Project Documentation

1 Abstract

Detached single family house in Voynegovtzi, Sofia, Bulgaria

1.1 Data of building

Year of construction	2016	**Space heating**	**12** **kWh/(m²a)**
U-value external wall	0.111 W/(m²K)		
U-value floor slab	0.144 W/(m²K)	**Primary Energy Renewable (PER)**	44 kWh/(m²a)
U-value roof	0.11 W/(m²K)	**Generation of renewable energy**	22 kWh/(m²a)
U-value window	0.85 W/(m²K)	**Non-renewable Primary Energy (PE)**	88 kWh/(m²a)
Heat recovery	91.2 %	Pressure test n_{50}	0.2 h-1
Special features	Solar collectors for hot water generation, treatment plant for wastewater and drilling for domestic water		

1.2 Brief Description

Passive House Classic Voynegovtzi

The Passive House is located on the southern slopes of Stara Planina. The house is situated on the highest part of the village of Voynegovtzi. It is surrounded by a picturesque nature and it has superb views to Sofia and Vitosha Mountain.

The idea to build this family house is to show that the profitability, the comfort and the environmental friendliness not only don't contradict, but rather complement. That's possible, thanks to the Passive House Standard, in Bulgaria also. The house is built with materials produced in Bulgaria. Considering the profitability, designers had not intended to use renewable energy sources. They were mainly driven by the principles of the design of Passive Houses.

The Passive House in Voynegovtzi, Sofia is designed to consume 5 times less energy than a house built according the existing regulation in Bulgaria, while providing excellent comfort in all seasons, thanks to the good insulation, high quality windows with correct orientation, carefully calculated shading, thermal bridge free construction and ventilation with high efficient heat recovery.

The Passive House is three-store detached single family house for a family with 2 children. The house is solid construction and has a large specific capacity, having constant comfortable temperature, even when it is not habitable for a long period of time. The TFA of the house is 151.5 m^2. The living room, the dining room and the kitchen are organized in open space on the first floor. On the sought part of the second floor are concentrated the bedrooms – the master bedroom and 2 children bedrooms. On the third floor there is a cabinet on the sought part of the floor. All the servicing rooms are concentrated on the north part of the house.

The house has its own source of domestic water and wastewater treatment plant, making it independent from fluctuations in central water supply. There is a solar system for DHW, which provides hot water for most of the year.

1.3 Responsible project participants

Architect	Eco Construction Ltd., CPHD Vanya Draganova, Snejina Aleksieva www.passivehousebg.com
Implementation planning	Svetlin Dobrevski, Vanya Draganova www.passivehousebg.com
Building systems	Tzvetomir Botev, Svetlin Dobrevski www.passivehousebg.com
Structural engineering	Krum Yankov
Building physics	Svetlin Dobrevski www.passivehousebg.com
Passive House project planning	Svetlin Dobrevski
Construction management	Bocal Engenering Ltd., Evrodom 2001 Ltd. www.bocal.bg www.evrodom2001.eu
Certifying body	Institut pre Energeticky Pasivne Domy
Certification ID	Project-ID 4736

Author of project documentation Svetlin Dobrevski

Date, Signature

2 Views of the Passive House in Voynegovtzi, Sofia

South side **of the Passive House in Voynegovtzi, Sofia** (Photograph: Aleksieva)

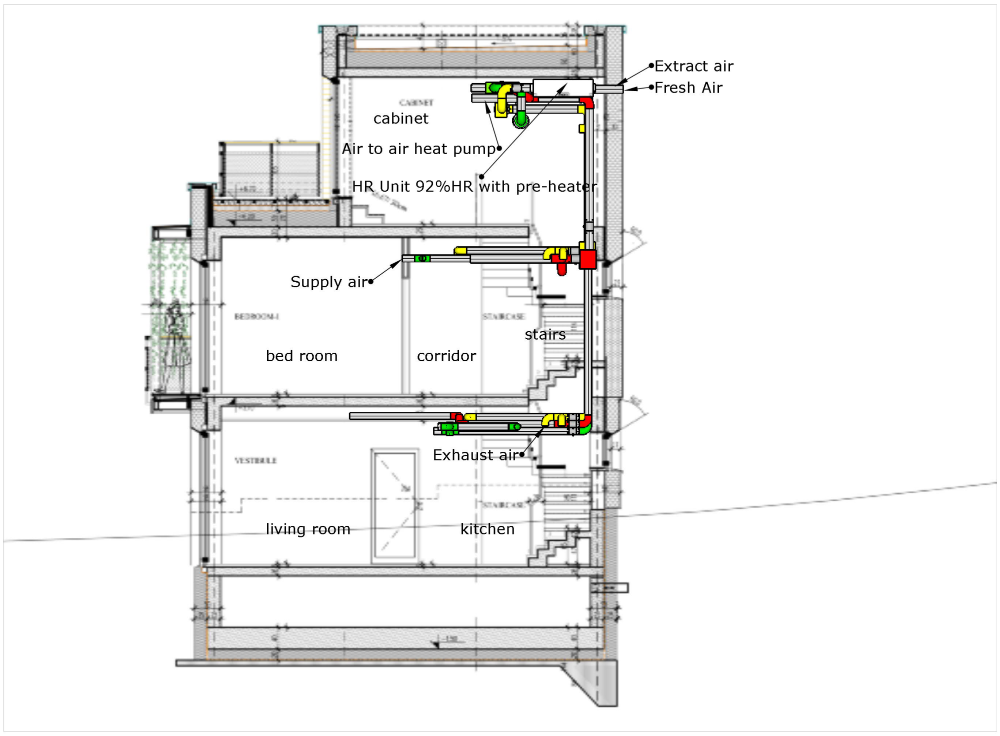
West side picture of the Passive House in Voynegovtzi, Sofia (Photograph: Aleksieva)

