Passivistas: The House Project

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1 Project description

The project "Passivistas: The House" is an energy upgrade and retrofit of a typical 142 m^2 single-family house of the 1960s in Athens according to the Passive House standard. The goal is to minimise the need for conventional heating or air conditioning.

The building (Figure 1) is located in the Papagou Municipality and was built in 1964 on a 520 m^2 corner plot, the two façades looking north-east and south-east. It consists of two units – a 98.80 m^2 two-bedroom private residence on the ground floor and a separate semi-basement 43.60 m^2 storage/boiler room; the second one will be converted into an office. The building's treated floor area (TFA) is 115.30 m^2, and for the existing building, the following figures were calculated in PHPP:

- Heating demand 301 kWh/(m^2a)
- Heating load 129 W/m^2
- Cooling demand 77 kWh/(m^2a)
- Cooling load 68 W/m^2
- Estimated airtightness n_{50} 5.00 /h

Figure 1: Before retrofit

Figure 2: After retrofit

2 Construction

2.1 Building envelope and thermal bridges

The existing building is of massive construction (reinforced concrete slabs and perforated brick walls) and was completely uninsulated, with major thermal bridges all around its perimeter due to balconies and protruding structural elements. It had wooden frame windows with single glazing.

The PHPP results for the retrofitted building (Figure 2) are shown in Table 1.

Parameter	Result	Criterion	Achieved?
TFA [m²]	114.6		
Heating demand [kWh/(m²a)]	11	≤ 15	yes
Heating load [W/m²]	11	–	
Cooling demand [kWh/(m²a)]	10	17	yes
Cooling load [W/m²]	9	≤ 11	
Frequency of high humidity (>12 g/kg) [%]	0	≤ 10	yes
Airtightness n_{50} [/h]	0.6	≤ 1.0	yes
PE demand [kWh/(m²a)]	90	–	
PER demand [kWh/(m²a)]	45	≤ 45	Yes
Generation of renewable energy (per projected building footprint) [kWh/(m²a)]	91	≥ 60	

Table 1: PHPP results

All existing thermal bridges were resolved to have minimum impact on the heating and cooling demands; their new ψ-values are calculated accordingly.

The Passive House modernisation concept consists of:

- Roof, external insulation: 30 cm of EPS [λ = 0.030 W/(mK)]
- External walls, external insulation: 15 cm of EPS [λ = 0.030 W/(mK)]
- Floor slabs, internal insulation: 5 cm of EPS [λ = 0.030 W/(mK)]
- New windows and doors: U_f = 0.78…1.00 W/(m²K), U_g = 0.50 W/(m²K), g = 0.54

The dimensions of the south-facing windows in the kitchen and the bathroom were increased, and all windows were converted to single opening in order to increase the glazing area.

2.2 Summer concept and shading

All south-east-, south-west- and north-west-facing windows have automatically controlled roller blinds for temporary shading in summer (Figure 3). All windows – except for one in the kitchen – can be opened or tilted for natural night cross-ventilation in summer and have mosquito nets on the outside. On the south-west and north-west side of the building – in the area of the two balconies – horizontal tents will be placed to shade the windows and the balcony's sitting area during midday and afternoon hours in summer.

