Passivhaus-Objektdokumentation
Project Documentation

Single family house / Einfamilienhaus Kuldar L. in Estonia- Põlva

Passive House Designer / Passivhaus Planer: Georg W. Reinberg,
http://www.reinberg.net/architektur/265

1.1 Data of building / Gebäudedaten

Year of construction Baujahr	2012 / 2013
U-value external wall / U-Wert Außenwand	0,105 W/(m²K)
U- value basement ceiling / U-value Wert Kellerdecke	0,116 W/(m²K)
U-value roof / U-Wert Dach	0,079 W/(m²K)
U-value window south / U-Wert Fenster süd/	0,63 W/(m²K)
U-value window east,west,north / U-Wert Fenster ost, west, nord	0,49 W/(m²K)
Wärmerückgewinnung / Heat recovery	93 ~ %
PHPP space heating / PHPP Jahresheizwärmebedarf	**14, 71 kWh (m²a)**
PHPP primary energy demand / PHPP Primärenergie	**101 kWh (m²a)**
Drucktest / Pressure test	**0,2 h^{-1}**

Special features / Besonderheiten

Warmwasserkollektoren, integriert in der Fassade (Winterbetrieb: 17,5 m²) und auf dem Dach (Sommerbetrieb: 11,6 m²), Pufferspeicher(2000Liter), kontrollierte Lüftung mit Lüftungswärmerückgewinnung und Grundwasser-Wärmepumpe. PV (90 m², 1,96 kWp) als Pergola-Elemente, Tiefenbohrung (2x80 Meter) und Wasserwärmemenge (5,9 kW und COP 4,51), Fußbodenheizung(39/33°)Hot water collectors, integrated into the facade (winter: 17,5 m²) and on the roof (in summer: 11,6m²), buffer(2000 L), controlled ventilation with heat recovery ventilation and ground water heat pump. PV (90 m²-1,96 kWp) as pergola elements, deep drilling(2x80 m) and warm water quantity(5,9 kW and COP 4,51), under floor heating (39/33°)

1.2 Brief Description of the Project / Kurzbeschreibung der Bauaufgabe

Auf dem Grundstück mit einem nicht mehr genutzten ca. 100 Meter tiefen Brunnen (zur ehemaligen Wasserversorgung des Ortes) wird an einer Geländekante ein Einfamilienhaus errichtet. Das Gebäude verfügt im Erdgeschoß über einen Wohnraum, Küche und Schlafzimmer sowie die entsprechenden Nebenräume. Im Kellergeschoß, das hangseitig frei steht, befinden sich eine Sauna und ein Dampfbad, entsprechende Nebenräume sowie Abstellräume. Im Obergeschoß sind die Kinderzimmer sowie ein Arbeitsstudio untergebracht. Das Wohnzimmer ist zweigeschossig und es öffnen sich alle Räume nach Süden zur Sonne. Ein zweites Dach, das auf Stützen über dem Gebäude schwebt, trägt Photovoltaik-Elemente (90 m²) und dient neben der Stromgewinnung der sommerlichen Beschattung. Am Dach befinden sich schräg gestellte thermische Kollektoren, optimiert für den Sommerbetrieb (11,6 m²) und in der Fassade vertikale thermische Kollektoren für den Winterbetrieb (17,5m²). Der Restwärmebedarf wird über eine Wärmepumpe aus Tiefenbohrungen gewonnen. Das Gebäude adaptiert das Passivhauskonzept für die nördliche Sonne und dient als Musterbeispiel für Passiv- und Plus-Energiegebäude in nördlichen Breiten.

The property consists of a rectangular plot that has two very different levels, divided by a diagonal slop running north-east to south-west; in the upper part of this plot, we find an old well in disused, about 100 meters deep (the former water supply of the place), on the ridge a house has been built. The building has the ground floor with a living room, kitchen and bedroom as well as the corresponding auxiliary rooms. In the basement, which is another hang freely, there are 1 sauna and steam bad, appropriate ancillary rooms and storage rooms. Upstairs, the nursery and a working studio are housed. The living room is two-storey and it is open all the rooms facing south towards the sun. A second roof that floats on stilts above the building is carrying the photovoltaic elements (90m²) and is in addition to the current production of the summer shade. On the roof there are slanted thermal panels, optimized for summer operation (11,6m) and vertical in the facade thermal collectors for winter operations (17,5 m²). The residual heat demand is obtained through a heat pump from the deep drilling again. The building adapts the passive house concept for the northern sun and serves as a model for passive and plus-energy buildings in the northern latitudes.

1.3 Project participants / Projektbeteiligte /

- Passive House Designer / Passivhaus Planer — Georg W. Reinberg
- Collaborator / Mitarbeiter : — Martha Enriquez Reinberg
- Consultants / Konsulenten — Tõnu Mauring, Jaanus Hallik und Kristo Kalbe
- Building physics and monitoring
Bauphysik und Monitorung / — University of Tartu
- Structural engineering / Tragwerksplaner — Johannes Riebenbauer, Graz
- Building systems / Haustechnik — S&P Climadesign GmbH
- Construction supervision
/ Projectmanagement und Bauaufsicht — Margus Valge, Sense OÜ
- Certifying Authority / Zertifizierungsstelle — Passive House OÜ, Estonia and Passive House Institute, Darmstadt

- **Exterior - Interior Photos**

Photo 01.-   South and -West Facade

Photo 02.- South and East Facade

Photo 03.- West Facade

Photo 04.- North Facade

Photo 05.- East Facade

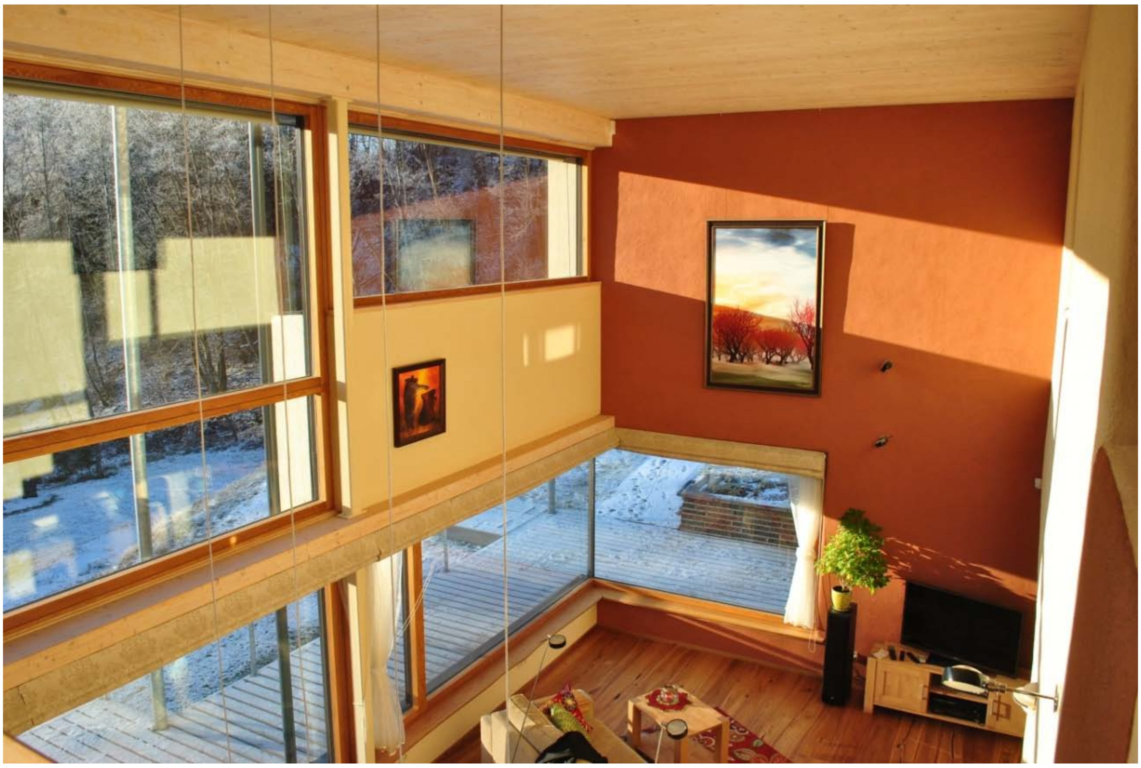


Photo 06.- Living room

Photo 07.- Gallery

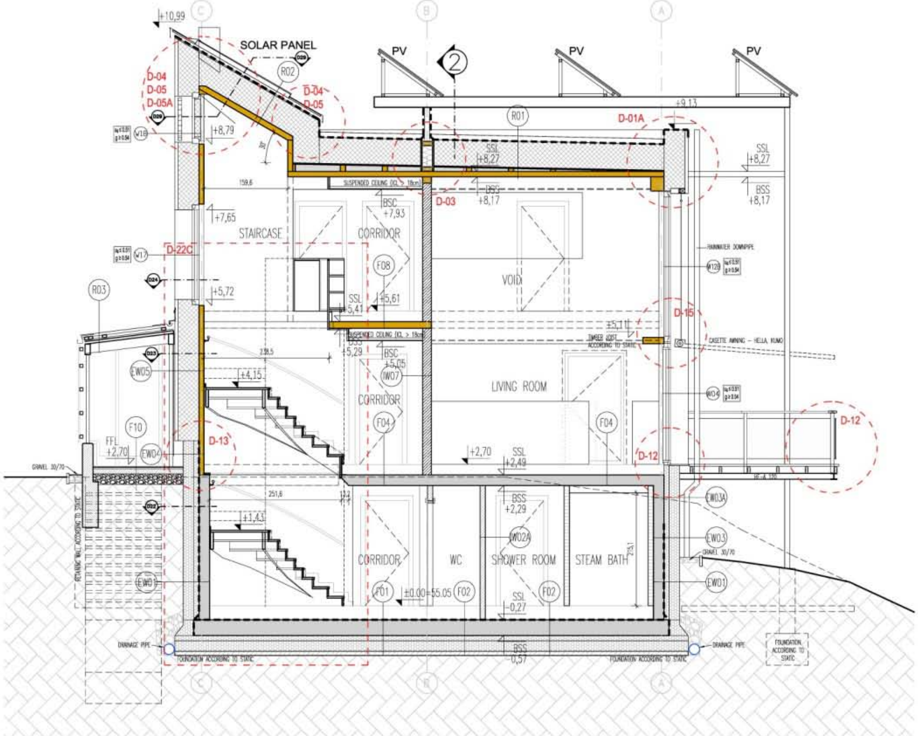
Photo 08.- view from the Conservatory towards south-east Garden

