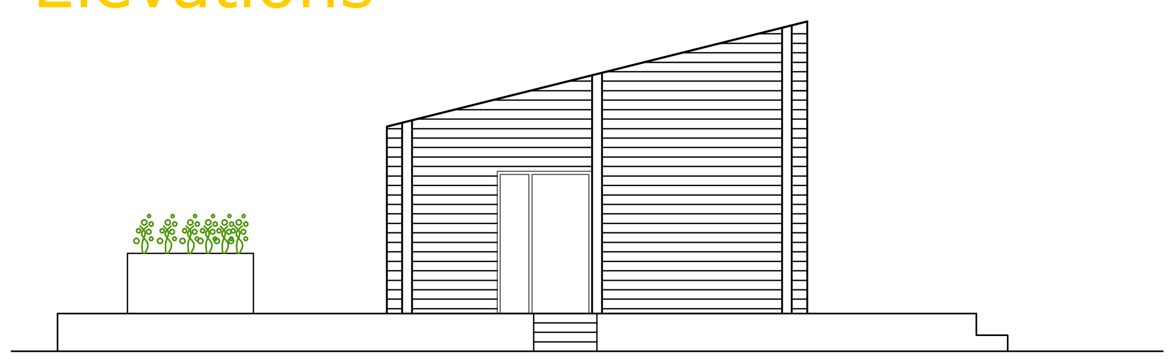
Roof plan 1:100

Section



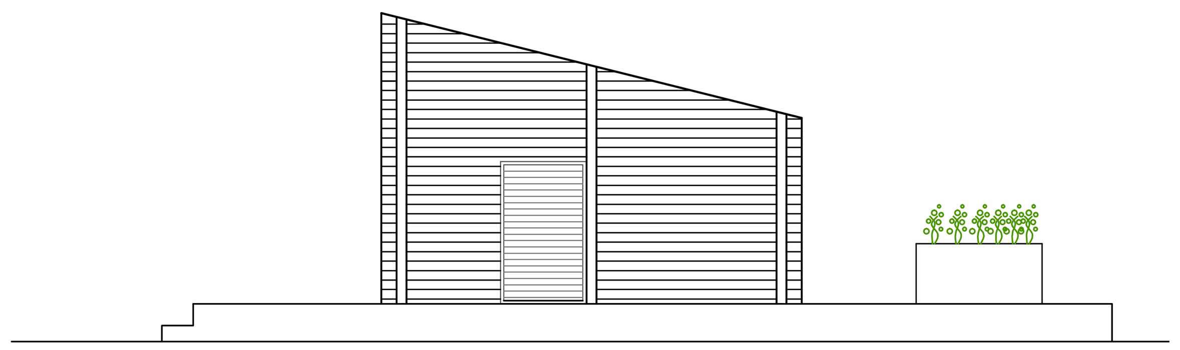
Section A-A 1:100

Elevations

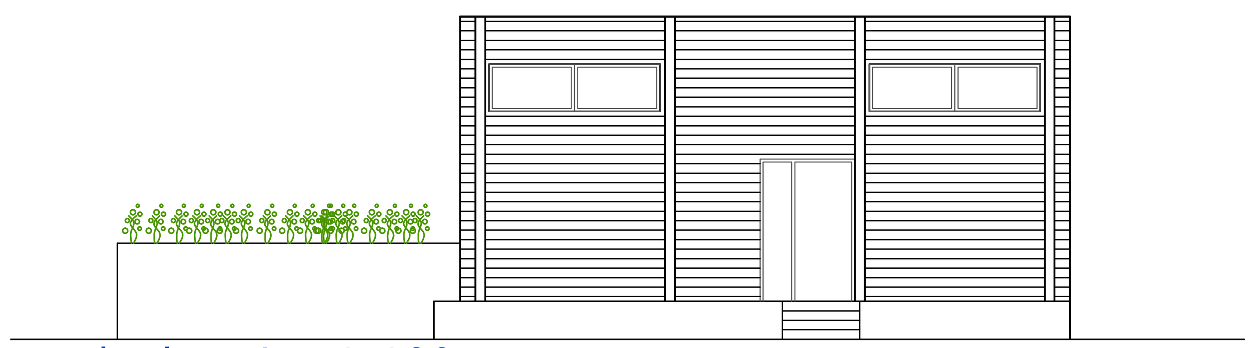


East elevation 1:100

South elevation 1:100



West elevation 1:100



North elevation 1:100

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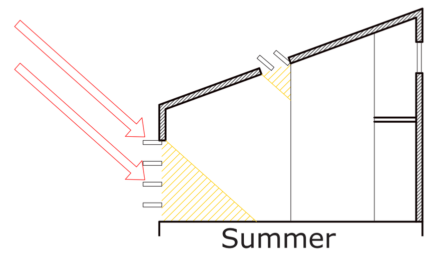
Passive strategies

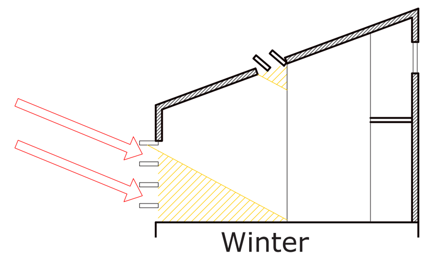
Daylight and shading



Higher sun angle

Shading to prevent excess heat

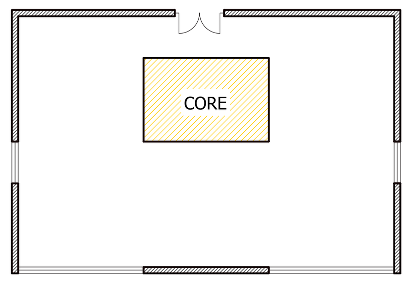
Large south windows and skylight to allow adequate daylight



Lower sun angle allows sun into the living spaces

Shading devices designed so as to allow max daylight and warmth

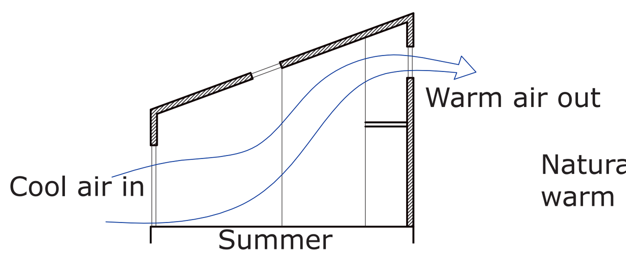
Plan form



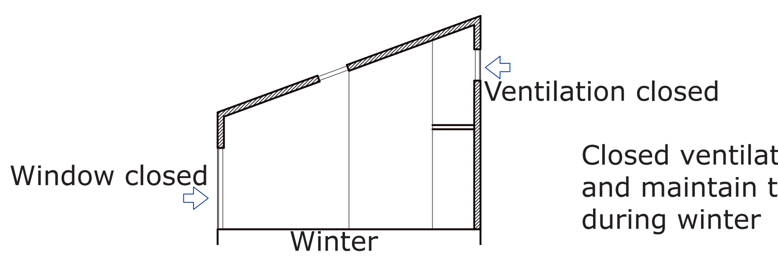
Compact plan form

Energy system concentrated in core

Natural ventilation

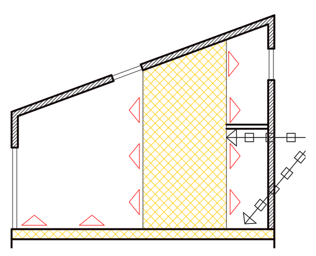


Natural cross ventilation to allow warm air out in summer time



Closed ventilation to reduce air flow and maintain the inside temperature during winter

