Passive House
Project Documentation

1 Abstract

Detached house, mixed type (Residence+Office) in Papagos Athens, Greece

1.1 Data of building

Year of construction	First construction 1964, Retrofit 2015-2016	**Space heating**	**12** **kWh/(m²a)**
U-value external wall	0.178 W/(m²K)		
U-value floor slab	0.485 W/(m²K)	**Primary Energy Renewable (PER) /**	47 kWh/(m²a)
U-value roof	0.100 W/(m²K)	**Generation of renewable energy**	68 kWh/(m²a)
U-value window	0.92 W/(m²K) including thermal bridges	**Non-renewable Primary Energy (PE)**	85 kWh/(m²a)
Heat recovery	92 % for the residence 89% for the office	Pressure test n_{50}	0.56 h^{-1}
Special features	Solar collectors for hot water generation, heat recovery taking advantage of geothermal energy for the residence, PV on the roof covering 125% of the needs.		

1.2 Brief Description

Retrofit of a detached house in Papagos, Athens

This project is a pilot project made by the Passivistas Team and members of the Hellenic Passive House Institute. It is a retrofit of a typical 130m^2 single-family house of the 60s, in order to minimize (if not eliminate entirely) the need for conventional heating or air conditioning.

The selected property is located in the Municipality of Papagou, less than 7 km from Athens City center. It consists of ground floor dwelling area E = 98,5m^2 and independent semi-basement area space E = 30,5 m^2. The building is angular projection, with the north-east and south-east facing the road, while being 1.000 meters from the exit of the Attiki Ring road and 1500 meters from the Metro Station of National Defence. It is a massive construction with garden, structured in a proper spatial planning and the living space of the ground floor has a living room, kitchen, bathroom and two bedrooms.

During the implementation phases of energy upgrading work, the aim of the pilot project was to act as an education- hub for technicians and engineers of all disciplines working in the field of energy renovation of buildings, student groups and citizens. After the implementation the building data of internal temperature, humidity, CO_2 concentration in several areas, external temperature and all electricity consumptions for heating, cooling, lighting and the rest of electrical appliances are monitoring. Compared to the previous consumption of the building the measured consumption of the retrofit building is reduced by 25 times less.

1.2 Σύντομη περιγραφή του έργου

Ανακαίνιση μονοκατοικίας στον Παπάγο, Αθήνα

Αυτό το έργο είναι ένα πιλοτικό έργο της ομάδας Passivistas και μελών του Ελληνικού Ινστιτούτου Παθητικού Κτιρίου. Πρόκειται για μια ανακαίνιση μιας τυπικής μονοκατοικίας των 125m^2 της δεκαετίας του 60, με σκοπό να μειωθεί (εάν όχι να εξαλειφθεί πλήρως) η απαίτηση συμβατικού συστήματος θέρμανσης ή κλιματισμού. Το επιλεγμένο ακίνητο βρίσκεται στο Δήμο Παπάγου. Αποτελείται από ισόγεια κατοικία εμβαδού Ε = 98,5m^2 και ανεξάρτητο ημιυπόγειο χώρο εμβαδού Ε = 30,5 m^2. Το κτίριο είναι γωνιακό, με βορειοανατολικό και νοτιοανατολικό προσανατολισμό, ενώ βρίσκεται σε απόσταση 1.000 μέτρων από την έξοδο του περιφερειακού δρόμου και 1500 μέτρων από το σταθμό του μετρό της Εθνικής Άμυνας. Πρόκειται για μια συμπαγή κατασκευή με κήπο, δομημένη σε κατάλληλο χωροταξικό σχεδιασμό και ο χώρος του ισογείου διαθέτει καθιστικό, κουζίνα, μπάνιο και δύο υπνοδωμάτια.

Κατά τη διάρκεια των φάσεων υλοποίησης των ενεργειακών αναβαθμίσεων, ο στόχος του πιλοτικού σχεδίου ήταν να λειτουργήσει ως κέντρο εκπαίδευσης για τεχνικούς και μηχανικούς όλων των κλάδων που εργάζονται στον τομέα της ενεργειακής ανακαίνισης κτιρίων, φοιτητικών ομάδων και πολιτών. Μετά την εφαρμογή, παρακολουθούνται τα εξής δεδομένα της κατασκευής της εσωτερικής θερμοκρασίας, της υγρασίας, της συγκέντρωσης CO2 σε διάφορες περιοχές, της εξωτερικής θερμοκρασίας και της κατανάλωσης ηλεκτρικής ενέργειας για θέρμανση, ψύξη, φωτισμό και των υπόλοιπων ηλεκτρικών συσκευών. Σε σύγκριση με την προηγούμενη κατανάλωση του κτιρίου, η μετρούμενη κατανάλωση του ανακαινισμένου κτιρίου είναι μειωμένη κατά 25 φορές λιγότερο.

1.3 Responsible project participants

Architect	Athanasia Roditi http://www.architect-lab.com/el/
Implementation planning	Aggeliki Stathopoulou http://www.netzero.gr
Building systems	Ilias Igoumenidis http://www.igoumenidis.gr/
Structural engineering	Aggeliki Stathopoulou http://www.netzero.gr
Building physics	Stefan Pallantzas http://www.passive.gr/
Passive House project planning	Stefan Pallantzas http://www.passive.gr/
Construction management	Stefan Pallantzas http://www.passive.gr/

Certifying body	Passive House Institute Dr. Wolfgang Feist www.passiv.de		
Certification ID	13070-13071_PHI_EP_20160205_STh_U0006	Project-ID (www.passivehouse-database.org) ID Έργου (www.passivehouse-database .org)	4539

