

Project Documentation/ Gebäude-Dokumentation



1 Abstract / Zusammenfassung



Single-family house in Torre Boldone (BG), Italy

1.1 Data of building / Gebäudedaten

Year of construction/ Baujahr	2021	Space heating/ Heizwärmebedarf	13,98 kWh/(m²a)
U-value external wall/ U-Wert Außenwand	0.119 W/(m ² K)		
U-value basement ceiling/U-Wert Kellerdecke	0.157 W/(m ² K)	Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)	32 kWh/(m ² a)
U-value roof/ U-Wert Dach	0.098 W/(m ² K)	Generation of renewable energy /Erzeugung erneuerb. Energie	30 kWh/(m ² a)
U-value window/ U-Wert Fenster	0.79W/mqK	Non-renewable Primary Energy (PE) /Nicht erneuerbare Primärenergie (PE)	68 kWh/(m ² a)
Heat recovery/ Wärmerückgewinnung	85 %	Pressure test n ₅₀ [1/h] Drucktest n ₅₀	0.6
Special features/ Besonderheiten	The building is equipped with a photovoltaic system integrated e coplanar with the roof lining. Despite the articulated and not very compact geometry, the building achieves the PH Standard – Classic		

1.2 Brief Description

This passive certified residential building is the result of sharing with clients and companies our ethical vision of the project and innovative vision of building by maximizing, in all phases (design, construction and management) the containment of the ecological and environmental impact of the building. Local companies and workers were chosen for the realization, partly already experienced and partly trained ad hoc with a specific course in the construction of passive wooden houses, bringing innovation to our territory, traditionally suited to brick.

Even the clients, a mature couple of art enthusiasts, initially oriented towards a traditional building, understood and accepted the project that responds to their request for bright and large spaces to house the large collection of paintings and antique objects collected during their travels, comfortable environments in every season and minimum energy costs. The design was therefore spontaneously oriented towards the use of natural materials, in particular wood for the structures, bales of wheat straw, a by-product of local agriculture, as an insulating element of the perimeter walls, wood fiber coats and insulation of wooden roofs with cellulose flakes, the use of internal plasters in raw earth and external lime that guarantee the walls breathability and the maintenance of a correct degree of humidity Internal.

The house is located on the hilly foothills of the Maresana in Torre Boldone (Bg). The steep lot, narrow and long in shape arranged east-west, has constrained its orientation.

The house is characterized by an above-ground garage in reinforced concrete and local stone, located facing the street, volumetrically integrated upstream to the residential part divided into 3 buildings of different heights, of which the main one, with an essential and iconic shape, is completely covered with ventilated facades of fiber-cement slabs. The others, more traditional, have gabled roofs and wooden eaves, slate tiles, external plaster and stone cladding, natural wood windows and a porch on the south side.

On the ground floor there is a large living room with dining area, kitchen, bathroom, pantry / ironing room, a bedroom as well as the master sleeping area with bedroom, private bathroom and walk-in closet. The living area is double height, with solids and voids and surfaces designed to house the collections and paintings, illuminated by recessed spotlights or on the beams. On the first floor there are: a mezzanine, a bedroom with access to the terrace above the garage, a bathroom, a study area and technical and storage rooms. The large openings in the living room and kitchen overlook the porch to the south, which is functional to mitigate summer solar gains, while the skylights guarantee the correct amount of solar radiation. On the roof with two asymmetrical pitches of the highest volume, coplanar and integrated into the roof, the photovoltaic panels are placed.

The building also has rainwater collection and recovery tanks for sanitary ware and irrigation of the large garden.

There are two underground rainwater collection tanks, one of which, with a volume of 45 cubic meters, for the storage and recovery of water dedicated to the garden's irrigation and the discharge of the toilet cisterns; the second is a 50 square meter first rainwater lamination tank, (depending on the hydraulic invariance of the soils)

1.3 Responsible project participants /Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Arch. Marco Celeri – CELERI ASSOCIATI Studio di architettura Via Rinada, 7 – 24020 Torre Boldone (BG), Italy
Implementation planning/ Ausführungsplanung	
Building systems/ Haustechnik	Ing. Simone Giulianelli Via Toscanini, 31 – 61121 Pesaro (PU), Italy
Structural engineering/ Baustatik	Ing. Davide Pini Via Pradello 2 – 24121 Bergamo
Building physics/ Bauphysik	Dr. Phys. Francesco Nesi – ZEPHIR Passivhaus Italia www.passivhausitalia.com
Passive House project planning/ Passivhaus-Projektierung	Dr. Phys. Francesco Nesi – ZEPHIR Passivhaus Italia www.passivhausitalia.com
Construction management/ Bauleitung	Punto Legno Snc di Belotti Luca, Fabio & Aldo Via S. Carlo, 7 - 24015 San Giovanni Bianco (BG)
Certifying body/ Zertifizierungsstelle	Ing. Stefanos Pallantzias - Hellenic Passive House Institute https://eipak.org/
Certification ID/ Zertifizierungs ID	Project-ID (www.passivehouse-database.org) ID 7674
Author of project documentation / Verfasser der Gebäude-Dokumentation	Arch. Marco Celeri – CELERI ASSOCIATI Studio di architettura Via Rinada, 7 – 24020 Torre Boldone (BG), Italy