Nord side of the Passive House in Voynegovtzi, Sofia (Photograph: Dobrevski)

East side of the Passive House and view of the south-facing balconies. (Photograph: Dobrevski)

View of the technical room and the ceiling of the kitchen (Photograph: Dobrevski)

3 Sectional drawing of the Passive House in Voynegovtzi, Sofia



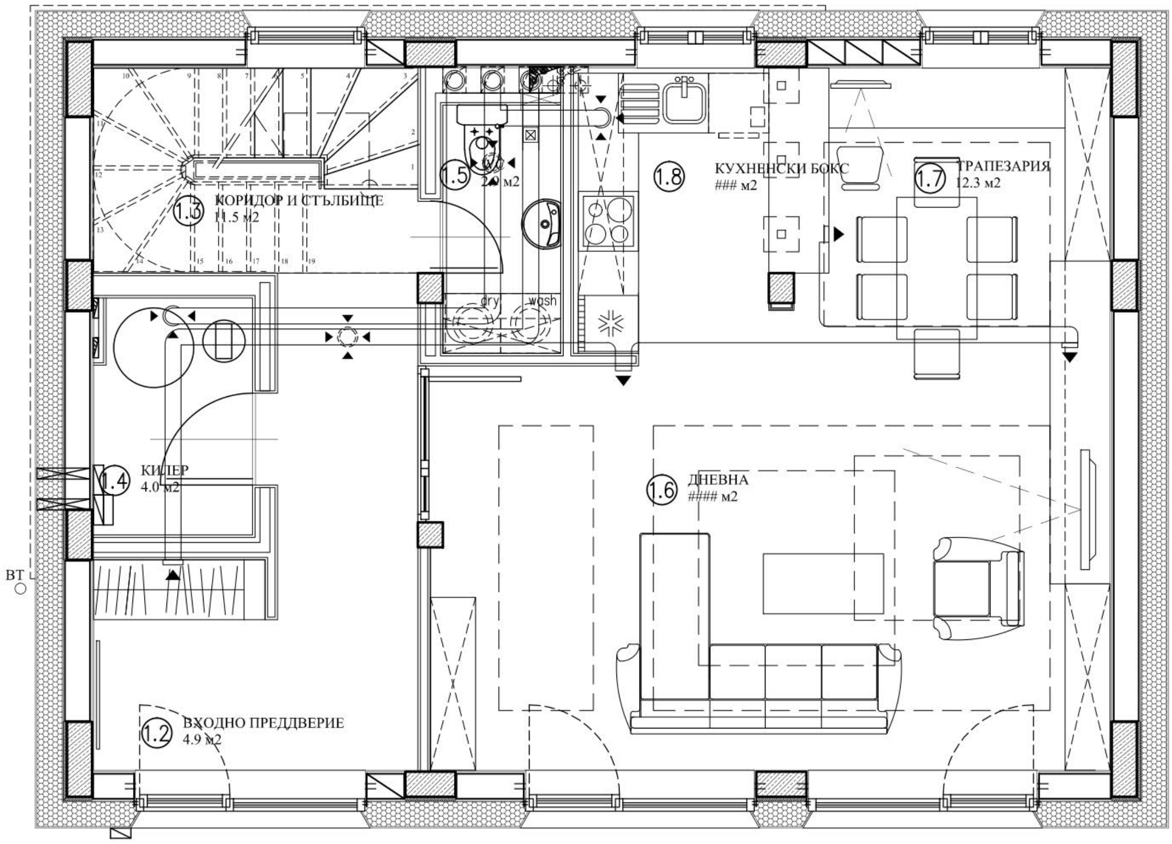
Cross-section through the Passive House in Voynegovtzi, Sofia.

The thermal envelope with excellent uninterrupted insulation is clearly distinguishable. The cross-section also shows the ductwork of the ventilation system: the combined grill is on the north façade. The heat recovery unit and the heat pump air of air are installed in the technical room, situated on the north part of the third floor. The outside air is pre-heated inside the heat recovery unit. After passing through the counter flow heat exchanger it is heated/cooled in the air to air pump and after that supplied to the living areas of the building on the southern sides. Used air is extracted at the north site of the building from the bathrooms, WC and kitchen and conducted towards the outside after heat recovery.