Author of project documentation	Stefan Pallantzas

Athens, 02/02/2020

2 Views of the EnerPHit detached house in Papagos, Athens

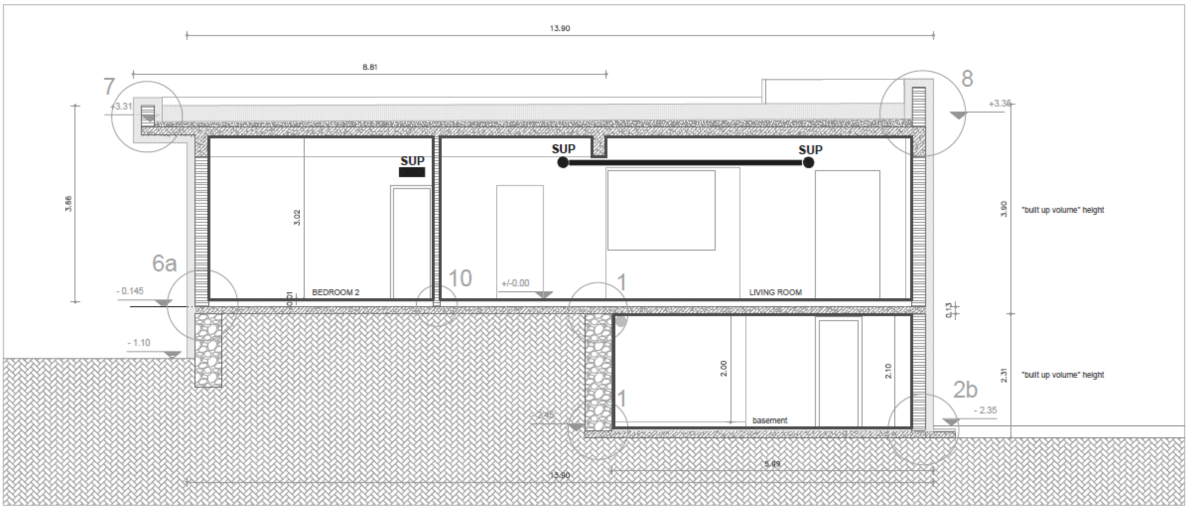
Picture 1. Northeast facade of the building

Picture 2. Northwest view of the building

Picture 3. Southwest view of the building

Picture 4. Interior view from the kitchen of the residenc

3 Sectional drawing of the EnerPHit detached house in Papagos, Athens

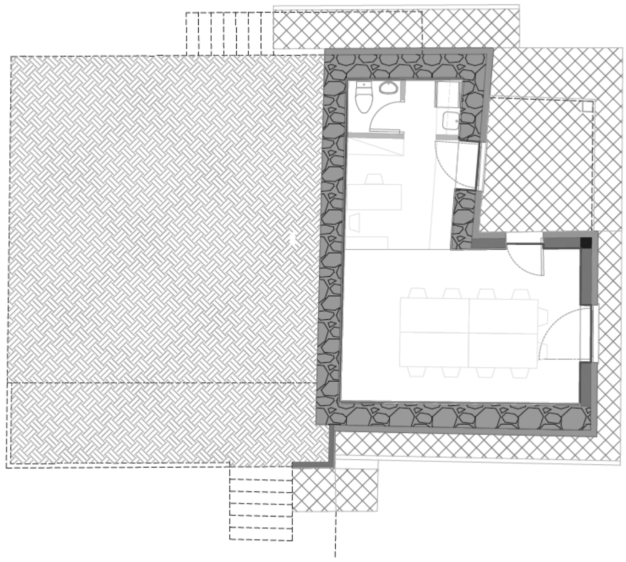


section A-A

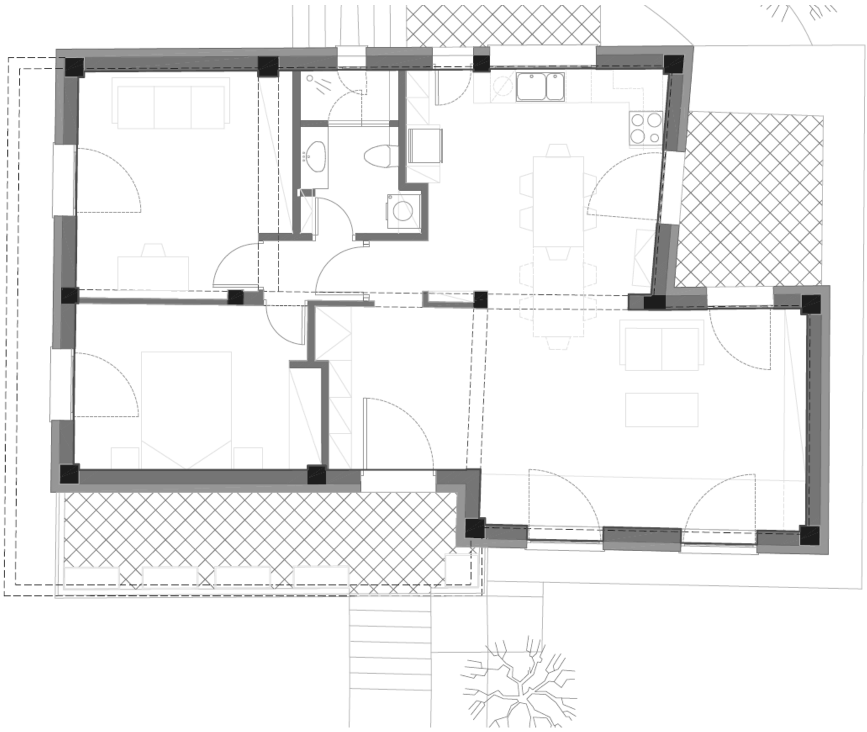
Picture 5. Cross section of the residence and the office

The image shows a cross section of the detached house in Papagos. The insulation of the exterior walls and roof is uninterrupted, but in the section of the office and of the floor slab the insulation is placed from the interior, because the building was existing. The garage is located outside of the building and the common areas are located to the residence. The house has a shape close to square which implies great compactness in the building and therefore minimizes losses through the envelope.

4 Floor plans of the EnerPHit detached house in Papagos, Athens



Picture 6. Floor plan of the office



Picture 7. Floor plan of the residence

The detached house is divided in two parts, the residence area and the office area. On the upper picture (see Picture 6) the floor plan of the office is shown. It includes the desk area, one small kitchen and a WC. On the next picture (see Picture 7) is the floor plan of the residence. The main entrance of the building is located on the northeast; it consists of a hall, a living room, an open plan kitchen, a bathroom and two bedrooms. It can also be accessed via a staircase from the southwest side of the building. The two areas are separated from each other, as well as their ventilation system. The main difference of these two systems is that the outdoor air that gets into the ventilation system of the residence is being preheated from a geothermal ground heat exchanger.