Date, Signature/
Datum, Unterschrift

30.09.2024



2 Views of the house in Torre Boldone (BG), Italy



East view of the house with garage entry and garden



Top view of the house



Southwest view of the house



Northwest view of the house

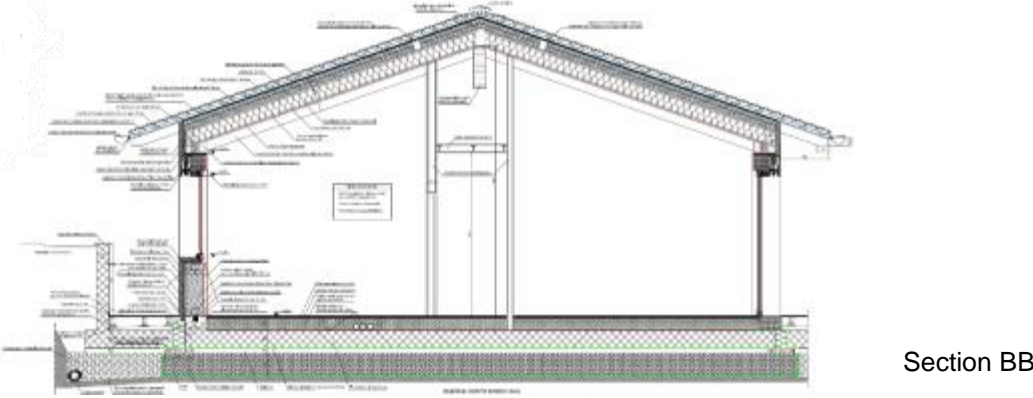
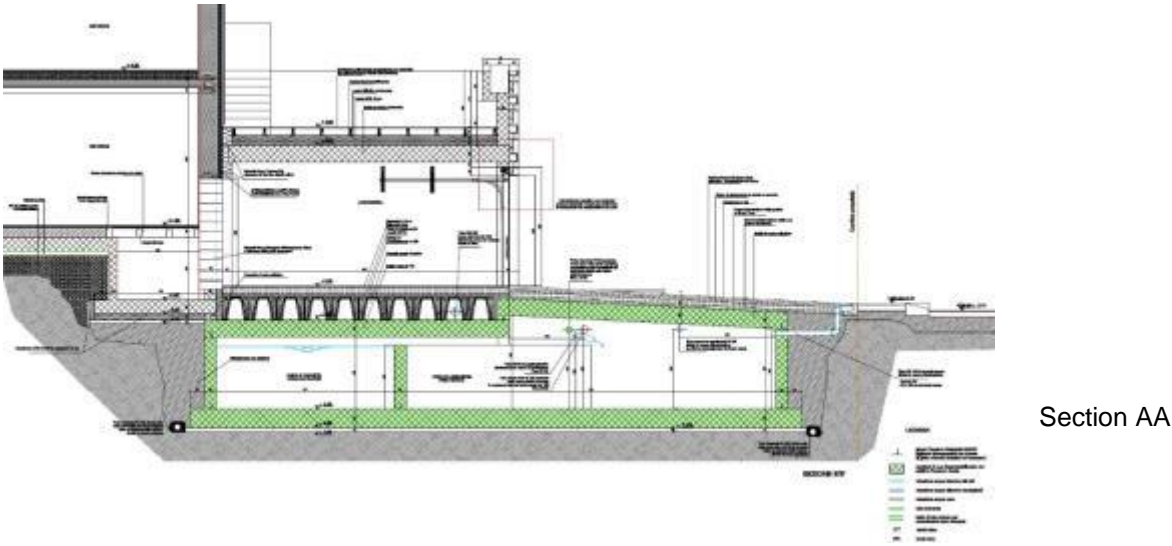
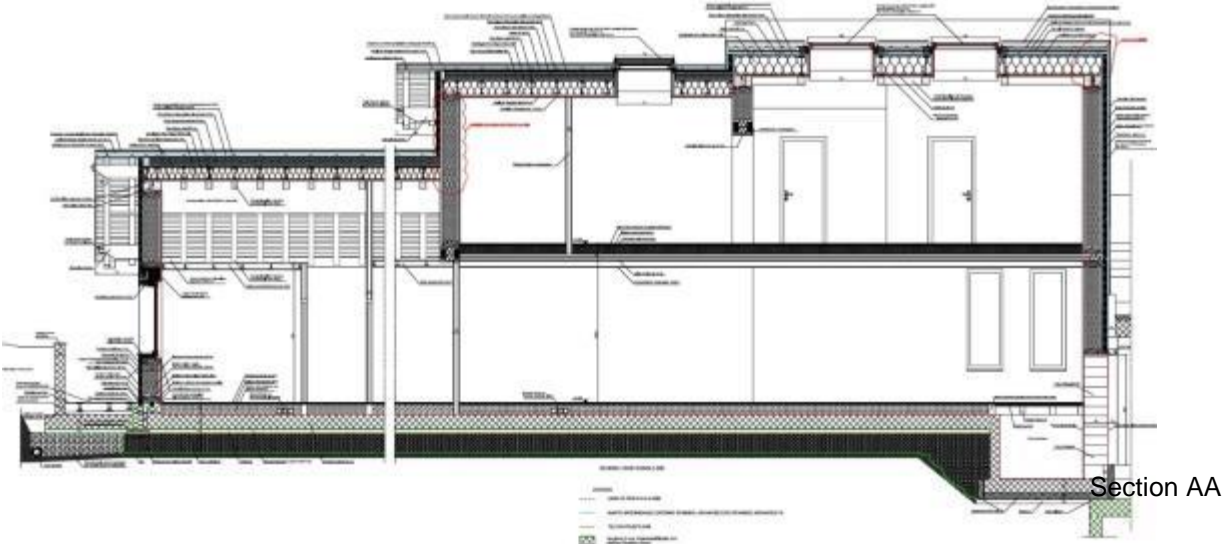


View of the living room and mezzanine before furnishing



View of the sleeping area and the volume that contains the master bathroom.