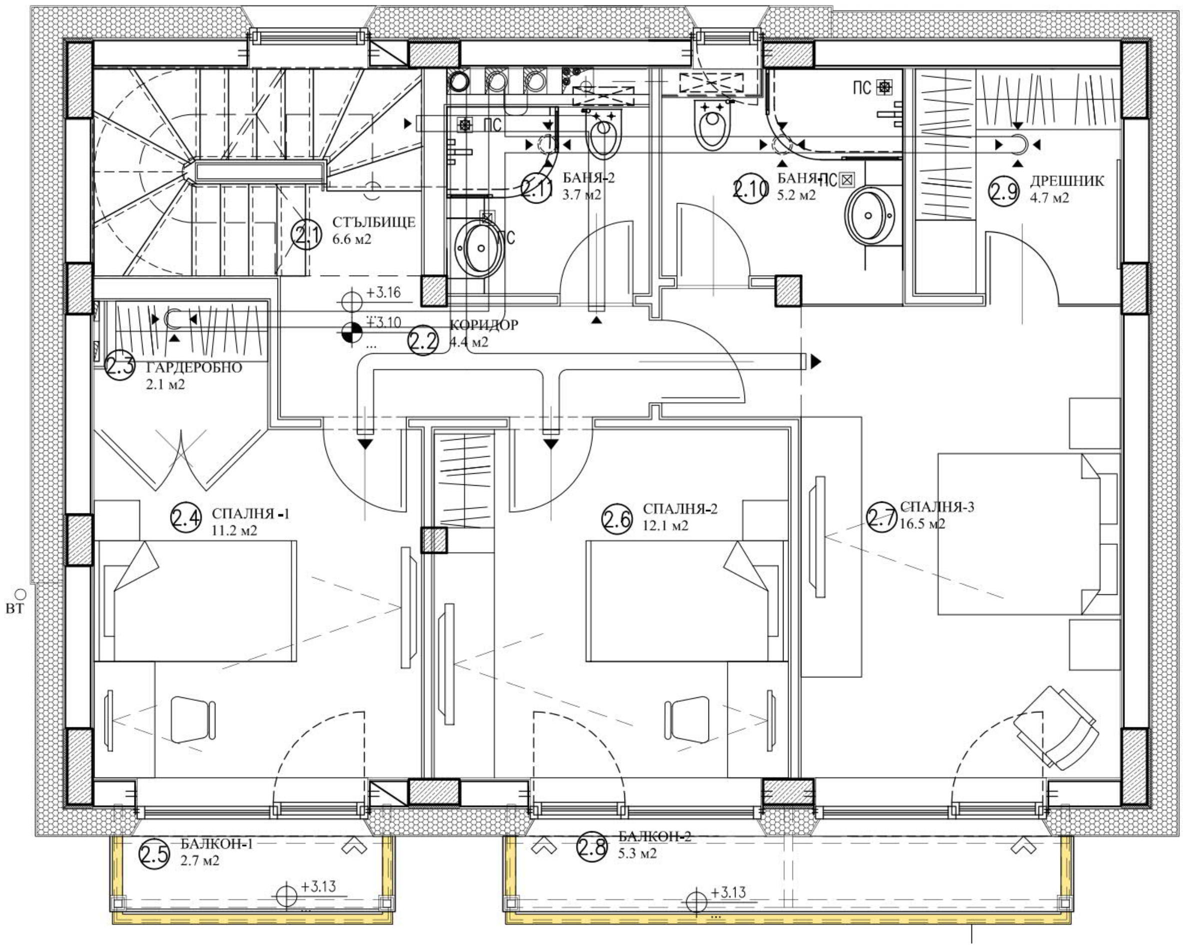
All living rooms are on the sought part of the house. All auxiliary rooms are at the north part of the house. The ground floor is a central installation zone (kitchen, WC and utility room), with the dining room on the north side and the living room on the south side. The sought area on the upper floor is taken by bedrooms and on the north side bathrooms and storerooms are situated. On the top floor, the north part is taken by the cabinet. On the north part the technical room is situated.

