# Passive House Object Documentation

“Casa Farhaus AF-1”: Detached single family house in Castellterçol/Barcelona – project ID: 2780

Project Designer  Jordi Fargas Soler i Associats FGRM

This detached family house was built for a young family on the outskirts of a Catalan village, situated in the province of Barcelona.
The building is a prefabricated, timber beam construction.

Special features: This is Catalonia’s first building to feature triple-glazed windows, with a construction system not commonly seen in the region (no brickwork), and an air-to-water heat pump.

| | | | |
|---|---|---|---|
| U-value exterior wall | 0.140 W/m2k | PHPP heating demand | 13.1 kWh/m2a |
| U-value basement | 0.249 W/m2k | PHPP primary energy demand | 105 kWh/m2a |
| U-value roof | 0.146 W/m2k | Overheating/ cooling demand | 7.1% |
| U-value windows | 1.254 W/m2k | Pressurisation test result n50 | 0.6/h |
| Heat recovery ventilation | 80.5% | | |

Passive House Design: Micheel Wassouf / Energiehaus

Constructor: FARHAUS

Author of report: Micheel Wassouf, architect

Barcelona, June 2013

## Index

# 1. Construction task

This object documentation concerns a detached single-family house named "House AF-1" about 45 km from the city of Barcelona. Due to the site´s elevation at approximately 650 m above sea level, the climate could be described as "Mediterranean-alpine", with high temperatures in summer (although not as high as in Barcelona) and cold winters (the region in the past delivered ice for the markets in Barcelona).
The constructor is both the project developer and the occupant of the building. The intention from the start was to reach the Passive House standard, an accolade not yet achieved by any building in Catalonia.
The constructor is from a longstanding family of professional carpenters, reaching back to the first half of the 20th century.

*Structural model of the building, scale 1/10*

## 2. Photographs of elevations

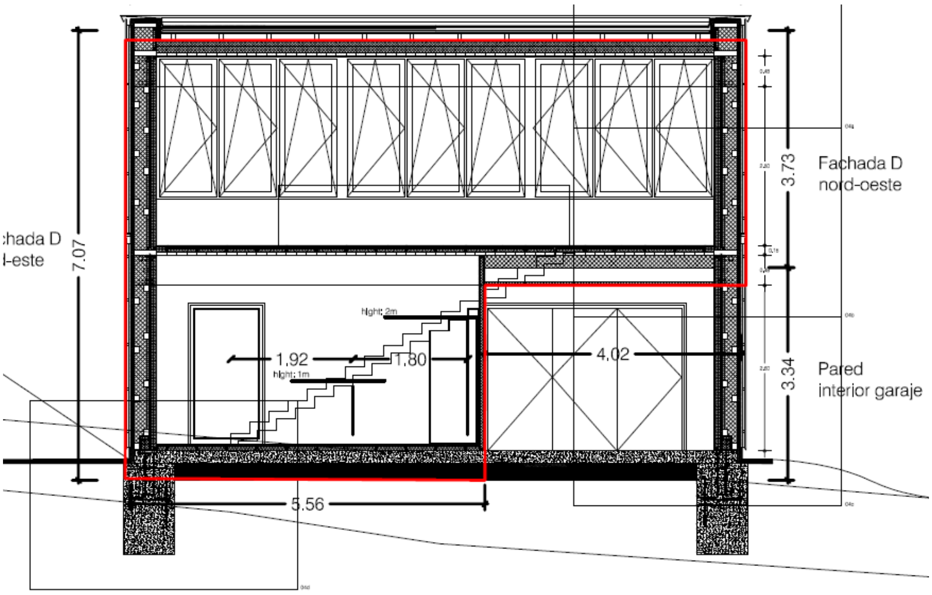
*View from the south west – to the right: south-eastern façade*

*View from the north west*

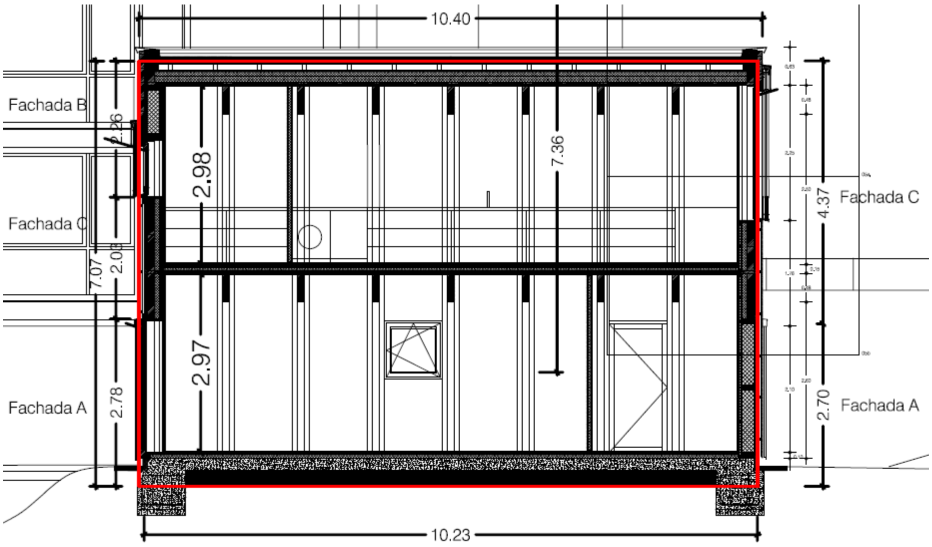
*View from the north east*

# 3. Photographs of the interior

# 4. Sections of the building plans

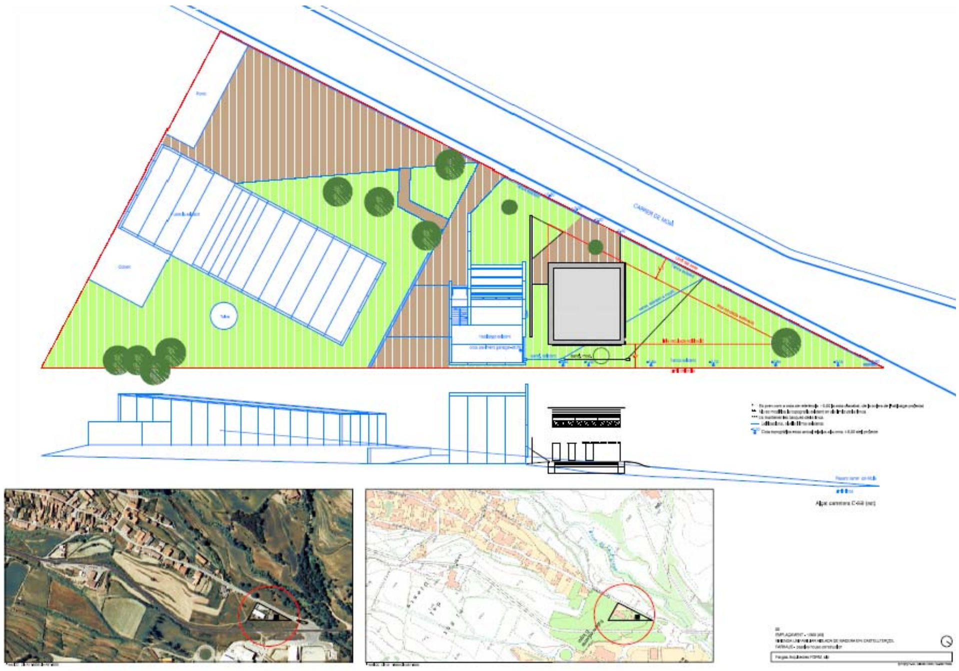



*Section: thermal envelope marked in red. Garage is outside of the thermal envelope.*

