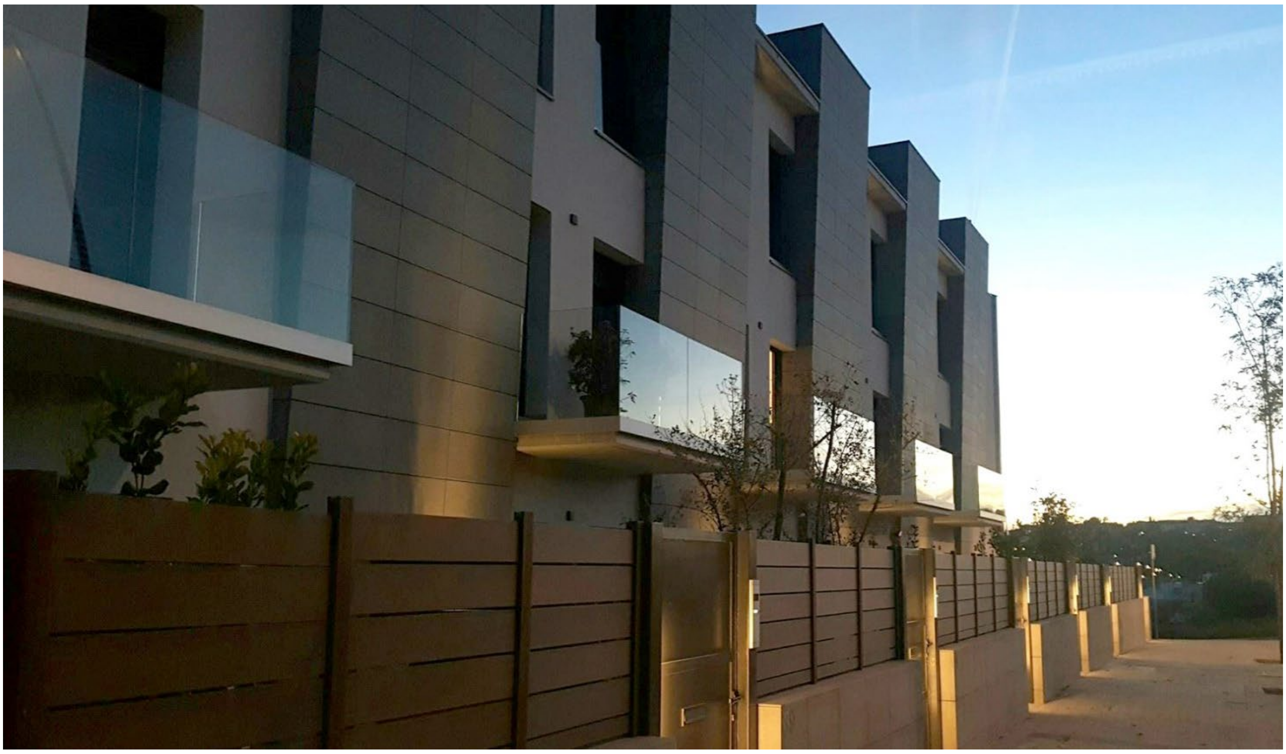
Project Documentation / Documentación del proyecto

1 Abstract / Resumen



Semi-detached house in Sitges (Barcelona), Spain

1.1 Data of building / Datos del edificio

Year of construction/ Año de construcción	2016	**Space heating / Demanda calefacción**	**13,74 kWh/(m²a)**
U-value external wall/ Valor-U pared exterior	0.167 W/(m²K)	**Space cooling / Demanda refrigeración**	**09,10 kWh/(m²a)**
U-value basement ceiling/ Valor-U solera	0.298 W/(m²K)	**Primary Energy Renewable (PER) / Energía primaria removable (PER)**	39,42 kWh/(m²a)
U-value roof/ Valor-U cubierta	0.206 W/(m²K)	**Generation of renewable energy / Generación energía renovable**	52,16 kWh/(m²a)
U-value window/ Valor-U ventana	1.80 W/(m²K)	**Non-renewable Primary Energy (PE) / Energía primaria no renovable (PE)**	81,46 kWh/(m²a)
Heat recovery/ Recuperación	84 %	Pressure test n_{50} / Ensayo presurización n_{50}	0.92 h-1
Special features/ Soluciones especiales	Air to earth heat exchanger combined with HRV / Recuperador de calor con POZO CANADIENSE y captación directa (con bypass domotizado).		

1.2 Brief description of the project

Passive House in Sitges - Barcelona

The project forms part of a development of 6 terraced houses in a self-promotion regime, each one designed according to the needs (distribution, materials, etc.) of each user. One of these 6 unities has been certified as “low energy building” and is exposed in this document.

The program consists of: a basement for a private garage, a laundry room and a storage room that are part of the thermal envelope; the ground floor with access for pedestrians, a bathroom, a kitchen open to the dining room and living room; the first floor with two, with dressing rooms and a shared bathroom; and the second floor consists of a suite with bathroom and dressing room and a large terrace overlooking the sea. In total 213 m2 built and 131,76 m2 of energy reference are treated.

The climate in Sitges has the peculiarity of being quite regular, with hot and humid summers and winters with few days of extreme cold, which is a difficulty when designing protection strategies and solar capture at the same time. It is also true that with the generous hours of sun during the winter days makes, with a good sun, the demand for heating is easier to reduce than the demand for cooling in summer where at night the thermometer does not descend enough to passively cool (for this reason it is opted for the implementation of an air to earth heat exchanger as passive cooling connected to double flow mechanical ventilation).

We opted for a building facing south and with a modern design with flat roofs that allowed to enjoy the good views of the sea. The length of the cantilevers in the different plants to the south was calculated taking into account the solstices, so that the openings would be protected from the direct entrance of the sun in summer and would allow a greater light input in winter. As for the east façade of the house, it is decided by a rain partition with a layer of 12cm of insulation inside and 6cm outside, protected by a ventilated façade. In the future, a neighboring project is planned to cover this part of the building. On the western side, an adiabatic behavior has been assumed, as it is directly bordered by the next housing unity.

1.2 Breve descripción de la vivienda

Casa Pasiva en Sitges – Barcelona

El proyecto de Casa Pletada empezó en 2014 y finalizó a principios de 2017. Se trata de una promoción de 6 viviendas unifamiliares adosados (entre las cuales se encuentra la única vivienda que se certifica) en régimen de autopromoción, desarrollando cada una según las necesidades (distribución, materiales, acabados, etc.) del usuario. El programa consta de: una planta sótano destinada a un garaje privado, un lavadero y un trastero que forman parte de la envolvente térmica; la planta baja con acceso para peatones, un baño, una cocina abierta al comedor y sala de estar; la planta primera con dos habitaciones distribuidas a las dos fachadas, con vestidores y un baño compartido; y la planta segunda formada por una suite con baño y vestidor y una gran terraza con vistas al mar. En total se tratan 213 m2 construidos y 131,76 m2 de ref. energética.