4 Floor plans of the Passive House in Voynegovtzi, Sofia

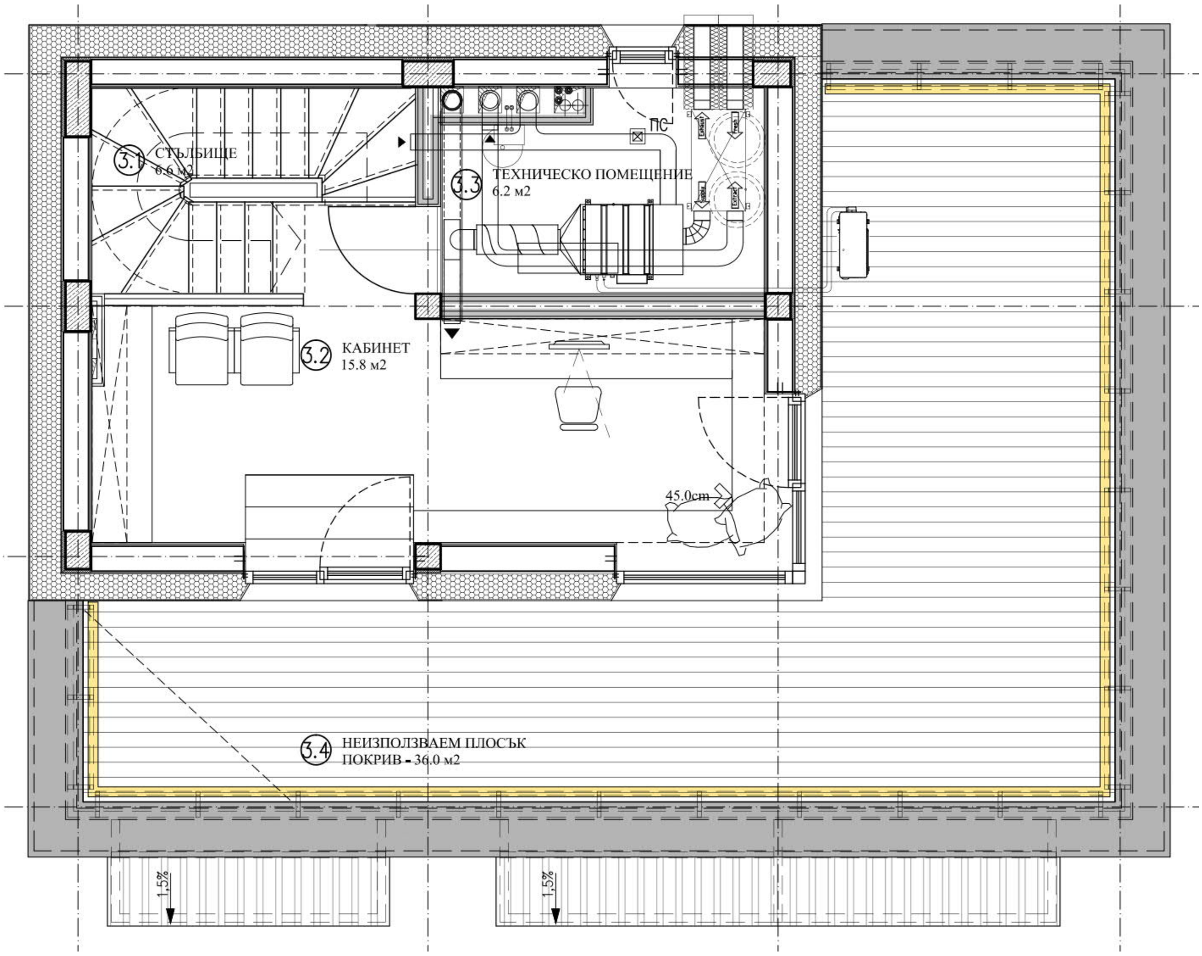
The ground floor is organized in open space. The living room, dining room and the kitchen are together. On the sought-west side there is the utility room and a vestibule. On the north-west site the staircase is situated.



The first floor is organized as a sleeping area. There are master bedroom and two children bedrooms on the south side of the floor. Two bathrooms and two utility rooms are situated on the north side of the floor.

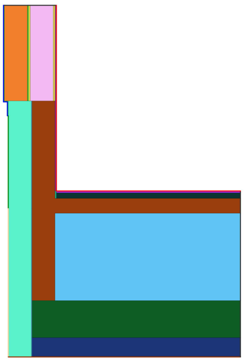


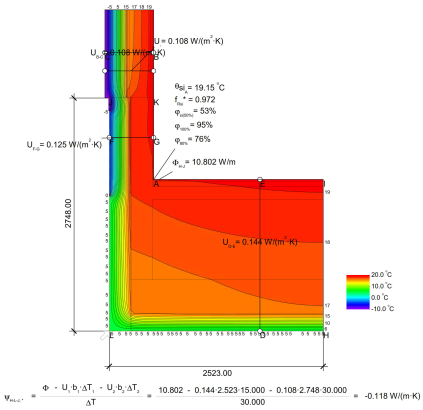
The sought part of the third floor is a cabinet and on the north part of the floor are situated the stairs and the thecnical room.



5 Construction details of the envelope and Passive House technology of the Passive House in Voynegovtzi, Sofia

5.1 Construction including insulation of the floor slab with connection points of exterior and interior walls



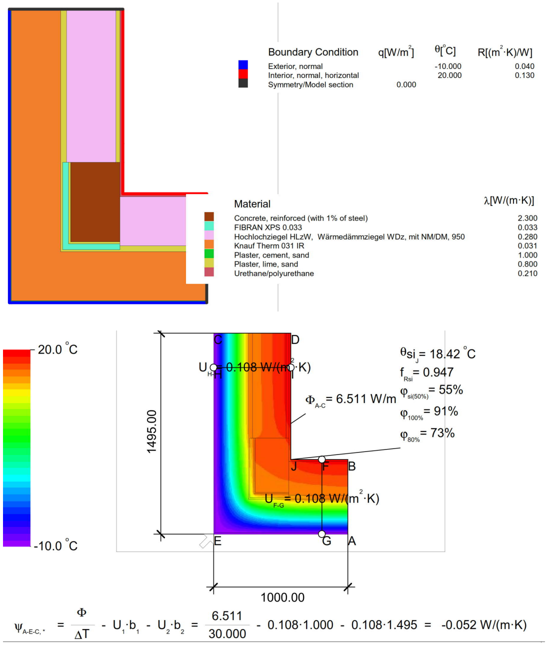


Thermal bridges and floor slab build-up. Because of the seismic reasons, the floor slab is 1788 mm. The thermal bridge is negative and compensate a large part of the heat losses through the walls to the ground. The clay assures additional specific capacity. The interior walls are from plasterboard and tin metal construction. Because of the huge thickness of the floor slab they don't form any thermal bridges. The first photograph shows the test of the hydro insulation and the second one the preparation of the reinforced concrete above the thermal insulation. The interior surface temperature covers the comfort criteria according EN 7730.

