Single Family House, Protochori, Kozani, Greece

Project Documentation
Έγγραφα έργου

1. Abstract / Περίληψη
### 1.1 Data of building / Δεδομένα κτιρίου

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Year of construction</td>
<td>2016</td>
</tr>
<tr>
<td>Space heating / Θέρμανση χώρου</td>
<td>11,00 kWh/(m²a)</td>
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<tr>
<td>U-value external wall</td>
<td>0,132 W/(m²K)</td>
</tr>
<tr>
<td>U-value floor slab</td>
<td>0,259 W/(m²K)</td>
</tr>
<tr>
<td>U-value roof</td>
<td>0,087 W/(m²K)</td>
</tr>
<tr>
<td>U-value window</td>
<td>0,78 W/(m²K)</td>
</tr>
<tr>
<td>Heat recovery</td>
<td>82,3%</td>
</tr>
<tr>
<td>Pressure test n50</td>
<td>0,30 h⁻¹</td>
</tr>
<tr>
<td>Special features</td>
<td>Solar collectors for hot water generation, heat recovery taking advantage of geothermal energy</td>
</tr>
</tbody>
</table>

#### U-value external wall / Τιμή -U εξωτερικού τοίχου
- Year of construction: 2016
- Value: 0,132 W/(m²K)

#### U-value floor slab / Τιμή -U εδαφόπλακας
- Year of construction: 2016
- Value: 0,259 W/(m²K)

#### U-value roof / Τιμή -U οροφής
- Year of construction: 2016
- Value: 0,087 W/(m²K)

#### U-value window / Τιμή -U κουφώματος
- Year of construction: 2016
- Value: 0,78 W/(m²K) including thermal bridges

#### Generation of renewable energy / Παραγωγή ανανεώσιμης ενέργειας
- Year of construction: 2016
- Value: 5 kWh/(m²a)

#### Primary Energy Renewable (PER) / Πρωτογενής Ενέργεια από Ανανεώσιμες πηγές (ΠΕΑ)
- Year of construction: 2016
- Value: 25 kWh/(m²a)

#### Non-renewable Primary Energy (PE) / Πρωτογενής ενέργεια από μη Ανανεώσιμες Πηγές (PE)
- Year of construction: 2016
- Value: 41 kWh/(m²a)

#### Special features / Ειδικά χαρακτηριστικά
- Solar collectors for hot water generation, heat recovery taking advantage of geothermal energy
1.2 Brief Project Description

Single Family House, Protochori, 50100, Kozani

The project concerns the construction of a detached house, with a TFA=163.40m², which was designed to reduce the requirement for a conventional heating or air conditioning system. The property is located in Protochori village, in the Prefecture of Kozani at a distance of 9km from the city of Kozani. It consists of a ground floor and a basement accessible by internal stairs. The building is freely located within the plot, with main openings to the southeast and southwest. The main functions are developed in the ground floor area which includes living room, dining room, kitchen, two bathrooms and three bedrooms. In the basement there are two bedrooms and storage spaces.

1.2 Σύντομη περιγραφή του έργου

Ισόγεια κατοικία με υπόγειο και στέγη, στο Πρωτοχώρι, 50100, Κοζάνη

Το έργο αφορά την κατασκευή μιας μονοκατοικίας, επιφάνειας TFA 163,40m², η οποία σχεδιάστηκε με σκοπό να μειωθεί η απαίτηση συμβατικού συστήματος θέρμανσης ή κλιματισμού. Το ακίνητο βρίσκεται στην Τ.Κ. Πρωτοχωρίου, στον Νομό Κοζάνης σε απόσταση 9km από την πόλη της Κοζάνης. Αποτελείται από ισόγεια κατοικία και υπόγειο χώρο προσβάσιμο με εσωτερική σκάλα. Το κτίριο είναι ελεύθερα τοποθετημένο μέσα στο οικόπεδο, με κύρια ανοίγματα νοτιοανατολικά και νοτιοδυτικά. Οι κύριες λειτουργίες αναπτύσσονται στον χώρο του ισογείου που περιλαμβάνει σαλόνι, τραπεζαρία, κουζίνα, δύο μπάνια και τρία υπνοδωμάτια. Στο υπόγειο βρίσκονται 2 υπνοδωμάτια και αποθηκευτικοί χώροι.
### 1.3 Responsible project participants / Συμμετέχοντες υπεύθυνοι για το έργο