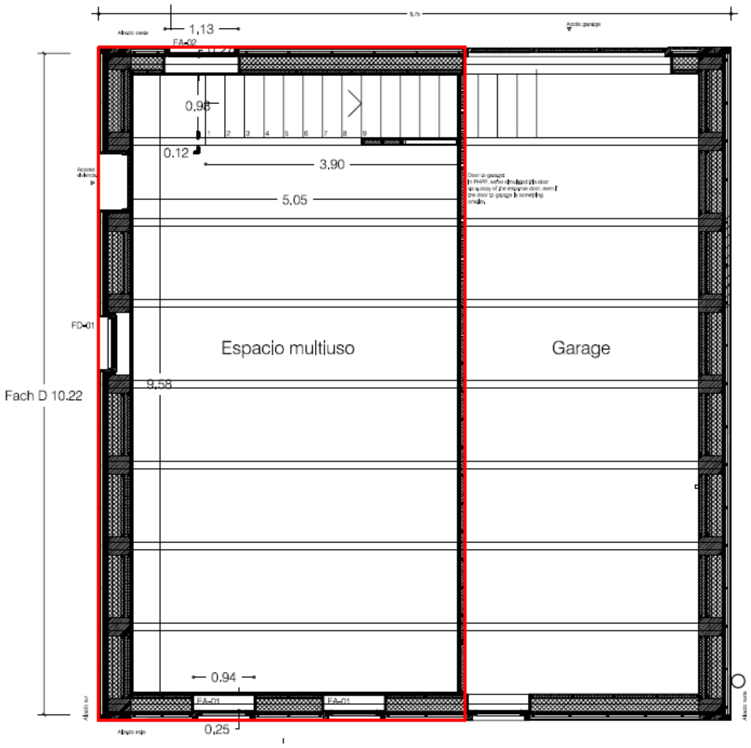



*Longitudinal section: thermal envelope marked in red.*

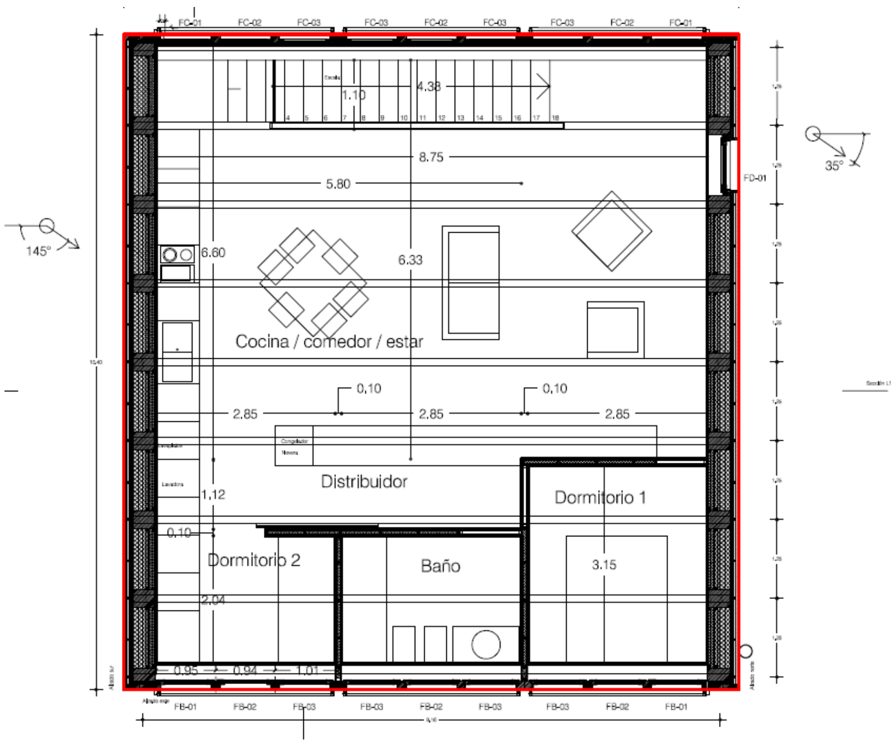
# 5. Site plans, floor plans & elevations