El clima en Sitges tiene la peculiaridad de ser bastante regular, con veranos calurosos y húmedos e inviernos con pocos días de frío extremo, lo que supone una dificultad a la hora de diseñar estrategias de protección y captación solar al mismo tiempo. También es cierto que con las generosas horas de sol durante los días de invierno hace que, con un buen asoleo, la demanda de calefacción sea más sencilla de reducir que la demanda de refrigeración en verano donde por las noches el termómetro no desciende lo suficiente para refrigerar pasivamente (por este motivo se opta por la implantación de un pozo canadiense como refrigeración pasiva conectado a la ventilación mecánica de doble flujo).

Se optó por un edificio orientado a sur y con un diseño moderno con cubiertas planas que permitieran disfrutar de las buenas vistas al mar. La longitud de los voladizos en las diferentes plantas a sur se calculó teniendo en cuenta los solsticios, de forma que las oberturas quedaran protegidas de la entrada directa de sol en verano y permitieran una mayor entrada de luz en invierno. En cuanto a la fachada este de la vivienda se decide por un tabique pluvial con una capa de 12 cm de aislamiento en el interior y 6 al exterior antes de la placa de fibrocemento, a la espera de la construcción del proyecto vecino, la oeste en cambio, se encuentra adosada por lo que se le supone un comportamiento adiabático.

1.3 Responsible project participants / Personal responsable del proyecto

Architect/ Arquitecto proyecto básico	Sergi Gargallo Soler, **SGArq** www.sgarq.com
Implementation planning/ Arq. Proyecto ejecución	Sergi Gargallo Soler, **SGArq** www.sgarq.com
Main builder/ Constructor principal	Marc Llorens, A.M. Llorens www.grupllorens.com/
Structural engineering/ Cálculo estructura	Mª Teresa Celsa, **Base2**
Building physics/ Físico de construcción	Sergi Gargallo Soler, **SGArq** www.sgarq.com
Passive House project planning/ Proyectista Passivhaus	Sergi Gargallo Soler, **SGArq** www.sgarq.com
Construction management/ Dirección de obra	Sergi Gargallo Soler, **SGArq** www.sgarq.com Santi Sellares Saiz, **SGArq** www.sgarq.com
Certifying body/ Certificador edificio PH	**Energiehaus Arquitectos** www.energiehaus.es/
Certification ID/ ID certificado edificio	Project-ID: **5875** (www.passivehouse-database.org)

Author of project documentation / Autor de la memoria	Sergi Gargallo Soler, **SGArq** www.sgarq.com
Date, Signature/ Fecha, firma	

21/09/2018

2 Views of the passive house / Imágenes de la Vivienda pasiva

North view of the of the terraced houses, with the certified unity marked in green