5 Construction details of the envelope

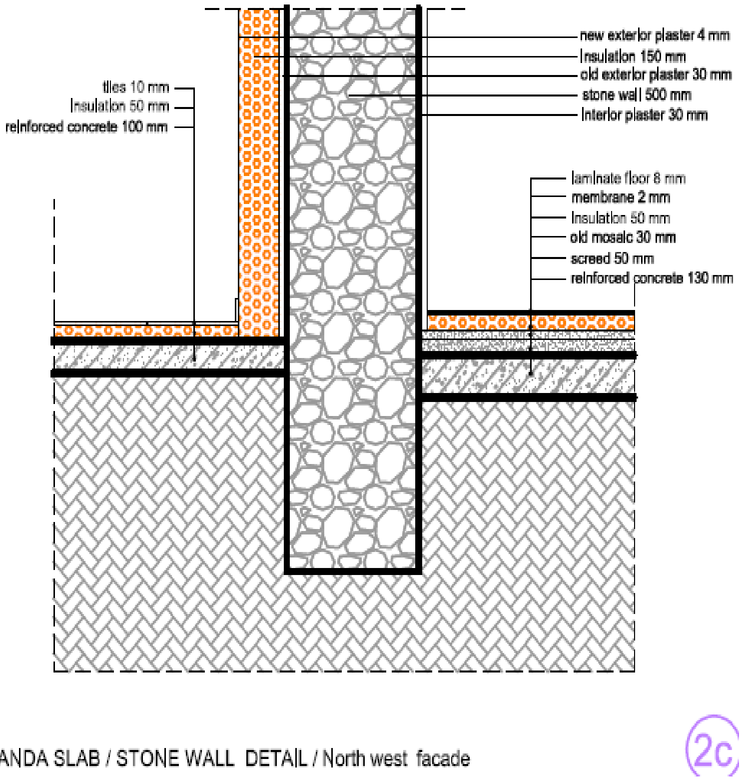
1.4 Exterior wall assembly

The pre-existing building of the Passivistas project had a usual construction type: it had reinforced concrete frames (slabs, columns and beams) and 25 cm thick brick walls plastered on each side, with a wall permeability factor of U=2.8-3.2 W / (m^2K) and for brick masonry U = 1,952 W / (m^2K). The building wasn‘t thermally insulated at all, with large thermal bridges all around its perimeter due to the reinforced concrete elements that protruded from the building envelope (balconies and roofs) and the usual placement of frames. The new exterior wall assembly has a U-value= 0.186 W/m^2K with an exterior insulation thickness of 15 cm.

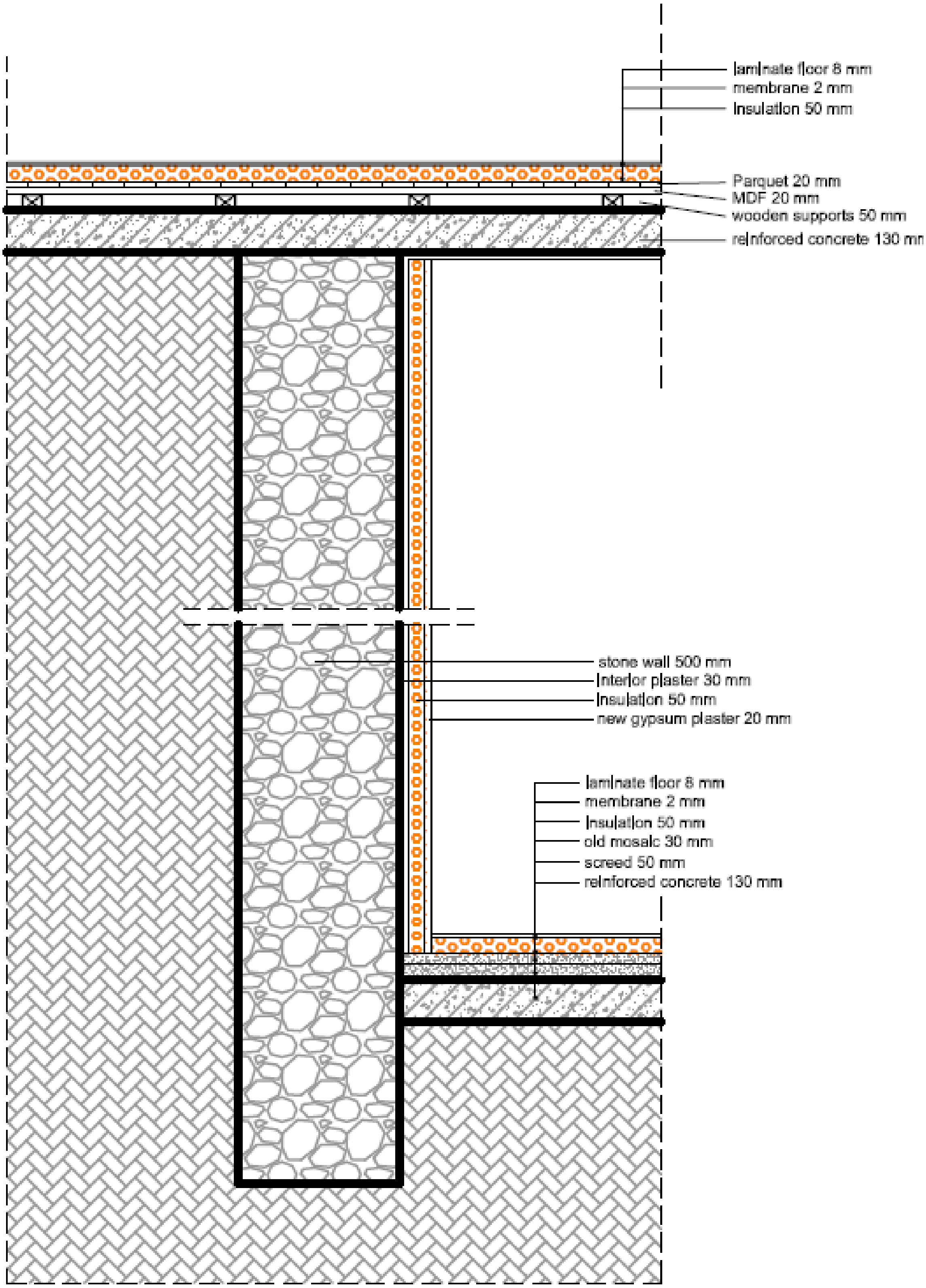
Picture 8. Placement of the exterior insulation of the thermal envelope

