D5.15 - Envelope components for on-field demonstration III

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Deliverable Information Sheet

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History of changes

Version	Date	Comments	Main Authors
0.1	12/08/2024	First draft, establishing document structure	S. García, J. García, A. Llamas, R. Menor, F. Gabaldón, A. Saráchaga (GAR)
0.2	27/08/2024	First version, incorporating input from all participants	S. García, J. García, A. Llamas, R. Menor, F. Gabaldón, A. Saráchaga (GAR)
0.3	02/09/2024	Quality review	L.Vanhoutteghem
1.0	27/09/2024	Final version addressing all further comments	L. Maestri (ZH) A. Llamas, A. Saráchaga (GAR)

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Disclaimer

1. Executive summary

This document provides an overview of the RE-SKIN envelope components designed for on-field demonstration, detailing their manufacturing status and intended deployment. The content presented in this document represents an advancement from the content found in D5.14 Envelope components for on-field demonstration II.

The technological components described in this deliverable are designed for the cladding, insulation and waterproofing of façades and pitched roofs as developed within the RE-SKIN project, while also providing ventilation of the cavity.

After conducting a thorough analysis to integrate the multifunctional façade cladding and BIPVT roof with other building components, the design phase is now complete. Different solutions have been developed and manufactured to allow the integration of envelope technologies with RE-SKIN components and existing building elements. Nevertheless, some components may still undergo updates to further optimize them as the project progresses and to adapt to the next demonstration cases, if necessary. The system concept for the façade has been enhanced to facilitate the integration of wiring, pipes, vents, and sensors. This design also incorporates an adaptable sealed chamber that can be opened in warmer seasons to facilitate air circulation, preventing moisture and heat buildup, or closed to maintain the building’s internal temperature in colder seasons. This innovative approach creates a holistic building envelope design that optimises hygrothermal performance. For the BIPVT roof, the design of the structure that integrates the PV modules and insulation panels, based on a combination of curtain wall and ventilated roof systems, has been finalised and manufactured.

The components are currently at various stages of production and are being dispatched to the first-case study building in Milan.

An additional version of this report is scheduled for release in month 29. This deliverable will incorporate further specifications and/or modifications based on the project’s progress.

2. Multifunctional façade cladding

The multifunctional façade consists of self-supporting sandwich panels and a substructure, designed to enhance energy performance and reduce environmental impact. The detailed description of the RE-SKIN façade system can be found in deliverable D5.3 Manufacturing Design of the Multifunctional Façade Cladding III.

Specifically, the system replaces conventional insulation with bio-based PUR foam and standard metallic coatings with sustainable steel. Recycled aluminium profiles and optimized assembly processes further contribute to its sustainability and cost-effectiveness. All metal components are recyclable, and panels and profiles are potentially reusable. Life-cycle assessment details will be available in the deliverable D7.1 Circular economy evaluation procedure/tool, which is scheduled for submission in Month 20.

For the first demo case, a final manufacturing design layout was developed, followed by prototype creation and foreseen testing to evaluate technical performance and ensure regulatory compliance. Part of this testing work is part of WP3, focusing on long-term reliability and resilience, with testing procedures outlined in deliverable D3.1. Test results will be included in D3.6 Lab Testing Report II and D3.7 Lab Testing Report III. Additionally, WP2's Task 2.6 is assessing the system's physical vulnerability to various hazards.

Detailed drawings of the Milan demonstration façade connections are provided in Annex 4.3. The manufacturing of the façade panels is currently underway. The steel thickness for the panels has been optimized to prevent damage, maintain a smooth surface, and facilitate ease of handling during installation. The substructure elements have been prototyped, tested at GAR facilities, produced, and are ready for dispatch to the first demonstration case.

The multifunctional façade system is comprised of different components:

Substructure	Cover	Insulation	Auxiliary

• Brackets
• Profiles
• Fixings
• Clamps
	• Metallic insulated sandwich panel
	• Metallic veneer
	  • Corners
	  • Windows (jambs, lintels, windowsills)
	  • Doors (jambs, lintel)
	  • Eaves
		• BioPUR in sandwich panels
		• Mineral wool
		  • Panels
		  • Jambs
		  • Lintels
		  • Windowsill
		• PIR sealing
			• Sealing
			• Rubber strip
			• Coupling ducts system
			• Ventilation grilles with damper
			• Drainage grid

In the following, these components are described and illustrated in detail. Later, the systems reaction to fire, façade aesthetics and panel distribution are discussed.