3 Section drawings of single-family house in Torre Boldone (BG), Italy



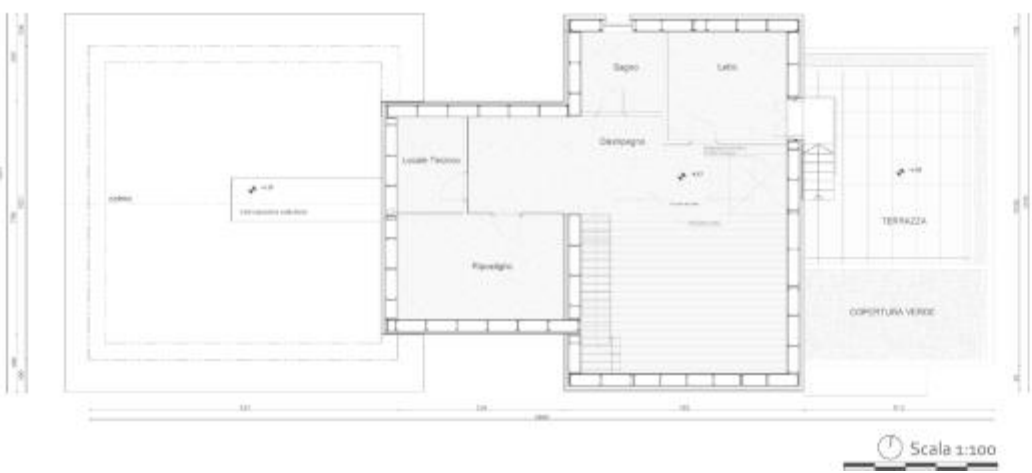
4 Floor plans of the single-family house in Torre Boldone (BG), Italy

PIANO TERRA



Ground floor plan

PIANO PRIMO



First floor plan

5 Building assemblies the single-family house in Torre Boldone (BG), Italy

5.1 Floor slabs

Elemento n°	03ud S1_Solaio di base				Coib. interna?	
Resistenza termica lineare [m²K/W]						
Orientamento elemento costruttivo	3-Pavimento	R _{si} interna	0,13			
verso	2-Terreno	R _{se} esterna	0,00			
Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Pavimento	0,130					15
Fermacell	0,320					20
Sottofondo EcoLight	0,082					220
Cls	2,300					300
Magrone	2,300					80
Ghaia vetro cellulare	0,120					400
% Sezione 1		% Sezione 2		% Sezione 3		Totale
100%						103,5 cm
Maggiorazione valore U		W/(m²K)		Valore U:	0,1541	W/(m²K)

Elemento n°	04ud S3_Solaio interpiano verso esterno nord (L.immondizie)				Coib. interna?	
Resistenza termica lineare [m²K/W]						
Orientamento elemento costruttivo	3-Pavimento	R _{si} interna	0,13			
verso	1-Aria esterna	R _{se} esterna	0,04			
Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Pavimento interno	0,130					15
Fibra di legno Naturatherm	0,038					10
Sottofondo EcoLight	0,082					190
Soletta Xlam	0,130					140
Fibra di legno Naturatherm	0,048					100
Fibra di legno Naturawall NK	0,043					100
Rasatura	0,900					10
Fermacell	0,320					20
% Sezione 1		% Sezione 2		% Sezione 3		Totale
100%						58,5 cm
Maggiorazione valore U		W/(m²K)		Valore U:	0,1187	W/(m²K)

Elemento n°	19ud S4_Solaio di base ingresso				Coib. interna?	
Resistenza termica lineare [m²K/W]						
Orientamento elemento costruttivo	3-Pavimento	R _{si} interna	0,13			
verso	1-Aria esterna	R _{se} esterna	0,04			
Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Pavimento	0,130					15
Fibrogesso	0,320					20
Sottofondo EcoLight	0,082					220
XPS Ursa	0,035					200
Cappa cls	2,300					60
% Sezione 1		% Sezione 2		% Sezione 3		Totale
100%						51,5 cm
Maggiorazione valore U		W/(m²K)		Valore U:	0,1140	W/(m²K)

5.2 External walls

Elemento n°	Descrizione elemento costruttivo				Coib. interna?	
01ud	M1_Parete in paglia					
Resistenza termica lineare [m²K/W]						
Orientamento elemento costruttivo		R _{si} interna		0,13		
verso		R _{se} esterna		0,04		
Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Intonaco in terra cruda	1,000					25
Balle in paglia	0,052			legno fibre parallele	0,308	282
Telaio paglia	0,052	Montanti e diagonali	0,130			78
Lana di roccia	0,035					0
Intonaco calce	1,000					10
Fermacell	0,320					15
Naturaboard	0,048					0
Pannello in fibra di legno Naturawall NK	0,043					60
% Sezione 1		% Sezione 2		% Sezione 3		Totale
85%		15,1%		0,4%		47,0 cm
Maggiorazione valore U		W/(m²K)		Valore U:		W/(m²K)
		0,04151		0,1207		0,02881

