SAFE Housing

Sustainable • Affordable • Flexible • Energy Efficient

11982
INTEGRATED
DESIGN PROJECT

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DTU Technical University of Denmark

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1. Overview

Readers Guide

This portfolio consists of 7 sections, displayed in the table of contents. Each of the sections have a designated colour, illustrating which section it belongs to. Chapter 2 to chapter 6 shows the journey of the project from the course background to the design conclusion. Section 7 is appendices.

Credits

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2. Background & Introduction

COURSE BACKGROUND

- In this course, the synthesis of function and structure is emphasized. Integrated Design is the keyword, where both anthropological and architectural approaches are integrated into one project
- Essentially, installations that are necessary for the building to function *must* comply with the structure but also with the needs of the occupants and vice versa
- End-user satisfaction is crucial
- Course where sustainable design of dwellings is concretized
    - Energy for operation
    - Embodied energy in materials and construction
    - Strain on natural resources
- Open assignment where the content and execution are up too you (within the given boundaries)

INTRODUCTION

This project is a part of the course 11982 - Integrated Design Project and addresses:
Densification and upgrade of suburbia - low-rise, sustainable, flexible, affordable as well as pre-fabricated dwellings of the future.

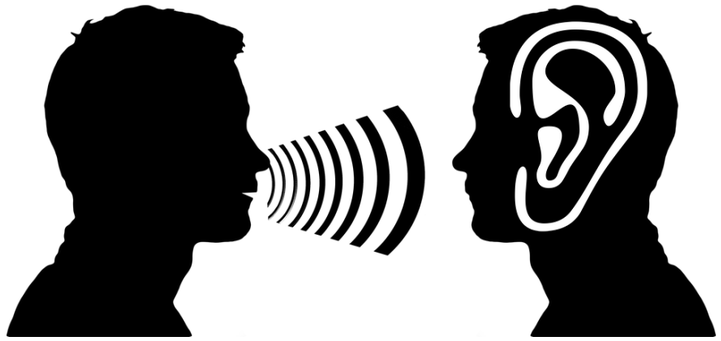
During the spring semester, a collaboration between four students at Technical University of Denmark (DTU) , with disciplines within Architectural and Structural Engineering together with Anthropologist students from University of Copenhagen (KU), was taken place. It has been an interdisciplinary project where the students have benefitted from the team members different competences. Among some, the Anthropologists have conducted analyses which together with the DTU students have made an impact on the dwelling concept. During the last section of the course, a 3-week period in June, the DTU students have finalized the project.

3. Concept – Anthropology Integration

In collaboration with the Anthropology students, the creation of the dwelling concept was made. Interviews with residents living in Albertslund, Copenhagen was conducted and subsequently analyzed and evaluated. The residents shared their own opinion, and explained their benefits and challenges living in their renovated house. In addition recording transcripts from the interviews was made, making a foundation for the analyses. The DTU students participated in the Anthropologic field work and got an impression of how Anthropologists operate.

The two most prominent findings during the analysis was the need for:

- **Flexible Housing**
- **Additional Storage Space**



"I like to change the interior of the house to the current family constellation" **GUNNARR**

"I build a diving wall to make an extra room in which I can play music" **GUNNARR**

"My house started renting out one wing of our house since our children left home" **KENNETH**

"We adapt ourselves to the house" **TIM**

FLEXIBLE HOUSING

PHASE 1

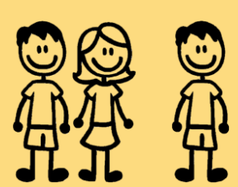
- 2 adults
- 1 child

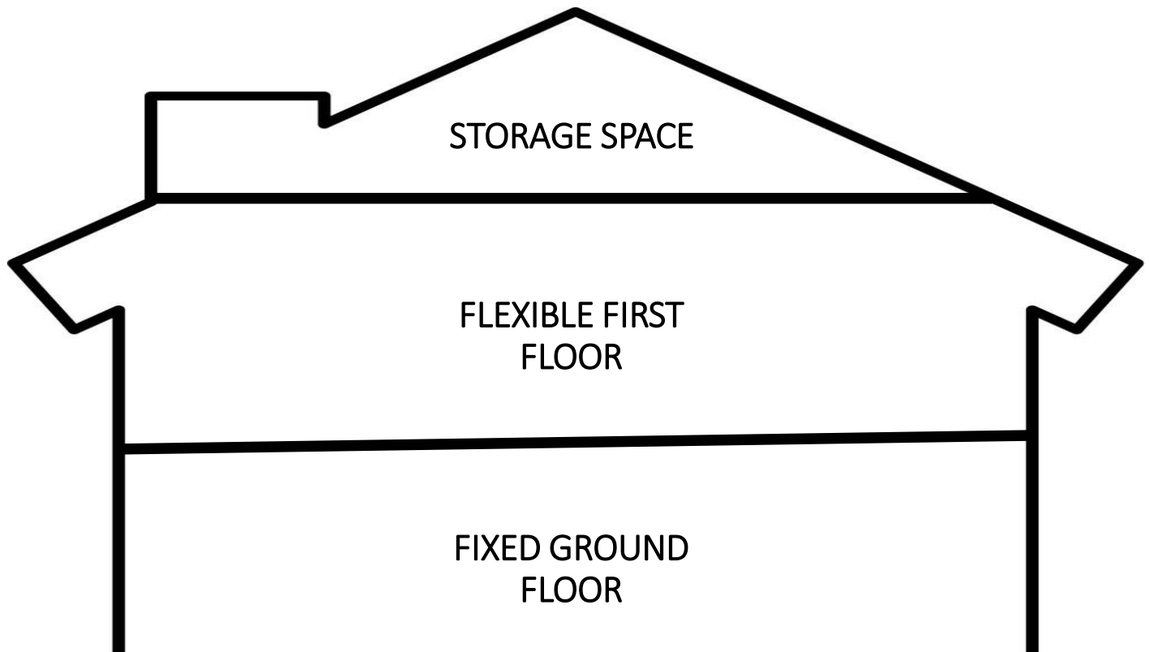
PHASE 2

- 2 adults
- 3 children

PHASE 3

- 2 adults
- 1 or 2 tenants





4. Design Overview

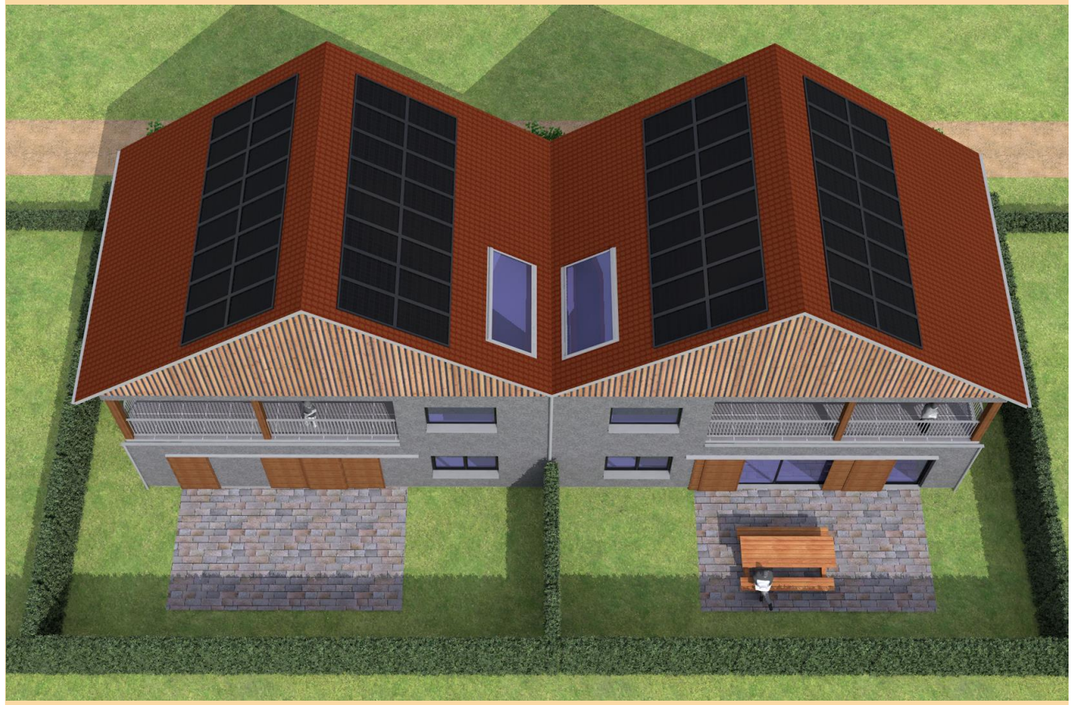
4.1 Building Design

4.2 Interior Design – Flexibility in Time

4.3 Daylight Design

4.4 Kitchen Design

4.5 Urban Design – Dwelling Concept



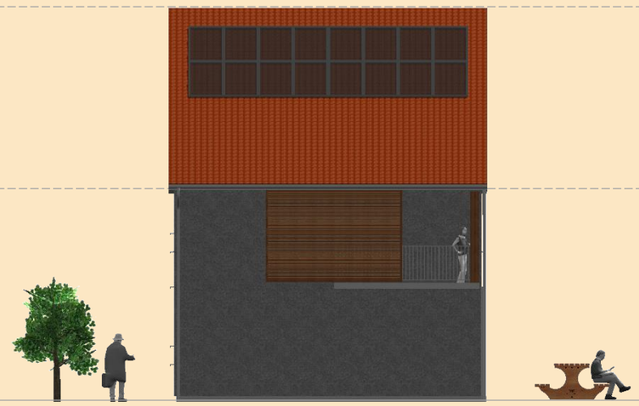
The proposed dwelling concept is aiming for flexibility in different aspects. The internal design is constructed to be able to host several additional partition walls, if the occupants desire to change their living space. Furthermore, the design allows to adapt to the current family constellation by providing the possibility to change rooms and add more interior space by closing in the terrace on the first floor. With this solution, the occupants can stay in their home over several decades without the need to adapt their living situation to the current family constellation. This leads to an economically, socially and environmentally beneficial dwelling concept where space is used efficiently and the house is able to adapt to the changing needs of the occupants.

In addition to this flexibility, the design provides sufficient storage space for the occupants, which was identified to be a major problem with current housing solutions. Besides storage rooms, the house includes a tilted roof which is providing the additional space for storage in the resulting attic. As the roof is tilted East and West with an angle of 35°, it is suitable to attach PV-Panels in order to cover the peak consumption of electricity in the morning and evening.

The dwelling is designed to create a semi-detached house which is mirrored on the South-North axis. There is a garden belonging to each house and separation of the properties are made with hedges, resulting in private and semiprivate space. Public space is established by two parks, each more than 5,000 m², which will improve the dwelling community.

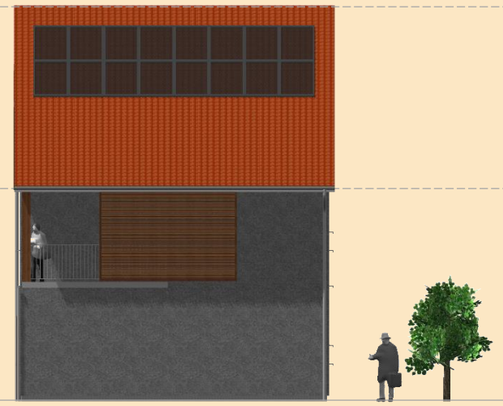
4.1 Building **Design**

WEST ELEVATION

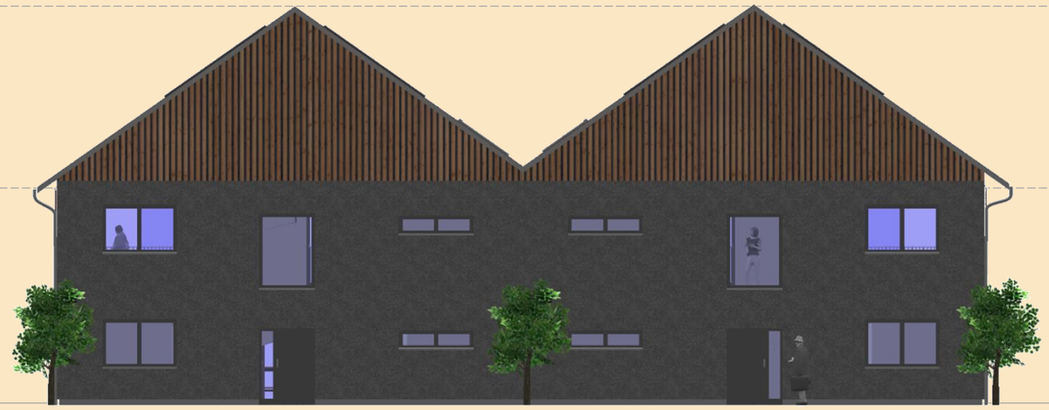


SOUTH ELEVATION

EAST ELEVATION



NORTH ELEVATION



4.2 Interior Design – Flexibility in Time

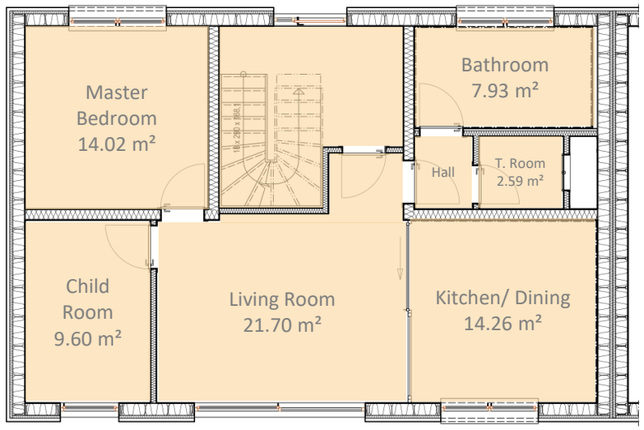
Occupant Phases

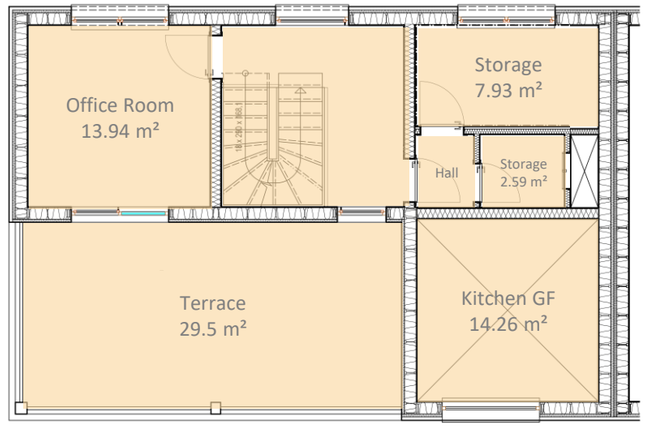
Fixed Ground Floor

Flexible First Floor

PHASE 1

- 2 adults
- 1 child

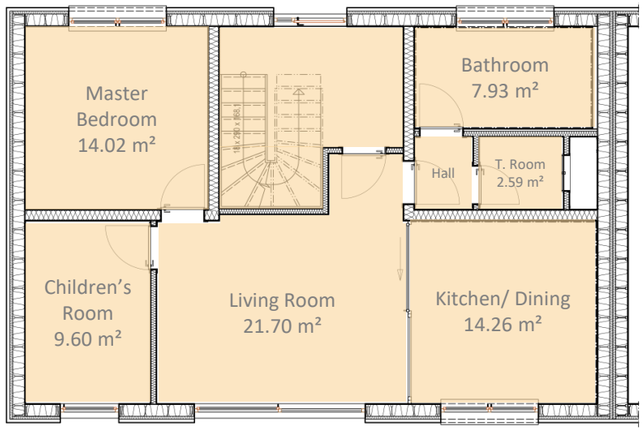


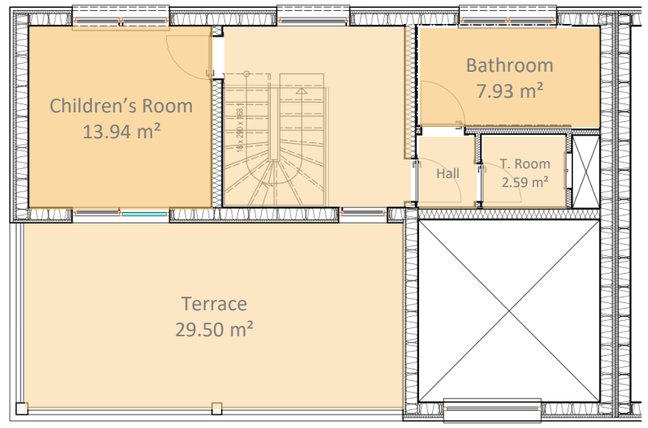


The first phase of the building is designed for a small family of two adults and one child.
The ground floor consists of the bedrooms, the living room and the kitchen as well as a bathroom. The kitchen is designed with a double height to allow natural ventilation. In the first floor, there is an office and sufficient storage capacity as well as a terrace for the well-being of the occupants.

PHASE 2

- 2 adults
- 3 children

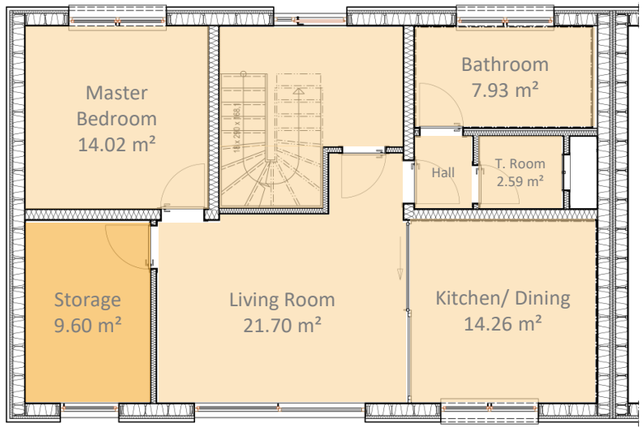


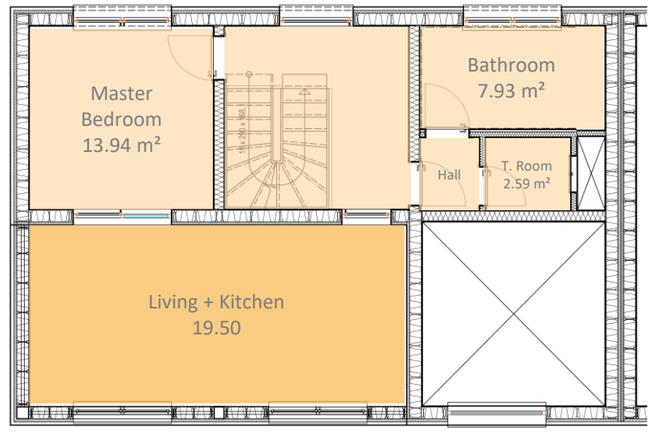


As the family grows, our design is able to adapt to the current family constellation. In this case, the family grows by two more children. In the proposed solution, the office will change to a children room for two children ad the storage in the first floor will turn into a bathroom. The piping for the bathroom is already installed in an installation strip on ground of the bathroom.

PHASE 3

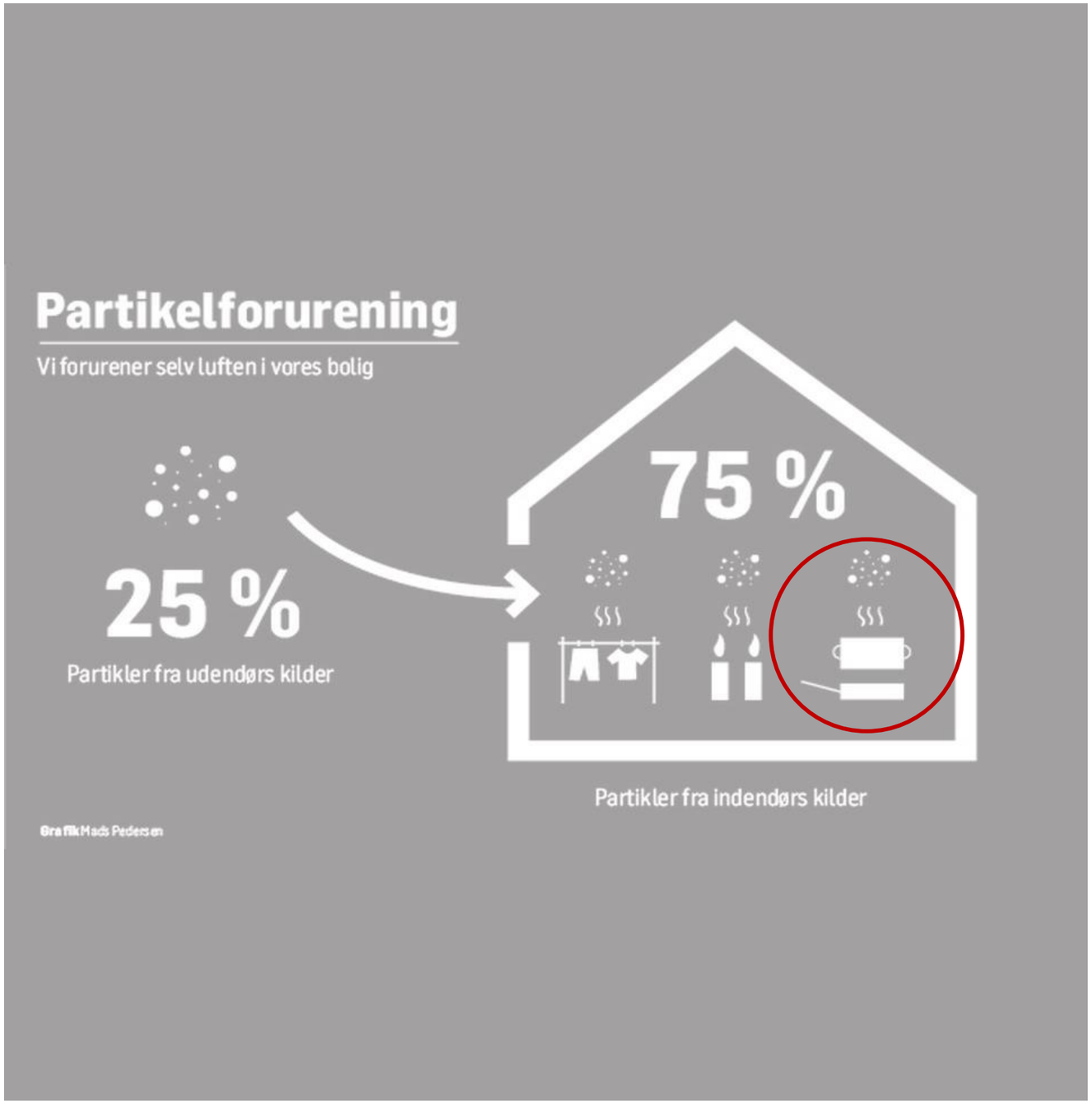
- 2 adults
- 1 or 2 tenants



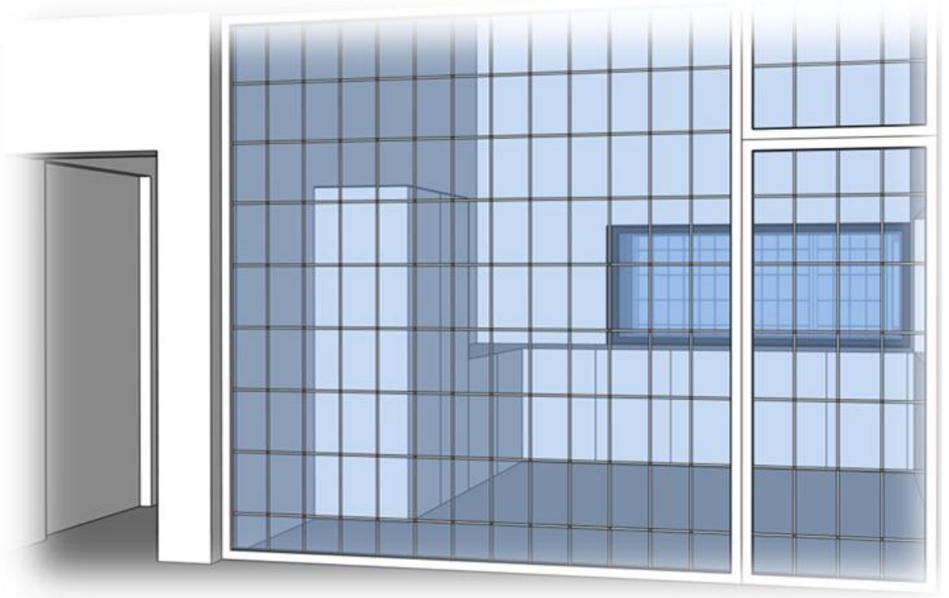


The biggest change is happening when the kids move out and the two parents are able to rent out the first floor. In this case, the terrace will be closed in with exterior walls and the already installed floor heating will be switched on. This flexibility enables the parents to stay in their known and loved home and still be able to use the not needed space efficiently.

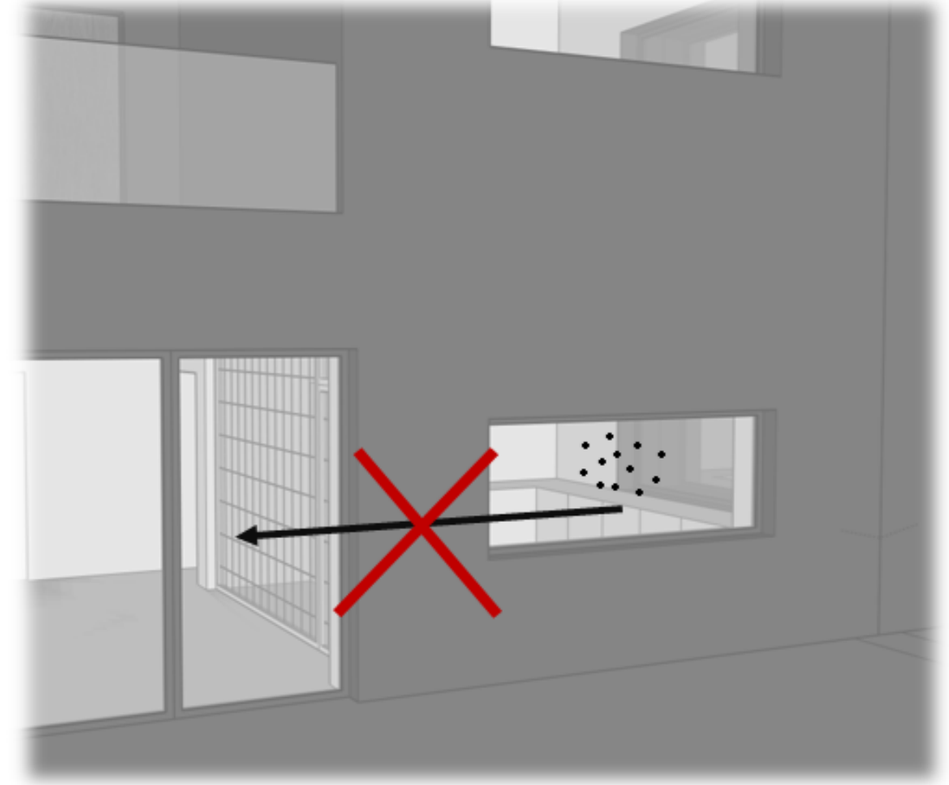
4.3 Kitchen Design



Curtain wall gives a feeling of a kitchen-dining area



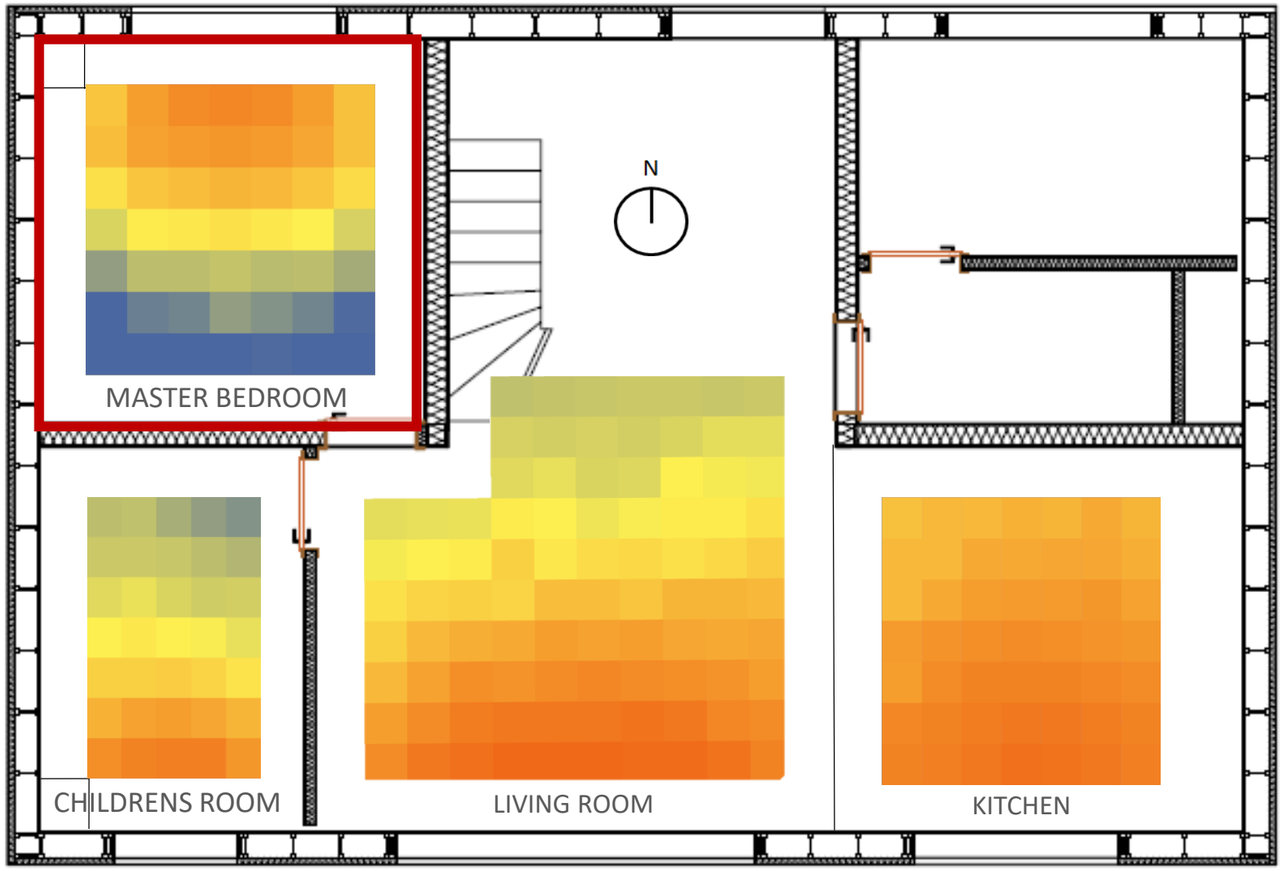
Curtain wall preventing particles to pollute



4.3 Daylight Design

Daylight requirement: Living and working spaces must be adequately illuminated

Documentation: Achievement of 300 lux in at least half of the room (the relevant floor area) for at least half of the daylight hours

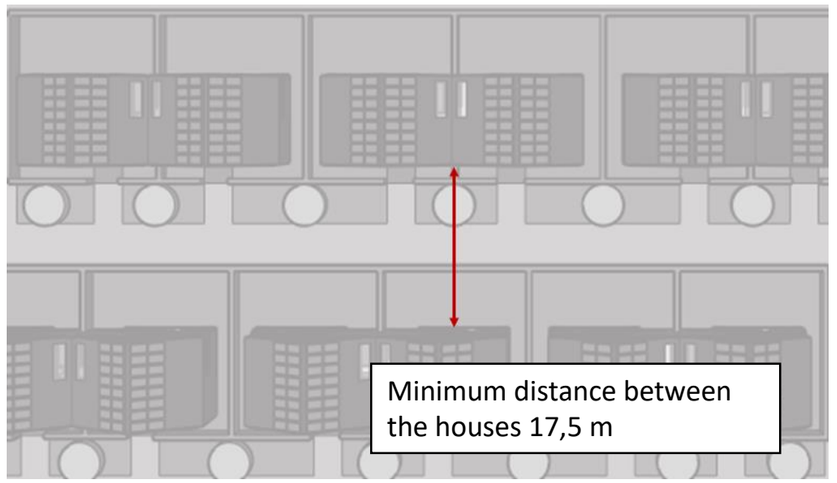


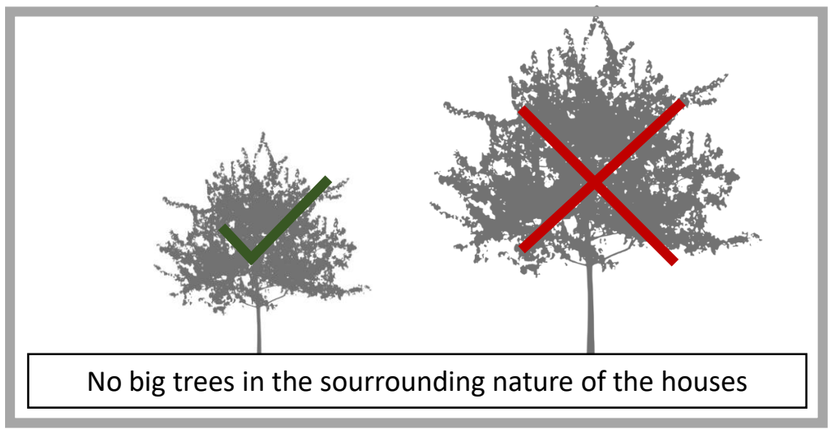
Daylit Area (DA$_{300lux}$[50%])

Kitchen: 100 % of floor area
Living room: 70 % of floor area
Childrens room: 51% of floor area
Master bedroom: 51 % of floor area

Most critical room: Master bedroom north facing

Alterations do to the most critical room



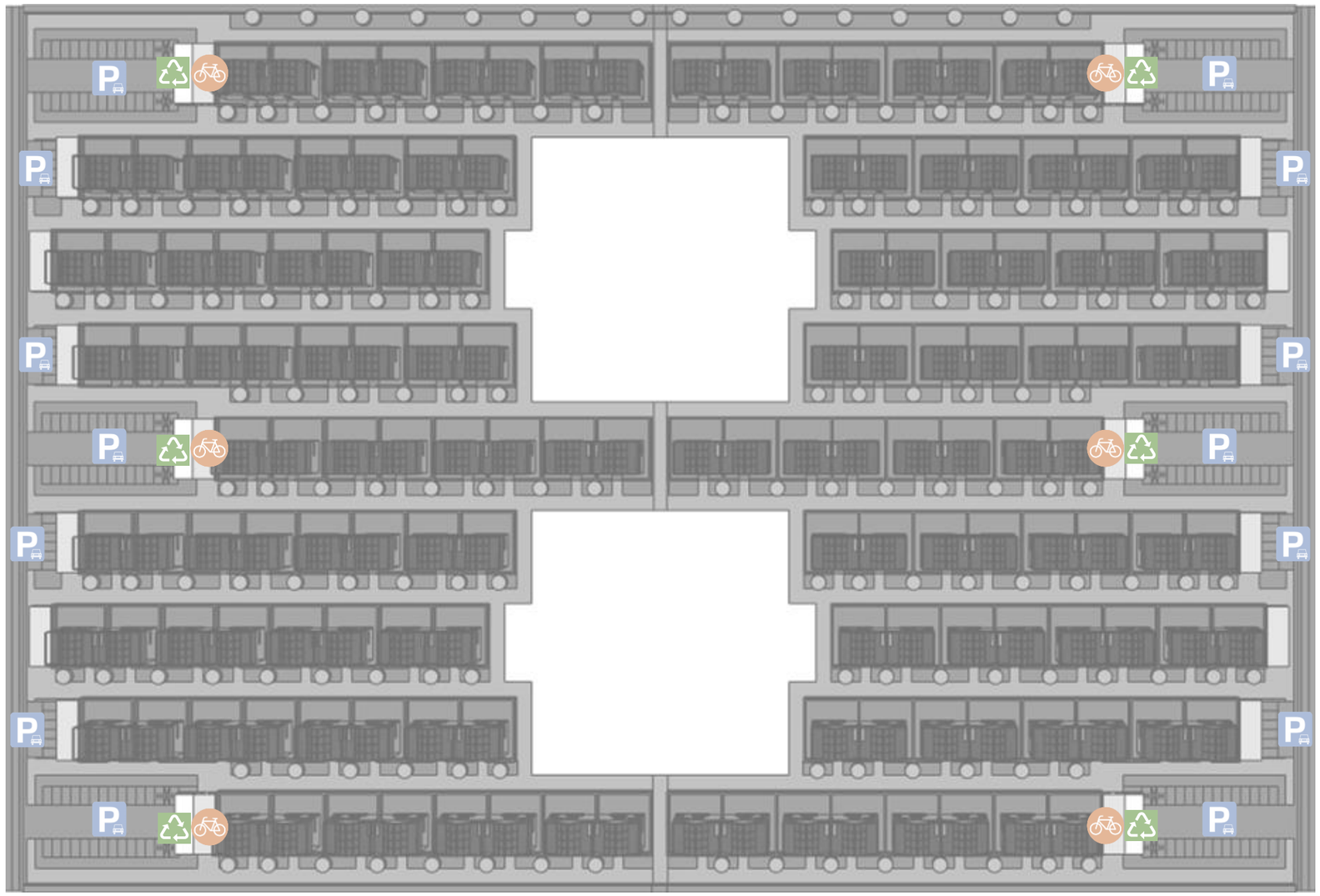


4.5 Urban Design – Dwelling Concept

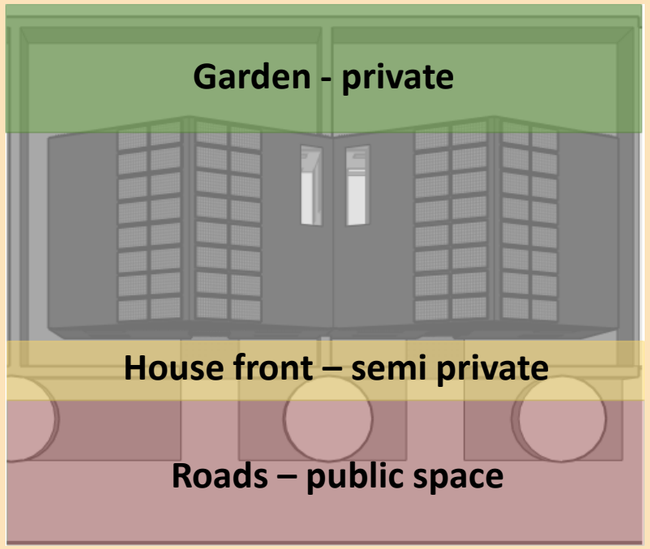
Parking spots: 1.5 pr. dwelling

Containers for trash: 0,8 pr. dwelling

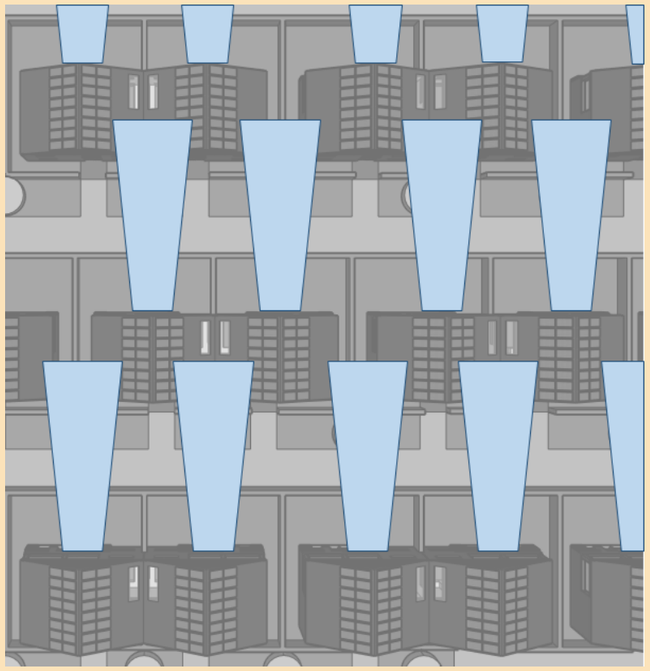
Bike parking: 6 pr. dwelling



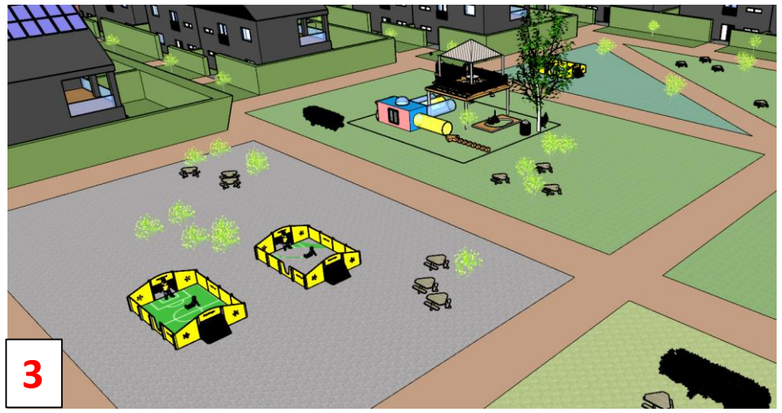
Privacy

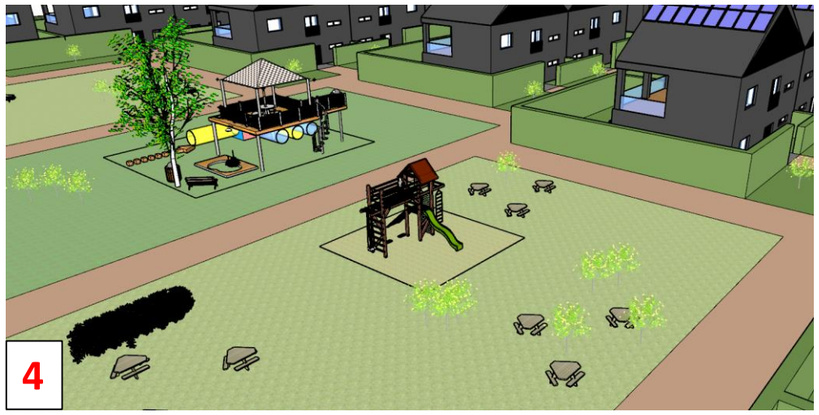


Directions of view - between the houses

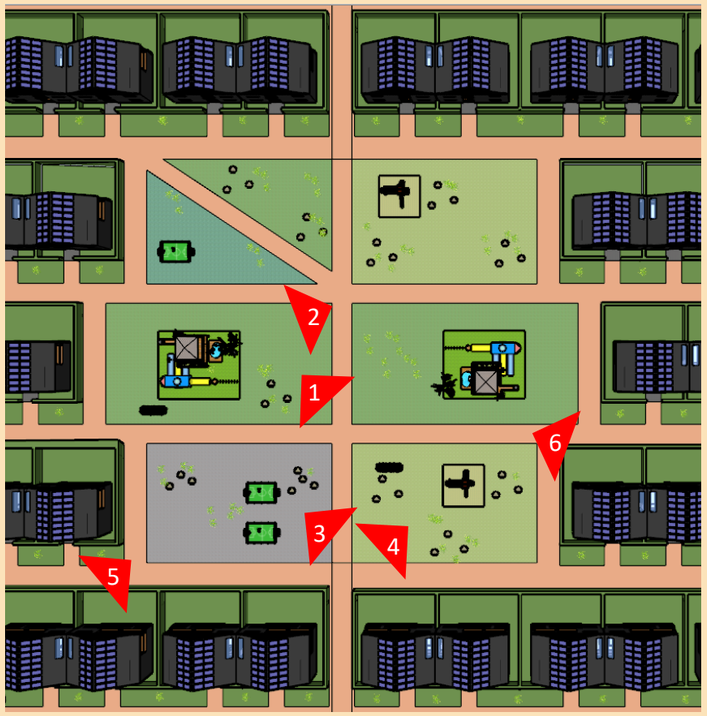


4.5 Urban Design – Dwelling Concept





Overview



A shared/common space divided into several areas with zones with walking paths surrounding the areas. The common space facilitate the opportunity for activities that are optional, necessary and social to occur. (Gehl)

Elements

- Playgrounds
- Mini-pitches for ball games
- Benches
- Trees
- Bushes

5. Technical Design

5.1 Structural System

5.2 Construction Parts

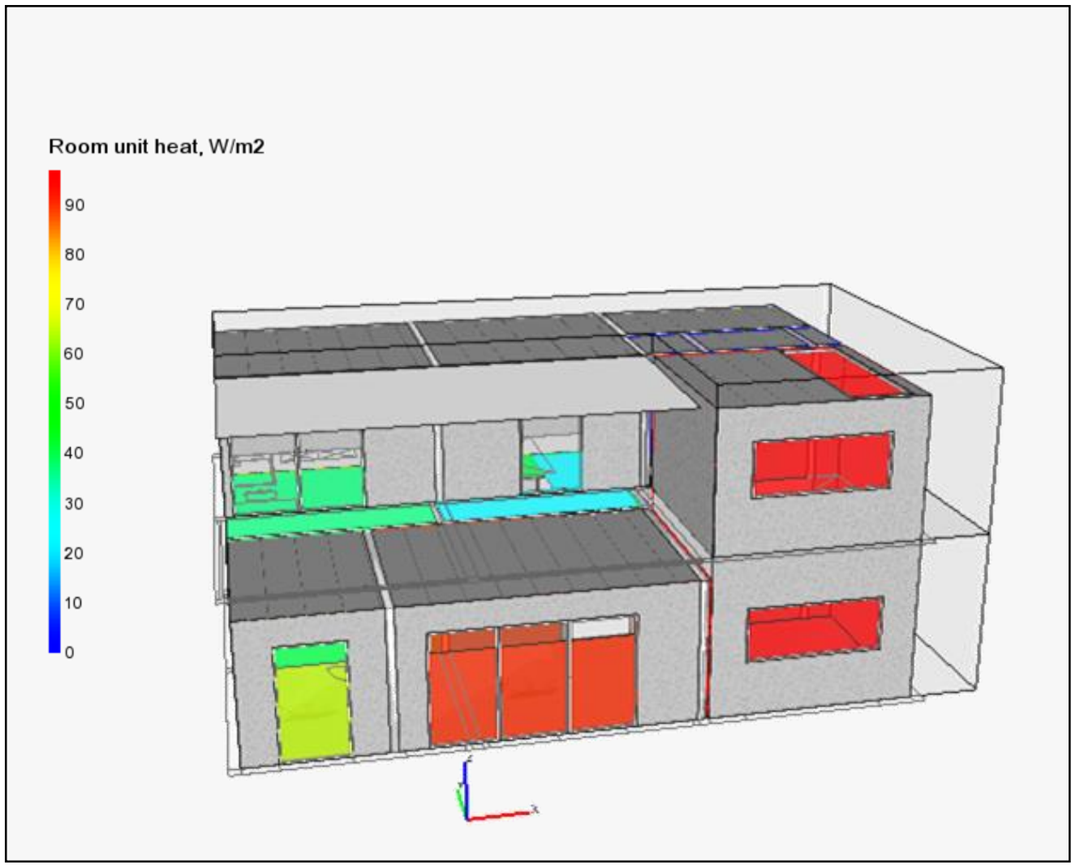
5.3 Fire Safety

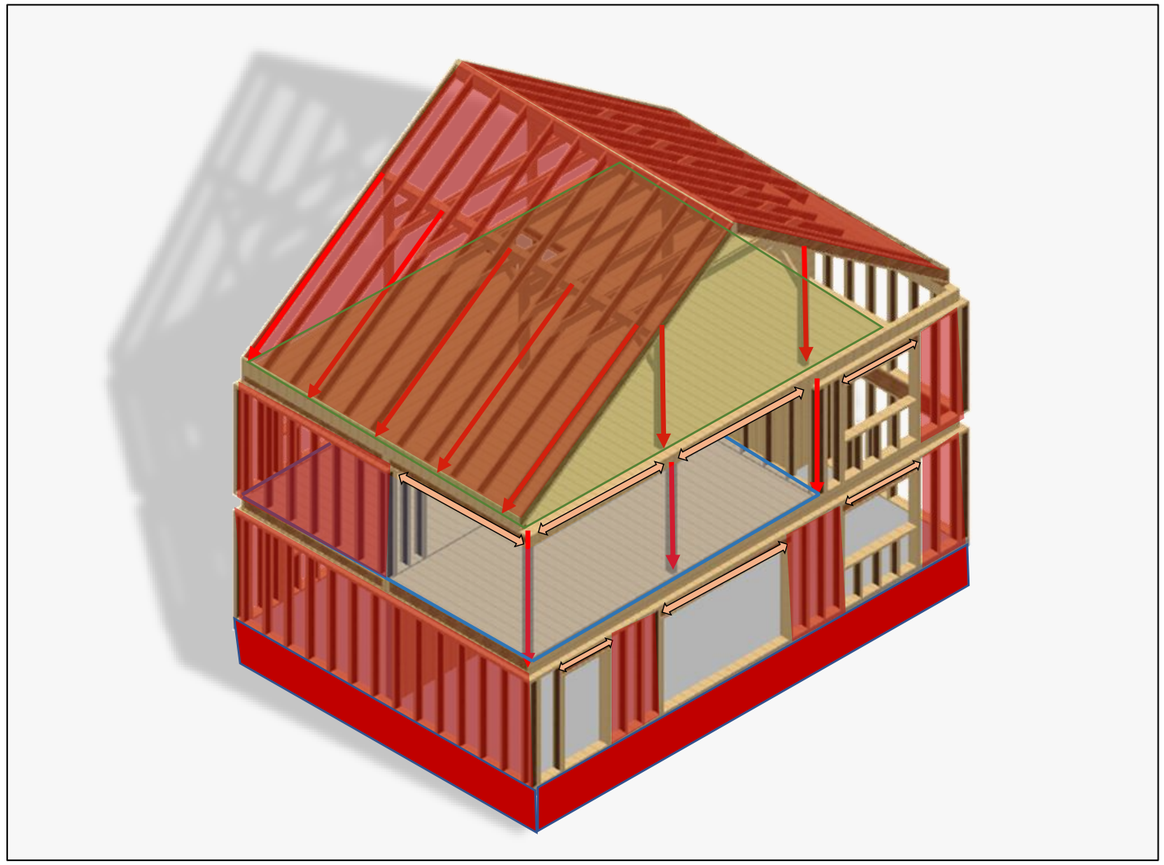
5.4 Roof Design

5.5 Heating, Cooling + DHW

5.6 Ventilation

5.7 Life Cycle Assessment





The Technical Design chapter is divided into the structural part as well as the building services as heating, domestic hot water and ventilation and is rounded up with a holistic LCA calculations based on LCA Byg and DGNB.