2.1. Substructure

The substructure for panel installation includes brackets, profiles, fixings, and clamps. The assembly process involves attaching brackets to the façade walls with fixings and plugs, securing upright profiles to the brackets, and mounting the panels, with the vertical profiles guiding the panel installation.

The substructure elements for the Milan demonstration case have been manufactured and machined and are ready for dispatch. An installation guide has been developed to facilitate the installation process, which can be found in Annex 4.4.

Before installation, a pull-off test (dynamometric) assesses wall tensile strength and fixing load capacity to determine the appropriate anchoring method. This test is required for all demos to ensure sufficient wall resistance, and is detailed in deliverable D5.3 Manufacturing Design of the Multifunctional Façade Cladding III.

Figure 1. Dynamometric test being performed in the Milan demonstration building

2.1.1. Brackets

Brackets of various shapes, made from 98% recycled aluminium and stainless steel, were manufactured to accommodate different connection types and span lengths (Figure 22).

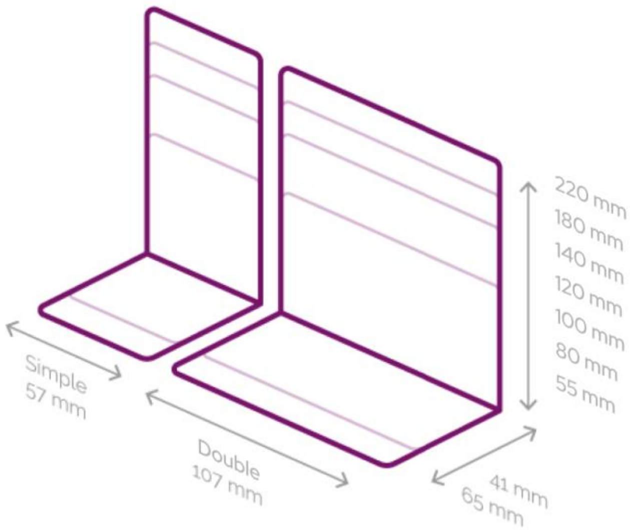


Figure 2. Bracket dimensions for different span lengths

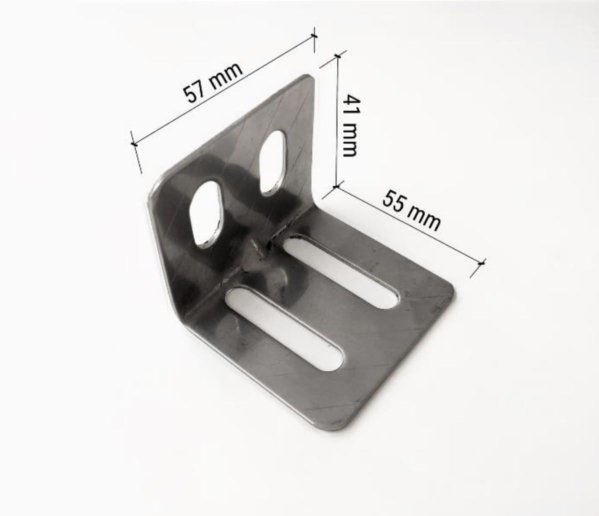


Figure 3. Simple bracket length 55mm

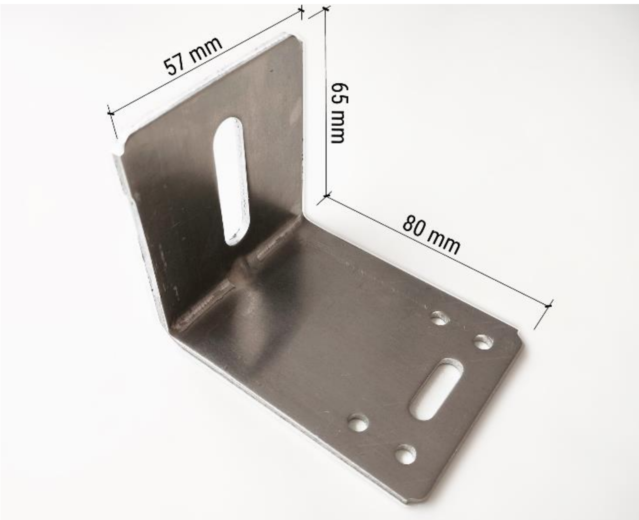


Figure 4. Simple bracket length 80mm

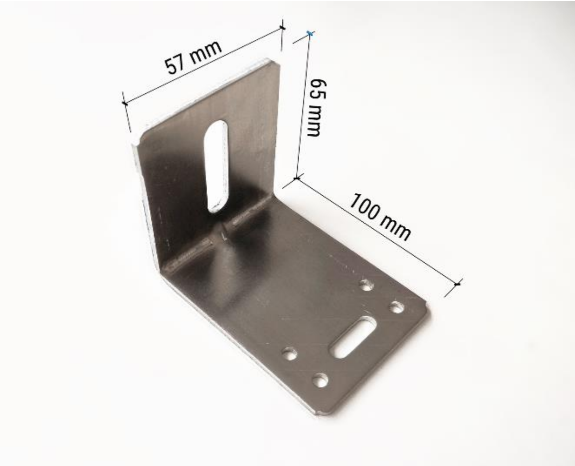


Figure 5. Simple bracket length 100mm

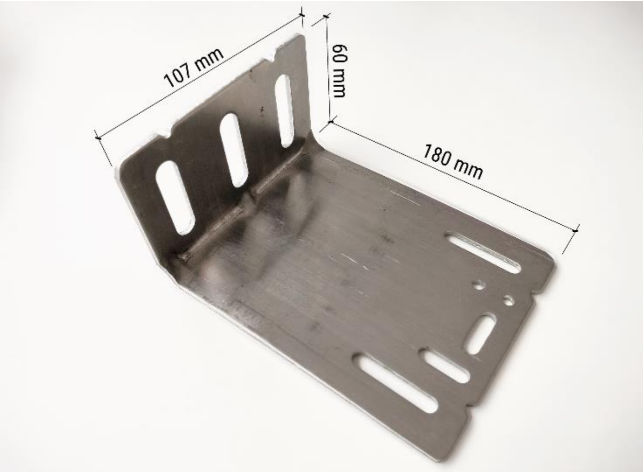


Figure 6. Double bracket length 180mm

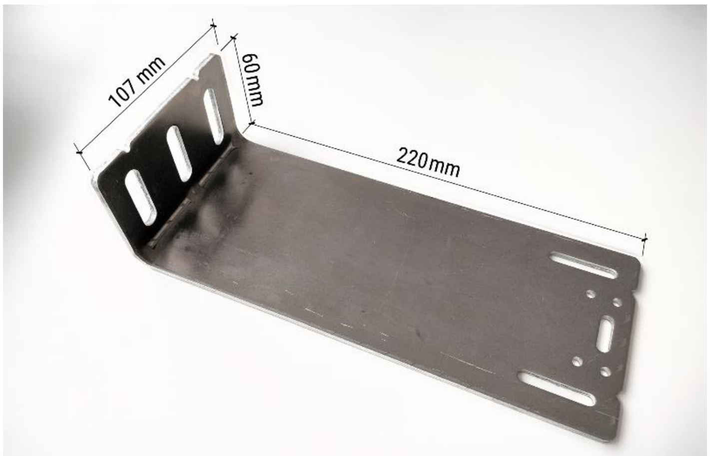


Figure 7. Double bracket length 220mm

The connection point between profiles, see next chapter, was enhanced to minimize installation time; see Figures 8 to 12. It consists of a bracket (1), a vertical profile (2), and an adjustable piece (3). This piece facilitates connections with large air chambers (depth > 50 mm) and allows profile-to-profile connections.

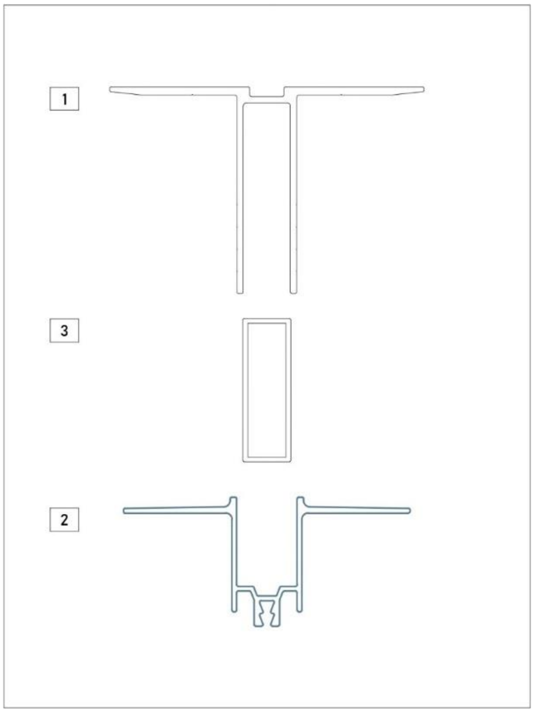


Figure 8. Components for the connection of the vertical profile to the façade [drawing created using AutoCAD]