2.1 Exterior Pictures

- Fotos exteriores

South view of the terraced houses, with the certified unity marked in green

Right: South street façade

2.2 Façade images

fotos de fachada

Left: North street façade

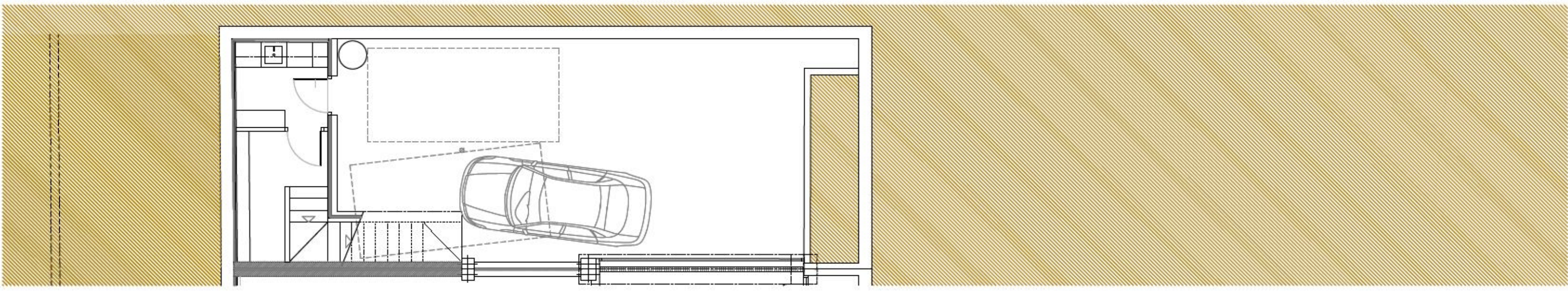
2.3 Interior images / fotos interiores

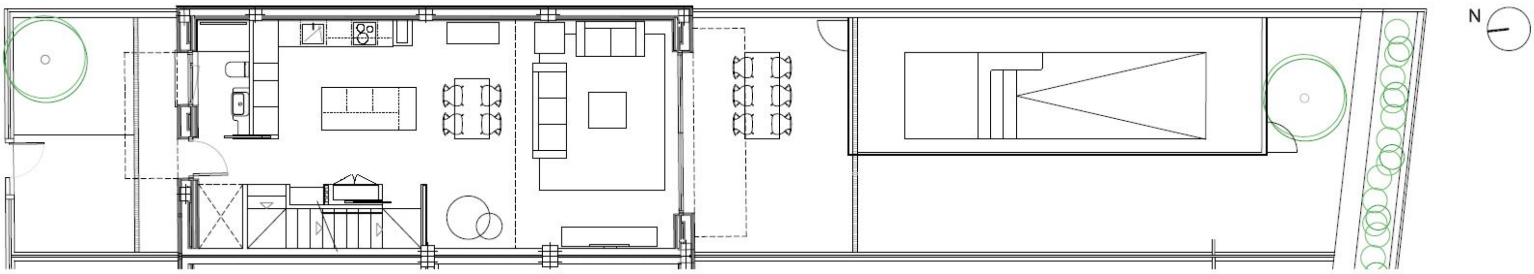
Interior pictures of the stairs

Picture of the second-floor terrace

3.1 Floor plans / Plantas del proyecto

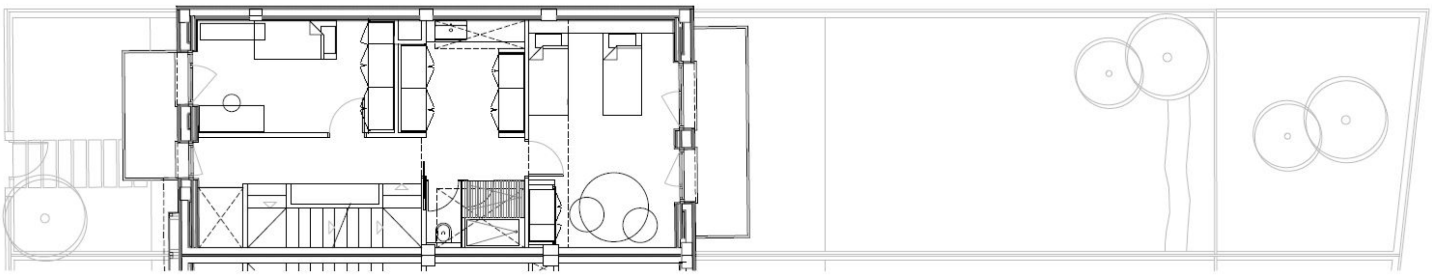
Basement floor plan

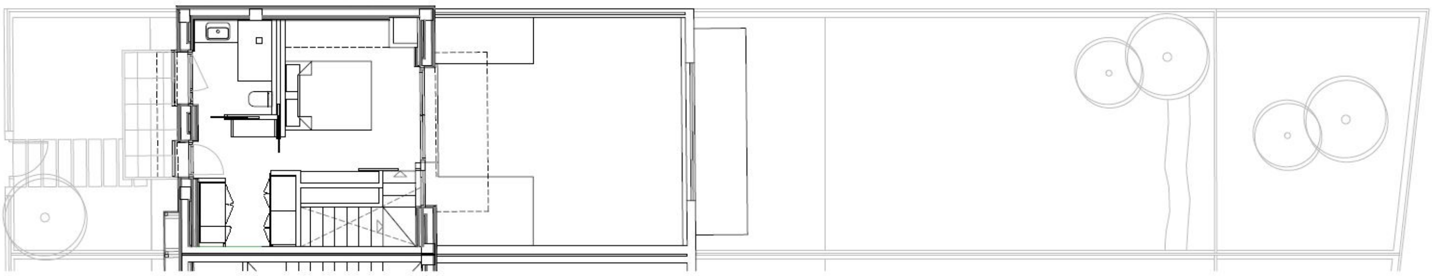




Ground floor plan

First floor plan



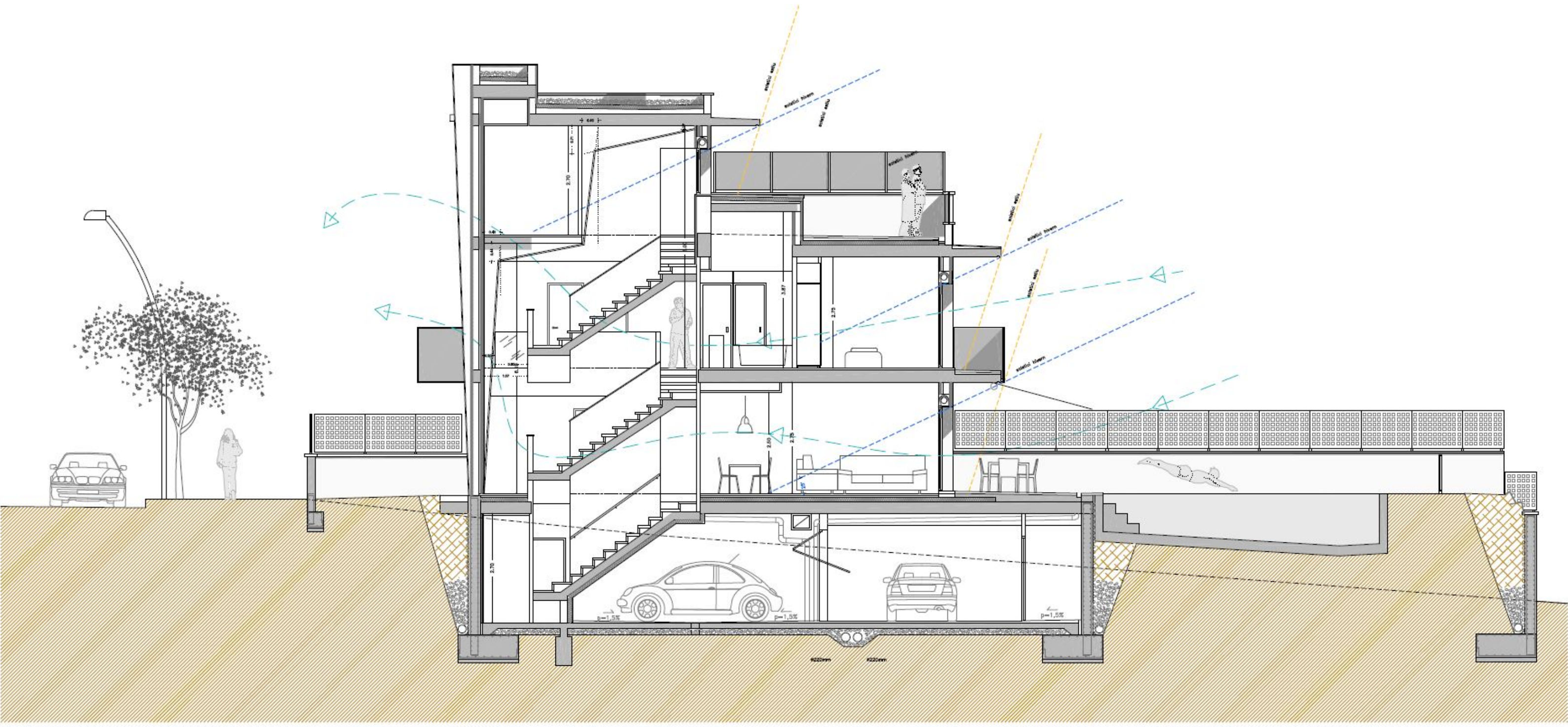


Second floor plan

3.2 Elevations and section / Alzados y sección del proyecto

North façade plan

Cross section plan

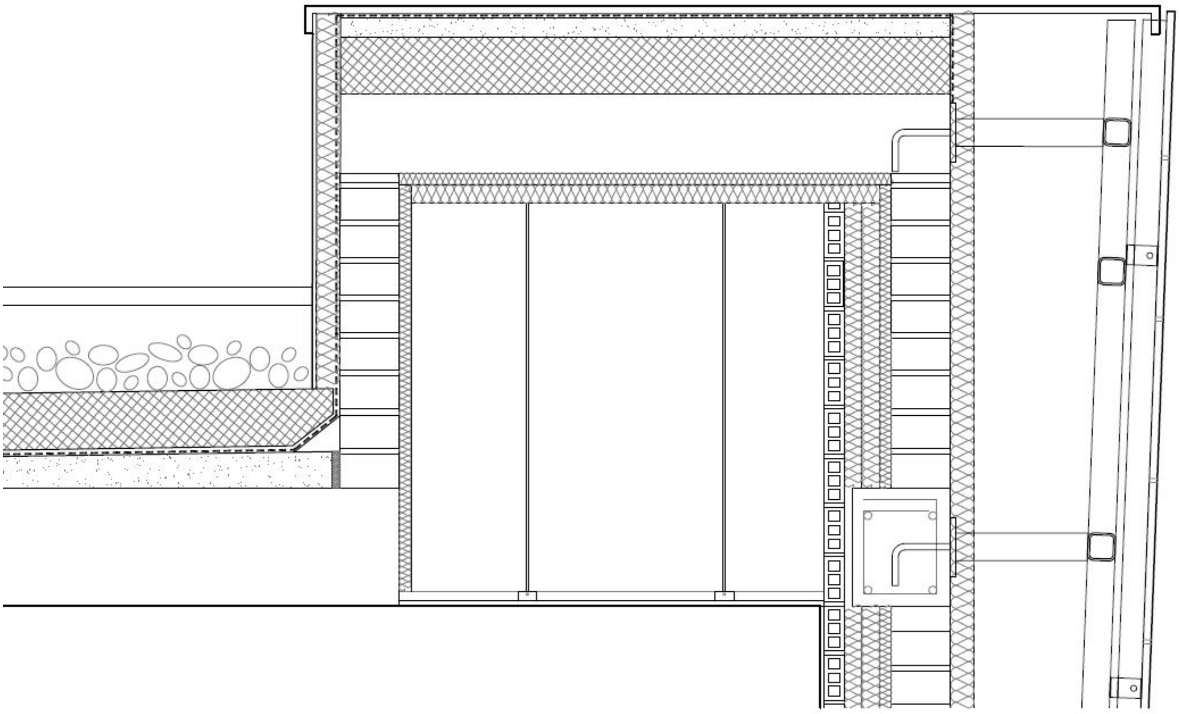


4.1 Structural analysis / Análisis estructural


The building stands over a concrete slab laid over foundation wells supported on the resistant substrate.