Structurally, the proposed design consists of prefabricated sandwich walls and floors connected through I-beams. The building parts facing the exterior are filled with insulation resulting in an overall average U-Value of 0.1921 W/(m2*K). The ground floor is based on a concrete slab with embedded floor heating, enabling to benefit from the concretes capability to store heat during the day and release it at night. On the first floor, a wood structure is used for a lightweight design. A remarkable design feature is the terrace, which is designed to be closed with exterior walls, when the need occurs for additional interior space. The detail explaining this change is made, is enclosed in the Appendix.

As mentioned before, the house is heated by space heating piping loops in each floor, providing an uniformly distributed thermal comfort based on the low temperature heating solution. Both the hot water for heating and domestic hot water will be provided by a heat pump with an integrated 200 l hot water tank. This means that the only energy use of the building is electricity, which is mainly covered by the solar panels (25 m² East and 25 m² West) on the tilted roof. Following up on this sustainable approach, the heat pump is powered by the most efficient heat exchanger, a horizontal ground heat exchanger with slinky loops. The needed area of 161 m² for the heat exchanger piping is covered by the space just in front of each house.

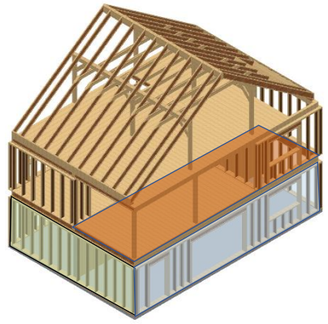
In order to establish a healthy indoor environment, different solutions to cover the ventilation needs based on Category II of DS/EN 15251 were investigated. As a result, a decentralized system with mini ventilations are chosen due to their energy efficient operation, heat recovery capabilities and the ability to integrate the mini ventilations already in the prefabrication process of the walls. In summer, when the temperature is high enough, solely natural ventilation is used to cover the need of air exchange. As the kitchen and staircase is evolving through both floors, powerful stack ventilation is enabled.

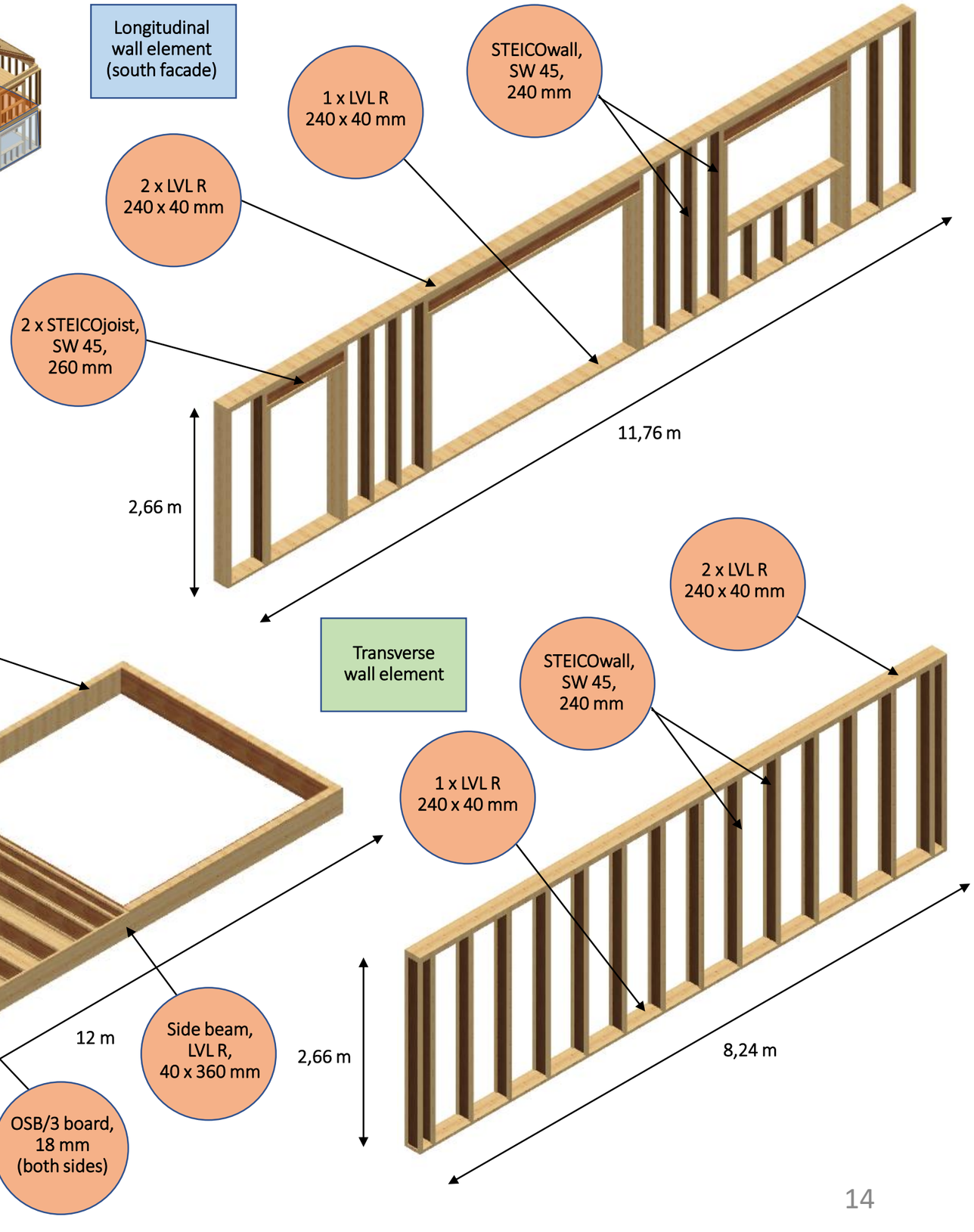
5.1 Structural System

5.1.a Components and elements

The structural system of the building is designed in a way to maximize a possibility of prefabrication and thus reduce amount of work on site and achieve shorter construction time with quality of prefabrication process. During an evaluation and choosing of the right construction material several criteria aspects were considered. Material should be sustainable with low environmental impact and it should enable quick and easy prefabrication and assembly procedure of the whole building.

Laminated veneer lumber (LVL) system was chosen as the best solution for building of this scale. Variety of systems offered by manufacturers were thoroughly evaluated choosing STEICO as final choice for this project. The system offers high performance material with large catalogue of well designed details and connections with software for easy construction assessment. STEICOwall is used as a main component for vertical load-bearing structure and STEICOjoist for horizontal load-bearing structure. Using these verified products together with LVL R, individual wall and floor slab elements were designed which will be prefabricated in the manufactory and then mounted on site with little additional work left. Beside the main load-bearing structure, the elements will arrive on the building site with thermal insulation, vapor barrier and battens to assemble exterior and interior cladding only leaving gaps to enable workers to make necessary connections. All the elements are designed so it can be transported by a truck and thus no element exceeds lenght of 12 m, height of 4 m or width of 4,5 m. All the wall and floor slab elements will have additional bracing transversely on the main beam component which is not indicated on these illustrations in order to increase horizontal in-plane stiffness.





STEICO *I-joists*		STEICO *LVL – Laminated Veneer Lumber*	
1	2	3	4
STEICO*joist*	**STEICO***wall*	**STEICO** *LVL R*	**STEICO** *LVL X*
I-joist to European Technical Approval ETA-06/0238	I-joist to European Technical Approval ETA-06/0238	CE certified and manufactured to EN 14374	CE certified and manufactured to EN 14374
For use as floor joists, rafters or wall studs	For use as wall studs or facades	Laminated Veneer Lumber for joists, beams, studs, purlins, rimboard	Laminated Veneer Lumber for structural panels, rimboard, headers and sole plates
CE	CE	CE	CE

5.1 Structural System

5.1.b Assembly of the building

Before the mounting of the elements can begin, foundations have to be laid down and concrete reinforced foundation slab poured. Perimeter strip foundation consist of insulated Leca blocks which provided excellent solution for eliminating thermal bridges at the wall-foundation connection and also provide sufficient bearing capacity for the whole structure. Leca blocks EH-240 (590 x 240 x 190 mm) with 60 mm EPS insulation in the middle and 90 + 90 mm of light aggregate concrete shell. Foundation slab is made of reinforced concrete C 25/30 with approx.. 2 % steel reinforcement.

1. Ground floor wall elements are put in place and anchored with HTA anchor to the foundation slab and connected together (see Detail 1 and Detail 5).

2. Internal walls are mounted consisting of LVL R 120 x 200 mm studs with OSB boards on both sides with thickness of 18 mm.

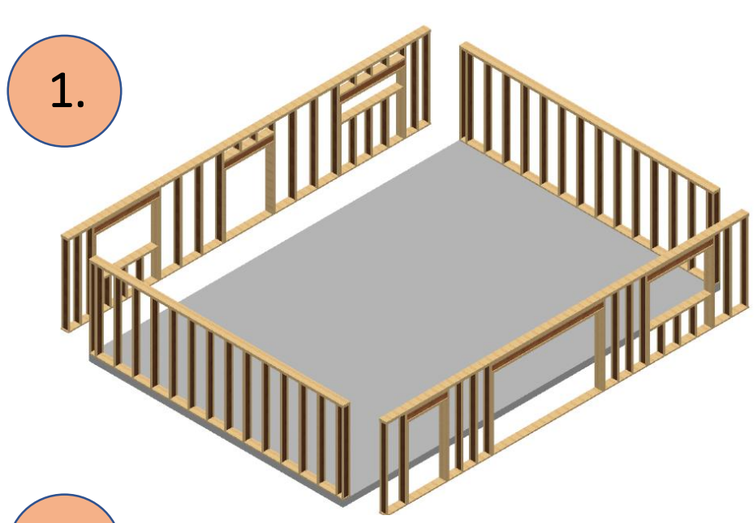
3. Floor slab elements are mounted.

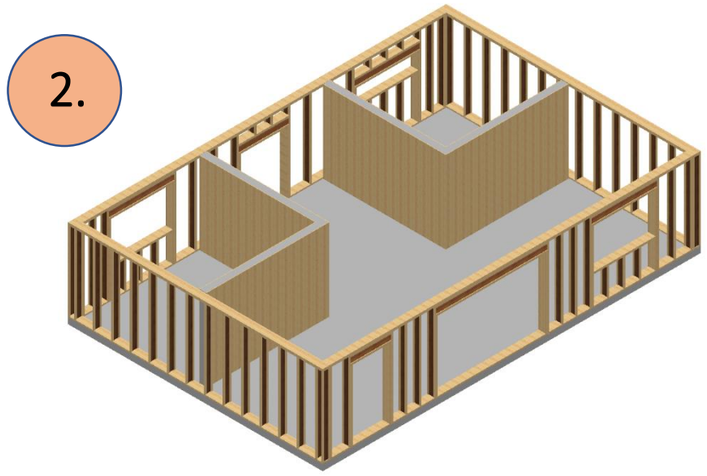
4. Wall elements of the first floor are mounted and connected with wall elements of the ground floor through the floor slab element and rigid EPS with high compressive strength which lines the perimeter at the floor slab height and eliminates thermal bridges.

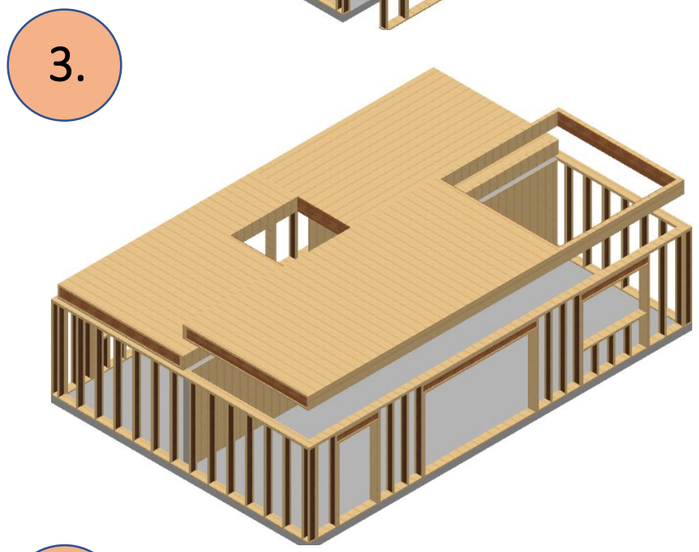
5. Internal walls of the first floor and terrace columns are mounted.

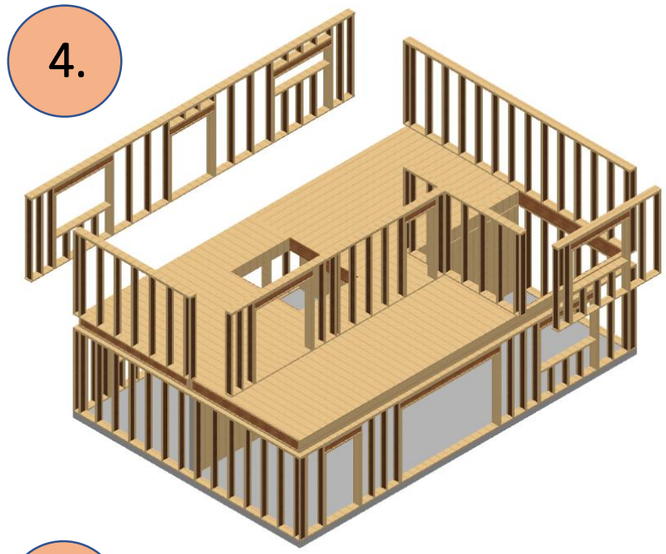
6. Upper floor slab elements under the roof is mounted and connected with the wall elements.

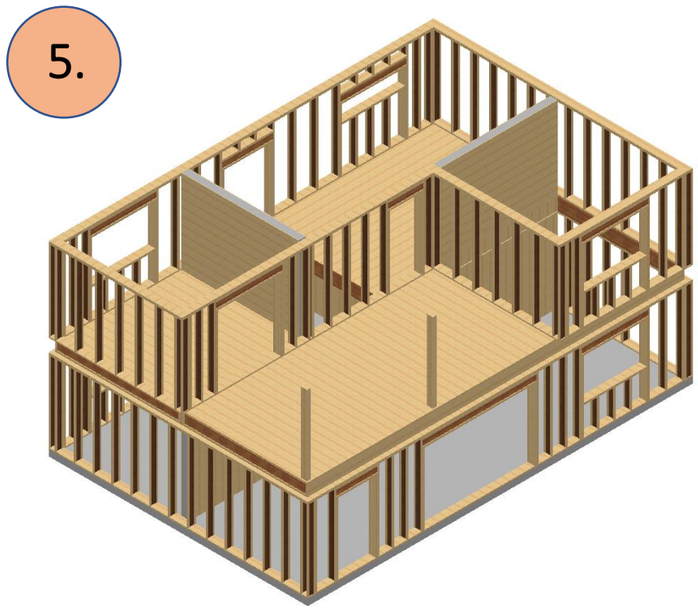
7. Roof structure is mounted and assembled.

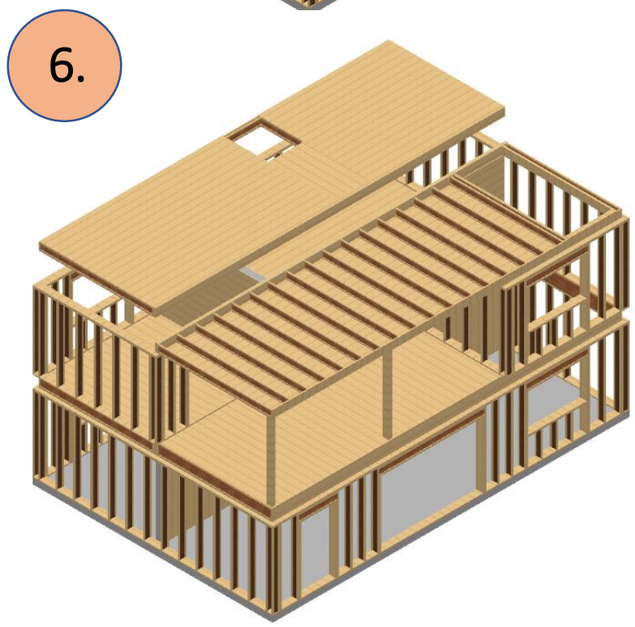


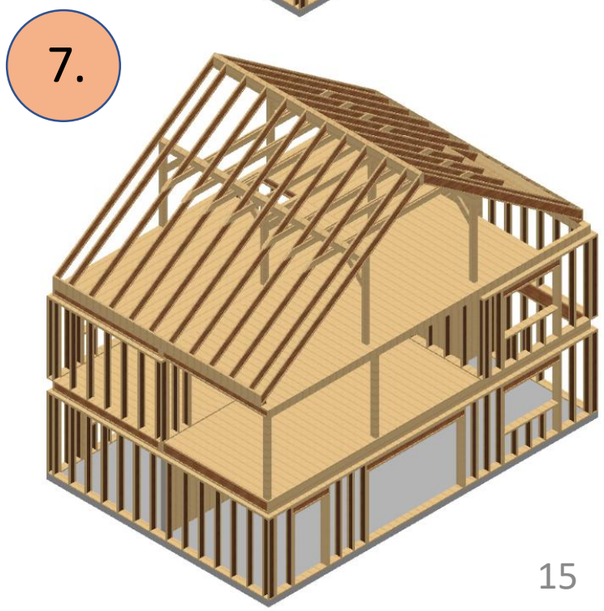












5.1 Structural System

5.1.c Load and stability

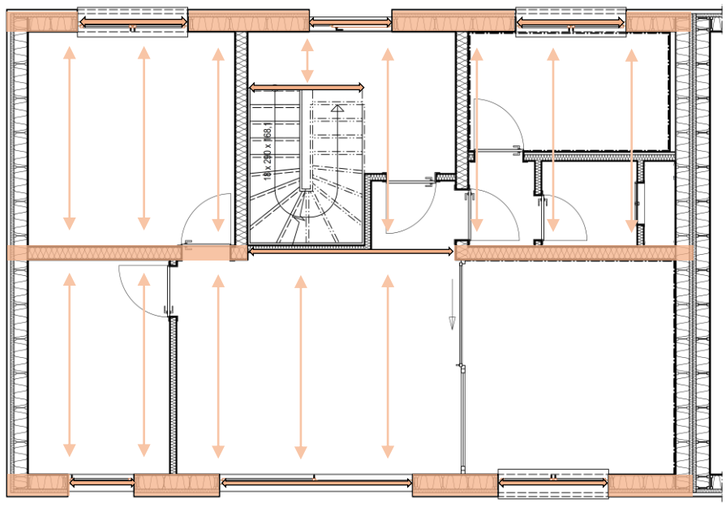
In order to assess all the structural elements correctly, at first, suitable structural system of bearing elements has to be determined. In this case, floor slabs consisting of I-beams with double OSB sheeting are placed on vertical load-bearing walls in one direction. The floor slabs are divided into to modules where the middle beam is supported by internal walls and columns.

To provide sufficient horizontal stability against the wind internal timber walls are added into the floor plan with double OSB board sheeting. All the wall elements have additional bracing between the I-beams in order to provide stiffness to the element.

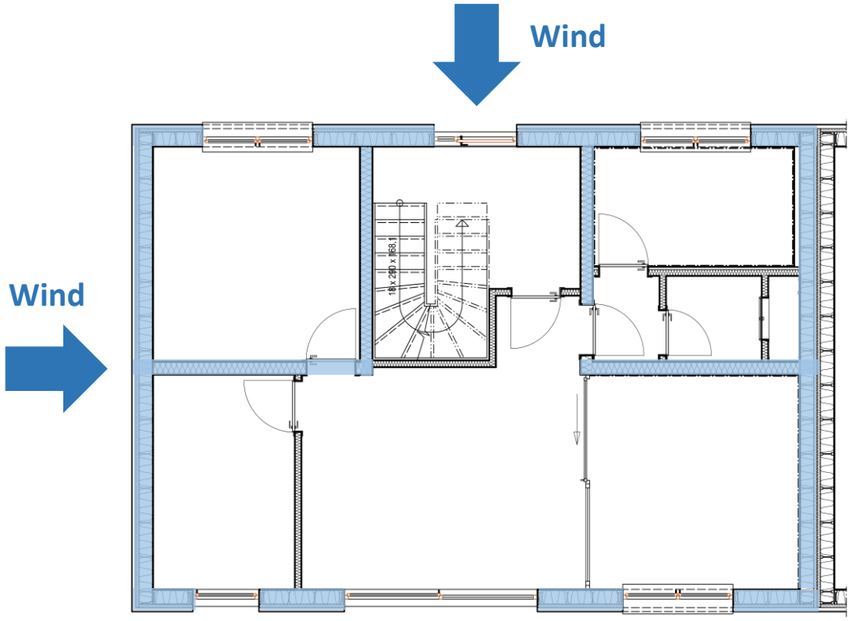
Acting load on the structure from the top of the roof (snow load, suction and compression from the wind load), through the living space (dead load of floors, partition walls and imposed load from residents) and to the bottom of the foundations has to be transferred safely and efficiently. In order to determine all the loads and set up correct load combinations, procedure according to *Eurocode 1: Actions on structures* was used. Load combinations 6.10a and 6.10b with suitable combination factors were used.

The most critical elements of the structure are assessed according to *Eurocode 5: Design to timber structures* in the appendix.

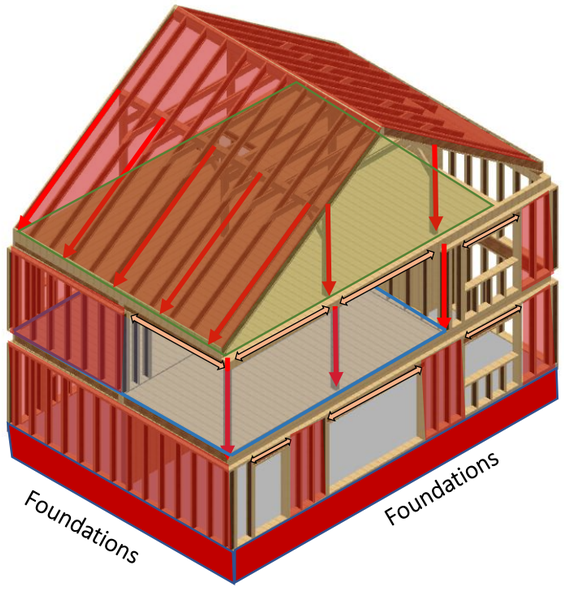
Vertical bearing walls and floor slab beams orientation

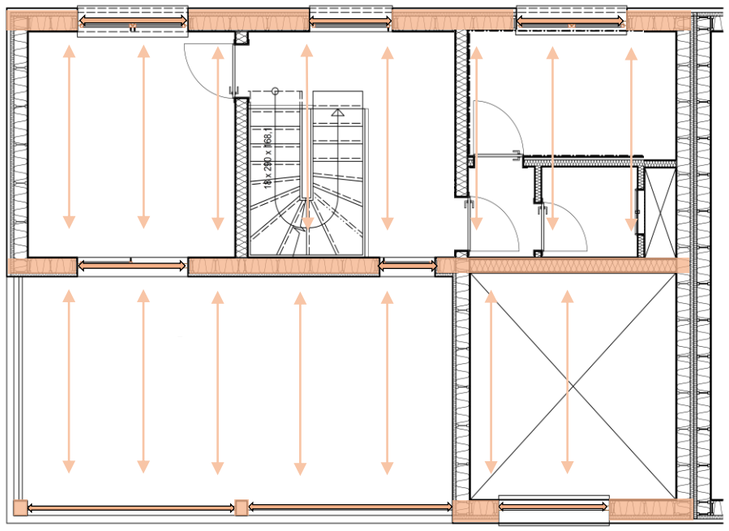


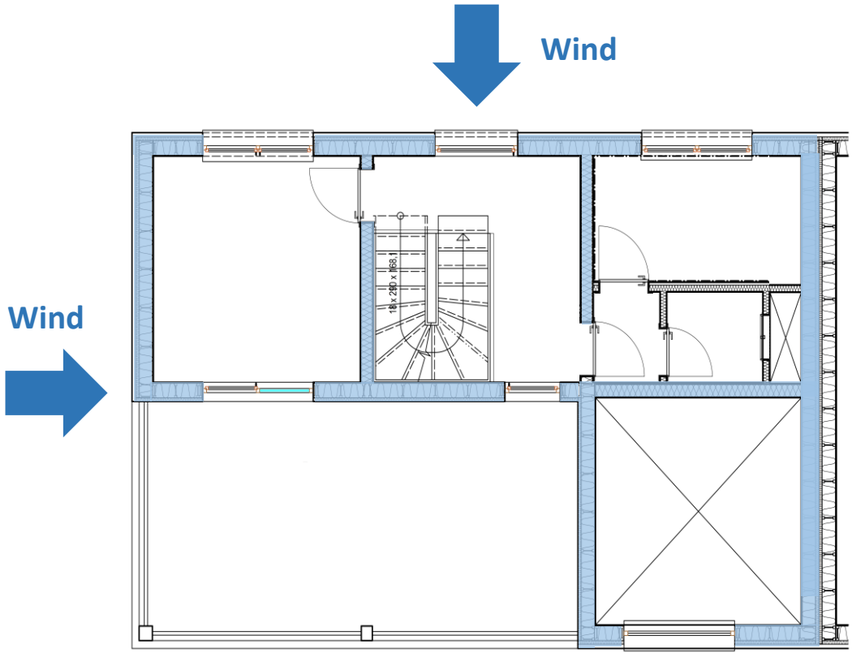
Stabilising elements againt horizontal wind load



Load flow diagram through the structure



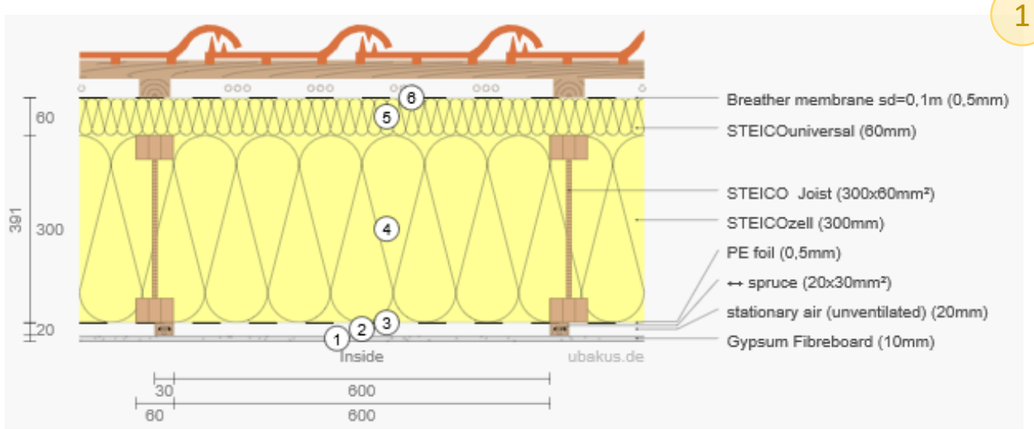


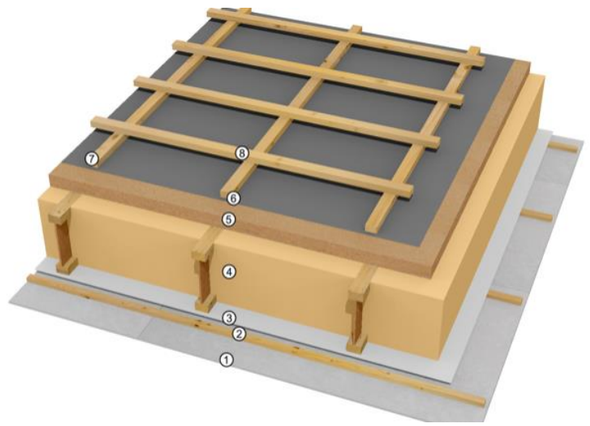


5.2 Construction Parts

Roof U-value: 0,117 W/m²K

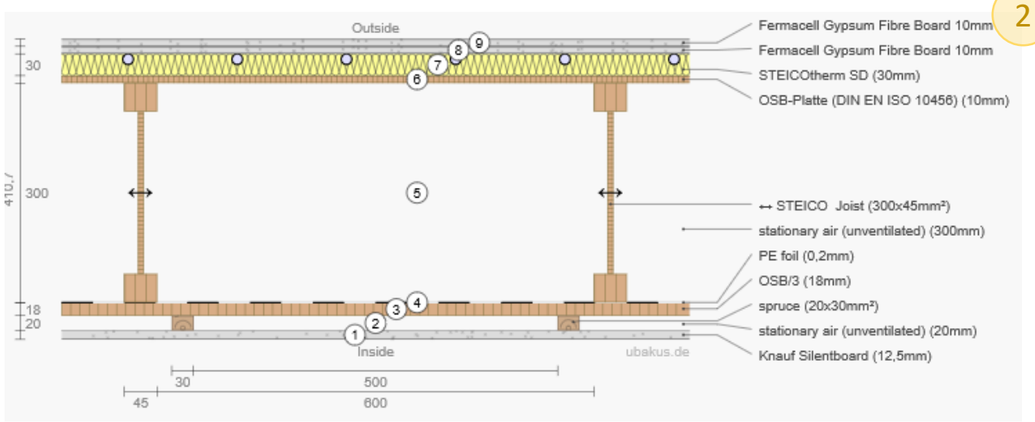
1

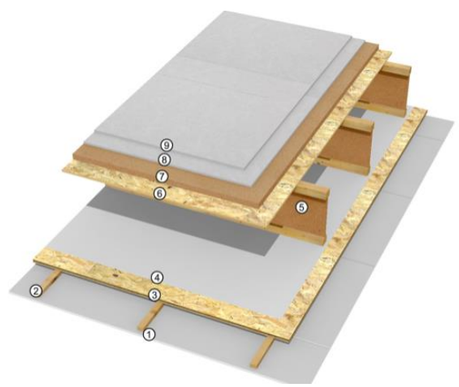


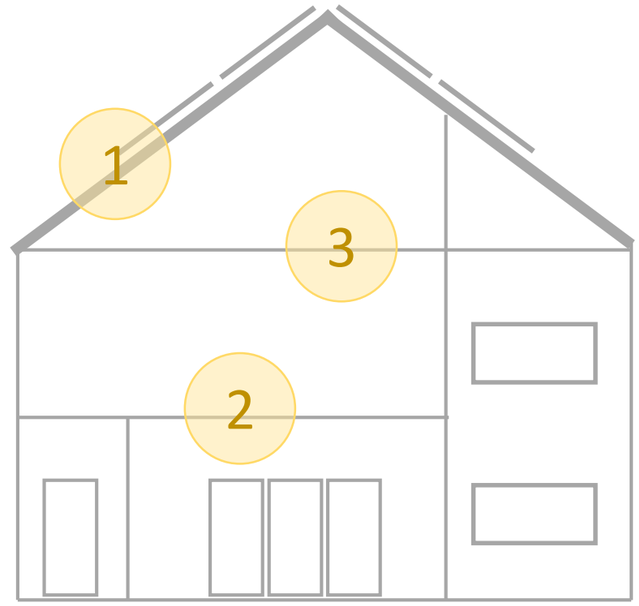


First floor U-value: 0,570 W/m²K

2

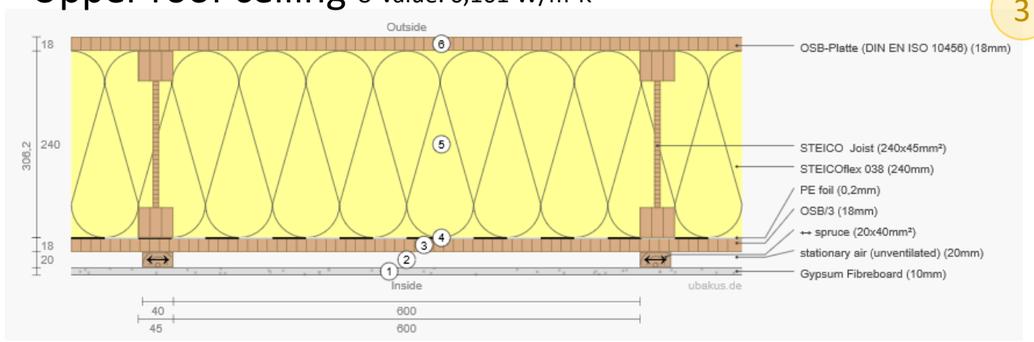


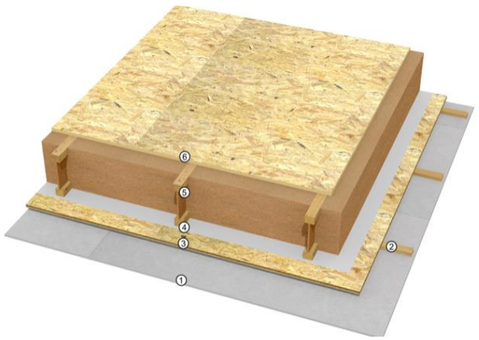




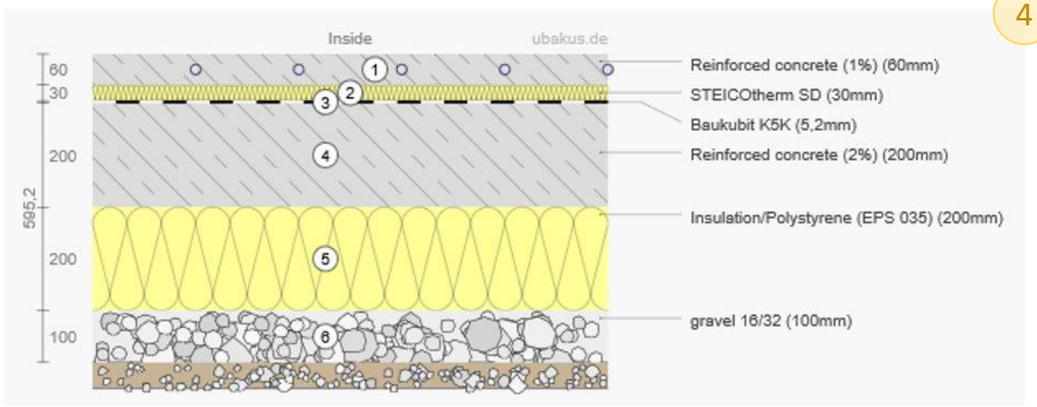
Upper roof ceiling U-value: 0,161 W/m²K

3





Ground floor U-value: 0,146 W/m²K



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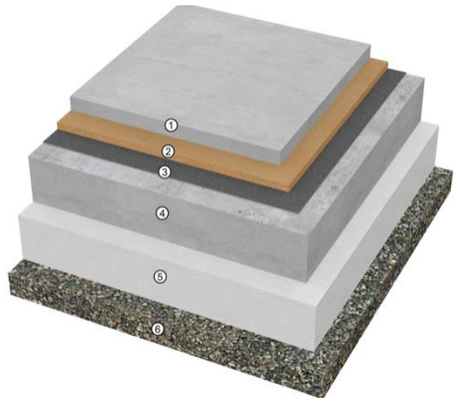
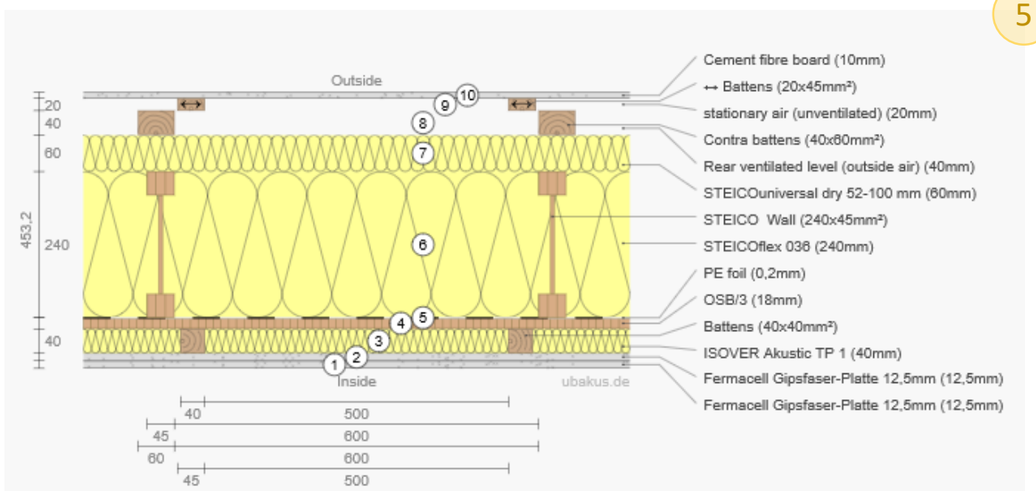


Exterior wall U-value: 0,116 W/m²K



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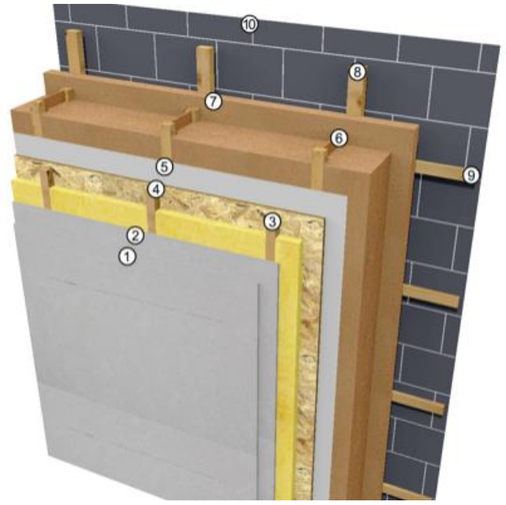
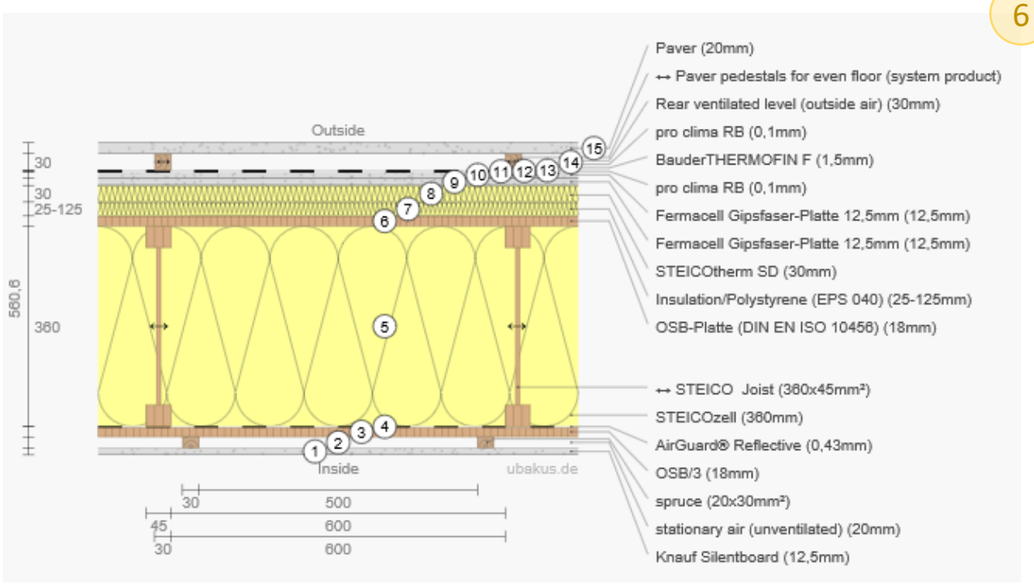


Terrace U-value: 0,085 W/m²K



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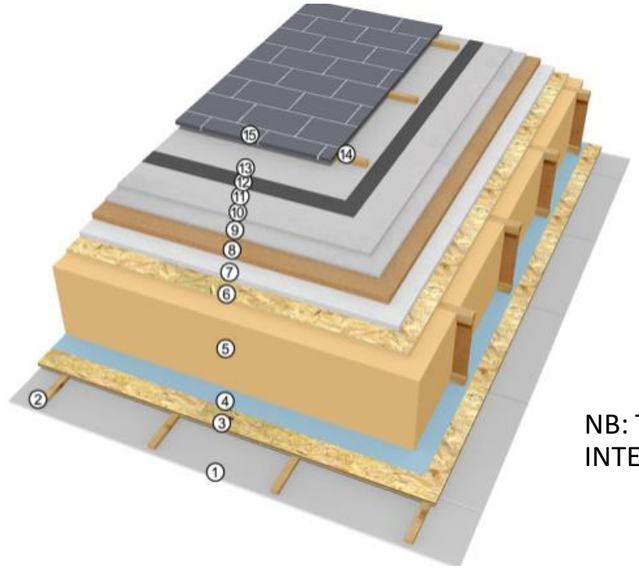
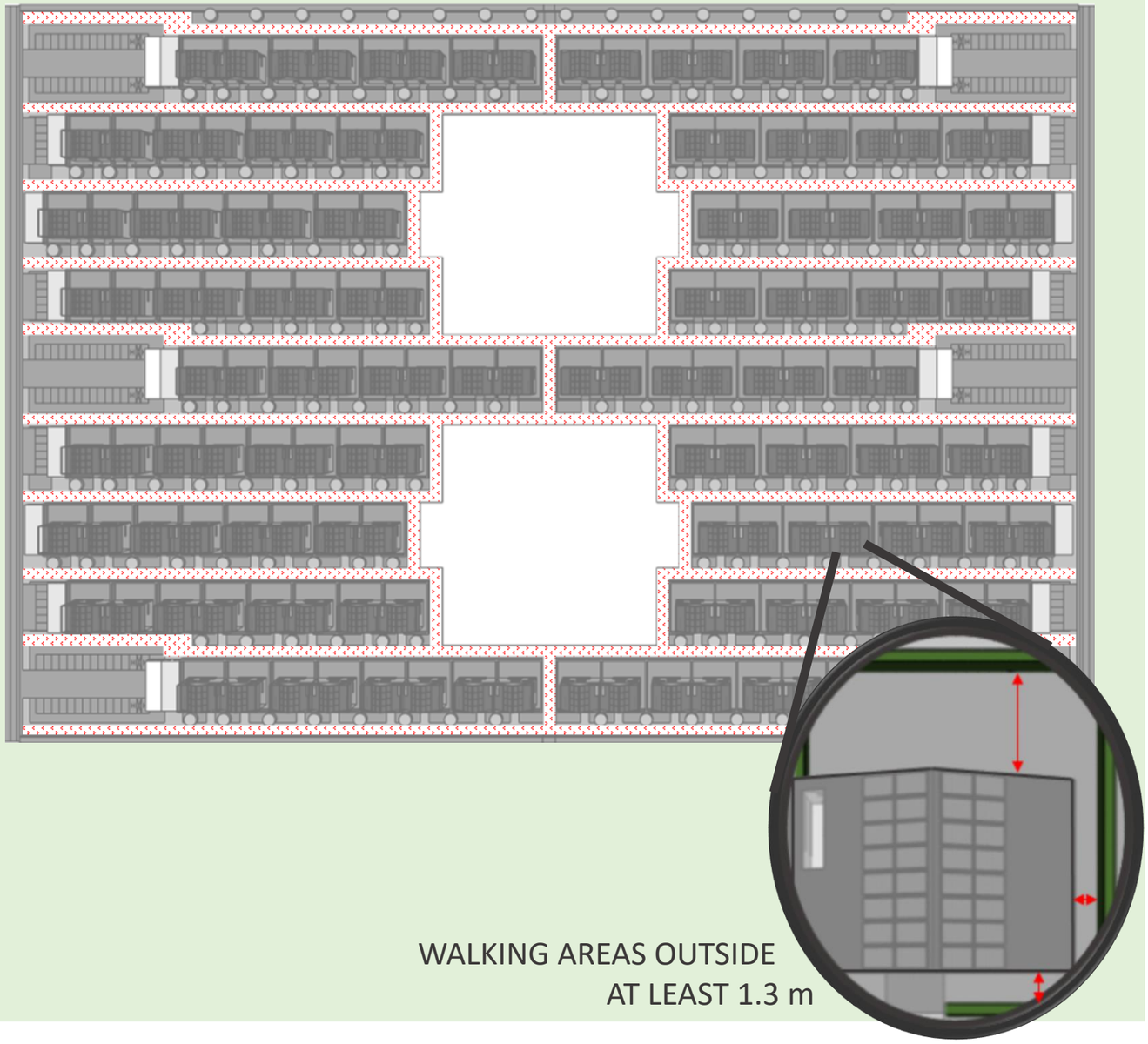


NB: TERRACE WILL BE USED AS INTERNAL SPACE IN PHASE 3!