Elemento n°	Descrizione elemento costruttivo				Coib. interna?	
02ud	M2_Parete in paglia_ventilata					
Resistenza termica lineare [m²K/W]						
Orientamento elemento costruttivo		R _{si} interna		0,13		
verso		R _{se} esterna		0,13		
Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Intonaco in terra cruda	1,000					25
Balle in paglia eq	0,042					282
Telaio paglia	0,042	Montanti e diagonali	0,130			78
Pannello in fibra di legno Naturawall NK	0,040			Travetti	0,130	60
Pannello in fibra di legno Naturawall NK	0,043			Travetti	0,130	40
Fermacell	0,320					15
% Sezione 1		% Sezione 2		% Sezione 3		Totale
71%		22,9%		6,1%		50,0 cm
Maggiorazione valore U		W/(m²K)		Valore U:		W/(m²K)
		0,0413		0,0928		0,0551
		0,0436				0,0466



Details: Perimeter walls in wood and straw

5.3 Roofs

Elemento n°						Colo. interna?	
06ud		T2_Tetto corpo medio					
Resistenza termica lineare [m²K/W]							
Orientamento elemento costruttivo: 1-Tetto		R _{si} interna		0,13			
verso: 3-Ventilato		R _{se} esterna		0,13			
Sezione 1	λ, W/(mK)	Sezione 2 (opzionale)	λ, W/(mK)	Sezione 3 (opzionale)	λ, W/(mK)	Spessore [mm]	
Fibrogesso	0,320					12,5	
Aria ferma	0,240					40	
Fibra di legno Steico	0,038	Travetto Steico J	0,130			39	
Fibra di legno Steico	0,038			Travetti in legno parallelo	0,308	202	
Fibra di legno Steico	0,038	Travetto Steico J	0,130			39	
Assito	0,130					25	
Naturatherm	0,038					160	
Naturaisolant	0,050					19	
% Sezione 1		% Sezione 2		% Sezione 3		Totale	
80%		17,6%		2,0%		53,7 cm	
Maggiorazione valore U:		W/(m²K)		Valore U:		W/(m²K)	
		0,0485		0,0849		0,0409	

Elemento n° 05ud **T1_Tetto corpo basso** Coib. interna?

Resistenza termica liminare [m²K/W]
 Orientamento elemento costruttivo verso 1-Tetto / 3-Ventilato
 R_{si} interna 0,13
 R_{se} esterna 0,13

Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Perline	0,130					25
Fibra di legno	0,038	Travetto Steico J	0,130			39
Fibra di legno	0,038			Travetti in legno parallelo	0,308	162
Fibra di legno	0,038	Travetto Steico J	0,130			39
Assito	0,130					25
Fibra di legno Naturatherm	0,038					160
Fibra di legno Naturaisolant	0,050					19
% Sezione 1		% Sezione 2		% Sezione 3		Totale
81%		17,3%		1,9%		46,9 cm

Maggiorazione valore U W/(m²K) 0,0408 Valore U: 0,0926 W/(m²K) 0,0485

Elemento n° 07ud **T3_Tetto corpo alto** Coib. interna?

Resistenza termica liminare [m²K/W]
 Orientamento elemento costruttivo verso 1-Tetto / 3-Ventilato
 R_{si} interna 0,13
 R_{se} esterna 0,13

Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Perline	0,130					25
Fibra di legno Steico	0,038	Travetto Steico	0,130			39
Fibra di legno Steico	0,038			Travetto in legno perpendicolare	0,140	282
Fibra di legno Steico	0,038	Travetto Steico	0,130			39
Assito	0,130					25
Naturaisolant	0,050					19
% Sezione 1		% Sezione 2		% Sezione 3		Totale
83%		15,5%		1,8%		42,9 cm

Maggiorazione valore U W/(m²K) 0,0468 Valore U: 0,1018 W/(m²K) 0,0391

Elemento n° 18ud **T4_Tetto ingresso** Coib. interna?

Resistenza termica liminare [m²K/W]
 Orientamento elemento costruttivo verso 1-Tetto / 1-Aria esterna
 R_{si} interna 0,13
 R_{se} esterna 0,04

Sezione 1	λ [W/(mK)]	Sezione 2 (opzionale)	λ [W/(mK)]	Sezione 3 (opzionale)	λ [W/(mK)]	Spessore [mm]
Intonaco	0,900					10
Multipor M4 TIP	0,040					60
CLS	2,300					160
XPS Ursa	0,035					100
XPS Ursa	0,035					60
Terra	2,000					160
Cartongesso	0,210					13
% Sezione 1		% Sezione 2		% Sezione 3		Totale
100%						56,3 cm

Maggiorazione valore U W/(m²K) Valore U: 0,1548 W/(m²K)



High roof: thin beam structure



Low roof: ridge beam insulation



High roof: blowing phase with wood fiber

5.4 Windows and window installations

Windows and French doors with 92 mm thick wood and cork frame - produced by Eurofinestra -model Zero Continentale –Versatile. One-piece frame in EPS with all-metal external venetian blind.

Triple laminated glazing, low emissivity, double chamber mod. P300-Ilear 4 mm + PVB + Planiclear +Eclaz - Argon 90% 16mm - Planiclear 4 mm - Argon 90% 18mm - Planiclear 4 mm + PVB + Planiclear + Eclaz with Styrene/Acrylonitrile spacers, supplied by European Glass srl and produced by Saint Gobain.