Photo 09.-view from the Living room into the south-west Garden

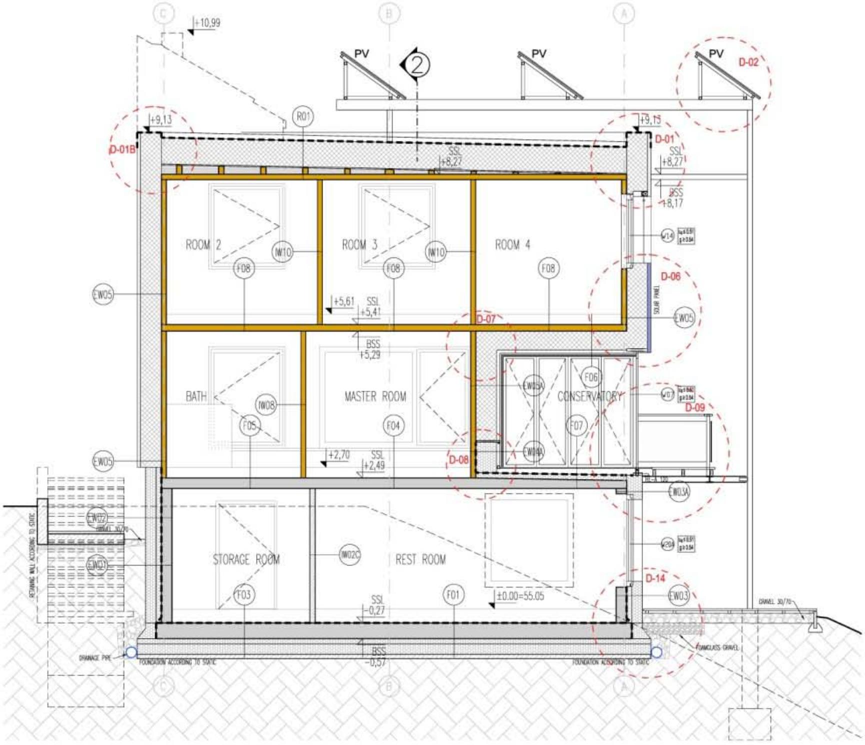
Photo 10. - Living room

Photo 11.- Living room

2 Sections



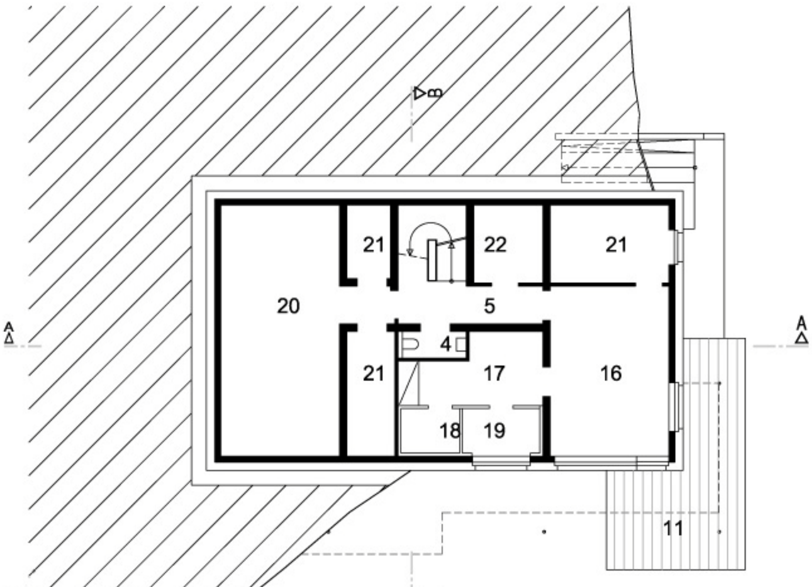
SECTION 1



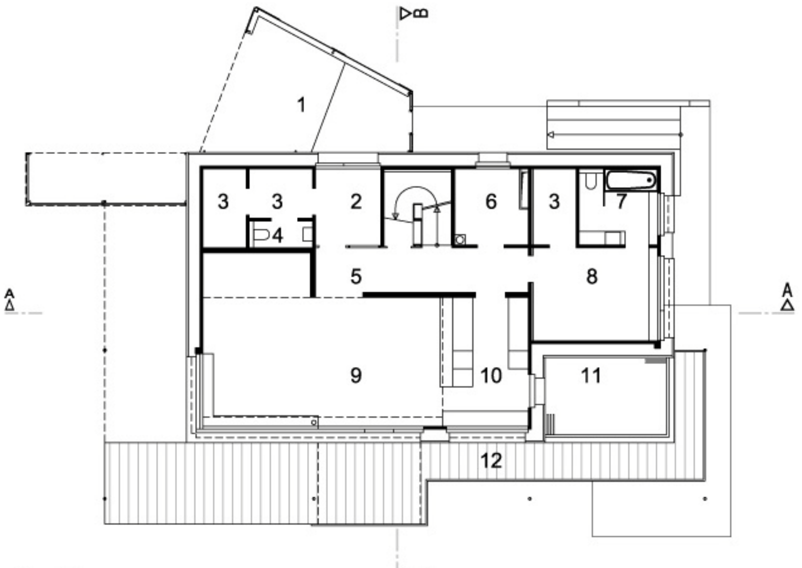
SECTION 2

3 Floor plans

1. cover space
2. Entrance
3. Wardrobe
4. WC
5. Corridor
6. Laundry room
7. Bathroom
8. Master Bedroom
9. Livingroom
10. Kitchen
11. Conservatory
12. Terrace
13. Gallery
14. Children room
15. Study room
16. Recreation room
17. Shawer room
18. Steambath
19. Sauna
20. Playroom
21. Storageroom
22. Thecnic room
23. Therm.Solar Coll.
24. PV

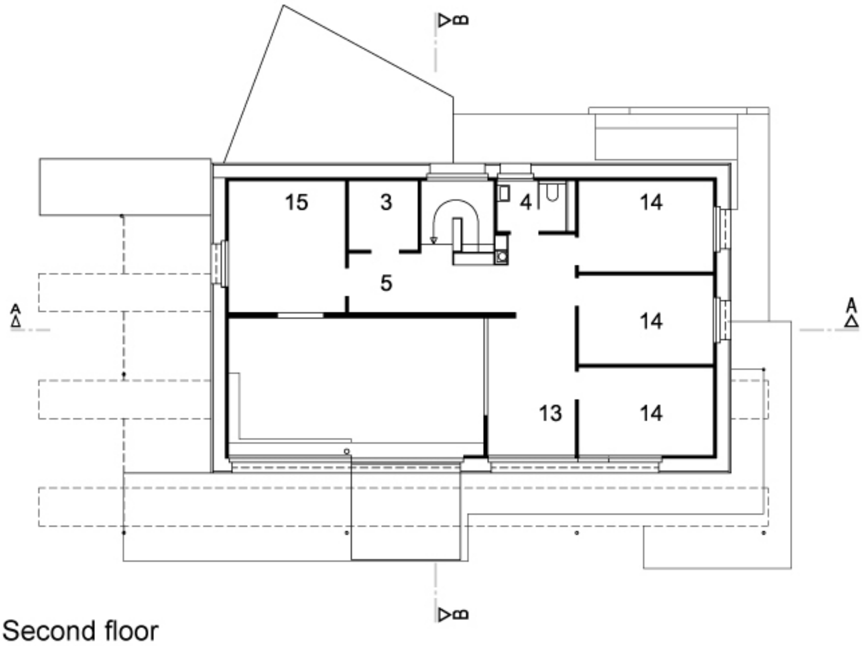


Basement floor

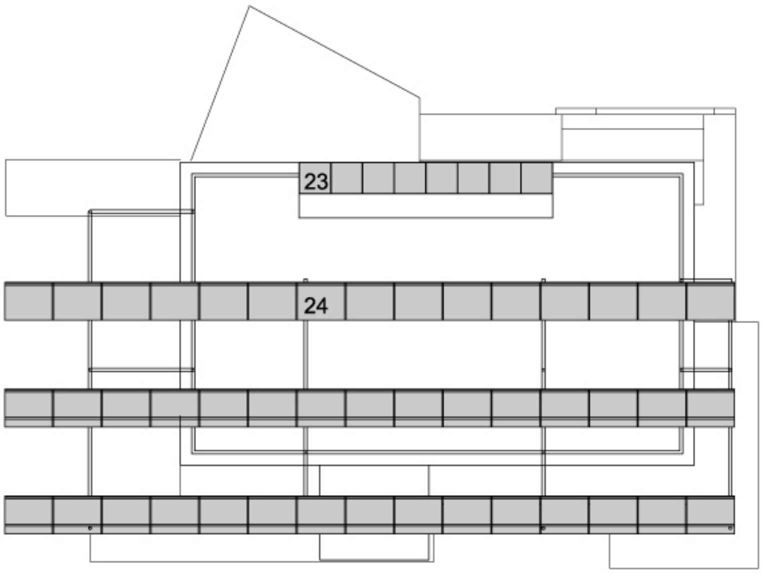


First floor

1. cover space
2. Entrance
3. Wardrobe
4. WC
5. Corridor
6. Laundry room
7. Bathroom
8. Master Bedroom
9. Livingroom
10. Kitchen
11. Conservatory
12. Terrace
13. Gallery
14. Children room
15. Study room
16. Recreation room
17. Shawer room
18. Steambath
19. Sauna
20. Playroom
21. Storageroom
22. Thecnic room
23. Therm.Solar Coll.
24. PV