Floor slab build-up:

Floor slab	Bitumen insulation 8mm; XPS L 500 200mm; Reinforced concrete 400mm; Clay 940mm; Reinforced concrete 160mm; Screed 60mm; Parquet 20mm	U-value 0.14 W/(m²K)

5.2 Construction including insulation of exterior walls



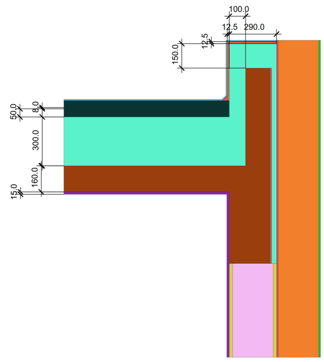
Exterior wall assembly. Typical solid construction of masonry of ceramic bricks combined with concrete skeleton are applied. An exterior insulation EPS with graphite and an insulation thickness of 250 and 300 mm and silicate plaster on the outside is applied on the outside. The U-value of this assembly is 0.108 W/(m²K) or 0.095 W/(m²K). To compensate the thermal bridge of the concrete 30 mm XPS is applied on all the concrete parts of the exterior walls (in the exterior angles also). The U-value of this assembly is the same as of the masonry - 0.108 W/(m²K). Top right: application of the XPS 30 mm on all concrete parts. Bottom right: application of exterior plaster on the masonry before application of the insulation. The masonry has the same thickness as the concrete. To assure space for plastering the masonry from both sites the masonry is made 20 mm outside the concrete elements. In this way the necessary space of 40 mm for gluing the XPS on the concrete elements is assured.

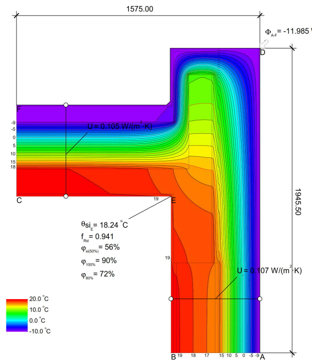
The insulation of EPS with graphite is one layer. The EIFS manufacturer supplied the insulation with thickness of 250 and 300mm.

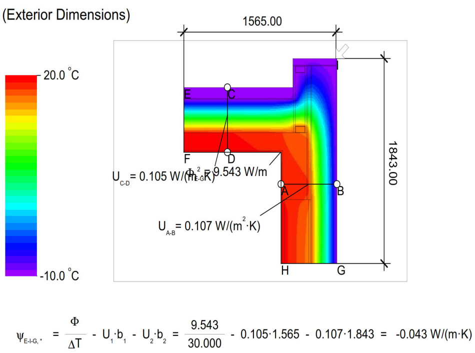
There is no thermal bridge on the flat parts of the exterior walls and the geometrical thermal bridge of the outside corner is negative – - 0.052 W/(m.K).

Exterior wall	Exterior silicate plaster 10mm; 250 mm EPS greywall; Ceramic brick masonry250 mm; 20 mm continuous interior gypsum plaster; dispersion paint coating	U-value 0.11 W/(m²K)

5.3 Construction including insulation of the roof







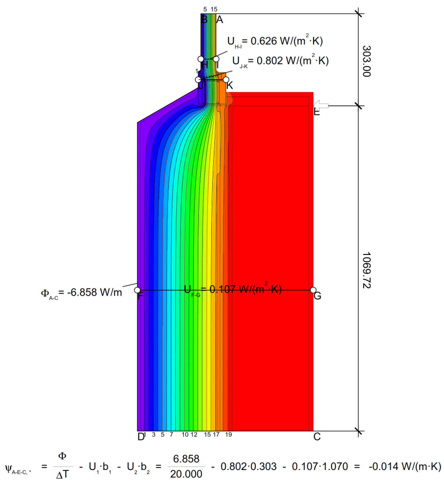
Roof build-up of the Passive House in Voynegovtzi, Sofia.

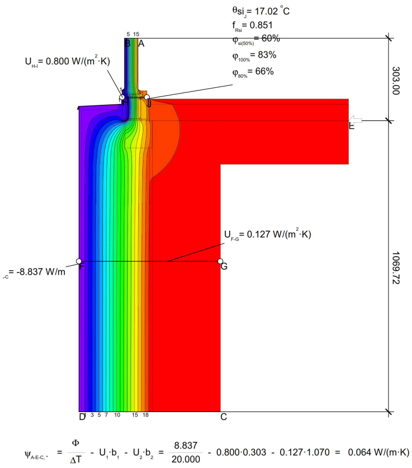
A flat roof is planned. The reason is to make a large terrace with beautiful view. Two different solutions are used for the parapet. On the level of the terrace is used more expensive but thinner build-up to make the terrace larger otherwise on the roof is used thicker build-up. The U-value of the roof is 0.11 W/(m²K) and there are no thermal bridges.

On the top left is shown the build-up of the roof. On the top center and right the calculation of the Ψ – value is shown. On the bottom left is shown the concrete above the insulation and the insulation of the parapet of the roof. Bottom right – the thermal brake between the concrete and the wall.