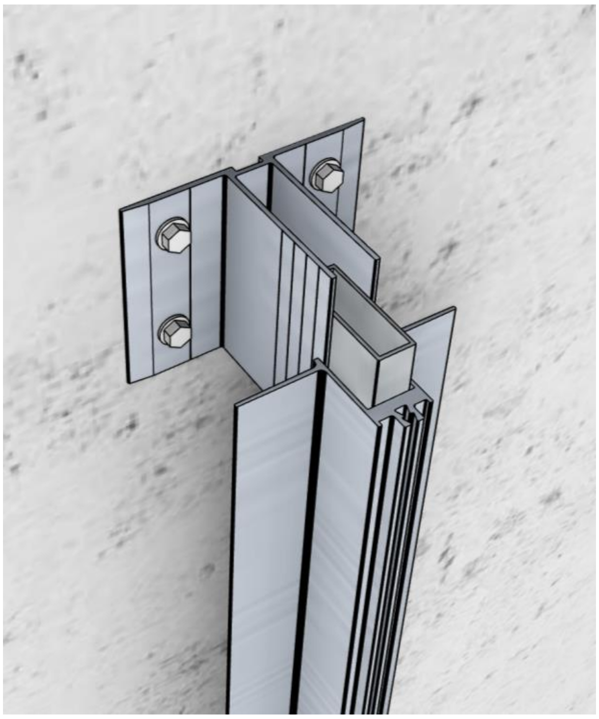


Figure 9. 3D view of the pieces connected [drawing created using SketchUp]

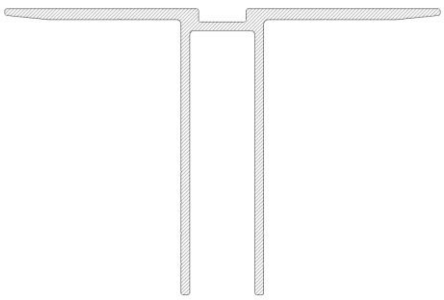


Figure 10. Detail drawing of the façade system's bracket [drawing created using AutoCAD]