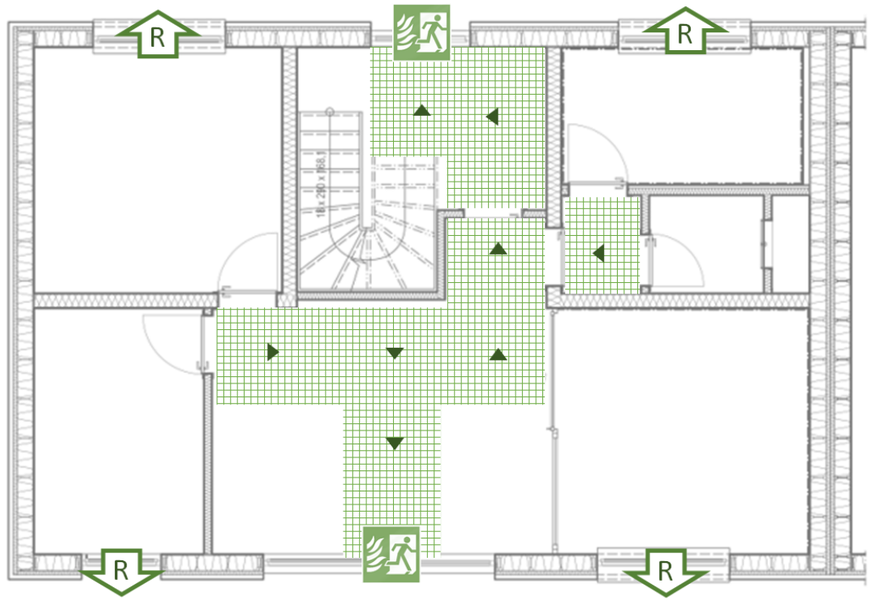
5.3 Fire Safety and Emergency Exits

URBAN ROADS

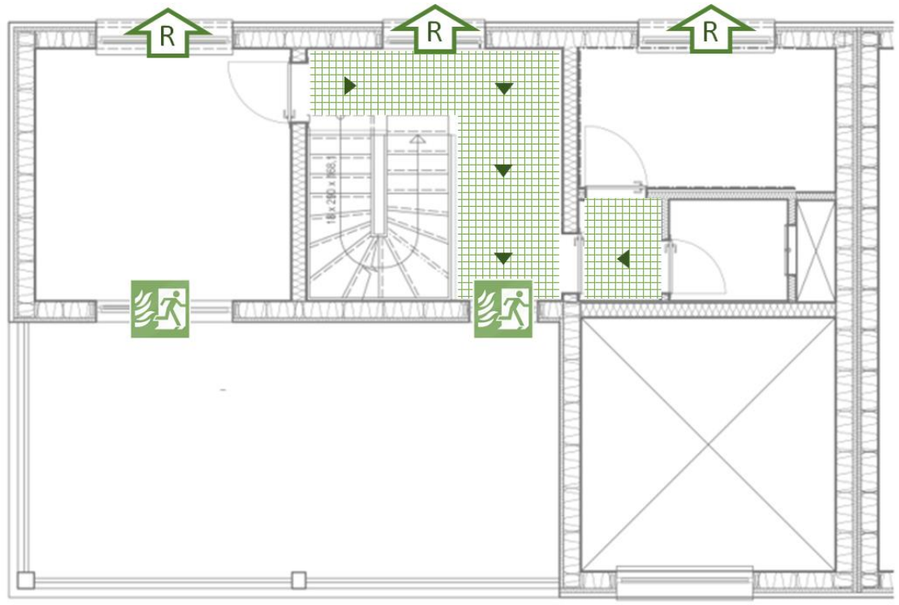


WALKING AREAS OUTSIDE
AT LEAST 1.3 m

Ground floor



First floor



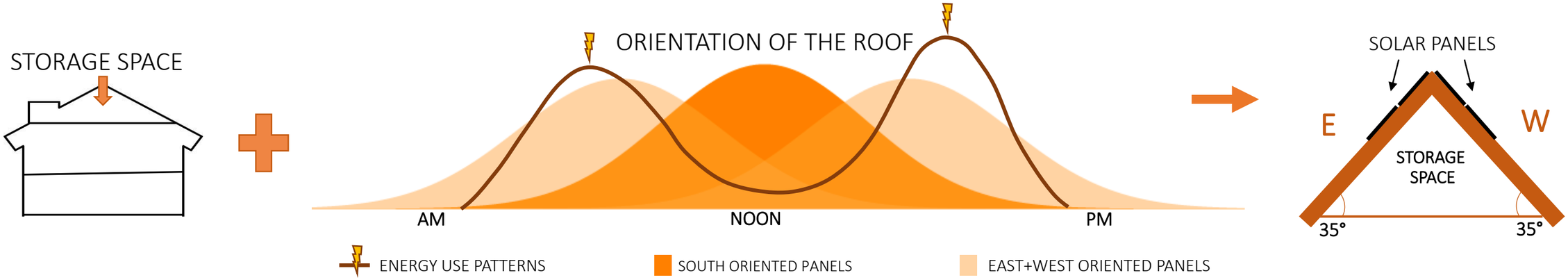
Ambulance and firetruck ways
min. 3.5 m width

Emergency escape

R Rescue opening

Escape route
min. 1.3 m. width

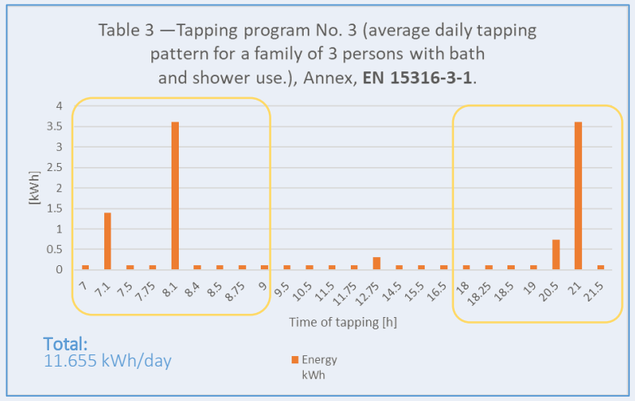
5.4 Roof Design



ALIGN THE ELECTRICITY PRODUCTION WITH THE CONSUMPTION OF THE OCCUPANTS

ENERGY USE PATTERNS

DOMESTIC HOT WATER	
Morning Energy Use (7:00-9:00)	49% (5.75 kWh)
Evening Energy Use (18:00-22:00)	42% (4.87 kWh)



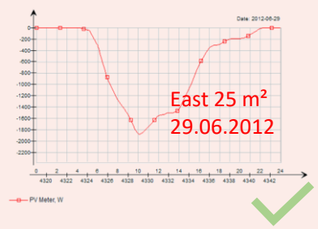
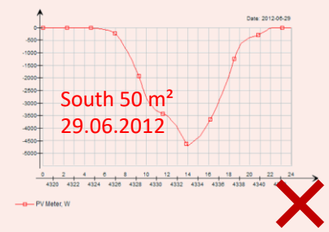
HEATING

THERMAL ACTIVATED BUILDING COMPONENTS WITH FLOOR HEATING

SMART CONTROLLER OF HEATING SYSTEM

FLEXIBLE ENERGY USE FOR HEATING BASED ON THERMAL NEEDS AND ELECTRICITY PRODUCTION

ENERGY PRODUCTION

EAST & WEST ORIENTATION		SOUTH ORIENTATION
PV Panels East	PV Panels West	PV Panels South
25 m²	25 m²	50 m²
2169.0 kWh/a	2171.0 kWh/a	5725.4 kWh/a
Peak Production: 7:00– 12:00	Peak Production: 14:00– 19:00	Peak Production: 12:00– 16:00
		

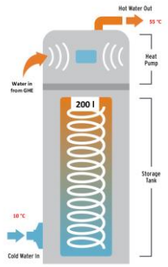
5.5 Heating, Cooling + DHW - OVERVIEW

Solar Electricity with PV-Panels

Solar Electricity Production to cover Heat Pump Power demand (compressor). The surplus electricity is used for home appliances or will be sold back to the grid (See chapter 6.2).

Domestic Hot Water System

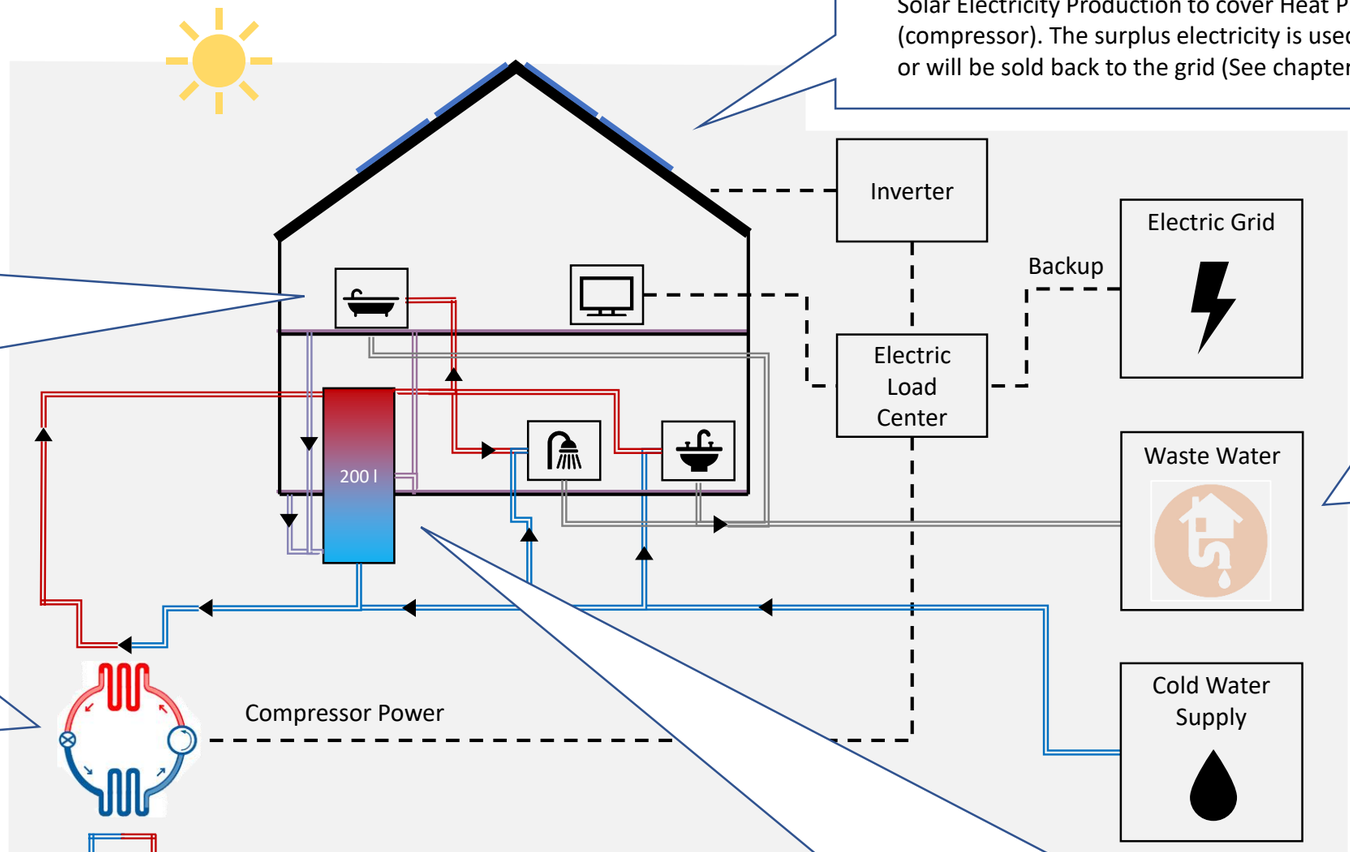
Hot Water Temp.	55 °C
Cold Water Temp.	10 °C
HW Piping Length	17.5 m
CW Piping Length	20.0 m
Pipe Diameter	18 mm
Yearly Consumption	250 l/m²/a



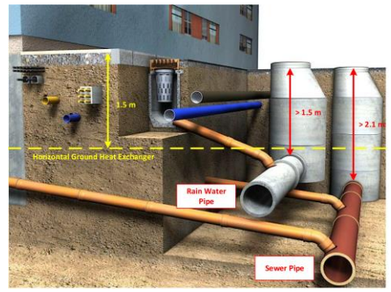
Ground coupled Heat Pump

Heating Power	10 kW
COP	3.0
Example HP:	COP = 5.5
	Integrated 200 l Water Tank
	3 – 12 kW Heating Power

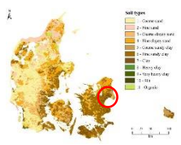
https://www.bosch-thermotechnology.com/dk/da/ocs/privat/compress-7000i-lwm-758040-p/



Waste Water System



Slinky Horizontal Ground Heat Exchanger (HGHE)



Horizontal Ground Heat Exchanger (HGHE)		
Soil type	Clay	
Extraction Power	25	W/m²
Heating Power of HP	10	kW
Area of GHE	400	m²
Control (128 m² x 3 m²/m²)	384	m²
Available Area for each house	231	m²
Depth of pipes	1.5	m
vertical slinky (lower tube)	2.3	m
Reference Area (10x10)	100	m²

Evaluation of different HGHE Types	Convential Horizontal Heat Exchanger	Slinky horizontal heat exchanger (horizontal installation)	Slinky horizontal heat exchanger (vertical installation)
Pitch of the loop		0.40 m	0.40 m
Length per trench length	2.00 m/m	6.94 m/m	6.94 m/m
Spacing (between tubes)	1.00 m	0.80 m	0.50 m
Spacing (between trenches)	1.00 m	2.00 m	1.70 m
Pipe length	100.00 m	247.86 m	315.45 m
Factor	1.00	2.48	3.15
Needed Area per House	400.00 m²	161.38 m²	126.80 m²

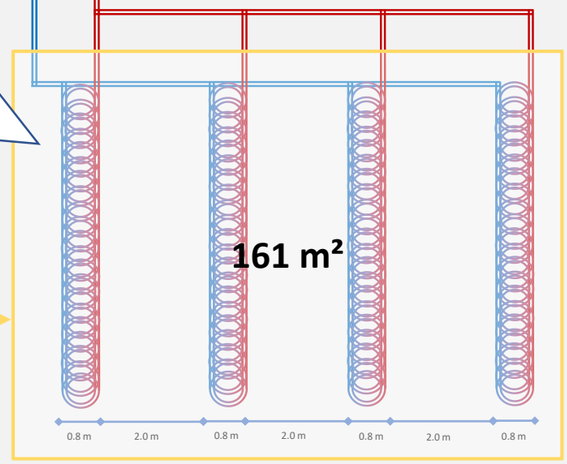
Maximum heat extraction from minimum area

Same efficiency as single line HGHE

Less expensive than vertical installation

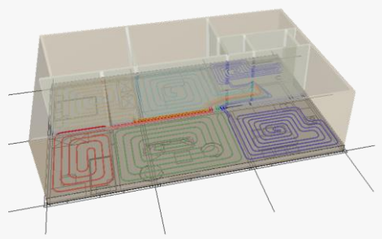
Even distr. of ground temperature

Ground Heat Exchange (Slinky, Horizontal)



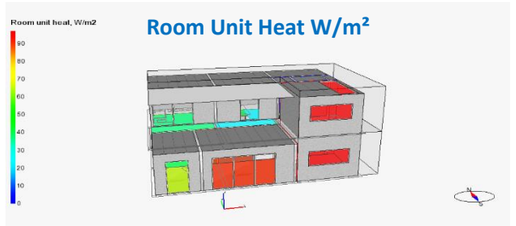
Heating

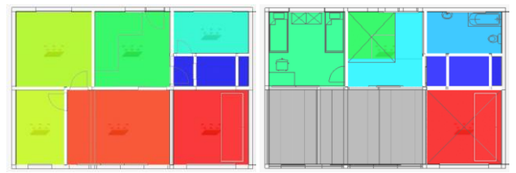
Floor Heating



System Energy	GF	Master Bedroom (GF)	Entrance (GF)	Children Room (GF)	Bathroom Pod (GF)	Hall (GF)	Technical Room (GF)	Living Room (GF)	TOTAL
		28.50 kWh	132.20 kWh	162.80 kWh	73.10 kWh	0.00 kWh	0.00 kWh	299.80 kWh	
	1. F	Kitchen (GF + 1F)	Shaft (GF + 1F)	Children Room (1F)	Staircase (1F)	Bathroom Pod (1F)	Hall (1F)	Storage (1F)	1,926.50 kWh
		383.10 kWh	0.00 kWh	331.00 kWh	392.50 kWh	123.50 kWh	0.00 kWh	0.00 kWh	

Room Unit Heat W/m²

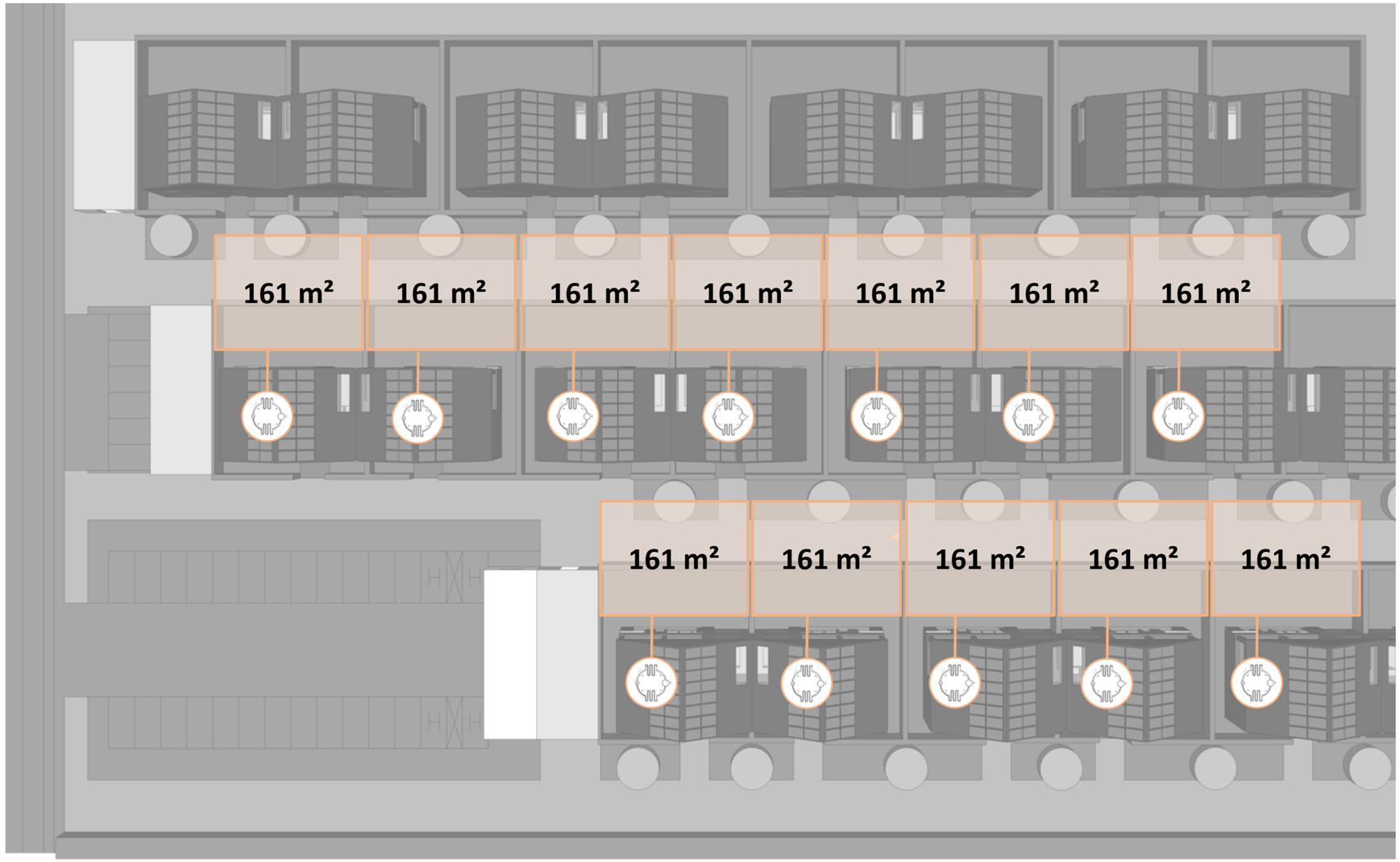




5.5 Heating, Cooling + DHW - HGHE

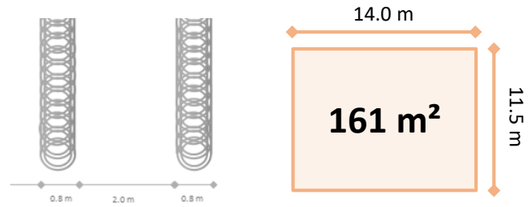
CHOSEN HEAT EXCHANGER

SLINKY HORIZONTAL GROUND HEAT EXCHANGER - HORIZONTAL INSTALLATION



DESIGN SPECIFICATIONS

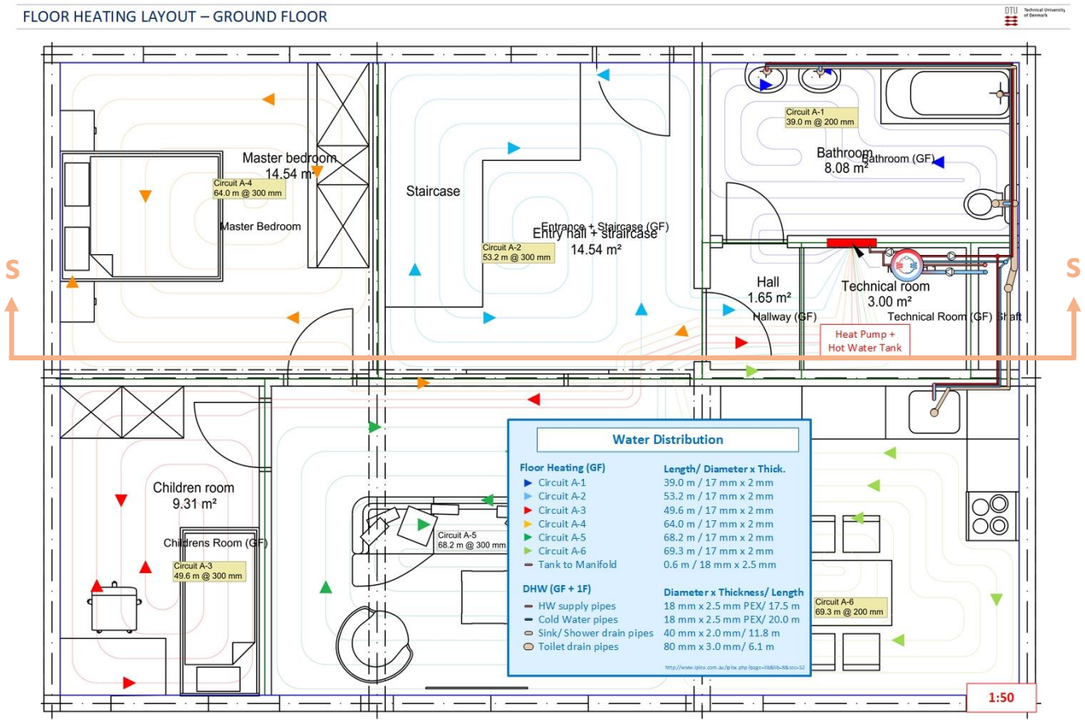
Pitch of the loop	0.40	m
Length per trench length	6.94	m/m
Spacing (between tubes)	0.80	m
Spacing (between trenches)	2.00	m
Pipe length	247.86	m
Factor	2.48	
Needed Area per House	161.38	m²



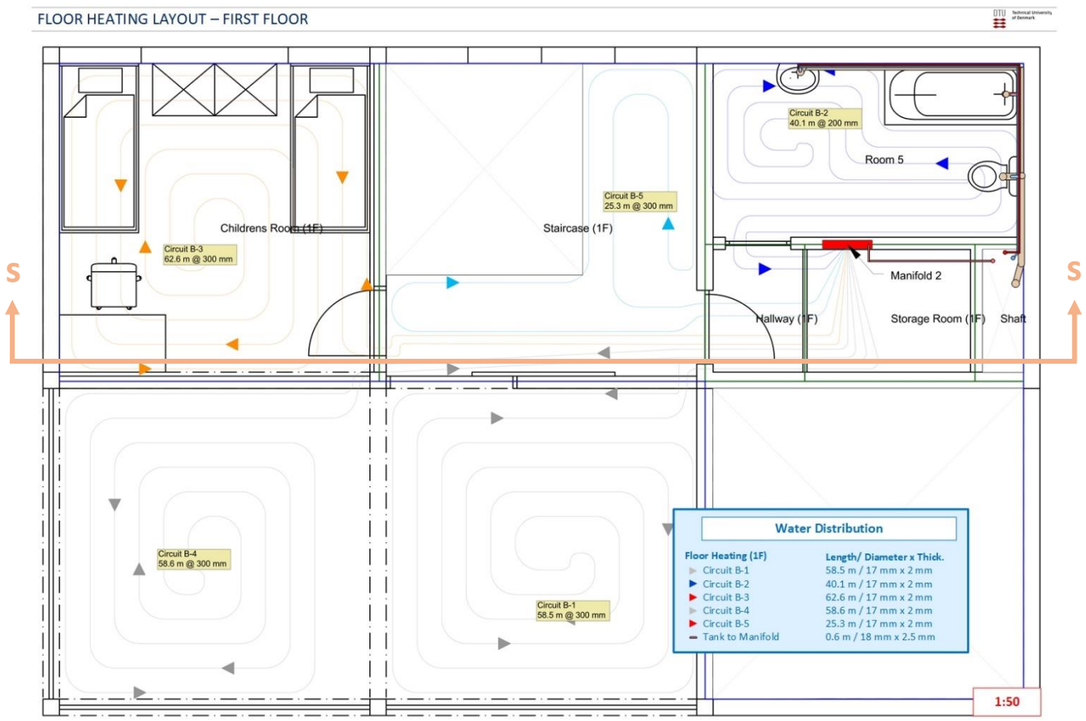
GROUND COUPLED HEAT PUMP

5.5 Heating, Cooling + DHW - SYSTEMATIC

0 GROUND FLOOR



1 FIRST FLOOR

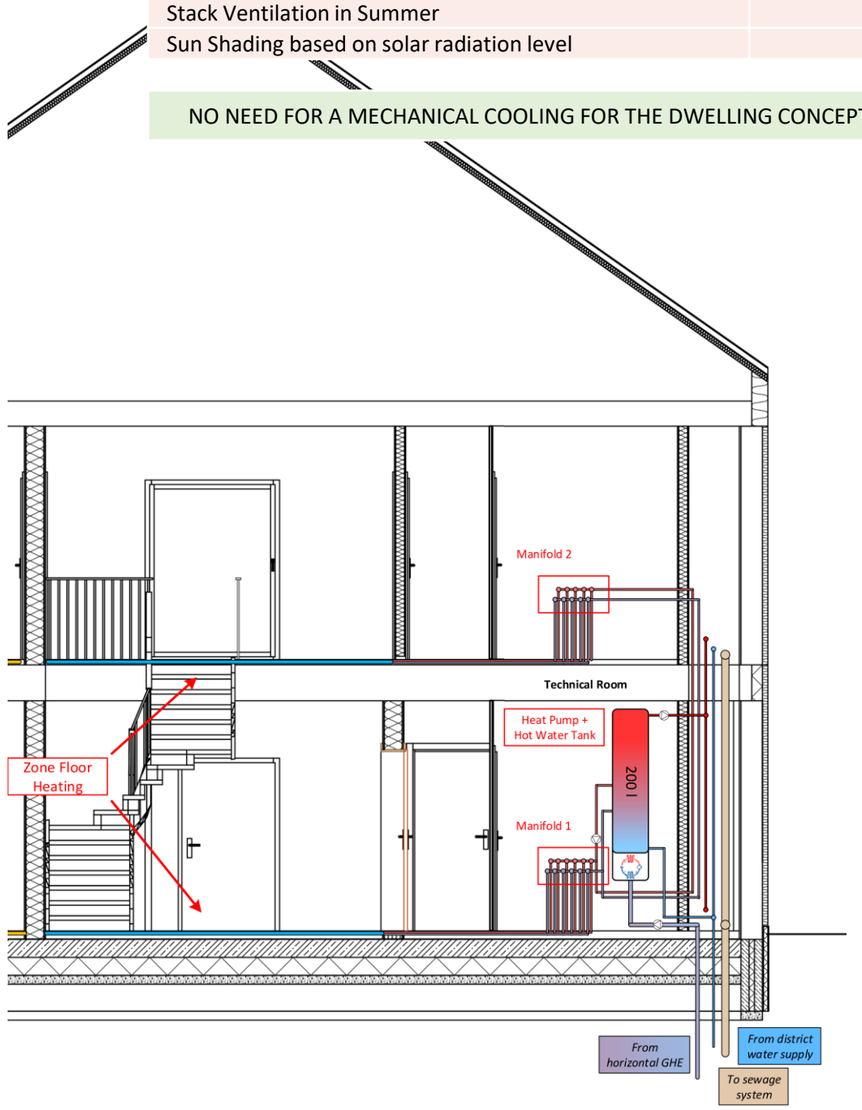


S SECTION TECHNICAL ROOM

OVERHEATING	
DS 469 yearly hours above 26 °C (< 100h)	13.4 h
DS 469 yearly hours above 27 °C (< 25h)	2.1 h

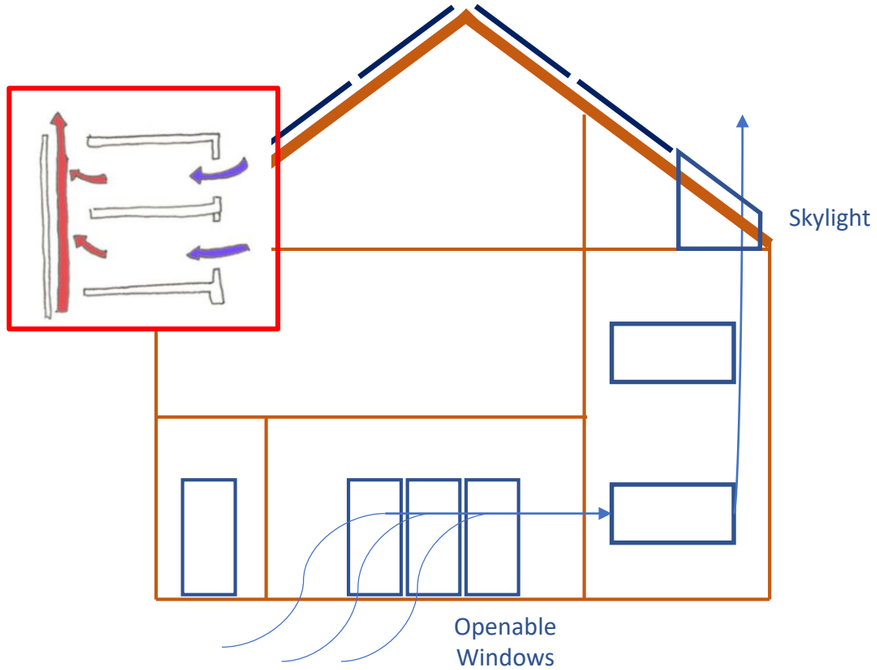
Openable Windows with Control Setpoint (Nov. - March)	25 °C
Control Setpoint (April - Oct.)	22 °C
Stack Ventilation in Summer	
Sun Shading based on solar radiation level	

NO NEED FOR A MECHANICAL COOLING FOR THE DWELLING CONCEPT

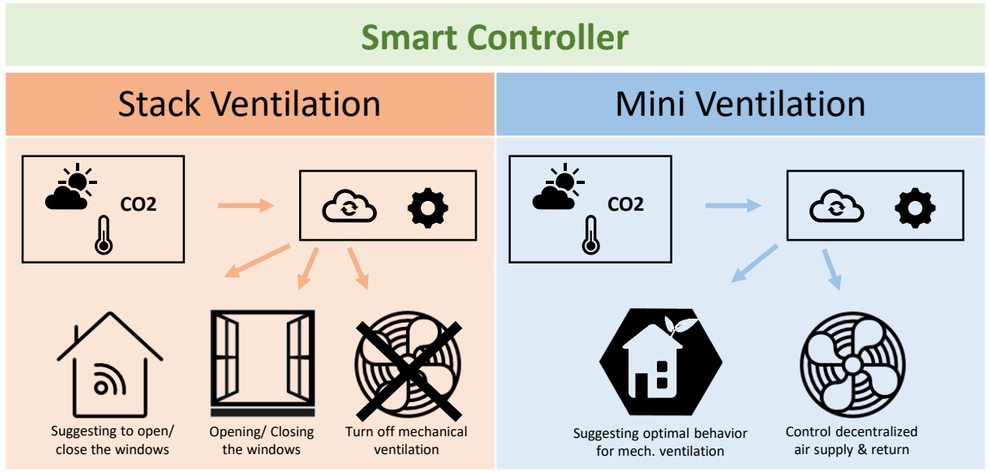


5.6 Ventilation System

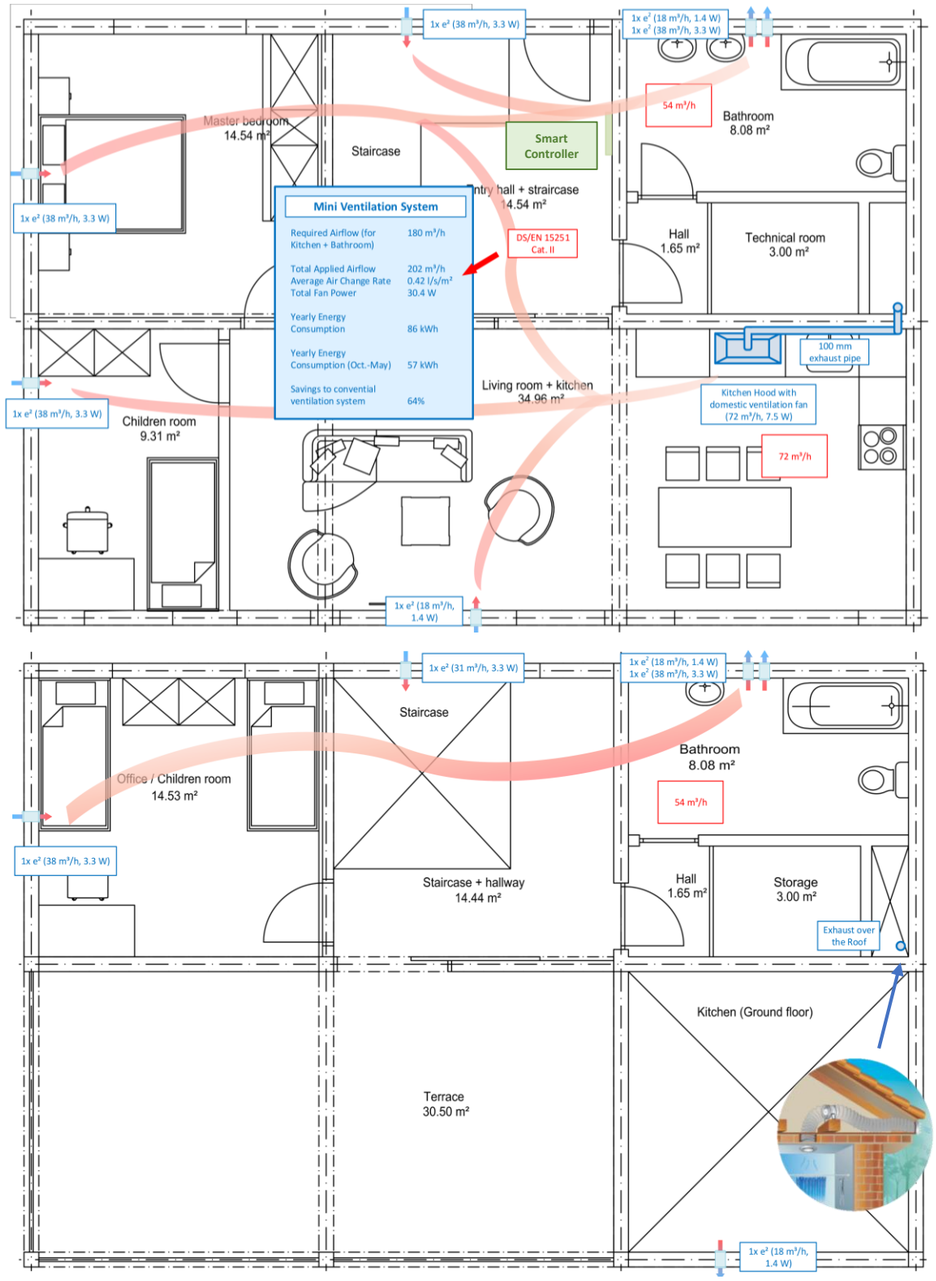
Summer — NATURAL STACK VENTILATION



Smart Controller

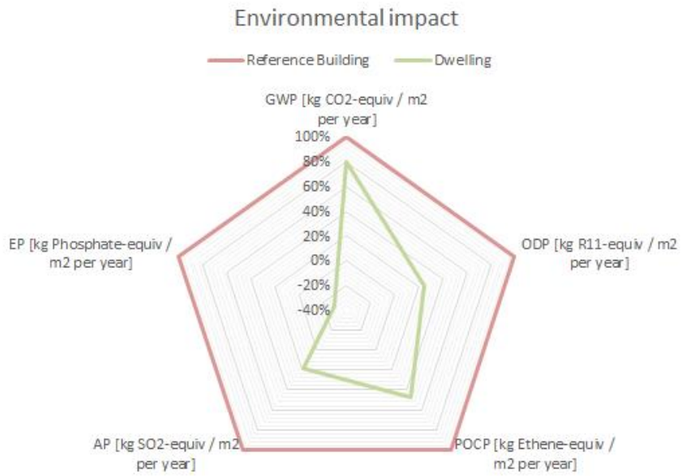


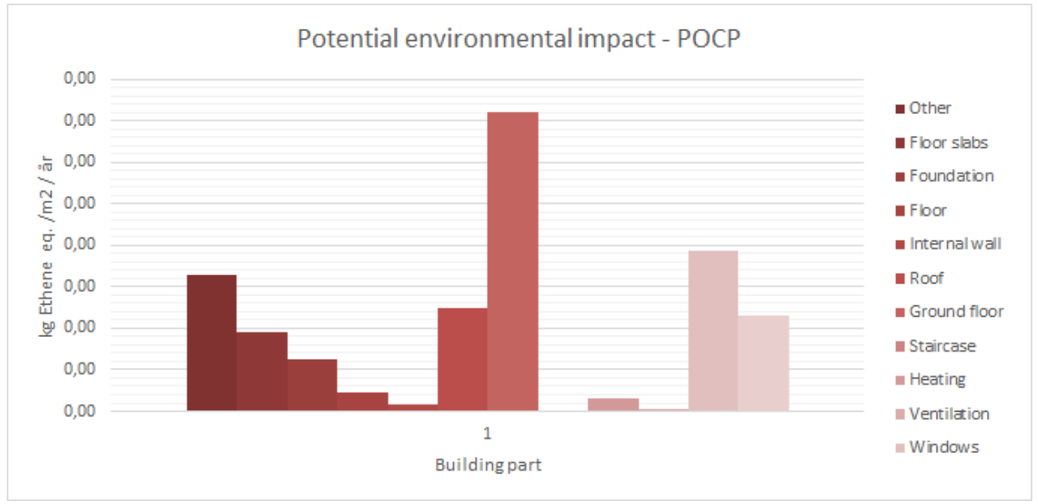
Winter — DECENTRALIZED VENTILATION SYSTEM

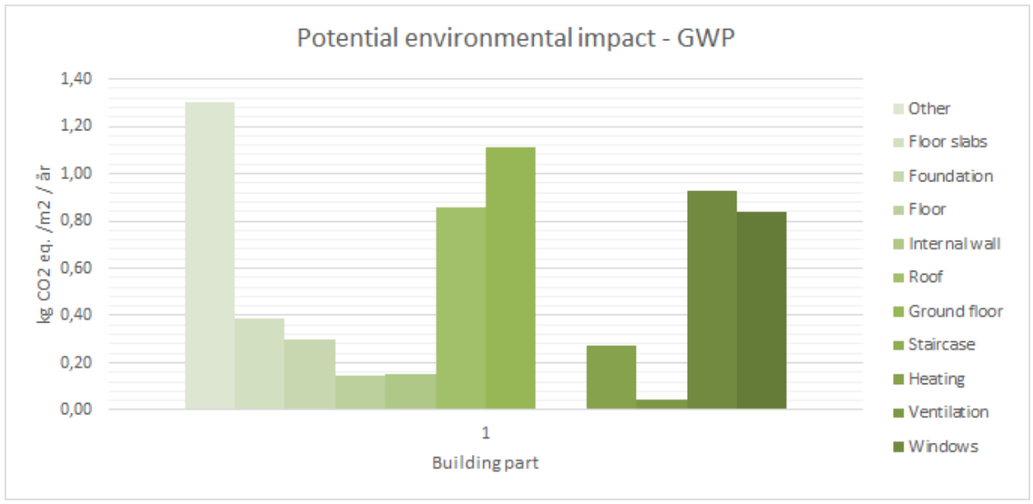


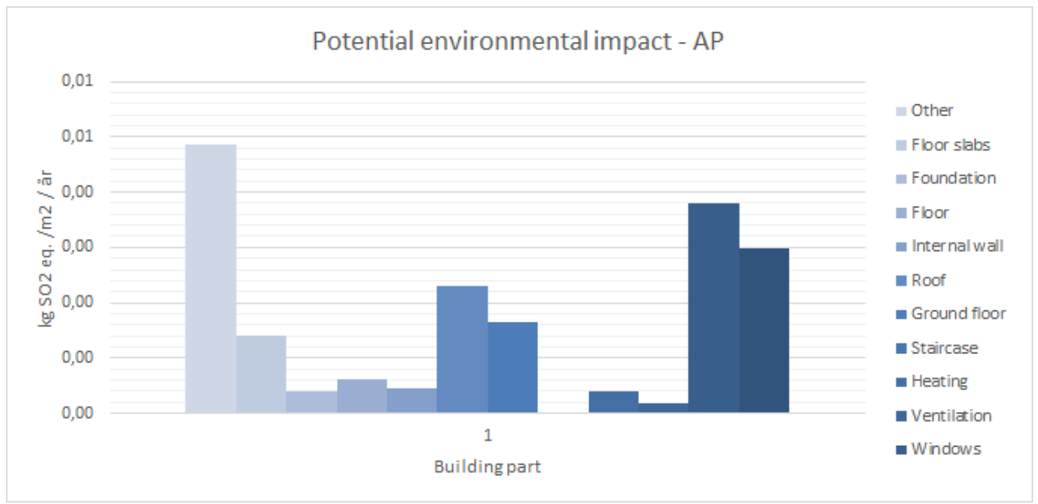
https://www.lunos.de/en/systems/

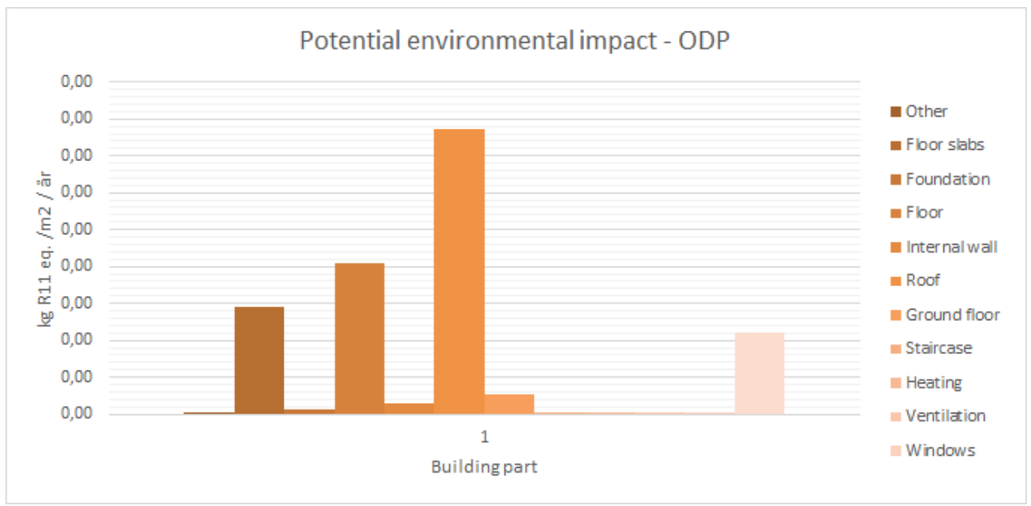
5.7 LCA

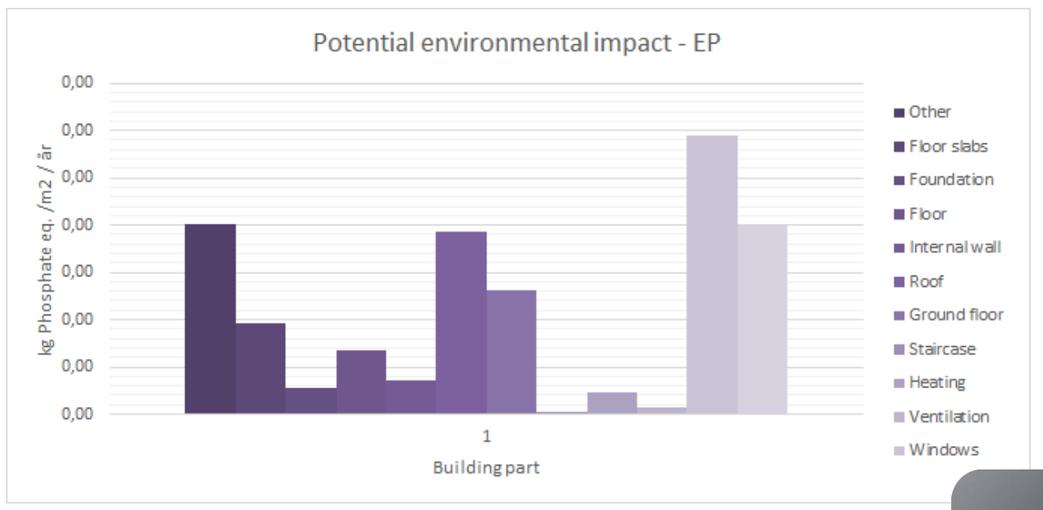












REFERENCE BUILDIG: 50 points out of 100

DWELLNG CONCEPT: 100 points out of 100

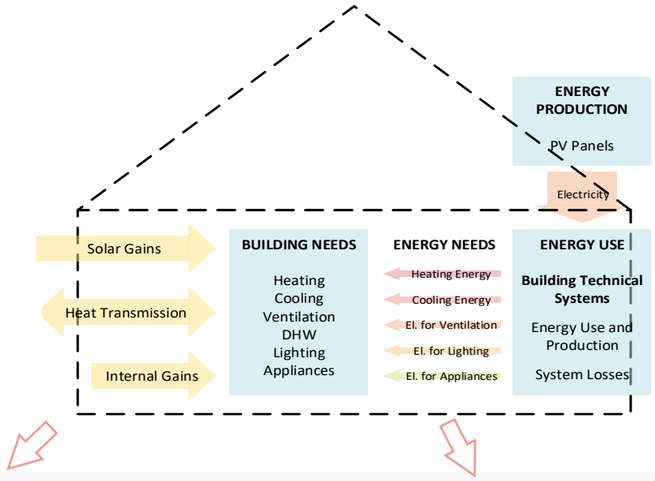
LCA PLATINUM DGNB

6. Energy Design

6.1 Energy Balance

6.2 Monthly Energy Consumption/Production and Costs

6.1 Energy Balance



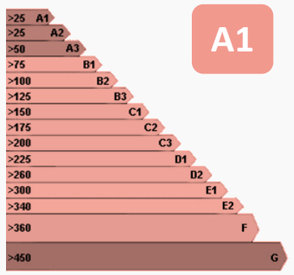
The Energy Balance is based on the building needs and the energy use of the building, as illustrated on the right. The numbers for this balance result from the energy calculation, performed with IDA ICE.
As our building is only using electricity for all building technical systems as heating, DHW and ventilation, the primary energy factor of 1.9 can be applied to all parts of the energy balance. After calculating the energy use, the energy production is subtracted with the same factor, leading to the net energy balance in kWh/a. Dividing the figure for both phase 1/2 and 3 with 128.1 m² and 157.1 m² respectively, the proposed building design achieves an energy efficiency rating of A1 for phase 1/2 (17.0 kWh/m²/a) and A2 for phase 3 (28.2 kWh/m²/a)

PHASE 1-2

ENERGY BALANCE PHASE 2			
Primary Energy Factor Electricity	1.9	Heated Floor Area	128.09 m²
		Room height	2.53 m
ENERGY USE		ELECTRICITY	PRIMARY ENERGY EPI
Home appliances		3924.6 kWh	7456.74 kWh
Embedded energy in materials (total 30y)		40.0 kWh	76.0 kWh
Building operation (Heating/Cooling/DHW) - Heat Pump		1464.9 kWh	2783.31 kWh
HVAC aux (Pumps)		55.4 kWh	105.2 kWh
Usage Sum		5484.9 kWh	10421.3 kWh
Usage Sum per m²		**42.82 kWh/m²**	**81.36 kWh/m²**
Usage Sum (no Equipment)		1560.3 kWh	2964.5 kWh
Usage Sum per m² (no Equipment)		12.18 kWh/m²	23.14 kWh/m²
PV Production		-4340.0 kWh	-8246.0 kWh
Solar Production		0 kWh	0 kWh
PVT Production		0 kWh	0 kWh
Production Sum		-4340.0 kWh	-8246.0 kWh
Production Sum per m²		**-33.88 kWh/m²**	**-64.38 kWh/m²**
Energy Balance		1144.9 kWh	2175.3 kWh
Energy Balance per m²		**8.9 kWh/m²**	**17.0 kWh/m²**
Energy Balance (no Equipment)		-2779.7 kWh	-5281.5 kWh
Energy Balance per m² (no Equipment)		**-21.7 kWh/m²**	**-41.2 kWh/m²**