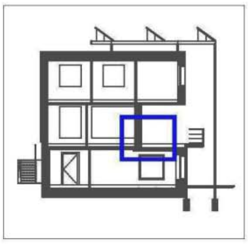
Second floor

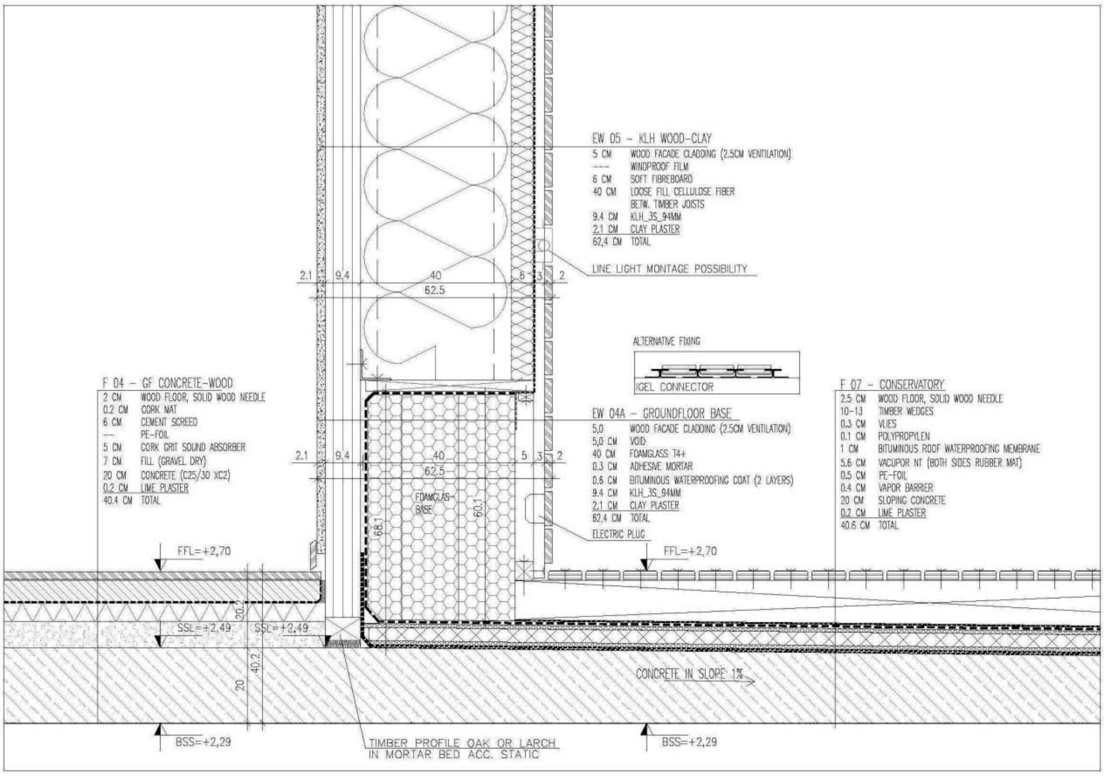


Roof

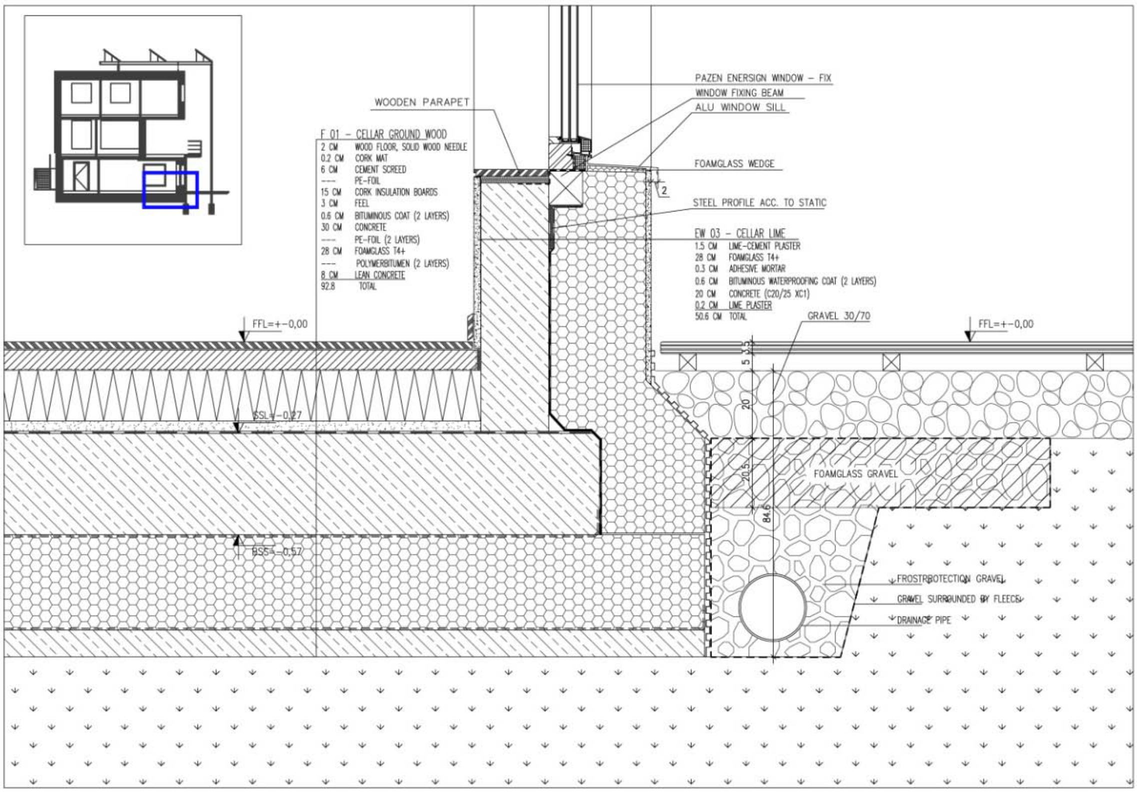
4 Construction Details

4.1 Floor between 1th floor and basement





4.2 Basement Floor



The basement (partly in ground and partly open to the sloping hillside) is casted concrete construction with thick layer of XPS/EPS insulation depending on the wall/floor type. The aboveground perimeter walls have 300mm of EPS insulation and belowground perimeter walls have 500mm of EPS insulation. The floor slab configuration features 300 mm of XPS insulation and 100mm of EPS insulation.

Construction of floor slab

Basement floor	80 mm concrete, 300 mm XPS, 300 mm concrete, 30 mm LECA granulate, 100 mm EPS, 60 mm concrete, 20 mm wood	U-value 0,086 W/(m²K)

4.3 External walls

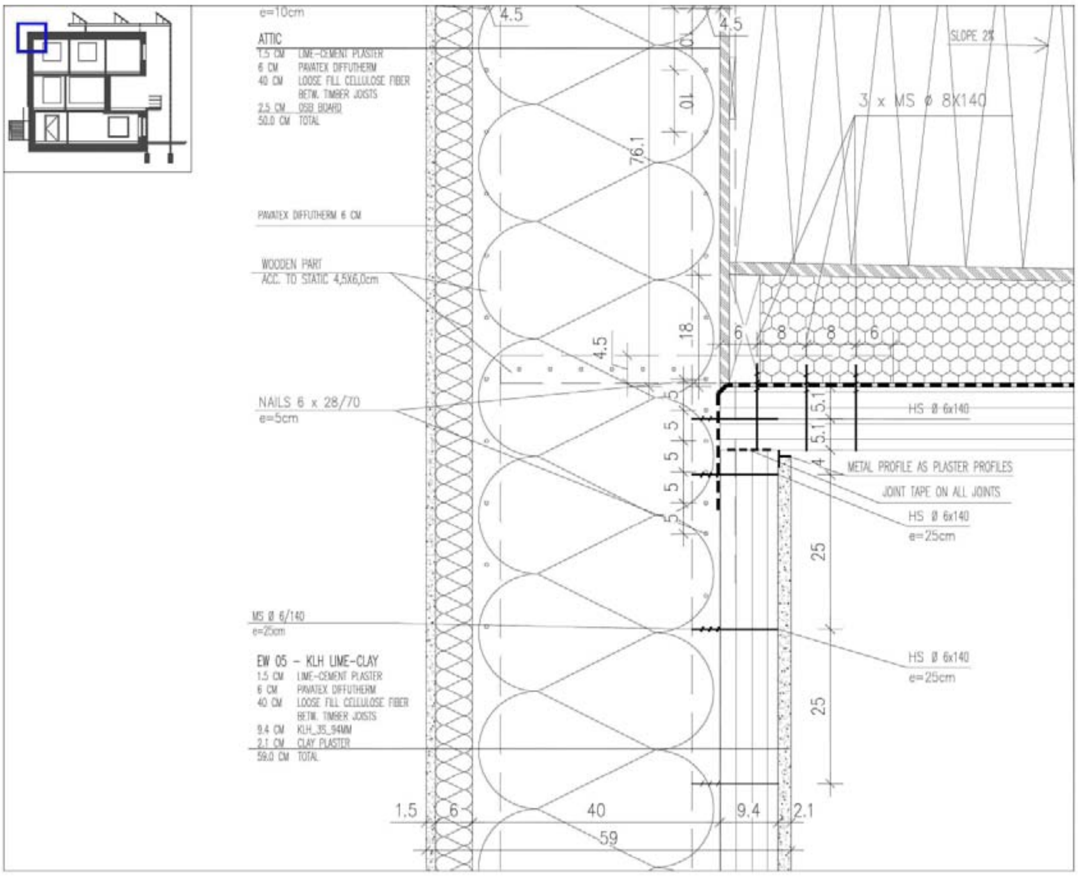
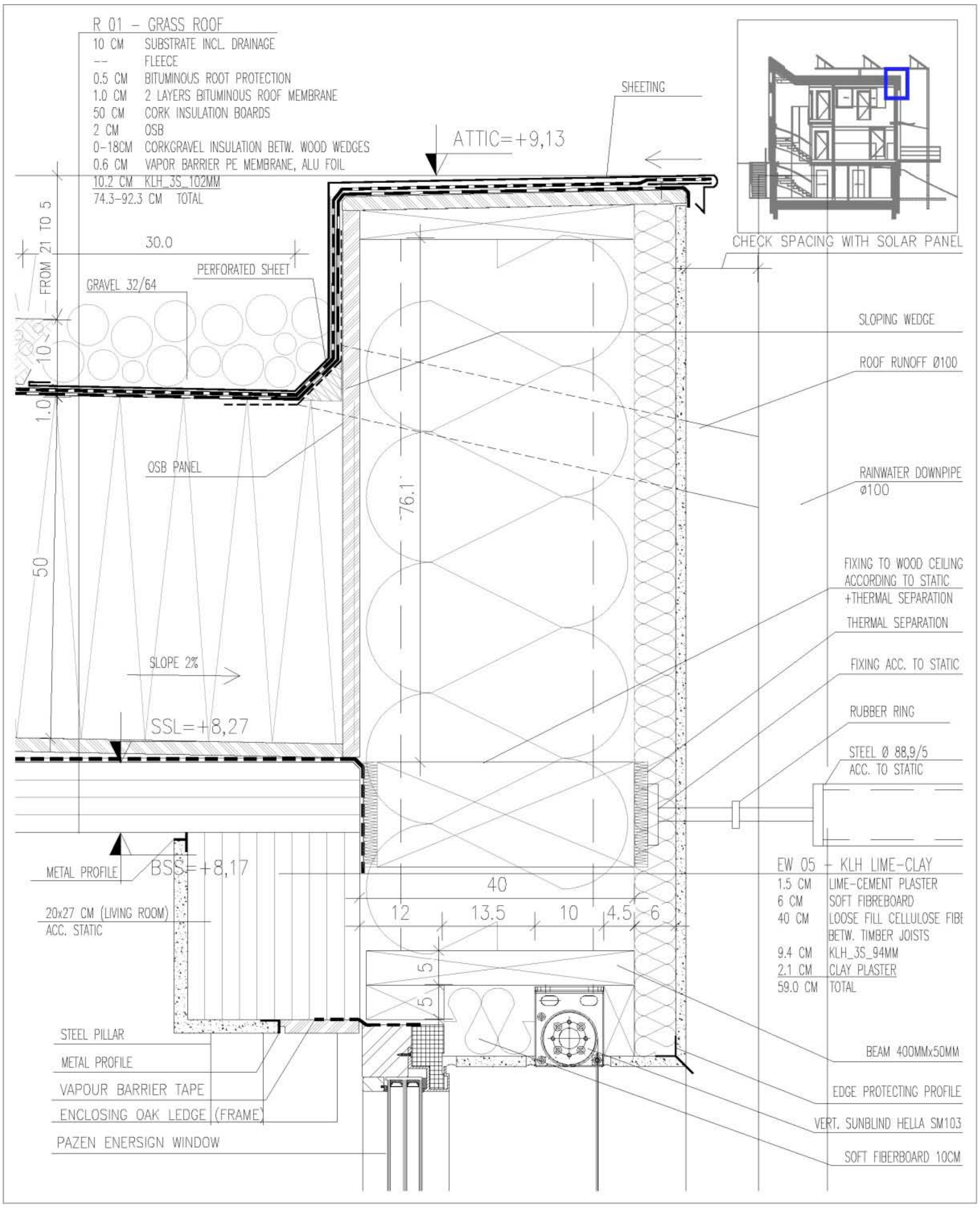