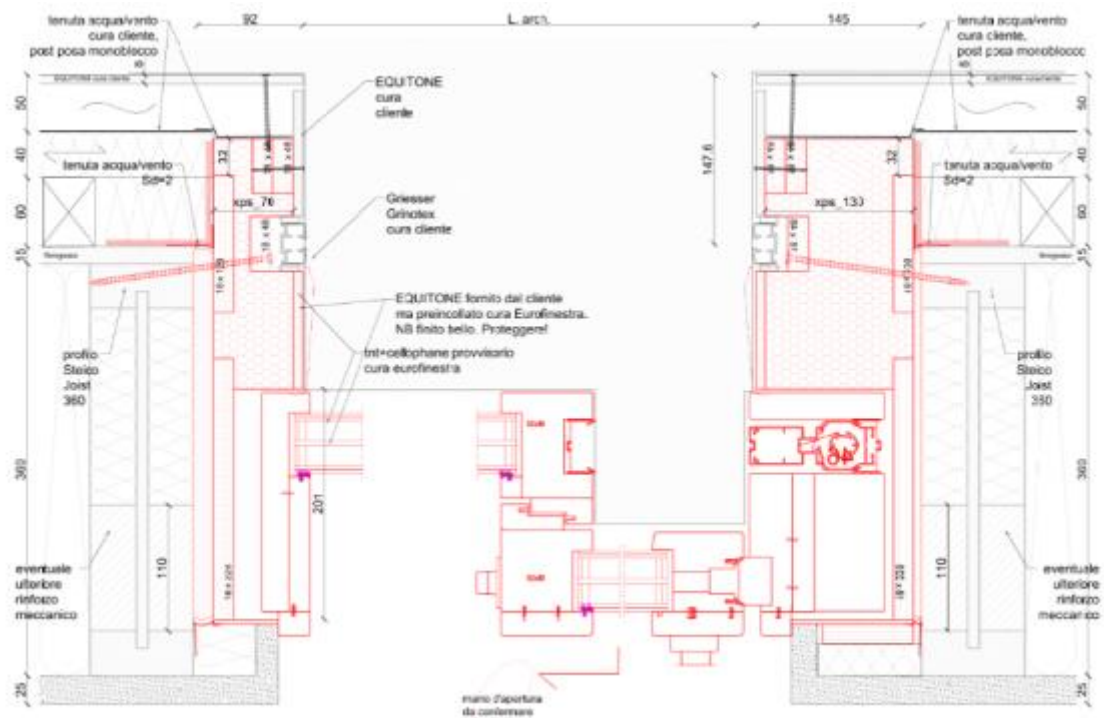
All the windows and French doors are specific to PH standard buildings.

U_w md: 0,79 W/mqK

U_g : 0,55 W/mqK

U_f : 0,97 W/mqK

PSI: 0,029 W/m



Lift-and-slide living room floor plan in correspondence with the façade cladding

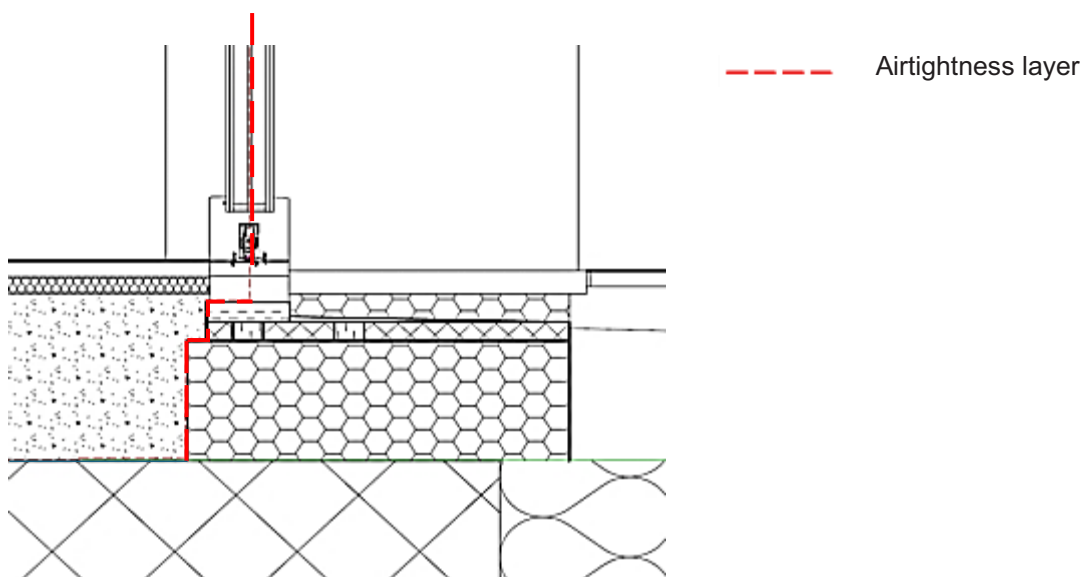
6 Description of the airtight envelope; documentation of the Blowerdoor test result

All building details were studied to guarantee the continuity of airtightness layer.