Energy Efficiency Rating

17.0 kWh/m²/a

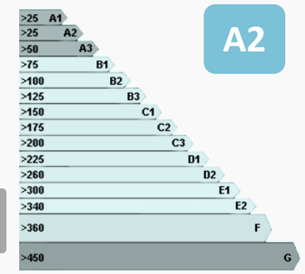


PHASE 3

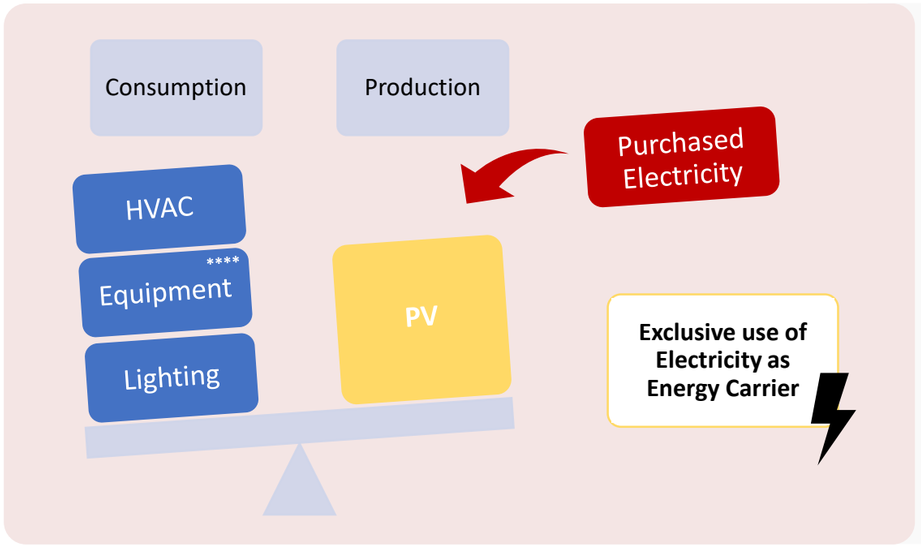
ENERGY BALANCE PHASE 3			
Primary Energy Factor Electricity	1.9	Heated Floor Area	157.07 m²
		Room height	2.53 m
ENERGY USE		ELECTRICITY	PRIMARY ENERGY EPI
Home appliances		5089.7 kWh	9670.4 kWh
Embedded energy in materials (total 30y)		40.0 kWh	76.0 kWh
Building operation (Heating/Cooling/DHW) - Heat Pump		1482.7 kWh	2817.1 kWh
HVAC aux (Pumps)		55.4 kWh	105.2 kWh
Usage Sum		**6667.8** kWh	12668.8 kWh
Usage Sum per m²		**42.5 kWh/m²**	**80.7 kWh/m²**
Usage Sum (no Equipment)		1578.1 kWh	2998.3 kWh
Usage Sum per m² (no Equipment)		**10.1 kWh/m²**	**19.1 kWh/m²**
PV Production		-4340.0 kWh	-8246.0 kWh
Solar Production		0 kWh	0 kWh
PVT Production		0 kWh	0 kWh
Production Sum		-4340.0 kWh	-8246.0 kWh
Production Sum per m²		**-27.6 kWh/m²**	**-52.5 kWh/m²**
Energy Balance		2327.8 kWh	4422.8 kWh
Energy Balance per m²		**14.8 kWh/m²**	**28.2 kWh/m²**
Energy Balance (no Equipment)		-2761.9 kWh	-5247.7 kWh
Energy Balance per m² (no Equipment)		**-17.6 kWh/m²**	**-33.4 kWh/m²**

Energy Efficiency Rating

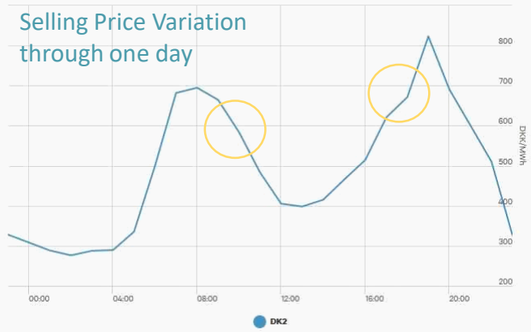
28.2 kWh/m²/a



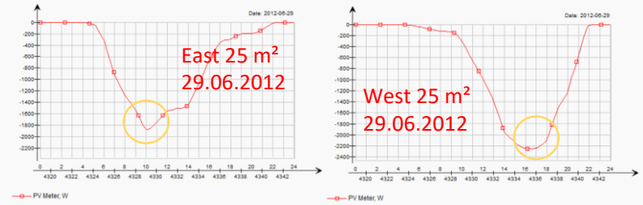
6.2 Monthly Energy Consumption/Production and Costs (Phase 2)



Surplus Electricity in Summer → **Selling back to the Grid**



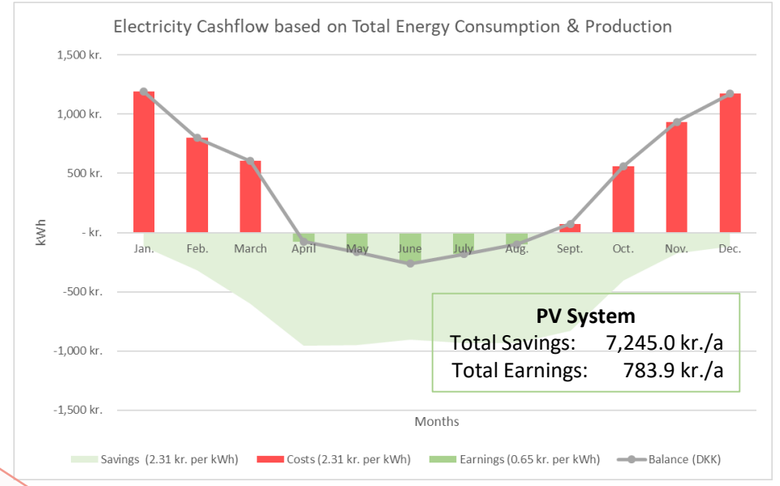
IDA ICE daily PV-production curve on example date



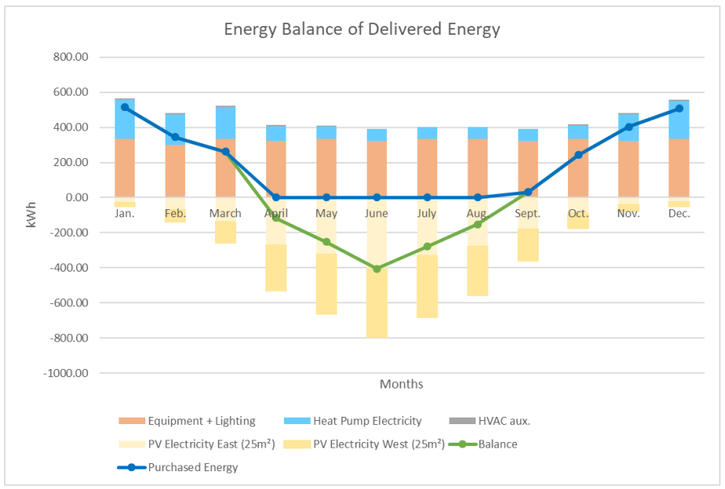
Average Selling Price: 650 DKK/MWh

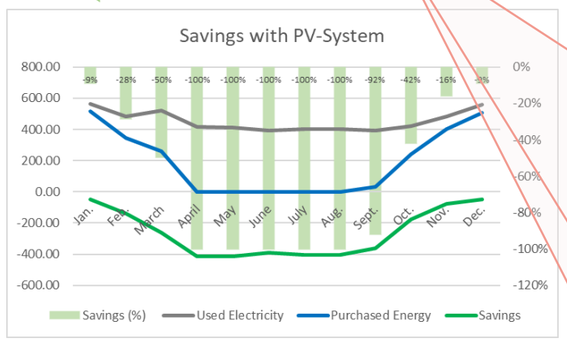
**https://www.vivaenergi.dk/elsalg?fbclid=IwAR3rhfz_Yt_m43SjV8dleLtCX-dJVFQHeWJLGaiaPjVPavNFV4PjRt5Qz6s

MONTHLY ENERGY BALANCE (kWh)	Equipment + Lighting	Heat Pump Electricity	HVAC aux.	PV Electricity East (25m²)	PV Electricity West (25m²)	Used Electricity	Produced Electricity	Balance		Purchased Energy	Savings	Savings (%)	* Costs (2.31 kr. per kWh)	** Earnings (0.65 kr. per kWh)	Balance (DKK)	Savings (2.31 kr. per kWh)
Jan.	333.30	225.50	7.04	-26.50	-24.30	565.84	-50.80	515.0	Buy	515.0	-50.8	-9%	1,190 kr.	- kr.	1,190 kr.	- 117 kr.
Feb.	301.10	175.10	6.58	-69.50	-67.80	482.78	-137.30	345.5	Buy	345.5	-137.3	-28%	798 kr.	- kr.	798 kr.	- 317 kr.
March	333.30	181.50	7.04	-137.40	-123.10	521.84	-260.50	261.3	Buy	261.3	-260.5	-50%	604 kr.	- kr.	604 kr.	- 602 kr.
April	322.60	85.10	6.81	-268.90	-261.50	414.51	-530.40	-115.9	Sell	0.0	-414.5	-100%	- kr.	- 75 kr.	- 75 kr.	- 958 kr.
May	333.30	71.50	7.04	-323.90	-341.00	411.84	-664.90	-253.1	Sell	0.0	-411.8	-100%	- kr.	- 164 kr.	- 164 kr.	- 951 kr.
June	322.60	68.50	0.00	-405.50	-390.70	391.10	-796.20	-405.1	Sell	0.0	-391.1	-100%	- kr.	- 263 kr.	- 263 kr.	- 903 kr.
July	333.30	70.20	0.00	-331.60	-351.50	403.50	-683.10	-279.6	Sell	0.0	-403.5	-100%	- kr.	- 182 kr.	- 182 kr.	- 932 kr.
Aug.	333.30	70.30	0.00	-276.10	-279.80	403.60	-555.90	-152.3	Sell	0.0	-403.6	-100%	- kr.	- 99 kr.	- 99 kr.	- 932 kr.
Sept.	322.60	68.50	0.00	-181.00	-178.50	391.10	-359.50	31.6	Buy	31.6	-359.5	-92%	73 kr.	- kr.	73 kr.	- 830 kr.
Oct.	333.30	78.60	7.04	-88.50	-87.70	418.94	-176.20	242.7	Buy	242.7	-176.2	-42%	561 kr.	- kr.	561 kr.	- 407 kr.
Nov.	322.60	151.90	6.81	-38.30	-38.60	481.31	-76.90	404.4	Buy	404.4	-76.9	-16%	934 kr.	- kr.	934 kr.	- 178 kr.
Dec.	333.30	218.20	7.04	-25.50	-25.10	558.54	-50.60	507.9	Buy	507.9	-50.6	-9%	1,173 kr.	- kr.	1,173 kr.	- 117 kr.
mean	327.05	122.08	4.61	-181.06	-180.80			-1206.0	Sell							
min	301.10	68.50	0.00	-405.50	-390.70			2308.5	Buy							
max	333.30	225.50	7.04	-25.50	-24.30											
Total	3924.60	1464.90	55.38	-2172.70	-2169.60	5444.88	-4342.30	1102.58		2308.53	-3136.34		5,332.71 kr.	- 783.87 kr.	4,548.84 kr.	- 7,244.96 kr.



PV System
Total Savings: 7,245.0 kr./a
Total Earnings: 783.9 kr./a





Total Operation Costs per year (DKK)
4,548.8 kr.

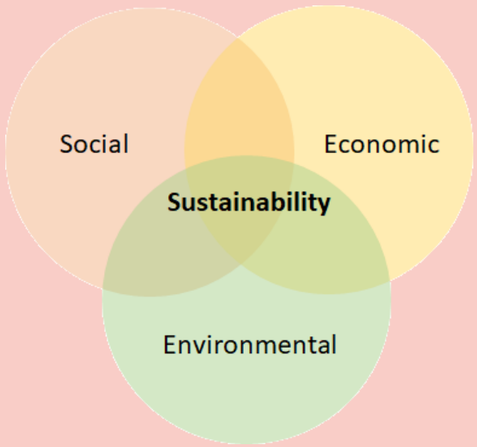
Average Yearly Costs for a Danish Family (4 people, 130 m²)***

ELECTRICITY
- Equipment + Lighting 4,450.0 DKK/year

HEAT
- District Heating 13,852.0 DKK/year
- New Oil Burner 18,800.0 DKK/year

SAVINGS
- EL + DH: 13,753.2 DKK/year
- EL + Oil: 18,701.2 DKK/year

6.3 Sustainability



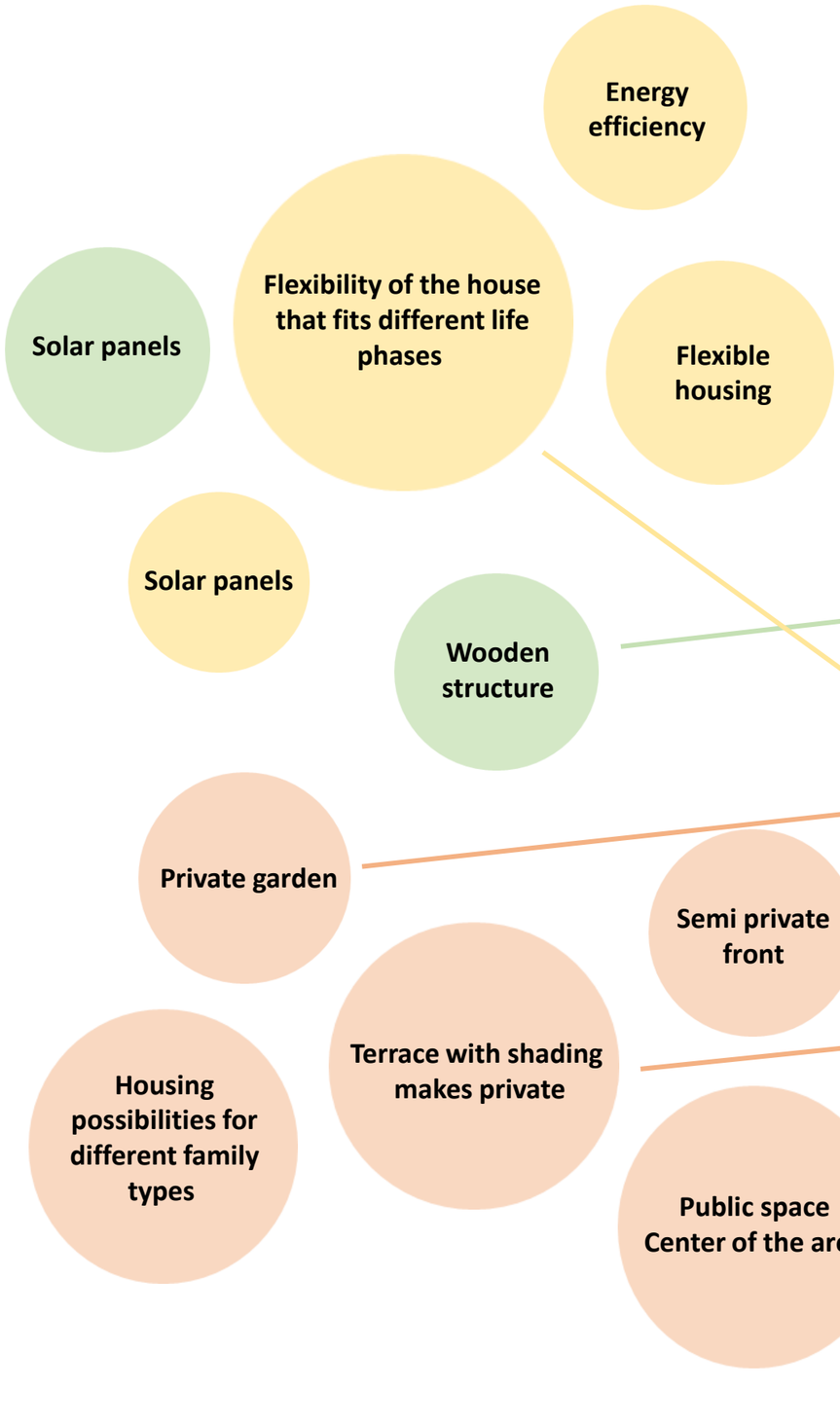
Sustainable

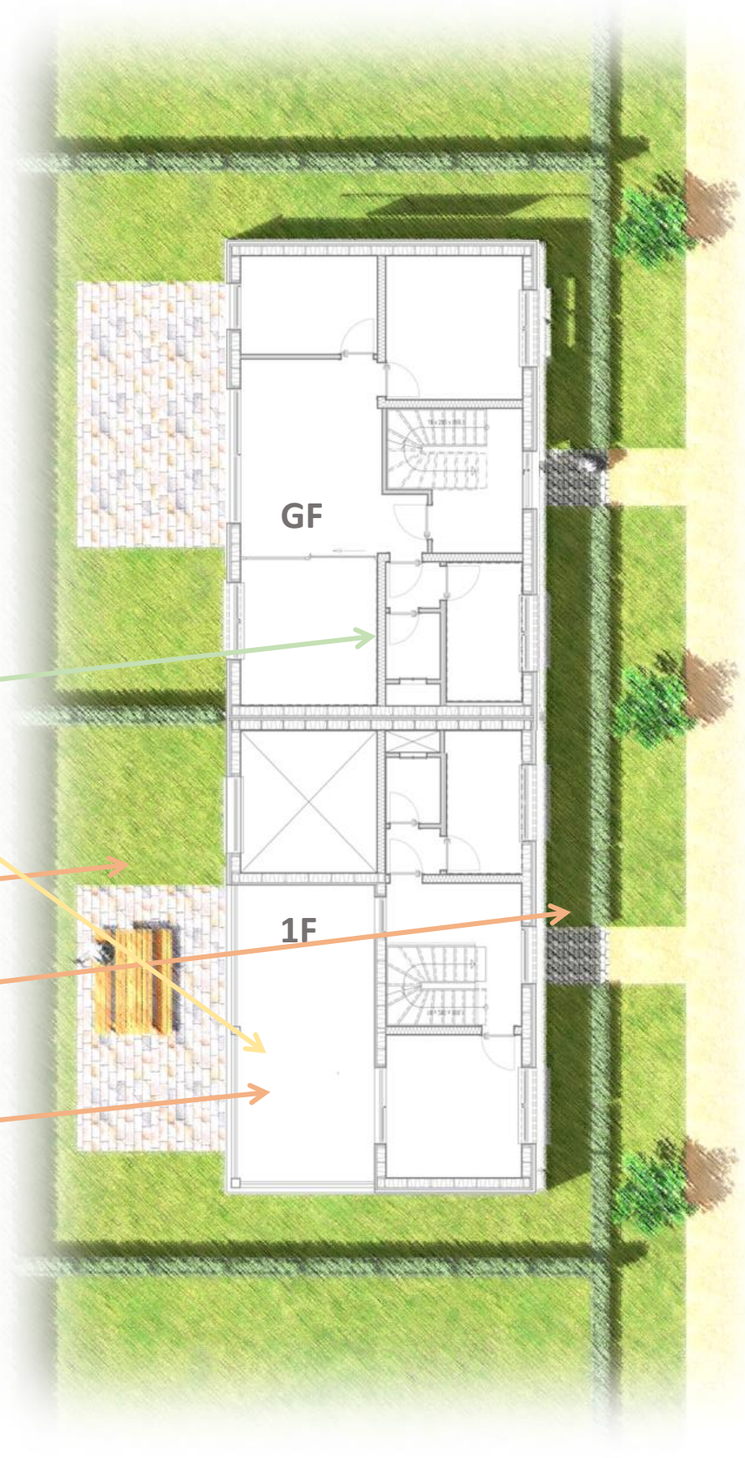
Affordable

Flexible

Energy efficient

HOUSING





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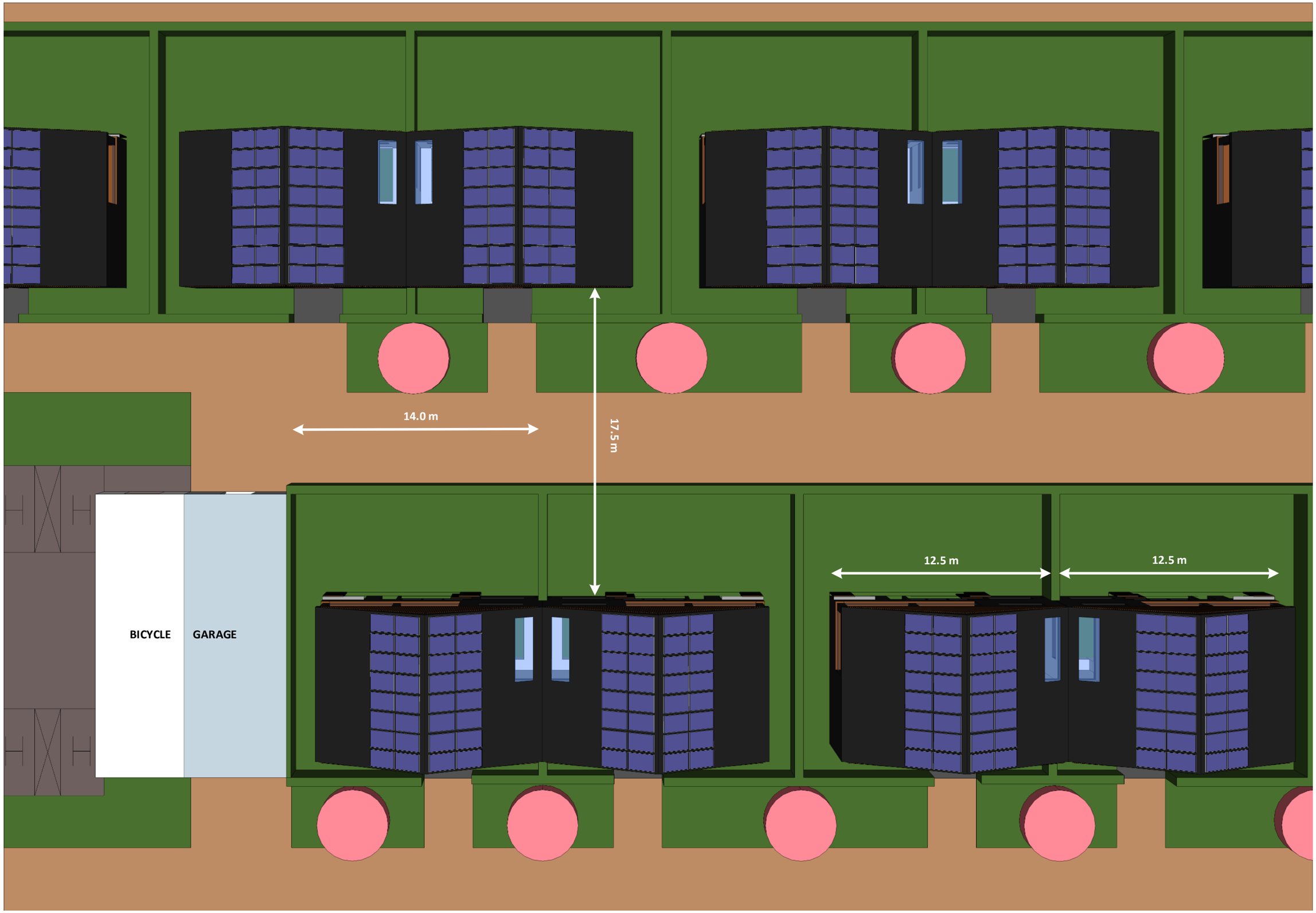
7.2 Appendix

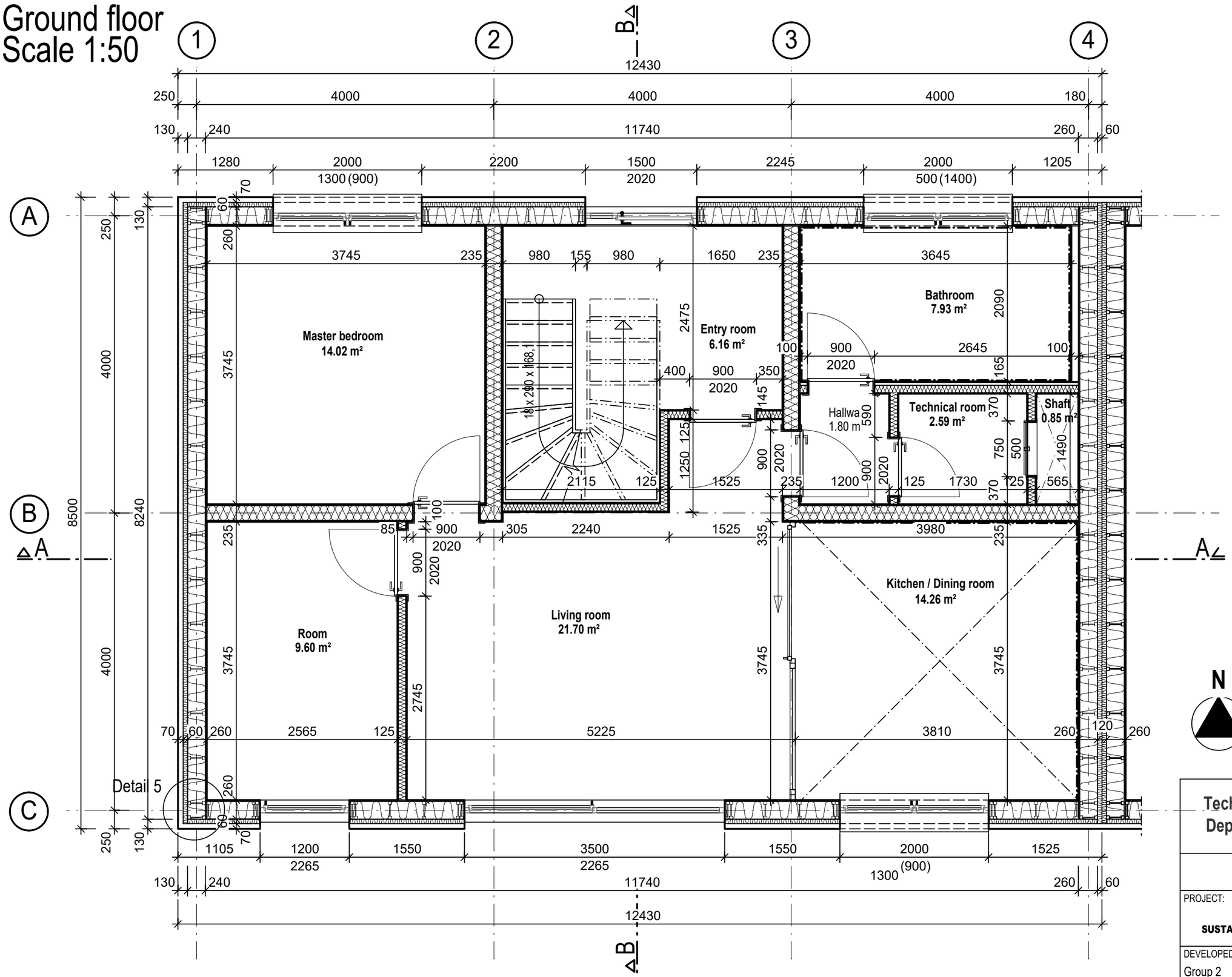
A1-1	Overview Plan	1:200
A2-1	Floor Plan – Ground Floor	1:50
A2-2	Floor Plan – First Floor	1:50
A2-3	Section A-A	1:50
A2-4	Section B-B	1:50
A3-1	Detail 1 - Wall - Foundation connection	1:5
A3-2	Detail 2 - Wall - Floor slab connection	1:5
A3-3	Detail 3 – Terrace + Wall connection (P1/2)	1:5
A3-4	Detail 4 – Terrace + Wall connection (P3)	1:5
A3-5	Detail 5 – Walls connection	1:5
A4-1	Elevation South Facade	1:50
A4-2	Elevation North Facade	1:50
A5-1	Water System - Ground Floor	1:50
A5-2	Water System - First Floor	1:50
A5-3	Water System - Section	1:50
A6-1	Ventilation Layout - Ground Floor	1:50
A6-2	Ventilation Layout - First Floor	1:50
A6-3	Ventilation Design & Energy Calculation	
A7-1	Structural Report	
A8-1	IDA ICE Input & Output Tables	
A8-2	IDA ICE Reports – Phase 2	
A9-1	LCA Calculation 50 years	
A9-2	LCA Calculation 80 years	

A1-1_Overview Plan_1:200


14.0 m
17.5 m
BICYCLE
GARAGE
12.5 m
12.5 m

A2-1_Floor Plan – Ground Floor_1:50

Ground floor
Scale 1:50



Material notation:

- Wood fibre thermal insulation
- Acustic insulation - mineral wool

Area of rooms		
Bathroom	7.93 m2	
Entry room	6.16 m2	
Hallway	1.80 m2	
Kitchen / Dining	14.26 m2	
Living room	21.70 m2	
Master bedroom	14.02 m2	
Room	9.60 m2	
Shaft	0.85 m2	
Technical room	2.59 m2	78.91 m2

N

Technical University of Denmark
Department of Civil Engineering

DTU

11982 Integated Desing Project

PROJECT:

SAFE HOUSING

SUSTAINABLE - AFFORDABLE - FLEXIBLE - ENERGY EFFICIENT

DEVELOPED BY:	LOCATION:
Group 2	København

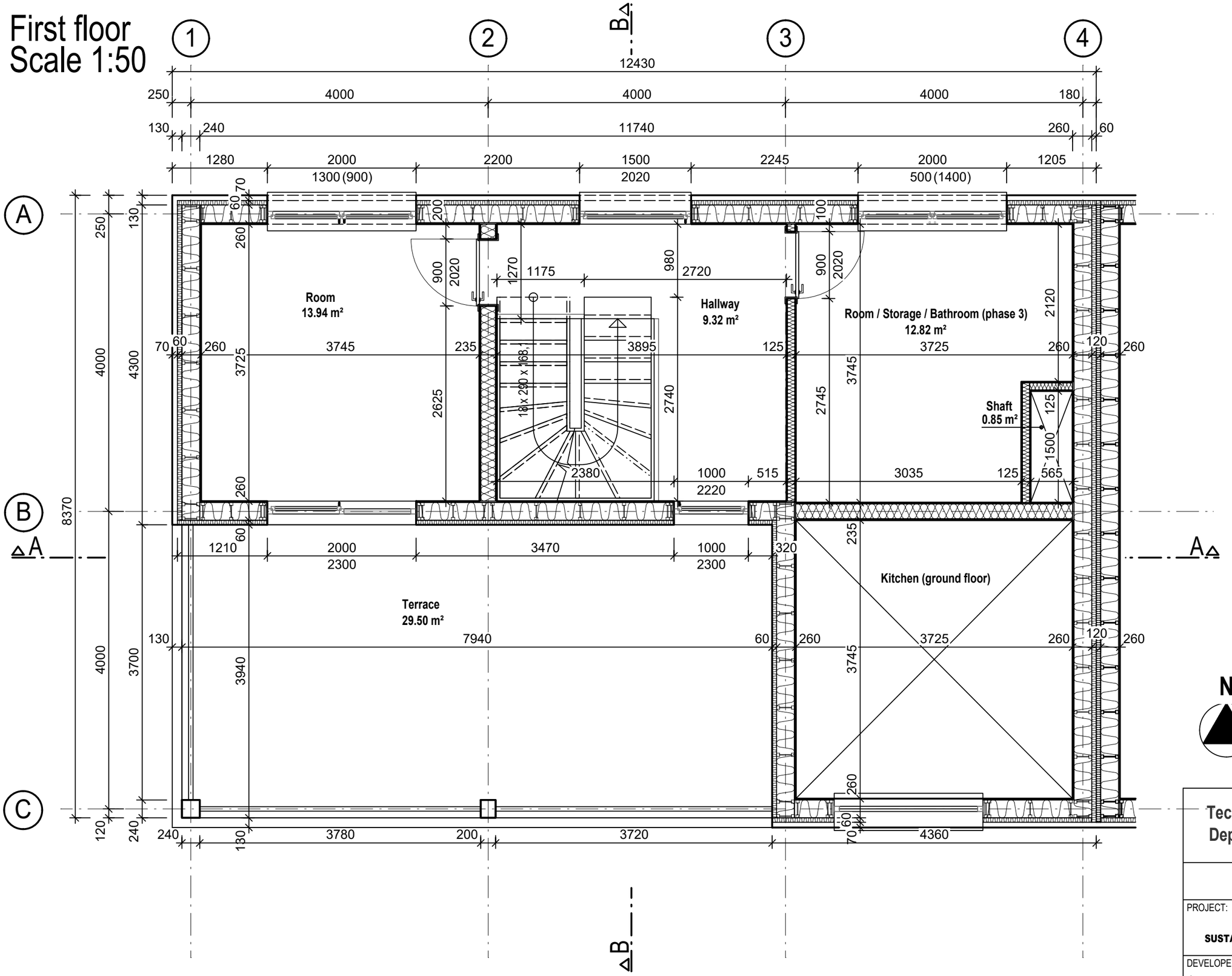
DRAWING TITLE:

Ground floor plan

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:50	DRAWING NO.:	1

A2-2_Floor Plan – First Floor_1:50

First floor
Scale 1:50



Material notation:

- Wood fibre thermal insulation
- Acustic insulation - mineral wool

Area of rooms		
Hallway	9.32 m2	
Room	13.94 m2	
Room / Storage /	12.82 m2	
Terrace	29.50 m2	65.58 m2

N

Technical University of Denmark
Department of Civil Engineering

DTU

11982 Integated Desing Project

PROJECT:
SAFE HOUSING
SUSTAINABLE - AFFORDABLE - FLEXIBLE - ENERGY EFFICIENT

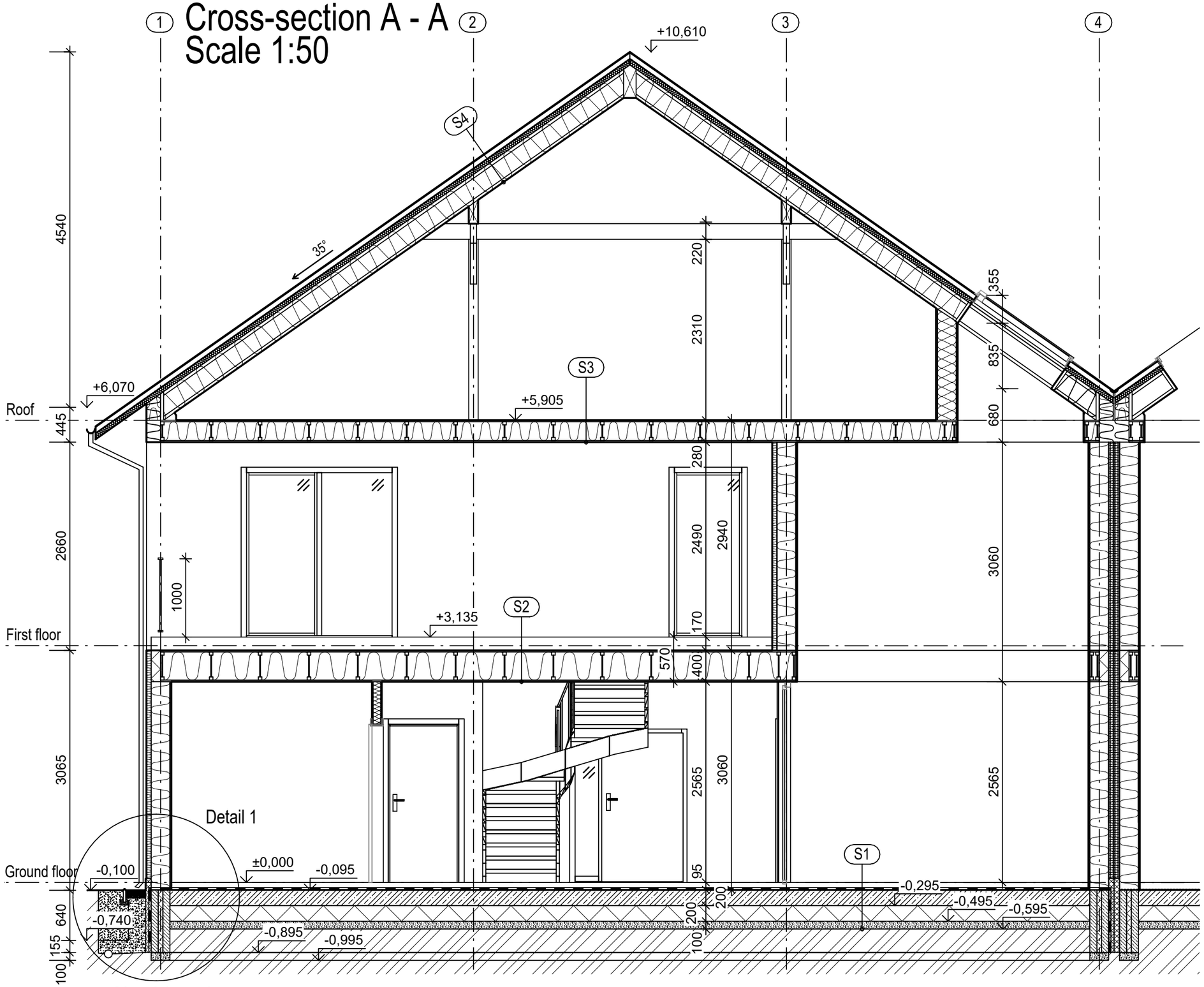
DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:
First floor plan

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:50	DRAWING NO.:	2

A2-3_Section A-A_ 1:50

Cross-section A - A
Scale 1:50



S1

- Concrete screed with wire mesh and floor heating	60 mm
- Acustic insulation STEICOtherm SD	30 mm
- Water barrier, Elastomer bituminous membrane Baukubit K5K	5,2 mm
- Foundation concrete slab	200 mm
- Thermal insulation EPS (λ = 0,035W/m.K)	200 mm
- Gravel 16/32	100 mm

S2

- Concrete or ceramic tiles	10 mm
- Metal pedestals + geotextile pad for protection against damaging	
- Water barrier, BauderTHERMOFIN F 15, FPO-PP foil, s_d = 300 m	1,5 mm
- 2x Fermacell gypsum board	25 mm
- Acustic insulation, STEICOtherm SD with floor heating	30 mm
- Sloped insulation (2%), EPS	25-100 mm
- OSB board	18 mm
- Thermal insulation, STEICOzell (λ = 0,04W/m.K) STEICO joist SW 45, height 360 mm	360 mm
- Vapor barrier, AirGuard Reflective, s_d = 2000 m	0,43 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S3

- OSB board	18 mm
- Thermal insulation, STEICOflex (λ = 0,04 W/m.K) STEICO joist SW 45, height 240 mm	240 mm
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S4

- Ceramic roof tiles	
- Battens 30x20 mm	
- Contra battens 60x40 mm	
- Breather membrane s_d = 0,1 m	0,2 mm
- Thermal insulation, STEICOuniversal	60 mm
- Thermal insulation, STEICOzell (λ = 0,04 W/m.K) STEICO joist SW 45, height 300 mm	300 mm
- Vapor barrier, PE foil	0,2 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

Material notation:

- Reinforced concrete
- EPS
- XPS
- Wood fibre thermal insulation
- Gravel
- Gravel + sand
- Soil backfill
- Original soil
- Water barrier
- Acustic insulation - mineral wool

Technical University of Denmark
Department of Civil Engineering
DTU

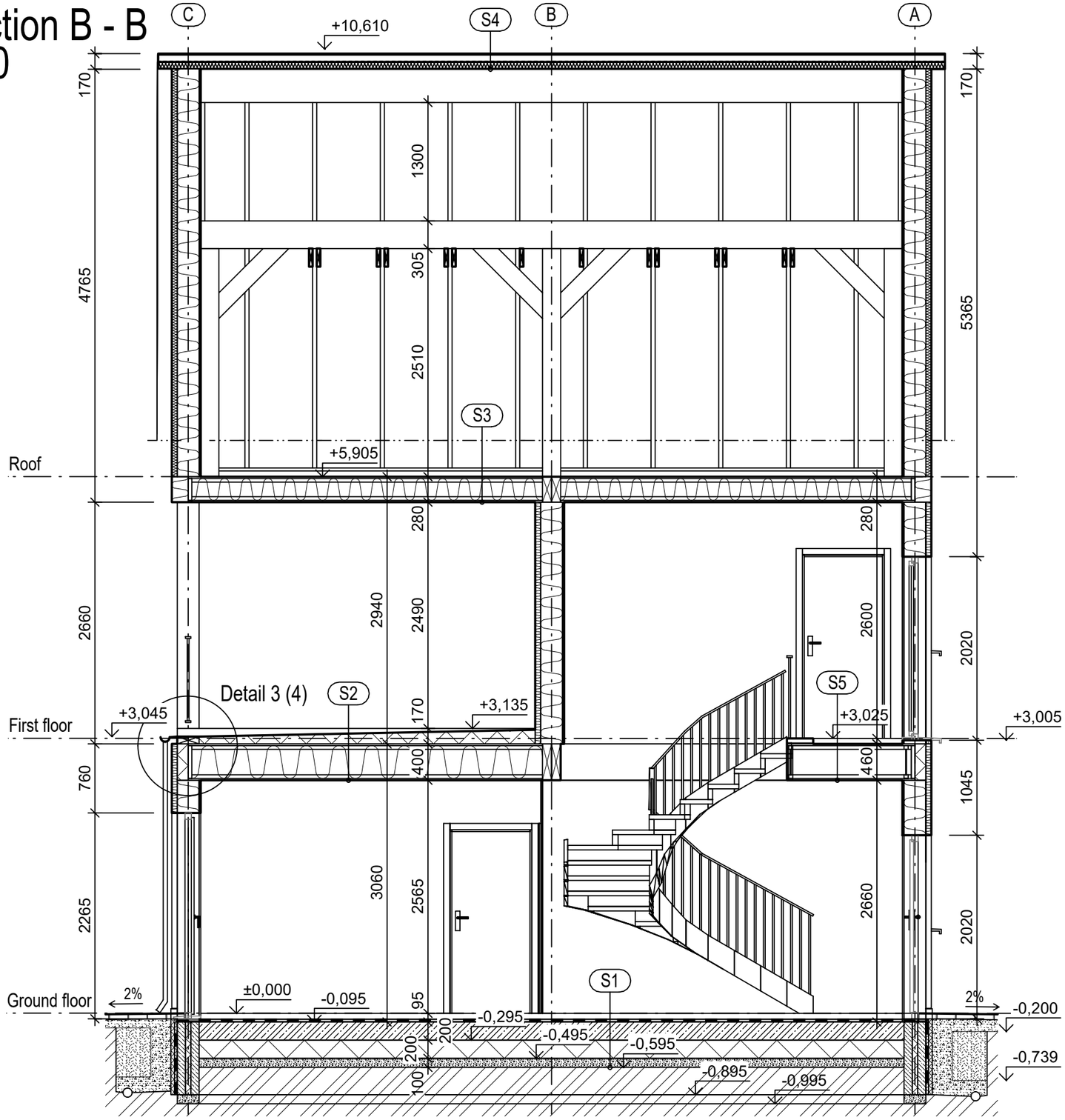
11982 Integated Desing Project

PROJECT:
SAFE HOUSING
SUSTAINABLE - AFFORDABLE - FLEXIBLE - ENERGY EFFICIENT

DEVELOPED BY: Group 2	LOCATION: København
DRAWING TITLE: **Cross-section A-A**	
DRAWN BY: Zdeněk Hlavsa	DATE: 25.06.2019
SCALE: 1:50	DRAWING NO.: 3

A2-4_Section B-B_ 1:50

Cross-section B - B
Scale 1:50



S2

- Concrete or ceramic tiles	10 mm
- Metal pedestals + geotextile pad for protection against damaging	
- Water barrier, BauderTHERMOFIN F 15, FPO-PP foil, s_d = 300 m	1,5 mm
- 2x Fermacell gypsum board	25 mm
- Acustic insulation, STEICOtherm SD with floor heating	30 mm
- Sloped insulation (2%), EPS	25-100 mm
- OSB board	18 mm
- Thermal insulation, STEICOzell (λ = 0,04W/m.K) STEICO joist SW 45, height 360 mm	360 mm
- Vapor barrier, AirGuard Reflective, s_d = 2000 m	0,43 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S3

- OSB board	18 mm
- Thermal insulation, STEICOflex (λ = 0,04 W/m.K) STEICO joist SW 45, height 240 mm	240 mm
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S4

- Ceramic roof tiles	
- Battens 30x20 mm	
- Contra battens 60x40 mm	
- Breather membrane s_d = 0,1 m	0,2 mm
- Thermal insulation, STEICOuniversal	60 mm
- Thermal insulation, STEICOzell (λ = 0,04 W/m.K) STEICO joist SW 45, height 300 mm	300 mm
- Vapor barrier, PE foil	0,2 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S5

- Parquete or laminate floor	10 mm
- 2x Fermacell gypsum fibre board	25 mm
- Acustic insulation, STEICOtherm SD with floor heating	30 mm
- OSB board	18 mm
- STEICOjoist SW 45, height 360 mm	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceilling cover, Knauf Silentboard gypsum fibre board	12,5 mm

Material notation:

- Reinforced concrete
- EPS
- XPS
- Wood fibre thermal insulation
- Original soil
- Gravel + sand
- Soil backfill
- Water barrier
- Acustic insulation - mineral wool

S1

- Concrete screed with wire mesh and floor heating	60 mm
- Acustic insulation STEICOtherm SD	30 mm
- Water barrier, Elastomer bituminous membrane Baukubit K5K	5,2 mm
- Foundation concrete slab	200 mm
- Thermal insulation EPS (λ = 0,035W/m.K)	200 mm
- Gravel 16/32	100 mm

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11982 Integated Desing Project

PROJECT:

SAFE HOUSING

SUSTAINABLE - AFFORDABLE - FLEXIBLE - ENERGY EFFICIENT

DEVELOPED BY:	LOCATION:
Group 2	København

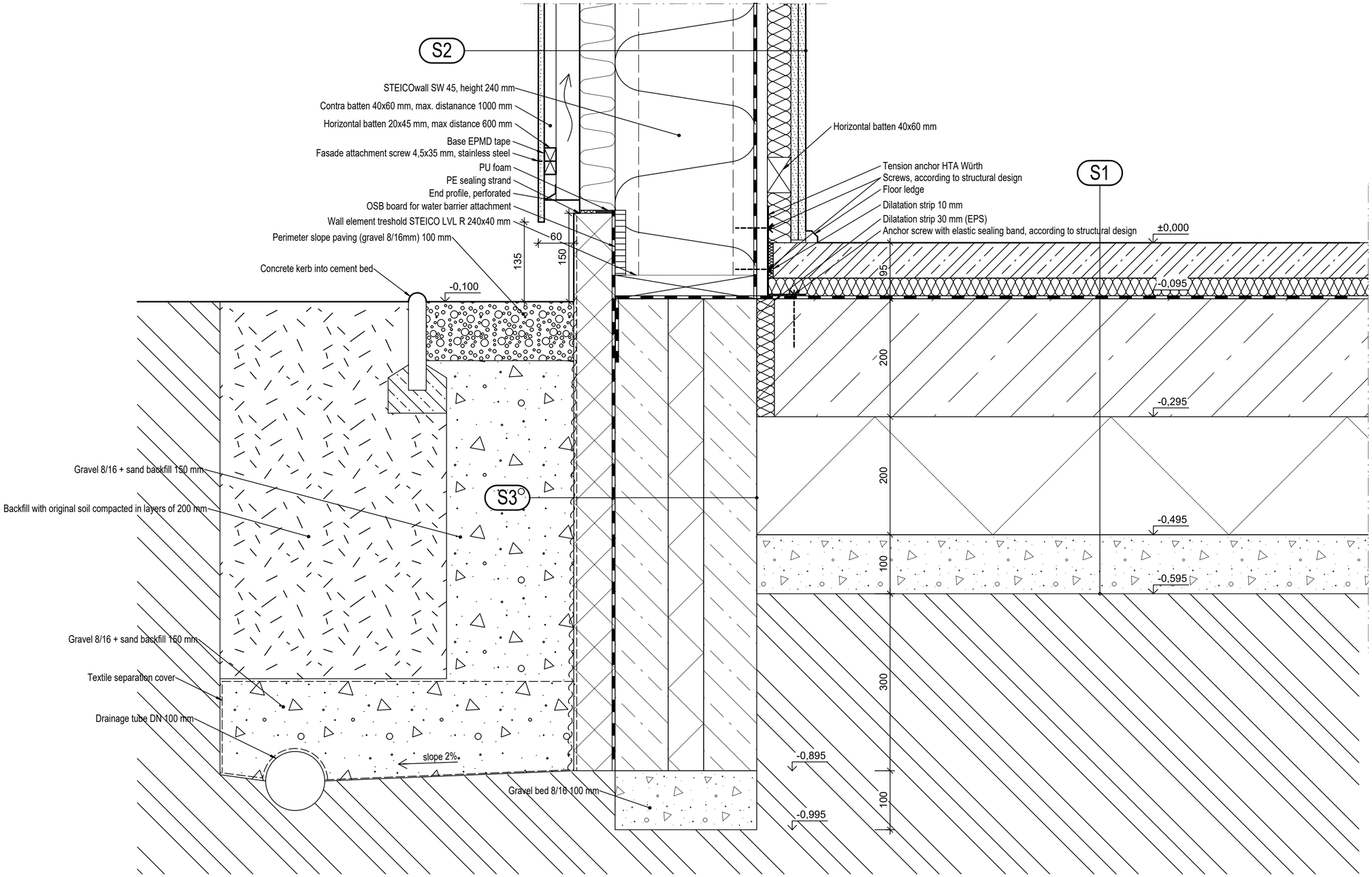
DRAWING TITLE:

Cross-section B-B

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:50	DRAWING NO.:	4

A3-1_Detail 1 - Wall - Foundation connection_1:5

Detail 1: Wall - foundation connection
Scale 1:5



S1

- Concrete screed with wire mesh and floor heating	60 mm
- Acustic insulation STEICOtherm SD	30 mm
- Water barrier, Elastomer bituminous membrane Baukubit K5K	5,2 mm
- Foundation concrete slab	200 mm
- Thermal insulation EPS (λ = 0,035W/m.K)	200 mm
- Gravel 16/32	100 mm

S2

- Exterior cladding, Cembrit Plank cement fibre boards	8 mm
Horizontal battens 20x45/75 mm	
Contra battens 40x60 mm	
- Thermal insulation STEICOuniversal (λ = 0,045W/m.K)	60 mm
- Thermal insulation STEICOflex 036 (λ = 0,038W/m.K)	240 mm
STEICOwall SW 45	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Installation shaft	40 mm
Mineral wool 40 mm + battens 40x60 mm	
- 2x Fermacell gypsum fibre board	12,5 mm

S3

- LECA blocks	240 mm
Expanded clay	90 mm
Thermal insulation EPS	60 mm
Expanded clay	90 mm
- Water barrier (bitumen)	5 mm
- Cement based glue	10 mm
- Thermal insulation XPS	60 mm
- Cement render with reinforcing mesh	10 mm
- Dimple membrane	2 mm

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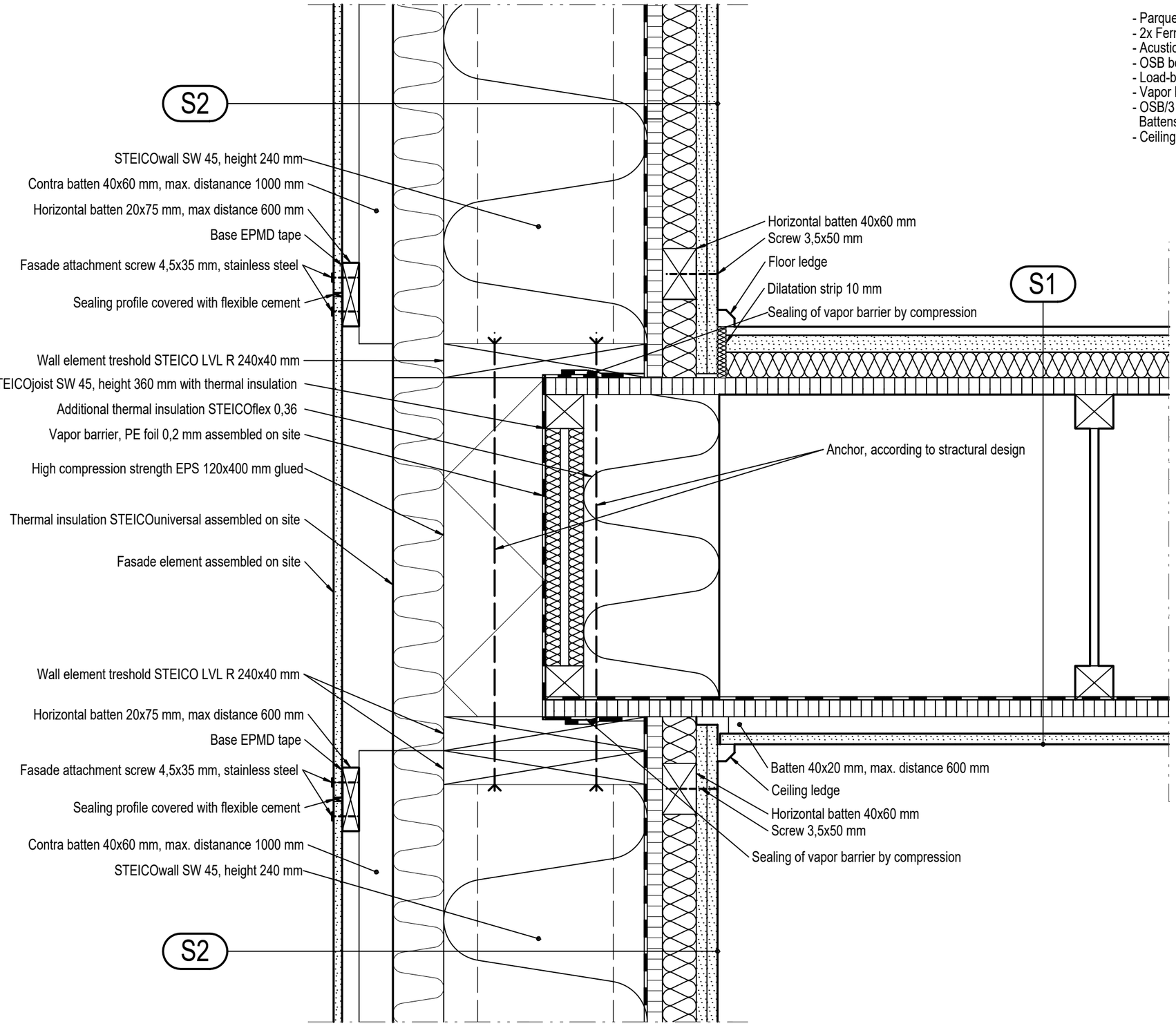
DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:
Detail 1 - Wall - Foundation connection

DRAWN BY: Zdeněk Hlavsa	DATE: 25.06.2019
SCALE: 1:5	DRAWING NO.: 5

A3-2_Detail 2 - Wall - Floor slab connection_1:5

Detail 2: Wall - Floor slab connection
Scale 1:5



S1

- Parquete or laminate floor covering + flooring underlay STEICOunderfloor (3 mm)	10 mm
- 2x Fermacell gypsum fibre board 12,5 mm	25 mm
- Acustic insulation, STEICOtherm SD	30 mm
- OSB board	18 mm
- Load-bearing structure, STEICOjoist SW 45, height 360 mm	360 mm
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
Battens 40x20 mm	20 mm
- Ceiling cover, Knauf Silentboard gypsum fibre board 12,5 mm	12,5 mm

S2

- Exterior cladding, Cembrit Plank cement fibre boards	8 mm
Horizontal battens 20x45/75 mm	
Contra battens 40x60 mm	
- Thermal insulation STEICOuniversal (λ = 0,045W/m.K)	60 mm
- Thermal insulation STEICOflex 036 (λ = 0,038W/m.K)	240 mm
STEICOwall SW 45	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Installation shaft	40 mm
Mineral wool 40 mm + battens 40x60 mm	
- 2x Fermacell gypsum fibre board	12,5 mm

Construction notes:

1. Wall element of the ground floor is mounted and strip of PE foil is prepared for connection with the upper wall element.
2. Floor slab element is mounted and rigid block of EPS is put in place glued with cement mortar.
3. PE foil is folded underneath the next wall element to provide seal vapor barrier with compression.
4. Wall element of the first floor is mounted and anchored through the floor slab and EPS block with the element of the ground floor. Mounting is done from outside via prepared gaps in the wall elements.
5. Outside insulation and exterior cladding at the connection location is assembled.

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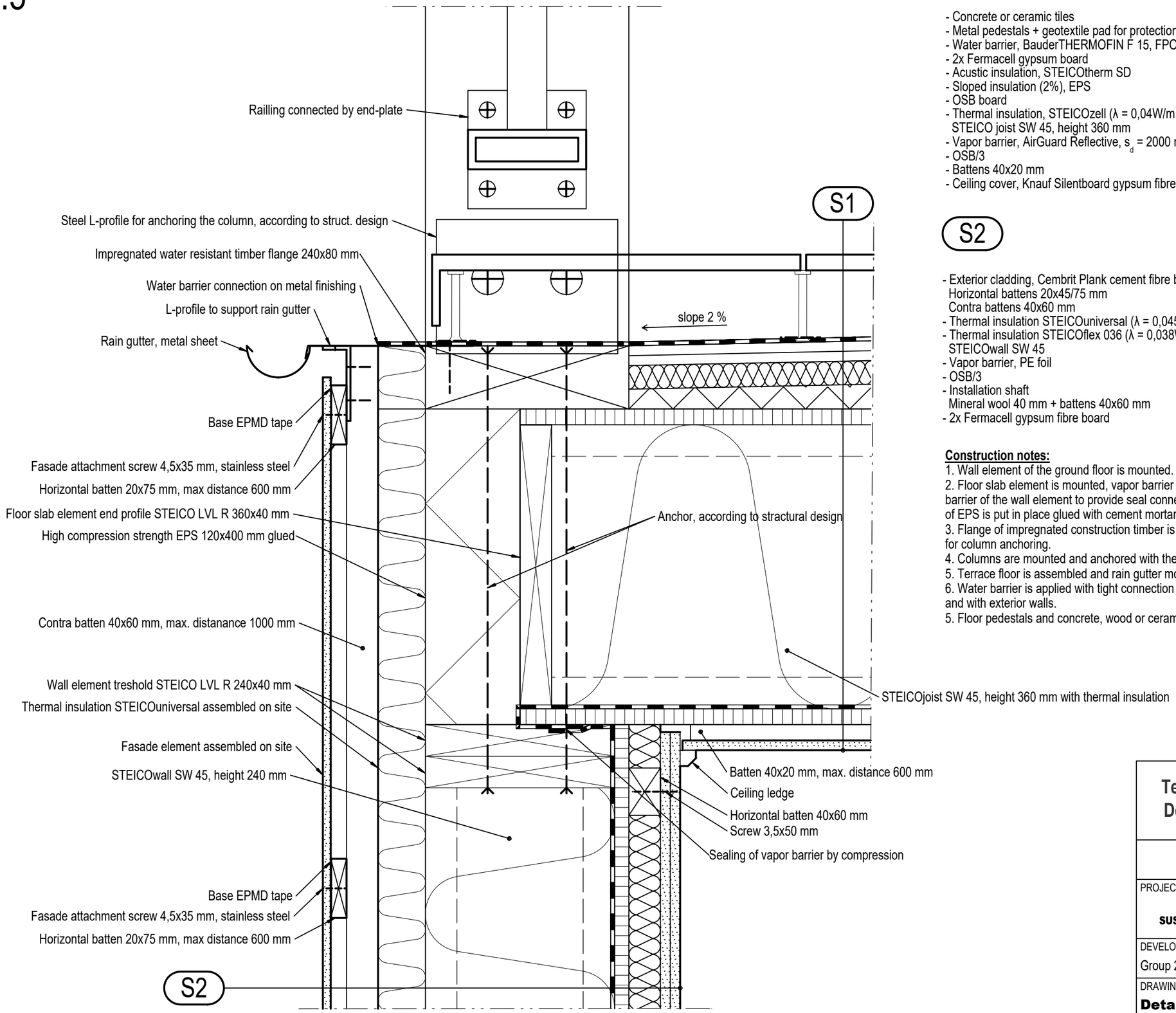
DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:
Detail 2 - Wall - Floor slab connection

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:5	DRAWING NO.:	6

A3-3_Detail 3 – Terrace + Wall connection (P1/2)_1:5

Detail 3: Terrace + Wall connection
Scale 1:5



S1

- Concrete or ceramic tiles	10 mm
- Metal pedestals + geotextile pad for protection against damaging	
- Water barrier, BauderTHERMOFIN F 15, FPO-PP foil, s_d = 300 m	1,5 mm
- 2x Fermacell gypsum board	25 mm
- Acustic insulation, STEICOtherm SD	30 mm
- Sloped insulation (2%), EPS	25-100 mm
- OSB board	18 mm
- Thermal insulation, STEICOzell (λ = 0,04W/m.K)	360 mm
STEICO joist SW 45, height 360 mm	
- Vapor barrier, AirGuard Reflective, s_d = 2000 m	0,43 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S2

- Exterior cladding, Cembrit Plank cement fibre boards	8 mm
Horizontal battens 20x45/75 mm	
Contra battens 40x60 mm	
- Thermal insulation STEICOuniversal (λ = 0,045W/m.K)	60 mm
- Thermal insulation STEICOflex 036 (λ = 0,038W/m.K)	240 mm
STEICOwall SW 45	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Installation shaft	40 mm
Mineral wool 40 mm + battens 40x60 mm	
- 2x Fermacell gypsum fibre board	12,5 mm

Construction notes:

1. Wall element of the ground floor is mounted.
2. Floor slab element is mounted, vapor barrier is folded and connected with vapor barrier of the wall element to provide seal connection by compression and rigid block of EPS is put in place glued with cement mortar.
3. Flange of impregnated construction timber is put in place with prepared steel profiles for column anchoring.
4. Columns are mounted and anchored with the lower wall element.
5. Terrace floor is assembled and rain gutter mounted.
6. Water barrier is applied with tight connection with gutter finishing, around the columns and with exterior walls.
5. Floor pedestals and concrete, wood or ceramic tiles are assembled.

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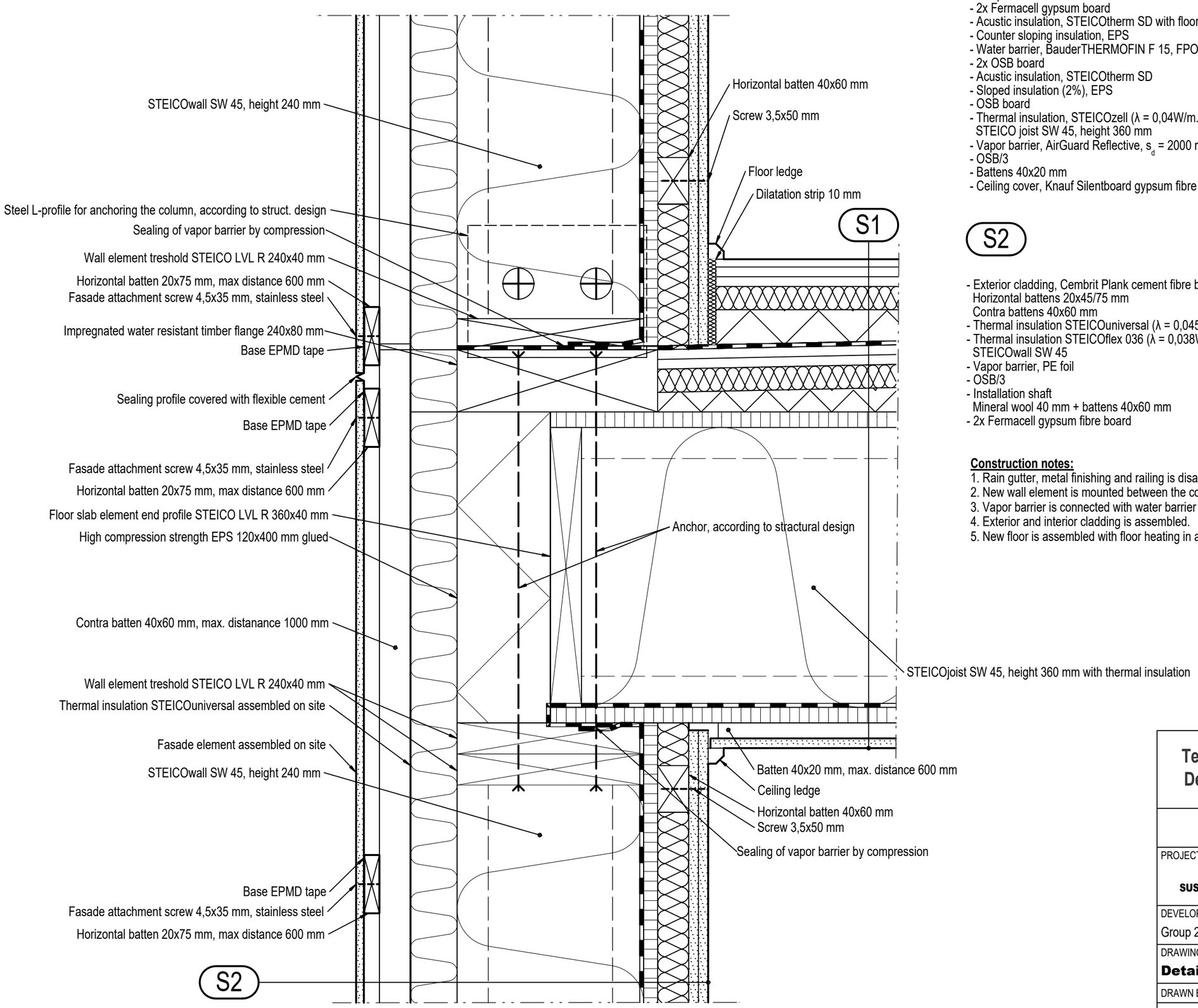
DEVELOPED BY: Group 2	LOCATION: København
DRAWING TITLE: **Detail 3 - Terrace + Wall connection**	
DRAWN BY: Zdeněk Hlavsa	DATE: 25.06.2019
SCALE: 1:5	DRAWING NO.: 7

A3-4_Detail 4 – Terrace + Wall connection (P3)_1:5

Detail 4: Terrace + Wall connection (phase 3)
Scale 1:5



S1

- Parquete or laminate floor	10 mm
- 2x Fermacell gypsum board	25 mm
- Acustic insulation, STEICOtherm SD with floor heating	30 mm
- Counter sloping insulation, EPS	10 - 85 mm
- Water barrier, BauderTHERMOFIN F 15, FPO-PP foil, s_d = 300 m	1,5 mm
- 2x OSB board	25 mm
- Acustic insulation, STEICOtherm SD	30 mm
- Sloped insulation (2%), EPS	25-100 mm
- OSB board	18 mm
- Thermal insulation, STEICOzell (λ = 0,04W/m.K)	360 mm
STEICO joist SW 45, height 360 mm	
- Vapor barrier, AirGuard Reflective, s_d = 2000 m	0,43 mm
- OSB/3	18 mm
- Battens 40x20 mm	
- Ceiling cover, Knauf Silentboard gypsum fibre board	12,5 mm

S2

- Exterior cladding, Cembrit Plank cement fibre boards	8 mm
Horizontal battens 20x45/75 mm	
Contra battens 40x60 mm	
- Thermal insulation STEICOuniversal (λ = 0,045W/m.K)	60 mm
- Thermal insulation STEICOflex 036 (λ = 0,038W/m.K)	240 mm
STEICOwall SW 45	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Installation shaft	40 mm
Mineral wool 40 mm + battens 40x60 mm	
- 2x Fermacell gypsum fibre board	12,5 mm

Construction notes:

1. Rain gutter, metal finishing and railing is disassembled.
2. New wall element is mounted between the columns and anchored to the columns with screws.
3. Vapor barrier is connected with water barrier of the terrace floor.
4. Exterior and interior cladding is assembled.
5. New floor is assembled with floor heating in acustic insulation.

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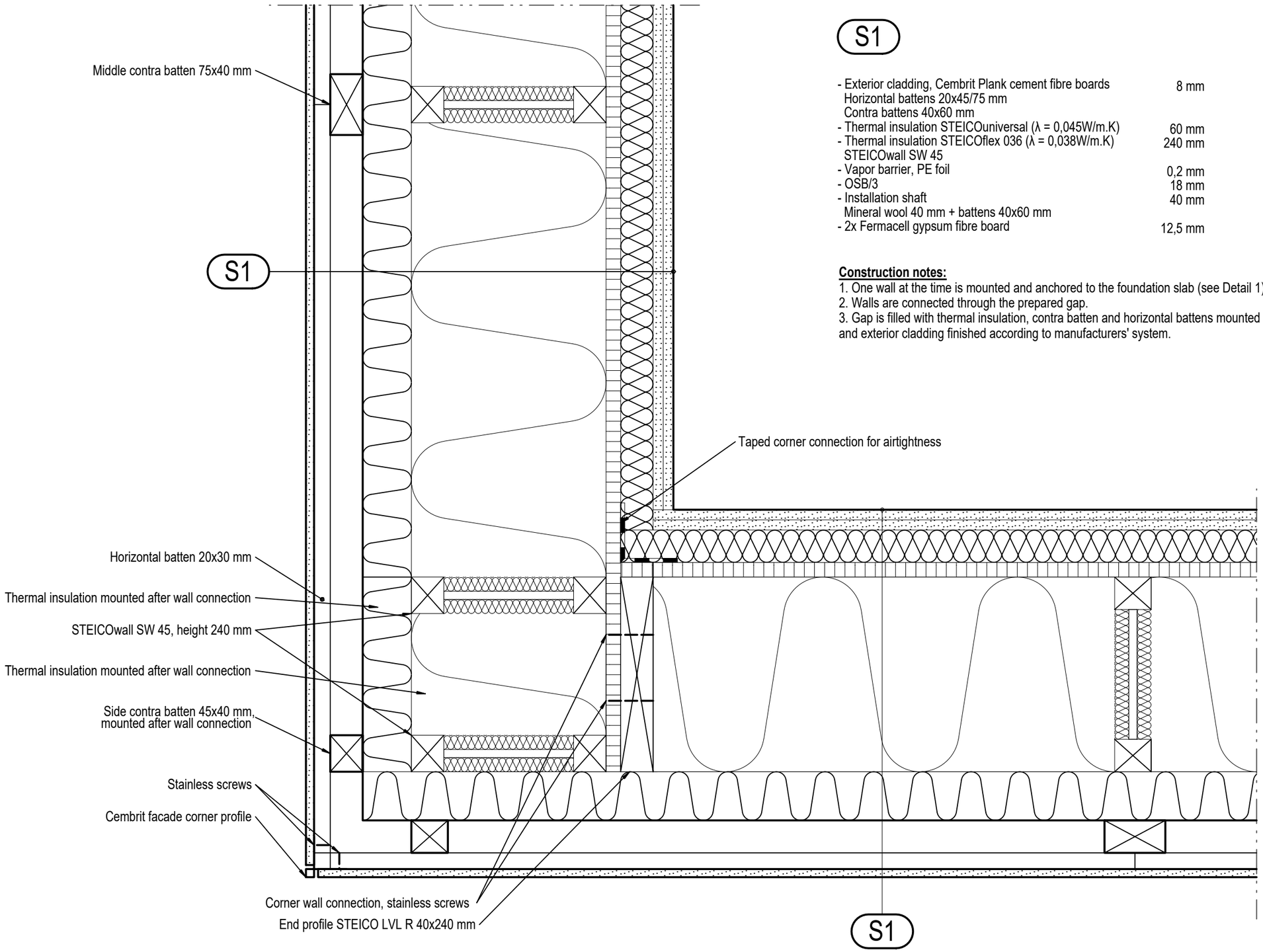
DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:
Detail 4 - Terrace + Wall connection (phase 3)

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:5	DRAWING NO.:	8

A3-5_Detail 5 – Walls connection_1:5

Detail 5: Walls connection
Scale 1:5



S1

- Exterior cladding, Cembrit Plank cement fibre boards	8 mm
Horizontal battens 20x45/75 mm	
Contra battens 40x60 mm	
- Thermal insulation STEICOuniversal (λ = 0,045W/m.K)	60 mm
- Thermal insulation STEICOflex 036 (λ = 0,038W/m.K)	240 mm
STEICOwall SW 45	
- Vapor barrier, PE foil	0,2 mm
- OSB/3	18 mm
- Installation shaft	40 mm
Mineral wool 40 mm + battens 40x60 mm	
- 2x Fermacell gypsum fibre board	12,5 mm

Construction notes:

1. One wall at the time is mounted and anchored to the foundation slab (see Detail 1)
2. Walls are connected through the prepared gap.
3. Gap is filled with thermal insulation, contra batten and horizontal battens mounted and exterior cladding finished according to manufacturers' system.

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DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:

Detail 5 - Walls connection

DRAWN BY:	Zdeněk Hlavsa	DATE:	25.06.2019
SCALE:	1:5	DRAWING NO.:	9

A4-1_Elevation South Façade_1:50

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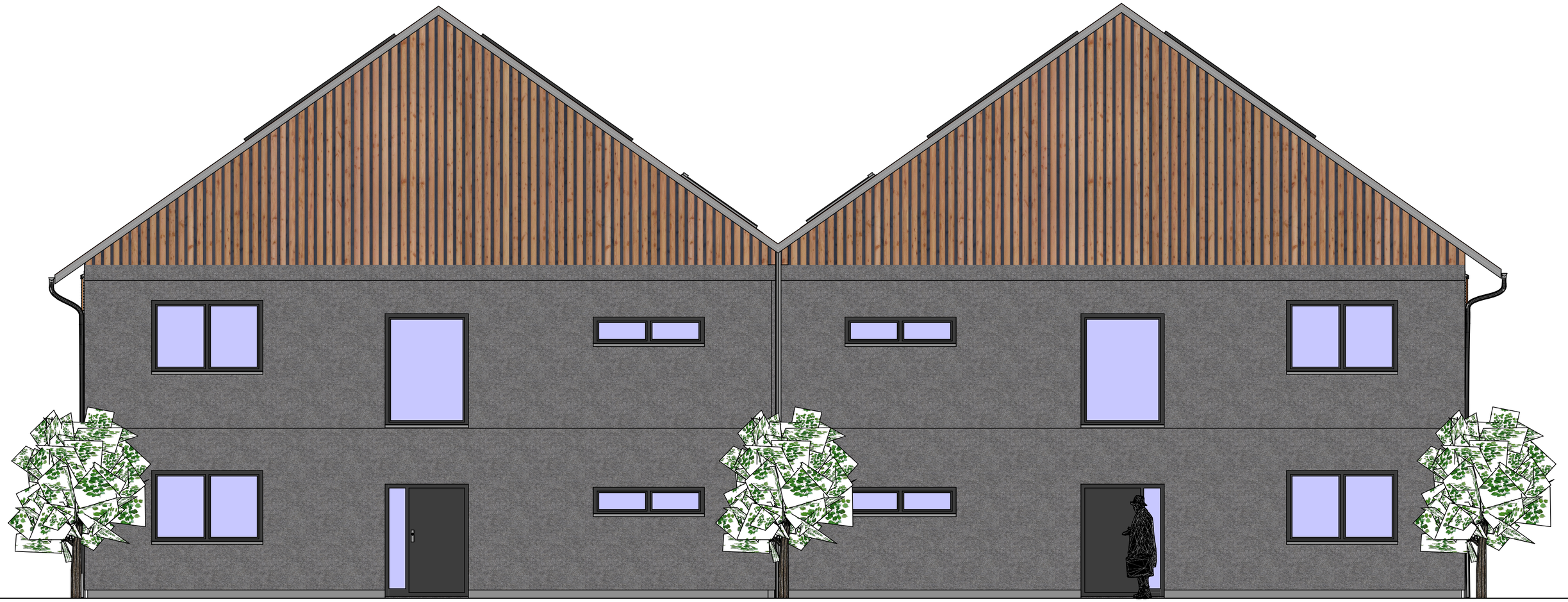
DEVELOPED BY:	LOCATION:
Group 2	København

DRAWING TITLE:

Elevation - South facade

DRAWN BY: Zdeněk Hlavsa	DATE: 25.06.2019
SCALE: 1:50	DRAWING NO.: 10

A4-2_Elevation North Façade_1:50



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DEVELOPED BY:	LOCATION:
Group 2	København

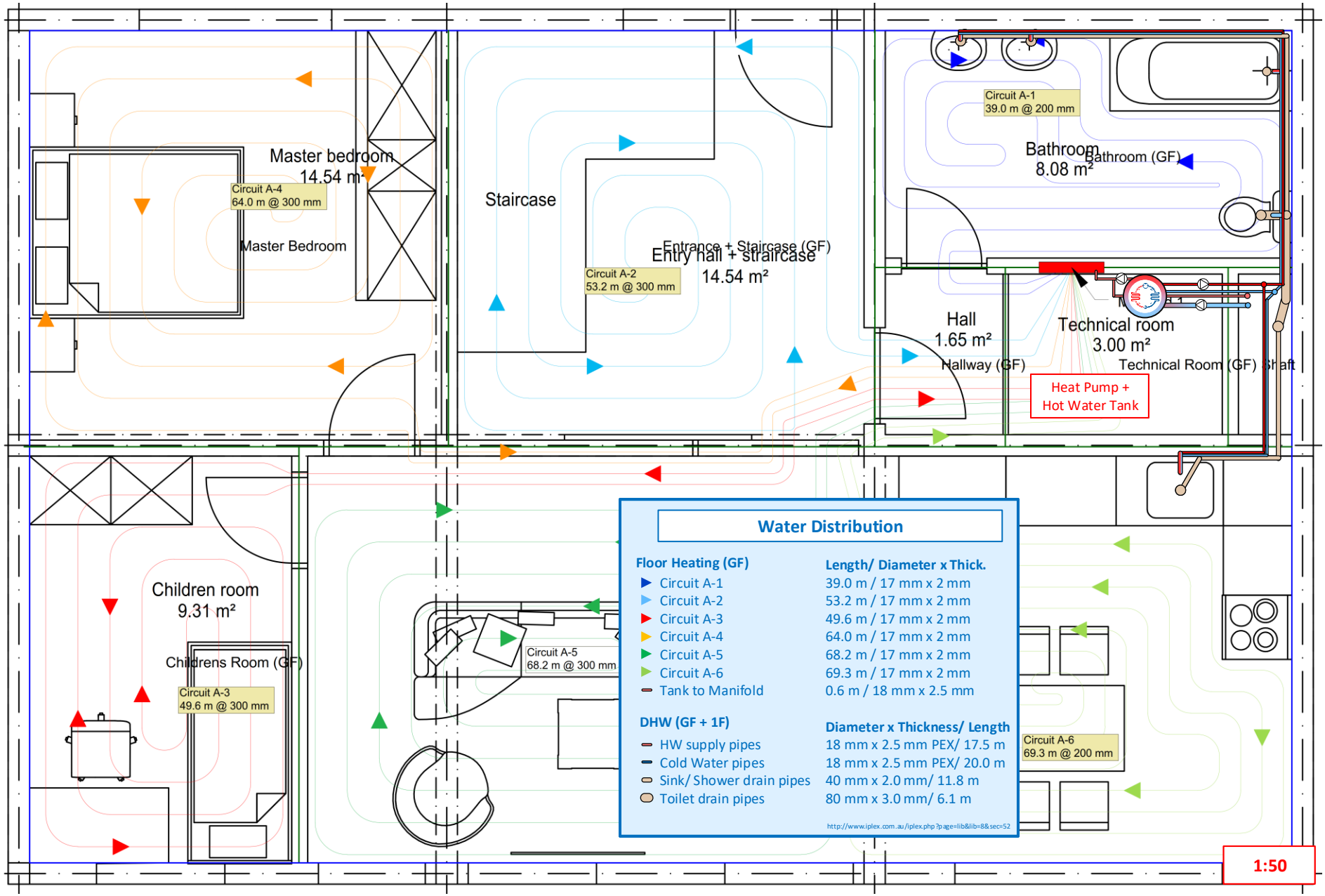
DRAWING TITLE:

Elevation - North facade

DRAWN BY: Zdeněk Hlavsa	DATE: 25.06.2019
SCALE: 1:50	DRAWING NO.: 11

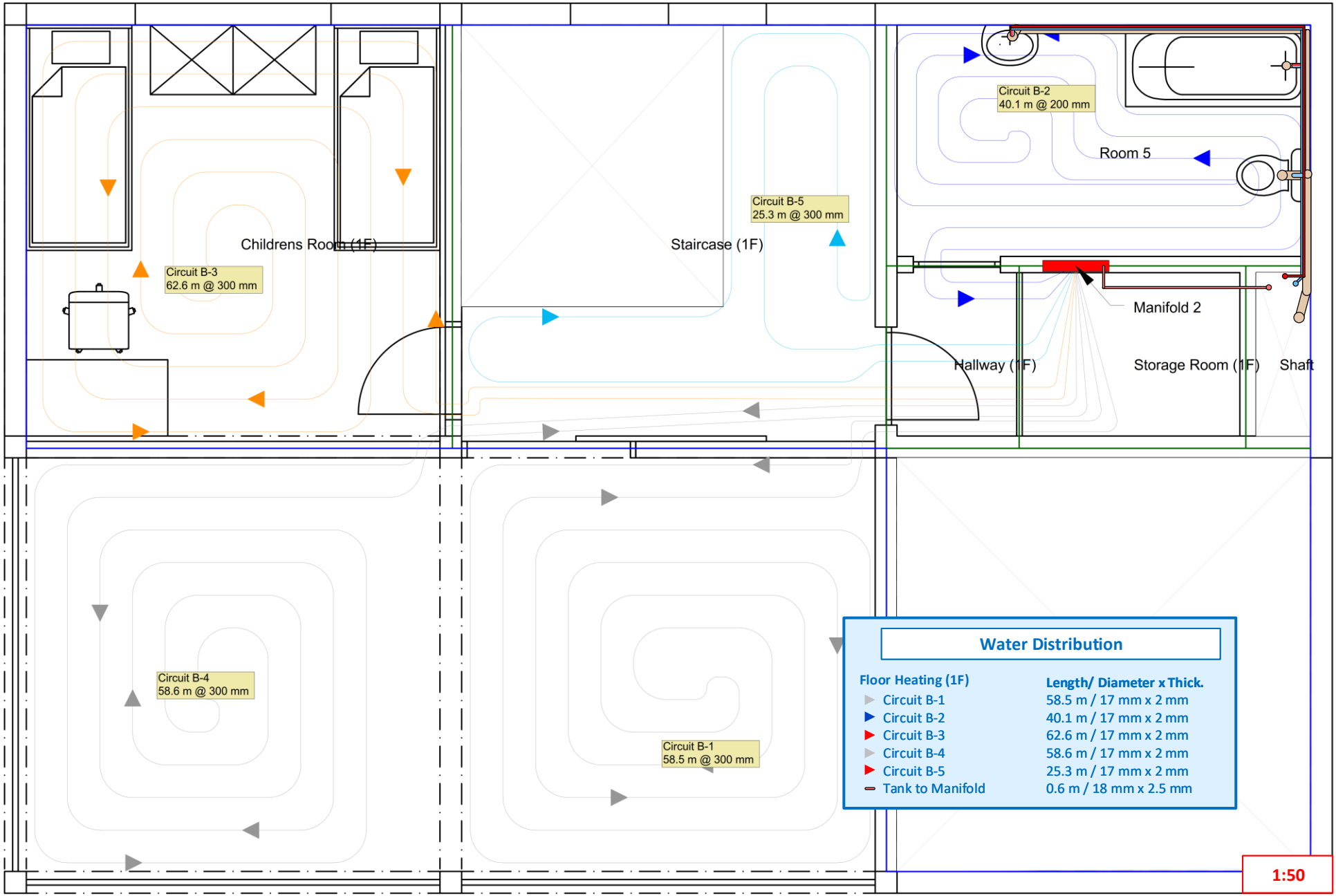
A5-1_Water System - Ground Floor_1:50

FLOOR HEATING LAYOUT – GROUND FLOOR

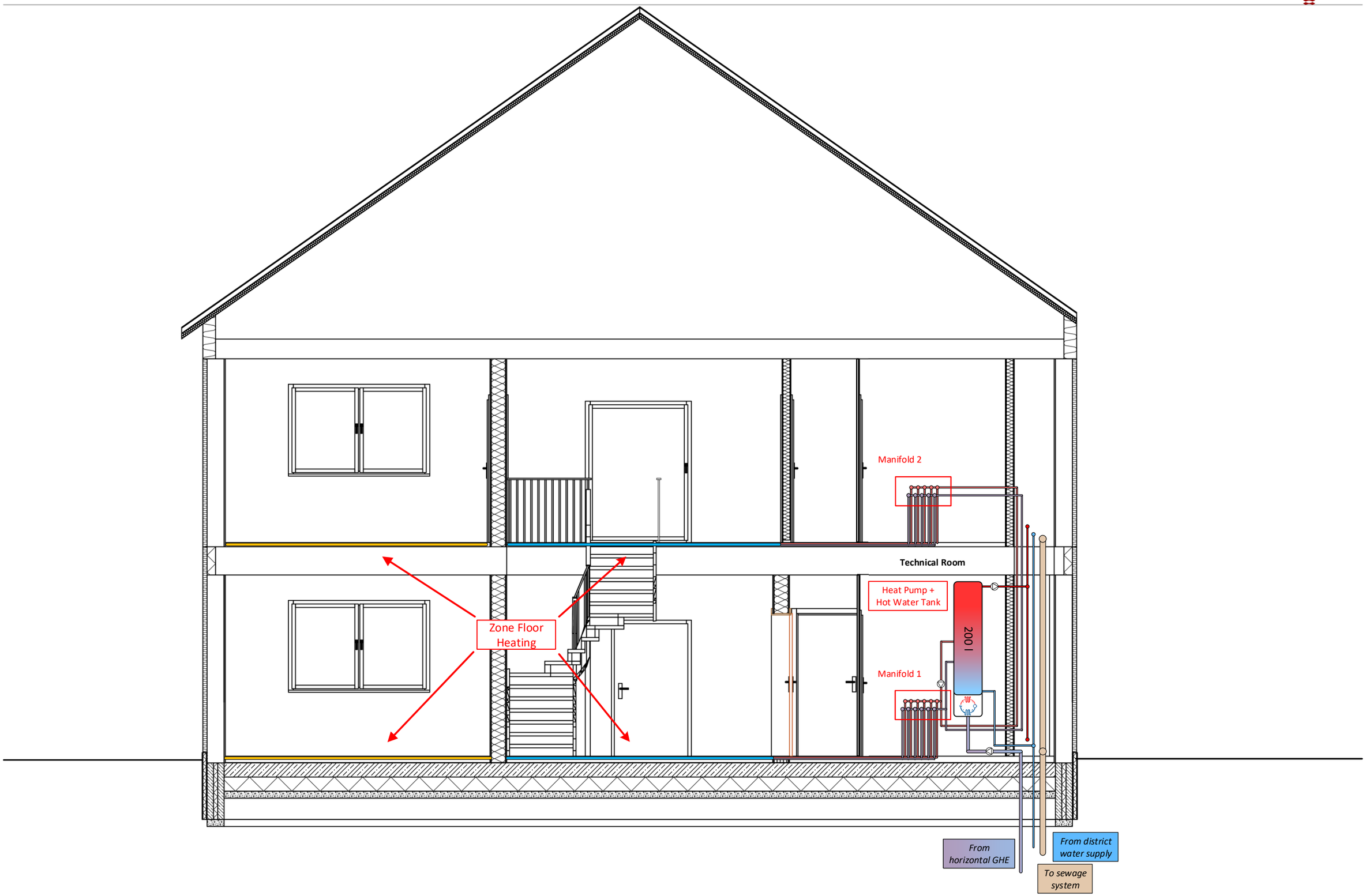


A5-2_Water System - First Floor_1:50

FLOOR HEATING LAYOUT – FIRST FLOOR



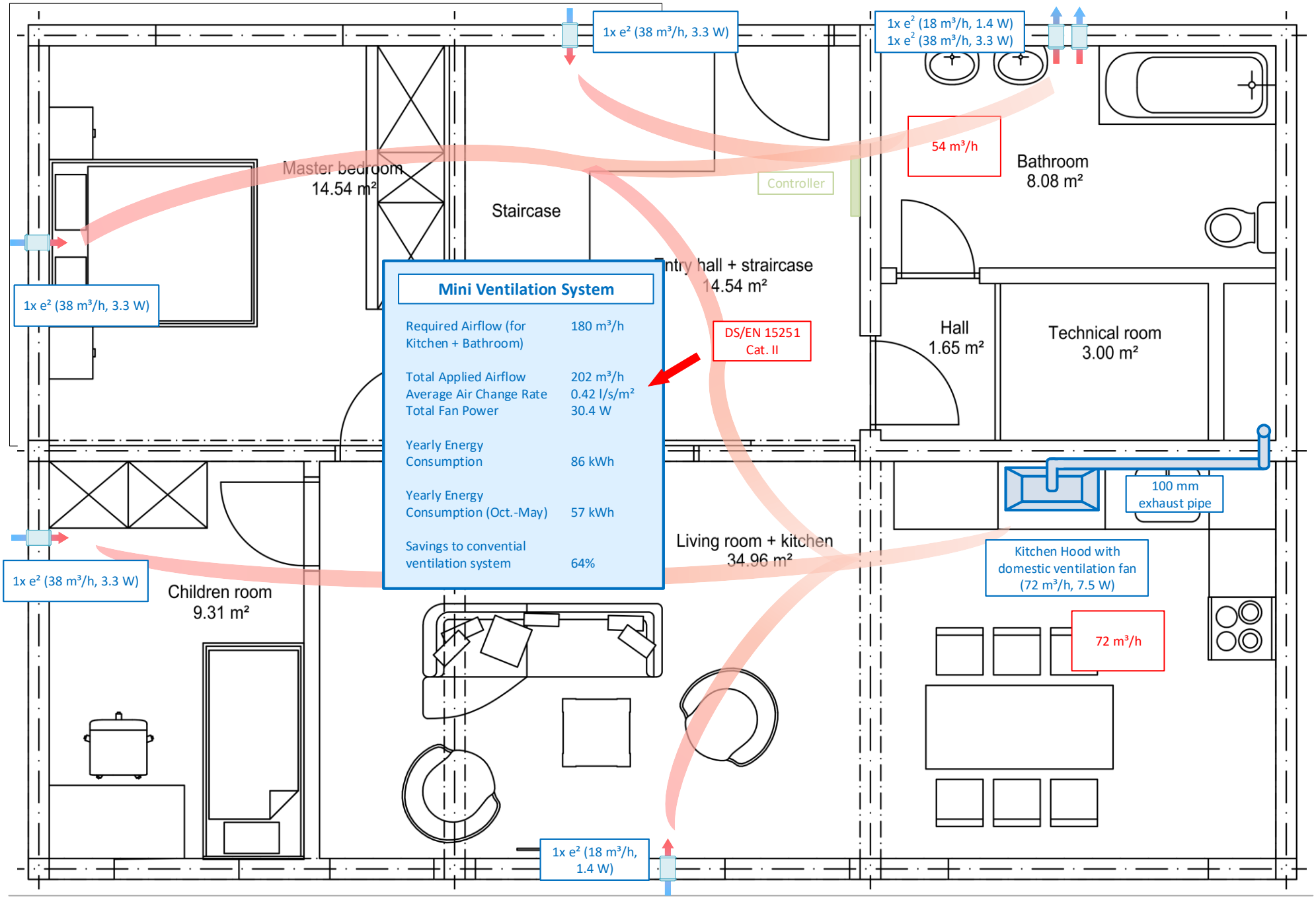
A5-3_Water System – Section_1:50


Manifold 2
Technical Room
Heat Pump +
Hot Water Tank
200 l
Zone Floor
Heating
Manifold 1
From
horizontal GHE
From district
water supply
To sewage
system

1:50

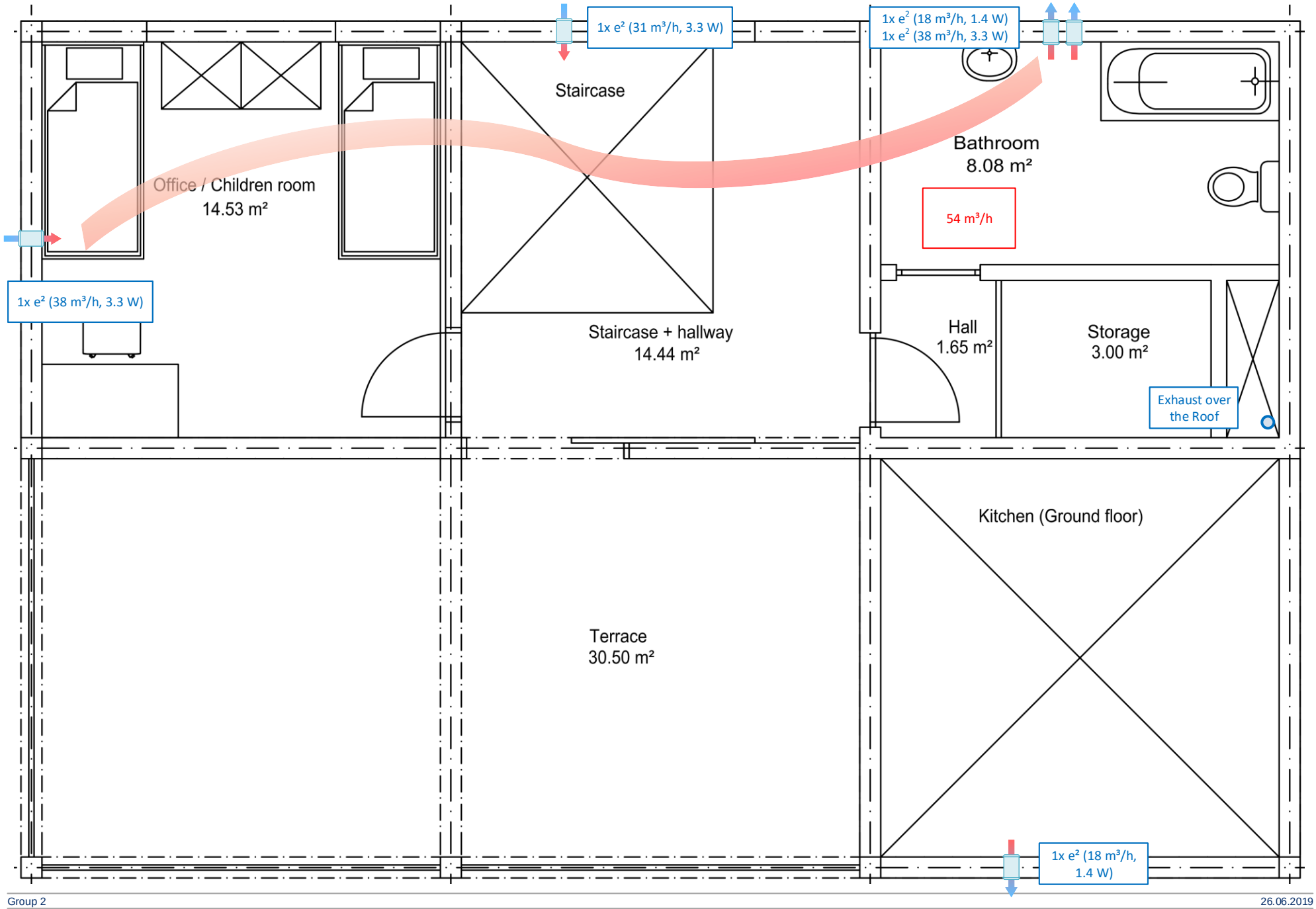
A6-1_Ventilation Layout - Ground Floor_1:50

VENTILATION LAYOUT – GROUND FLOOR



A6-2_Ventilation Layout - First Floor_1:50

VENTILATION LAYOUT – 1. FLOOR



A6-3_Ventilation Design & Energy Calculation

Decentralized Ventilation System - Design Validation & Energy Calculation

Name	Floor area, m2	Required Exhaust Air Flow, l/s	Required Inlet Air Flow, l/s/m²	Required Inlet Air Flow, l/s	Required Exhaust Air Flow, m³/h	Required Inlet Air Flow, m³/h	Mini Ventilation e²					Kitchen Hood Exhaust Fan					Total Air Flow, m³/h	Total Power, W
							Air flow, m³/h	Power, W	Quantity	Total Air flow	Total Power, W	Air flow, m³/h	Power, W	Quantity	Total Air flow	Total Power, W		
Master Bedroom (GF)	14.73		0.57	8.37	0	30	38	3.3	1	38	3.3						38	3
Entrance (GF)	14.54		0.57	8.26	0	30	38	2.8	1	38	2.8						38	3
Children Room (GF)	9.31		0.57	5.29	0	19	38	1.4	1	38	1.4						38	1
Bathroom Pod (GF)	8.075	15		0.00	54	0	18 38	2.8 1.4	1 1	56	4.2						56	4
Hall (GF)	1.575		0.57	0.89	0	3				0	0						0	0
Technical Room (GF)	3		0.57	1.70	0	6				0	0						0	0
Children Room (1F)	14.73		0.57	8.37	0	30	38	1.4	1	38	1.4						38	1
Staircase (1F)	14.54		0.57	8.26	0	30	31	2.8	1	31	2.8						31	3
Bathroom Pod (1F)	8.075	15		0.00	54	0	18 38	2.8 1.4	1 1	56	4.2						56	4
Hall (1F)	1.575		0.57	0.89	0	3				0	0						0	0
Storage (1F)	3		0.57	1.70	0	6				0	0						0	0
Shaft	0.75									0	0							
Living Room (GF)	19.75		0.57	11.22	0	40	18	1.4	1	18	1.4						18	1
Kitchen (GF + 1F)	14.5	25		0.00	90	0	18	1.4	1	18	1.4	72	7.5	1	72	7.5	90	9
TOTAL INLET	**128.15**	**55**		**55**		**198**	**201**	**13.1**	**6**	**201**	**13.1**						**201**	**13.1**
TOTAL OUTLET					**198**		**130**	**9.8**	**5**	**130**	**9.8**	**72**	**7.5**	**1**	**72**	**7.5**	**202**	**17.3**
		Double Height																**30.4**

Mounting examples

https://www.lunos.de/en/systems/

e² Fixed-matrix regenerator

16,5 dB at 18 m³/h 19,5 dB at31 m³/h 26 dB at 38 m³/h
1,4 W at 18 m³/h 2,8 W at 31 m³/h 3,3 W at 38 m³/h

e^go Dual fixed-matrix regenerator
(for balanced flow from one unit)

16,8 dB at 5 m³/h 24,0 dB at 10 m³/h 38,1 dB at 20 m³/h 38,1 dB at 45 m³/h exhaust air mode
1,0 W at 5 m³/h 1,7 W at 10 m³/h 4,5 W at 20 m³/h 4,9 W at 45 m³/h exhaust air mode

Technical data

Model	Speed	Frequency [Hz]	Voltage [V]	Power consumption [W]	Current [A]	r.p.m.	Maximum air capacity [m³/h]	Sound Pressure Level at 3 m [dB(A)]	Weight [kg]
VENTS Quietline 100	-	50	220-240	7.5	0.049	2100	100	25	0.61
VENTS Quietline 100 [220-240 W/60 Hz]		60							
VENTS Quietline 100 Duo	min.	50	220-240	4.5	0.029	1650	75	22	
	max.			7.5	0.049	2100	100	25	
VENTS Quietline 100 Duo [220-240 W/60 Hz]	min.	60	220-240	4.5	0.029	1650	75	22	
	max.			7.5	0.049	2100	100	25	
VENTS Quietline 100 12	-	50	12	7.5	0.99	2100	100	25	
VENTS Quietline 100 12 [12 W/60 Hz]		60							
Vents Quietline 125	-	50	220-240	13	0.085	2250	197	32	0.75
Vents Quietline 125 [220-240 W/60 Hz]		60							
Vents Quiteline 125 Duo	min.	50	220-240	10	0.065	1950	145	29	
	max.			13	0.085	2250	197	32	
Vents Quiteline 125 Duo [220-240 W/60 Hz]	min.	60	220-240	10	0.065	1950	145	29	
	max.			13	0.085	2250	197	32	
VENTS Quietline 150	-	50	220-240	22	0.095	2250	335	39	1.3
VENTS Quietline 150 [220-240 W/60 Hz]		60							
VENTS Quietline 150 Q	-	50	220-240	26	0.085	1900	305	37	
VENTS Quietline 150 Q [220-240 W/60 Hz]		60							
VENTS Quietline 150 Duo	min.	50/60	220-240	19	0.087	1950	250	36	
	max.			22	0.095	2250	335	39	
VENTS Quietline 150 Extra	min.	50/60	220-240	22	0.103	2300	285	36	
	max.			25	0.109	2600	375	41	

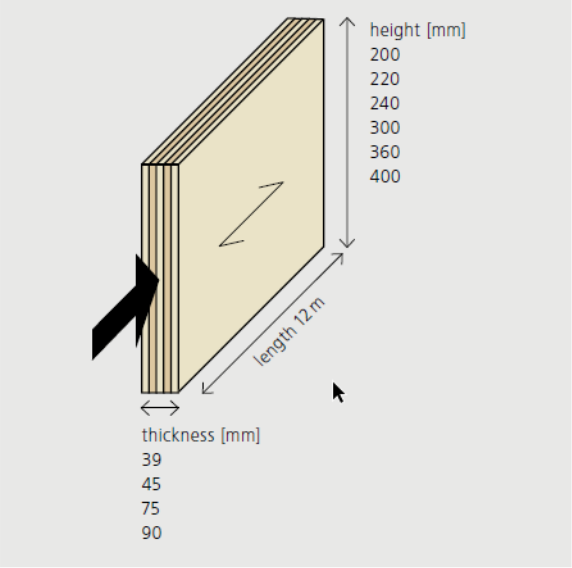
A7-1_Structural Report

Structural material

Here is the summary of the products and their properties which were used as a construction material for this project.