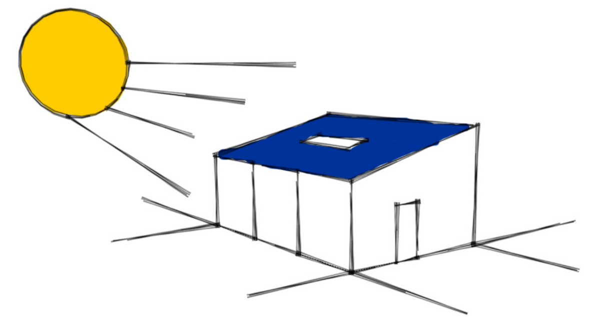
Thermal mass



Thermal mass applied to the floor and core, releases heat during cold days

Active strategies

PV



Roof surface with PV: 50 m2 gains 4 kW

Madrid conditions

Performance of Grid-connected PV

PVGIS estimates of solar electricity generation

Location: 40°18'46" North, 3°41'29" West, Elevation: 0 m a.s.l.,

Nominal power of the PV system: 4.0 kW (CdTe)
Estimated losses due to temperature: 1.9% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.9%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 18.1%

	Fixed system: inclination=17 deg., orientation=0 deg.			
Month	Ed	Em	Hd	Hm
Jan	9.44	293	2.75	85.2
Feb	11.50	323	3.40	95.2
Mar	17.30	536	5.24	162
Apr	17.70	532	5.45	163
May	21.30	659	6.61	205
Jun	22.90	688	7.17	215
Jul	23.40	726	7.35	228
Aug	21.80	677	6.79	210
Sep	18.60	557	5.67	170
Oct	13.90	432	4.15	129
Nov	9.78	293	2.85	85.6
Dec	7.69	238	2.23	69.2
Year	16.30	496	4.98	152
Total for year		5950		1820

Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Trondheim conditions

Performance of Grid-connected PV

PVGIS estimates of solar electricity generation

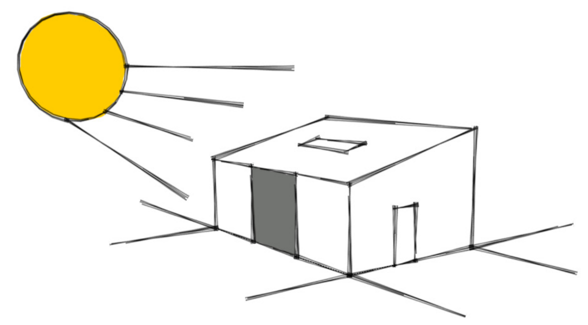
Location: 63°26'8" North, 10°27'32" East, Elevation: 0 m a.s.l.,

Nominal power of the PV system: 4.0 kW (CdTe)
Estimated losses due to temperature: -1.7% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 4.0%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 16.1%

	Fixed system: inclination=17 deg., orientation=0 deg.			
Month	Ed	Em	Hd	Hm
Jan	1.05	32.6	0.31	9.49
Feb	3.99	112	1.16	32.4
Mar	8.31	258	2.43	75.2
Apr	13.10	393	3.87	116
May	16.40	510	4.93	153
Jun	17.80	533	5.37	161
Jul	16.00	497	4.84	150
Aug	12.60	391	3.77	117
Sep	8.07	242	2.36	70.9
Oct	4.16	129	1.21	37.5
Nov	1.64	49.1	0.48	14.3
Dec	0.47	14.7	0.14	4.22
Year	8.66	263	2.58	78.4
Total for year		3160		941

Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Solar collector



Surface with vacuum panel: 9 m2

Heated water demand: 50 liters/person/day = 3 kWh/person/day

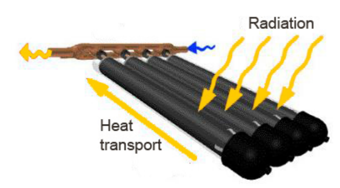
Solar collector can produce: 300-700 kWh/m2 per year.

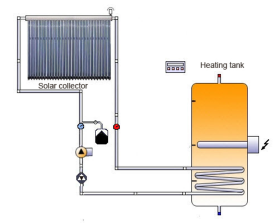
If our house is for 2 people and the vacuum panel produces 300 kWh/m2 per year:

Heated water used 3 kWh * 2 persons * 365 days = 2190 kWh

Produced by solar collector 300 kWh * 9 m2 = 2700 kWh

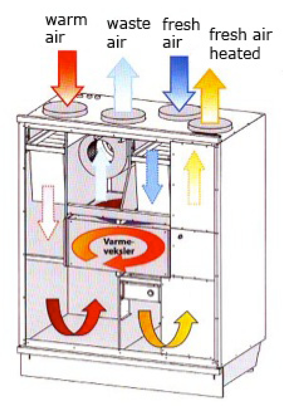
The conclusion is that we probably have enough surface for the solar collector to meet the heated water demand





Principle

Mechanical ventilation



Principle

Mechanical ventilation with rotating heat exchanger.

This will be dimensioned for the cold season, in the hot season it will be assisted or replaced by natural ventilation.

By placing this in the service core we get very short ducts and very low energy energy consumption by fans. We also get the ducts and systems inside the thermal envelope, and thus avoid condensation problems.

We might end up connecting the ventilation system with a heat pump to preheat incoming air in winter and cool air in summer. This can easily be done inside the service core.