Roof	Gravel fraction 16-20mm 100mm; Bitumen insulation 16mm; Concrete 100mm; XPS L 300 300mm; Reinforced concrete 150mm, Interior plaster 15 mm	0.11 W/(m²K)

5.4 Window sections including installation drawing





Excellent glazing with three panes was used. For the glazing is used a certified glazing of Guardian 6nrG+16Argon+4clear+16Argon+6nrG with U_g value of the glazing is 0.69 W/(m²K) and g-value of 0.62. The Ug value is not of the best on the market but thanks to the grate g-value the heat gains through the windows are 50% more thn the losses.

For the frames a certified aluminum system of Alumil S91 is used. The U-value is 0.79 W/(m²K). The disadvantage of the high height of the system has been turned into a plus as much of the frame was overlapped with isolation which from outside was sloped at 30 degrees to maximize solar gains. This overlap with insulation allows to become negative the lateral and top thermal bridges.

The permanent shading elements were carefully calculated to assure maximum solar gains in the winter period and to overshadow the glazing during hot summer days. Additional temporary shading is planned to decrees the cooling demand and to assure better comfort in the summer.

On the top left pictures, the installation of the windows is shown. It can be seen the quality of the glass panels on the forth top picture. On the top right picture is shown the angle window of the cabinet which hasn't got profiles (warm edge). The thermal losses through the warm edge are less than with profiles and it makes bigger the glazed surface but these positive for the heat balance phenomena are not taken into account in the calculations.

Window data

Window	Certified triple low-e glazing filled with argon. Certified aluminum window frames.	0.85 W/(m²K)

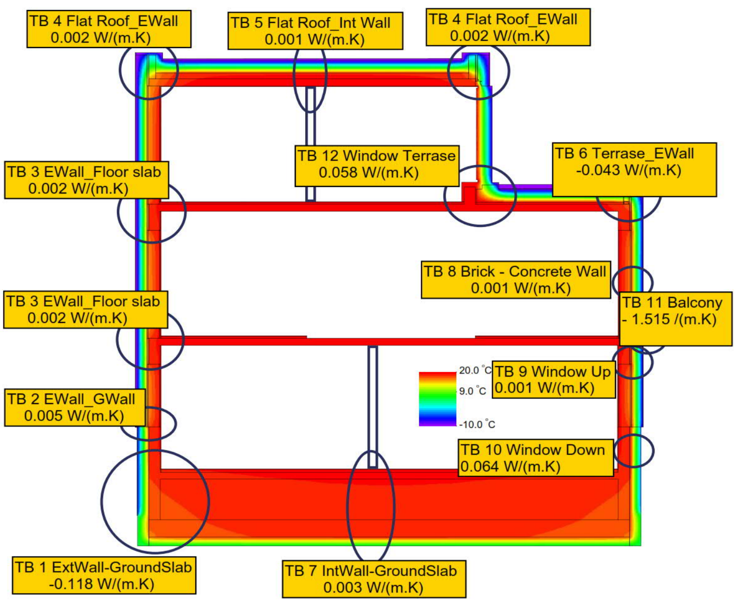
6 Description of the airtight envelope; documentation of the pressure test result; thermal bridges

A very airtight building envelope is essential for a Passive House. Based on existing experience with airtight buildings, a target value of less than 0.6 h^{-1} for the 50 Pa pressure test air change rate was set in [Feist 1993].

Exterior walls: The exterior masonry is covered with interior and exterior plaster for better airtightness. All penetrations in the building were carefully treated.

Roof and floor slab: The reinforced concrete is used as aright layer.

Windows: Windows are installed in the insulation layer. They are treated with exterior and interior tapes for airtightness.



Thermal bridges: All potential thermal bridges were carefully calculated and optimized.

The final result of all the optimization of the thermal bridges, without taking into account the window installation is positive for the building – -0.01 W/(m^2K)

Results of pressure test on 02.07.2016 in the Passive House in Voynegovtzi, Sofia

Two air leakage tests were carried out before the final measurement. The test results helped to determine and eliminate some of the leaks. Zephair and Flir camera were used.

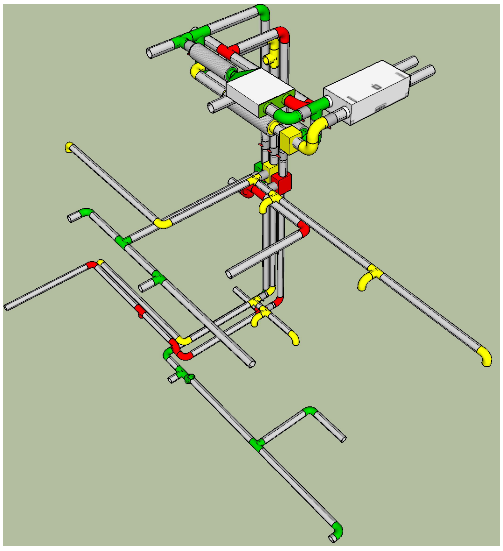
The result of the pressure test under 50Pa is excellent – 0.23 $^{-h}$. Retrotec Q4E and Fluke 922 Airflow meter were used for the test.