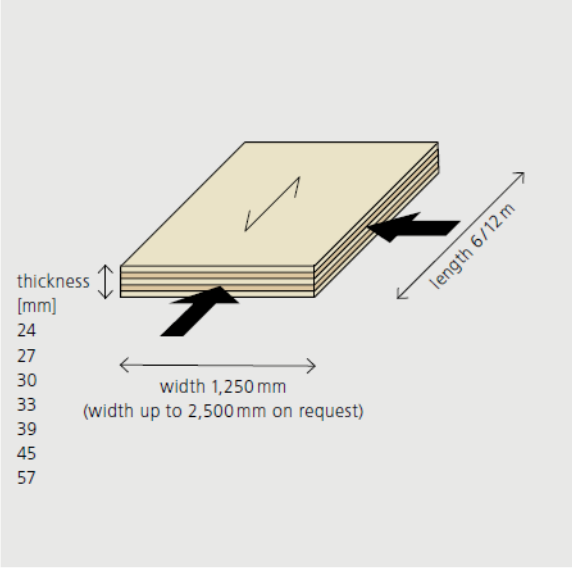
STEICO *LVL R*
Laminated Veneer Lumber

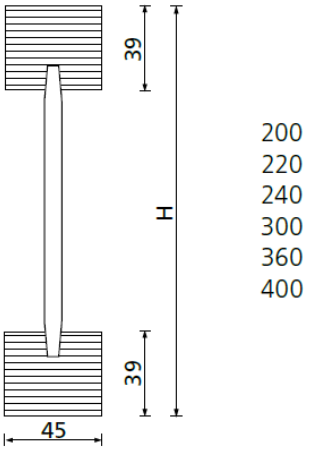
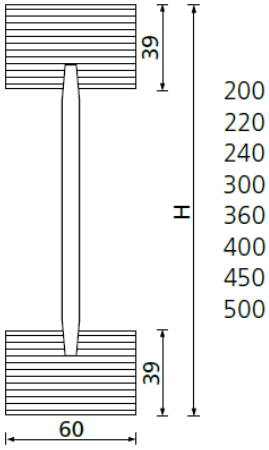
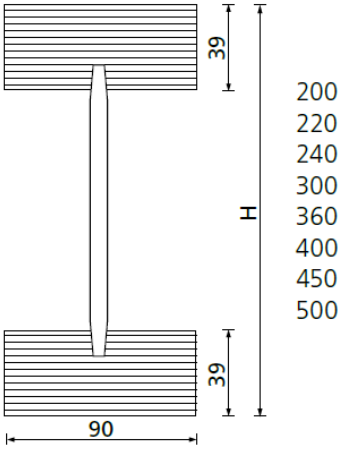
Powerful engineered timber product for rectangular cross-sections. With STEICO *LVL R* elements all veneer layers are glued together longitudinally.

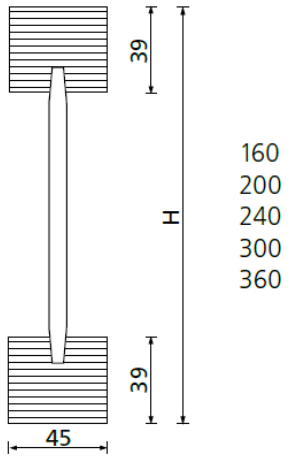
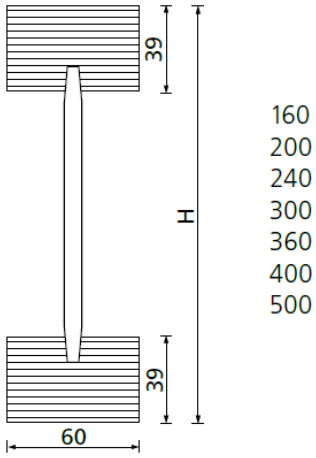
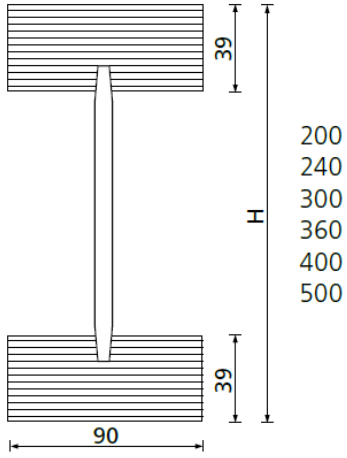


STEICO *LVL X*
Laminated Veneer Lumber with cross-layers

Cross laminated STEICO *LVL X* means that ca. one-fifth of the veneers are glued crosswise – improving the lateral bending strength and stiffness of the joist.



STEICO*joist* SJ_L 45	STEICO*joist* SJ_L 60	STEICO*joist* SJ_L 90
		
Package = 43 pieces/package	Package = 33 pieces/package	Package = 23 pieces/package

STEICO*wall* SW$_L$ 45	STEICO*wall* SW$_L$ 60	STEICO*wall* SW$_L$ 90
		
Package = 43 pieces/package	Package = 33 pieces/package	Package = 23 pieces/package

Explanation of the mechanical properties

The following table describes the relation between support, loading and labelling. The symbols refer to the table "Mechanical properties of STEICO *LVL*" on the previous page.

Bending stregth f_m and elastic modulus E

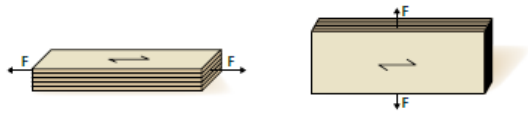
A $f_{m,0,edge}$ and $E_{0,edge}$ Edgewise, parallel to grain♦

B $f_{m,90,edge}$ and $E_{90,edge}$ Edgewise, perp. to grain♦♦

C $f_{m,0,flat}$ and $E_{0,flat}$ Flatwise, parallel to grain♦

D $f_{m,90,flat}$ and $E_{90,flat}$ Flatwise, perp. to grain♦♦

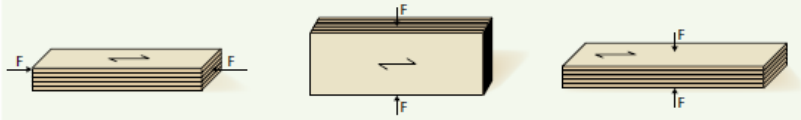
Tensile strength f_t



E $f_{t,0}$ parallel to grain♦

F $f_{t,90,edge}$ Edgewise, perp. to grain♦♦

Compressive strength f_c

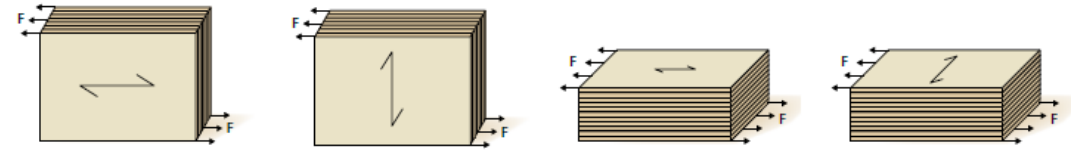


G $f_{c,0}$ parallel to grain♦

H $f_{c,90,edge}$ Edgewise, perp. to grain♦♦

I $f_{c,90,flat}$ Flatwise, parallel to grain♦♦

Shear strength f_v and modulus G



J $f_{v,0,edge}$ and $G_{0,edge}$ Edgewise, parallel to grain♦

K $f_{v,90,edge}$ Edgewise, perp. to grain♦♦

L $f_{v,0,flat}$ and $G_{0,flat}$ Flatwise, parallel to grain♦

M $f_{v,90,flat}$ and $G_{90,flat}$ Flatwise, perp. to grain♦♦

♦ parallel to the top veneer grain ♦♦ perpendicular to the top veneer grain

Main parameters	Symbol	Figure	Unit	STEICO *LVL R*	STEICO *LVL X* (t ≤ 24 mm)	STEICO *LVL X* (t ≥ 27 mm)
Bending strength						
Edgewise, parallel to grain (depth 300 mm)	$f_{m,0,edge,k}$	A	N/mm²	44	30	32
Size effect parameter	s	–		0.15	0.15	0.15
Edgewise, perpendicular to grain (depth 300 mm)	$f_{m,90,edge,k}$	B	N/mm²	NPD	10	8
Flatwise, parallel to grain	$f_{m,0,flat,k}$	C	N/mm²	50	32	36
Flatwise, perpendicular to grain	$f_{m,90,flat,k}$	D	N/mm²	NPD	7	8
Tensile strength						
Parallel to grain (length 3 000 mm)	$f_{t,0,k}$	E	N/mm²	36	18	18
Perpendicular to grain, edgewise	$f_{t,90,edge,k}$	F	N/mm²	0.9	7	5
Compression strength						
Parallel to grain	$f_{c,0,k}$	G	N/mm²	40	26	30
Perpendicular to grain, edgewise	$f_{c,90,edge,k}$	H	N/mm²	7.5	9	9
Perpendicular to grain, flatwise	$f_{c,90,flat,k}$	I	N/mm²	3.6	4	4
Shear strength						
Edgewise parallel to grain	$f_{v,0,edge,k}$	J	N/mm²	4.6	4.6	4.6
Edgewise perpendicular to grain	$f_{v,90,edge,k}$	K	N/mm²	NPD	4.6	4.6
Flatwise, parallel to grain	$f_{v,0,flat,k}$	L	N/mm²	2.6	1.1	1.1
Flatwise, perpendicular to grain	$f_{v,90,flat,k}$	M	N/mm²	NPD	1.1	1.1
Modulus of elasticity						
Parallel to grain	$E_{0,mean}$	A C	N/mm²	14,000	10,000	10,600
Parallel to grain	$E_{0,k}$	A C	N/mm²	12,000	9,000	9,000
Perpendicular to grain, edgewise	$E_{90,edge,mean}$[1]	B	N/mm²	430	3,500	3,000
Perpendicular to grain, edgewise	$E_{90,edge,k}$[2]	B	N/mm²	350	2,700	2,300
Perpendicular to grain, flatwise	$E_{m,90,flat,mean}$	D	N/mm²	NPD	1,300	2,500
Perpendicular to grain, flatwise	$E_{m,90,flat,k}$	D	N/mm²	NPD	1,000	1,800
Shear modulus						
Edgewise, parallel to grain	$G_{0,edge,mean}$	J	N/mm²	600	600	600
Edgewise, parallel to grain	$G_{0,edge,k}$	J	N/mm²	400	400	400
Flatwise, parallel to grain	$G_{0,flat,mean}$	L	N/mm²	560	150	150
Flatwise, parallel to grain	$G_{0,flat,k}$	L	N/mm²	400	130	130
Flatwise, perpendicular to grain	$G_{90,flat,mean}$	M	N/mm²	NPD	150	150
Flatwise, perpendicular to grain	$G_{90,flat,k}$	M	N/mm²	NPD	130	130
Density						
Mean value	ρ_{mean}	–	kg/m³	550	530	530
Fifth percentile value	ρ_k	–	kg/m³	480	480	480
Reaction to fire	–	–	–	D-s1, d0	D-s1, d0	D-s1, d0
Release of formaldeyde	–	–	–	E1	E1	E1
Natural durability against biological attack	–	–	–	4	4	4

Load according to Eurocode 1

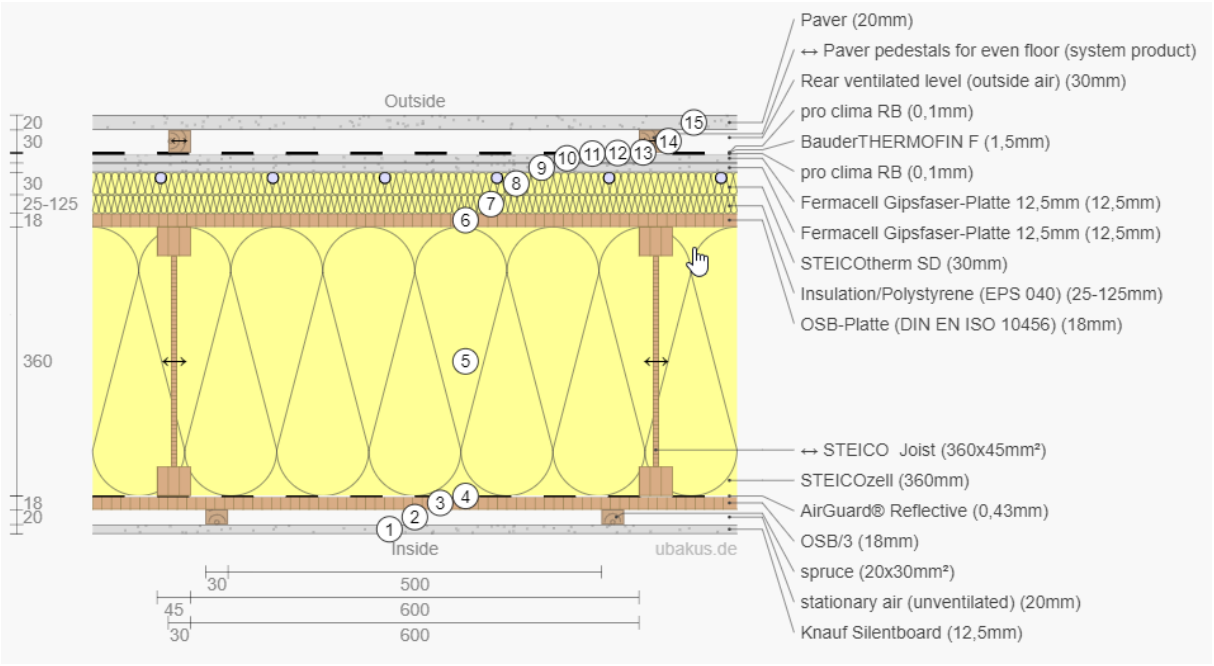
Dead load

Self-weight

Since almost every assessment is made in software where self weight load is automaticaly considered, only in necessary cases will be self-weight load mentioned.

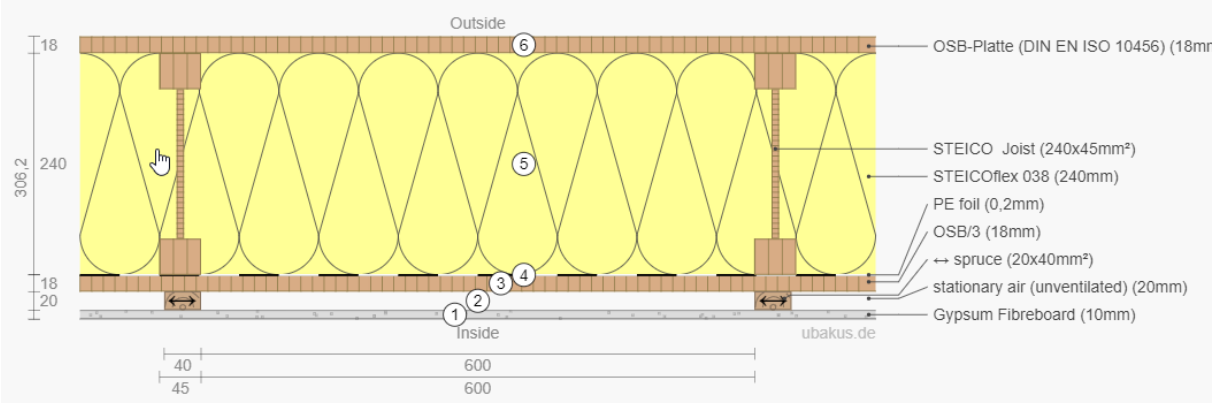
Floors

Terrace



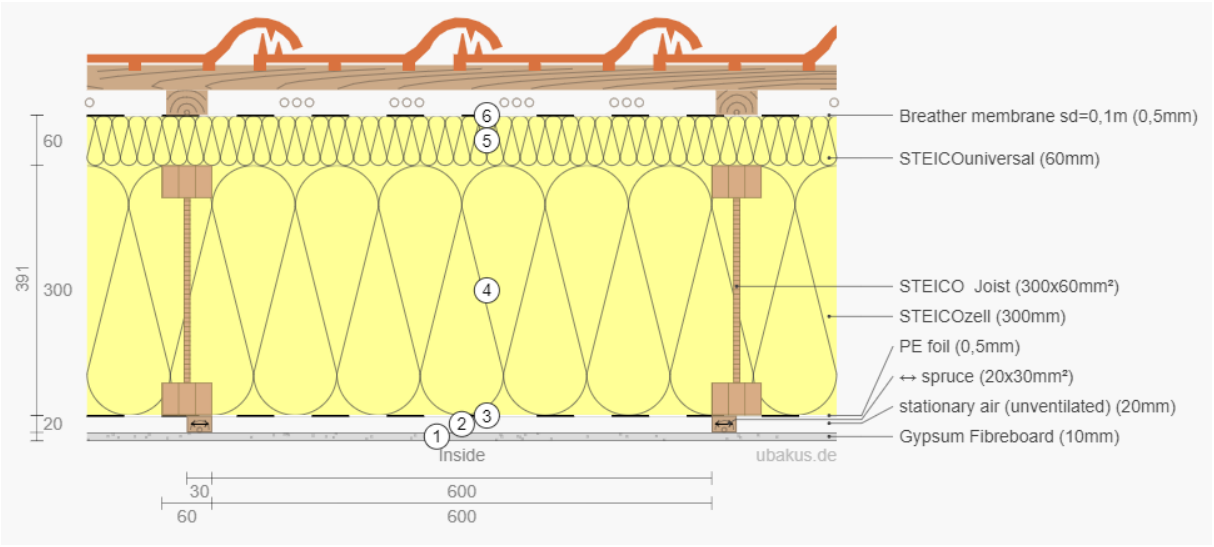
layer name	g_k [kN/m²]
floor construction	1,5
2x OSB	0,3
thermal insulation + beams	0,2
gypsum boards + battens	0,15
	2,15

Upper floor slab



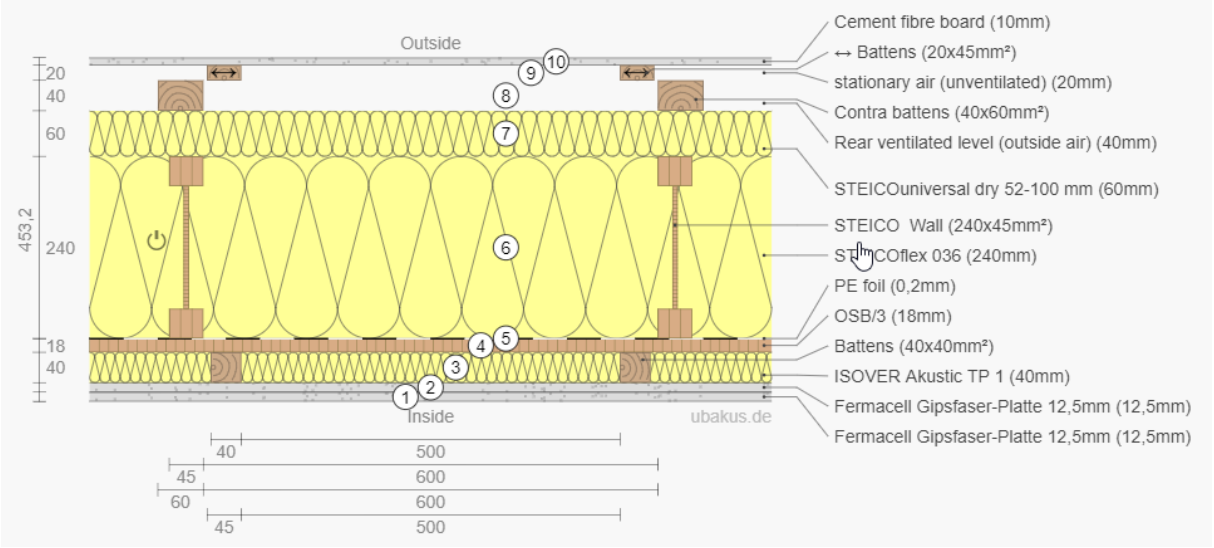
layer name	**g_k [kN/m²]**
2x OSB	0,3
thermal insulation + beams	0,2
gypsum boards + battens	0,15
	0,65

Roof



popis vrstvy	**g_k [kN/m²]**
roof tiles + battens	0,55
thermal insulation	0,15
thermal insulation + beams	0,25
PE + battens + gypsum	0,15
	1,1

Exterior walls



popis vrstvy	**g_k [kN/m^2]**
exterior cladding + battens	0,2
thermal insulation 60 mm	0,15
thermal insulation + beams	0,2
OSB board	0,15
mineral wool + gypsum board + battens	0,2
	0,9

Partition walls

Since any of the partition walls does not exceed load of 1,0 kN/m‘, complementary uniform load of 0,5 kN/m^2 can be taken into account.

Live load

Imposed load

According to Eurocode 1, imposed load in residential building is equal to 2,0 kN/m^2. Roof was determined as non-accessible with imposed load 0,75 kN/m^2, but snow load will be considered instead since it’s more relevant.

Snow load

Snow load was determined using software FIN EC 2019 Loading.

1 Loading report: Snow load

Load according to EN 1991-1-3

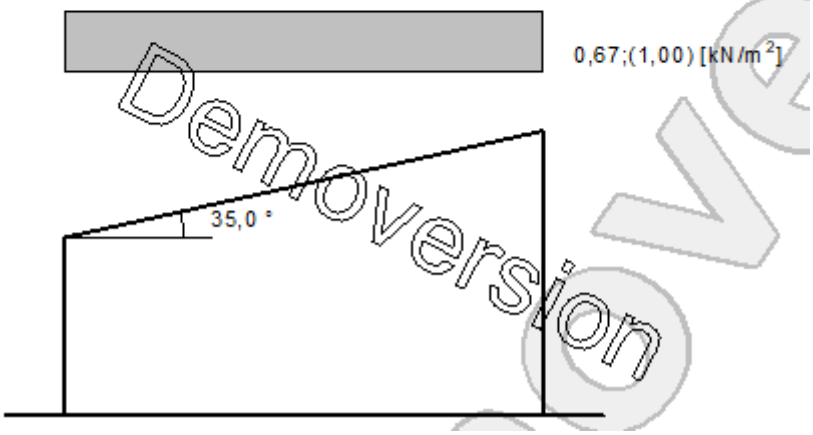
Characteristic value of load	s_k	= 1,00 kN/m²
Landscape type:		common
Exposition coefficient	C_e	= 1,00
Thermal coefficient	C_t	= 1,00
Load factor	γ_f	= 1,50

Roofing type: mono pitch roof

Roof slope	α	= 35,0 °
Shape coefficient	μ_1	= 0,67

Characteristic load value (design value in brackets)

s_1 = 0,67 kN/m² (1,00 kN/m²)



Wind load

Wind load was determined using software FIN EC 2019 Loading.

Wind load on roof:

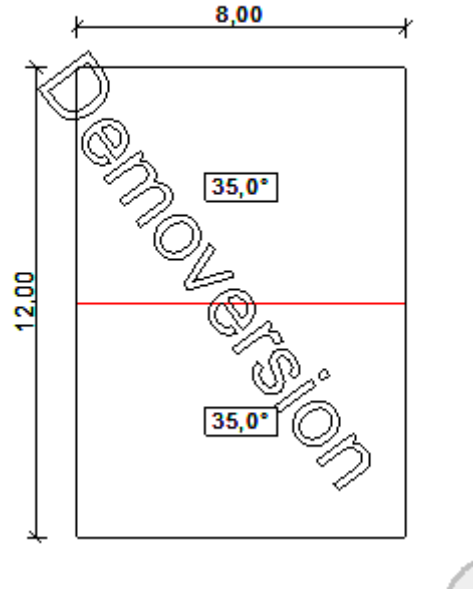
1 Loading report: Wind load

Load according to EN 1991-1-4

Wind speed	$v_{b,0}$	=	24,00	m/s
Terrain category:			II	
Building reference height	z_e	=	10,20	m
Wind direction coefficient	c_{dir}	=	1,00	
Season coefficient	c_{season}	=	1,00	
Air mass density	ρ	=	1,250	kg/m^3
Orographical factor	c_o	=	1,00	
Maximum dynamic pressure	q_p	=	0,85	kN/m^2
Load factor	γ_f	=	1,50	
Area for determination c_{pe}	A	=	96,00	m^2

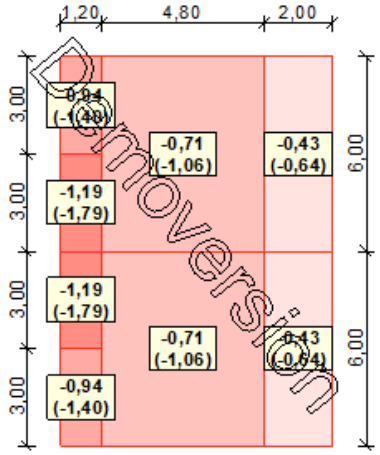
Roof

Constr. measurements

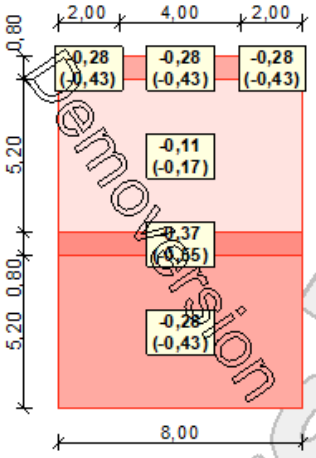


Characteristic load values (design values in brackets)

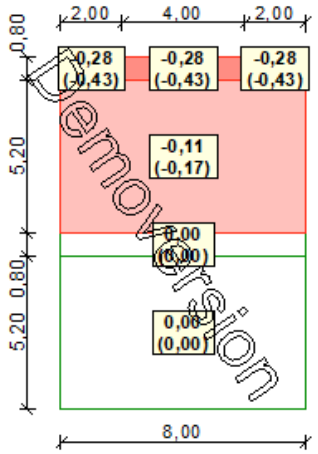
Wind from left (suction) [kN/m²]



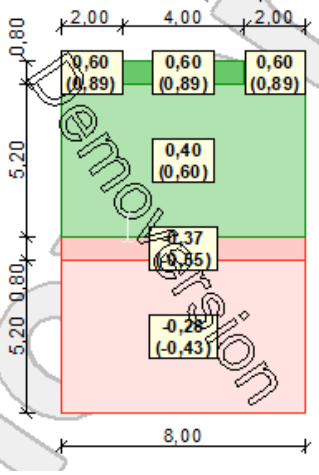
Wind from above 1 (suction) [kN/m²]



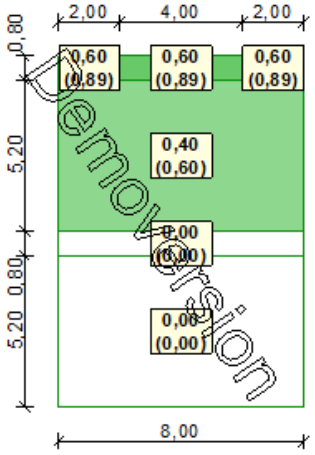
Wind from above 2 (suction) [kN/m²]



Wind from above 3 (Compression and suction) [kN/m²]



Wind from above 4 (compression) [kN/m²]



Wind load on facade:

LOADING REPORT: WIND LOAD

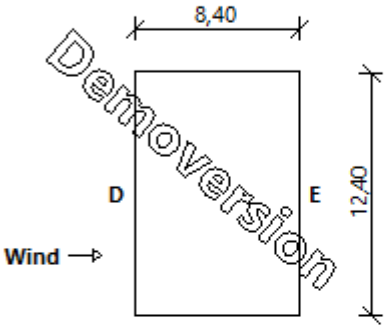
Load according to EN 1991-1-4

Wind speed	$v_{b,0}$	= 24,00	m/s
Terrain category:		II	
Building reference height	z_e	= 10,20	m
Wind direction coefficient	c_{dir}	= 1,00	
Season coefficient	c_{season}	= 1,00	
Air mass density	ρ	= 1,250	kg/m³
Orographical factor	c_o	= 1,00	
Maximum dynamic pressure	q_p	= 0,85	kN/m²
Load factor	γ_f	= 1,50	
Area for determination c_{pe}	A	= 98,00	m²

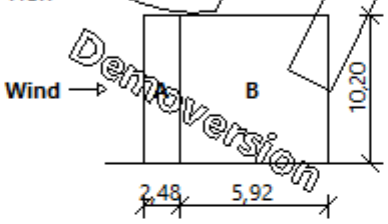
Walls of rectangular plan buildings - direction 1

Object height h = 10,20 m
Object length d = 8,40 m
Object width b = 12,40 m

Plan



View



Characteristic load values (design values in brackets)

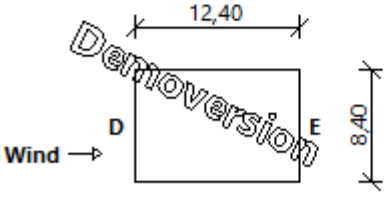
Height above terrain	Wind pressure in areas [kN/m²]			
[m]	A	B	D	E
10,20	-0,88 (-1,31)	-0,58 (-0,88)	0,58 (0,88)	-0,37 (-0,56)

Insufficient correlation of pressures is considered by the coefficient 0,86.

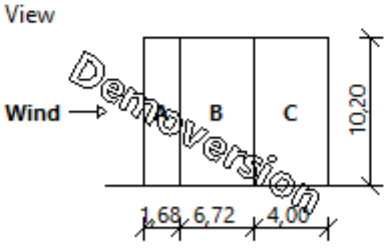
Walls of rectangular plan buildings - direction 2

Object height h = 10,20 m
Object length d = 12,40 m
Object width b = 8,40 m

Plan



View



Characteristic load values (design values in brackets)

Height above terrain	Wind pressure in areas [kN/m²]				
[m]	A	B	C	D	E
10,20	-0,87 (-1,30)	-0,58 (-0,87)	-0,36 (-0,54)	0,56 (0,84)	-0,33 (-0,49)

Insufficient correlation of pressures is considered by the coefficient 0,85.

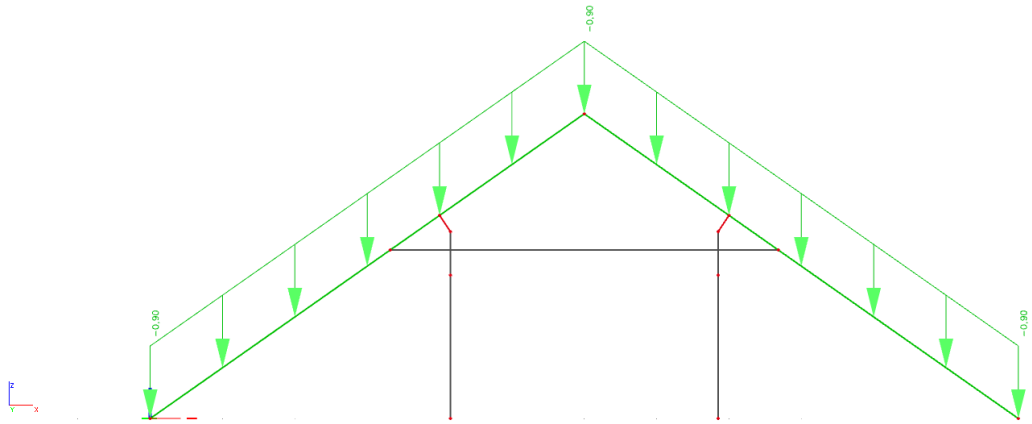
Assessment of load-bearing components

All the main horizontal elements will be assessed in software STEICOxpress which provides effective and reliable tool to design constructions made of STEICO products. This apply for roof rafters, roof purlins, upper roof floor beams and first floor beams.

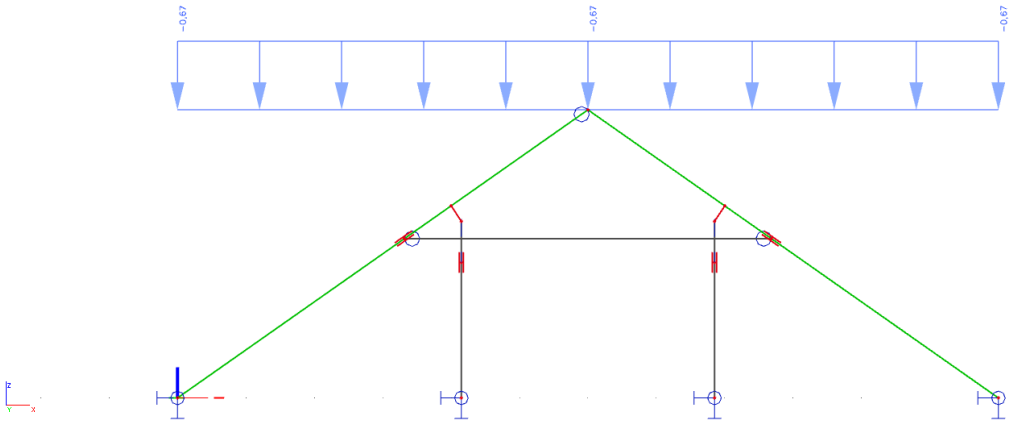
Roof

Load cases:

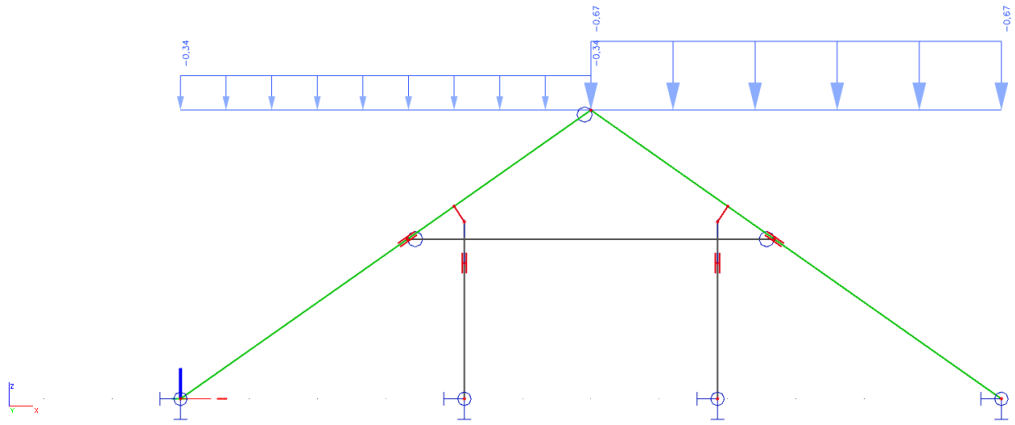
1. Dead load



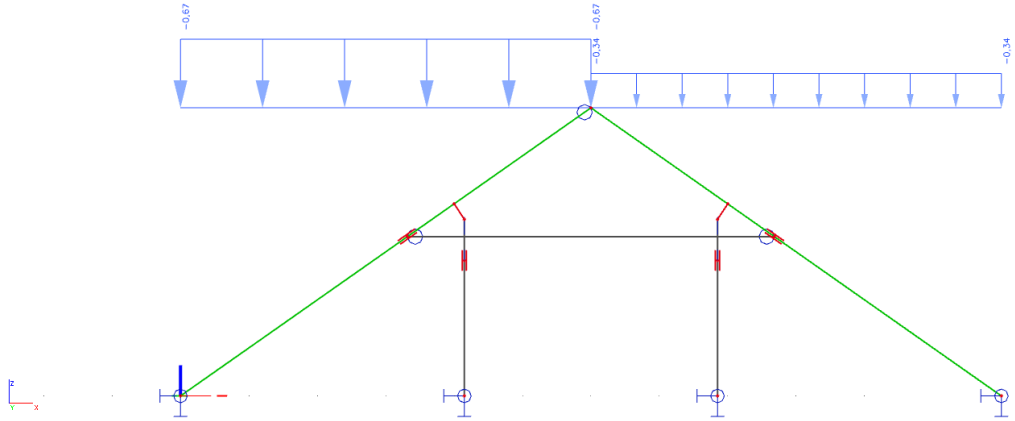
2. Snow load full



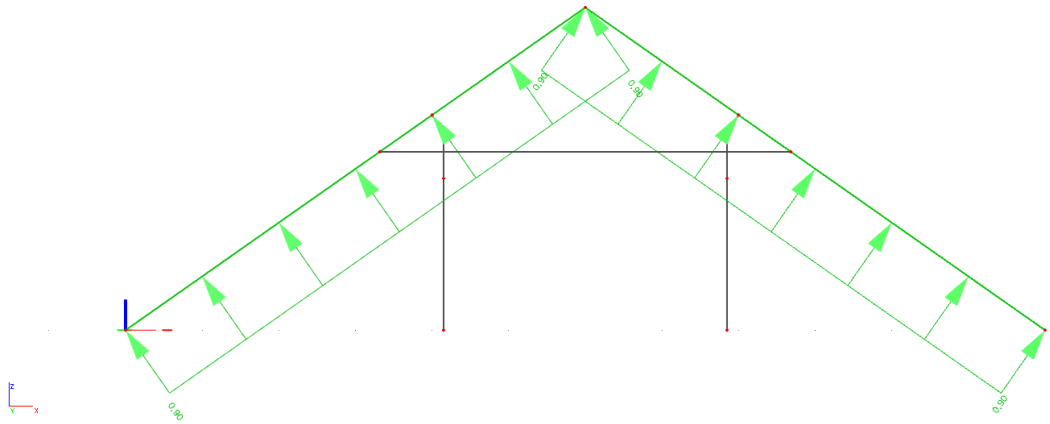
3. Snow load ½ left and full right



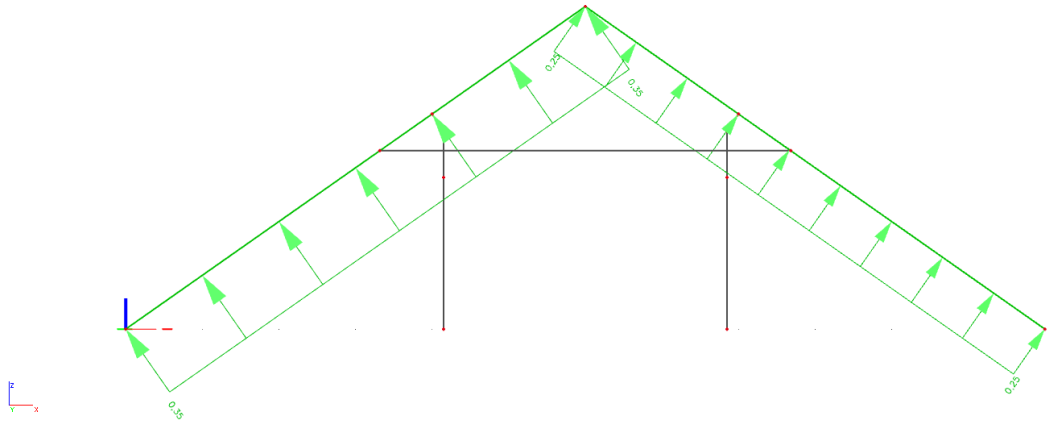
4. Snow load full left and ½ right



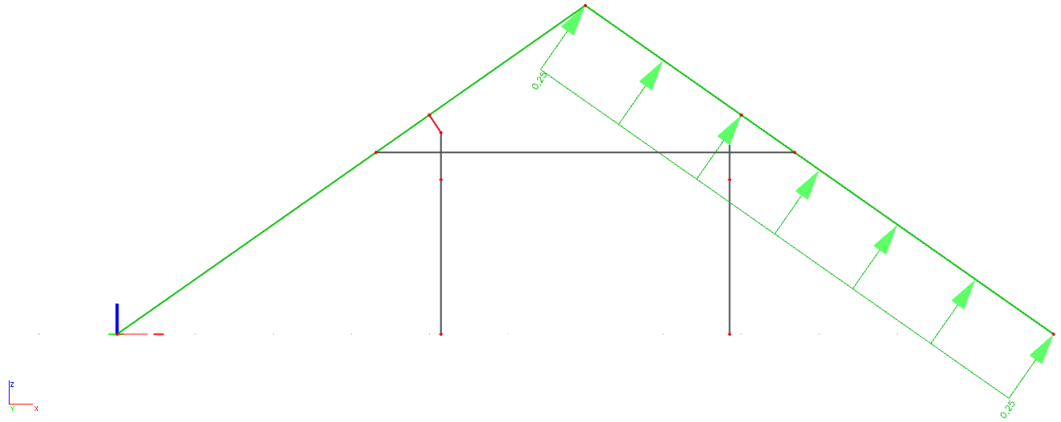
5. Wind load 1



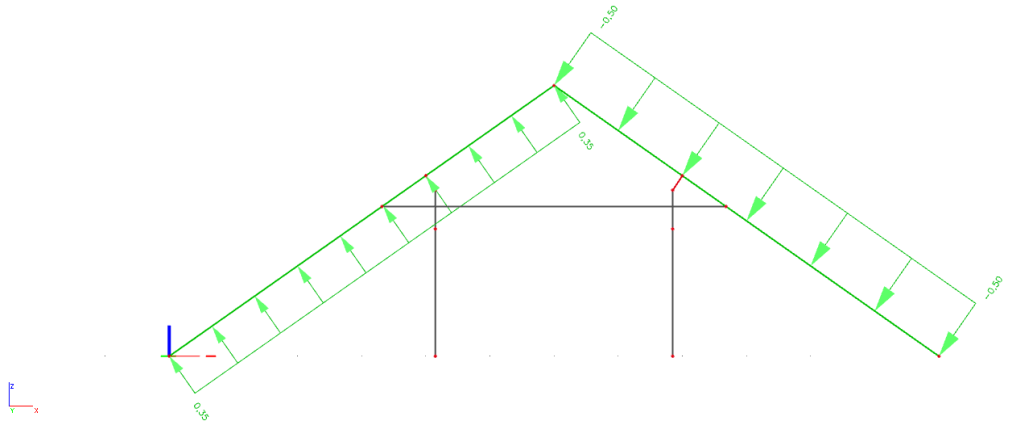
6. Wind load 2



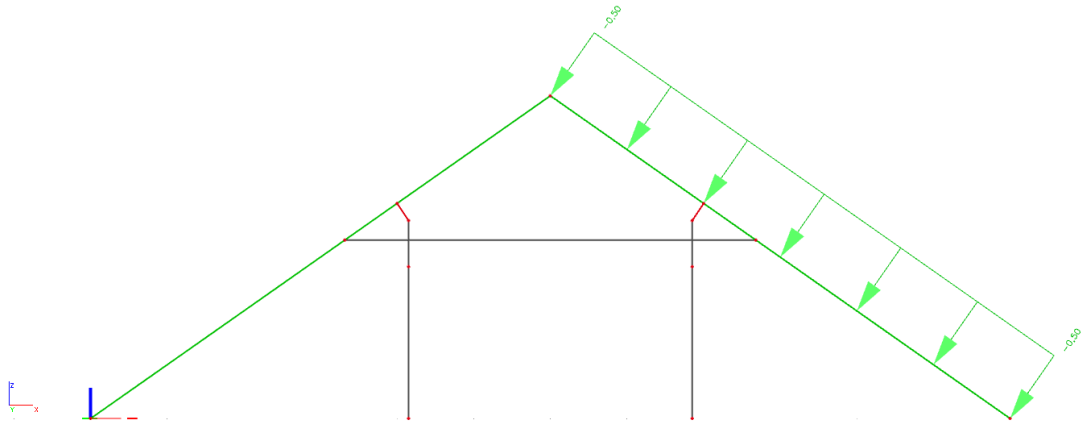
7. Wind load 3



8. Wind load 4



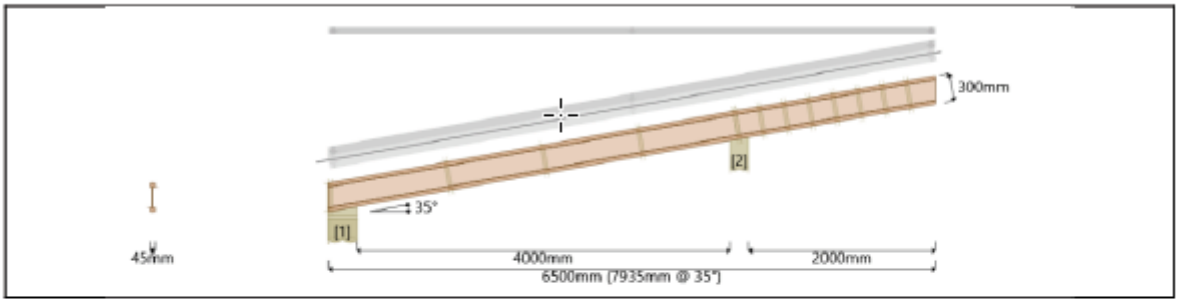
9. Wind load 5



Rafter:

Level/Label	**Roof - Roof - truss**	**Design code**	**DIN EN 1995-1-1:2010-12+A1+A2**
Project	Project	Certificate	ETA-06/0238
Address			
Customer			
Designer			

STEICO - XPRESS



Hanger(s) [left]	Member	Design result	Hanger(s) [right]
	SJ [LVL,HB] 45 - 300mm @ 680mm spacing	**Design passed**	

Loading (general)	0.90kN/m² Dead Load, 0.67kN/m² Snow Load, 0.50kN/m² Wind Load, -0.90kN/m² Wind Uplift Load
Decking	16mm - OSB3 - Glued / Nailed
Ceiling	12.5mm - Ceiling (GYPSUM BOARD)

General — Service Class : 1

	Max. / Control	Max.	Control	Ratio/DOL	Location	Load case
Wnet,fin	27.87%	4.18mm	15mm	L/613	7935mm	Gk SLS-Wn,f ALL
Winst	83.87%	12.58mm	15mm	L/204	7935mm	Gk+Wk+Qk+Sk SLS-Winst EVEN
Wfin	91.4%	13.71mm	15mm	L/187	7935mm	Gk+Wk+Qk+Sk SLS-Wd2 EVEN
[M] Moment (+)	37.56%	3.33kN·m	8.88kN·m	Short Term	2355mm	Gk+Wk+Qk+Sk ULS- ODD
[M] Moment (-)	52.18%	-4.63kN·m	8.88kN·m	Short Term	5371mm	Gk+Wk+Qk+Sk ULS- ALL
[V] Shear	53.64%	2.18kN	4.06kN	Permanent	5249mm	Gk ULS- ALL
[R] Bearing (1)	52.23%	4.09kN	7.82kN	Short Term	0mm	Gk+Wk+Qk+Sk ULS- ODD
[R] Bearing (2)	68.7%	10.08kN	14.68kN	Short Term	5371mm	Gk+Wk+Qk+Sk ULS- ALL

All load cases by code have been verified. Only decisive load cases are displayed.