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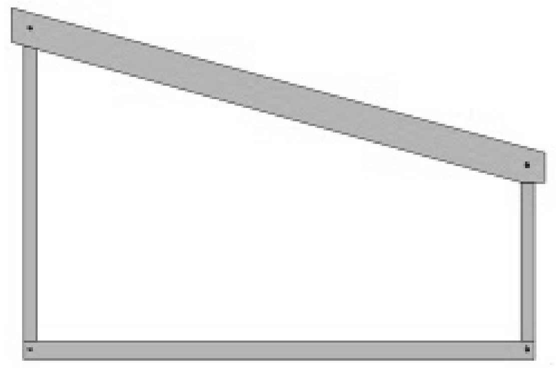
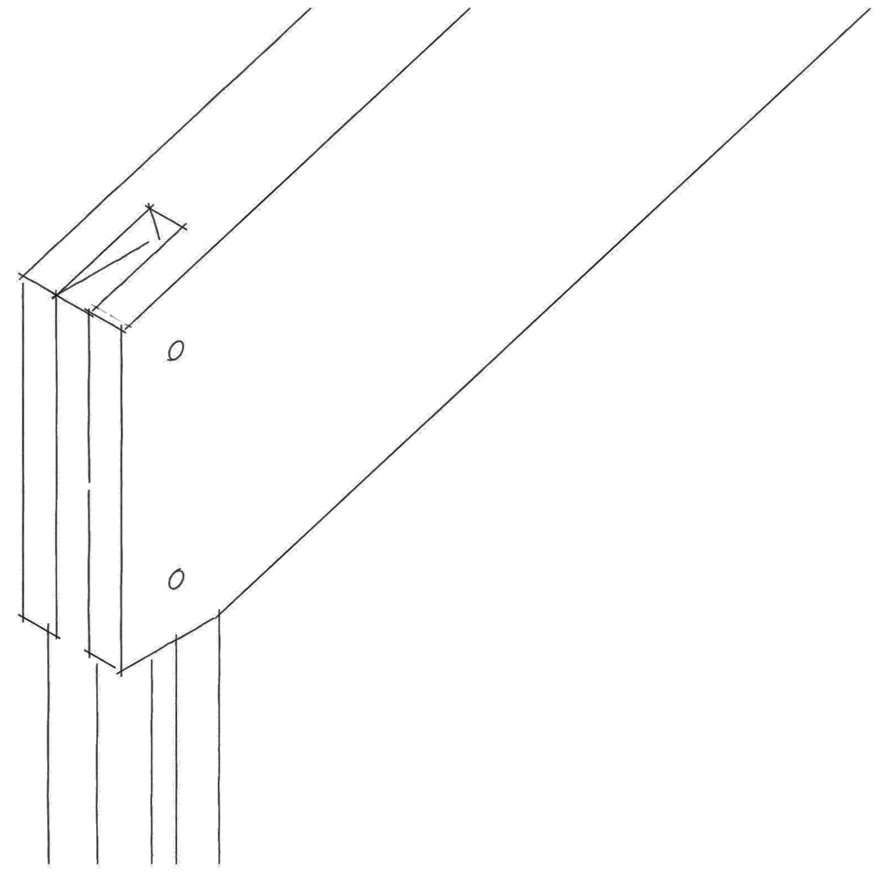
Construction



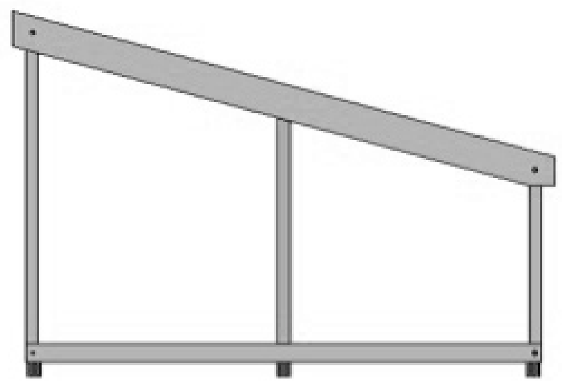
Primary constructon of prefabricated frames made of glue-laminated wood.

These are easiest to assemble horisontally.

Posts 150 x 150mm, roof beams approximately 150 x 450mm.

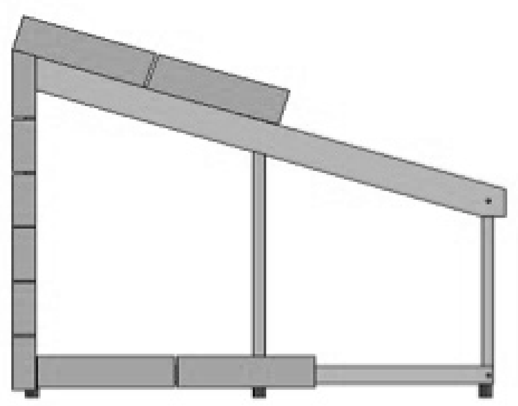


Joint between post and beam in the frame

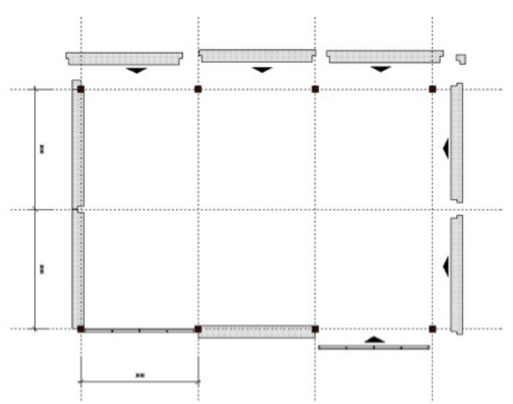


Adding secondary construction in the end walls (yellow).

These posts are only needed to support wall elements.

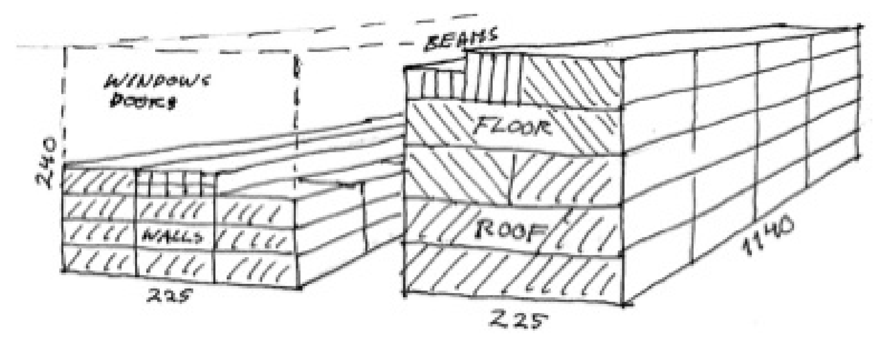


Then we add elements to close walls, roof and floor. These elements (slabs) consist of structurally insulated panels, and are strong enough to support themselves in the 3m spans. Some of the element-slabs can be custom-made for increased thermal storage, with phase-changing material (or thermal mass if the transport allows it). This is preferably done in the floor, or walls of the service core. The service core is made of massive wood. This will contribute with some thermal mass, and is convenient to fill with pipes and wires. It also provides a finished surface on both sides and is robust enough to be transported as a box of its own. With the system of prefabricated wall elements it is also possible to change some of the materials during the planning process.

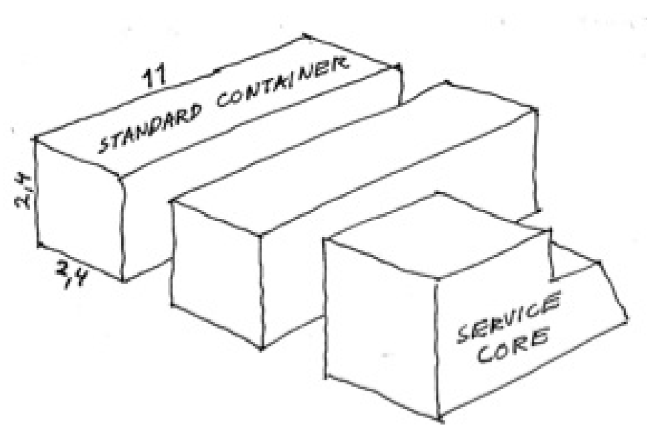


The walls are 30cm, the roof 50cm and the floor 40cm. This can be adjusted without problem as the grid line (3m element grid) is through the center of the posts. In that way we have the same element length with different combinations of walls and house size. The posts do not extrude into the room, but are visible from the inside.