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Website</th>
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<tr>
<td>Architect/ Αρχιτέκτονας</td>
<td>George Liakos / Alexia Chalkia</td>
<td><a href="http://www.liakosmelkat.gr">www.liakosmelkat.gr</a></td>
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<tr>
<td>Implementation planning/ Σχεδιασμός υλοποίησης</td>
<td>George Liakos</td>
<td><a href="http://www.liakosmelkat.gr">www.liakosmelkat.gr</a></td>
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<td>Building systems/ H/M</td>
<td>Kampourlidis Ilias</td>
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<td>Structural engineering/ Στατική Μηχανική</td>
<td>George Liakos</td>
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<td>George Liakos</td>
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<td>Passive House project planning/ Ενεργειακός Σχεδιασμός Passive House</td>
<td>George Liakos / Alexia Chalkia</td>
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<td>George Liakos</td>
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<tr>
<td>Author of project documentation / Συντάκτης του παρόντος εγγράφου</td>
<td>George Liakos</td>
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</tr>
<tr>
<td>Date, Signature/ Ημερομηνία, Υπογραφή</td>
<td>Kozani, 13/07/2021</td>
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![Signature Image]
2. Views of the Passive Single Family House in Protochori, Kozani

*Picture 1. East view of the building*

*Picture 2. South view of the building*
Picture 3. Southwest view of the building

Picture 4. Northwest view of the building
3. **Sectional drawing of the Passive Single Family House in Protochori, Kozani**

![Sectional drawing of the Passive Single Family House in Protochori, Kozani](image)

*Picture 5. Cross section of the residence*

The drawing shows a cross section of the single family house in Protochori. The insulation of the exterior walls, roof, floor and basement is uninterrupted. Most of the basement exterior walls are below ground level.

4. **Floor plans of the Passive Single Family House in Protochori, Kozani**

![Floor plans of the Passive Single Family House in Protochori, Kozani](image)

*Picture 6. Basement Floor plan*
The detached house consists of two floors, the ground floor and the basement. The basement floor plan is shown on Picture 6 and it includes two bedrooms, the utility room and storage areas. The ground floor plan is shown on Picture 7 and consists of the living room, the dining room, the kitchen, two bathrooms and three bedrooms. The main entrance of the building is located on the northeast. The two floors are connecting with interior stair. The house has a complex outline, which implies an increased thermal envelope area and losses through the envelope, which had to be covered with a thicker insulation layer.

5. Construction details of the envelope

5.1 Exterior wall assembly

The building is constructed with reinforced concrete frames (slabs, columns and beams) and 25cm thick brick walls, lime plastered from the inside. The building is thermally insulated, with external insulation of 20cm thick EPS80 with $\lambda=0,031\,W/mK$, all around its perimeter. The exterior brick wall assembly has a U-value= 0,102 W/m2K and the concrete sections a U-value= 0,148 W/m2K.
5.2 Basement exterior wall and floor slab assembly

The insulation of the basement walls and the basement floor slab has been placed externally, with EPS200 that had a thickness of 14cm in the walls and 10cm below the slab. The interruption between floor and slab insulation has been taken into account as thermal bridge in PHPP. The U-value of the external concrete wall of the basement is 0,222 W/(m2K) and for the basement slab is 0,300 W/(m2K).
5.3 Roof/Ceiling

The roof consists of three independent parts. Each part consists of the concrete ceiling slab, the insulation layer and a wooden roof construction with concrete roof tiles. The insulation layer is EPS80 with $\lambda=0.031$ W/mK and 35cm thickness and is uninterrupted with the external walls insulation, with thermal bridge free design. The roof assembly has a U-value = 0.087 W/(m2K).
5.4 Thermal Bridges

All existing thermal bridges have been calculated and designed to have the least impact on heating or cooling demand of the building and the $\psi$-values are entered in PHPP. For example, the up and down surfaces of the balconies were covered with EPS80 with 5cm thickness and the thermal bridge $\psi$-value is calculated 0.34W/mK. Additionally, the shading components were constructed with lightweight dry wall construction above the insulation.
Picture 1410. Balcony thermal bridge

Picture 15. Shading construction
5.5 Windows installation details

The placement of the windows was designed to minimize thermal bridges to achieve the Passive House Standard. Windows were hung on the external side of the brick walls, inside the insulation layer. The frames are Aluplast energeto 8000 foam inside with $U_f=0.79\text{W/}(\text{m}^2\text{K})$ and triple insulated glazing Planitherm XN 4:/18/4/18/:4 with $U_g=0.50\text{W/}(\text{m}^2\text{K})$ and $g$-value=0.54 with Swisspacer ultimate glazing spacer.

![Diagram showing window installation and temperature distribution](image)

*Picture 16. Details of the installation of the windows*
Picture 117. Window installation
6. Description of the airtight envelope; documentation of the pressure test result

The airtightness is essential in the construction of a passive house, so that the uncontrolled heat losses are minimized. The basic blower door test system includes three components: a calibrated fan, a door panel system, and a pressure measuring 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 the inside and outside of the building. This pressure differential 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. For a Passive House project, the goal is to achieve $n_{50} = 0.60 \text{ h}^{-1}$ or lower at a pressure of 50 Pa.