5.1 Exterior wall basement assembly- floor slab basement

The insulation of basement walls and the basement slab has been placed internally, with expanded polystyrene that had a thickness of 5 cm, so as not to be interrupted from the existing building assemblies. The U-value of the external stone wall of the basement is 0.138 $W/(m^2K)$ and for the basement slab is 0.484 $W/(m^2K)$.



BASEMENT / VERANDA SLAB / STONE WALL DETAIL / North west facade

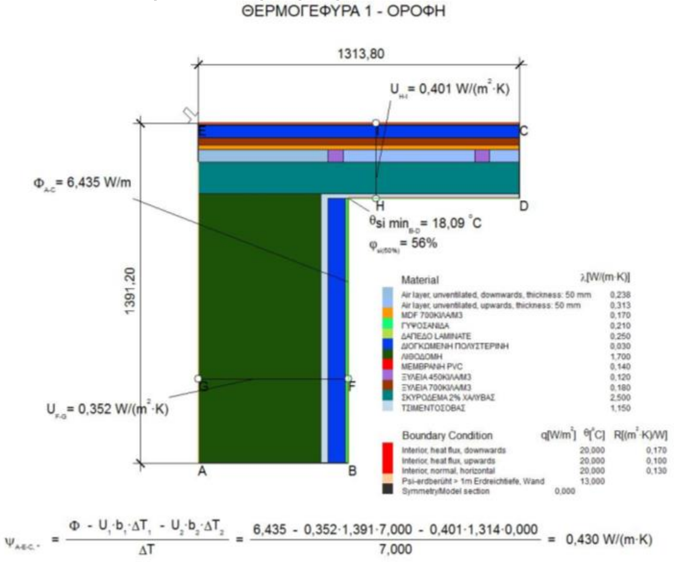


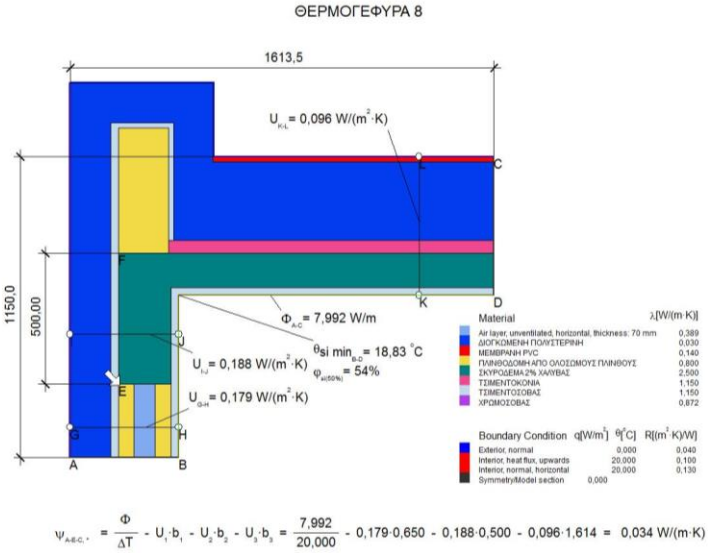
BASEMENT / GF SLAB - STONE WALL DETAIL / Section

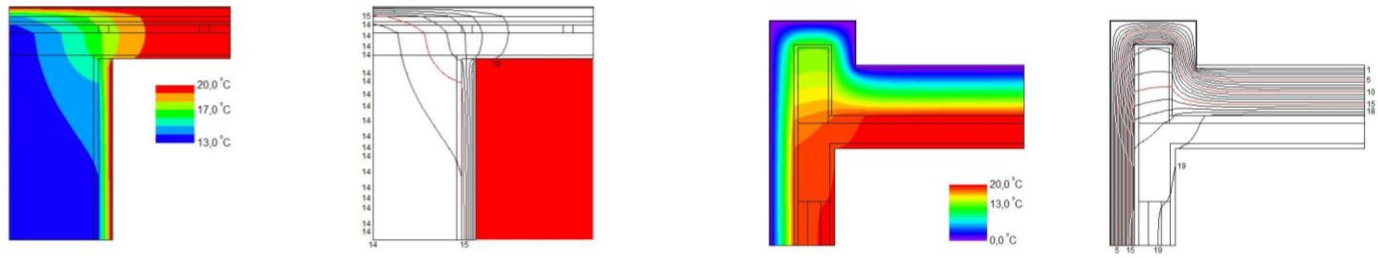
Picture 9. Placement of insulation on the basement

1.5 Roof/ Ceiling

On the roof a lightweight insulation (was selected for static reasons) consisting of expanded polystyrene 30 cm thick and two asphalt stickers, U-value = 0.1 W/(m^{2}K). Also, all existing thermal bridges have been studied and resolved so as to have the least impact on heating or cooling demand of the building. So as to face them, the projecting elements of the building envelope (balconies and roofs) were covered with expanded polystyrene 5 cm thick and 4 mm thick acrylic plaster. On the floor of the balconies were used special ceramic tiles with expanded polystyrene stuck to their underside.