Transport



As the whole construction is based on pre-fabrication it is easy to transport the house.
The posts, beams and elements for roof, floor and walls can be stacked in a compact way



This fits easily into 2 standard containers. In addition the service core is transported as a box of itself; 3m by 3m, and 4,5m tall. This means we want to lay it on the side.

H O U S

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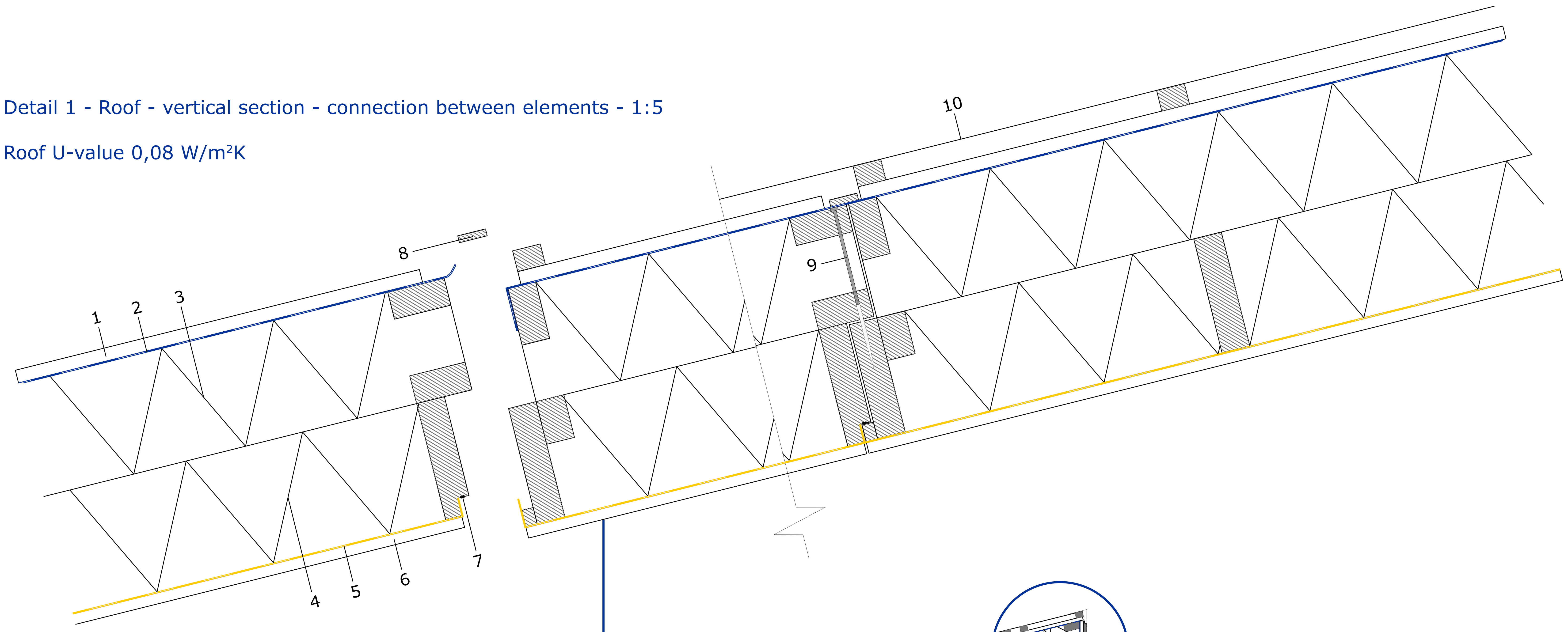
Details

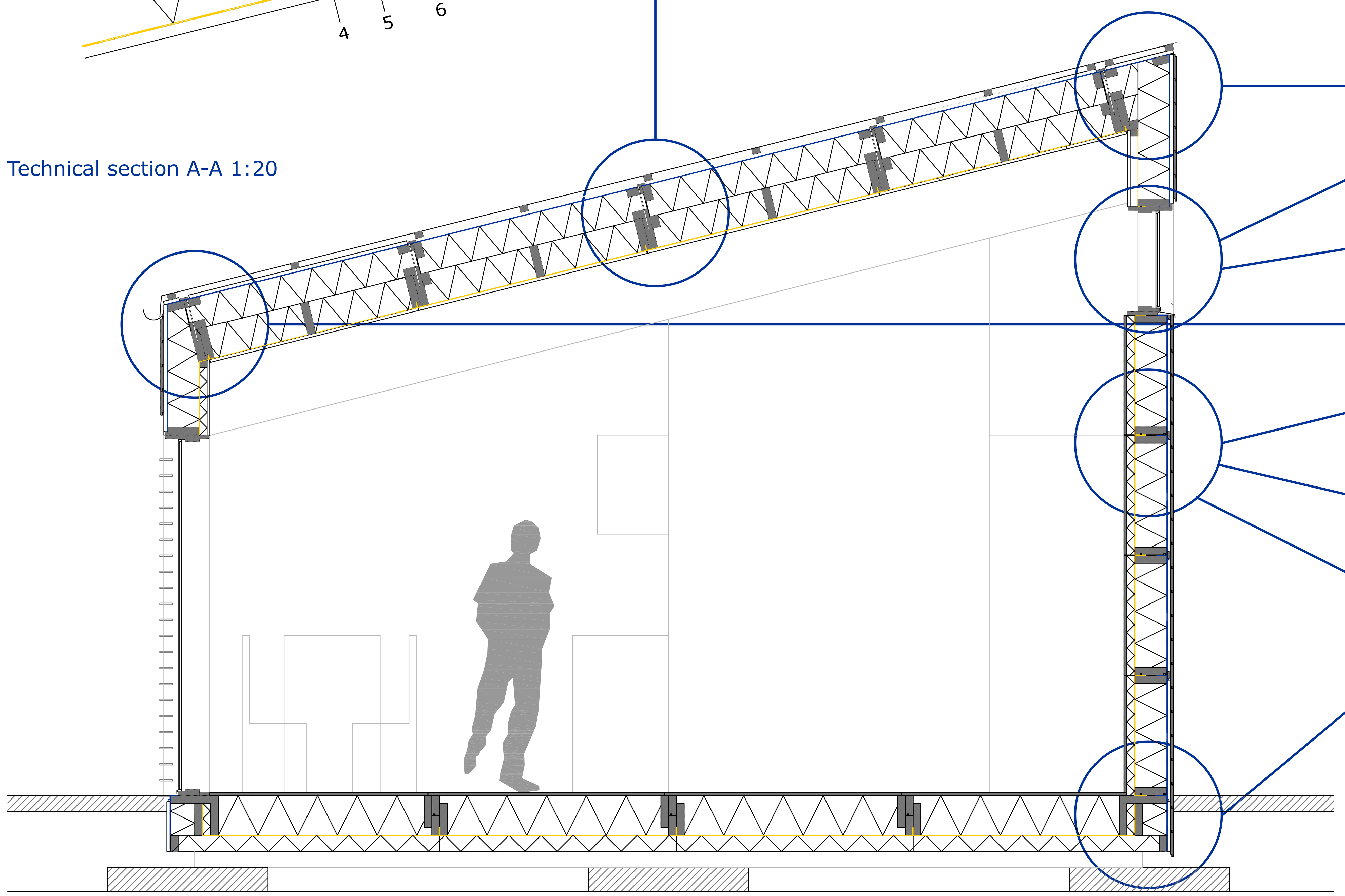
Detail 1 - Roof - vertical section - connection between elements - 1:5