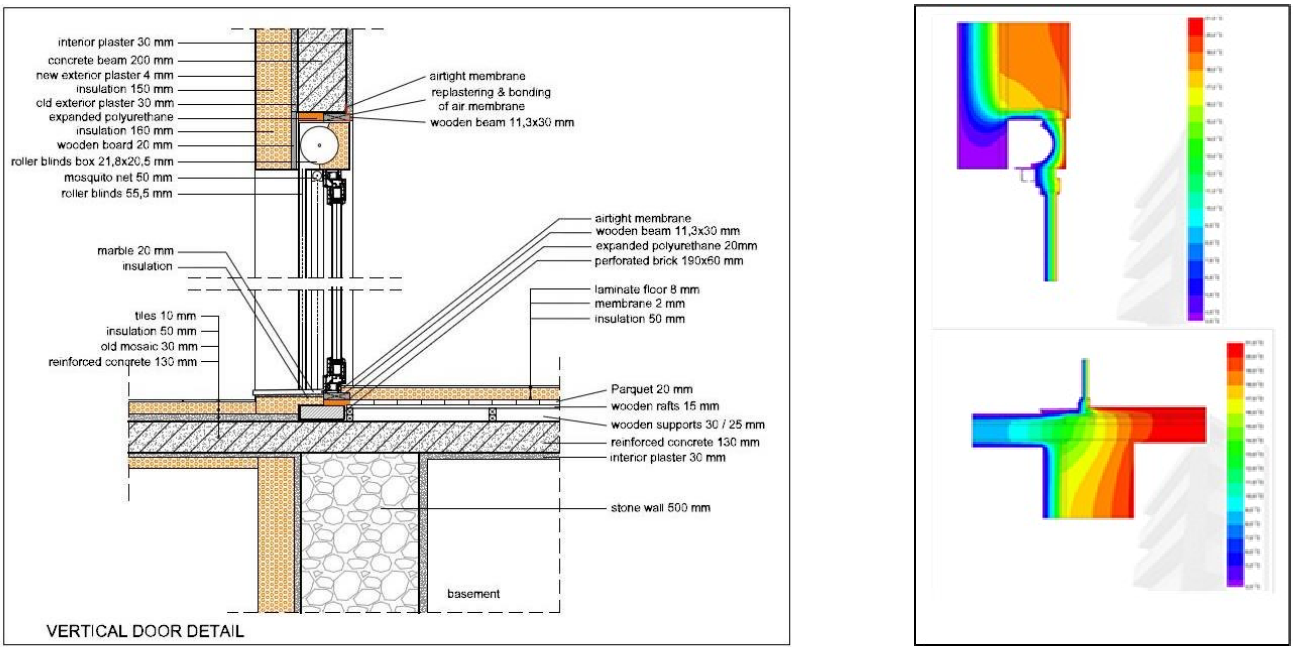

Figure 3: Patio door with roller blinds: build-up (left), thermal images (right)

Night ventilation with tilted windows to the north and the south-east is used for passive cooling. The ground heat exchanger decreases the incoming air temperature down to 25–27 °C. A 2.5 kW inverter split unit, installed in the living room, actively covers the cooling demand.

2.3 Ventilation and heating concept

The existing building was heated with oil and radiators and a traditional fireplace, and had two 2.5 kW split units for cooling. All of these were demolished.

New heat recovery ventilation (HRV) systems were installed, one for each unit (house and office; Figures 4 and 5). For the residence unit, the normal air-flow is 110 m^3/h. For the office, we have chosen a bigger unit with 250 m^3/h capacity to cover the presence of 10 people, for example, during courses. Both units have a 1 kW supply air heater, which will cover the remaining heating demand. The split unit will serve as backup, installed mainly for cooling. The residence unit is also coupled with a 30 m long, 1.50 m deep ground heat exchanger.

3 Blower door test and monitoring

The blower door test was performed after finishing the internal airtightness layer (plastering) and was unexpectedly perfect! Two separate tests were done, one for the residence unit (n_{50} = 0.48 /h) (Figure 6) and one for the office (n_{50} = 0.85 /h). We expect to have better values in the office, which was not completely ready during the first test. The average n_{50}-value of the entire building was 0.56 /h at 50 Pa.

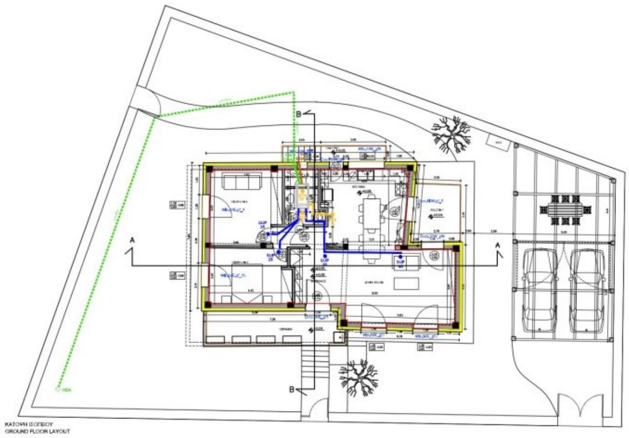

Figure 4: Ventilation system residence

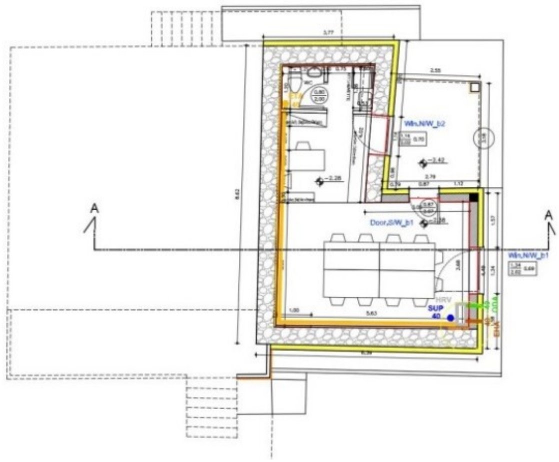

Figure 5: Ventilation system office

Results			V =	261 m³	A_F =	85 m²	A_E =	250 m²
	V_{50} m³/h	Uncertainty %	n_{50} 1/h	Uncertainty %	w_{50} m³/m²h	Uncertainty %	q_{50} m³/m²h	Uncertainty %
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.