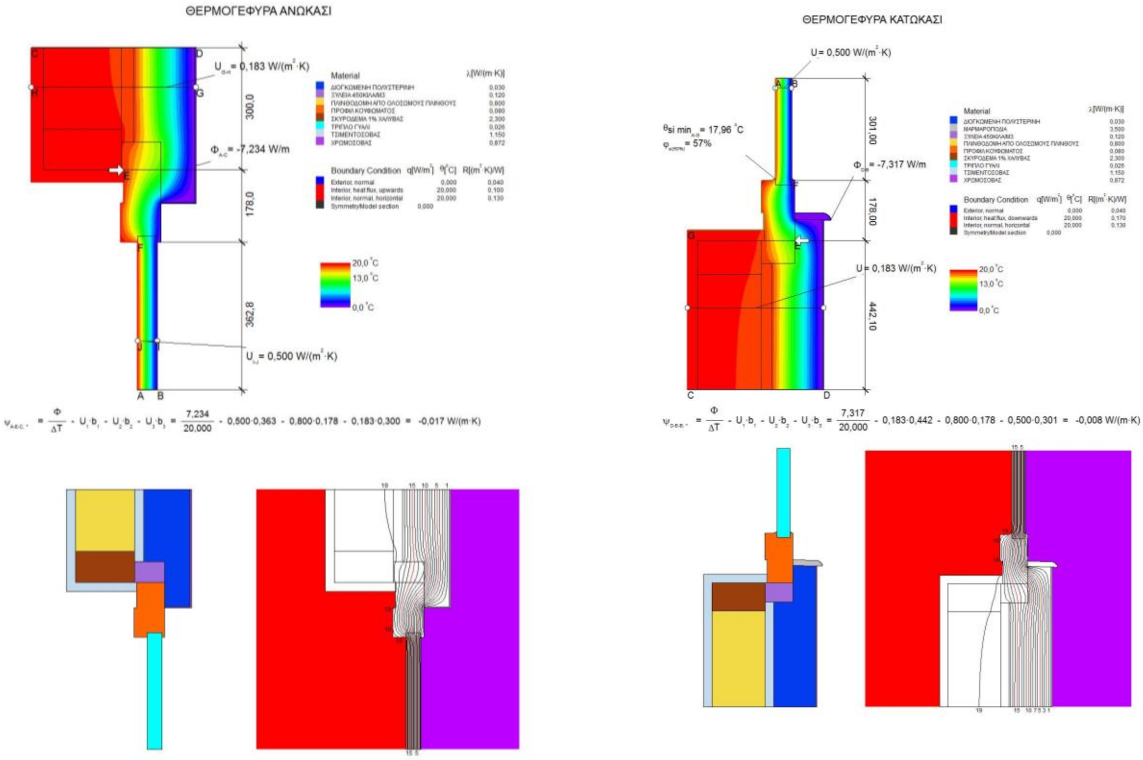




Picture 10. Ceiling detail / Thermal bridge imaging

1.6 Windows installation details

The pre-existing building had wooden opening frames with single glazing and shutters. To achieve the Passive House Standard for the retrofit the placement of the frames was redesigned to minimize thermal bridges, the dimensions of the southern windows in the kitchen and the bathroom were increased and all windows were converted to single opening in order to increase the glazing area. New front door and windows were installed with the following characteristics, Uf=0,78-1,00 W/(m²K) Ug=0,50 W/(m²K), g=0,54.



Picture 11. Thermal imaging of the installation of the windows

Picture 12. Window installation in the office

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

The airtightness in the construction of a passive house is essential, so that to minimize uncontrolled heat losses. For a basic blower door system three components are included: a calibrated fan, a door panel system, and a pressure measurement device. The blower door fan is used to blow air into or out of the building, creating either a positive or negative pressure differential between inside and outside. This pressure difference forces air through all holes and penetrations in the building enclosure. The tighter the building (e.g. fewer holes), the less air is needed from the blower door fan to create a change in building pressure. At the retrofit our goal was to achieve n_{50}=1 h^{-1} at a pressure of 50 Pa.

The blower door test was made after finishing the internal airtightness layer (plastering) and the result was unexpectedly perfect! Two separated tests were made, one for the residence with 0,48 1/h result and one for the office with 0,85 1/h result. We expect to have better values in the office, which was not fully ready during the test. So, the average value for the building was 0,56 1/h at n_{50}.

Results			V =	261 m³	A_F =	85 m²	A_E =	250 m²
	V_{50}	Uncertainty	**n_{50}**	Uncertainty	**w_{50}**	Uncertainty	**q_{50}**	Uncertainty
	m³/h	%	1/h	%	m³/m²h	%	m³/m²h	%
Depressurisation	**131**	+/- 7 %	0,50	+/- 7 %	1,5	+/- 7 %	0,52	+/- 7 %
Pressurisation	**118**	+/- 7 %	0,45	+/- 7 %	1,4	+/- 7 %	0,47	+/- 7 %
Average	**125**	+/- 7 %	**0,48**	+/- 7 %	**1,5**	+/- 7 %	**0,50**	+/- 7 %
Regulation complied with:			**EnerPHit**					
Maximum allowable:			**1**	1/h				

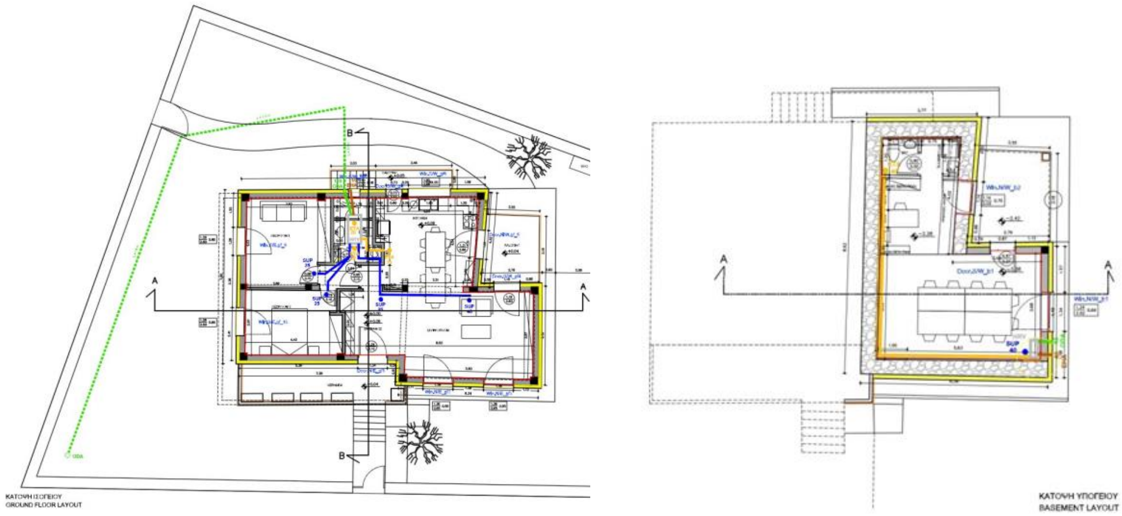
The test results meet the regulation.