Roof U-value 0,08 W/m²K



1 Wooden batten, 22*48 mm
2 Soft wind barrier
3 Glava insulation 200 mm, λD = 0,033 W/mK
4 Glava insulation 200 mm with paper, λD = 0,033 W/mK
5 Vapour barrier 0,15 mm
6 Ply panel 18 mm
7 Rubber gasket
8 Wooden batten, 15*48 mm
9 Wood screw
10 Steel cladding with PV thinfilm

Technical section A-A 1:20



Detail 6 - wall - vertical section - connection to roof northern side - 1:5

Detail 9 - window - horizontal section - 1:5

Detail 8 - window - vertical section - 1:5

Detail 7 - wall - vertical section - connection to roof southern side - 1:5

Detail 2 - wall - horizontal section - corner detail - 1:5

Detail 3 - wall - vertical section - connection between elements - 1:5

Detail 4 - wall - horizontal section - connection between elements - 1:5

Detail 5 - wall - vertical section - connection to ground - 1:5

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Pablo Alarco` Mila Shrestha Elisabetta Caharija Vegard Heide Ole Kristian Kråkmo

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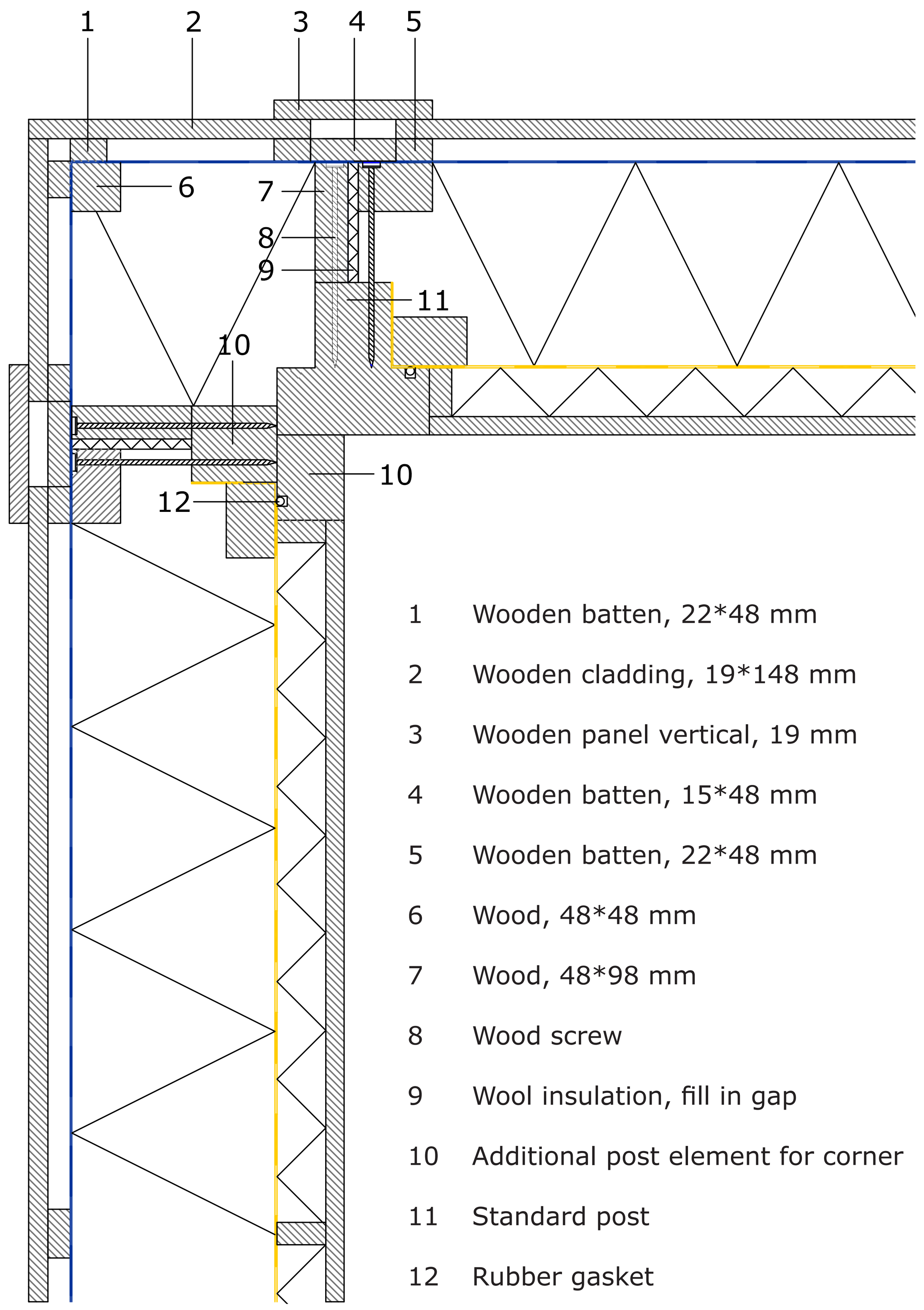
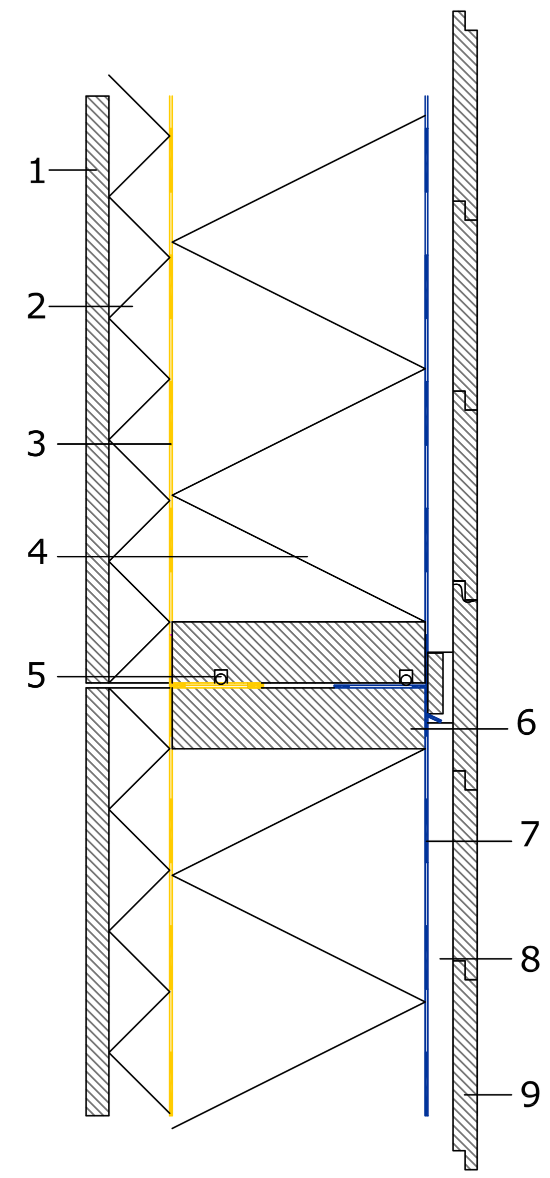
Detail 2 - wall - horizontal section - corner detail - 1:5