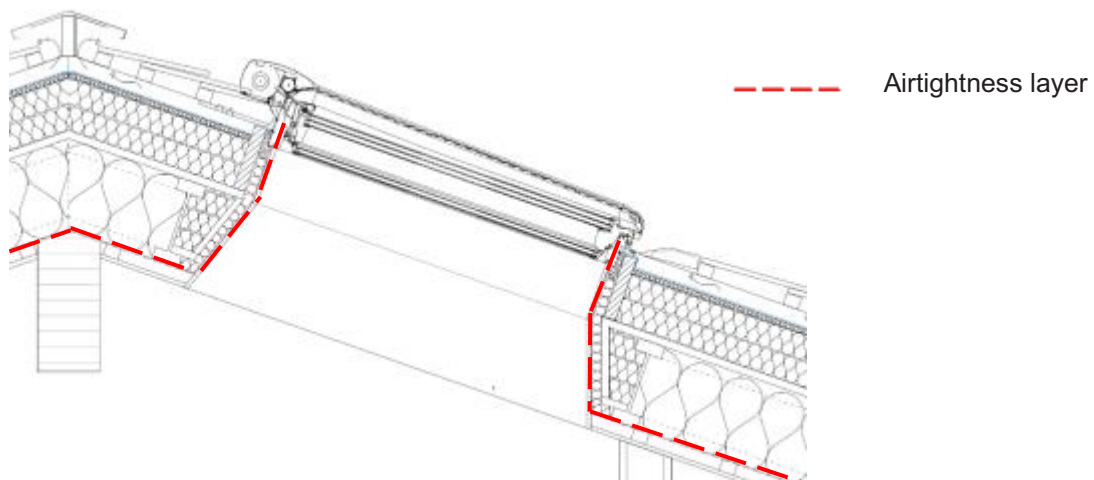
In particular, the airtightness membrane has been positioned on the inner side of the roofs and between the screed and the foundation slab, connecting it by means of accurate taping with the perimeter walls where airtightness is guaranteed by the raw earth or lime plaster. Great care has been taken in correspondence with any interruptions in continuity, such as electrical sockets or air vents, to ensure the perfect seal of the casing.

Two Blower Door Tests were conducted during the construction phase: the first at rough building before window installation, and the last when the entire building was finished.

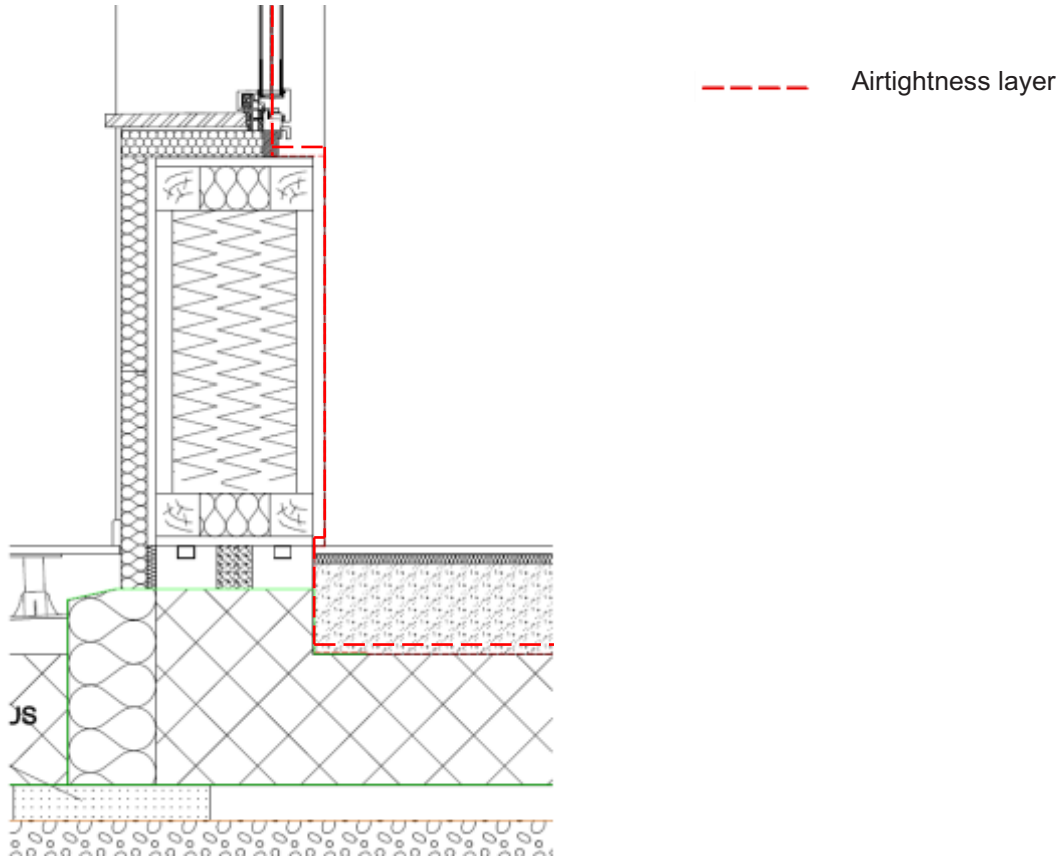
The result of the Blower Door Test is $n_{50} = 0.6$ 1/h.



Building detail: Special airtightness of the French window threshold



Building detail: Airtightness layer on the roof and roof window



Building detail: External wall/concrete slab

Petrotec FanTestic	version: 5.12.34	Azienda: Geom Giovanni Bettinelli
Test dato: 2022-02-10	Tecnico: Geom. Giovanni Bettinelli	
Client:	Celeri Associati Studio D'architettura	
Building Lot Number:		
Indirizzo dell'edificio:	Via Rinada SN Torre Boldone, BG Italy 24020	

Caratteristiche Edificio	
File informatico:	EN13829-EU 2022-02-10 1738
Volume netto, V [m³]:	874,7
Altezza involucro [m]:	9
Superficie [m²]:	270
Superficie involucro, A _{TRAT} [m²]:	602,1
Altitudine [m]:	278
Esposizione al vento involucro	Edificio altamente esposto
Accuratezza delle misure	10%

Risultati	
Flusso d'aria a 50 Pa, [m³/h]	342,90
Ricambi d'aria orari a 50 Pa, n ₅₀ [/h]	0,39
Permeabilità a 50 Pa, [m³/h/m²]	0,570
Portata specifica infiltrazione a 50 Pa, [m³/h/m²]	1,270
Effective leakage area at 50 Pa, [cm²]	104,5
Equivalent leakage area at 50 Pa, [cm²]	171,5
Leakage per Envelope Area at 50 Pa, [cm²/m²]	0,17359
Leakage per Floor Area at 50 Pa, [cm²/m²]	0,387