Photo 12.- External wall Construction

External wall Construction

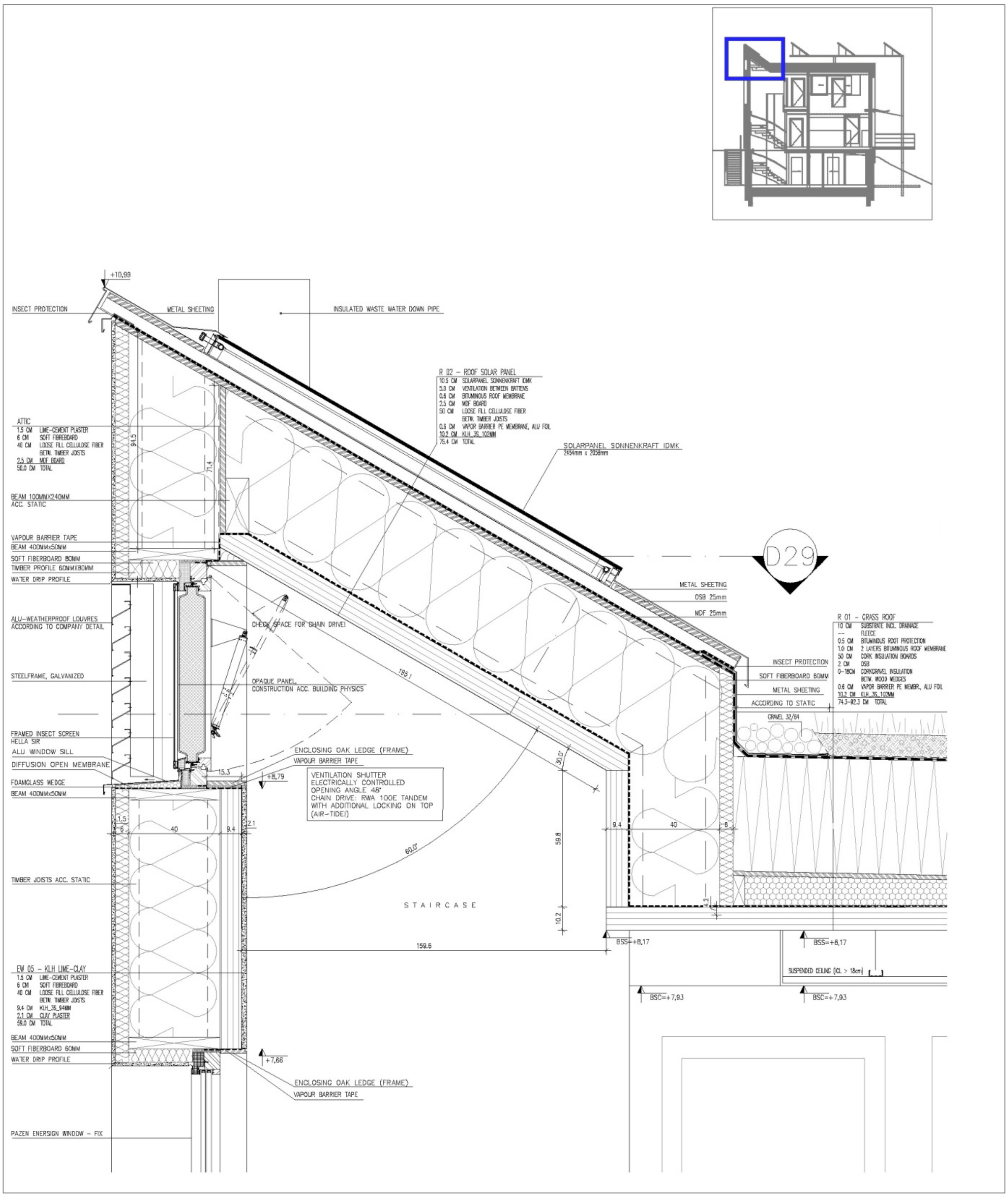
External wall	15 mm Kronopol, 400 mm cellulose wool, 94 mm KLH massive wood, 15 mm clay plaster **First floor wall construction**: 15 mm outside plaster, 300 mm EPS, 200 mm concrete, 15 mm plaster	U-value 0,104... W/(m²K)

4.4 Roof



Dachkonstruktion / Roof construction

Roof	15 mm SBS roofing, 30 mm Isover OL-TOP, 380-500 mm EPS(wedge shape), 102 mm KLH massive wood	U-value W/(m²K) 0,071


+10,99
INSECT PROTECTION
METAL SHEETING
INSULATED WASTE WATER DOWN PIPE
R 02 – ROOF SOLAR PANEL
10.5 CM SOLARPANEL SONNENKRAFT IDMK
5.0 CM VENTILATION BETWEEN BATTENS
0.6 CM BITUMINOUS ROOF MEMBRANE
2.5 CM MDF BOARD
50 CM LOOSE FILL CELLULOSE FIBER BETW. TIMBER JOISTS
0.6 CM VAPOR BARRIER PE MEMBRANE, ALU FOIL
10.2 CM KLH_3S_102MM
75.4 CM TOTAL
SOLARPANEL SONNENKRAFT IDMK
2454mm x 2058mm
ATTIC
1.5 CM LIME-CEMENT PLASTER
6 CM SOFT FIBREBOARD
40 CM LOOSE FILL CELLULOSE FIBER BETW. TIMBER JOISTS
2.5 CM MDF BOARD
50.0 CM TOTAL
94.5
71.4
BEAM 100MMX240MM ACC. STATIC
VAPOUR BARRIER TAPE
BEAM 400MMx50MM
SOFT FIBERBOARD 80MM
TIMBER PROFILE 60MMX80MM
WATER DRIP PROFILE
D29
METAL SHEETING
OSB 25mm
MDF 25mm
R 01 – GRASS ROOF
10 CM SUBSTRATE INCL. DRAINAGE
-- FLEECE
0.5 CM BITUMINOUS ROOT PROTECTION
1.0 CM 2 LAYERS BITUMINOUS ROOF MEMBRANE
50 CM CORK INSULATION BOARDS
2 CM OSB
0–18CM CORKGRAVEL INSULATION BETW. WOOD WEDGES
0.6 CM VAPOR BARRIER PE MEMBR., ALU FOIL
10.2 CM KLH_3S_102MM
74.3–92.3 CM TOTAL
INSECT PROTECTION
SOFT FIBERBOARD 60MM
METAL SHEETING
ACCORDING TO STATIC
GRAVEL 32/64
ALU-WEATHERPROOF LOUVRES ACCORDING TO COMPANY DETAIL
CHECK SPACE FOR CHAIN DRIVE!
STEELFRAME, GALVANIZED
OPAQUE PANEL, CONSTRUCTION ACC. BUILDING PHYSICS
195.1
FRAMED INSECT SCREEN HELLA SIR
ALU WINDOW SILL
DIFFUSION OPEN MEMBRANE
FOAMGLASS WEDGE
BEAM 400MMx50MM
ENCLOSING OAK LEDGE (FRAME)
VAPOUR BARRIER TAPE
15.3
+8,79
VENTILATION SHUTTER
ELECTRICALLY CONTROLLED
OPENING ANGLE 48°
CHAIN DRIVE: RWA 100E TANDEM
WITH ADDITIONAL LOCKING ON TOP
(AIR-TIDE!)
30.0°
1.5
6
40
9.4
2.1
9.4
40
6
59.8
60.0°
TIMBER JOISTS ACC. STATIC
STAIRCASE
10.2
4.2
159.6
BSS=+8,17
BSS=+8,17
SUSPENDED CEILING (ICL > 18cm)
BSC=+7,93
BSC=+7,93
EW 05 – KLH LIME-CLAY
1.5 CM LIME-CEMENT PLASTER
6 CM SOFT FIBREBOARD
40 CM LOOSE FILL CELLULOSE FIBER BETW. TIMBER JOISTS
9.4 CM KLH_3S_94MM
2.1 CM CLAY PLASTER
59.0 CM TOTAL
BEAM 400MMx50MM
SOFT FIBERBOARD 60MM
WATER DRIP PROFILE
+7,66
ENCLOSING OAK LEDGE (FRAME)
VAPOUR BARRIER TAPE
PAZEN ENERSIGN WINDOW – FIX

4.5 Airtight envelope / Lüftdichte Hülle:

R01 Grassdach
5,0 cm Substrat
0,0 cm Vlies
5,0 cm Drainagekies
0,5 cm Bitumen Wurzelschutzbahn
0,6 cm Bitumenbahn 2 Lagig
50, cm Korkplatte
2,0 cm OSB im Gefälle 2%
18,0 cm Korkschrotdämmung (zw. Holzkeilen)
0,6 cm Dampfbremse (PE+Alu)
10,2 cm Brettsperrholzplatte
91,0 cm

R02 Kollektor
10,5 cm Solarkollektor SONNENKRAFT IDMK
5,0 cm Lattung + Lüftung
0,6 cm Bitumenbahn 2 Lagig
2,5 cm Weichfaserplatte
50,0 cm Korkplatte
0,6 cm Dampfbremse (PE+Alu)
10,2 cm Brettsperrholzplatte
79,4cm

EW 04A KLH Holz-Lehm (Loggia)
5,0 cm Holzverkleidung (2,0 cm Schalung + 3,0 cm Hinterlüftung)
28,0 cm Foamglas Platte T4+
0,3 cm Klebermörtel
0,6 cm bituminöse Abdichtung 3mm
9,4 cm Brettsperrholzplatte 3S_94
2,1 cm Lehmputz
62,0 cm

EW 05 KLH Holz-Lehm
1,5 cm Kalkzement putz
6,0 cm Weichfasserplatte
40,0 cm Zellulosefaserflocken
9,4 cm Brettsperrholzplatte 3S_94
2,1 cm Lehmputz
59,0 cm

EW 07 KLH-Kollektor-Lehm
14,0 cm Kollektor
0,0 cm Winddichte Folie, UV-beständig
2,0 cm OSB
40,0 cm Zellulosefaserflocken
0,0 cm Dampfbremse
9,4 cm Brettsperrholzplatte 3S_94
2,1 cm Lehmputz
67,5 cm