1 Wooden batten, 22*48 mm
2 Wooden cladding, 19*148 mm
3 Wooden panel vertical, 19 mm
4 Wooden batten, 15*48 mm
5 Wooden batten, 22*48 mm
6 Wood, 48*48 mm
7 Wood, 48*98 mm
8 Wood screw
9 Wool insulation, fill in gap
10 Additional post element for corner
11 Standard post
12 Rubber gasket

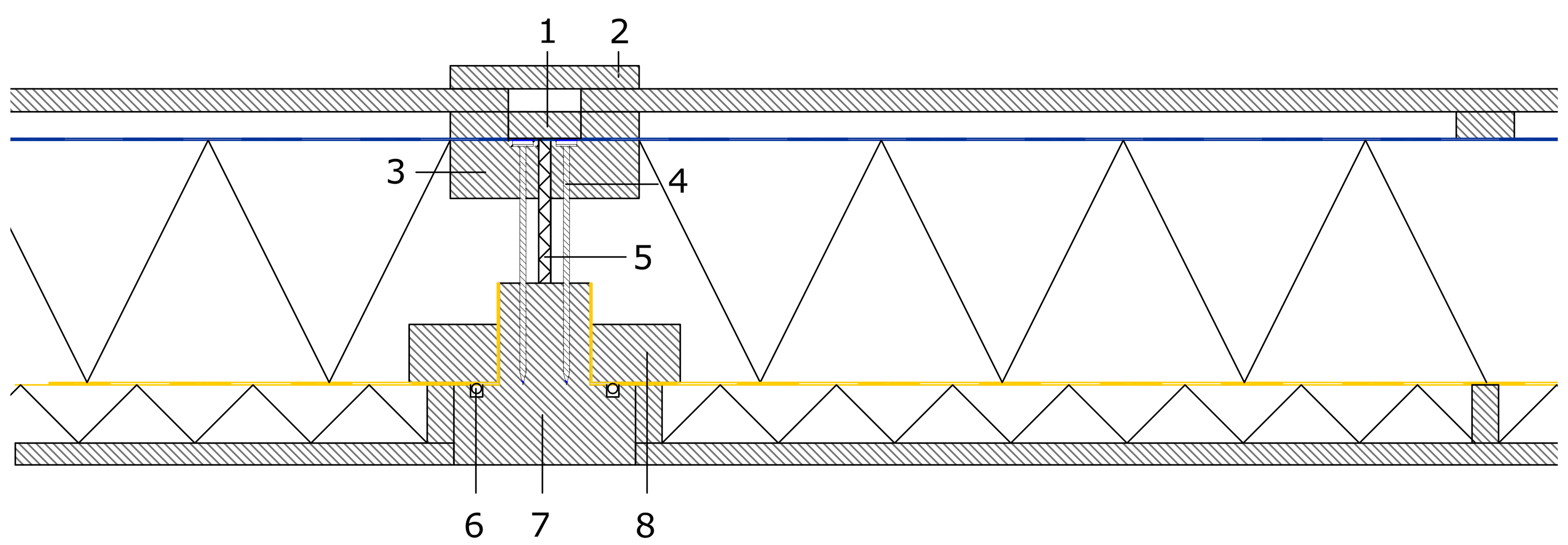
Detail 3 - wall - vertical section - connection between elements - 1:5

Wall U-value 0,13 W/m²K



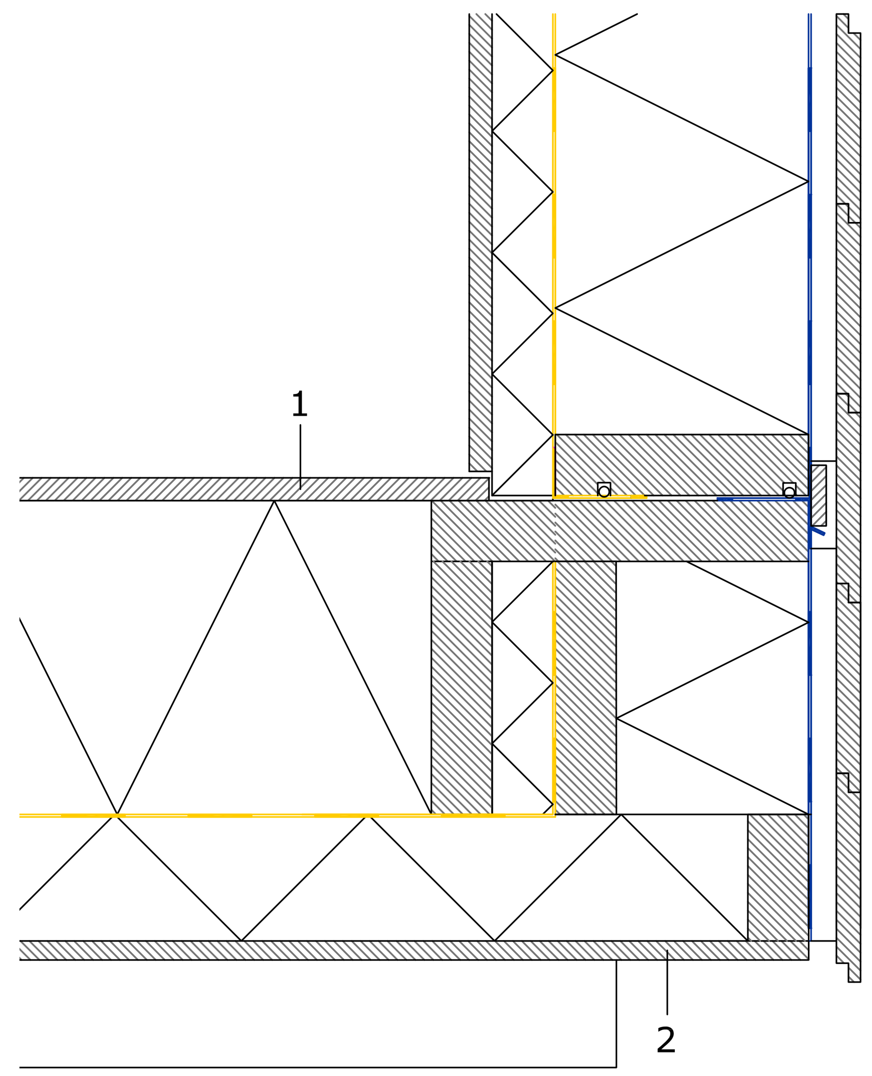
1 Ply panel, 18 mm
2 Glava insulation, 50 mm, λD = 0,033 W/mK
3 Vapour barrier, 0,15 mm
4 Glava insulation, 200 mm, λD = 0,033 W/mK
5 Rubber gasket
6 Wood, 48*198 mm
7 Soft wind barrier
8 Air gap, 22 mm
9 Wooden cladding, 19*148 mm