Blower door report

Pictures of the airtightness implementation





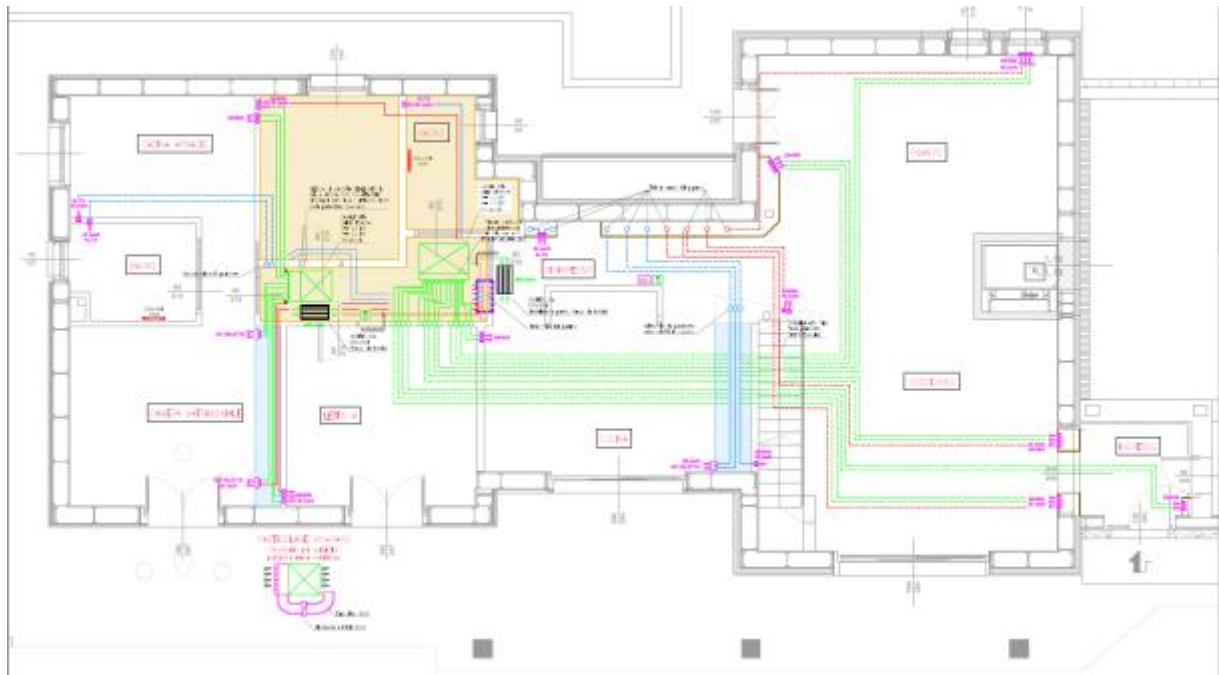
Clay plaster and connection of the airtightness sheets and tapes on the window and roof



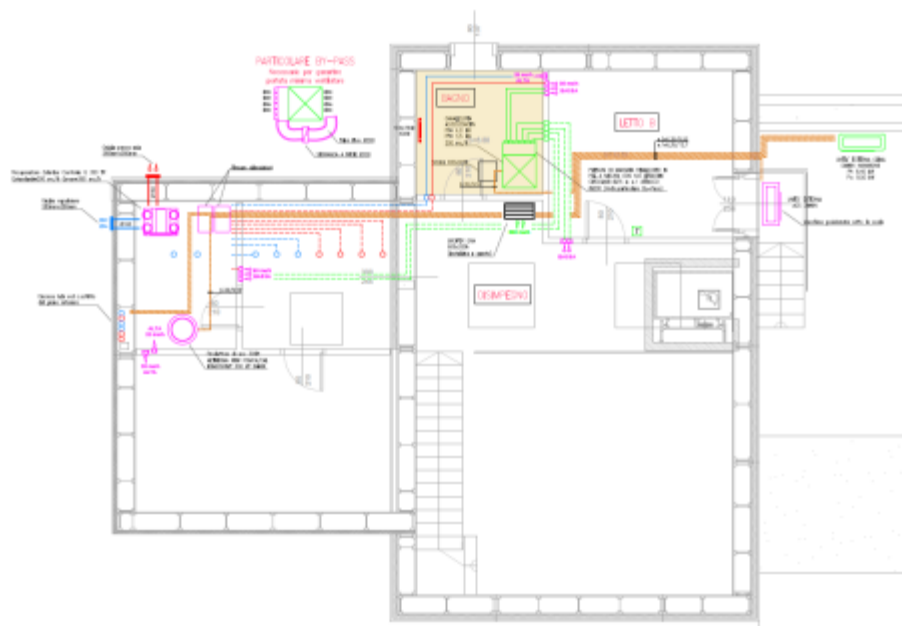
Clay plaster and connection of the airtightness sheets and tapes on the floor

7 Ventilation, heating and cooling system





Ground floor plan – Ventilation, heating and cooling system



First floor plan - Ventilation, heating and cooling system

The supplementary energy supply to the solar inputs, which are the main source of the passive house, consists of a multi-split air-to-air heat pump air conditioning system integrated with the CMV. This ventilation, heating and cooling system is of the centralized type, with 3 supply plenums recessed in the false ceilings of the corridors and bathrooms, and with a high-efficiency heat recovery unit (86%). It allows each unit to be managed independently to achieve the desired temperature in each room or only in the rooms where it is needed. The heat pump is DAIKIN multisplit 4MXM80 combined with ducted machinery by Daikin mod. FBA50A/FBA35A. The heat recovery unit is the Zehnder ComfoAir Q350 type. As far as the production of domestic hot water is concerned, there is a heat pump water heater mod Daikin EKHHP-A2V3 with a 300 l storage tank + ECH2O split ERWQ02AV outdoor unit combined with the photovoltaic solar system.