Picture 13. Results of the Blower Door test in the residence

In order to achieve the airtightness goal, the layer of airtightness was at the connection of the concrete slab and the internal plaster. The windows were sealed in their perimeter with special airtightness tapes, all the connections of ducts to the thermal envelope with airtightness collars and the socket boxes were filled with plaster. The following pictures are the proofs of this good work.

Picture 14. Airtightness measures in window installation

7 Planning of ventilation ductwork



Picture 15. Ventilation layout of the residence/ office

The existing building was heated with oil and radiators and a traditional fireplace and had two 2,5KW split units for cooling. All these were demolished. In order to reduce heat losses through ventilation, a dual-flow mechanical ventilation system with high efficiency air-to-air heat exchanger unit was installed one for each area (house and office). For the residence the normal air-flow is 110m3/h. For the office we have chosen a bigger unit with 250m3/h capacity to cover the presence of nearly 10 people, e.g. during courses. The heat recovery rate of both systems used exceeds 85%. It is important to mention that in the residence the outdoor air is preheated by a ground heat exchanger that is 30m long and 1,50m deep.

Picture 16. Geothermal probes/ ventilation ducts

8 Heat supply – Domestic Hot Water - PV

The heating and cooling demand is covered by two simple split heat pump, Daikin model RXM-M20 2.0 kW. One unit is located in the living room of the house and the other in the office. The hot water is heated by a solar water heater with a capacity of 200 liters. Both the water tank and 4.2 m^2 panels are installed on the roof of the building which covers 85% of the building in hot water needs. The installation of photovoltaic panels with 4kWp (around 14 panels) will cover all the needs of energy consumption of the building.

Picture 17. Photovoltaic panels placed on the top of the roof

9 PHPP calculations

Finally, the data has been exported to the PHPP v9 planning program, in which the construction model has been finished, verifying that the construction criteria are met under the Passivhaus standard.

EnerPHit Verification

Building:	Passivistas:TheHouseProject		
Street:	Anastaseos 112 str		
Postcode/City:	GR-15669	Papagou Athens	
Province/Country:	Attiki	GR-Greece	
Building type:	Detached house		
Climate data set:	ud---03-Athens-Jessica		
Climate zone:	5: Warm	Altitude of location:	244 m
Home owner / Client:	Stefan Pallantzas		
Street:	Anastaseos 112		
Postcode/City:	GR-15669	Papagou, Athen	
Province/Country:	Attiki	GR-Greece	

Architecture:	Athanasia Roditi -	Aggeliki Stathopoulou		Mechanical system:	Ilias Igoumenidis		
Street:	Chryssanthemon 18	Spetson 18		Street:	Michael Agelou 44		
Postcode/City:	GR-15354	Glyka Nera	15344 Gerakas	Postcode/City:	GR-45333	Ioannina	
Province/Country:	Attiki	GR-Greece		Province/Country:	Epirus	GR-Greece	
Energy consultancy:	Stefan Pallantzas			Certification:	Passive House Institute		
Street:	Anastaseos 112			Street:	Rheinstr. 44/46		
Postcode/City:	GR-15669	Papagou, Athen		Postcode/City:	64283	Darmstadt	
Province/Country:	Attiki	GR-Greece		Province/Country:	Hessen	DE-Germany	

Year of construction:	2015	Interior temperature winter [°C]:	20,0	Interior temp. summer [°C]:	25,0
No. of dwelling units:	2	Internal heat gains (IHG) heating case [W/m²]:	3,0	IHG cooling case [W/m²]:	3,0
No. of occupants:	3,2	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	114,6				
Space heating	Heating demand kWh/(m²a)	12	≤	15	-	yes
	Heating load W/m²	11	≤	-	-	
Space cooling	Cooling & dehum. demand kWh/(m²a)	12	≤	16	16	yes
	Cooling load W/m²	10	≤	-	11	
	Frequency of overheating (> 25 °C) %	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg) %	0	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0,6	≤	1,0		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	85	≤	-		-
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	47	≤	45	47	yes
	Generation of renewable energy kWh/(m²a)	68	≥	60	62	