4.6 Window Sections

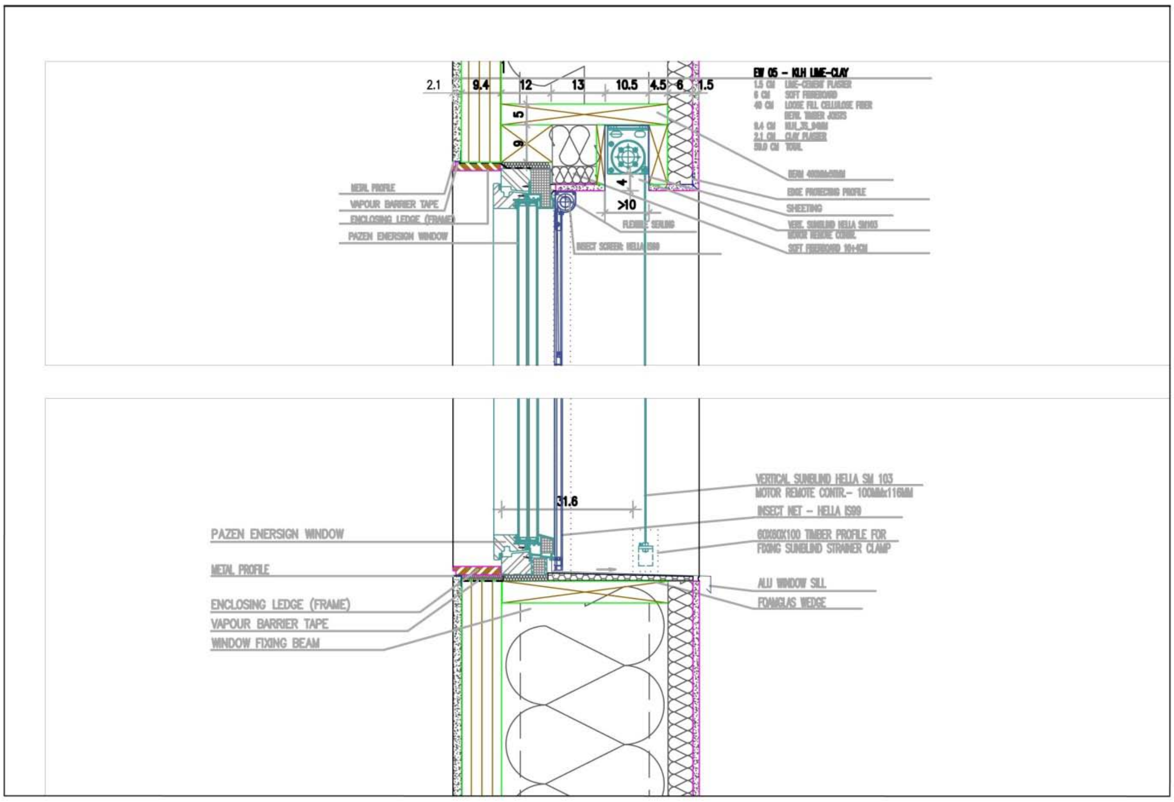


Photo 13.- Hot water collectors, integrated into the facade

frame	SmartWien Eesti OÜ, SmartWien and SmartWin fixed Timber window frame with thermal insulation inside the frame and also on the outside surface of the frame, optimized frame width	0.66….. W/(m²K)
window	Guardian- climaGuard nrG(Argon 90%) g=60% Guardian- ClimaGuard Premium(Krypton 90%) g=32%	0.63….. W/(m²K)

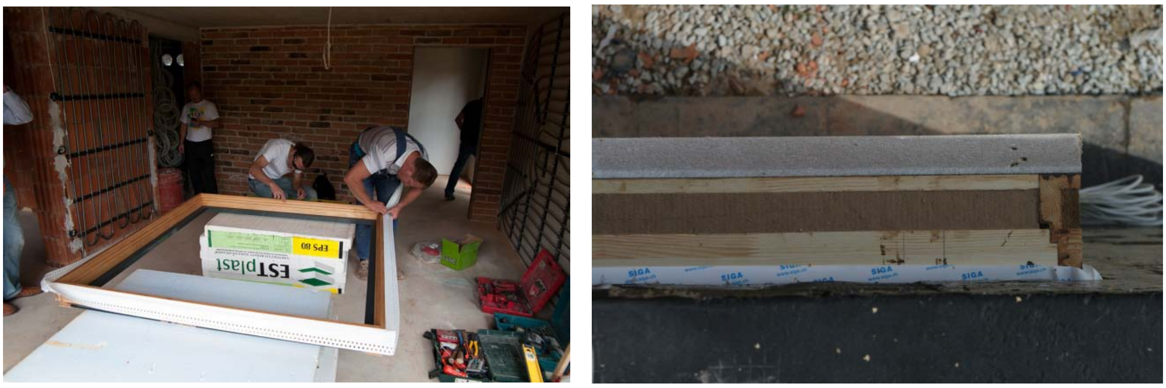
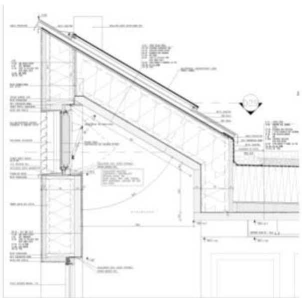


Photo 14.-Windows; Passivehaus Standard

4.7 Thermal Bridge Calculation

As the Passive House criteria is challenging in Estonian climate then all possible measures were taken to lower the heat losses including the optimization of thermal bridges. The thermal bridging in main junction types were avoided by the selection of construction type with uniform outside insulation. However, the bulk amount of different window connection details were calculated with LBNL Therm software to achieve as good as possible solutions for regular installation, but also for fixing the shading rolls on southern façade.

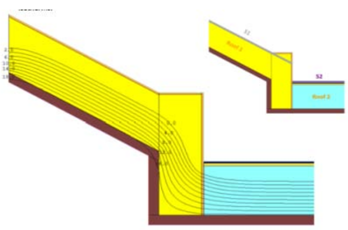
Almost all possible junctions were assessed with finite element calculation in order to gain all possible reductions in heat balance calculation. A sample figure of finite element calculation results is given below. An overall reduction by 1.92 kWh/(m2*year) to annual net heat demand was achieved compared to situation with no thermal bridge input.



Ventilation area roof to roof

$Uroof1_{1D}$	0.0753	W/m²K
l1	2104.1	mm
$Uroof2_{1D}$	0.0651	W/m²K
l2	1122.0	mm
U_{2D}	0.0659	W/m²K
Respective length	3868.44	mm
L_{1D}	0,231	W/mK
L_{2D}	0,255	W/mK
Ψ	0,023	W/mK

Boundary conditions		
	R_s (W/mK)	θ (°C)
Exterior	0,04	-10,0
Interior ceiling	0,13	20,0



5 Thermal envelope

The house is built with mixed construction system – the basement (partly in ground and partly open to the sloping hillside) is casted concrete construction with thick layer of XPS/EPS insulation depending on the wall/floor type. The aboveground perimeter walls have 300 mm of EPS insulation and belowground perimeter walls have 500 mm of EPS insulation. The floor slab configuration features 300 mm of XPS insulation and 100 mm of EPS insulation.

Ground floor and upper floor have a 94 mm thick cross-laminated timber block elements (KLH) as the static layer and 400 mm of cellulose insulation with custom made C-joists made out of timber and OSB sheets. The roof panel is insulated with wedge shaped EPS insulation (380 mm - 550 mm). The walls of the upper floors have façade solution with ventilated cavities mainly covered with rendering boards and partly covered by vertical solar collectors.

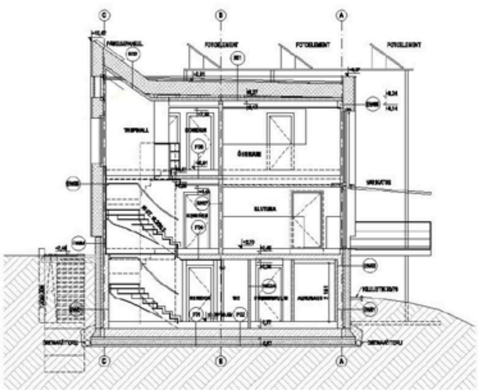
Special construction was applied to unheated (but inside building's rectangular form) conservatory floor, which needed 80 mm of vacuum insulation panels (Vacupor Vacuspeed) to achieve the needed thermal resistance and also lower the thermal bridges in surrounding junctions.

The glazed areas feature krypton filled triple glazing with different low-emissivity coatings depending on the orientation of the windows and glazed doors. The declared Ug values of the glazing units are 0,60 W/(m2K) for the southern façade and 0,49 W/(m2K) for other orientations, the SHGC values for these glazing units are accordingly 0,59…0,62 for southern façade and 0,36…0,37 for other facades depending on the glazing thickness. The glazing properties are differentiated to maximize the solar gain during the heating season. The wooden window frames with thermal separation (SmartWin) have very low thermal conductivity (average Uf value for openable windows 0,75 W/(m2K) and 0,59 W/(m2K) for fixed windows) to minimize the heat losses.

Additionally all possible measures were taken to lower the heat losses including the optimization of thermal bridges. The thermal bridging in main junction types were avoided by the selection of construction type with uniform outside insulation. However, the bulk amount of different window connection details were calculated with LBNL Therm software to achieve as good as possible solutions for regular installation, but also for fixing the shading rolls on southern façade. Almost all possible junctions were assessed with 2D finite element calculation in order to gain all possible reductions in heat balance calculation. An overall reduction by 1,9 kWh/(m2yr) to annual net heat demand was achieved compared to situation with no thermal bridge input using external dimensions.

In total the average thermal conductivity of the whole building envelope (including windows, doors and linear thermal bridges) is 0,146 W/(m²K).

Thermal envelope



Wall
400 mm cellulose fiber, 94 mm KLH
Massive wood, U = **0,105** W/(m²K)

Ceiling
500 mm EPS, 102 mm KLH
U = **0,079** W/(m²K)

Wall, underground
500 mm EPS, 200 mm concrete
U = **0,066** W/(m²K)

Floor
300 mm XPS, 300 mm concrete,
100 mm EPS
U = **0,086** W/(m²K)

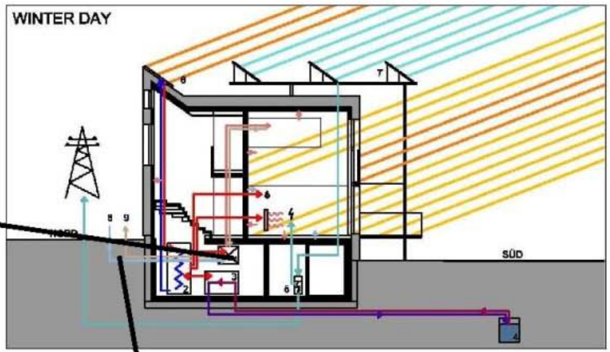
6 Ventilation System

The building has balanced mechanical ventilation system with PHI certified passive house ventilation unit (Paul Novus 300 with exhaust side heat recovery efficiency 93% according to PHI certification system) [Passivhaus Inst 2009]. Fresh air with no additional heating is supplied to living-room and bedrooms and then exhausted from kitchen, bathrooms. The airflows have been reduced to limit the risk of overly dry air during the winter season. The average airflow rate measured during the startup of the ventilation system is 280 m3/h, which corresponds to average air change rate of 0,4 h-1. Preliminary measurements show that CO_2 levels are low enough to further lower the airflows if necessary.

The frost protection of the ventilation unit is solely by sub-soil brine heat-exchanger. The system features 226 m (with 40 mm diameter) of plastic pipe buried horizontally in the depth of approx 1,0 to 1,2 m and connected to Paul Sole Defroster unit SD-550, which controls the fluid flow speed of the system according to air-temperature before the ventilation unit. Preliminary measurement results show stable air temperatures around 1°C after the defrosting unit for the first heating period.

The infiltration and exfiltration of the air through the building envelope is reduced radically through the use of special airtightness products and careful planning and execution. Measured average airtightness at the 50 Pa pressure difference (average air change rate n50 of the under- and over pressurization test, blower door test) is 0,36 1/h.