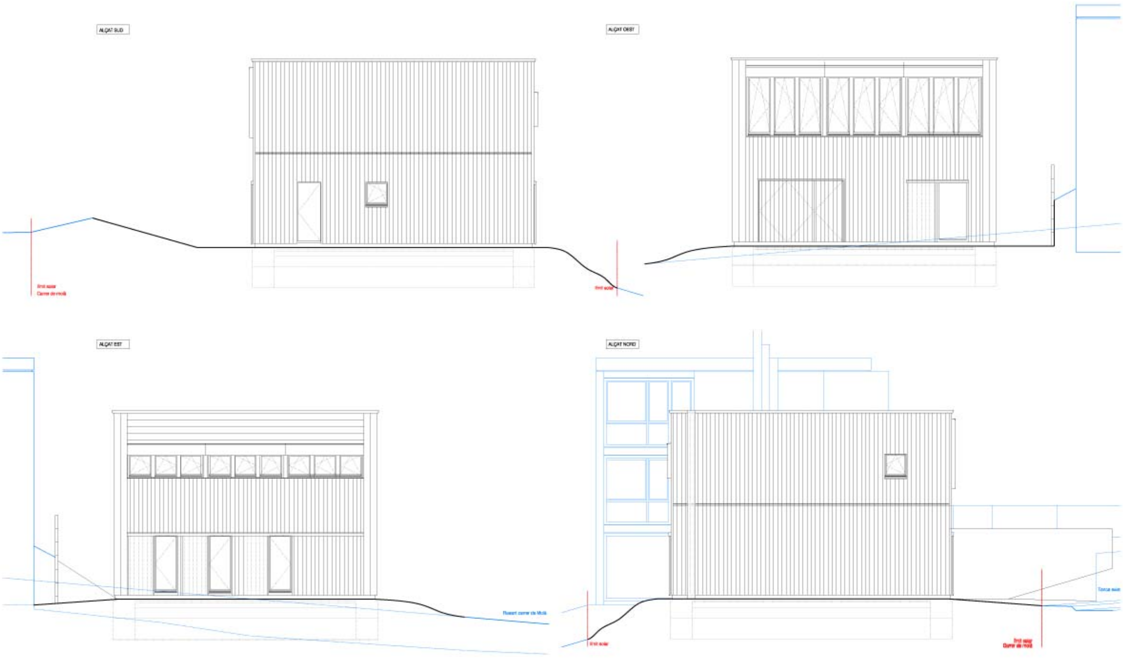
*Site plan*




*Ground floor: thermal envelope marked in red.*



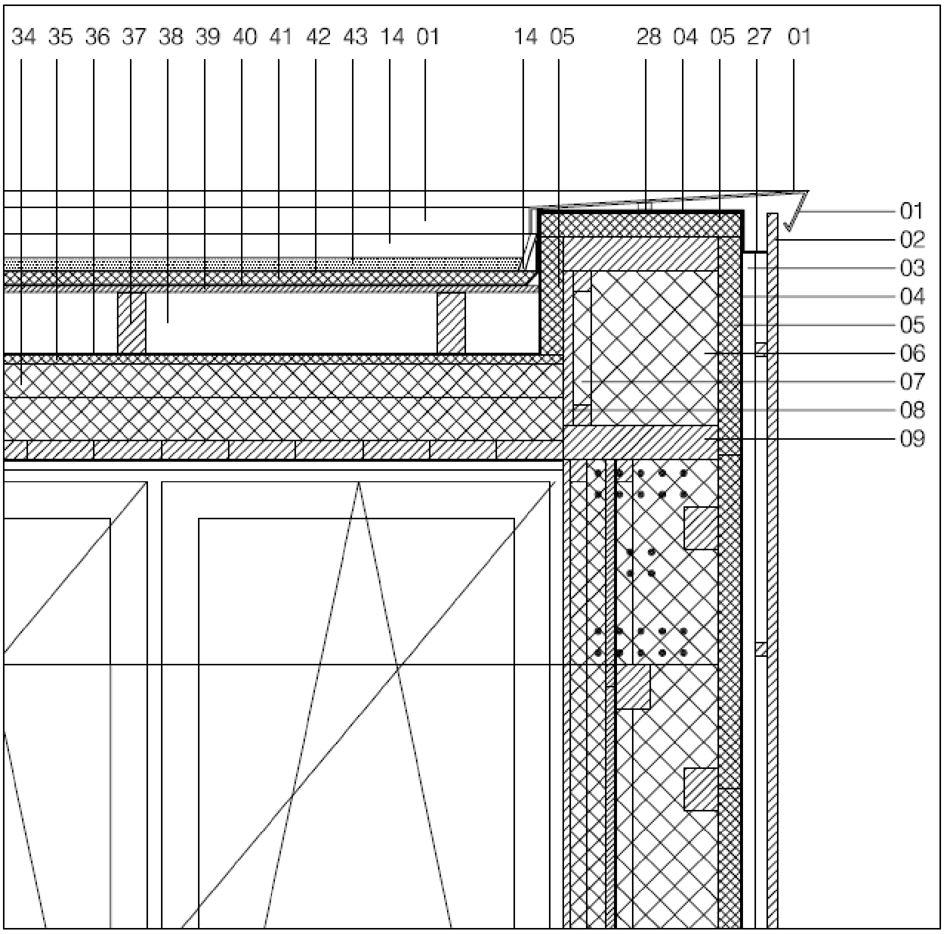

*First floor: thermal envelope marked in red.*



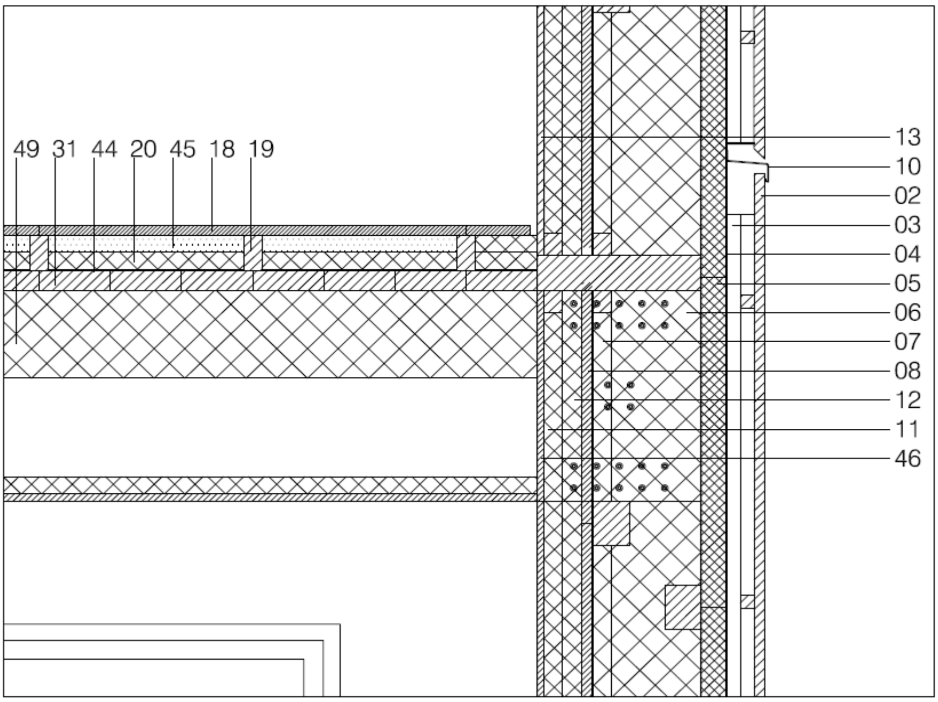

*Elevation of the building*

# 6. Construction details of the Passive House envelope

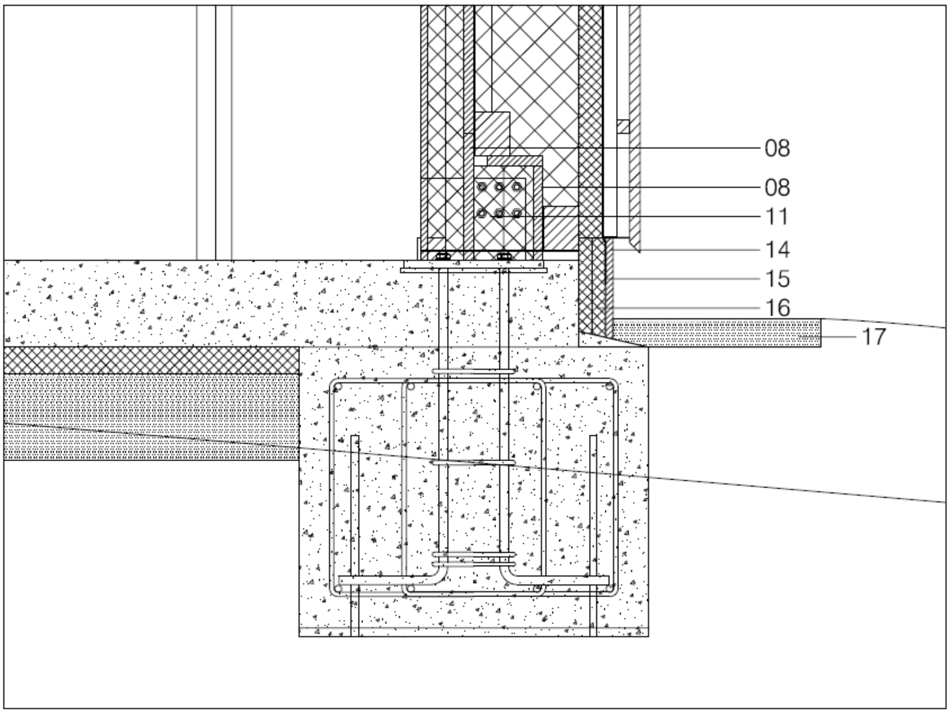
Material legend:
01 Cornisa plancha de aluminio plegada
02 Enlistondo Pino Douglas 24x155 mm
03 Rastrel y contra rastrel de Aveto 30x30 mm. Goma/espuma sellado anclajes
04 Tela transpirable Ampack F2
05 Ailante térmico Isoroof 52 mm
06 Aislante tèrmico a base de celulosa 240 mm
07 Marco anclaje OSB escuadrias de aveto 30x30mm. Goma espuma en unión tablero
08 Panel OSB4 22 mm
09 Travesaño de aveto estructural GL28 360x80 mm
10 Vierteaguas de plancha de aluminio plegada
11 Marco de escuadrias de aveto 30x30mm para anclaje panel Tricapa/Fermacell. Goma espuma en unión tablero
12 Camara instalaciones, Aislante Pavaflex 80 mm
13 Tablero tricapa de aveto 15 mm
14 Tablero madera-cemento Betonyp 16 mm
15 Impermeabilización emulsión bituminosa ED
16 Aislante poliestireno extrusionado 60 mm
17 Gravas 60 mm
18 Tarima de roble 22 mm
19 Rastrelado de soporte tarima roble 30x80 mm
20 Aislante térmico Pavatherm 80 mm
21 Velo de polietileno
22 Solera de hormigón armado hidrófugo 200 mm
23 Velo de polietileno
24 Ailante térmico poliestireno extruido 60 mm
25 Subbase de gravas 200 mm
26 Terreno natural
27 Tela antiinsectos
28 Rastrel anclaje cornis de plancha de aluminio
29 Ventana oscilobatiente pino Douglas, triple goma de cierre. Marco 140mm espesor, ventana 80mm espesor / Acristalamiento doble camara climalit SGG plus planitherm futur N 4/16/5/12/3+3 silence
30 Biga estructural de Aveto GL-28 480x120mm
31 Forjado de Aveto tricapa Aveto Duo 45 mm
32 Barrera de vapor DB-90
33 Aislante térmico Pavatherm 100 mm
34 Aislante térmico Pavatherm 80 mm
35 Aislante térmico Pavaboard 20 mm
36 Tela Ampack Duo
37 Rastrelado soporte en madera de aveto
38 Camara ventilada, altura media 100 mm
39 Tablero OSB4 15mm
40 Doble làmina cruzda de EPDM, lámina impermeable con refuerzos perimetrales
41 Poliestireno extruido 30 mm
42 Geotextil
43 Acabado de gravas 30 mm
44 Ailante ruido impacto Ampack DB-90
45 Capa 40 mm de grava límpia. Inércia térmica
46 Placa Fermacell 15 mm
47 Aislante tèrmico lana de roca semirígido 40 mm
48 Camara de aire no ventilada 220 mm
49 Aislnte térmico Pavaflex 200mm
50 Tablón de pino Dougles
51 Persiana replegable i orientable en alumini
52 Rastrel soporte ventana madera de aveto