Summary of the final results of the Blower Door Test

FanTestic
version: 5.8.37 licensed to: Hexagon-Build Ltd
Test date: 2016-07-02 By: Bogomil Stefanov Hexagon-Build Ltd
Customer: Svetlin Dobrevski
Building Lot Number:
Building address: 8 Roza Str
Voinegovtzi 1223, Sofia, Bulgaria
Building and Test Information
Test file name: EN13829-EU 2016-07-02 1301
Building volume: 483
Building Height (from ground to top): 8
Floor Area: 175
Envelope Area: 588
Building Exposure to wind Highly exposed building
Accuracy of measurements 3%
Results
Air flow at 50 Pa, [mi/h] 113,5
Air changes at 50 Pa, n
[/h] 0,23
Flow per Envelope Area at 50 Pa, [mi/h/mI] 0,193
Flow per Floor Area at 50 Pa, [mi/h/mI] 0,649
Effective leakage area at 50 Pa, [cmI] 34,60
Equivalent leakage area at 50 Pa, [cmI] 56,70
Leakage per Envelope Area at 50 Pa, [cmI/mI]: 0,059
Leakage per Floor Area at 50 Pa, [cmI/mI]: 0,198

7 Planning of ventilation ductwork

In order to greatly reduce the ventilation losses, a balanced supply air/extract system with a highly efficient counterflow air-to-air heat exchanger was used. A heat recovery rate of 91.2 % was calculated with certified heat recovery unit with a pre-heater ComfoAir 200.The unit is certified by PHI and has electrical consumption of 0.42 Wh/m^3



Supply air rooms include all main living areas (on the left in green: supply air duct): study, children's room, bedroom, dining room and living room.

Extract air rooms include bathrooms, WCs and the kitchen.

The exhaust and fresh air ducts are very short (less than 1 m). They are incorporated with insulation in the north exterior wall of the technical room on the third floor.

The heat recovery unit is mounted on the ceiling of the technical room very close to the exterior wall. Silencers could be seen in the left photo.

Air transfer takes place through air transfer grilles with silencer (SilentDuct) in the walls in the corridor and the stairwell. From here, air travels through air transfer openings through the SilentDucts into the rooms with high humidity levels. From here, used air is returned to the heat exchanger via the extract air ductwork.

All ducts are insulated with 4 cm wool with aluminum foil except the supply ducts of the bathrooms on the second floor. The missing insulation of those ducts helps to rise up the temperature in these rooms without additional heating.


8 Heat supply

The solar coverage of the thermal flat plate collectors in the Passive House is 50%.The rest of the hot water generation through a combined electrical boiler 300 l.

The heating and cooling supply necessary for the building is assured by small heat pump air to air attached to the ventilation system.
To assure the additional quantity of air of the heat pump a third circulation clone of ducts is build. In order not to be polluted with odors and humidity It takes the air from the corridors and stairs.

The outside part of the heat pump is installed on the roof terrace. The control panel is in the living room near to the control panel of the heat recovery unit.

9 PHPP calculations

All analyses and calculations were carried out with PHPP9 and DesignPH. The use of

Passive House Verification

Building:	Single Family House
Street:	No.1884.5615.57, RLP V-57, quarter 7, Voinegovtci
Postcode/City:	1223 Sofia
Province/Country:	BG-Bulgaria
Building type:	SFH
Climate data set:	BG0007a-Sofia
Climate zone:	3: Cool-temperate; Altitude of location: 619 m
Home owner / Client:	Svetlin Stefanov Dobrevski
Street:	38A, Bogovetz str.
Postcode/City:	Sofia
Province/Country:	Bulgaria; BG-Bulgaria

Architecture:	ECO CONSTRUCTION Ltd. V. Draganova, S. Aleksieva	**Mechanical system:**	Tzvetomir Botev, Svetlin Dobrevski
Street:	112, Hristo Botev Str.	Street:	75, Georgi Dimitrov Str.
Postcode/City:	1202 Sofia	Postcode/City:	1000 Sofia
Province/Country:	BG-Bulgaria	Province/Country:	BG-Bulgaria
Energy consultancy:	Svetlin Dobrevski	**Certification:**	Inštitút pre energaticky pasívne domy
Street:	38A, Bogovetz Str.	Street:	Námestie slobody 19
Postcode/City:	1612 Sofia	Postcode/City:	81106 Bratislava
Province/Country:	BG-Bulgaria	Province/Country:	SK-Slovakia

Year of construction:	2015	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m^2]:	2.4	IHG cooling case [W/m²]:	2.9
No. of occupants:	2.9	Specific capacity [Wh/K per m² TFA]:	204	Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	151.5				
Space heating	Heating demand	kWh/(m²a)	12.00	≤	15	-	yes
	Heating load	W/m²	12.22	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	6.58	≤	15	15	yes
	Cooling load	W/m²	7.93	≤	-	10	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0.23	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	88	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	44	≤	60	60	yes
	Generation of renewable energy	kWh/(m²a)	22	≥	-	-	