8 Electrical systems

The building is connected to the electricity grid but equipped on the roof with a system of 15 photovoltaic solar panels combined with the heat pump to serve the production of DHW. The plant has a power of 5.85kW and guarantees coverage from renewable sources of 77% of the needs.


9 PHPP calculations

PHPP version 9 was used for this project. Results are summarized below:

Verifica Passivhaus			
Foto o disegno		Edificio: Edificio residenziale Baggi	
		Via: Via Rinada	
		CAP/Città: 24020 Torre Boldone	
		Provincia/Paese: Bergamo IT-Italia	
		Tipo di costr.: Casa unifamiliare	
		Set dati climatici: IT0027a-Bergamo	
		Zona climatica: 4: Caldo temperato	Altitudine: 296 m slm
		Committente/i: Liliana Baggi	
		Via: Via Rinada	
		CAP/Città: 24020 Torre Boldone	
		Provincia/Paese: Bergamo IT-Italia	
Architetto: Dott. Arch. Marco Celeri		Termotecnico/a: EnerGi - Ing. Simone Giulianelli	
Via: Via Rinada, 7		Via: Via Toscanini, 31	
CAP/Città: 24020 Torre Boldone		CAP/Città: 61122 Pesaro	
Provincia/Paese: Bergamo IT-Italia		Provincia/Paese: Pesaro Urbino IT-Italia	
Consul. energ.: ZEPHIR Passivhaus Italia		Certificazione: Hellenic Passive House Institute	
Via: Via Pennella, 51/A		Via: Tz.Alevizatou 64	
CAP/Città: 38057 Pergine Valsugana		CAP/Città: Papagou	
Provincia/Paese: Trento IT-Italia		Provincia/Paese: Attiki GR-Grecia	
Anno di costr.: 2021	Temperatura interna inverno [°C]: 20,0	Temp. interna estate [°C]: 25,0	
Nr. unità abitative: 1	Apporti termici interni (Appl) - riscaldamento [W/m²]: 2,3	Appl - raffrescam. [W/m²]: 2,3	
Nr. di persone: 3,2	Capacità specifica [Wh/K per m² di S _{utile}]: 100	Raffrescamento meccanico: x	

Indici riferiti alla superficie utile netta				Criteri		Conseguito? ²
				alternativi		
Riscaldamento	Superficie utile netta m²	255,0				sì
	Fabb. termico annuo per risc. kWh/(m²a)	13,98	≤	15	-	
	Carico termico W/m²	11	≤	-	10	sì
Raffrescamento	Fabb. frigorifero e di deumidif. kWh/(m²a)	6	≤	15	15	sì
	Carico frigorifero W/m²	7	≤	-	10	
	Frequenza di surriscaldamento (> 25 °C) %	-	≤	-	-	-
	Freq. superam. benessere igrometrico (> 12 g/kg) %	1	≤	10	-	sì
Tenuta all'aria	Risultato test Blower-Door n ₅₀ 1/h	0,6	≤	0,6	-	sì
Energia primaria non rinnovabile (EP)	Fabbisogno EP kWh/(m²a)	68	≤	-	-	-
Energia prim. rinnovabile (EPR)	Fabbisogno EPR kWh/(m²a)	32	≤	60	60	sì
	Prod. di energia rinn. (rif. impronta sostenibile) kWh/(m²a)	30	≥	-	-	

² cella vuota: Dati mancanti; "-": nessun requisito

Confermo che i valori inseriti sono stati determinati in accordo alla procedura di calcolo del PHPP sulla base dei valori caratteristici dell'edificio. Si allegano alla presente verifica i calcoli ottenuti con il PHPP.				Passivhaus Classic?	sì
Ruolo	Nome	Cognome	Firma		
2.Certificatore	Stefanos	Pallantzias			
ID Certificato	Rilasciato il	Luogo			
	16/02/23	Athens, GREECE			

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ ΚΑΙ ΚΛΙΜΑΤΟΣ
ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΚΑΛΩΣ ΕΛΘΟΝΤΩΝ
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Extract from Verification sheet in PHPP

10 Construction costs

The overall construction cost of the building was particularly challenging partly due to the design choices related to the site (very articulated geometry of the building, complexity of the construction site with excavation plans on several levels and at different times), partly due to the use of particularly valuable coatings and/or finishes (e.g. cladding of local stone and ventilated facades, high quality of plasterboard finishes to ensure the highest high visual requirements, outdoor spaces and garden).

Mainly, however, the high cost is due to the unpredictable global increases in the prices of raw materials and semi-finished products recorded during the period of the Covid pandemic (2020-2021) during the construction phase of the building. This has led to a lengthening of construction times and, in some cases, to surcharges of 30% (e.g. construction iron, wood, etc.).

Considering only the costs related to the structural and insulation part of the house, on the other hand, it is evident that the wall package consisting of a structure with thin beams and internal insulation of straw bales with a plaster fiber slab and cladding has a rather affordable cost per square meter compared to other construction systems.

Anyway, the annual operating costs of the passive house proved to be very low and more convenient compared to those relating to other solutions initially less expensive but less performing.