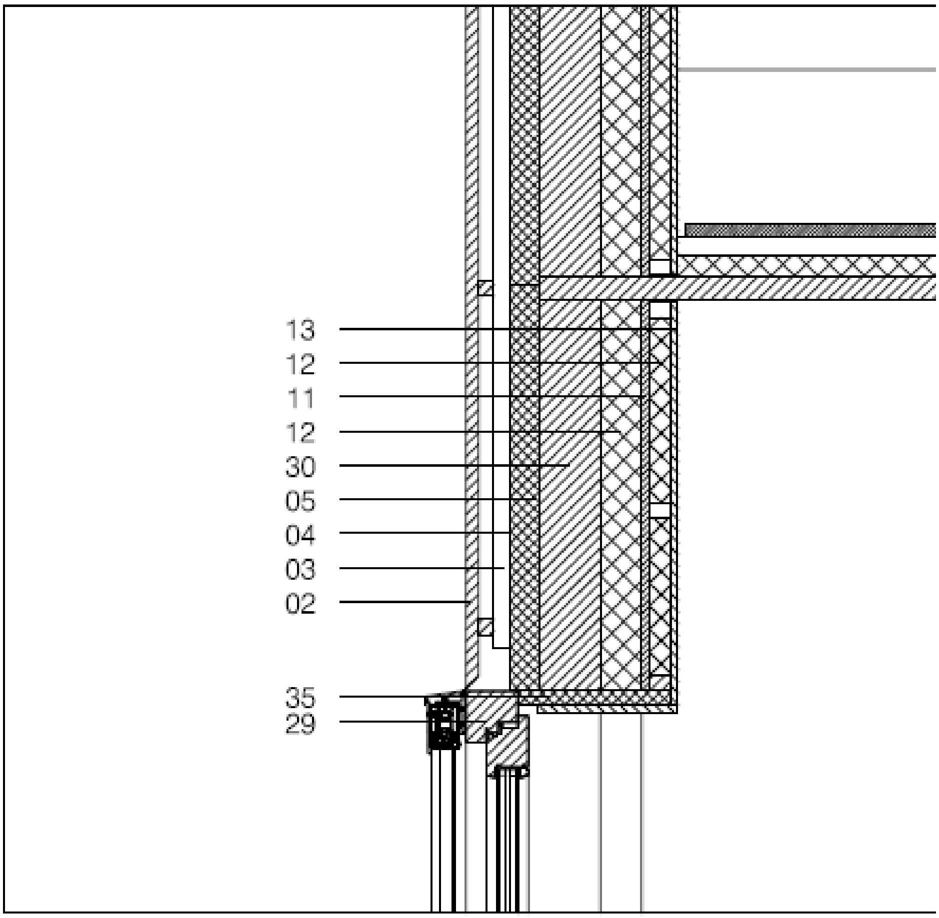

*Section through southeast/northwest façades- roof*



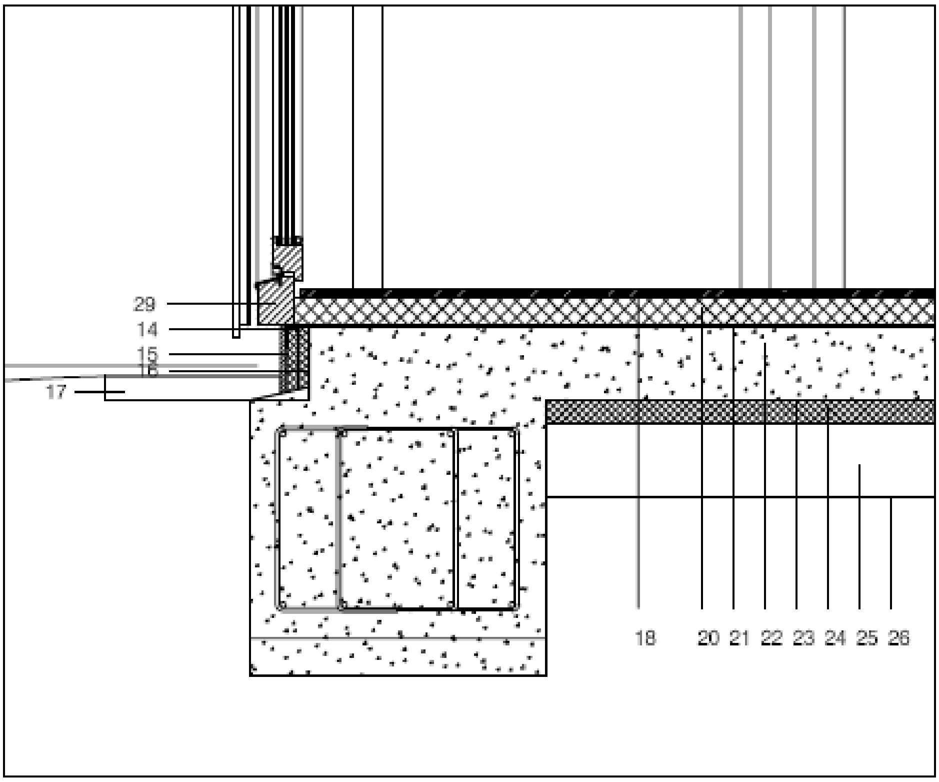

*Section through southeast/northwest façades- first floor*



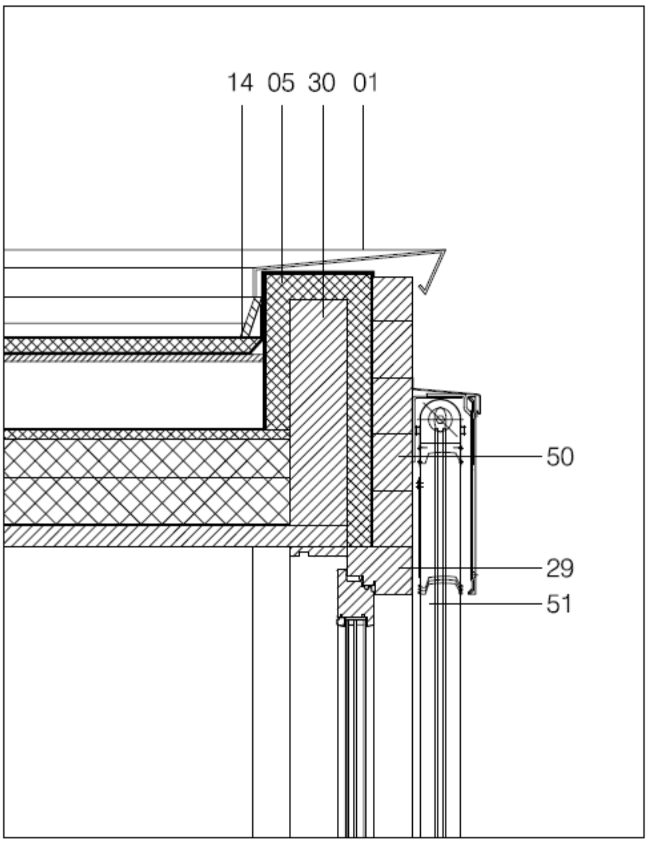

*Section through southeast/northwest façades- ground floor*



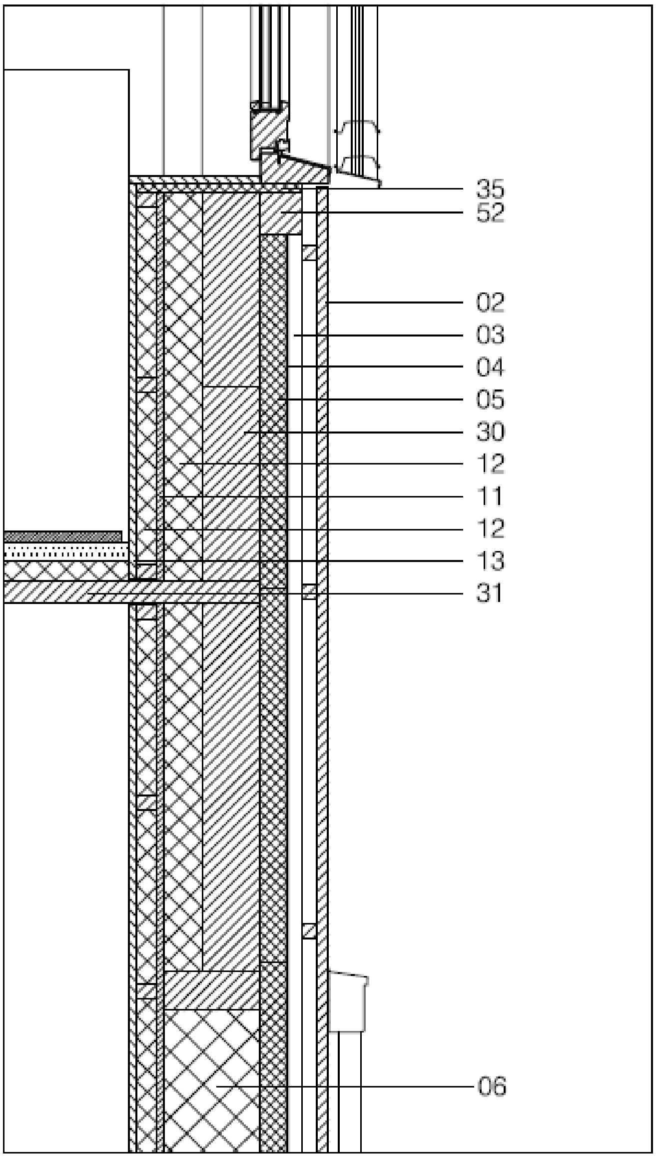

*Section through northeast façades – first floor*




*Section through northeast façades – ground  floor*




*Section through southwest façades – roof*



*Section through southwest façades – first floor*

## 7. Description of airtight envelope

The Blower-Door test was done in November 2012, giving a result of n50 = 0.61/h. With the objective of measuring infiltrations through the ground floor entrance door, the Blower-Door machine was positioned in one of the windows of the living room, on the first floor.
The test was done following the recommendations of the Passive House Institute. Only the outside air ducts of the heat recovery unit were sealed.

*Provisional sealing of the outside air ducts of the heat recovery unit*

The largest infiltrations were detected through the entrance door and the door to the garage.

We made a recommendation to the owner to repeat the Blower-Door test in 2-3 years, in order to monitor the building´s on-going air infiltration rate and the durability of the air tightness detailing.


*Control of infiltrations during the first Blower-Door test*

# 8. Documentation of the Blower Door

## BlowerDoor Test

**EN 13829, Method A**

**Building Test Info and Air-Moving Equipment**

**Building Information**

| | |
|---|---|
| Building: | Casa Farhaus - AF1 |
| | |
| Address: | C/Moiá 168 |
| | 8183 Castelterçol |
| Year of Construction: | 2012 |
| Test Date: | 20.11.2012 |

**Customer Information**

| | |
|---|---|
| Name: | Farhaus |
| | Albert Fargas |
| Address: | C/Moiá 168 |
| | 8183 Castelterçol |
| Phone: | 938666061 |
| Fax: | |

**Business Info**

| | | | |
|---|---|---|---|
| Name: | Energiehaus scp. | Technician: | Micheel Wassouf |
| | | Phone: | +34-932215223 |
| Address: | Avda. Bogatell 21, 1-1 | Fax: | |
| | E-08005 Barcelona | | |

**Test Method**

| | |
|---|---|
| Method: | A Test of a building in use |
| Standard: | Following EN 13829 |
| Note: | The test has been done following the Passivhaus-Institutes protocol. |

**Test object:**

| | | | | |
|---|---|---|---|---|
| Test object: | The machine has been installed in the window at first floor, to take acount of the infiltration of the 2 doors in the ground level. Building finished. VMC off. Exhaust and Entry of fresh air sealed wit 2 balloons. All other undesired openings not touched. | | | |
| Internal Volume V: | 399 m³ | Error: | +/- 5 % | Calculation Reference Values: |
| Net Floor Area $A_F$: | 135 m² | | | see appendix |
| Envelope Area $A_E$: | | | | |
| Type of Ventilation: | Yes | VMC Zehnder Comfoair 350 | | |
| Type of Heating System: | Air to water heat pump | | | |
| Type of Air Conditioning: | Without AC | | | |

Read additional Information in the report.

**Air-moving Equipment**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Device: | Minneapolis BlowerDoor Modell 4, DG-700 | | | | | | |
| Serial Numbers: | Fan: | 3041 | Pressure Gauge: | DG700 - 60805 | Calibration: | 03.08.12 | |
| Other Devices: | Anemometer and Fogg-machine | | | | | | |

# BlowerDoor Test

**Test Standard EN 13829, Method A**

Minneapolis BlowerDoor Modell 4 - Tectite Express 3.6.7.0

| | | | |
|---|---|---|---|
| Object: | Casa Farhaus - AF1 | Technician: | Micheel Wassouf |
| | 8183 Castelterçol | Date: | 20.11.2012 |

**Temperature and Wind Conditions**

| | | | |
|---|---|---|---|
| Inside Temperature: | 22 °C | Wind Force: | 1 |
| Outside Temperature: | 17 °C | Number of exterior pressure taps: | 1 |
| Barometric Pressure: (geogra.): | 92773 Pa | Building Wind Exposure: | B |
| | | Uncertainty because of Wind (Table Geißler): | **0 %** |

**Depressurization**

| Zero Flow (baseline) | $\Delta p_{01+}$ | $\Delta p_{01-}$ | $\Delta p_{02+}$ | $\Delta p_{02-}$ |
|---|---|---|---|---|
| | - | -1,3 Pa | - | -1,8 Pa |