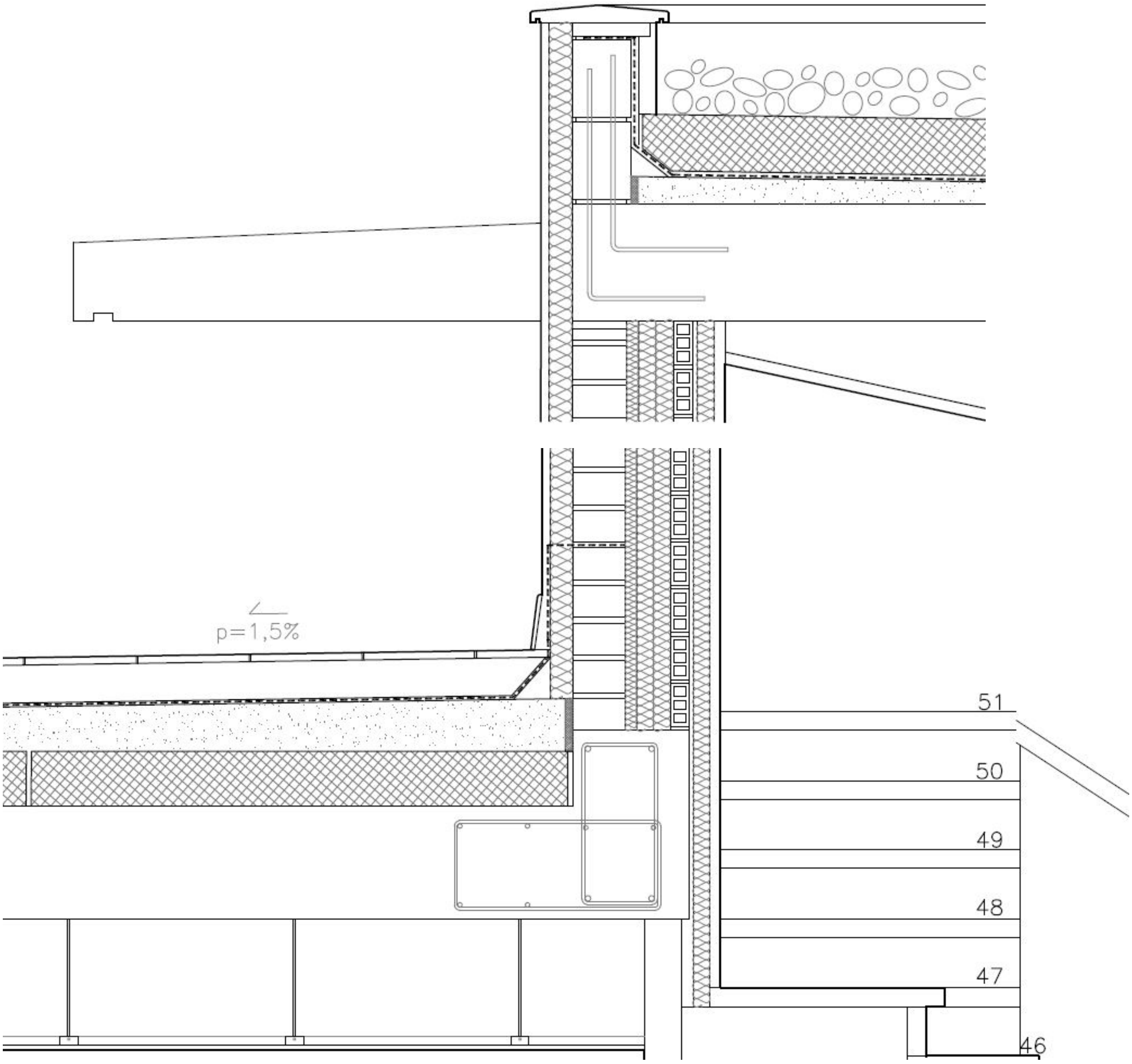

The vertical structure rises with 140 mm brick partition and grid concrete slab. Also, the three types of façades: ceramic cavity-wall, etix and weatherproof paneling.


5.1 Construction PH details / Planos detalle de construcción



FAÇANA

F1. Revestiment contínu de morter de ciment, de E=15 mm
F2. Bloc H llis de 40x20x25 cm, de morter de ciment gris per revestir
F3. Bloc H llis de 40x20x15 cm, de morter de ciment gris per revestir, farcit de formigó.
F4. Sistema weber.therm etics acabat acrílico, amb plaques aïllants de poliestirè expandit
F5. Acabat exterior
F6. Junta de poliestirè expandit
F7. Paret de tancament recolzada d'espessor 14 cm, de maó calat, de 290x140x100 mm
F8. Cambra de aire
F9. Llana de roca e=45mm
F10. Trasdosat autoportant de cartró guix 15—13+48/600 mm
F11. Caixa de persiana
F12. Corredera de dues fulles amb vidre laminat transparent Ref COR—VISION.
F13. Placa ceràmica estrusionada casa GRECO GRES FRONTEK model iceberg , de 300 mm de alçada x 600 mm
F14. Subestructura de GRECO GRES
F15. Subestructura de subjecció de façana ventilada de tubs d'acer galvanitzat de 70.70.5mm
F16. Espuma rígida de poliuretà projectat de e min=60 mm
F17. Espuma rígida de poliuretà projectat de e min=30 mm
F18. Barana exterior de vidre
F19. Impermeabilització formada per dues capes de pintura de poliuretà liquida color gris de la casa SIKA o similar.
F20. Escopidor de pedra de Sant Vicente e=2cm



COBERTA "A" COBERTA INVERTIDA TRANSITABLE

Ca1. Sòcol ceràmic de gres, de 7 cm
Ca2. Rajoles ceràmiques de GRECO GRES model jupiter de 30x60 cm
Ca3. Morter de ciment M-5 de e=4 cm
Ca4. Placa de poliestirè extruit de e=15 cm de 1250x600, U:0.036 W/(mK)
Ca5. Impermeabilització formada per làmina de mòdul de cautxú e.p.d.m de e=1.14 mm de Rubbergard de Firestone.
Ca6. Làmina de geotextil de separació de 90gr/ m2
Ca7. Mitja canya
Ca8. Formigó cel.lular de pendents
Ca9. Junta de dilatació perimetral amb poliestirè expandit e=20mm