[2] Empty field: Data missing; '-': No requirement

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

Passive House Classic? yes

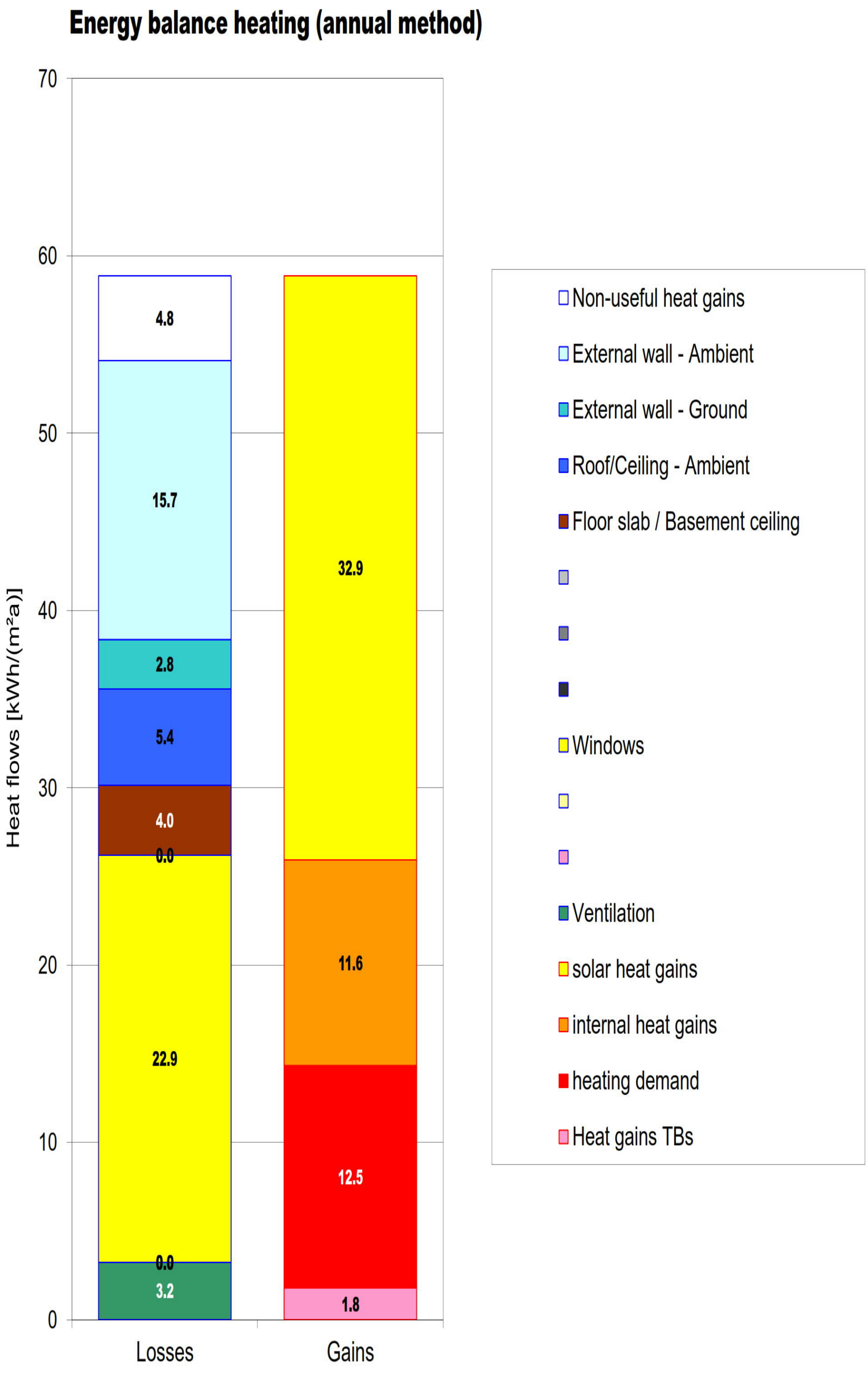
Task:	First name:	Surname:	Signature:
2-Certifier	Lorant	Krajcsovics	
Certificate ID	**Issued on:**	**City:**	
	16.01.16	Bratislava	

the PHPP started at the very beginning of the project and was used not only to check the heating balance but as a designing tool, also.

PHPP document for the detached single family Passive House in Voynegovtzi, Sofia.

The designers involved are also mentioned here. With otherwise identical data, a heating demand of 12.00 kWh/(m²a) results for the house. The cooling demand is 6.58 kWh/(m²a). There are no PER except the solar collectors for DHW. The main reason for not using other PER sources is the profitability of the investment.

The heating demand balance of the Passive House in Voynegovtzi, Sofia, calculated using the PHPP.



The main heat losses are through the windows 44%, and the exterior walls account 30%.

63% of the losses are compensated again by the solar gains through the windows.

Internal heat gains account compensate 22% of the heat losses, while the heating only accounts of just over 12 kWh/(m²a).

10 Construction costs

The Passive House in Voynegovtzi, Sofia is built in 2016. The investment in Passive House components increases the cost of construction with 11%. Taking in to account the elimination of the big costs for heating system this percentage becomes less than 6%. The additional cost will be reimbursed in less than 6 years taking into account the interest rates and inflation in Bulgaria. The price of the construction is 1350 Euros/TFAm². The price according to Bulgarian regulations (including walls, stairs and balconies) is 850 Euros/m². The price for new flats and houses in Sofia varies between 750 and 1300 Euros/m². It is obvious that the Passive House in Voynegovtzi could be sold with very satisfactory profit of 25-40% without exceeding these prices.

A model of the same house according to the national regulation was made with PHPP. The results show the model house will consume 4.5 times more energy as total compared with the existing building made in accordance with the Passive House concept.