**Pressurization**

| Zero Flow (baseline) | $\Delta p_{01+}$ | $\Delta p_{01-}$ | $\Delta p_{02+}$ | $\Delta p_{02-}$ |
|---|---|---|---|---|
| | 0,1 Pa | -1,5 Pa | 1,9 Pa | -1,8 Pa |

**Sets of Measurement**

Depressurization:

| Ring | Building Pressure | Fan Pressure | Fan Flow $V_r$ | Tolerance |
|---|---|---|---|---|
| O ABCDE | [Pa] | [Pa] | [m³/h] | [%] |
| $\Delta p_{01}$ | -1,3 | — | — | — |
| B | -73 | 15 | 309 | 0,25 |
| B | -68 | 13 | 295 | 0,53 |
| C | -62 | 163 | 267 | -2,39 |
| C | -55 | 143 | 249 | -0,38 |
| C | -49 | 118 | 226 | -0,98 |
| C | -47 | 115 | 222 | 1,74 |
| C | -42 | 95 | 202 | -0,42 |
| C | -36 | 79 | 183 | 3,33 |
| C | -31 | 62 | 162 | 2,63 |
| C | -26 | 42 | 133 | -4,08 |
| $\Delta p_{02}$ | -1,8 | — | — | — |

| | | | Confidence interval | |
|---|---|---|---|---|
| *Correlation Coefficient r:* | | *0,996* | | |
| $C_{env}$ | [m³/(h Paⁿ)] | 13 | max. 16 | min. 11 |
| $C_L$ | [m³/(h Paⁿ)] | 13 | max. 16 | min. 11 |
| n | [-] | 0,75 | max. 0,80 | min. 0,70 |

Pressurization:

| Ring | Building Pressure | Fan Pressure | Fan Flow $V_r$ | Tolerance |
|---|---|---|---|---|
| O ABCDE | [Pa] | [Pa] | [m³/h] | [%] |
| $\Delta p_{01}$ | -1,5 | — | — | — |
| B | 69 | 15 | 311 | 2,49 |
| B | 63 | 13 | 292 | 2,29 |
| C | 59 | 170 | 273 | 0,03 |
| C | 53 | 138 | 245 | -2,70 |
| C | 49 | 121 | 229 | -2,76 |
| C | 43 | 105 | 212 | -1,96 |
| C | 39 | 92 | 199 | 0,29 |
| C | 35 | 78 | 183 | -0,14 |
| C | 28 | 62 | 162 | 3,03 |
| C | 26 | 51 | 147 | -0,36 |
| $\Delta p_{02}$ | -0,6 | — | — | — |

| | | | Confidence interval | |
|---|---|---|---|---|
| *Correlation Coefficient r:* | | *0,996* | | |
| $C_{env}$ | [m³/(h Paⁿ)] | 13 | max. 16 | min. 11 |
| $C_L$ | [m³/(h Paⁿ)] | 13 | max. 16 | min. 11 |
| n | [-] | 0,75 | max. 0,80 | min. 0,70 |

**Results**

| V = | 399 m³ | $A_F$ = | 135 m² | $A_E$ = | |
|---|---|---|---|---|---|

| | $V_{50}$ | Uncertainty | $n_{50}$ | Uncertainty | $w_{50}$ | Uncertainty | $q_{50}$ | Uncertainty |
|---|---|---|---|---|---|---|---|---|
| | m³/h | % | 1/h | % | m³/m²h | % | m³/m²h | % |
| Depressurisation | **239** | +/- 5 % | 0,60 | +/- 7 % | 1,8 | +/- 7 % | | |
| Pressurisation | **245** | +/- 5 % | 0,61 | +/- 7 % | 1,8 | +/- 7 % | | |
| Average | **242** | +/- 5 % | **0,61** | +/- 7 % | **1,8** | +/- 7 % | | |

**Regulation complied with:** **Passivhaus certification**

**Maximum allowable:** **0,64** 1/h

**The test results meet the regulation.**

**Note:** The result does not exclude faults in the construction. The air-tightness should be re-proofed each 2-3 years.

**Business Info:** Micheel Wassouf, architect

Energiehaus scp.