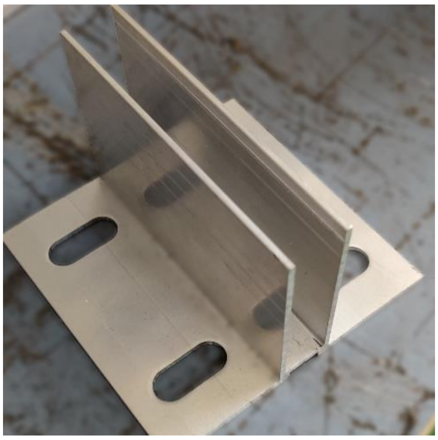


Figure 11. U-shaped bracket for horizontal connection

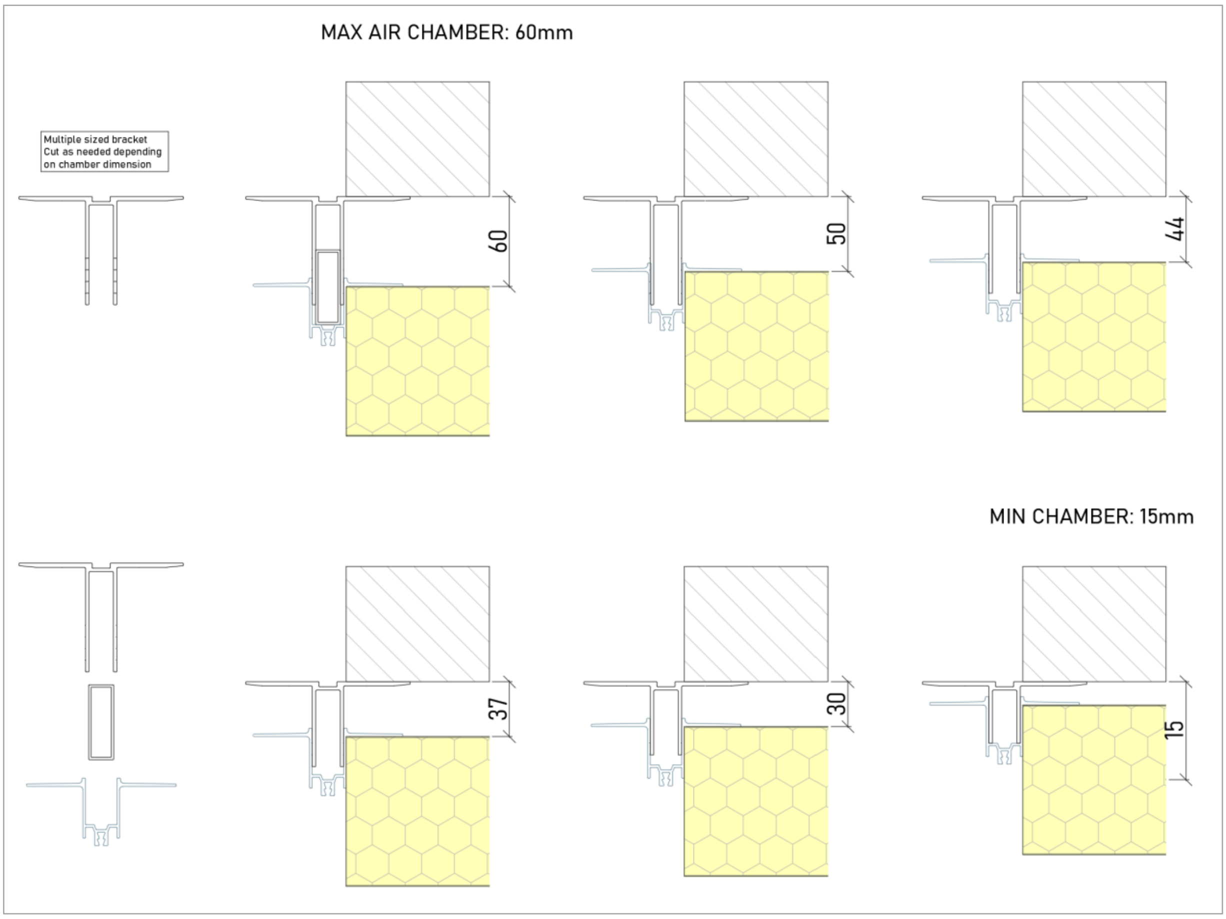


Figure 12. Vertical connection adapted to the size of the chamber [drawing created using AutoCAD]

When the air gap exceeds 35 mm, either to accommodate the installation of ducts and wires required by RE-SKIN project devices and units or to address uneven surfaces, reinforcement brackets must be installed before anchoring the panels, see Figures 13 to 16. These brackets extend an additional 40 mm and are also recommended in areas where the support wall fails the pull-off test, indicating insufficient strength.