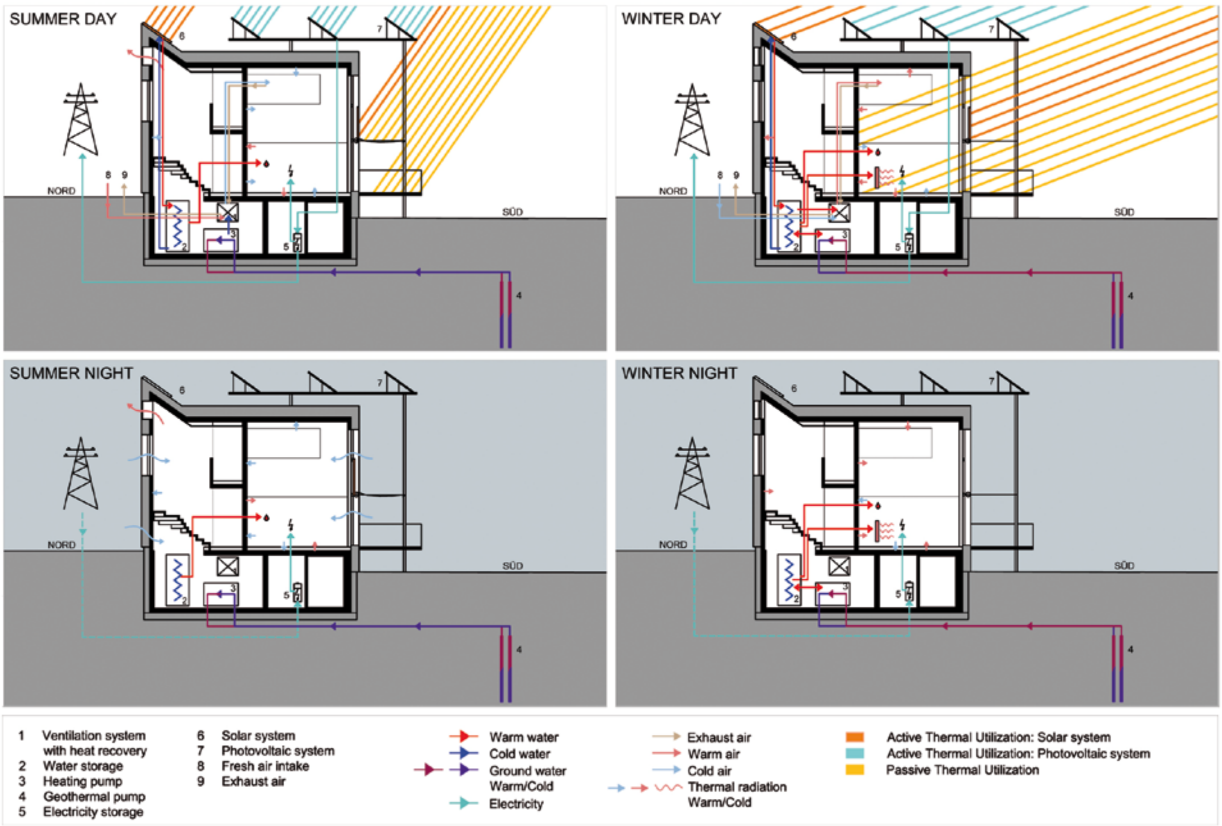
Photo 15.- Ventilation System

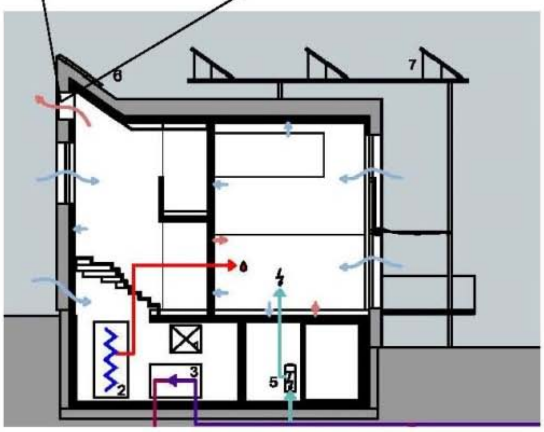


Ventilation unit
Paul Novus 300 Heat recovery 93% (PHI def)

Paul Sole Defroster SD-550, 226 m long 40 mm pipe

Electrical efficiency / Elektroeffizienz in Wh/m³: 0,29





Summer
night ventilation

Passive House Planning

VENTILATION DATA

Building: Kuldar Leis

Treated Floor Area A_{TFA}	m²	285	(Areas worksheet)
Room Height h	m	2,5	(Annual Heating Demand worksheet)
Room Ventilation Volume (A_{TFA}*h) = V_V	m³	711	(Annual Heating Demand worksheet)

Ventilation System Design - Standard Operation

Occupancy	m²/P	47				
Number of occupants	P	6,0				
Supply air per person	m³/(P*h)	30				
Supply air demand	m³/h	180				
Extract air rooms		Kitchen	Bathroom	Shower	WC	
Quantity		1	2	1	3	
Extract air demand per room	m³/h	60	40	20	20	
Total extract air demand	m³/h	220				

The design air flow rate must achieve, at minimum, the exhaust air requirement!

Design Air Flow Rate (Maximum)	m³/h	213

Average Air Change Rate Calculation

Type of Operation	Daily Operation Duration h/d	Factors Referenced to Maximum	Air Flow Rate m³/h	Air Change Rate 1/h
Maximum	24,0	1,00	213	0,30
Standard		0,77	164	0,23
Basic		0,54	115	0,16
Minimum		0,40	85	0,12
Average value		1,00	Average Air Flow Rate (m³/h): 213	Average Air Change Rate (1/h): 0,30

Infiltration Air Change Rate

Wind Protection Coefficients e and f		
Coefficient e for Screening Class	Several Sides Exposed	One Side Exposed
No Screening	0,10	0,03
Moderate Screening	0,07	0,02
High Screening	0,04	0,01
Coefficient f	15	20

			for annual demand:	for heating load:				
Wind Protection Coefficient, e			0,07	0,18				
Wind Protection Coefficient, f			15	15	Net Air Volume for Press. Test	V_{n50}	Air Permeability	q_{50}
Air Change Rate at Press. Test	n_{50}	1/h	0,30	0,30	901	m³	0,31	m³/(hm²)

Type of Ventilation System

Bessere Drucktestergebnisse bedeuten weitere Verbesserungen des Energiekennwerts

				for annual demand:	for heating load:
x	Balanced PH Ventilation	Please Check			
	Pure Extract Air				
	Excess Extract Air		1/h	0,00	0,00
	Infiltration Air Change Rate	$n_{V,Res}$	1/h	0,027	0,067

Effective Heat Recovery Efficiency of the Ventilation System with Heat Recovery

x	Heat recovery unit within the thermal envelope.
	Heat recovery unit outside of the thermal envelope.

Efficiency of Heat Recovery	η_{HR}		0,93	Paul Novus 300
Conductance Ambient Air Duct	Ψ	W/(mK)	0,240	Calculation see Secondary Calculation
Length Ambient Air Duct		m	1,2	1.2m laut Plänen! Besser: 0.6m!
Conductance Exhaust Air Duct	Ψ	W/(mK)	0,240	Calculation see Secondary Calculation
Length Exhaust Air Duct		m	1,2	Room Temperature (°C): 20
Temperature of Mechanical Services Room		°C	20	Av. Ambient Temp. Heating P. (°C): -0,5
(Enter only if the heat recovery unit is outside of the thermal envelope.)				Av. Ground Temp (°C): 7,2

Effective Heat Recovery Efficiency	$\eta_{HR,eff}$	92,2%

Effective Heat Recovery Efficiency Subsoil Heat Exchanger

SHX Efficiency	η^*_{SHX}	
Heat Recovery Efficiency SHX	η_{SHX}	0%

Secondary Calculation:

Ψ-value Supply or Ambient Air Duct

20mm Dämmung laut Plänen! Laut vorherig

Nominal Width	160	mm
Insul. Thickness:	100	mm
Reflective? Please mark with an "x"!		
x Yes		
No		
Thermal Conductivity	0,035	W/(mK)
Nominal Air Flow Rate	213	m³/h
Δϑ	20	K
Interior Duct Diameter	0,160	m
Interior Diameter	0,160	m
Exterior Diameter	0,360	m
α-Interior	13,20	W/(m²K)
α-Surface	2,64	W/(m²K)
Ψ-value	**0,240**	**W/(mK)**
Surface Temperature Difference	2,380	K

PHPP 2007, Ventilation

7 Heating System

The heating system is based on ground source heat pump combined with split solar thermal system. Wiessmann “Vitocal 300 G BWC” ground source (two 80 m deep vertical boreholes) heat pump unit with 5,9 kW heating power output and declared (EN 14511) COP of 4,51 (for B0W35 conditions at flow/return difference of 5K) is combined with Sonnenkraft roof-mounted (11,6 m2 active area) and vertical wall-mounted (13,1 m2 active area) solar thermal panels and 2 x 1000 l storage tanks (PSC1000E). The panels are oriented directly to south. The storage tanks are covered with 200 mm insulation to reduce the stand-by heat losses and lower the overheating of the rooms on the basement floor.

A very short DHW circulation system with connected distribution pipes as well as piping from storage tanks to wall- and floor-heating collectors are insulated with 40 mm mineral wool or 13 mm Armaflex technical insulation depending on the placement of the piping.

The heat is distributed through water based wall- and floor-heating system with supply and return temperatures of 39/33 °C. The wall-heating system was chosen to lower the fluid temperatures and provide more uniform temperature distribution for greater indoor comfort.

Photo 16.- 39/33° C supply/return temperature

Photo 17.- 2x1000 L

8 Grid –connected PV system

The system consists of 66 panels SolarWorld Sunmodule Plus SW 196 Vario poly with unit dimensions 1001 x 1357 mm. The total panel area is 89, 8 m2. Maximum power Pmax under standard test conditions (STC) is 196 Wp. The panels are located in 3 rows, 22 units in each row (figure 4). Tilt angle from horizontal is 38°.

Photo 18.- PV on the Roof and Solar thermal collectors on the left.

Inverter is Solutronic Solplus 100, 11 kW, 98% efficiency. The system has Solutronic Loger with LAN output. Maximum output AC is 11000 W.

According to PVGIS calculation (Photovoltaic Geographical Information System for Europe) [ECJRC Institute for Environment and Sustainability 2013], the annual production of the system is 10120 kWh (setting 5% losses).

9 PHPP Results

Passive House Verification

Photo or Drawing

Building:	Kuldar Leis	
Location and Climate:	Tartu, Estland	PHI verified Tõravere, Estonia
Street:		
Postcode/City:		
Country:	Estland	
Building Type:		
Home Owner(s) / Client(s):		
Street:		
Postcode/City:		
Architect:	Architekturbüro Reinberg	
Street:	Lindengasse 39/10	
Postcode/City:	1070 Wien	
Mechanical System:		
Street:		
Postcode/City:		

Year of Construction:	2012				
Number of Dwelling Units:	1		Interior Temperature:	20,0	°C
Enclosed Volume V_e:	1586,4	m^3	Internal Heat Gains:	2,1	W/m^2
Number of Occupants:	6,0				

Specific Demands with Reference to the Treated Floor Area

Treated Floor Area:	284,5	m^2		
	Applied:	Monthly method	PH Certificate:	Fulfilled?
Specific Space Heating Demand:	14,71	$kWh/(m^2a)$	15 $kWh/(m^2a)$	Yes
Heating Load:	13	W/m^2	10 W/m^2	
Pressurization Test Result:	0,30	h^{-1}	0,6 h^{-1}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	101	$kWh/(m^2a)$	120 $kWh/(m^2a)$	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	44	$kWh/(m^2a)$		
Specific Primary Energy Reduction through Solar Electricity:		$kWh/(m^2a)$		
Frequency of Overheating:	0	%	over 25 °C	
Specific Useful Cooling Energy Demand:		$kWh/(m^2a)$	15 $kWh/(m^2a)$	
Cooling Load:	2	W/m^2		

We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The calculations with PHPP are attached to this application.