COBERTA "B" COBERTA INVERTIDA NO TRANSITABLE

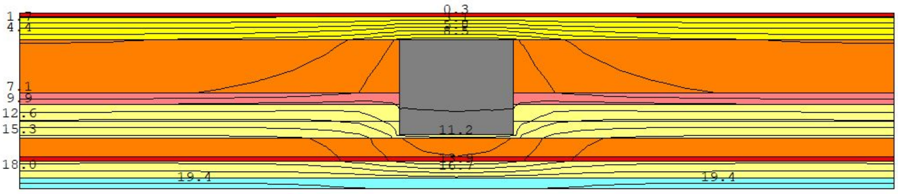
Cb1. Canto rodat e=10cm
Cb2. Placa de poliestirè extruit de e=15 cm de 1250x600
Cb3. Impermeabilització formada per làmina de mòdul de cautxú e.p.d.m de e=1.14 mm de Rubbergard de Firestone.
Cb4. Làmina de geotextil de separació de 90gr/ m2
Cb5. Mitja canya
Cb6. Formigó cel.lular de pendents
Cb7. Junta de dilatació perimetral amb poliestirè expandit e=20mm
Cb8. Peça de remat de façana d'acer galvanitzat e=0.5mm

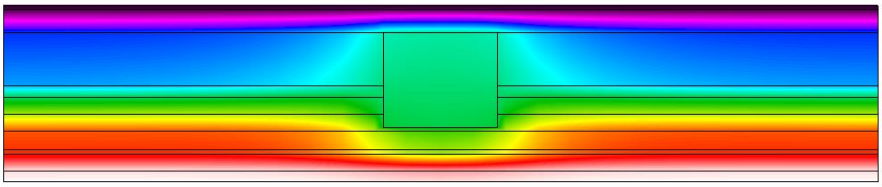
5.2 Insulation / Aislamiento

The roof is insulated with 150 mm of XPS on its upper part. The thermo-clay bloc is wrapped to the outside by a 60 mm EPS insulation with acrylic mortar plaster. On the inside there is insulation with 30 mm of EPS, followed by a projected of 90 mm mineral wool insulation, a 50 mm of brick partition finished with 45 mm of mineral wool insulation and laminated plasterboard.

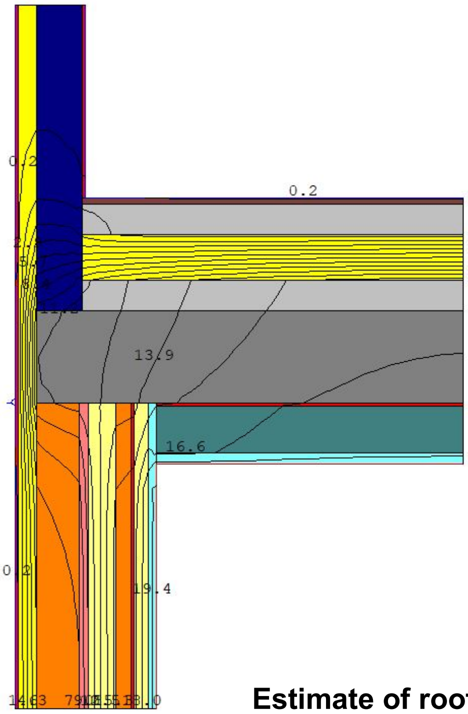
5.3 Thermal bridges / Puentes térmicos

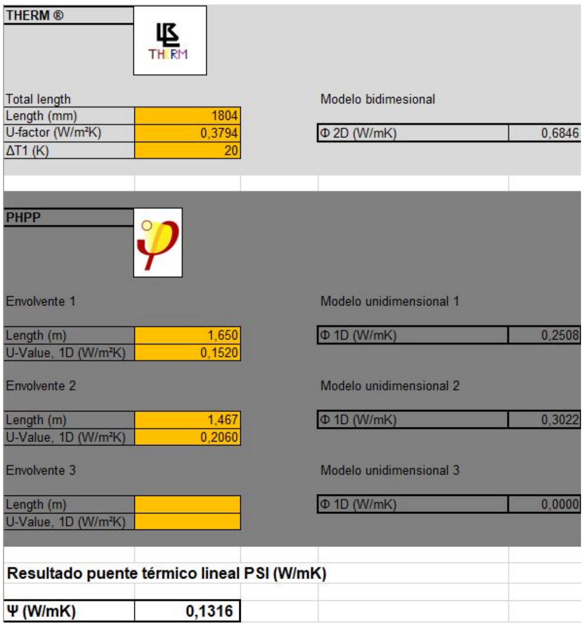
The insulation of slab, facade and roof is provided in continuity to minimize thermal bridges and the envelope is only traversed by the main pillars of the façade structure whose incidence in energy calculations has been conveniently considered in PHPP.





Pillar in façade





THERM ®		Modelo bidimesional	
Total length			
Length (mm)	1804	Φ 2D (W/mK)	0,6846
U-factor (W/m²K)	0,3794		
ΔT1 (K)	20		

PHPP			
Envolvente 1		Modelo unidimensional 1	
Length (m)	1,650	Φ 1D (W/mK)	0,2508
U-Value, 1D (W/m²K)	0,1520		
Envolvente 2		Modelo unidimensional 2	
Length (m)	1,467	Φ 1D (W/mK)	0,3022
U-Value, 1D (W/m²K)	0,2060		
Envolvente 3		Modelo unidimensional 3	
Length (m)		Φ 1D (W/mK)	0,0000
U-Value, 1D (W/m²K)			

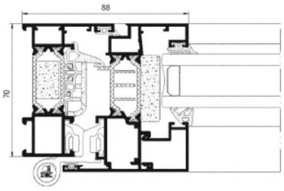
Resultado puente térmico lineal PSI (W/mK)

Ψ (W/mK)	0,1316

Estimate of roof thermal bridge

5.4 Windows / Ventanas

Aluminum windows of Cortizo (COR 70 serial and COR Vision serial) have been installed with low transmittance of frames and double glass 3+3/16/4+4 gsun -



Ug - Uvalue of glass: 1,10 (W/m2K)

G - Value of glazing: 0,69 (W/m2K)

Uf - Uvalue of frame: 2,09 (W/m2K)

EFICIENCIA ENERGÉTICA

Coeficiente de transmisión térmica
U_w desde 1,3 (W/m²K)
Consultar tipología, dimensión y vidrio.

CTE- Apto para zonas climáticas*:
α A B C D E
* En función de la transmitancia del vidrio.

AISLAMIENTO ACÚSTICO

Máximo acristalamiento: 30 mm.
Máximo aislamiento acústico: Rw = 41 dB.

CATEGORÍAS ALCANZADAS EN BANCO DE ENSAYOS

Protección frente a los agentes atmosféricos

Permeabilidad al aire (UNE-EN 12207:2000):	Clase 4
Estanqueidad al agua (UNE-EN 12208:2000):	Clase 7A
Resistencia al viento (UNE-EN 12210:2000):	Clase C5

* Ensayo de referencia balconera 1,23 x 1,55 m, 1 hoja + 1 fijo.