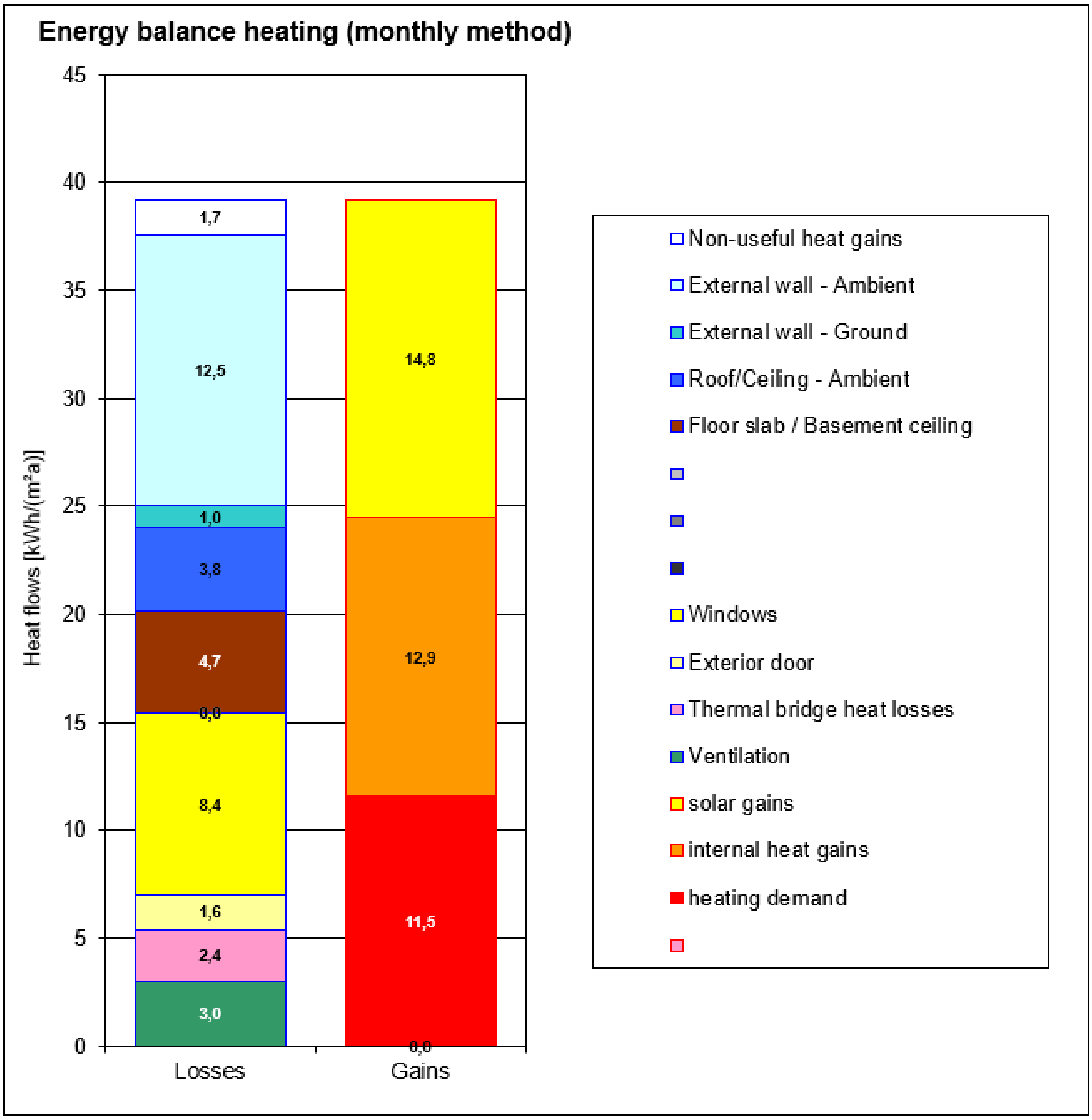
[2] Empty field: Data missing; '-': No requirement

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.

EnerPHit Plus? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Gergina	Radeva	
Certificate ID	Issued on:	City:	
13070-13071_PHI_EP_20160205_STh_U0006	05.04.17	Darmstadt	

Picture 18. Verification worksheet of the PHPP v9. The summary of calculation results is detailed in the following pages.



Picture 19. The heating demand balance of the single-family house in Papagos, Athens, calculated by the PHPP.

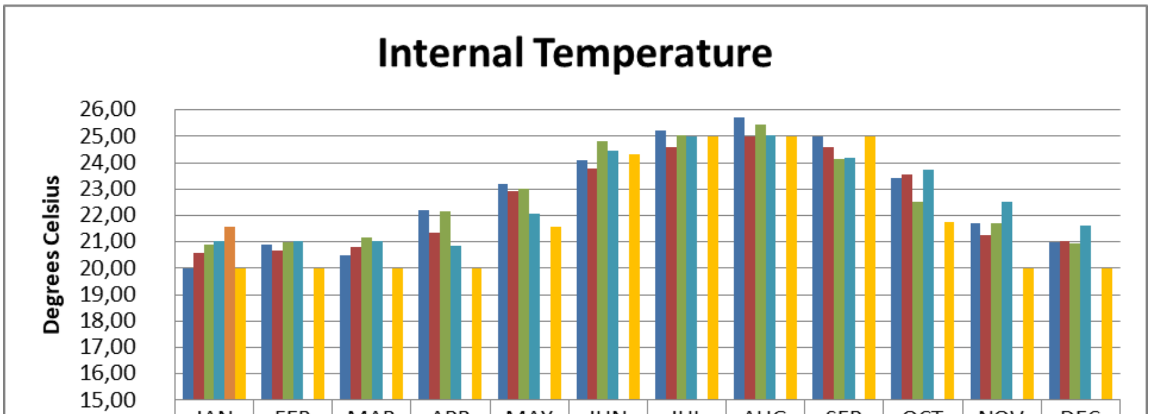
The external walls account almost the half of the heat losses and the second biggest loss is because of the windows. On the contrary almost the half of the heat gains come from the windows and the internal heat gains account for about one third, while the remaining heating demand is about 11.54 kW/(m^2a).

10 Construction costs

Whole renovation cost (VAT and taxes included): 76,900 €
Renovation cost for energy efficiency improvements (VAT and taxes included): 57,150 €
Seventy percent (70%) of the whole renovation cost was funded from sponsors -companies that gave all material and equipment needed (http://passivistas.com/sponsors/). Ten percent (10%) of this cost was covered by an international crowdfunding via Indiegogo (https://www.indiegogo.com/projects/passivistas-thehouseproject)
The cost for the renovation was only 7% more than the present building standard cost in Greece.