Issued on:

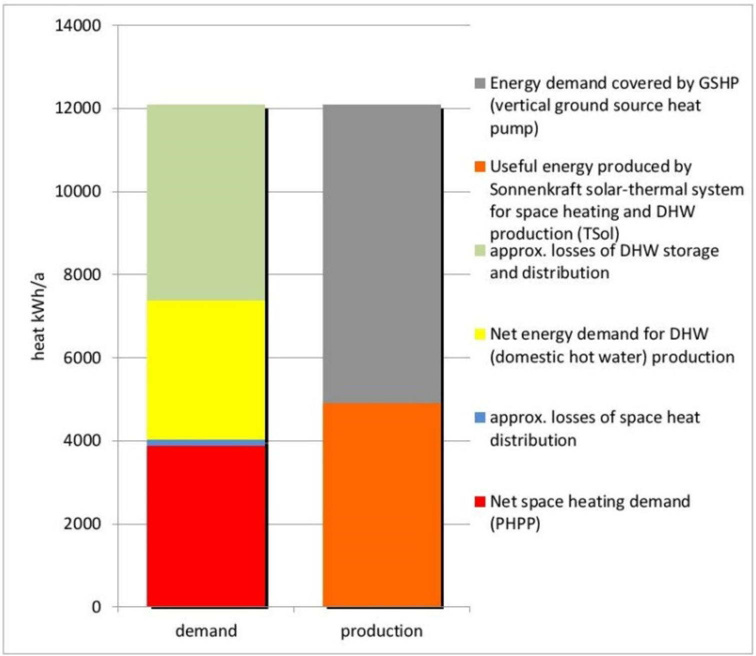
signed:

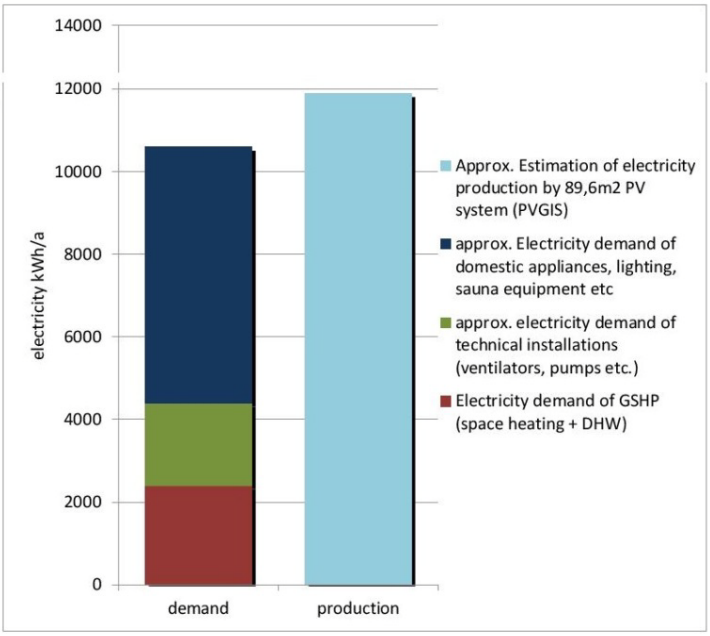
PHPP 2007, Verification 0118_Tartu_KuldarLeis_PHPP_PHI_20120319

Total Energy Balance of the building

	demand	production	
Net space heating demand (PHPP)	3891		kWh/a
approx. losses of space heat distribution	142		kWh/a
Net energy demand for DHW (domestic hot water) product	3352		kWh/a
approx. losses of DHW storage and distribution	4693		kWh/a
Useful energy produced by Sonnenkraft solar-thermal system for space heating and DHW production (TSol)		4910	kWh/a
Energy demand covered by GSHP (vertical ground source heat pump)		**7168**	**kWh/a**

	demand	production	
Electricity demand of GSHP (space heating + DHW)	2389		kWh/a
approx. electricity demand of technical installations (ventilators, pumps etc.)	2000		kWh/a
approx. Electricity demand of domestic appliances, lighting, sauna equipment etc	6207		kWh/a
Total electricity demand of the building	**10596**		**kWh/a**
Approx. Estimation of electricity production by 89,6m2 PV system (PVGIS)		11900	kWh/a





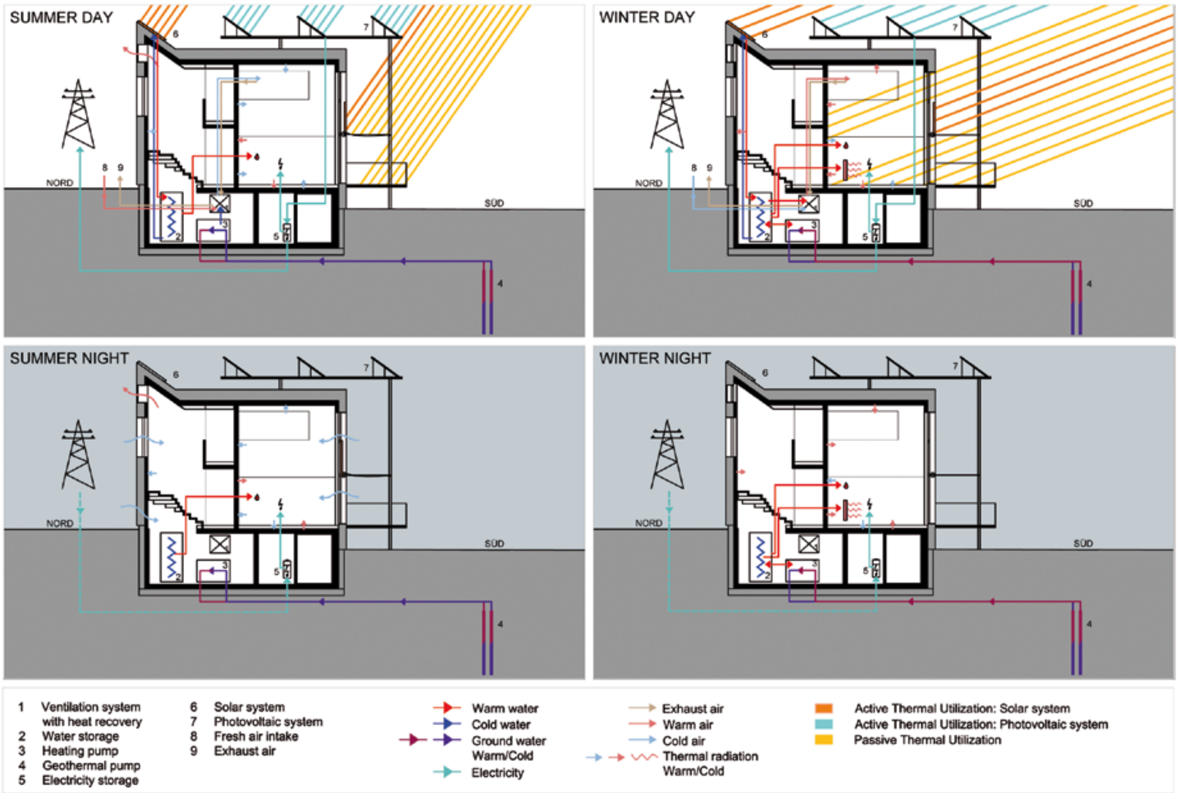
10 Construction costs

20.000–	plot
64.700 –	project
11.400 –	project management and supervision
357.000 –	construction cost (incl garage)
82.500 –	ventilation, heating system, electricity, sewage (incl. Materials and montage)
15.000 –	Solar Collectors
14.000 –	PV construction
19.000 –	PV system + installation

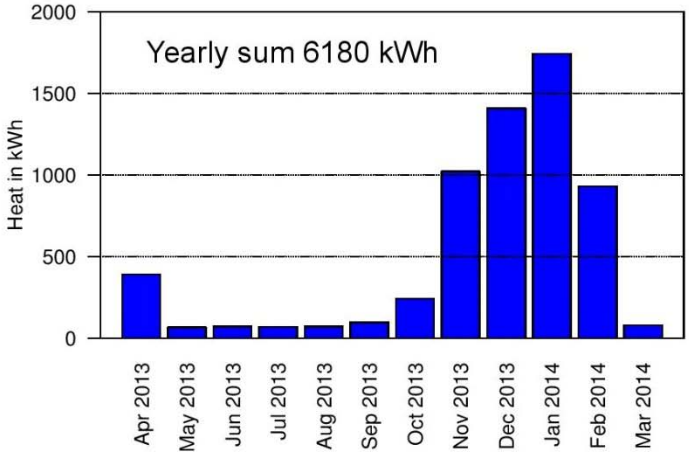
These costs are not including the cost of interior finishes such as clay plaster, wooden floors, furniture, etc. and Garden)

11 Measurements of the house

Energy concept



Space heating *Sontex heat meter.*



Measured @ 24°C

22,0 kWh/(m² a)

(6180 kWh / TFA 281m²)

PHPP calculated @ 20°C

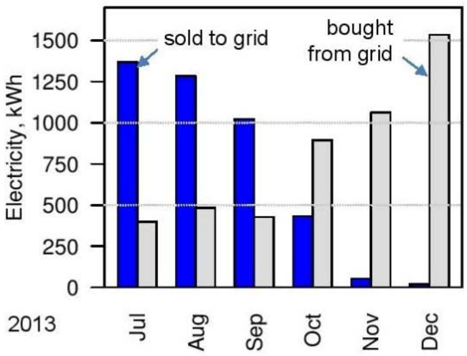
14,4 kWh/(m² a)

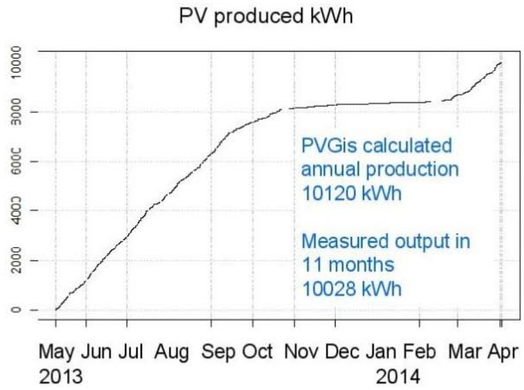
(certification)

PHPP calculated @ 24°C

22,0 kWh/(m² a)

Grid-connected PV operation





Kuldar Leis, Metsa 5a, Põlva, Estonia

Data monitored within research program by University of Tartu and Tallinn Technical University (Estonia)

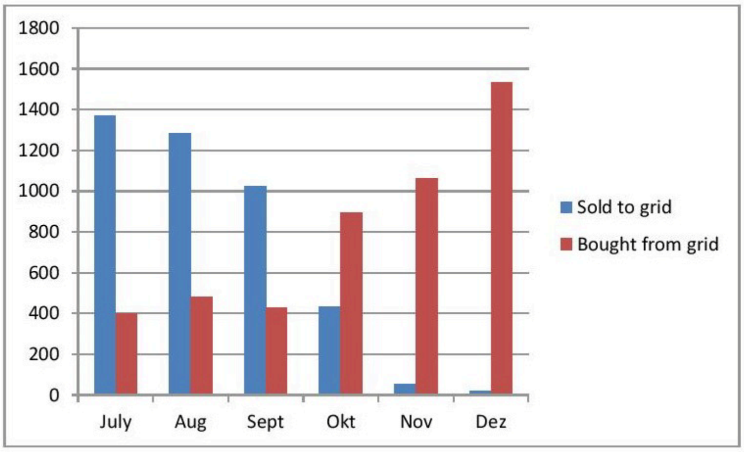


Fig. Measured monthly amount of electrical energy sold to grid and bought from grid in kWh.