SECCIONES	Marco 116 mm Tricarril 182 mm Hoja 37 mm
ESPESOR PERFILERÍA	Puerta 1,7 mm
DIMENSIONES MÁXIMAS	Ancho (L) = 2.200 mm Alto (H) = 3.000 mm
PESO MÁXIMO/ HOJA	320 Kg
DRENAJE	Posibilidad canaleta de drenaje y rejilla inox

Consultar peso y dimensiones máximas según tipología.

ALEACIÓN DE EXTRUSIÓN
6063 T-5

LONGITUD VARILLA POLIAMIDA
Poliamida 6.6 reforzada con un 25% de fibra de vidrio de 16 a 24 mm

POSIBILIDADES DE APERTURA
Corredera de 2, 3, 4 y 6 hojas. Posibilidad mono y tricarril (1 hoja+1 fijo) (2 hojas+1 fijo). Posibilidad de encuentros a 90º sin parteluz. Galandage de 1 y 2 hojas

Second floor window picture

6.1 Blower door: documentation of the pressure test / Documentación de la prueba de presión

Airtight cover's detail

Blower door test pictures

All the windows have been sealed, as we can see in the picture, applying Soudatight LQ paint between the wood pre-frames and the internal lining of the façade and covering with expansive tape the gaps between the pre-frames and the carpentry. The roof areas have been sealed with a plaster under the concrete slab, as the same way as the façades, but in this case on the inside of the thermo-clay, creating a continuous airtight cover. Blower Door tests were carried out during the works and concluded with a satisfactory result of 0.92 r/h, within the limits established by PH for low energy demand buildings.

Blower door test results

	Resultados	Intervalo de confianza de 95%		Incertidumbre
Caudal a 50 Pa, V50 [m³/h]	368,5	353,0	384,5	+/-4,3%
Renovaciones a 50 Pa, n50 [/h]	0,92	0,8731	0,9695	+/-5,2%
Permeabilidad a 50 Pa, v50 [m³/h/m²]	0,865	0,820	0,911	+/-5,2%
Perdida específica a 50 Pa, w50 [m³/h/m²]	5,389	5,108	5,671	+/-5,2%
Área efectiva de pérdida 50 Pa, AL [cm²]	112,5	107,5	117,5	+/-4,4%
Área equivalente de pérdida 50 Pa, AL [cm²]	184,0	176,5	192,0	+/-4,3%

7.1 Ventilation system / Sistema de ventilación

It is very important, in order to achieve controlled ventilation, we opted for the installation of a heat recovery system of Zehnder Q350ERV with a SEC of -15,3 kWh/m2a, and with an electrical efficiency of 0,29 Wh/m3. This allows us to carry out a double flow system with a yield around 84%. In this case, in addition to the intake of the fresh air to the heat recovery unit on the area of the roof, we also have the absorption in basement floor through the air to earth heat exchanger, that allows us, through an automatic bypass, to select the most suitable air to be circulated. It supplies air in the basement corridor (one conduct with one impulse grid), in the living room (two conducts with two impulse grids) and in the four bedrooms (with four conducts with four impulse grids). It extracts air from the basement laundry (one conduct with one extraction grid), from the kitchen (two conducts with two extraction grids), and from the three bathrooms (four conducts with four extraction grids).

8.1 Heating-cooling / Frío-calor

To supply the small demand for heating and cooling existing in the building is achieved with 3 equipment with direct expansion heat pump independent plants distributed through air conducts. For the distribution of sanitary hot water, an air to water heat pump is used.

Fancoil for heating and cooling

Acumulator heat pump for ACS

9.1 Photovoltaic system / Sistema fotovoltaico

In order to achieve the highest possible level of self-supply with electricity, all available roof areas were covered with PV modules. The modules were set up with a lightly ballasted flat roof mounting system with a substructure, which could be installed without roof penetration.

The electricity produced is primarily used for own use, and surpluses are currently being fed into the public grid.

The sunny roof areas were covered with 14 PV modules in south orientation, modules of 250Wp with 4,4 KW/h batteries accumulation.

Photovoltaic plates on the roof

9.2 Air to earth heat exchanger / Pozo canadiense

"Pozo canadiense" installation process

Its construction is based on the installation in the subsoil of ducts at a depth between 2 and 4 meters and a length of about 35 meters and circulate air through them. In contact with the ducts the air acquires the temperature of the ground, which later, with extra contribution or not of temperature, we will introduce it in the rooms of the house. We estimate that at a depth of about 3 meters we already find temperatures that we can consider close to the optimum comfort temperatures in a house (17º to 25º).

Double admission

10.1 Report of PHPP results / Resultados extraídos del PHPP

The building maintains constant temperatures throughout the most extreme months of the year, needing a minimum energy contribution that replaces the one already achieved through the photovoltaic system. To the month of August with maximum temperatures of 35º to the exterior, we found an interior temperature consisting of 25º-26º and with a humidity relative of 65-70%. On the other hand, the coldest days of winter with minimum external temperatures of 0º, we find in the interior of the house constant temperatures of 20-22º and with a relative humidity of 60%.

PHI Edificio de baja demanda energética Comp

Edificio:	14_15		
Calle:	Casa Pletada 39		
CP / Ciudad:	8870	Sitges	
Provincia/País:	Barcelona	ES-España	
Tipo de edificio:	Vivienda unifamiliar pareada		
Datos climáticos:	ud---00-Barcelona		
Zona climática:	5: Cálido	Altitud de la localización:	54 m
Propietario / cliente:	Sergi Gargallo Soler		
Calle:	Casa pletada 39		
CP / Ciudad:	8870	Sitges	
Provincia/País:	Barcelona	ES-España	

Arquitectura:	Arquitectura i eficiència energètica SLPU		**Instalaciones:**	IND Serveis	
Calle:	AV/ Camí dels Capellans, 81 local 2A		Calle:	Mercè Amell 2 BJ - Vallpineda	
CP / Ciudad:	8870	Sitges	CP / Ciudad:	8810	Sant Pere de Ribes
Provincia/País:	Barcelona	ES-España	Provincia/País:	Barcelona	ES-España
Consultoría:	Sergi Gargallo Soler		**Certificación:**	Energiehaus SLP	
Calle:	AV/ Camí dels Capellans, 81 local 2A		Calle:	Carrer Ramón Turró, 100-104, 3º3ª	
CP / Ciudad:	8870	Sitges	CP / Ciudad:	08005	Barcelona
Provincia/País:	Barcelona	ES-España	Provincia/País:	Barcelona	ES-España

Año construcción:	2016	Temp. interior invierno [°C]:	20,0	Temp. interior verano [°C]:	25,0
Nr. de viviendas	1	Ganancias internas de calor (GIC); caso calefacción [W/m²]:	2,5	GIC caso refrigeración [W/m²]:	2,5
Nr. de personas:	2,8	Capacidad específica [Wh/K por m² de SRE]:	60	Refrigeración mecánica:	x