www.energiehaus.es

Energiehaus - Passive House Design in Spain

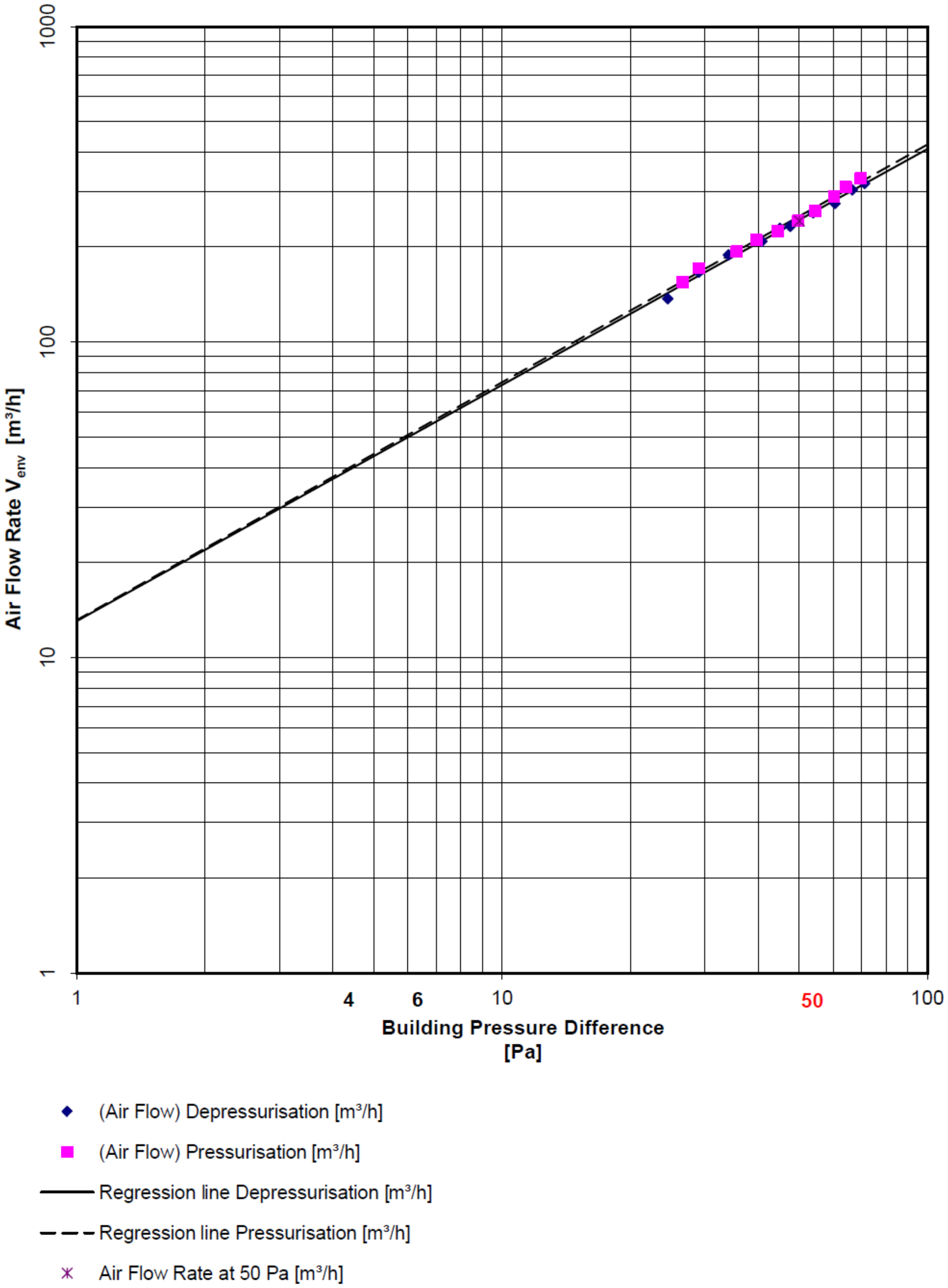
Date, Sign

21/11/2012 ميشيل وسوف

ENERGIEHAUS
Avda. Bogatell 21, 1-1
08005 Barcelona
www.energiehaus.es

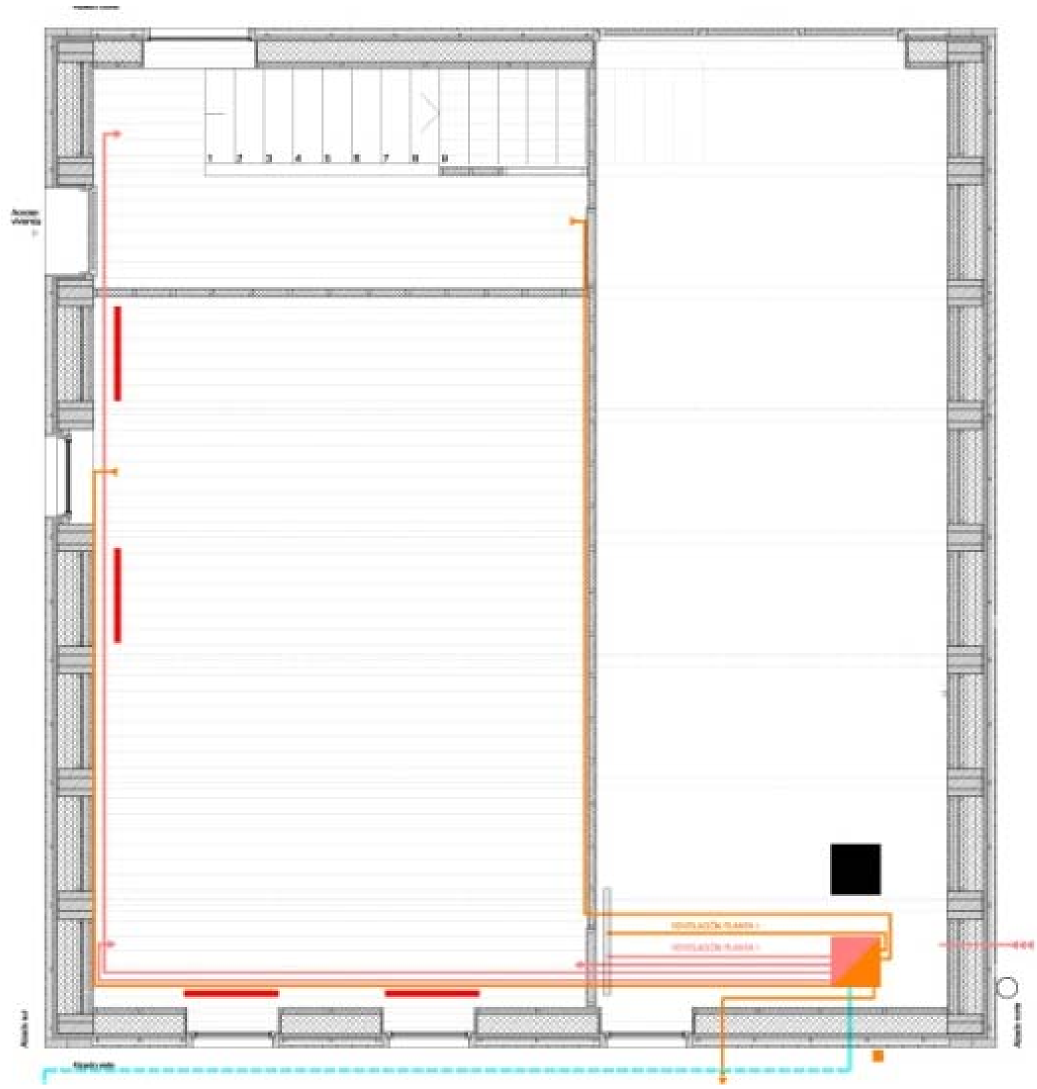
Stamp

**BlowerDoor Air Leakage Graph**
**Object: Casa Farhaus - AF1**

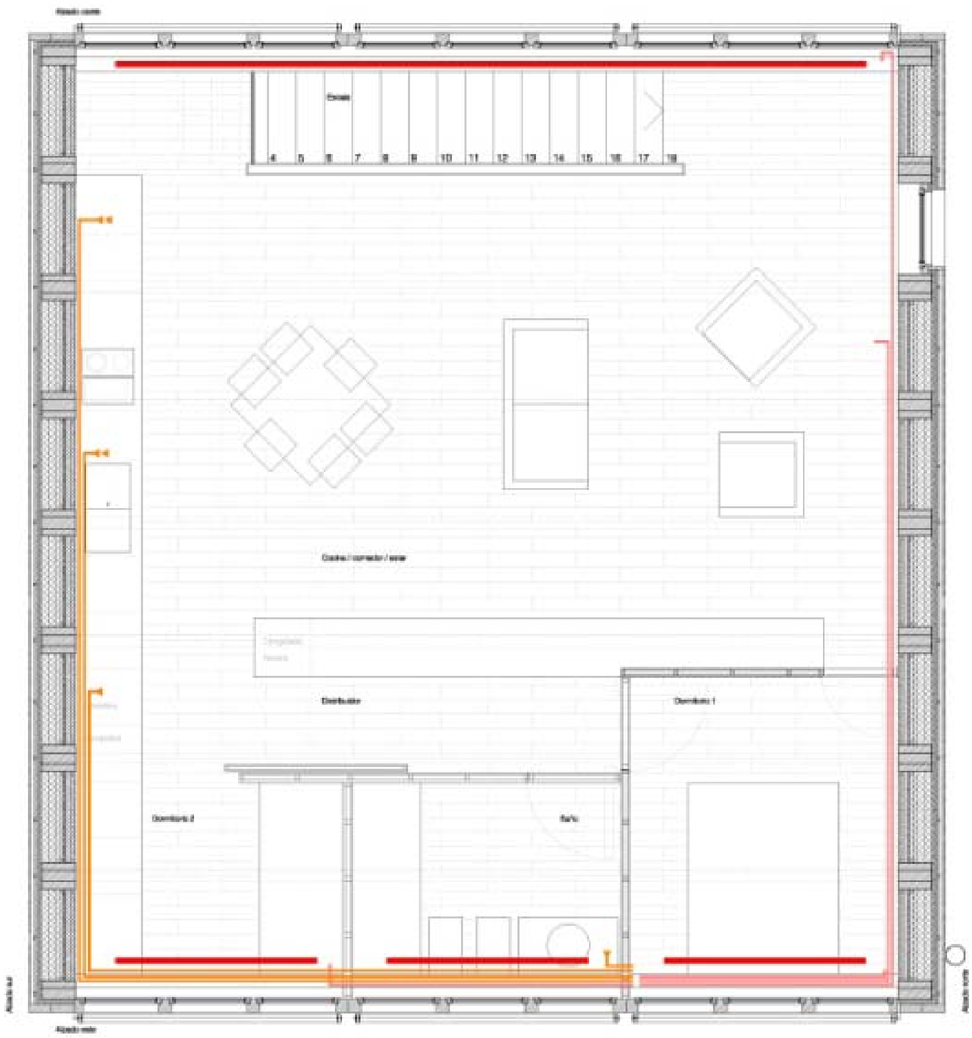


## 9. Ventilation system

A Zehnder Comfoair 350 W was installed to guarantee the required ventilation air change rate for hygiene and energy reasons. The PH certified heat-recovery efficiency of the unit is 84%, with an electric efficiency of 0.29 Wh/m3. The real estimated heat-recovery efficiency is assumed to be 80.5% (following PHPP calculation).
The mechanical ventilation unit has been installed in the garage. This space has the same thermal envelope as the rest of the house. Only the garage-car-door contributes to higher energy losses, in comparison to the rest of the building.
In PHPP, the average winter temperature of the garage has been estimated as the mean of the outside average winter temperature and 20ºC.



*Ground floor: ventilation system – the ground floor is actually used as a multifunctional space, with possible future use as a children´s bedroom. This space is provided with extract and supply air valves.*



*First floor: ventilation system – extraction from the kitchen and bathroom*

- ventilación aire insuflado (inferior) Ø 80
- ventilación extracción succión (superior) Ø80
- radiadores calefacción
- puntos de impulsión/extracción
- puntos de extracción con filtro de grasas
- Recuperador eestático
- Entrada renovación aire Ø160
- Expulsión aire Ø160
- Sonda temperatura exterior
- Aportación aire pozo canadiense a intercambiador
- Tubo enterrado sistema pozo canadiense
- Admisión aire exterior para pozo canadiense
- Bomba de calor DAIKIN aire / agua

*Legend of ventilation plan*

*Flexible duct work (radial system), integrated in the suspended floor section*

*Ductwork (high density PE) in the floor and in the services cavity (first floor)*

*Heat recovery unit in the garage: photo taken during the Blower Door test: the exhaust and the exterior air ducts are disconnected*

*Air extraction valves in the bathroom*

*Kitchen hood extractor with recirculation*

Calibration of the heat recovery unit:
To guarantee maximum efficiency and high levels of comfort, the real ventilation air change rates for both supply and extract were measured and balanced following completion of the building.
For Passive House criteria, the maximum misbalance between extract and supply ACR cannot exceed 10%. In the case of our building, the ACR at the standard velocity of the ventilation unit was measured as:

| | VELOCITAT 2 | | | | | | | VELOCITAT 1 | VELOCITAT 3 |
|---|---|---|---|---|---|---|---|---|---|
| | **Prova** | **Prova** | **Prova** | **Prova** | **Prova** | **Prova** | **Prova** | **Prova** | **Prova** |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 1 |
| Percentatge | 50% | 48% | 46% | 44% | 43% | 40% | 42% | 27% | 72% |
| Sala Estar - Menjador | 23,8 + 18,6 | 19 + 22 | 19 + 22 | 16 + 20 | 17 + 20 | 17 + 17 | 23 + 17 | 11 + 10 | 32 + 34 |
| Dormitori Ppal | 19,5 + 30,5 | 19 + 31 | 20 + 20 | 22 + 22 | 21 + 23 | 19 + 19 | 19 + 21 | 13 + 11 | 38 + 34 |
| Entrada | 20 | 18 | 21 | 19 | 20 | 16 | 18 | 9 | 28 |
| Habitació 1 | 20 | 20 | 23 | 23 | 27 | 19 | 21 | 13 | 38 |
| Habitació 2 | 20 | 19 | 22 | 23 | 20 | 18 | 21 | 12 | 36 |
| Habitació 3 | 24,6 | 23 | 21 | 21 | 21 | 20 | 20 | 12 | 32 |
| **TOTAL** | **177** | **171** | **168** | **166** | **169** | **145** | 160 | 91 | 272 |
| Percentatge | 50% | 41% | 40% | | | | | 25% | 70% |
| Cocina | 23 + 23 | 18 + 18 | 18 + 18 | | | | | 10 + 10 | 29 + 29 |
| Entrada | 27 + 26 | 23 + 22 | 22 + 21 | | | | | 13 + 12 | 37 + 36 |
| Passadís | 23 | 19 | 18 | | | | | 10 | 31 |
| Bany 1 | 24 | 21 | 19 | | | | | 13 | 35 |
| Bany 2 | 27 + 25 | 22 + 21 | 22 + 22 | | | | | 12 + 12 | 37 + 36 |
| **TOTAL** | **198** | **164** | 160 | | | | | 92 | 270 |

*Calibration protocol (October 2012) performed by Zehnder Group Iberica Indoor Climate*

*Reading the air flow rate in a supply air valve*

# 10. Space heating

Heat generation for space heating is produced by an air-to water heat pump: Mitsubishi Ecodan 4.5kw, also used for DHW production.
Two hot water tanks were installed to store and manage the thermal energy generated.
The space heating temperatures are programmed at 42ºC, distributing thermal energy to plinth-radiators, designed to work at low temperatures.
Each floor has its own thermostat.
The heat pump is installed next to the garage, in a protected zone to prevent freezing.