Detail 4 - wall - horizontal section - connection between elements - 1:5



1 Wooden batten, 15*48 mm
4 Wood screw
7 Standard post
2 Wooden panel vertical, 19 mm
5 Wool insulation, fill in gap
8 Wood 48*73 mm
3 Wood 48*73 mm
6 Rubber gasket

1 Hardwood floor
2 Oriented strand board 15 mm



Detail 5 - wall - vertical section - connection to ground - 1:5

Floor U-value 0,09 W/m²K

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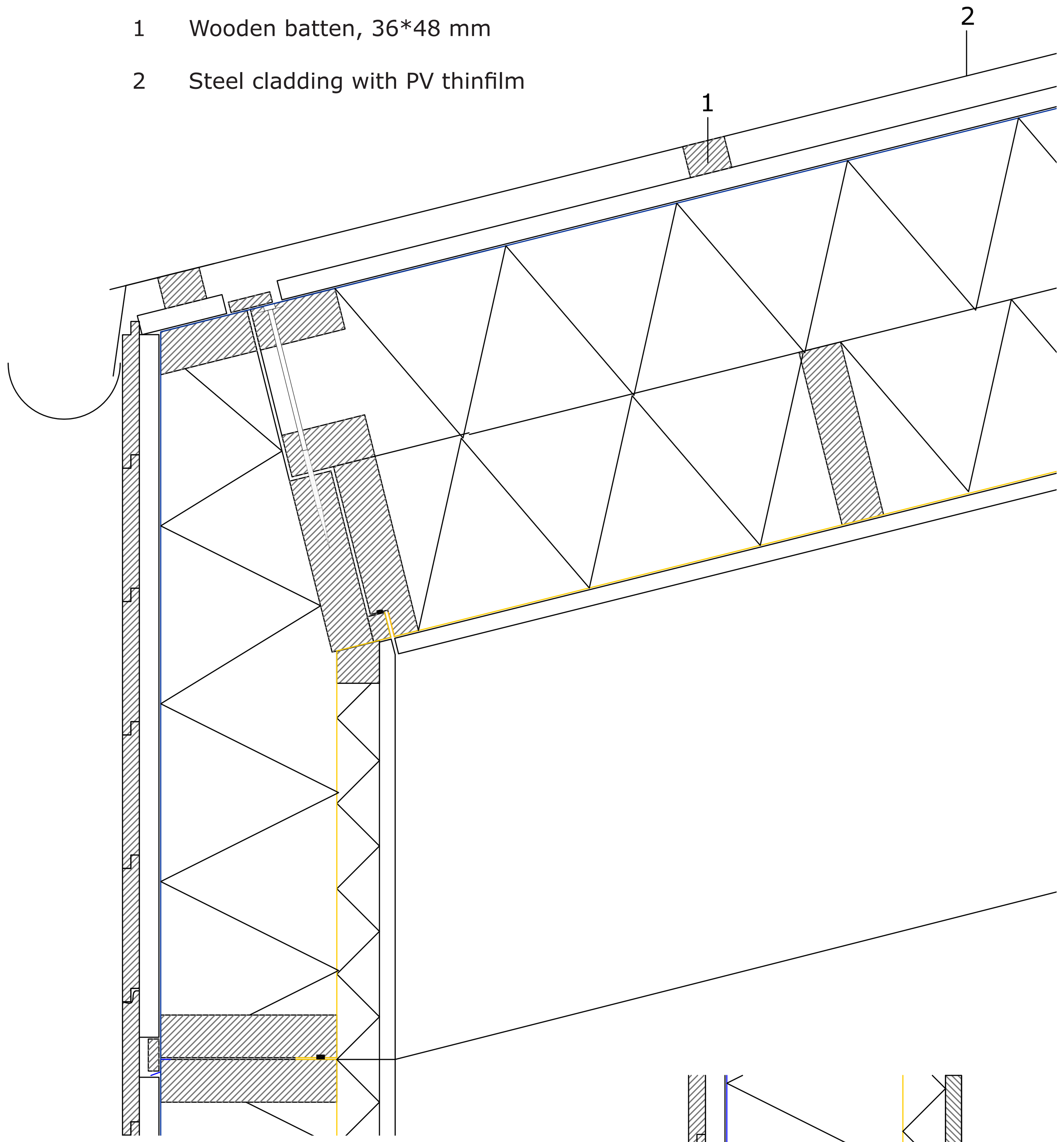
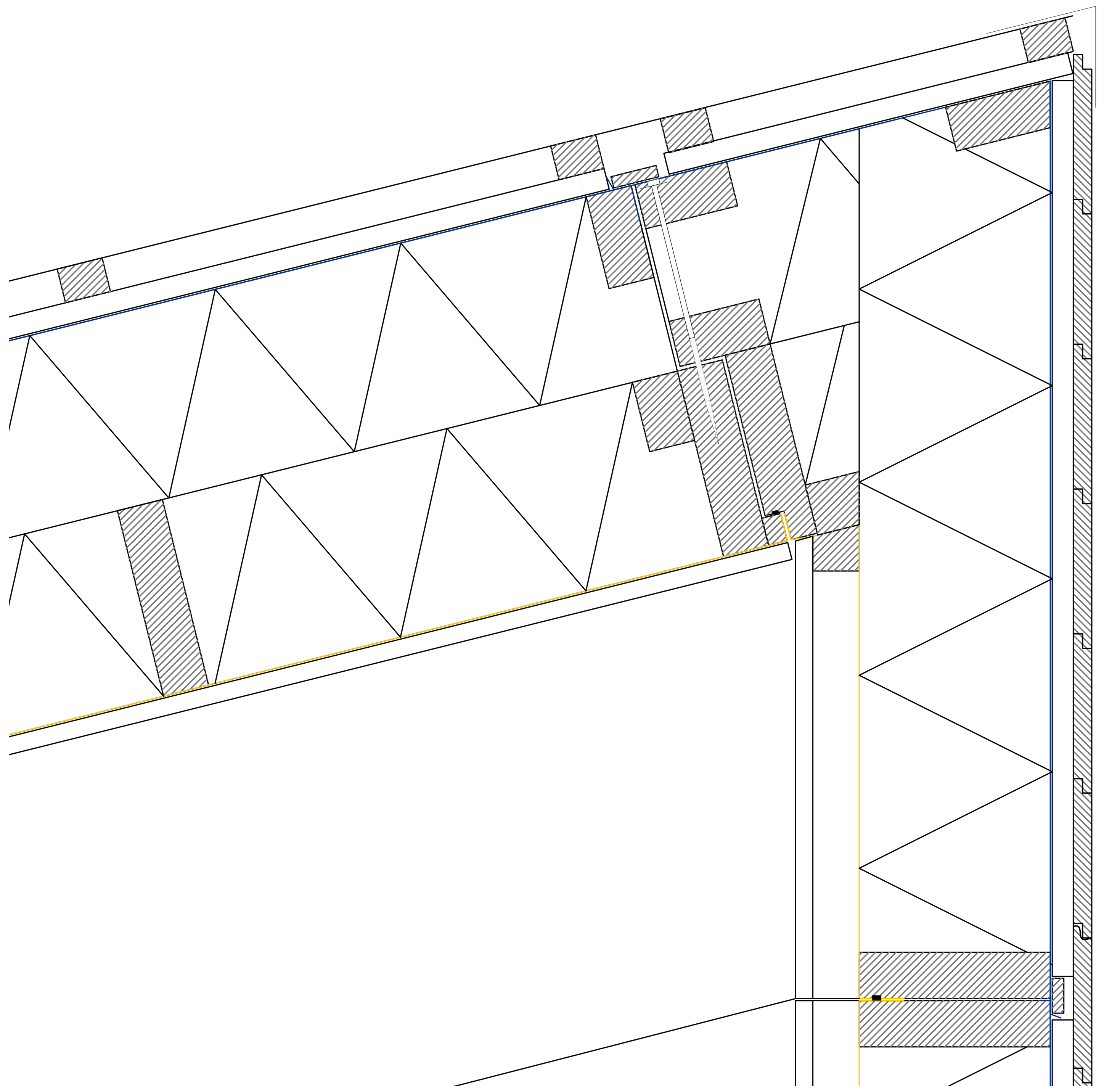
Detail 6 - wall - vertical section - connection to roof southern side - 1:5