Valores específicos referenciados a la superficie de referencia energética

					Criterio	Criterios alternativos	¿Cumplido?[2]
	Superficie de referencia energética	m²	133,3				
Calefacción	Demanda de calefacción	kWh/(m²a)	13,74	≤	30	-	Sí
	Carga de calefacción	W/m²	23,97	≤	-	-	
Refrigeración	Demanda refrigera. & deshum.	kWh/(m²a)	11,64	≤	33	-	Sí
	Carga de refrigeración	W/m²	8,48	≤	-	-	
	Frecuencia de sobrecalentamiento (> 25 °C)	%	-	≤	-		-
	Frecuencia excesivamente alta humedad (> 12 g/kg)	%	0,00	≤	10		Sí
Hermeticidad	Resultado ensayo presión n_{50}	1/h	0,92	≤	1,0		Sí
Energía Primaria no renovable (EP)	Demanda EP	kWh/(m²a)	81,46	≤	-		-
Energía Primaria Renovable (PER)	Demanda PER	kWh/(m²a)	39,42	≤	75	75	Sí
	Generación de Energía Renovable	kWh/(m²a)	52,16	≥	-	-	

[2] Celda vacía: Falta dato; '-': No requerimiento

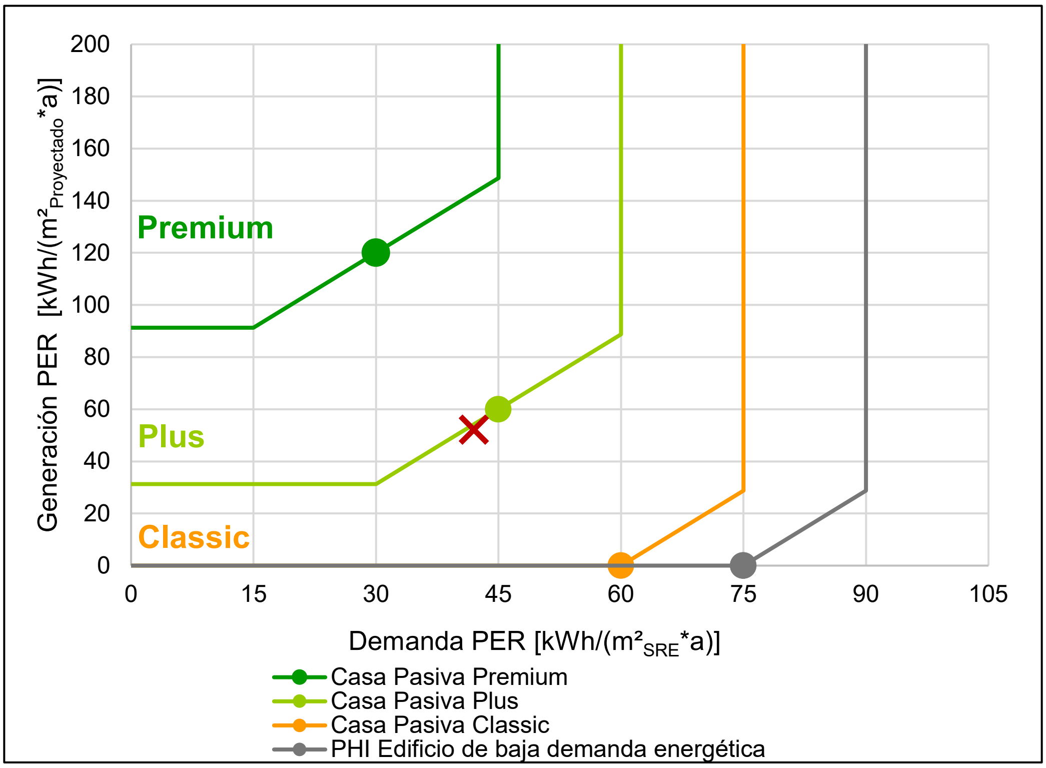
Confirmo que los valores aquí presentados han sido determinados siguiendo la metodología de PHPP y están basados en los valores característicos del edificio. Los cálculos de PHPP están adjuntos a esta comprobación.

baja demanda energética? **Sí**

Función:	Nombre:	Apellido:	Firma:
1-Diseñador	Sergi	Gargallo	
PEPES_141115_288116721_es09	Fecha emisión: 25/05/18	Ciudad: Sitges	

Project data imported from designPH 1.1.55	Código desplegado PHPP9:	287927851_141115_PEPES_es09

10.2 PER graphic / Gráficos PER



Primary Energy Renewable (PER) / **Energía primaria renovable (PER)**	39,42 kWh/(m²a)
Generation of renewable energy / **Generación energía renovable**	52,16 kWh/(m²a)
Non-renewable Primary Energy (PE) / **Energía primaria no renovable (PE)**	81,46 kWh/(m²a)

11.1 Construction costs / Costes de producción

Building costs...1.400 €/m2 (living space without furniture)

Construction costs..300.000 € (living space without furniture)

The extra cost to build a house following the standard Passivahus instead of a house following the CTE is almost a 7% of the construction cost. The increase is minimum if we check the building demand of energy that we reduce with the follow measures: the control of the airtightness of all the building details and the blower door documentation of the pressure test; the higher quality windows have been installed with low transmittance of frames; the insulation of the all parts of the building, taking care of the smallest details to avoid the heat loss; the controlled ventilation with the installation of a heat recovery system.

12.1 Experiences – publications / Experiencia usuario – Publicaciones

Publications:

https://sgarq.com/proyecto/casa-pletada

Experiences:

The house has a uniform temperature without sudden changes in temperature. While outside, there may be thermal difference between day and night of 10 to 15 degrees, inside the variations range between 2 and 3 degrees. It breathes an interior air without odors, the house gets dirty less than a conventional one because there is no need to open windows to ventilate. The fact that the house has a high airtightness, involves a great acoustic insulation from the exterior. Beyond the energy (and therefore economic) saving of the house, the high degree of interior comfort that is enjoyed is highlighted. Thermal insulation, acoustic, without feeling of humidity even in the laundry located in the basement and with constant humidity and temperature conditions and without large variations.