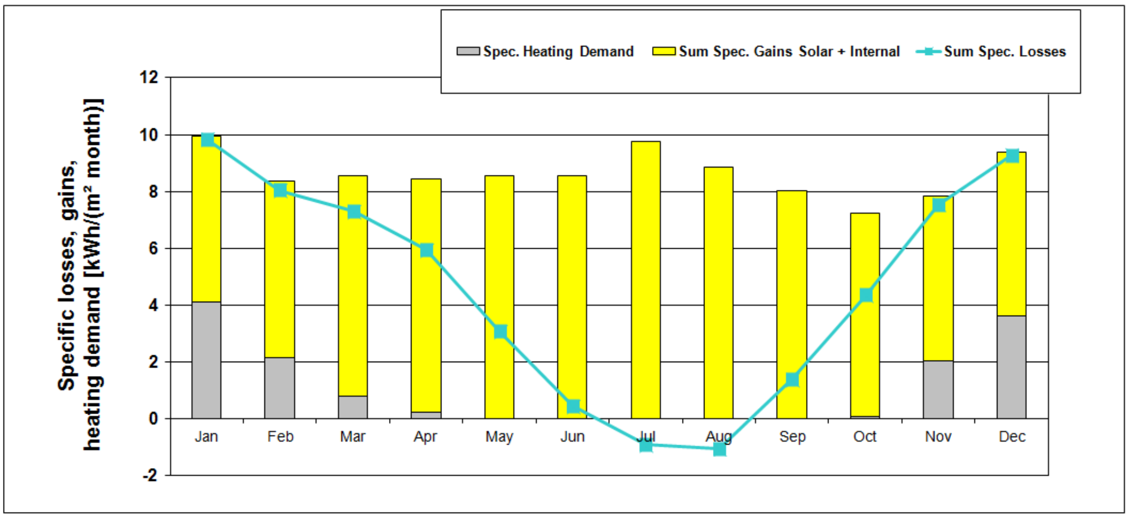
*The protected heat pump (exterior evaporator)*

*Below: hot water storage tank for heating / Above: storage for DHW*

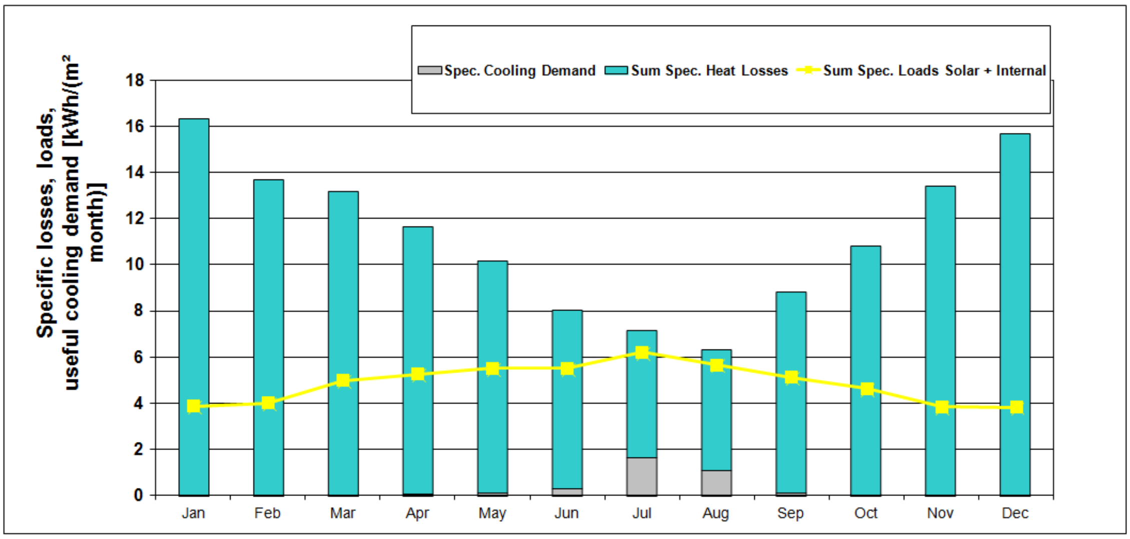
# 11. Summary of results PHPP

| Specific building demands with reference to the treated floor area | | | | use: Monthly method | |
|---|---|---|---|---|---|
| | Treated floor area | 124,5 | m² | **Requirements** | **Fulfilled?*** |
| **Space heating** | Annual heating demand | **13** | **kWh/(m²a)** | 15 kWh/(m²a) | **yes** |
| | Heating load | **12** | **W/m²** | 10 W/m² | **-** |
| **Space cooling** | Overall specific space cooling demand | | **kWh/(m²a)** | - | **-** |
| | Cooling load | | **W/m²** | - | **-** |
| | Frequency of overheating (> 25 °C) | 7,1 | % | - | **-** |
| **Primary Energy** | Space heating and cooling, dehumidification, household electricity. | **105** | **kWh/(m²a)** | 120 kWh/(m²a) | **yes** |
| | DHW, space heating and auxiliary electricity | 72 | kWh/(m²a) | - | **-** |
| | Specific primary energy reduction through solar electricity | | kWh/(m²a) | - | **-** |
| **Airtightness** | Pressurization test result $n_{50}$ | **0,6** | **1/h** | 0,6 1/h | **yes** |

*“Verification” – sheet of the PHPP*




*Heating demand per month ("Monthly Method"-sheet of the PHPP)*




*Cooling demand per month ("Cooling"-sheet of the PHPP): there is no need for air conditioning, as the frequency of overheating is below 10%/a.*

## 12. Construction costs

Estimated construction cost of the home is € 1,330/m2 (ex VAT, without architectural fees and foundation works). This results in a total construction cost of around € 166,250. Additional costs for the "Passive House"-components are estimated to be around 12% of this construction cost: € 19,950.

The average yearly calculated monthly heating bill (based on measured consumption data) is € 20, assuming a € 0.2/kWh unit energy cost (electricity). This leads to a yearly heating bill of € 240.
"Conventional" detached houses in the region have heating bills of around € 3,000 per year (fuel oil mostly). If we assume a more conservative value of € 2,500, the "economic" simple payback time of the "Passive House"-additional cost would be around 9 years.

## 13. Year of construction

The building was constructed in 2010. The construction period, including prefabrication, was 5 months. For economic reasons, interior finishes were not completed until summer 2012.

## 14. Architectural design

The building is a prefabricated, timber beam construction. The client wanted a spacious living room, without any pillars. Therefore the clear span of the construction goes from one end of the building to the other (around10 meters). The architectural design follows simple and clear rules: compact, with simple cube geometry. No reminiscence of eclectic design. The dark colour of the ventilated façade gives the building a certain touch of the sublime.

The building envelope is highly insulated:

- Walls with 8cm of wood-fibre insulation (services cavity) and 20cm of cellulose insulation.
- Roof with 20cm of wood-fibre insulation
- Basement slab with 8cm of wood-fibre insulation and 6cm of XPS (beneath the concrete slab).

## 15. Building services design

The building services design was done by the constructor himself, in coordination with local HVAC and electricity contractors. The design approach is representative of single family homes in Mediterranean countries.

# 16. Photographic documentation of the construction process

*Prefabrication*



*Assembly of the timber structure -1*




*Assembly of the timber structure -2*


*Installation of the wood-fibre insulation in the outer side of the walls*


*Installation of the wind barriers for the ventilated facade*

*Installation of the wood-fibre insulation in the roof*


*Blowing in of cellulose insulation*

*Floor slab of first floor with gravel to improve summer performance (thermal mass)*