Reactions

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Support reactions (transferred) (kN) Dead Perm.	Snow Short	Wind Short	WindUp Short	Details WS SB	Reinf. Blocking
1	366	+	4.09	Short	1.34	0.80	0.91		No	
		–	-1.12	Short		-0.18	-0.21	-1.27	No	No
2	244	+	10.08	Short	3.79	1.75	1.99		No	
		–	-3.15	Short				-3.59	No	Yes

WS=Web stiffener - SB=Squash block

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Horizontal reactions () Dead	Snow	Wind Short	WindUp Short	Details WS SB	Reinf. Blocking
1	366	+	0.00				0.52		No	
		–	0.00				-0.12	-0.73	No	No
2	244	+	0.00				0.62		No	
		–	0.00					-2.06	No	Yes

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Reactions normal to the member (kN) Dead Perm.	Snow Short	Wind Short	WindUp Short	Details WS SB	Reinf. Blocking
1	366	+	3.35	Short	1.10	0.66	0.91		No	
		–	0.00			-0.15	-0.21	-1.27	No	No
2	244	+	8.26	Short	3.11	1.43	1.99		No	
		–	0.00					-3.59	No	Yes

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Reactions parallel to the member (kN) Dead Perm.	Snow Short	Wind	WindUp	Details WS SB	Reinf. Blocking
1	366	+	0.00		0.77	0.46			No	
		–	0.00			-0.10			No	No
2	244	+	0.00		2.18	1.00			No	
		–	0.00						No	Yes

Loads

#	Type		Location	Dead	Snow	Wind	WindUp	Trib.width	Appl.	Dir. (Wind)
1	Level loads [kN/m²]	From	0mm	0.90	0.54	0.50	-0.90	680mm NC	T	N
		to	7935mm							
2	Member wei [kN/m]	From	0mm	0.04				0mm NC	T	
		to	7935mm							

NC=Not continuous (x1.00)/C=Continuous span (x1.25) - H=Horizontal length/P=Pitched length - T=Top/B=Bottom/L=Left/R=Right/C=Centre - V=Vertical/N=Normal to the roof plane

Member properties

Material	Steico SJ [LVL,HB]
Grade/Type	SJ [LVL,HB] 45 - 300mm
Certificate/Norm	ETA-06/0238

Stiffness properties

	Value	Unit	Kdef
Flexural Rigidity	912.00e9	N·mm²	0.6
Shear Rigidity	4180000.00	N	2.25

Deflection limits

	Wnet,fin	Winst	Wfin
Ratio	L/300	L/300	L/200
Max.			

Member properties

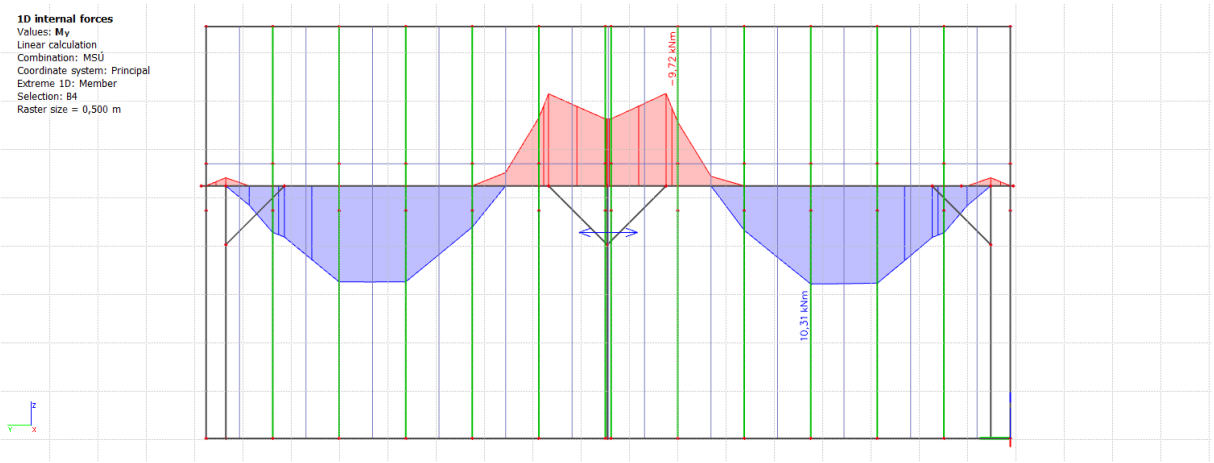
		Value	γM	Ksys	Kmod Perm.	Long	Medium	Short	Instant.
Moment	M(+)	12.82kN·m	1.3	1	0.6	0.7	0.8	0.9	1.1
Moment Up	M(-)	12.82kN·m	1.3	1	0.6	0.7	0.8	0.9	1.1
Shear	V	17.61kN	1.3	1	0.3	0.45	0.65	0.85	1.1
Bearing @ 1	R(1)	11.30kN	1.3	1	0.6	0.7	0.8	0.9	1.1
Bearing @ 2	R(2)	21.20kN	1.3	1	0.6	0.7	0.8	0.9	1.1

Notes

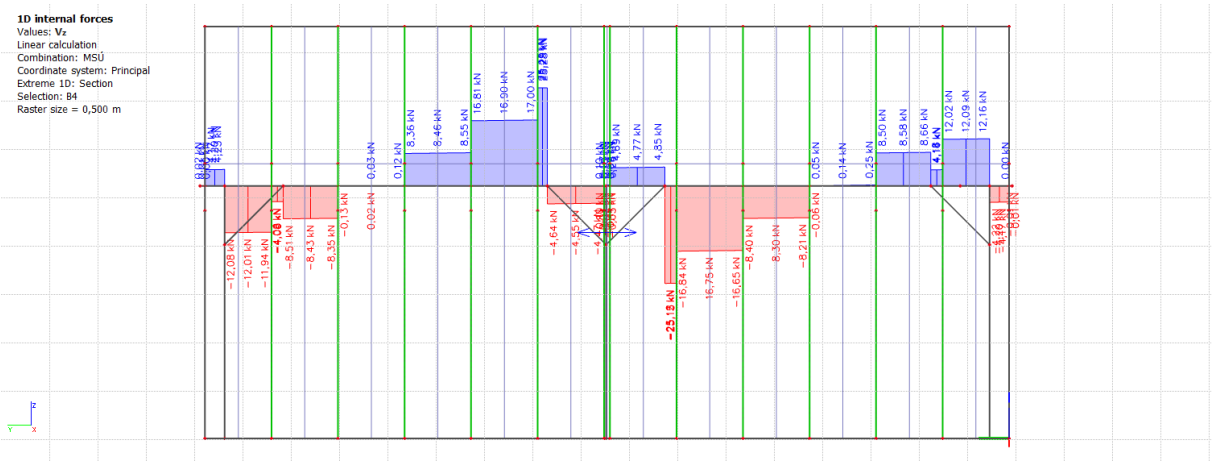
- All Dimensions, Supports and Holes are measured or numbered from the left end.
- Design spans are based on 1/2 minimum bearing length. Values for each span are: 5027mm 2564mm
- All Support Reactions are indicated unfactored, unless stated otherwise.
- Indicated support reactions are based on maximum value.
- Warning: At least one load case generates uplift at one of the supports.
- Sliding forces are adjusted for duration of load and safety factor where applicable.
- Top edge is considered continuously braced (decking/sheathing), no further bracing required.
- Maximum unbraced length along the bottom edge = 360mm (= compact length: spacing of lateral braces when determining [M]oment capacity)
- Bracing has been taken into account at the following locations: 0mm 5371mm
- Additional Bracing is required at the following locations: 1601mm 2858mm 4115mm 5692mm 6012mm 6333mm 6653mm 6974mm 7294mm 7615mm

Purlin:

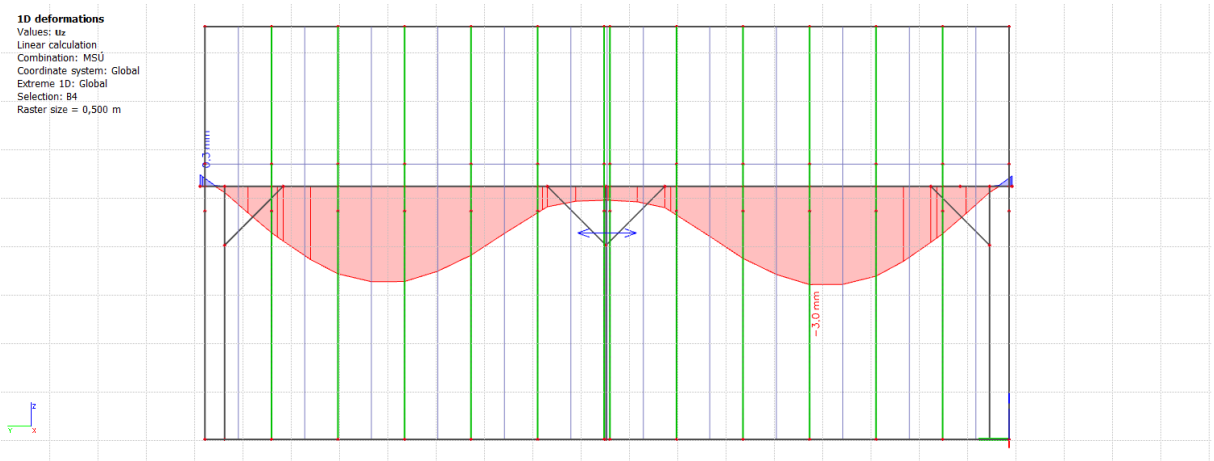
Bending moment



Shearing force



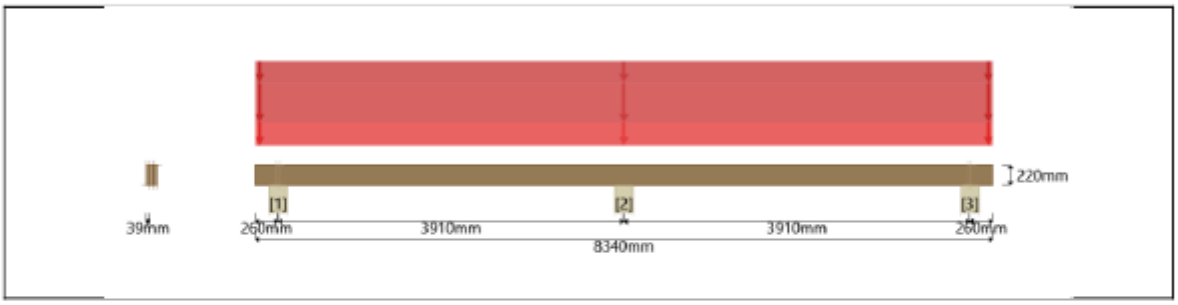
Deformation



Assessment in STEICOxpress

Level/Label	**Level 2 - Roof - longitudinal binder**	Design code	DIN EN 1995-1-1:2010-12+A1+A2
Project	Project	Certificate	EN 14374
Address			
Customer			
Designer			

STEICO - XPRESS



Hanger(s) [left]	Member	Design result	Hanger(s) [right]
	3 plies - 39x220mm STEICOLVL R	Design passed	

Loading (general) -
Decking 18mm - OSB3 - Nailed
Ceiling 12.5mm - Ceiling (GYPSUM BOARD)

General — Service Class : 1

	Max. / Control	Max.	Control	Ratio/DOL	Location	Load case
Wnet,fin	56.87%	7.41mm	13.03mm	L/528	1824mm	Gk SLS-Wn,f ALL
Winst	85.19%	11.1mm	13.03mm	L/352	6125mm	Gk+Sk+Qk+Wk SLS-Winst ODD
Wfin	70.69%	13.82mm	19.55mm	L/283	6516mm	Gk+Sk+Qk+Wk SLS-Wd2 ODD
[M] Moment (+)	51.42%	15.49kN·m	30.12kN·m	Short Term	6516mm	Gk+Sk+Qk+Wk ULS- ODD
[M] Moment (-)	77.99%	-23.49kN·m	30.12kN·m	Short Term	4170mm	Gk+Sk+Qk+Wk ULS- Adj.2
[V] Shear	50.17%	27.42kN	54.65kN	Short Term	4270mm	Gk+Sk+Qk+Wk ULS- Adj.2
[R] Bearing (1)	12.11%	22.96kN	189.54kN	Short Term	260mm	Gk+Sk+Qk+Wk ULS- Adj.1
[R] Bearing (2)	31.76%	60.21kN	189.54kN	Short Term	4170mm	Gk+Sk+Qk+Wk ULS- Adj.2
[R] Bearing (3)	12.11%	22.96kN	189.54kN	Short Term	8080mm	Gk+Sk+Qk+Wk ULS- Adj.3
[M] Conc. (+)	29.25%	7.83kN·m	26.77kN·m	Medium Term	1824mm	Gk+Qk ULS-Qconc ConcM
[M] Conc. (□)	46.13%	-12.35kN·m	26.77kN·m	Medium Term	4170mm	Gk+Qk ULS-Qconc ConcM
[V] Conc.	32.99%	16.03kN	48.58kN	Medium Term	4070mm	Gk+Qk ULS-Qconc ConcV
[R] Conc.	18.96%	31.94kN	168.48kN	Short Term	4170mm	Gk+Qk ULS-Qconc ConcR

All load cases by code have been verified. Only decisive load cases are displayed.

Reactions

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Support reactions (transferred) (kN) Dead Perm.	Floor	Snow Short	Wind Short	WindUp	Details WS SB	Reinf. Blocking
1	200	+	22.96	Short	8.07		4.95	5.15		No	
		–	0.00				-0.60	-0.63		No	Yes
2	200	+	60.21	Short	22.55		12.22	12.71		No	
		–	0.00				-0.06	-0.07		No	No
3	200	+	22.96	Short	8.07		4.95	5.15		No	
		–	0.00				-0.60	-0.63		No	Yes

WS=Web stiffener - SB=Squash block

Loads

#	Type		Location	Dead	Floor	Snow	Wind	WindUp	Trib.width	Appl.	Dir. (Wind)
2	Line Para. [kN/m]	From	0mm	4.50		2.50	2.60		0mm NC	T	N
		to	8340mm								
3	Member wei [kN/m]	From	0mm	0.14					0mm NC	T	
		to	8340mm								

NC=Not continuous (x1.00)/C=Continuous span (x1.25) - H=Horizontal length/P=Pitched length - T=Top/B=Bottom/L=Left/R=Right/C=Centre - V=Vertical/N=Normal to the roof plane

Member properties

Material	LVL
Grade/Type	39x220mm STEICOLVL R
Certificate/Norm	EN 14374

Stiffness properties

	Value	Unit	Kdef
Flexural Rigidity	484.48e9	N·mm²	0.6
Shear Rigidity	5148000.00	N	0.6

Deflection limits

	Wnet,fin	Winst	Wfin
Ratio	L/300	L/300	L/200
Max.			

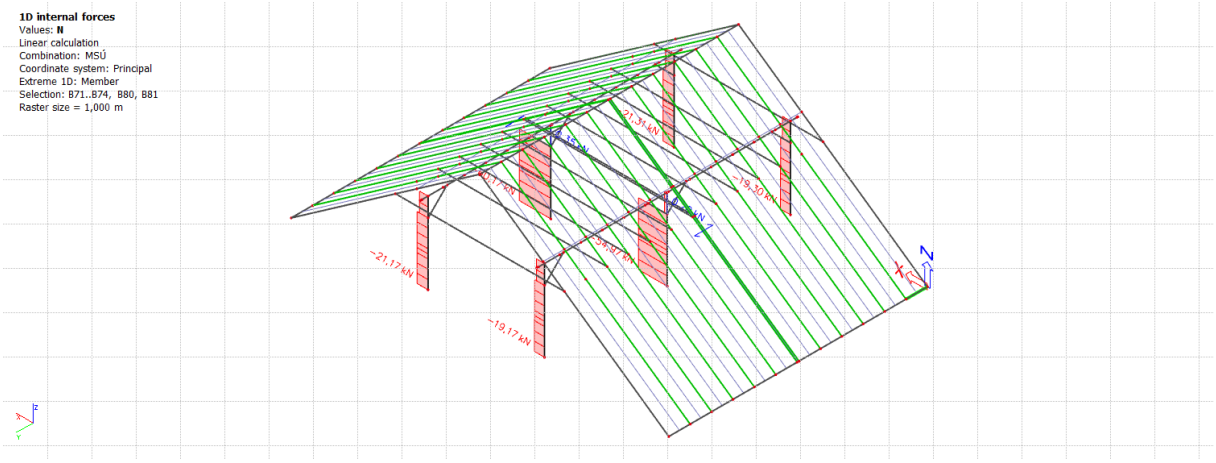
Member properties

		Value	γM	Ksys	Kmod Perm.	Long	Medium	Short	Instant.
Moment	M(+)	14.50kN·m	1.3	1	0.6	0.7	0.8	0.9	1.1
Moment Up	M(-)	14.50kN·m	1.3	1	0.6	0.7	0.8	0.9	1.1
Shear	V	26.31kN	1.3	1	0.6	0.7	0.8	0.9	1.1
Bearing @ 1	R(1)	76.05kN	1.3	1	0.6	0.7	0.8	0.9	1.1
Bearing @ 2	R(2)	76.05kN	1.3	1	0.6	0.7	0.8	0.9	1.1
Bearing @ 3	R(3)	76.05kN	1.3	1	0.6	0.7	0.8	0.9	1.1

Notes

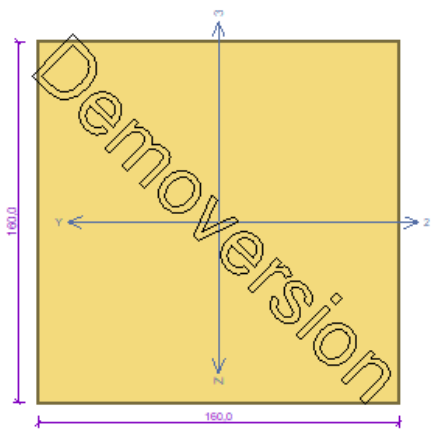
- All Dimensions, Supports and Holes are measured or numbered from the left end.
- Design spans are based on 1/2 minimum bearing length. Values for each span are: 260mm 3910mm 3910mm 260mm
- All Support Reactions are indicated unfactored, unless stated otherwise.
- Indicated support reactions are based on maximum value.
- Vibration control has been disabled by the user.
- Top edge is considered continuously braced (decking/sheathing), no further bracing required.
- Maximum unbraced length along the bottom edge = 35727mm (Kcrit=1)
- Refer to manufacturer literature for multiple-ply connection details.
- Design Bearing Resistances have been calculated with Kc90 = 1.00, and multiplied by 1.20 in service class 1.
- Additional Bracing is required at the following locations: 260mm 8080mm
- Member properties are indicated for a single ply.

Columns:



Assessment in FIN EC Timber

Column



Standard **EN 1995-1-1/Default EC**.

LVL, basic load combination : γ_M = 1,200
Accidental load combination : γ_M = 1,000

Service class: 2

Section: rectangle 160x160
Dimensions:
Cross-section heigi i h = 160,0 mm
Cross-section width b = 160,0 mm

Material: STEICO (user defined input)
Material kind: LVL
Material characteristics:

Bending strength perpendicular to board plane	$f_{m,k}$	: 44,0	MPa
Bending strength in board plane	$f_{m,k}$	: 50,0	MPa
Tensile strength in board plane	$f_{t,k}$	: 36,0	MPa
Compressive strength in board plane	$f_{c,k}$	: 40,0	MPa
Shear strength in board plane	$f_{v,k}$	: 2,6	MPa
Elastic modulus	E_{mean}	: 14000	MPa
5% elastic modulus quantile	$E_{0,05}$	: 12000	MPa
Shear modulus	G_{mean}	: 600	MPa
Mean value of density	ρ_k	: 550,0	kg/m^3

Internal forces in system of cross-section coordinates:
Load with maximal utilization
Load 1
Permanent load
N = -60,000 kN
M_y = 0,000 kNm M_z = 2,000 kNm
V_z = 0,000 kN V_y = 0,000 kN

Buckling:
Calculation with buckling
Sector length for buckling L_z = 2,500 m
Buckling length factor k_z = 1,000 Buckling length $L_{cr,z}$ = 2,500 m
Sector length for buckling L_y = 2,500 m
Buckling length factor k_y = 1,000 Buckling length $L_{cr,y}$ = 2,500 m

Results
Decisive load: Load 1
Internal forces: N = -60,000 kN; M_y = 0,000 kNm; M_z = 2,000 kNm; V_z = 0,000 kN; V_y = 0,000 kN

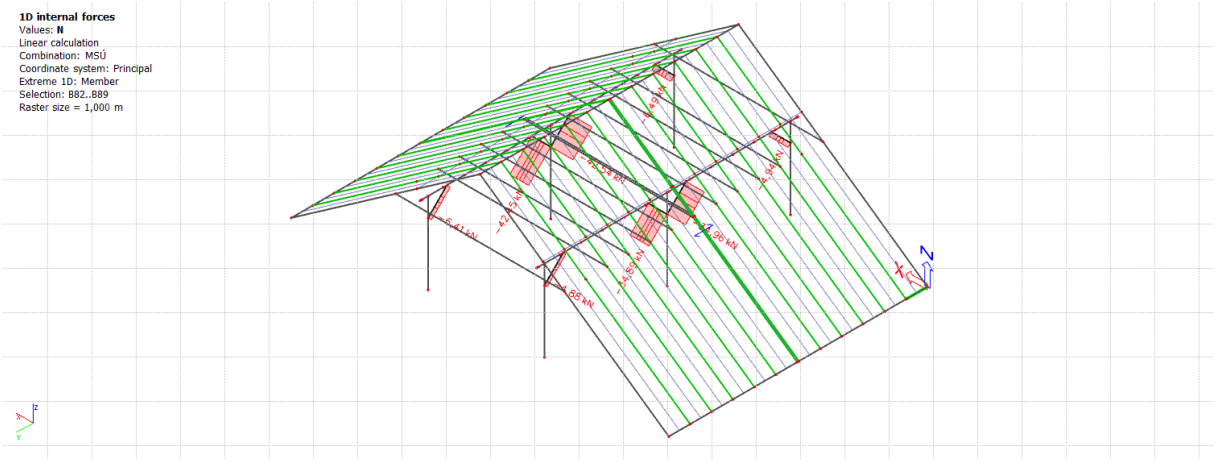
Compression and bending moment combination check:
Resistances: N_R = 395,463 kN; $M_{z,R}$ = -18,174 kNm
| -0,152 + 0,000 + -0,110 | = |-0,262| < 1 **Pass**

Member slenderness: 54,1

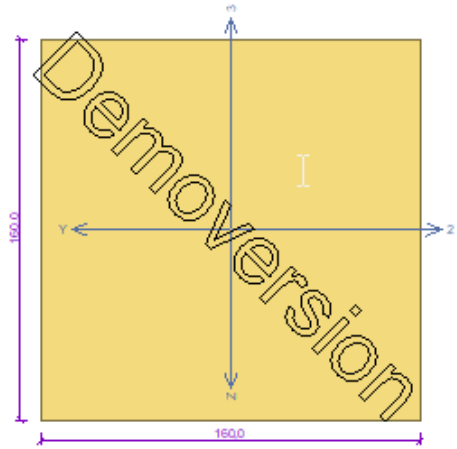
Section ok

PASS

Bracing:



Bracing



Standard **EN 1995-1-1/Default EC**

LVL, basic load combination : γ_M = 1,200
Accidental load combination : γ_M = 1,000

Service class: 2

Section: rectangle 160x160
Dimensions:
Cross-section height h = 160,0 mm
Cross-section width b = 160,0 mm

Material: STEICO (user defined input)
Material kind: LVL
Material characteristics:

Bending strength perpendicular to board plane	$f_{m,k}$	44,0	MPa
Bending strength in board plane	$f_{m,k}$	50,0	MPa
Tensile strength in board plane	$f_{t,k}$	36,0	MPa
Compressive strength in board plane	$f_{c,k}$	40,0	MPa
Shear strength in board plane	$f_{v,k}$	2,6	MPa
Elastic modulus	E_{mean}	14000	MPa
5% elastic modulus quantile	$E_{0,05}$	12000	MPa
Shear modulus	G_{mean}	600	MPa
Mean value of density	ρ_k	550,0	kg/m³

Internal forces in system of cross-section coordinates:
Load with maximal utilization
Load 1
Permanent load
N = -45,000 kN
M_y = 0,000 kNm M_z = 0,000 kNm
V_z = 0,000 kN V_y = 0,000 kN

Buckling:
Calculation with buckling
Sector length for buckling L_z = 0,800 m
Buckling length factor k_z = 1,000 Buckling length $L_{cr,z}$ = 0,800 m
Sector length for buckling L_y = 0,800 m
Buckling length factor k_y = 1,000 Buckling length $L_{cr,y}$ = 0,800 m

Results
Decisive load: Load 1
Internal forces: N = -45,000 kN; M_y = 0,000 kNm; M_z = 0,000 kNm; V_z = 0,000 kN; V_y = 0,000 kN

Buckling compression check:
Resistance: N_R = 510,959 kN
| -0,088 | < 1 **Pass**

Member slenderness: 17,3

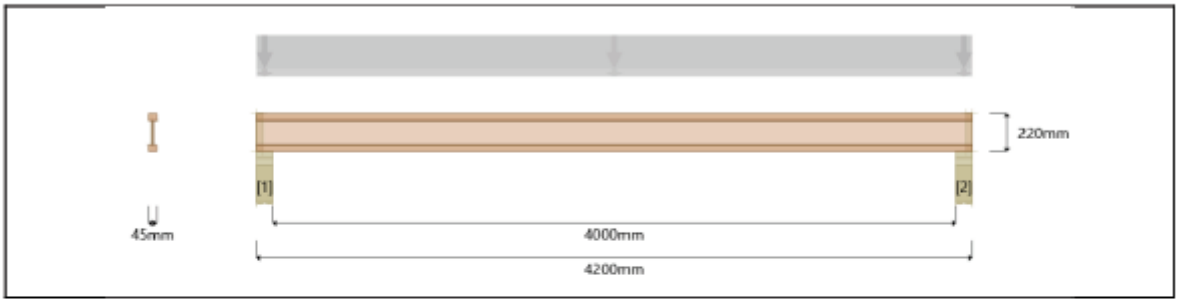
Section ok

PASS

Upper floor slab:

Level/Label	**Level 2 - J3 - Joist**	Design code	DIN EN 1995-1-1:2010-12+A1+A2
Project	Project	Certificate	ETA-06/0238
Address			
Customer			
Designer			

STEICO - XPRESS



Hanger(s) [left]	Member	Design result	Hanger(s) [right]
	SJ [LVL,HB] 45 - 220mm @ 625mm spacing	**Design passed**	

Loading (general) 0.40kN/m² Dead Load, 2.00kN/m² Floor Imposed Load
Decking 18mm - OSB3 - Nailed
Ceiling 12.5mm - Ceiling (GYPSUM BOARD)

General						Service Class : 1
	Max. / Control	Max.	Control	Ratio/DOL	Location	Load case
Wnet,fin	73.96%	9.97mm	13.48mm	L/408	2100mm	Gk+Qk SLS-Wn,f ALL
Winst	99.55%	13.42mm	13.48mm	L/301	2100mm	Gk+Qk SLS-Winst ALL
Wfin	87.24%	17.64mm	20.22mm	L/229	2100mm	Gk+Qk SLS-Wd2 ALL
[M] Moment	77.44%	4.61kN·m	5.95kN·m	Medium Term	2100mm	Gk+Qk ULS- ALL
[V] Shear	57.87%	4.51kN	7.79kN	Medium Term	100mm	Gk+Qk ULS- ALL
[R] Bearing (1)	61.87%	4.73kN	7.65kN	Medium Term	0mm	Gk+Qk ULS- ALL
[R] Bearing (2)	61.87%	4.73kN	7.65kN	Medium Term	4200mm	Gk+Qk ULS- ALL

All load cases by code have been verified. Only decisive load cases are displayed.

Reactions

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Support reactions (transferred) (kN) Dead Perm.	Floor Medium	Snow	Wind	WindUp	Details WS SB	Reinf. Blocking
1	100	+	4.73	Medium	0.59	2.62				No	
		–	0.00							No	No
2	100	+	4.73	Medium	0.59	2.62				No	
		–	0.00							No	No

WS=Web stiffener - SB=Squash block

Loads

#	Type		Location	Dead	Floor	Snow	Wind	WindUp	Trib.width	Appl.	Dir. (Wind)
1	Level loads [kN/m²]	From	0mm	0.40	2.00				625mm NC	T	
		to	4200mm								
2	Member wei [kN/m]	From	0mm	0.03					0mm NC	T	
		to	4200mm								

NC=Not continuous (x1.00)/C=Continuous span (x1.25) - H=Horizontal length/P=Pitched length - T=Top/B=Bottom/L=Left/R=Right/C=Centre - V=Vertical/N=Normal to the roof plane

Member properties

Material	Steico SJ [LVL,HB]
Grade/Type	SJ [LVL,HB] 45 - 220mm
Certificate/Norm	ETA-06/0238

Stiffness properties

	Value	Unit	Kdef
Flexural Rigidity	433.00e9	N·mm²	0.6
Shear Rigidity	2840000.00	N	2.25

Deflection limits

	Wnet,fin	Winst	Wfin
Ratio	L/300	L/300	L/200
Max.			

Member properties

		Value	γM	Ksys	Kmod Perm.	Long	Medium	Short	Instant.
Moment	M(+)	8.79kN·m	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Moment Up	M(-)	8.79kN·m	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Shear	V	14.16kN	1.3	1.1	0.3	0.45	0.65	0.85	1.1
Bearing @ 1	R(1)	11.30kN	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Bearing @ 2	R(2)	11.30kN	1.3	1.1	0.6	0.7	0.8	0.9	1.1

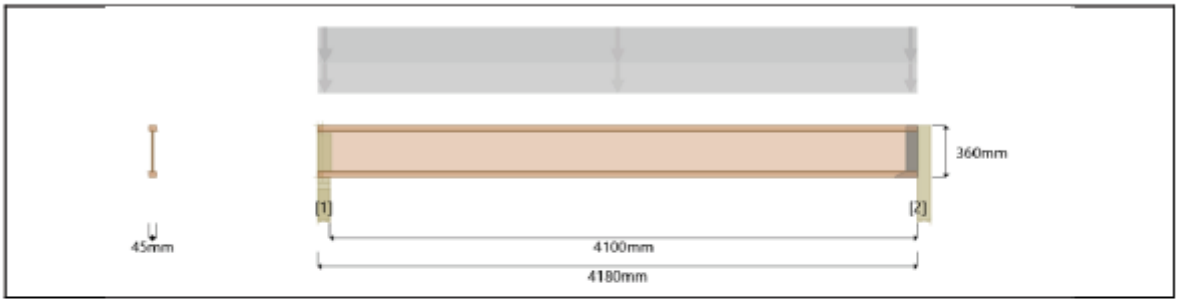
Notes

- All Dimensions, Supports and Holes are measured or numbered from the left end.
- Design spans are based on 1/2 minimum bearing length. Values for each span are: 4044mm
- All Support Reactions are indicated unfactored, unless stated otherwise.
- Indicated support reactions are based on maximum value.
- Vibration control has been disabled by the user.
- Top edge is considered continuously braced (decking/sheathing), no further bracing required.
- No negative [M]oment present, no further bracing along the bottom edge required
- Bracing has been taken into account at the following locations: 0mm 4200mm

First floor slab:

Level/Label	**Ground floor - First floor slab**	Design code	DIN EN 1995-1-1:2010-12+A1+A2
Project	Project	Certificate	ETA-06/0238
Address			
Customer			
Designer			

STEICO - XPRESS



Hanger(s) [left]	Member	Design result	Hanger(s) [right]
	SJ [LVL,HB] 45 - 360mm @ 625mm spacing	**Design passed**	HUH-46-350-EN

Loading (general)	2.10kN/m² Dead Load, 0.50kN/m² Partition Load, 2.00kN/m² Floor Imposed Load
Decking	18mm - OSB3 - Nailed
Ceiling	12.5mm - Ceiling (GYPSUM BOARD)

General — Service Class : 1

	Max. / Control	Max.	Control	Ratio/DOL	Location	Load case
Wnet,fin	80.99%	10.99mm	13.57mm	L/370	2092mm	Gk+Qk SLS-Wn,f ALL
Winst	63.45%	8.61mm	13.57mm	L/473	2092mm	Gk+Qk SLS-Winst ALL
Wfin	66.68%	13.57mm	20.35mm	L/300	2092mm	Gk+Qk SLS-Wd2 ALL
[M] Moment	79%	8.54kN·m	10.80kN·m	Medium Term	2092mm	Gk+Qk ULS- ALL
[V] Shear	95.72%	4.52kN	4.73kN	Permanent	80mm	Gk ULS- ALL
[R] Bearing (1) WS	62.05%	8.62kN	13.89kN	Medium Term	0mm	Gk+Qk ULS- ALL
[R] Bearing (2) WS	62.7%	8.62kN	13.74kN	Medium Term	4180mm	Gk+Qk ULS- ALL
f1	83.78%	9.5Hz	8Hz		1mm	
U1kN	40.13%	0.6mm	1.5mm		2092mm	
v	33.25%	0.01	0.02		1mm	

All load cases by code have been verified. Only decisive load cases are displayed.

Reactions

Bearings #	Width [mm]		Max. factored reactions [kN]	DOL	Support reactions (transferred) (kN) Dead Perm.	Floor Medium	Snow	Wind	WindUp	Details WS SB	Reinf. Blocking
1	80	+	8.62	Medium	3.48	2.61				Yes	
		–	0.00							No	No
2	75	+	8.62	Medium	3.48	2.61				No	
		–	0.00							No	No

WS=Web stiffener - SB=Squash block

Loads

#	Type		Location	Dead	Floor	Snow	Wind	WindUp	Trib.width	Appl.	Dir. (Wind)
1	Level loads [kN/m²]	From	0mm	2.10	2.00				625mm NC	T	
		to	4180mm								
2	Member wei [kN/m]	From	0mm	0.04					0mm NC	T	
		to	4180mm								

Lightweight partitions loads : 0.50kN/m²

NC=Not continuous (x1.00)/C=Continuous span (x1.25) - H=Horizontal length/P=Pitched length - T=Top/B=Bottom/L=Left/R=Right/C=Centre - V=Vertical/N=Normal to the roof plane

Member properties

Material	Steico SJ [LVL,HB]
Grade/Type	SJ [LVL,HB] 45 - 360mm
Certificate/Norm	ETA-06/0238

Stiffness properties

	Value	Unit	Kdef
Flexural Rigidity	1397.0e9	N·mm²	0.6
Shear Rigidity	5.19	N	2.25

Deflection limits

	Wnet,fin	Winst	Wfin
Ratio	L/300	L/300	L/200
Max.			

Member properties

		Value	γM	Ksys	Kmod Perm.	Long	Medium	Short	Instant.
Moment	M(+)	15.96kN·m	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Moment Up	M(-)	15.96kN·m	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Shear	V	18.62kN	1.3	1.1	0.3	0.45	0.65	0.85	1.1
Bearing @ 1	R(1) WS	20.52kN	1.3	1.1	0.6	0.7	0.8	0.9	1.1
Bearing @ 2	R(2) WS	20.30kN	1.3	1.1	0.6	0.7	0.8	0.9	1.1

Notes

- All Dimensions, Supports and Holes are measured or numbered from the left end.
- Design spans are based on 1/2 minimum bearing length. Values for each span are: 4069mm
- All Support Reactions are indicated unfactored, unless stated otherwise.
- Indicated support reactions are based on maximum value.
- Hanger at Bearing 2: required load carrying capacity = 14.00kN Medium Term
- Hanger at Bearing 2: required uplift carrying capacity = 0.00kN Permanent
- Top edge is considered continuously braced (decking/sheathing), no further bracing required.
- No negative [M]oment present, no further bracing along the bottom edge required
- Bracing has been taken into account at the following locations: 0mm

A8-1_IDA ICE Input & Output Tables

Heating/ Cooling & DHW System with IDA ICE

Requirements

Heating Demand

No mech. Cooling is needed if requirements of DS 469 are met. Heating should supply temp. of minimum 20 C all year round.

Design Outdoor Temp. CPH	-12	°C
DS 469 yearly hours above 26 °C	100	h
DS 469 yearly hours above 27 °C	25	h
Floor Heating supply Temp.	35	°C
Floor Heating return Temp.	25	°C

Domestic Hot Water

Cold Water Temp.	10	°C
Hot Water Temp.	55	°C

Ventilation (Danish Building Code)

In single family houses, natural ventilation is fine, but in other domestic buildings, a demand-controlled ventilation is required

Min. fresh air supply of each habitable room	0.3	l/s/m²	
DS/EN 15251 Air change rate Cat. I	0.49	l/s/m²	
DS/EN 15251 Air change rate Cat. II	**0.42**	**l/s/m²**	
DS/EN 15251 Air change rate Cat. III	0.35	l/s/m²	
Min. Exhaust Air flow KITCHEN	20	l/s	72 m³/h
Min. Exhaust Air flow BATHROOM	15	l/s	54 m³/h
Min. Exhaust Air flow TOILETS	10	l/s	36 m³/h
Forced Mode from kitchen hood for efficiency	40	l/s	144 m³/h

IDA ICE Settings (Basis Model)

Design Heat Load of the building

Determined with ideal heater/ cooler + AHU (mech. Ventilation) and no passive cooling (shading or opening of windows)

Floor Area of the building	128.09	m²
Design Heat Load (with AHU)	23.41	W/m²
--> See 'Floor Heating Zones' for details		

Heating/ Cooling

Water Tank Volume (integrated in Heat Pump!)	200	l
Height to diameter	4	-
Diameter	0.40	m
Height	1.60	m
Ground coupled Heat Pump		
Ground temp.	4	°C
Area of horizontal piping (heated Area)	128.09	m²
Heat Pump capacity	10	kW
COP	3.6	-
Zones		
Occupants	Acc. to Danish Guide	
Equipment + Lighting	3.5	W/m²
Cooling		
Openable windows	PI-Control	
Control Setpoint (Nov. - March)	25	°C
Control Setpoint (April - Oct.)	22	°C
Interior integrated sun shading		
Control	Sun	
Ventilation		
Control	VAV, CO2	

Building Materials

Material	U-Value		Comment
Windows			
Saint-Gobain T4-12 m. COOL-LITE SKN 174+ar+PLANITHERM ULTRA	0.70	W/m²K	0.9/0.8 required for BR15/20
Normal Window: 2 pane glazing, clear, 4-12-4 (example)	2.90	W/m²K	
Walls			
External Walls (0.38m, prefab. Wood composition)	0.12	W/m²K	
Internal Walls (0.15m, prefab. Wood composition)		W/m²K	
Floors/Ceiling			
Ground Floor with Foundation (0.52m, piping in slab)	0.15	W/m²K	
First Floor (0.41m, prefab. Wood composition)	0.57	W/m²K	
Ceiling on First Floor (	0.16	W/m²K	
Terrace Floor (0.53m, prefab. With on site membrane fitting)	0.10	W/m²K	
Roof			
Tilted Roof (0.52m, wood composition with tiles)	0.12	W/m²K	

Ventilation

	m²	l/s/m²	Equipment W
Master Bedroom (GF)	14.73	0.45	51.56
Entrance (GF)	14.54	0.45	50.89
Children Room (GF)	9.31	0.45	32.59
Bathroom Pod (GF)	8.075	0	28.26
Hall (GF)	1.575	0	5.51
Technical Room (GF)	3	0.45	10.50
Children Room (1F)	14.73	0.45	51.56
Staircase (1F)	14.54	0.45	50.89
Bathroom Pod (1F)	8.075	0.45	28.26
Hall (1F)	1.575	0	5.51
Storage (1F)	3	0	10.50
Shaft (GF + 1F)	0.75	0	2.63
Living Room (GF)	19.75	0.45	69.13
Kitchen (GF + 1F)	14.44	0.45	50.54
	128.09	**0.42**	**448.32**

Results (Basis Model)

Overheating

DS 469 yearly hours above 26 °C (Kitchen)	13.4	h
DS 469 yearly hours above 27 °C (Kitchen)	2.1	h

Delivered Energy

HVAC aux	153.9	kWh/a
Heat Pump Electricity	1464.9	kWh/a
Equipment + Lighting, tenant	3924.6	kWh/a
Total	**5543.40**	**kWh/a**

HVAC aux

Fan Power (max)	56	W
Fan Average Power (House Living Schedule)	17.42	W
HVAC aux	153.02	kWh
factor (% of Time fan is running)	0.31	
Mini Ventilation Total Power	30.4	W
Mini Ventilation Yearly Energy Consumption (x 8784h)	83.07	kWh
Mini Ventilation Yearly Energy Consumption (Oct.-May)	55.38	kWh
Savings to Ventilation System	**64**	**%**

PV Panel Setting 1

Annual PV Production (East Facing)	2169.0	kWh/a	25m² Panels on Roof
Annual PV Production (West Facing)	2171.0	kWh/a	25m² Panels on Roof
Total	4340.0	kWh/a	

PV Panel Setting 2

Annual PV Production (South Facing)	5725.4	kWh/a	50m² Panels on Roof

PV Panel Setting 3

Annual PV Production (East Facing)	1086.8	kWh/a	12.5m² Panels on Roof
Annual PV Production (West Facing)	1085.2	kWh/a	12.5m² Panels on Roof
Total	2172.0	kWh/a	

Systems energy

Zone heating	1926.5	kWh/a
Dom. hot water	1861.5	kWh/a
Cooling	0	kWh/a
Energy Needs	**3788**	**kWh/a**
per m²	**29.6**	**kWh/m²/a**

Electricity Production

Annual PV Production (West + East Facing)	4340.0	kWh/a
Annual PV Production (South Facing)	5725.4	kWh/a
Rool of Thumb (10m² = 1000 - 1500 kWh/year)		

Energy Balance Phase 2

Primary Energy Factor Electricity 1.9 — Heated Floor Area 128.09 m² — Room height 2.53 m

	Electricity (kWh)		Primary Energy EPI	
Home appliances	3924.6	kWh	7456.74	kWh
Embedded energy in materials (total 30y)	40.0	kWh	76.0	kWh
Building operation (Heating/Cooling/DHW) - Heat Pump	1464.9	kWh	2783.31	kWh
HVAC aux (Pumps)	55.4	kWh	105.2	kWh
Usage Sum	**5484.9**	**kWh**	**10421.3**	**kWh**
Usage Sum per m²	**42.82**	**kWh/m²**	**81.36**	**kWh/m²**
	0		0	
Usage Sum (no Equipment)	**1560.3**	**kWh**	**2964.5**	**kWh**
Usage Sum per m² (no Equipment)	**12.18**	**kWh/m²**	**23.14**	**kWh/m²**
	0		0	
PV Production	-4340.0	kWh	-8246.0	kWh
Solar Production	0	kWh	0	kWh
PVT Production	0	kWh	0	kWh
Production Sum	**-4340.0**	**kWh**	**-8246.0**	**kWh**
Production Sum per m²	**-33.88**	**kWh/m²**	**-64.38**	**kWh/m²**
	0		0	
Energy Balance	**1144.9**	**kWh**	**2175.3**	**kWh**
Energy Balance per m²	8.9	kWh/m²	17.0	kWh/m²
	0		0	
Energy Balance (no Equipment)	**-2779.7**	**kWh**	**-5281.5**	**kWh**
Energy Balance per m² (no Equipment)	-21.7	kWh/m²	-41.2	kWh/m²

Energy Balance Phase 3

Primary Energy Factor Electricity 1.9 — Heated Floor Area 157.07 m² — Room height 2.53 m

	Electricity (kWh)		Primary Energy EPI	
Home appliances	5089.7	kWh	9670.4	kWh
Embedded energy in materials (total 80y)	40.0	kWh	76.0	kWh
Building operation (Heating/Cooling/DHW) - Heat Pump	1482.7	kWh	2817.1	kWh
HVAC aux (Pumps)	55.4	kWh	105.2	kWh
Usage Sum	**6667.8**	**kWh**	**12668.8**	**kWh**
Usage Sum per m²	**42.45**	**kWh/m²**	**80.7**	**kWh/m²**
Usage Sum (no Equipment)	**1578.1**	**kWh**	**2998.3**	**kWh**
Usage Sum per m² (no Equipment)	**10.05**	**kWh/m²**	**19.09**	**kWh/m²**
PV Production	-4340.0	kWh	-8246.0	kWh
Solar Production	0	kWh	0.0	kWh
PVT Production	0	kWh	0.0	kWh
Production Sum	**-4340.0**	**kWh**	**-8246.0**	**kWh**
Production Sum per m²	**-27.63**	**kWh/m²**	**-52.50**	**kWh/m²**
Energy Balance	**2327.8**	**kWh**	**4422.8**	**kWh**
Energy Balance per m²	14.8	kWh/m²	28.16	kWh/m²
Energy Balance (no Equipment)	**-2761.9**	**kWh**	**-5247.7**	**kWh**
Energy Balance per m² (no Equipment)	-17.58	kWh/m²	-33.41	kWh/m²

A8-2_IDA ICE Reports – Phase 2

Delivered Energy Report

Project		Building	
		Model floor area	128.1 m^2
Customer		Model volume	378.5 m^3
Created by	Jakub Kolarik	Model ground area	91.8 m^2
Location	Copenhagen	Model envelope area	338.4 m^2
Climate file	Copenhagen DRY	Window/Envelope	11.2 %
Case	ICE Model P2-FINAL_Open W (A-O) _190620	Average U-value	0.1921 W/(m^2 K)
Simulated	6/20/2019 3:14:51 PM	Envelope area per Volume	0.8939 m^2/m^3