12.2 Data monitoring / Monitorización de datos

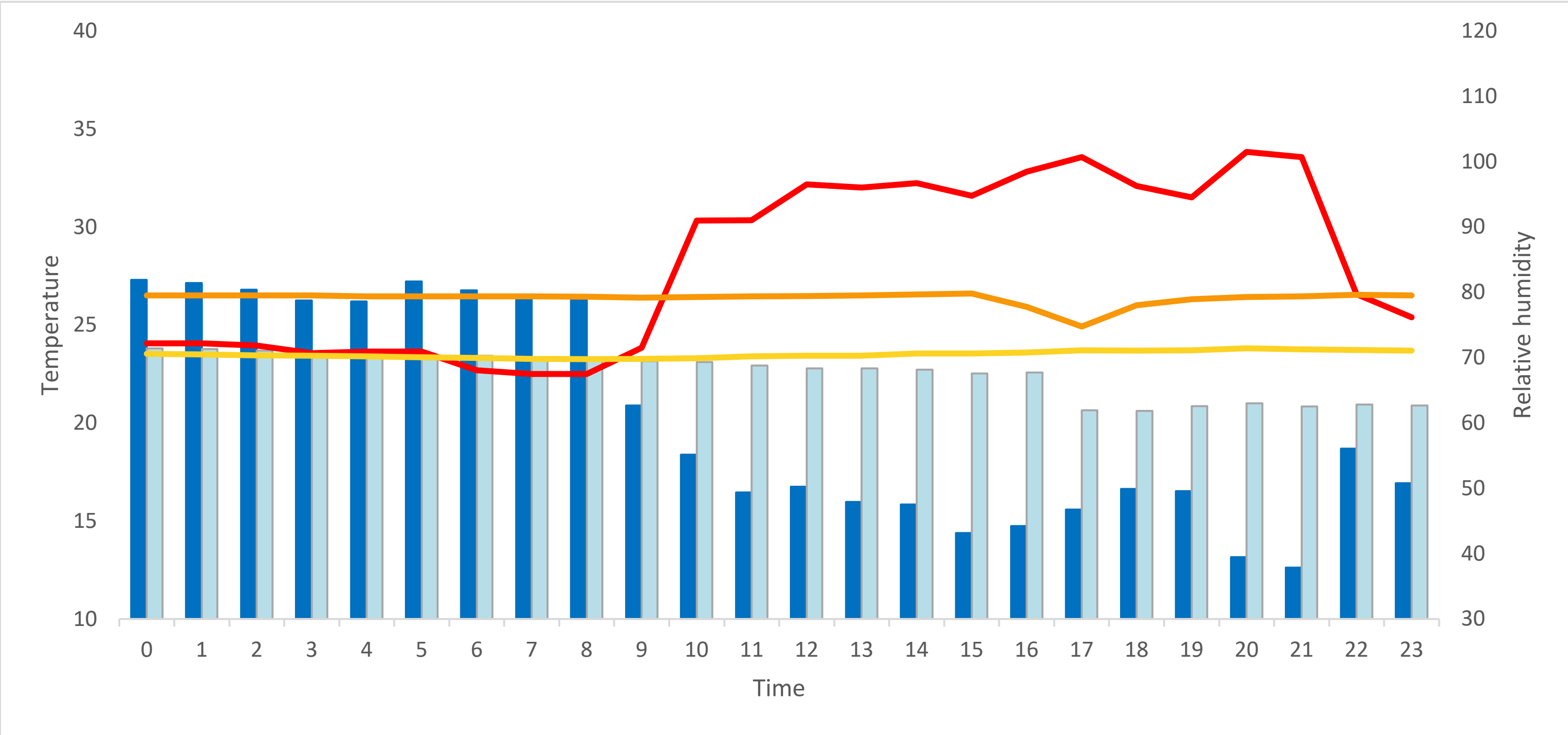
Photovoltaic system data of March 2018

Self-supply photovoltaic:

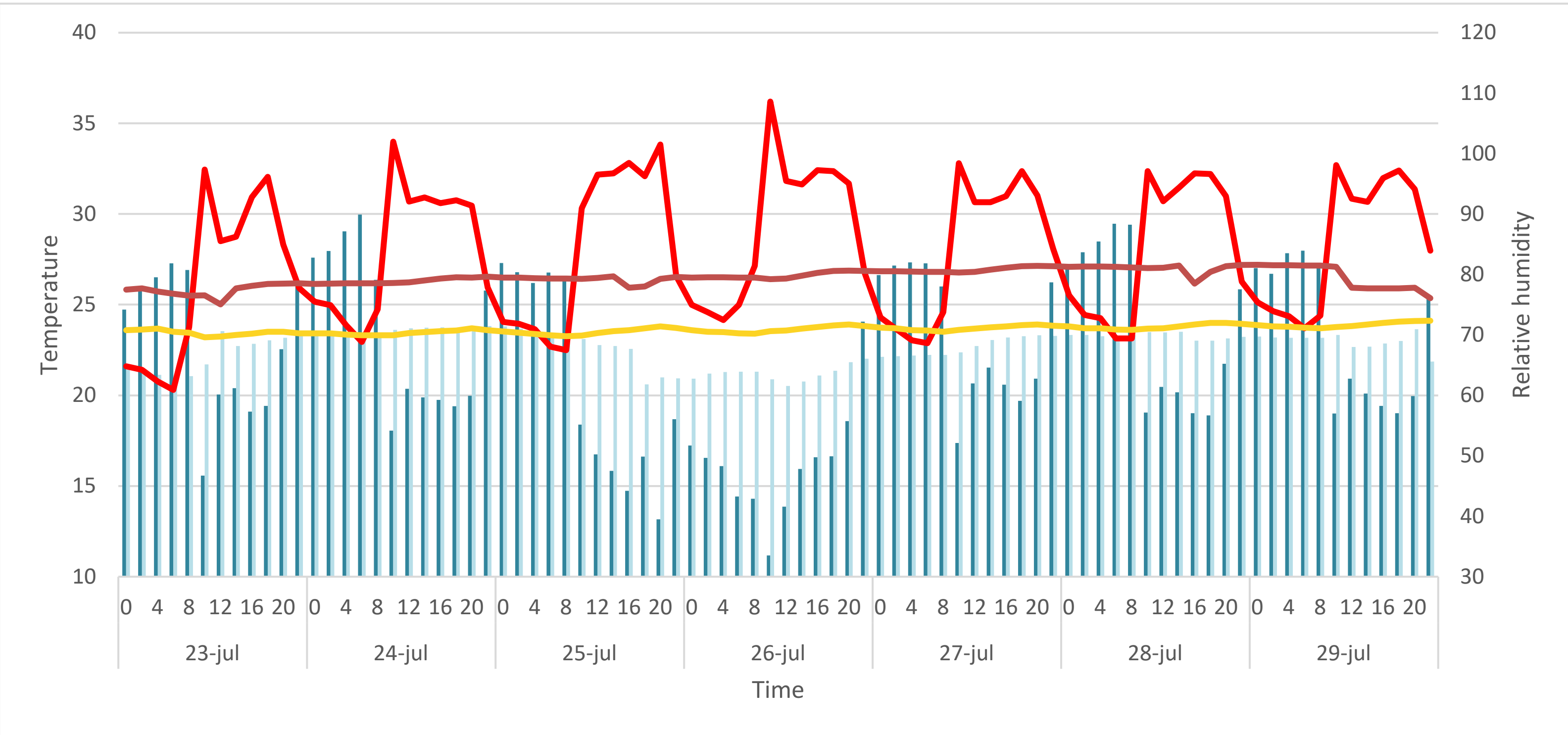
The electricity produced is primarily used for own use, and surpluses are currently being fed into the public grid, and in case that it has not enough the remaining is obtained from the public grid too. The sunny roof areas were covered with 14 PV modules in south orientation, modules of 250Wp with 4,4 KW/h batteries accumulation.

We can see in the graphic the intake (554,2 kWh) of March, and almost the 66% of this electricity is self-supplied by photovoltaic system. The 34% remaining is obtained from the public grid. We have to keep in mind that in March there is a south radiation of 39 (kWh/m2month), and the year’s average is 52,50 (kWh/m2month). So, we will have better results the rest of the months, increasing to generate almost the totally of the electricity that the house needs.

Photovoltaic system generation   Obtained from the public grid



Temperature and humidity data of 25th of July 2018



Temperature and humidity data of July 2018

Humity Out. Humity Ground floor Temp. Out Temp. Ground floor Temp. Air to earth heat exchanger