Figure 6: Blower door test results – residence

4 Lessons learned

The experience with the 9th version of PHPP was great. We have used the variants tool to create several alternative scenarios for the envelope. The new user-friendly interface helped us to increase the productivity and make fewer mistakes. Especially the new windows section allowed us to check every single window and to optimise their gains and losses.

Our calculations showed that we could reach the target of 15 kWh/(m^2a) with nearly less than 10 cm of external insulation and double-glazed windows. But we decided to go further and increase the thickness to achieve the 10 W/m^2 criterion and eliminate the need for conventional heating. This was achieved with 20 cm of insulation and double-glazed windows with a high g-value. Then we found out that there was no option in the Greek market to find windows with a g-value above 0.54. So we decided, in order to keep the positive balance of the windows, to use triple-glazing with a U_g-value of 0.5 W/(m^2K) and a g-value of 0.54. This reduced the wall insulation thickness to 15 cm.

Many thermal bridges had to be taken into consideration and accurately calculated. Due to balconies and projecting structural elements, 18 different structural thermal bridges were identified; two of them were solved using insulation methods and the rest were calculated and taken into account in PHPP. Also, due to three types of windows used, combined in two different installation strategies, 16 different window installation thermal bridges had to be calculated.

A lot of tradespersons training had to take place on site, as very few were familiar with the Passive House concept. This slowed down the construction process a bit, and some repair work regarding the airtight envelope had to be done.

We were excited with the blower door test result. Although it was an old house and we were afraid of not achieving the specification easily, the result was extraordinary. We believe that this was due to the good internal plastering of the house, which is a big advantage of the way houses are built in Greece.

In Greece, there is little knowledge about planning and installing ventilation systems. The whole procedure was developed and implemented by the team of engineers, all of whom are Passive House designers. After planning the duct system and calculating the airflows and the pressure drops, the unit and the ducts as well as the preheater were installed, the system was made airtight and the noise was reduced, the flows were measured and the system was calibrated. In this respect, the suppliers should educate their staff on installing ventilation units.

5 Social impact

This project is a stepping stone on the road to the Greek Nearly Zero-Energy Building (NZEB) of 2020. We want to show the people, the engineers, the market and the government that energy efficiency is achievable and cost-effective. Furthermore, by using renewable sources, it is easy to achieve a house which has a positive energy balance, i.e. a truly sustainable house.

The design process, the step-by-step implementation and the subsequent monitoring project will promote collaborative processes among executives of the Hellenic Passive House Institute (HPHI), certified Passive House building designers, engineers and technicians from all sectors and commercial and technical departments of companies that are manufacturing and marketing Passive House components. It will offer all the information required on how to drastically save domestic energy to everybody through an open public database, while improving quality of life and contributing substantially to the fight against global warming.

After completion of the project, the house works as a media and collaborative process hub aimed to prove in practice the ability to upgrade the energy consumption of residential buildings in Greece and the Mediterranean area so that they do not need conventional heating or air conditioning, while drastically reducing energy costs and improve the indoor quality. And all this at an acceptable cost to the community.

Figure 7: Certified European Passive House Designer (CEPH) course at passivistas

Specifically, the project will implement the following functions:

- The ground floor will act as an open residence for seven consecutive years. Guided visits, lectures and public presentations will be organised.
- The basement will serve as headquarters of HPHI and will be hosting seminars (Figure 7) and training materials.
- HPHI created the project website and will cover all the steps and aspects of the project via an interactive blog. On the website, everybody can learn about the design process, stages of implementation, the specifications of materials and controls, and take a look at online measurements and the actual operation and consumption of the building. On the other hand, all companies that participated in the project will have access to all data available, concerning the behaviour of the building, of all materials and equipment and will cooperate with HPHI and the project management to further improve the quality of their products.

The team developed info materials available to everyone, in the form of videos, posters, brochures, a technical handbook etc. The building will be the first to be certified as an EnerPHit Plus in the Mediterranean area, which means that it will be the first building in the region producing more energy than consuming. It is expected to consume about 3.000 kWh annually, while the photovoltaic system produces more than 7.000 kWh. For now, this amount of energy will be sold to a public energy company via net metering, but in the future, we are thinking of making the building totally autonomous.

6 References

www.passivistas.com

https://www.facebook.com/passivistas/

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Summary

Passivistas: TheHouseProject is a stepping stone on the road to the Greek NZEB. We, all engineers and Passive House designers and members of the Hellenic Passive House Institute, want to show to the people, to the engineers, to the market, to the government that energy efficiency is achievable and cost effective.