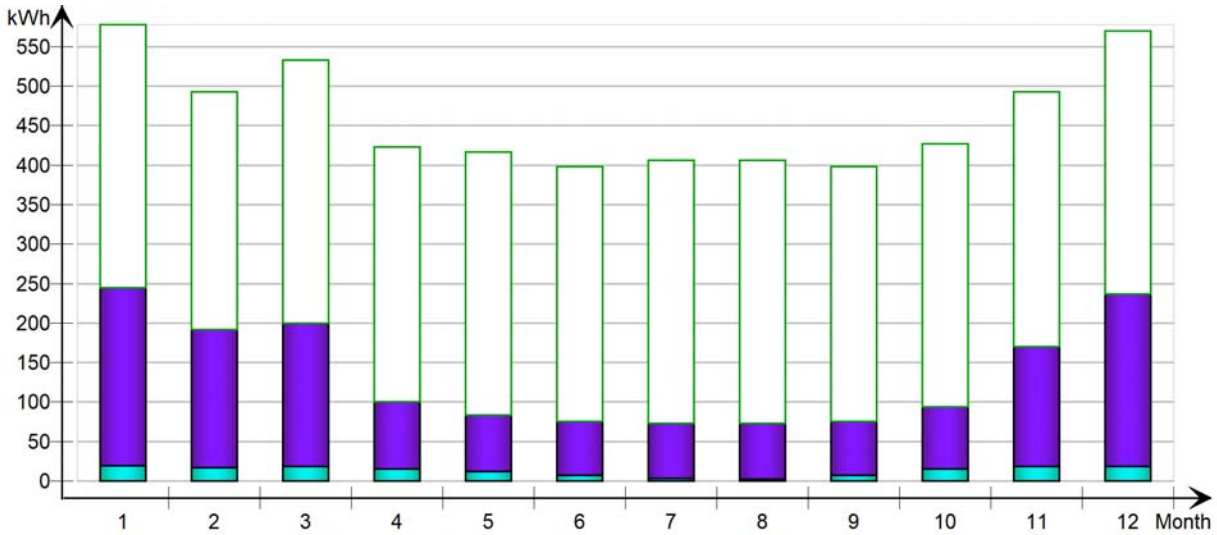
Building Comfort Reference

Percentage of hours when operative temperature is above 27°C in worst zone	0 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	9 %

Delivered Energy Overview

		Purchased energy		Peak demand
		kWh	kWh / m^2	kW
	Lighting, facility	0	0.0	0.0
	HVAC aux	154	1.2	0.06
	Electric heating	0	0.0	0.0
	Heat Pump Electricity	1465	11.4	2.62
	Total, Facility electric	1619	12.6	
	Total	1619	12.6	
	Equipment, tenant	3925	30.6	0.45
	Total, Tenant electric	3925	30.6	
	Grand total	5544	43.3	

Monthly Purchased / Sold Energy



Month	Facility electric				Tenant electric
	Lighting, facility	HVAC aux	Electric heating	Heat Pump Electricity	Equipment, tenant
	(kWh)	(kWh)	(kWh)	(kWh)	(kWh)
1	0.0	19.2	0.0	225.5	333.3
2	0.0	17.1	0.0	175.1	301.1
3	0.0	18.7	0.0	181.5	333.3
4	0.0	15.1	0.0	85.1	322.6
5	0.0	11.7	0.0	71.5	333.3
6	0.0	7.2	0.0	68.5	322.6
7	0.0	3.0	0.0	70.2	333.3
8	0.0	2.7	0.0	70.3	333.3
9	0.0	7.4	0.0	68.5	322.6
10	0.0	14.9	0.0	78.6	333.3
11	0.0	18.2	0.0	151.9	322.6
12	0.0	18.8	0.0	218.2	333.3
Total	0.0	153.9	0.0	1464.9	3924.6

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Energy for whole building

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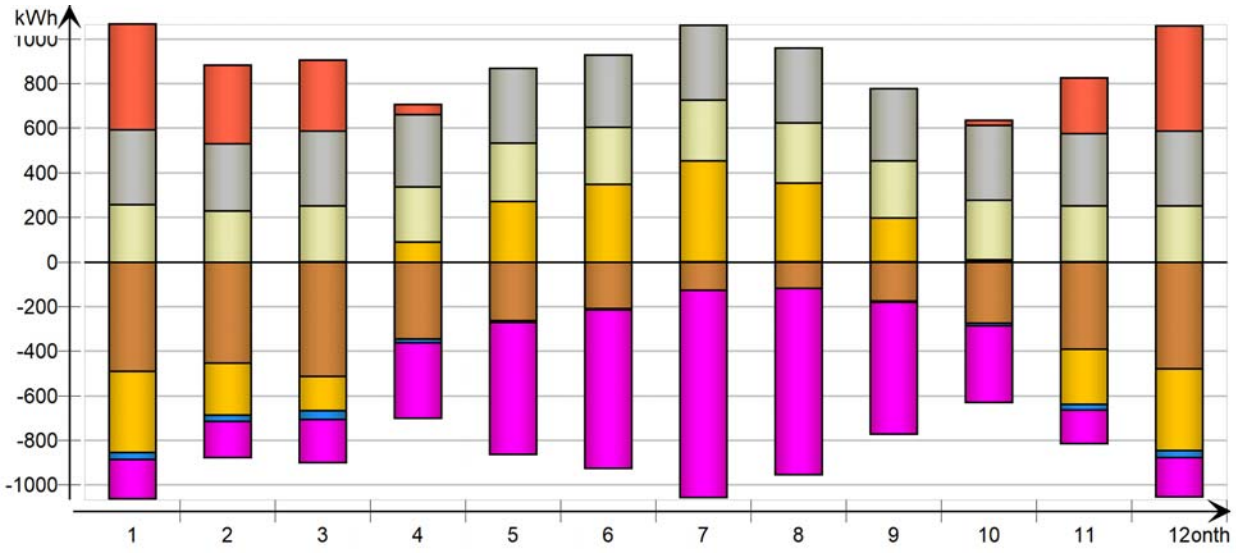
Simulated	6/20/2019 3:14:51 PM	Envelope area per Volume	0.8939 m^2/m^3

All zones

kWh (sensible only)

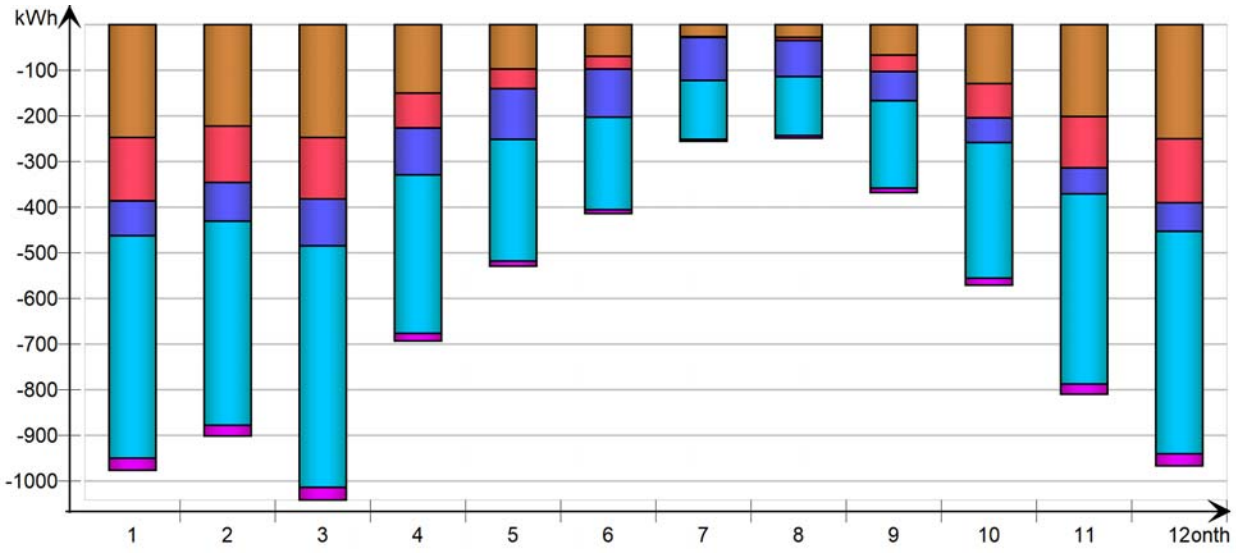
Month	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
1	-490.2	-1.0	-365.7	-32.1	-178.3	257.1	333.3	0.0	474.3	-0.0	0.0
2	-453.7	-1.5	-234.4	-29.6	-163.9	229.4	301.1	0.0	350.9	-0.0	0.0
3	-512.7	0.5	-154.0	-41.2	-193.7	250.0	333.3	0.0	315.8	-0.0	0.0
4	-345.8	-2.6	90.8	-17.1	-339.6	245.0	322.6	0.0	44.6	-0.0	0.0
5	-263.6	-1.2	270.6	-9.7	-593.1	261.5	333.3	0.0	0.0	-0.0	0.0
6	-210.1	-0.3	348.2	-5.6	-711.4	254.5	322.6	0.0	0.0	-0.0	0.0
7	-125.1	0.2	451.8	-2.0	-930.9	270.2	333.3	0.0	0.0	-0.0	0.0
8	-118.5	0.4	351.7	-1.9	-836.0	268.5	333.3	0.0	0.0	-0.0	0.0
9	-174.5	0.7	193.8	-5.7	-593.5	254.4	322.6	0.0	0.0	-0.0	0.0
10	-273.7	1.3	6.2	-12.9	-344.1	265.1	333.3	0.0	22.7	-0.0	0.0
11	-391.9	1.2	-248.7	-28.0	-152.1	247.6	322.6	0.0	248.3	-0.0	0.0
12	-478.7	-0.3	-366.6	-33.5	-178.6	252.3	333.3	0.0	469.9	-0.0	0.0
Total	-3838.4	-2.5	343.7	-219.3	-5215.1	3055.6	3924.4	0.0	1926.5	-0.0	0.0
During heating (MIXED h)	-1953.9	218.5	-1480.1	-108.6	-761.3	703.9	1429.1	0.0	1926.6	0.0	0.0
During cooling (MIXED h)	-1307.1	-58.9	1917.0	-52.2	-4190.3	1764.0	1931.3	0.0	0.0	0.0	0.0
Rest of time	-577.4	-162.1	-93.2	-58.5	-263.5	587.7	564.0	0.0	-0.1	-0.0	0.0



Envelope transmission

kWh

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
1	-247.9	-139.5	-76.5	-488.0	-26.4	0.0
2	-222.0	-123.9	-84.1	-447.6	-23.7	0.0
3	-246.7	-135.4	-103.3	-529.5	-27.3	0.0
4	-149.8	-76.7	-102.3	-347.9	-17.0	0.0
5	-97.6	-42.5	-111.7	-266.4	-11.8	0.0
6	-68.8	-27.2	-105.9	-203.5	-8.2	0.0
7	-26.4	-0.9	-93.9	-129.8	-3.9	0.0
8	-28.1	-6.5	-79.1	-129.0	-4.9	0.0
9	-66.6	-35.5	-63.3	-191.8	-9.1	0.0
10	-129.4	-74.8	-54.2	-298.0	-15.3	0.0
11	-201.2	-111.9	-56.9	-417.4	-21.9	0.0
12	-249.6	-139.8	-63.0	-487.3	-26.3	0.0
Total	-1734.0	-914.5	-994.2	-3936.3	-195.7	0.0
During heating	-991.8	-549.4	-278.4	-2105.3	-134.2	0.0
During cooling	-494.7	-208.3	-556.3	-1285.4	-47.9	0.0
Rest of time	-247.5	-156.8	-159.5	-545.6	-13.6	0.0



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EQUA SIMULATION TECHNOLOGY GROUP		Systems Energy	
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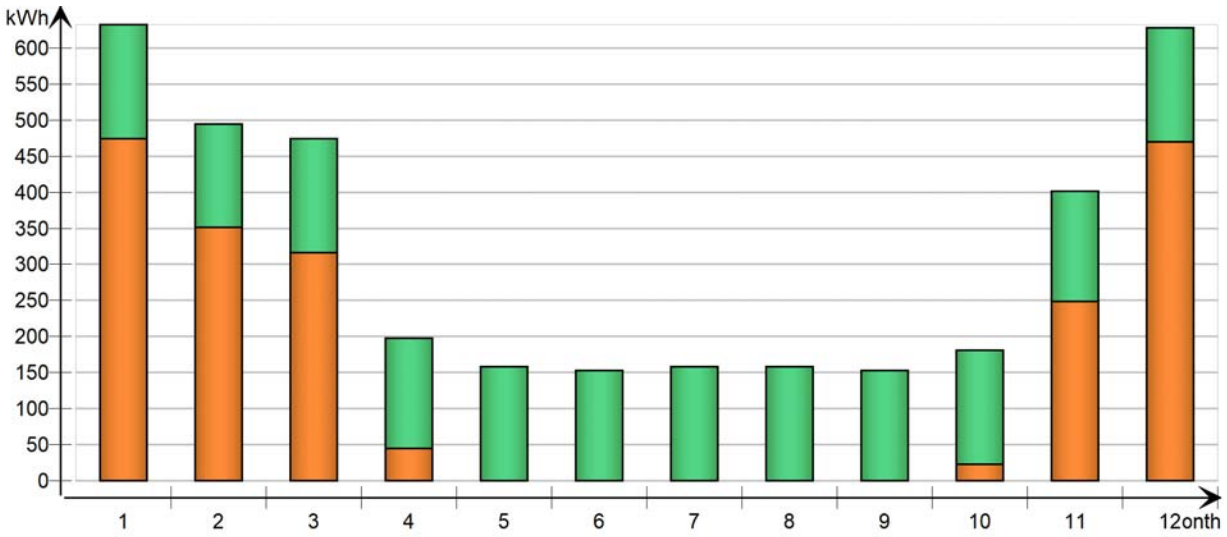
Simulated	6/20/2019 3:14:51 PM	Envelope area per Volume	0.8939 m^2/m^3

Used energy

kWh (sensible and latent)

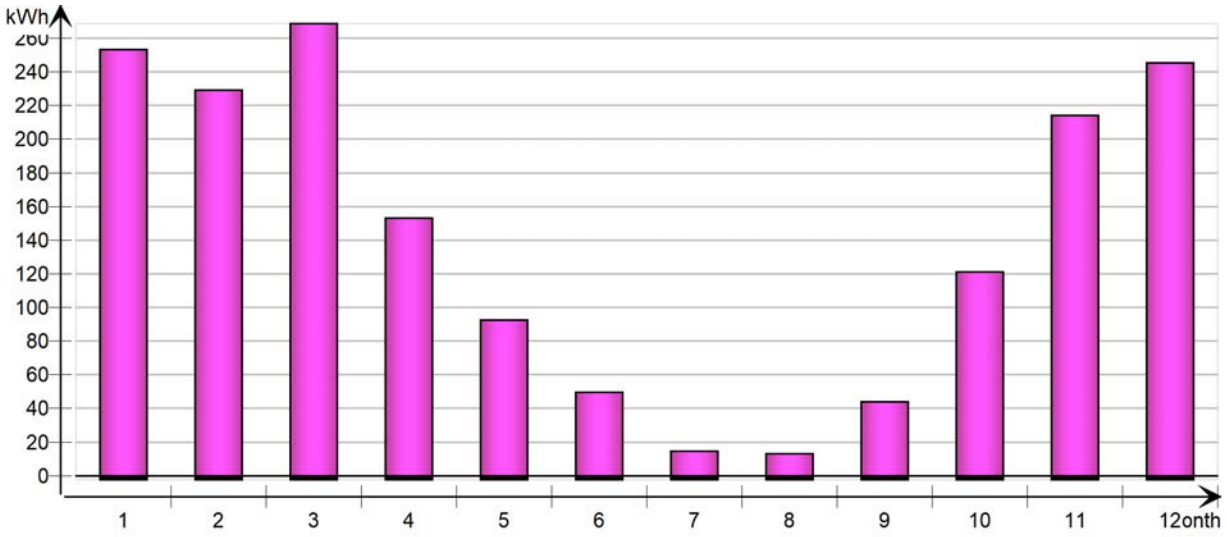
Month	Zone heating	Zone cooling	AHU heating	AHU cooling	Dom. hot water
1	474.3	0.0	0.0	0.0	158.1
2	350.9	0.0	0.0	0.0	142.8
3	315.8	0.0	0.0	0.0	158.1
4	44.6	0.0	0.0	0.0	153.0
5	0.0	0.0	0.0	0.0	158.1
6	0.0	0.0	0.0	0.0	153.0
7	0.0	0.0	0.0	0.0	158.1
8	0.0	0.0	0.0	0.0	158.1
9	0.0	0.0	0.0	0.0	153.0
10	22.7	0.0	0.0	0.0	158.1
11	248.2	0.0	0.0	0.0	153.0
12	470.0	0.0	0.0	0.0	158.1
Total	1926.5	0.0	0.0	0.0	1861.5



Utilized free energy

kWh (sensible and latent)

Month	AHU heat recovery	AHU cold recovery	Plant heat recovery	Plant cold recovery	Solar heat	Ground heat	Ground cold	Ambient heat	Ambient cold
1	253.1	0.0	-0.0	-1.2		0.0	-1.2		
2	229.0	0.0	-0.0	-1.0		0.0	-1.0		
3	268.7	0.0	-0.0	-1.2		0.0	-1.2		
4	153.2	0.0	-0.0	-1.1		0.0	-1.1		
5	92.7	-0.0	-0.0	-1.2		0.0	-1.2		
6	49.6	-0.0	-0.0	-1.1		0.0	-1.1		
7	14.5	-0.0	-0.0	-1.2		0.0	-1.2		
8	13.3	-0.0	-0.0	-1.2		0.0	-1.2		
9	44.0	-0.0	-0.0	-1.1		0.0	-1.1		
10	121.1	0.0	-0.0	-1.2		0.0	-1.2		
11	214.1	0.0	-0.0	-1.1		0.0	-1.1		
12	245.5	0.0	-0.0	-1.2		0.0	-1.2		
Total	1698.7	-0.1	-0.0	-13.6		0.0	-13.6		



Generated electric energy

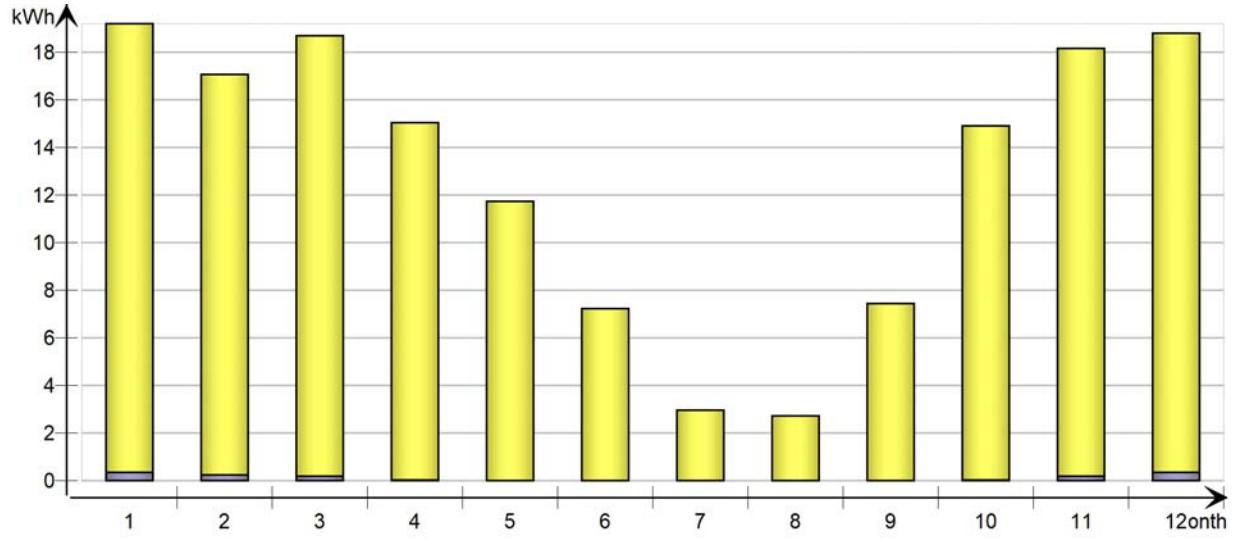
kWh

Month	Solar (PV)	Wind turbine	CHP
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
Total			

Auxiliary energy

kWh

Month	Humidification	Fans	Pumps
1		18.9	0.3
2		16.8	0.2
3		18.5	0.2
4		15.0	0.0
5		11.7	0.0
6		7.2	0.0
7		3.0	0.0
8		2.7	0.0
9		7.4	0.0
10		14.9	0.0
11		18.0	0.2
12		18.5	0.3
Total		152.5	1.4



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A9-1_LCA Calculation 50 years

24.06.2019_Dwelling.concept_50y

LCAbyg 3.2.0.4

Miljø profil

Albertslund Vest/Syd

11982

Bygningstype: Bolig-parcelhus

Opvarmet etageareal: 128 m^2

Samlet brutto etageareal: 180 m^2

Start år: 2019

Betragtningsperiode: 50 år

Energiforbrug - el: -22 kWh/m^2 år

Energiforbrug - varme: 0 kWh/m^2 år

Drift varmeforsyning: El

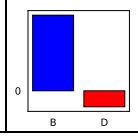
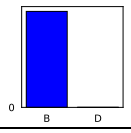
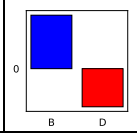
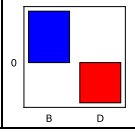
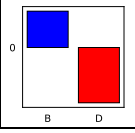
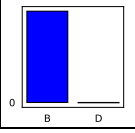
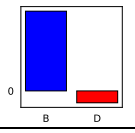
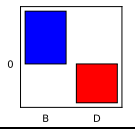
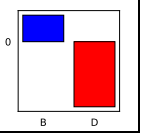
Drift scenarie: Fremskrivning 2015-2050

Nærmere beskrivelse af bygningen: The house is a dwelling concept for future residential ares. The dwelling concept fulfills the requirements of BR18.

SAMLET RESULTAT - BYGNINGSDELE OG DRIFT

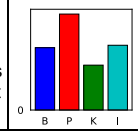
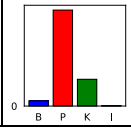
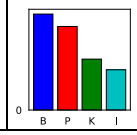
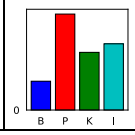
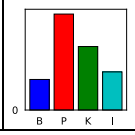
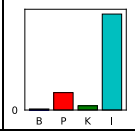
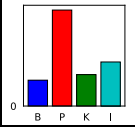
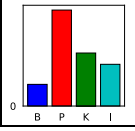
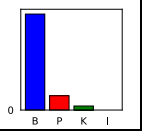
Fordelt på 9 indikatorer* samt individuelle indikatorresultater fordelt på henholdsvis bygningsdele(B) og drift(D)

NB. De individuelle indikatorresultater kan ikke sammenlignes på tværs, da hver indikator har forskellig enhed.

	GWP	ODP	POCP	AP	EP	ADPe	ADPf	PEtot	Sek
Enhed	kg CO_2 eq/m^2 år	kg R11 eq/m^2 år	kg Ethene eq/m^2 år	kg SO_2 eq/m^2 år	kg PO_4^{-3} eq/m^2 år	kg Sb eq/m^2 år	MJ/m^2 år	kWh/m^2 år	kWh/m^2 år
Drift(D)	-1,370	-0,053 x 10^{-9}	-0,003	-0,015	-0,004	-0,709 x 10^{-6}	-13,281	-29,660	-1,541
Bygningsdele(B)	6,474	0,092 x 10^{-6}	0,005	0,019	0,003	0,191 x 10^{-3}	89,050	40,260	0,628
Sum	5,104	0,091 x 10^{-6}	0,001	0,004	-0,001	0,190 x 10^{-3}	75,769	10,600	-0,914
									

HOVEDRESULTATER - BYGNINGSDELE

Fordelt på 9 indikatorer* samt individuelle indikatorresultater fordelt på følgende hovedkategorier:

	GWP	ODP	POCP	AP	EP	ADPe	ADPf	PEtot	Sek
Enhed	kg CO_2 eq/m^2 år	kg R11 eq/m^2 år	kg Ethene eq/m^2 år	kg SO_2 eq/m^2 år	kg PO_4^{-3} eq/m^2 år	kg Sb eq/m^2 år	MJ/m^2 år	kWh/m^2 år	kWh/m^2 år
Bygningsbasis (B)	1,505	0,004 x 10^{-6}	0,002	0,002	0,350 x 10^{-3}	0,002 x 10^{-3}	11,671	4,109	0,527
Primære bygningsdele (P)	2,319	0,068 x 10^{-6}	0,001	0,007	0,001	0,028 x 10^{-3}	43,317	18,190	0,079
Komplettering (K)	1,085	0,019 x 10^{-6}	0,879 x 10^{-3}	0,004	0,726 x 10^{-3}	0,007 x 10^{-3}	14,175	10,051	0,022
Installationer (I)	1,565	0,289 x 10^{-9}	0,695 x 10^{-3}	0,005	0,436 x 10^{-3}	0,154 x 10^{-3}	19,887	7,910	0
Fordelt på andel af bygningsdelenes samlede resultat									

*De 9 indikatorer

- GWP: Global Warming Potential – Global opvarmning
- ODP: Ozone Depletion Potential – Ozonnedbrydning
- POPC: Photochemical Ozone Creation Potential – Fotokemisk Ozondannelse
- AP: Acidification Potential – Forsuring
- EP: Eutrophication Potential – Næringssaltbelastning
- ADPe: Abiotic Depletion Potential, Elements – Abiotisk ressourceudtømning, grundstoffer
- ADPf: Abiotic Depletion Potential, Fossil fuel – Abitoisk ressourceutømning, fossil
- PEtot: Primary Energy – Primærenergi, samlet tal for primærenergi fossil og vedvarende
- Sek: Secondary Energy – Sekundære brændsler, samlet tal for sekundærenergi fossil og vedvarende

Formålet med studiet

Systemafgrænsning - Inkluderet i vurderingen

Konstruktion	Overflader	Teknik og anlæg
✓ Bygningsbasis	✓ Udvendige	✓ Sanitet
✓ Etagedæk	✓ Indvendige	✓ Afløb
✓ Ydervægge		✓ Køling
✓ Indervægge		✓ Vand - centrale anlæg
✓ Tag		✓ Vand - fordeling
✓ Søjler/bjælker		✓ Varme - centrale anlæg
✓ Døre		✓ Varme - fordeling
✓ Vinduer		✓ Ventilation - centrale anlæg
✓ Loft		✓ Ventilation - fordeling
✓ Gulv		✓ Kabler/ledninger
✓ Trapper/ramper		✓ Elevatorer

Andet

Bygningsdele

Navn	Beskrivelse	Mængde	Vægt	Levetid
Foundation	Bygningsdel	40,8 m	18.782,28 kg	-
→ Beton C30/37	Byggevare	7,14 m³	17.136,00 kg	120 år
→ Termoblok - vanger	Byggevare	3,26 m³	1.540,61 kg	60 år
→ Termoblok - isolering	Byggevare	4,08 m³	105,67 kg	60 år
Ground floor	Bygningsdel	100 m²	117.418,00 kg	-
→ Beton C25/30	Byggevare	26 m³	62.400,00 kg	100 år
→ Kapillarbrydende lag (Singels 2-15 mm)	Byggevare	30 m³	54.000,00 kg	100 år
→ Tagpap, bitumen afdækningslag	Byggevare	20 kg	20,00 kg	80 år
→ EPS isolering (Styrofoam ®) til lofter / gulve og som kantisolering B / P-035	Byggevare	20 m³	518,00 kg	50 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	3 m³	480,00 kg	60 år
Doors	Bygningsdel	1 stk.	494,76 kg	-
→ Dør, Hoveddør_HM	Byggevare	3,8 m²	108,30 kg	50 år
→ Dør, Indvendig dør	Byggevare	11,3 m²	386,46 kg	50 år
Exterior Wall	Bygningsdel	159,9 m²	11.012,13 kg	-
→ Træ, konstruktionstræ (stolper og regler)	Byggevare	0,64 m³	315,26 kg	100 år
→ Mineraluld, alm	Byggevare	6,56 m³	172,09 kg	80 år
→ Dampspærre, PE pr m³	Byggevare	0,03 m³	30,06 kg	80 år
→ Cellulosefiberplader	Byggevare	1,6 m³	127,92 kg	80 år
→ Træ, gran	Byggevare	12,63 m³	6.088,67 kg	50 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	9,59 m³	1.535,04 kg	60 år
→ OSB plader	Byggevare	2,88 m³	1.726,92 kg	40 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	5,92 m³	857,86 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	2 m²	19,99 kg	40 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	2 m²	19,99 kg	40 år
→ Beslag mv, stål	Byggevare	95,94 kg	95,94 kg	120 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	22,39 kg	22,39 kg	15 år
Window kitchen	Bygningsdel	1 m²	72,00 kg	-
→ Glas 3 mm	Byggevare	9,6 m²	72,00 kg	40 år
Internal wall	Bygningsdel	82 m²	3.416,99 kg	-
→ Gipskartonplade 13 mm, hulplade	Byggevare	328 m²	2.788,00 kg	80 år
→ Træ, konstruktionstræ (stolper og regler)	Byggevare	0,9 m³	444,60 kg	100 år
→ Mineraluld, alm	Byggevare	6,15 m³	161,44 kg	100 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	22,96 kg	22,96 kg	15 år
Upper roof ceiling	Bygningsdel	67,7 m²	2.678,16 kg	-
→ Mineraluld, alm	Byggevare	20,31 m³	533,14 kg	120 år
→ OSB plader	Byggevare	1,22 m³	731,16 kg	80 år
→ Konstruktionstræ	Byggevare	1,15 m³	567,28 kg	120 år
→ Skruer, forzinket jern	Byggevare	13,54 kg	13,54 kg	50 år
→ Dampspærre PE pr m²	Byggevare	67,7 m²	13,54 kg	50 år
→ OSB plader	Byggevare	1,22 m³	731,16 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,68 m²	6,77 kg	60 år
→ Træ, gran	Byggevare	0,17 m³	81,58 kg	80 år
First floor	Bygningsdel	68 m²	2.364,82 kg	-
→ Konstruktionstræ	Byggevare	1,36 m³	670,34 kg	100 år
→ Skruer, forzinket jern	Byggevare	13,6 kg	13,60 kg	50 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,85 m²	8,50 kg	40 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,85 m²	8,50 kg	40 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	0,85 m³	123,25 kg	50 år
→ OSB plader	Byggevare	0,68 m³	408,00 kg	80 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	2,04 m³	326,40 kg	60 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	9,52 kg	9,52 kg	15 år
→ Dampspærre PE pr m²	Byggevare	0,14 m²	0,03 kg	50 år
→ OSB plader	Byggevare	1,22 m³	734,40 kg	80 år
→ Træ, gran	Byggevare	0,13 m³	62,27 kg	80 år
Staircase	Bygningsdel	1 stk.	231,36 kg	-
→ Træ, gran	Byggevare	0,48 m³	231,36 kg	80 år

Terrace	Bygningsdel	32 m²	1.689,39 kg	-
→ Konstruktionstræ	Byggevare	0,26 m³	126,18 kg	100 år
→ Celluloseflis-isolering, løsfyld, indblæsning	Byggevare	10,56 m³	475,20 kg	60 år
→ Plast profil SBR	Byggevare	99,84 kg	99,84 kg	50 år
→ Skruer, forzinket jern	Byggevare	6,4 kg	6,40 kg	50 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	4,48 kg	4,48 kg	15 år
→ OSB plader	Byggevare	0,58 m³	345,60 kg	80 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	0,4 m³	58,00 kg	50 år
→ OSB plader	Byggevare	0,58 m³	345,60 kg	80 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	0,96 m³	153,60 kg	50 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,4 m²	4,00 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,4 m²	4,00 kg	80 år
→ Træ, gran	Byggevare	0,06 m³	29,31 kg	80 år
→ Dampspærre PA	Byggevare	1,38 m²	0,11 kg	50 år
→ Tagfolie, PVC	Byggevare	0,05 m²	0,07 kg	50 år
→ EPS isolering (Styrofoam ®) til lofter / gulve og som kantisolering B / P-040	Byggevare	2 m³	37,00 kg	80 år
Roof	Bygningsdel	110,9 m²	10.826,56 kg	-
→ Konstruktionstræ	Byggevare	1,66 m³	819,94 kg	120 år
→ Tagsten i tegl	Byggevare	3.327 kg	3.323,67 kg	60 år
→ Dampspærre, PE pr m³	Byggevare	0,04 m³	41,70 kg	40 år
→ Undertag, EPDM folie	Byggevare	22,18 kg	22,18 kg	40 år
→ Gipsflisplade 10 mm	Byggevare	110,9 m²	1.109,00 kg	40 år
→ Træplader, 3-lags	Byggevare	5,55 m³	2.830,72 kg	25 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	6,65 m³	1.064,64 kg	50 år
→ Træ, gran	Byggevare	0,55 m³	267,27 kg	25 år
→ Celluloseflis-isolering, løsfyld, indblæsning	Byggevare	29,94 m³	1.347,44 kg	40 år
Windows	Bygningsdel	43,2 m²	1.494,72 kg	-
→ Vinduesprofil, karm, træ, hvidmalet	Byggevare	302,4 kg	393,12 kg	25 år
→ Energirude (2-lags), termorude 2x4 mm, argonfyldt	Byggevare	51,84 m²	1.036,80 kg	25 år
→ Vinduesprofil, karm, alu. pulverlak.	Byggevare	64,8 kg	64,80 kg	25 år
Solar shading	Bygningsdel	7,33 m²	130,72 kg	-
→ Træ, gran	Byggevare	0,27 m³	130,72 kg	80 år
Wooden floor	Bygningsdel	110 m²	979,00 kg	-
→ Trægulv, flerlags laminat, 10-12 mm	Byggevare	110 m²	979,00 kg	50 år
Tile floor	Bygningsdel	48 m²	648,00 kg	-
→ Keramikfliser, u-glaseret	Byggevare	0,24 m³	480,00 kg	100 år
→ Mørtel, fliseklæber	Byggevare	168 kg	168,00 kg	100 år
Circulation Pump	Bygningsdel	3 stk.	7,41 kg	-
→ Cirkulationspumpe, < 50 W	Byggevare	3 stk.	7,41 kg	30 år
Hot water tank	Bygningsdel	1 stk.	91,40 kg	-
→ Varmvandsbeholder	Byggevare	85 kg	85,00 kg	30 år
→ Isolering XPS	Byggevare	0,2 m³	6,40 kg	30 år
Floor heating	Bygningsdel	128 m	243,20 kg	-
→ Gulvarmeslange, PEX, 100 mm afstand	Byggevare	128 m²	243,20 kg	60 år
Ventilation device	Bygningsdel	12 stk.	44,29 kg	-
→ Ventilationsanlæg decentraliseret med varmegenvinding (væg & loft) 60 m3 / h	Byggevare	12 stk.	44,29 kg	50 år
Solar panels	Bygningsdel	50 stk.	450,00 kg	-
→ Solcelleanlæg 1000 kWh / m2 * a	Byggevare	50 m²	450,00 kg	40 år

A9-2_LCA Calculation 80 years

23.06.2019_Dwelling.concept_80y

LCAbyg 3.2.0.4

Miljø profil

Albertslund Vest/Syd

11982

Bygningstype: Bolig-parcelhus

Opvarmet etageareal: 128 m^2

Samlet brutto etageareal: 180 m^2

Start år: 2019

Betragtningsperiode: 80 år

Energiforbrug - el: -22 kWh/m^2 år

Energiforbrug - varme: 0 kWh/m^2 år

Drift varmeforsyning: El

Drift scenarie: Fremskrivning 2015-2050

Nærmere beskrivelse af bygningen: The house is a dwelling concept for future residential ares. The dwelling concept fulfills the requirements of BR18.

SAMLET RESULTAT - BYGNINGSDELE OG DRIFT

Fordelt på 9 indikatorer* samt individuelle indikatorresultater fordelt på henholdsvis bygningsdele(B) og drift(D)

NB. De individuelle indikatorresultater kan ikke sammenlignes på tværs, da hver indikator har forskellig enhed.

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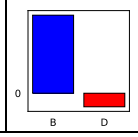
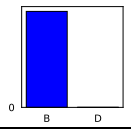
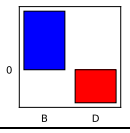
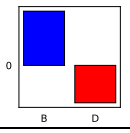
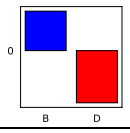
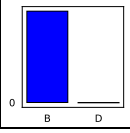
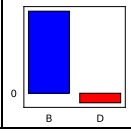
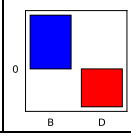
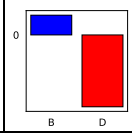
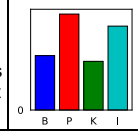
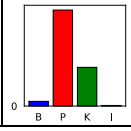
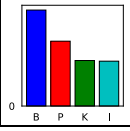
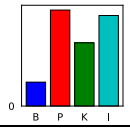
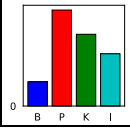
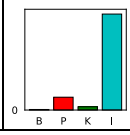
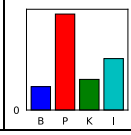
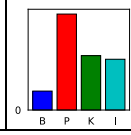
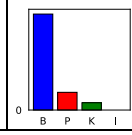
Drift(D)	-1,054	-0,050 x 10^{-9}	-0,003	-0,013	-0,003	-0,724 x 10^{-6}	-10,363	-28,208	-1,511
Bygningsdele(B)	6,063	0,086 x 10^{-6}	0,005	0,019	0,002	0,225 x 10^{-3}	88,946	39,983	0,415
Sum	5,009	0,086 x 10^{-6}	0,002	0,006	-0,788 x 10^{-3}	0,224 x 10^{-3}	78,583	11,774	-1,096
									

HOVEDRESULTATER - BYGNINGSDELE

Fordelt på 9 indikatorer* samt individuelle indikatorresultater fordelt på følgende hovedkategorier:

	GWP	ODP	POCP	AP	EP	ADPe	ADPf	PEtot	Sek
Enhed	kg CO_2 eq/m^2 år	kg R11 eq/m^2 år	kg Ethene eq/m^2 år	kg SO_2 eq/m^2 år	kg PO_4^{-3} eq/m^2 år	kg Sb eq/m^2 år	MJ/m^2 år	kWh/m^2 år	kWh/m^2 år
Bygningsbasis (B)	1,165	0,003 x 10^{-6}	0,002	0,002	0,242 x 10^{-3}	0,001 x 10^{-3}	10,321	3,444	0,329
Primære bygningsdele (P)	2,056	0,059 x 10^{-6}	0,001	0,007	0,958 x 10^{-3}	0,026 x 10^{-3}	42,382	17,435	0,061
Komplettering (K)	1,044	0,024 x 10^{-6}	0,849 x 10^{-3}	0,004	0,716 x 10^{-3}	0,007 x 10^{-3}	13,535	9,878	0,025
Installationer (I)	1,798	0,357 x 10^{-9}	0,836 x 10^{-3}	0,006	0,522 x 10^{-3}	0,192 x 10^{-3}	22,708	9,226	0
Fordelt på andel af bygningsdelenes samlede resultat									

*De 9 indikatorer

- GWP: Global Warming Potential – Global opvarmning
- ODP: Ozone Depletion Potential – Ozonnedbrydning
- POPC: Photochemical Ozone Creation Potential – Fotokemisk Ozondannelse
- AP: Acidification Potential – Forsuring
- EP: Eutrophication Potential – Næringssaltbelastning
- ADPe: Abiotic Depletion Potential, Elements – Abiotisk ressourceudtømning, grundstoffer
- ADPf: Abiotic Depletion Potential, Fossil fuel – Abitoisk ressourceutømning, fossil
- PEtot: Primary Energy – Primærenergi, samlet tal for primærenergi fossil og vedvarende
- Sek: Secondary Energy – Sekundære brændsler, samlet tal for sekundærenergi fossil og vedvarende

Formålet med studiet

Systemafgrænsning - Inkluderet i vurderingen

Konstruktion	Overflader	Teknik og anlæg
✓ Bygningsbasis	✓ Udvendige	✓ Sanitet
✓ Etagedæk	✓ Indvendige	✓ Afløb
✓ Ydervægge		✓ Køling
✓ Indervægge		✓ Vand - centrale anlæg
✓ Tag		✓ Vand - fordeling
✓ Søjler/bjælker		✓ Varme - centrale anlæg
✓ Døre		✓ Varme - fordeling
✓ Vinduer		✓ Ventilation - centrale anlæg
✓ Loft		✓ Ventilation - fordeling
✓ Gulv		✓ Kabler/ledninger
✓ Trapper/ramper		✓ Elevatorer

Andet

Bygningsdele

Navn	Beskrivelse	Mængde	Vægt	Levetid
Foundation	Bygningsdel	40,8 m	18.782,28 kg	-
→ Beton C30/37	Byggevare	7,14 m³	17.136,00 kg	120 år
→ Termoblok - vanger	Byggevare	3,26 m³	1.540,61 kg	60 år
→ Termoblok - isolering	Byggevare	4,08 m³	105,67 kg	60 år
Ground floor	Bygningsdel	100 m²	117.418,00 kg	-
→ Beton C25/30	Byggevare	26 m³	62.400,00 kg	100 år
→ Kapillarbrydende lag (Singels 2-15 mm)	Byggevare	30 m³	54.000,00 kg	100 år
→ Tagpap, bitumen afdækningslag	Byggevare	20 kg	20,00 kg	80 år
→ EPS isolering (Styrofoam ®) til lofter / gulve og som kantisolering B / P-035	Byggevare	20 m³	518,00 kg	50 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	3 m³	480,00 kg	60 år
Exterior Wall	Bygningsdel	159,9 m²	11.012,13 kg	-
→ Træ, konstruktionstræ (stolper og regler)	Byggevare	0,64 m³	315,26 kg	100 år
→ Mineraluld, alm	Byggevare	6,56 m³	172,09 kg	80 år
→ Dampspærre, PE pr m³	Byggevare	0,03 m³	30,06 kg	80 år
→ Cellulosefiberplader	Byggevare	1,6 m³	127,92 kg	80 år
→ Træ, gran	Byggevare	12,63 m³	6.088,67 kg	50 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	9,59 m³	1.535,04 kg	60 år
→ OSB plader	Byggevare	2,88 m³	1.726,92 kg	40 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	5,92 m³	857,86 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	2 m²	19,99 kg	40 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	2 m²	19,99 kg	40 år
→ Beslag mv, stål	Byggevare	95,94 kg	95,94 kg	120 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	22,39 kg	22,39 kg	15 år
Doors	Bygningsdel	1 stk.	494,76 kg	-
→ Dør, Hoveddør_HM	Byggevare	3,8 m²	108,30 kg	50 år
→ Dør, Indvendig dør	Byggevare	11,3 m²	386,46 kg	50 år
Window kitchen	Bygningsdel	1 m²	72,00 kg	-
→ Glas 3 mm	Byggevare	9,6 m²	72,00 kg	40 år
Internal wall	Bygningsdel	82 m²	3.416,99 kg	-
→ Gipskartonplade 13 mm, hulplade	Byggevare	328 m²	2.788,00 kg	80 år
→ Træ, konstruktionstræ (stolper og regler)	Byggevare	0,9 m³	444,60 kg	100 år
→ Mineraluld, alm	Byggevare	6,15 m³	161,44 kg	100 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	22,96 kg	22,96 kg	15 år
Upper roof ceiling	Bygningsdel	67,7 m²	2.678,16 kg	-
→ Mineraluld, alm	Byggevare	20,31 m³	533,14 kg	120 år
→ OSB plader	Byggevare	1,22 m³	731,16 kg	80 år
→ Skruer, forzinket jern	Byggevare	13,54 kg	13,54 kg	50 år
→ Konstruktionstræ	Byggevare	1,15 m³	567,28 kg	120 år
→ Dampspærre PE pr m²	Byggevare	67,7 m²	13,54 kg	50 år
→ OSB plader	Byggevare	1,22 m³	731,16 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,68 m²	6,77 kg	60 år
→ Træ, gran	Byggevare	0,17 m³	81,58 kg	80 år
First floor	Bygningsdel	68 m²	2.364,82 kg	-
→ Konstruktionstræ	Byggevare	1,36 m³	670,34 kg	100 år
→ Skruer, forzinket jern	Byggevare	13,6 kg	13,60 kg	50 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,85 m²	8,50 kg	40 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,85 m²	8,50 kg	40 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	0,85 m³	123,25 kg	50 år
→ OSB plader	Byggevare	0,68 m³	408,00 kg	80 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	2,04 m³	326,40 kg	60 år
→ Dampspærre PE pr m²	Byggevare	0,14 m²	0,03 kg	50 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	9,52 kg	9,52 kg	15 år
→ OSB plader	Byggevare	1,22 m³	734,40 kg	80 år
→ Træ, gran	Byggevare	0,13 m³	62,27 kg	80 år
Staircase	Bygningsdel	1 stk.	231,36 kg	-
→ Træ, gran	Byggevare	0,48 m³	231,36 kg	80 år

Terrace	Bygningsdel	32 m²	1.689,39 kg	-
→ Konstruktionstræ	Byggevare	0,26 m³	126,18 kg	100 år
→ Celluloseflis-isolering, løsfyld, indblæsning	Byggevare	10,56 m³	475,20 kg	60 år
→ Skruer, forzinket jern	Byggevare	6,4 kg	6,40 kg	50 år
→ Plast profil SBR	Byggevare	99,84 kg	99,84 kg	50 år
→ Overflade, Indendørsmaling, emulsions maling, slidstærk	Byggevare	4,48 kg	4,48 kg	15 år
→ OSB plader	Byggevare	0,58 m³	345,60 kg	80 år
→ Lyddæmpende loft, trykfast mineraluld	Byggevare	0,4 m³	58,00 kg	50 år
→ OSB plader	Byggevare	0,58 m³	345,60 kg	80 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	0,96 m³	153,60 kg	50 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,4 m²	4,00 kg	80 år
→ Gipskartonplade 13 mm, imprægneret	Byggevare	0,4 m²	4,00 kg	80 år
→ Træ, gran	Byggevare	0,06 m³	29,31 kg	80 år
→ Dampspærre PA	Byggevare	1,38 m²	0,11 kg	50 år
→ Tagfolie, PVC	Byggevare	0,05 m²	0,07 kg	50 år
→ EPS isolering (Styrofoam ®) til lofter / gulve og som kantisolering B / P-040	Byggevare	2 m³	37,00 kg	80 år
Roof	Bygningsdel	110,9 m²	10.826,56 kg	-
→ Konstruktionstræ	Byggevare	1,66 m³	819,94 kg	120 år
→ Tagsten i tegl	Byggevare	3.327 kg	3.323,67 kg	60 år
→ Dampspærre, PE pr m³	Byggevare	0,04 m³	41,70 kg	40 år
→ Undertag, EPDM folie	Byggevare	22,18 kg	22,18 kg	40 år
→ Gipsflisplade 10 mm	Byggevare	110,9 m²	1.109,00 kg	40 år
→ Træplader, 3-lags	Byggevare	5,55 m³	2.830,72 kg	25 år
→ Træfiberisoleringsplade (våd proces)	Byggevare	6,65 m³	1.064,64 kg	50 år
→ Træ, gran	Byggevare	0,55 m³	267,27 kg	25 år
→ Celluloseflis-isolering, løsfyld, indblæsning	Byggevare	29,94 m³	1.347,44 kg	40 år
Solar shading	Bygningsdel	7,33 m²	130,72 kg	-
→ Træ, gran	Byggevare	0,27 m³	130,72 kg	80 år
Windows	Bygningsdel	43,2 m²	1.494,72 kg	-
→ Vinduesprofil, karm, træ, hvidmalet	Byggevare	302,4 kg	393,12 kg	25 år
→ Energirude (2-lags), termorude 2x4 mm, argonfyldt	Byggevare	51,84 m²	1.036,80 kg	25 år
→ Vinduesprofil, karm, alu. pulverlak.	Byggevare	64,8 kg	64,80 kg	25 år
Tile floor	Bygningsdel	48 m²	648,00 kg	-
→ Keramikfliser, u-glaseret	Byggevare	0,24 m³	480,00 kg	100 år
→ Mørtel, fliseklæber	Byggevare	168 kg	168,00 kg	100 år
Wooden floor	Bygningsdel	110 m²	979,00 kg	-
→ Trægulv, flerlags laminat, 10-12 mm	Byggevare	110 m²	979,00 kg	50 år
Floor heating	Bygningsdel	128 m	243,20 kg	-
→ Gulvarmeslange, PEX, 100 mm afstand	Byggevare	128 m²	243,20 kg	60 år
Hot water tank	Bygningsdel	1 stk.	91,40 kg	-
→ Varmvandsbeholder	Byggevare	85 kg	85,00 kg	30 år
→ Isolering XPS	Byggevare	0,2 m³	6,40 kg	30 år
Circulation Pump	Bygningsdel	3 stk.	7,41 kg	-
→ Cirkulationspumpe, < 50 W	Byggevare	3 stk.	7,41 kg	30 år
Ventilation device	Bygningsdel	12 stk.	44,29 kg	-
→ Ventilationsanlæg decentraliseret med varmegenvinding (væg & loft) 60 m3 / h	Byggevare	12 stk.	44,29 kg	50 år
Solar panels	Bygningsdel	50 stk.	450,00 kg	-
→ Solcelleanlæg 1000 kWh / m2 * a	Byggevare	50 m²	450,00 kg	40 år