The blower door test was performed after finishing the internal airtightness layer (plastering) and it showed the excellent performance of $n_{50}=0.31 \text{ h}^{-1}$.

<table>
<thead>
<tr>
<th>Test Results at 50 Pascals:</th>
<th>Depressurization</th>
<th>Pressurization</th>
<th>Average</th>
</tr>
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<tbody>
<tr>
<td>V50: m³/h Airflow</td>
<td>177 (+/- 0.9%)</td>
<td>155 (+/- 1.6%)</td>
<td>165</td>
</tr>
<tr>
<td>n50: 1/h (Air Change Rate)</td>
<td>0.33</td>
<td>0.29</td>
<td>0.31</td>
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<tr>
<td>w50: m³/h[m² Floor Area]</td>
<td>0.95</td>
<td>0.83</td>
<td>0.89</td>
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<tr>
<td>q50: m³/h[m² Envelope Area]</td>
<td>0.30</td>
<td>0.26</td>
<td>0.28</td>
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Leakage Areas:
- Canadian EcLA @ 10 Pa (cm²):
  |  | 66.7 (+/- 1.8%) | 61.4 (+/- 3.0%) | 64.1 |
- cm²/m² Surface Area:
  | 0.11  | 0.10  | 0.11 |
- LBL ELA @ 4 Pa (cm²):
  | 34.8 (+/- 2.6%) | 32.9 (+/- 5.9%) | 33.9 |
- cm²/m² Surface Area:
  | 0.06  | 0.05  | 0.06 |

Building Leakage Curve:
- Air Flow Coefficient (Cev) (m³/h/Pa²):
  | 12.6 (+/- 4.3%) | 12.5 (+/- 8.1%) |
- Air Leakage Coefficient (CL) (m³/h/Pa²):
  | 12.7 (+/- 4.3%) | 12.5 (+/- 8.1%) |
- Exponent (n):
  | 0.873 (+/- 0.012) | 0.842 (+/- 0.033) |
- Correlation Coefficient:
  | 0.99975 | 0.9994 |

Test Standard: EN 13829
Test Mode: Depressurization and Pressurization
Type of Test Method: B
Regulation complied with: Passive House Standard $n_{50} \leq 0.6 \text{ h}^{-1}$

![Picture 12. Blower Door Test Results](image)
In order to achieve the airtightness goal, the airtightness layer was 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 special airtight electrical junction boxes were installed.

*Picture 139. Windows airtight installation*

*Picture 20. Sealing collars on ducts*
7. Planning of ventilation ductwork

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. The normal air-flow is 130m³/h. The unit is WOLF CWL-300 Excellent with effective heat recovery rate 82.3%. It is important to mention that the outdoor air is preheated by a ground heat exchanger, that is 40m long and minimum 1.50m deep.
Picture 22. Basement ventilation plan

Picture 23. Ground floor ventilation plan
8. Building services (heating, cooling, DHW)

The heating and cooling demand is covered by two air conditioners split unit, DAIKIN model FDXS25F, 3.2kW each and COP=4.00. Each split unit is connected with ducts, that supply air in all rooms. One unit covers the heating needs of bedrooms 2 and 3, W.C.1, hallway and kitchen and the second one covers the heating needs of bedroom 1, W.C.2 and the living room.

The heating demands are alternatively covered by an airtight fireplace Lotus Unico in the living room.

For the domestic hot water, a 500lt water tank has been installed in the basement with 6m² solar panels on the roof of the building which covers 87% of the building DHW demands. The remaining demands are covered with a 4kW electric water heater.
Picture 26. Split unit air condition

Picture 27. Fireplace with airtight installation
Picture 28. DHW installation
9. PHPP calculations

All the building data have been imported to the PHPP v9 planning program, verifying that the Passive House Classic certification criteria are met.

![Passive House Verification](image)

**Picture 29. Verification worksheet of the PHPP v9.**
Most of the heating losses are caused by the windows and the external walls to the ambient. On the contrary most of the heat gains come from the windows and the internal heat gains account for about one third. The remaining heating demand is about 11.4kWh/(m²a).
10. **Construction costs**

Total building cost (VAT and taxes included): 130.000 €
The landscaping works are not included.
The cost for the building was only 5% more than the current standard building cost in Greece.

11. **References**

- Video presentation: [https://www.youtube.com/watch?v=o4LmG74wu0Y](https://www.youtube.com/watch?v=o4LmG74wu0Y)