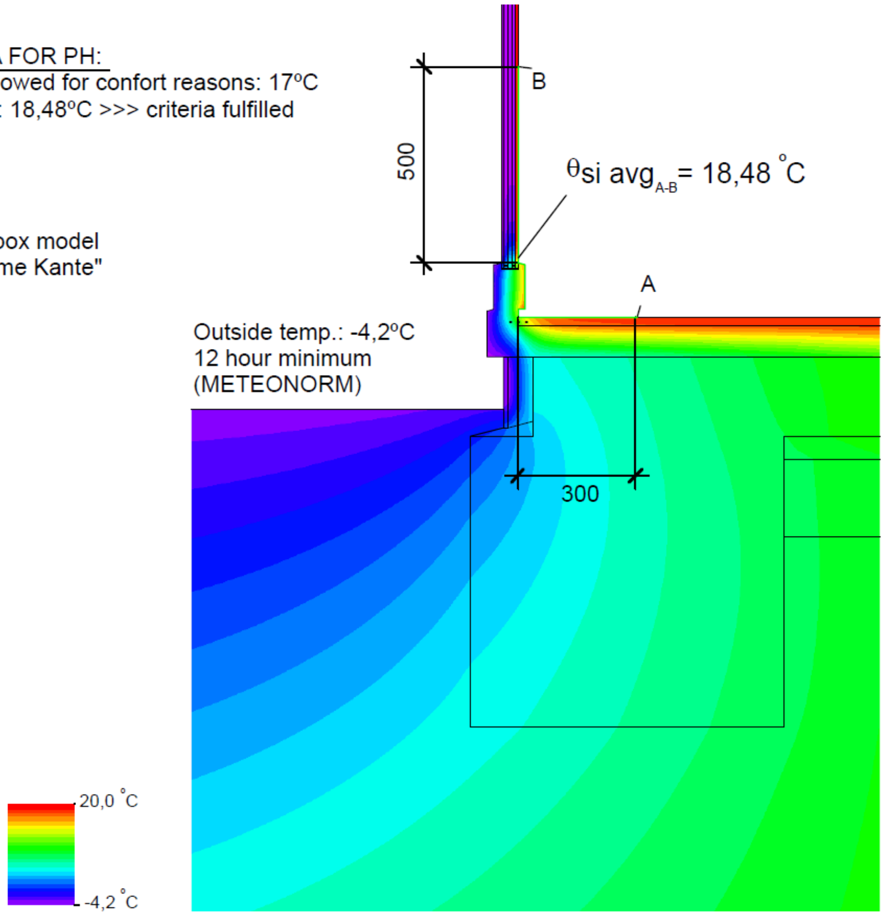
# 17. Comfort and hygiene criteria

As the Windows U-value is between 1.2 - 1.3 W/m$^2$K, instead of the 0.8 W/m$^2$K compulsory for Passive Houses in cold-temperate climate, ENERGIEHAUS proceeded with the justification of the comfort and hygene criteria of the PHI (software used: Flixino V6).
The timber window frames are around 80mm wide, with a thermal transmittance of 1.0 – 1.1 W/m$^2$K (EN-12412-2).
The glazing is triple pane, but with air cavity instead of noble gas.
(Ug 1.1 W/m$^2$K (EN-673) and solar factor 52% (EN-410).
The glazing spacer used is Thermix TX.N.

*The used window frame is in the centre of the photo*

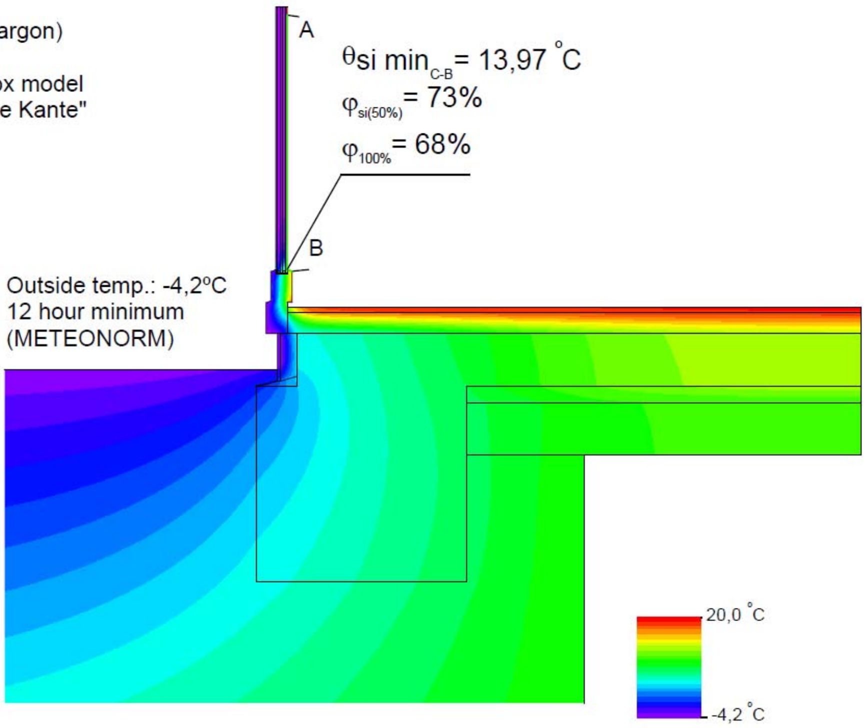
COMFORT CRITERIA FOR PH:
Min. average temp. allowed for confort reasons: 17°C
Calculated avg. temp.: 18,48°C >>> criteria fulfilled

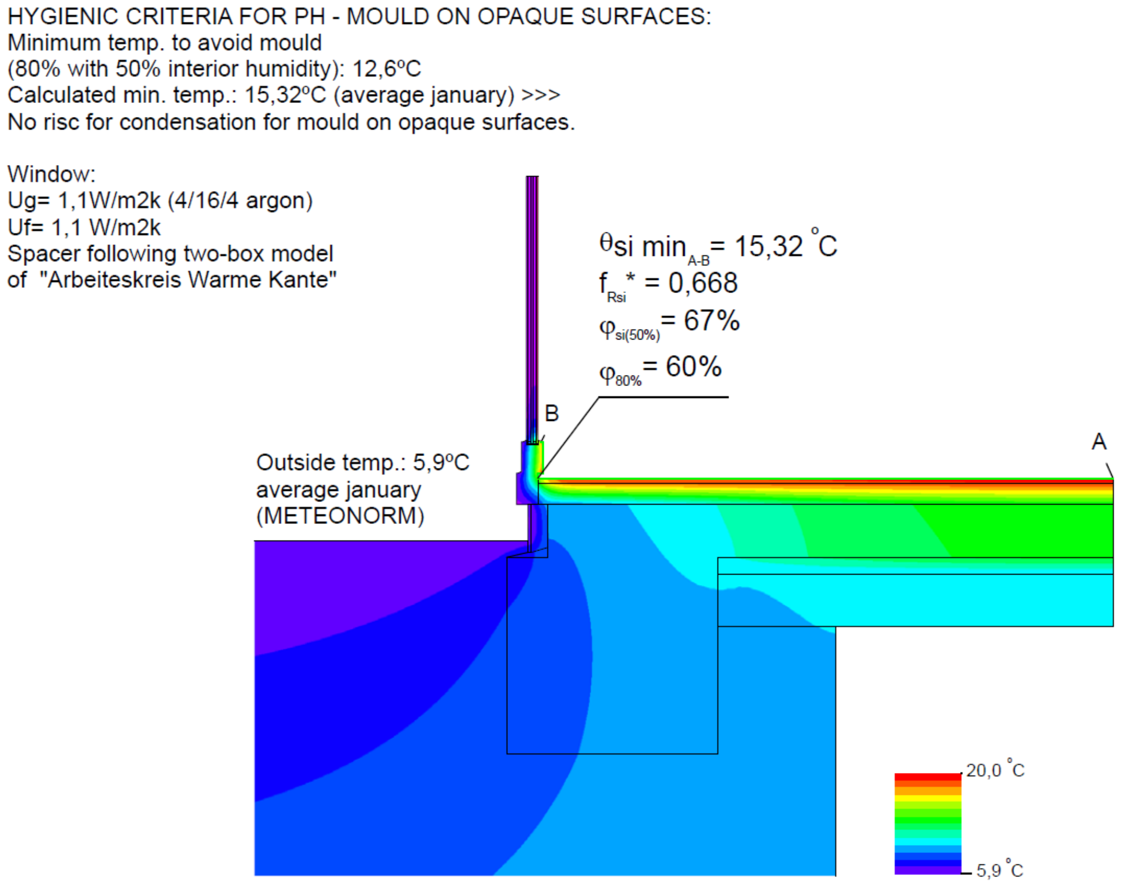
Window:
Ug= 1,1W/m2k
Uf= 1,1 W/m2k
Spacer following two-box model
of "Arbeiteskreis Warme Kante"




HYGIENIC CRITERIA FOR PH - CONDENSATION ON GLAS:
Minimum temp. to avoid condensation
(100% with 50% interior humidity): 9,3°C
Calculated min. temp.: 13,97°C >>>
No risc for condensation on the glass.

Window:
Ug= 1,1W/m2k (4/16/4 argon)
Uf= 1,1 W/m2k
Spacer following two-box model
of "Arbeitskreis Warme Kante"






## 18. Summer comfort

The PHPP-calculation assumed that the building has a thermal inertia of 84 Wh/K and square meter.
It has been assumed that one of the 6 envelope elements (4 walls + 1 roof + 1 slab) is heavy: the intermediate floor (first floor) with gravel in-fill, and the ground floor slab of concrete (but with thermal insulation in-between).
The main façades have external blinds, vertically and horizontally adjustable. We have assumed a solar reduction factor for shading of 40%, according to DIN-4108-2.
In regards to summer ventilation, we expected a daily minimum ventilation via the mechanical ventilation system (ACR = 0.30/h). In night time, the user should turn off the mechanical ventilation and cool the building with natural cross-ventilation. The strategy agreed with the user is to open 4 windows, so the equivalent ACR would be approximately 0.46/h.
With these hypotheses, the theoretical overheating frequency in summer rises to 7.1% (reference temperature 25ºC). We advised the client that with a good user-control, no air conditioning is necessary for summer.

*External blinds on the south western facade*

## 19. Experiences

The building is currently undergoing a simple monitoring process: registration of the monthly electricity consumption and hourly CO2/temperatures/humidity data logging (Wöhler CDL-210).
The user is highly satisfied with the thermal and acoustic comfort of the building.
The first summer of 2012 showed a very good thermal performance, unfortunately without having any quantitative data to scientifically demonstrate this.
The first economic analysis (winter 2012/13) shows that the building is consuming about 10 times less energy for space heating than other similar residential buildings in the region.