2013	Sold to grid	Bought from grid	Balance
July	1369	398	971
Aug	1283	482	801
Sept	1022	428	594
Okt	434	895	-461
ov	54	1062	-1008
Dez	20	1535	-1515

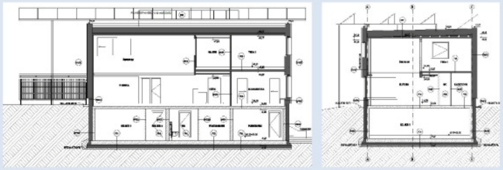
Comment: sauna monthly electricity use, which is specific to this family, is 250 kWh per month in average.

Monitoring

Winter performance of certified Passive House building in Northern European cold climate

Background

Single-familiy home (TFA 281 m²) was built in 2012. It is a pilot certified Passive House in Estonia [Reinberg 2013]. Building aims to cover the energy demand from local renewable sources.



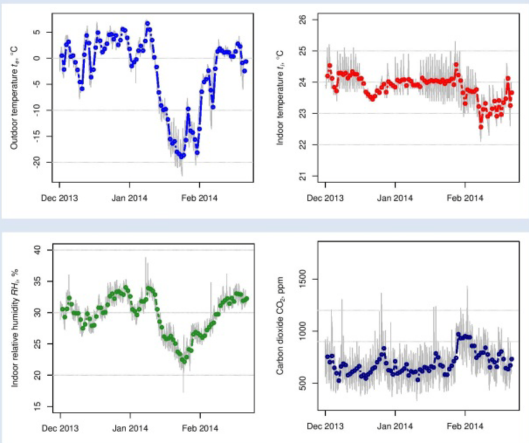
View from SW and the sections from the house

Location
58,0531° N
27,0517° E
Põlva, Estonia

Climate
Ambient air temperatures:
- occassionally below -30 °C
- frequently below -15 °C

Monitoring results

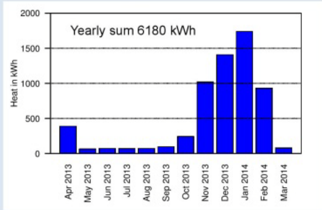
Monitoring is performed within joint research project by University of Tartu and Tallinn University of Technology (code 3.2.0801.11-0035).



Measured hourly values, dots indicate the daily mean values.

Space heating

Sontex heat meter.

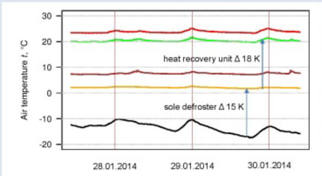


Measured @ 24°C
22,0 kWh/(m² a)
(6180 kWh / TFA 281m²)

PHPP calculated @ 20°C
14,4 kWh/(m² a)
(certification)

PHPP calculated @ 24°C
22,0 kWh/(m² a)

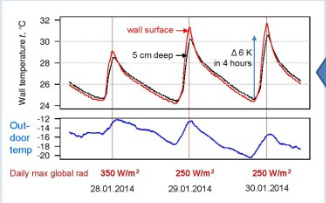
Ventilation unit temperatures



Paul Novus 300

Paul Sole Defroster
SD-550, 226 m contour

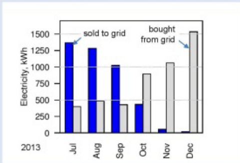
Interior wall temperature

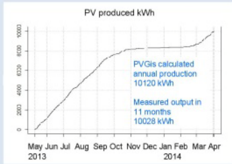


Massive clay wall temperature daily amplitude

Example, cold and sunny winter days, no heating is used.

Grid-connected PV operation





Conclusions

- Space heat demand is in good accordance with calculated values; ventilation air sole defroster pre-heating has shown as very stable and effective in cold days.
- PV system energy delivery fits well with initial PVGis calculation; the system was able to deliver in the second halfyear 2013 balance almost all the energy the building and occupants need.
- Solar thermal system and heat pump functioning was fully adjusted first in April 2014, thus the final energy demand in cold period is not properly assessed yet.

Project data

Building owner: Kuldar Leis
Architects: G. W. and M. Reinberg, www.reinberg.net
Project lead: Sense OÜ, www.sense.ee
Energy modelling: PassiveHouse OÜ, www.passivehouse.ee

References

Reinberg [2013] . Reinberg, G., Mauring, T., Hallik, J., Valge, M., Kalbe, K. First Certified Passive House in Estonia. In: Feist, W. (Ed.), Proceedings of 17th International Passive House Conference (in germany), pages 315-321 (2013).

Authors
Tõnu Mauring, Jaanus Hallik, Kristo Kalbe, Margus Valge
Institute of Technology, University of Tartu, Estonia
Nooruse 1, 50411 Tartu, ESTONIA
phone +372 55 566 988, e-mail: tonu.mauring@ut.ee
www.tuit.ut.ee/en/core-facilities/energy-efficient-building-core-facility

Acknowledgement
This research was supported by the European Union through the European Regional Development Fund.

European Union Regional Development Fund
Investing in your future

Passive House Institute

Passive House Institute
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

Certificate

The Passive House Institute awards the seal "Certified Passive House – Pilot Project" to the following building

SFH Kuldar Leis in Estonia **Metsa 5a, EE 63305 Põlva, ESTONIA**

Certified Passive House
Passive House Institute

Client: **Kuldar Leis**
Metsa 5a, EE 63305 Põlva, ESTONIA

Architect: **Architekturbüro Reinberg**
Lindengasse 39/10, A 1070 Wien, AUSTRIA

Building Services: **S&P climadesign GmbH**
Mitterweg 1, A-4694 Ohlsdorf, AUSTRIA

This building was designed to meet Passive House criteria as defined by the Passive House Institute. With appropriate on-site implementation, this building will have the following characteristics:

- Excellent thermal insulation and optimised connection details with respect to building physics. The heating demand or heating load will be limited to
  15 kWh per m² of living area and year or a heating load of 10 W/m², respectively
- When outdoor temperatures are high, thermal comfort can be ensured with passive solutions or with minimal energy demand for cooling and dehumidification according to the location-specific Passive House requirements.
- A highly airtight building envelope, which eliminates draughts and reduces the heating energy demand: The air change rate through the envelope at a 50 Pascal pressure difference, as verified in accordance with ISO 9972, is less than
  0.6 air changes per hour with respect to the building's volume
- A controlled ventilation system with high quality filters, highly efficient heat recovery and low electricity consumption, ensuring excellent indoor air quality with low energy consumption
- A total primary energy demand for heating, domestic hot water, ventilation and all other electric appliances during normal use of less than
  120 kWh per m² of living area and year

This certificate is to be used only in combination with the associated certification documents, which describe the exact characteristics of the building.

Passive Houses offer high comfort throughout the year and can be heated or cooled with little effort, for example, by heating/cooling the supply air. Even in times of cold outdoor temperatures the building envelope of a Passive House is evenly warm on the inside and the internal surface temperatures hardly differ from indoor air temperatures. Due to the highly airtight envelope, draughts are eliminated during normal use. The ventilation system constantly provides fresh air of excellent quality. Energy costs for ensuring excellent thermal comfort in a Passive House are very low. Thanks to this, Passive Houses offer security against energy scarcity and future rises in energy prices. Moreover, the climate impact of Passive Houses is low as they reduce energy use, thereby resulting in the emission of comparatively low levels of carbon dioxide (CO_2) and air pollutants.

issued:
Darmstadt, Date 18.04.2013

Wolfgang Feist

Dr. Wolfgang Feist

Certificate-ID: **5978_PHI_PH-Pilot_20130418_JSt**

Passive House Cerfitication

12 Publications

- **Ein (Netto-)Plus-Energiegebäude im kalten Klima**
  Vortrag im Rahmen des 4. Symposiums Aktiv Solarhaus von Martha Enriquez-Reinberg
  OTTI Training Seminare, Tagungen, S. 184-191 — 04/2013
  Projekt Pölva, Estland_265

- **First certified Passive House in Estonia**
  Vortrag im Rahmen der 17. Internationalen Passivhaustagung in Frankfurt
  Tagungsband, S. 315 — 04/2013
  Projekt Pölva, Estland_265

- **Eesti esimene passiivmaja**
  Artikel in der Zeitschrift „ Meie Kodu“, S. 15 – 22 — 03/2013
  Projekt Pölva, Estland_265

- **Aktiivne Kuldar Leis ja tema passiivne kodu**
  Artikel in der Zeitung LounaLeht, S. 10 – 11 — 06/2013
  Projekt Pölva, Estland_265

- **Plus Energy Building in Estonia**
  Seite 114-115
  Proceedings of the Sustainable Building Conference 2013, 25.-28.September, — 09/2013
  Graz University of Technology - TU Graz, Vortrag am 27.09.2013,
  SB13 Graz - Sustainable Buildings, Construction Products & Technologies
  Edited by Karl Höfler, Peter Maydl, Alexander Passer
  ISBN: 978-3-85125-299-6, Verlag der TU Graz (www.ub.tugraz.at/Verlag)
  Projekt Pölva, Estland_265

- **SB13 Graz - Sustainable Buildings, Construction Products &Technologies** — 9/2013
  Edited by Karl Höfler, Peter Maydl, Alexander Passer
  ISBN: 978-3-85125-299-6, Verlag der TU Graz (www.ub.tugraz.at/Verlag)
  Projekt Pölva, Estland_265

- **Eesti Passiivmajaliit**
  Kuldar Leis — 2013
  Projekt Pölva Estland _ 265

- **GLASS FOR EUROPE**
  “The smart use of glass in sustainable buildings” — 2013
  Smart City Wien _
  Projekt Estland-Pölva_265

- **Aasta jagu heaolu**
  Oma Maja S. 28-32 — 4/2014
  Projekt: Estland-Pölva_265

- **Esimene aasta passiivmajas**
  Kuldar Leis, Inseeneria S.30 - 31, 4/2014
  Projekt: Estland-Pölva_265

- **Demontrationsprojekt Einfamilenhaus in Pölva, Estland** 04-06/2014
  XIA intelligente architektur, Zeitschrift für Architektur und Technik
  Projekt Estland, Pölva_265

- **Auch in Estland wohnt man passiv** 11/2014
  architektur 07, Seite 58 - 61
  Projekt Estland Pölva_265

- **Ich kann nichts Schlechtes an einer intelligenteren Gesellschaft erkennen**
  Architektur - Aktuell - the art of building 12/2014
  Seite 10 - 19
  Projekt Ernstbrunn_270
  Projekt Estland Pölva_265
  Projekt Eschweiler_280
  Projekt Ernstbrunn_270_295