1 Wooden batten, 36*48 mm

2 Steel cladding with PV thinfilm

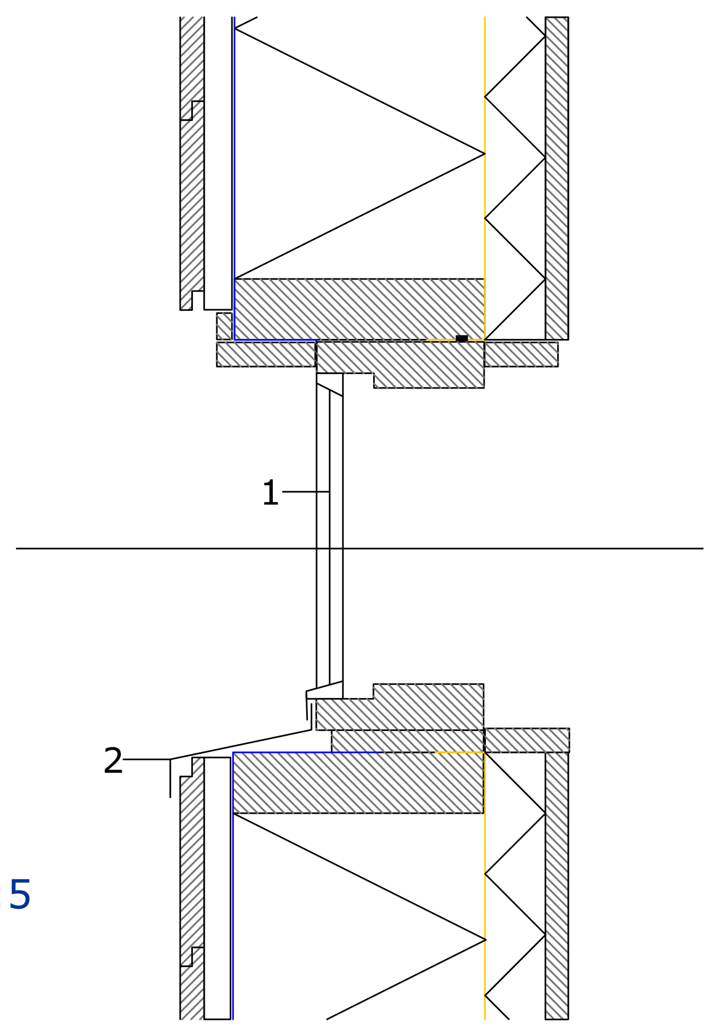


Detail 7 - wall - vertical section - connection to roof northern side - 1:5



1 Tripple glazing, argon filling

2 Metal cladding



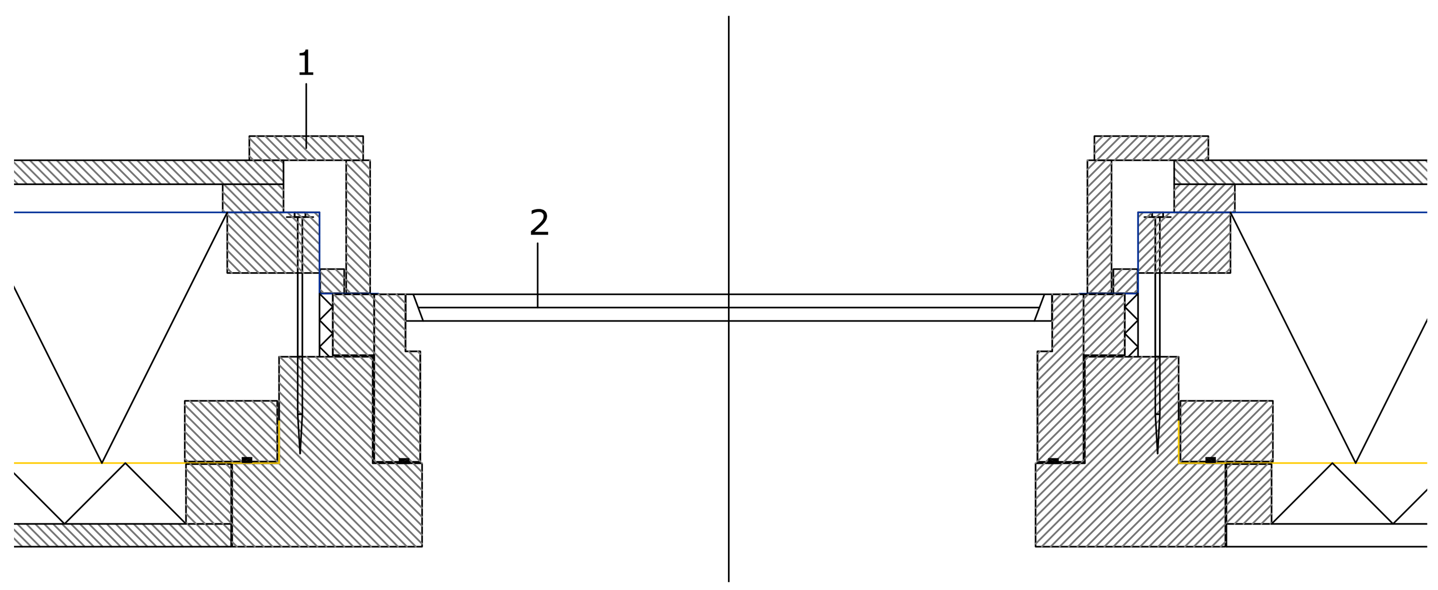
Detail 8 - window - vertical section - 1:5

Window U-value 0,7 W/m²K

Detail 9 - window - horizontal section - 1:5

1 Wooden panel vertical, 19 mm

2 Tripple glazing, argon filling



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