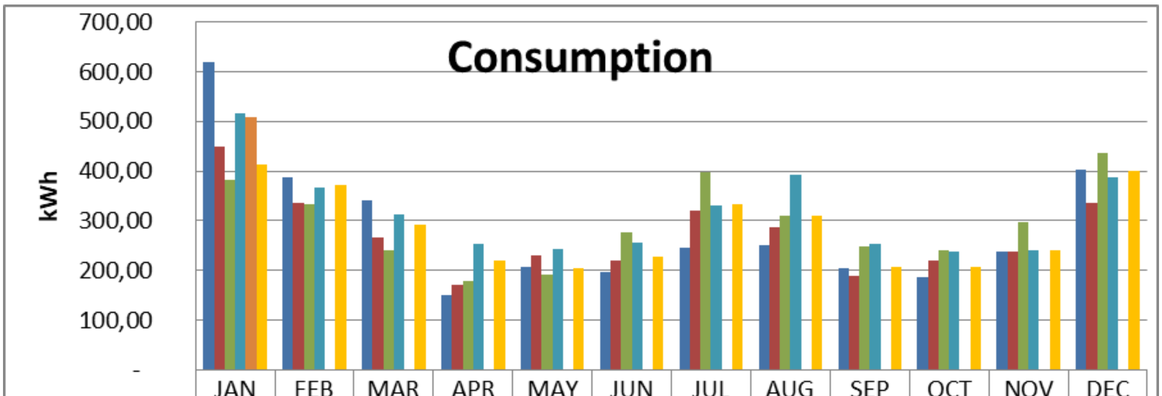
11 Measured results of the EnerPHit detached house in Papagos, Athens

The building data of internal temperature, humidity, CO_2 concentration in several areas, external temperature and all electricity consumptions for heating, cooling, lighting and the rest of electrical appliances, since the date when the retrofit was completed are monitoring. Below you can see some of the results.



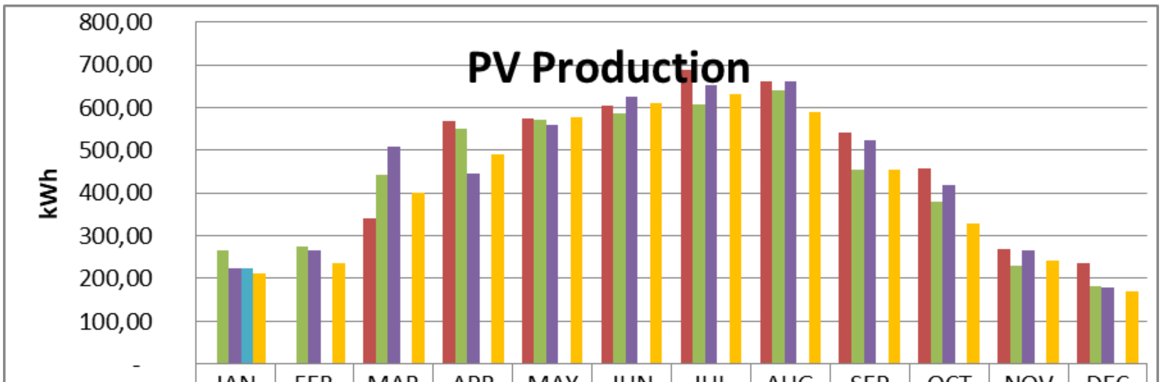
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	20,00	20,90	20,50	22,20	23,20	24,10	25,20	25,70	25,00	23,40	21,70	21,00
2017	20,58	20,67	20,82	21,33	22,94	23,79	24,57	24,98	24,59	23,56	21,25	21,02
2018	20,90	20,99	21,16	22,15	22,99	24,83	25,03	25,43	24,12	22,53	21,70	20,92
2019	21,01	21,03	21,04	20,85	22,08	24,46	24,98	25,06	24,20	23,74	22,52	21,61
2020	21,57											
phpp	20,00	20,00	20,00	20,00	21,57	24,30	25,00	25,00	25,00	21,74	20,00	20,00

Picture 20. Measured internal temperature through the years 2016-2019



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2016	619,	388,	339,	151,	205,	195,	246,	251,	204,	186,	237,	402,
2017	448,	336,	265,	171,	229,	220,	320,	287,	187,	219,	237,	335,
2018	381,	333,	241,	178,	191,	275,	396,	309,	249,	241,	296,	436,
2019	516,	367,	311,	253,	243,	255,	330,	393,	253,	237,	241,	388,
2020	508,	-	-	-	-	-	-	-	-	-	-	-
phpp	413,	371,	291,	219,	204,	227,	333,	311,	207,	206,	239,	400,

Picture 21. Measured consumption through the years 2016-2019



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2017	-	-	340,	567,	574,	603,	688,	660,	541,	458,	268,	236,
2018	265,	276,	443,	550,	572,	586,	606,	640,	454,	379,	230,	183,
2019	222,	264,	507,	445,	558,	625,	653,	660,	524,	418,	264,	179,
2020	222,	-	-	-	-	-	-	-	-	-	-	-
phpp	213,	235,	401,	490,	576,	610,	630,	590,	455,	327,	241,	170,

Picture 22. Measured production of the PVs through the years 2016-2019

12 References

- Passivistas.com the house project: http://passivistas.com/
- Passive House Data Base: https://passivehouse-database.org/?fbclid=IwAR0c-7KnmL_vfCEN0yLlOCvat4UOTZ2X1e-H7fSIZcuV1XoitkJeyPQXtJY#d_4539
- Build Up, the European Portal for Energy Efficiency in Buildings: https://www.buildup.eu/en/practices/cases/passivistas-house-project-retrofit-towards-nzeb-2020?fbclid=IwAR1LIX6r6qen5SrGaCKCEpm-CZ7CkkTYKXSn0fLsxXbUEe05t3a0TiVj4Ls
- Design and realisation of the Passive House concept in different climate zones, Jürgen Schnieders, Tim Delhey Eian, Marco Filippi , Javier Florez, Berthold Kaufmann, Stefanos Pallantzas, Monte Paulsen, Elena Reyes, Micheel Wassouf, Shih-Chieh Yeh. https://link.springer.com/epdf/10.1007/s12053-019-09819-6?author_access_token=SbU5-SzDwYG7LW_TsHjorPe4RwlQNchNByi7wbcMAY7OBnOJASnnFkQQfhQfYDgm7VPcqZ_rNZ1v_y9fXIPgMah7R8RxMa3fLXPai2ItOgX-pNJsyWtD4HcEkYJE3W1MILg8sSKqVsv2N2KFAXPkRg%3D%3D