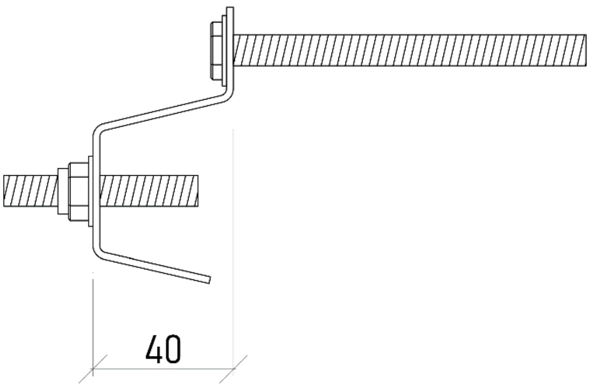


Figure 13. Reinforcement bracket 40mm distance

Figure 14. 3D view of reinforcement bracket

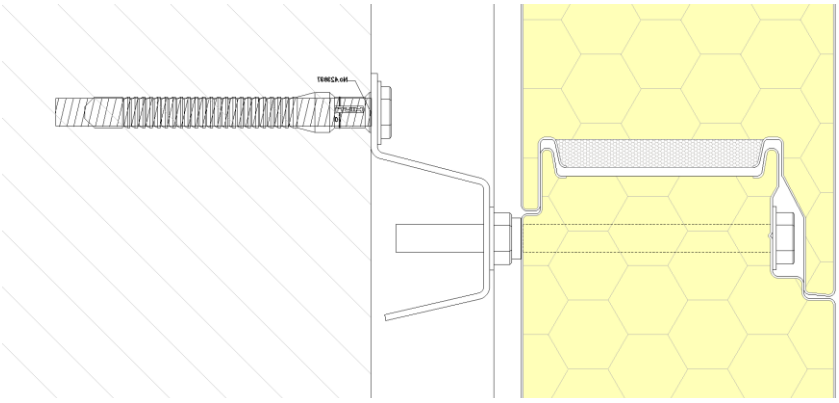


Figure 15. Vertical section of reinforcement bracket

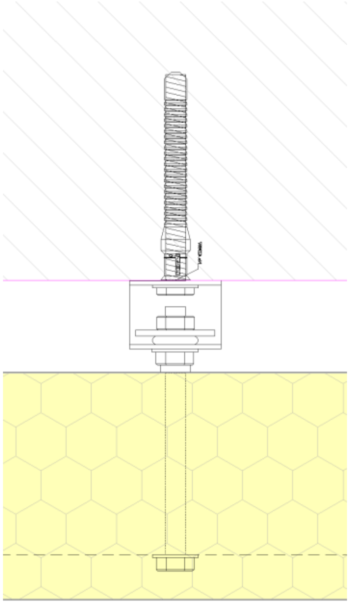


Figure 16. Horizontal section of reinforcement bracket

Thermal insulation pads will be installed with the brackets to prevent thermal bridging between the metallic brackets and the wall, see Figure 17.

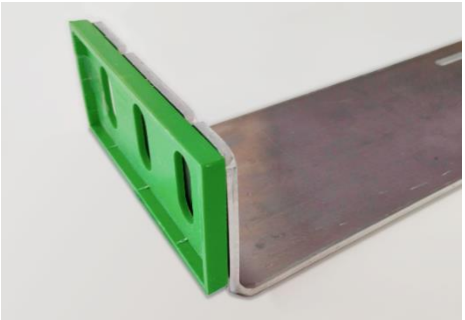


Figure 17. Thermal insulation pad to separate the bracket from the wall

2.1.2. Profiles

A dedicated extrusion die was developed to produce vertical profiles, also made from 98% recycled aluminium. The profile manufacturer, Exlabesa, tested the profiles to ensure that the extruded profile met the dimensions defined in the design plan, then adjusted and manufactured them to match the chosen sandwich panel thickness (100 mm) for all demonstration cases of the project.

There are various vertical profiles utilized in the system, as illustrated in the figures below. Additionally, a horizontal starting profile is implemented at the base of the assembly to secure the panels. The connection detail beneath the roof is yet to be defined, and no profiles are incorporated at the corners of the façade.

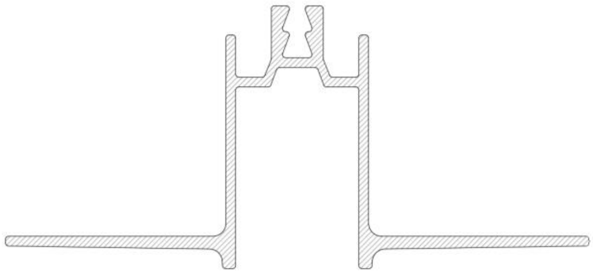


Figure 18. Detail drawing of profile [AutoCAD]

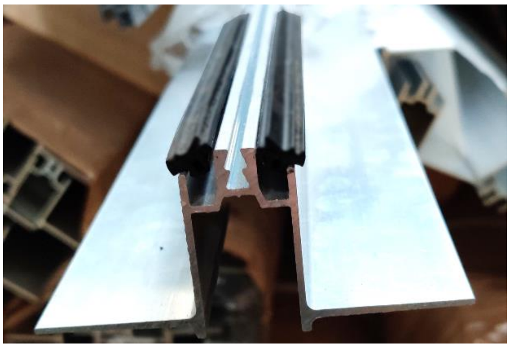


Figure 19. Vertical profile for connection

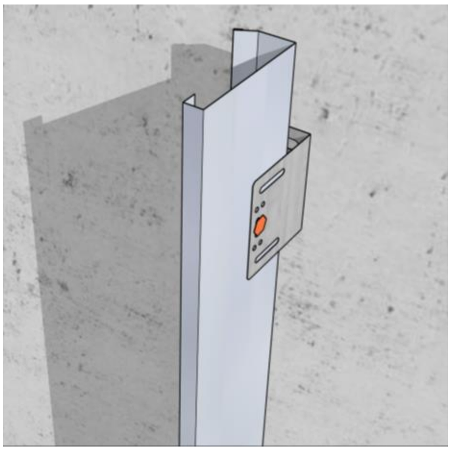


Figure 20. 3D view of vertical profile and bracket

Figure 21. Vertical profile

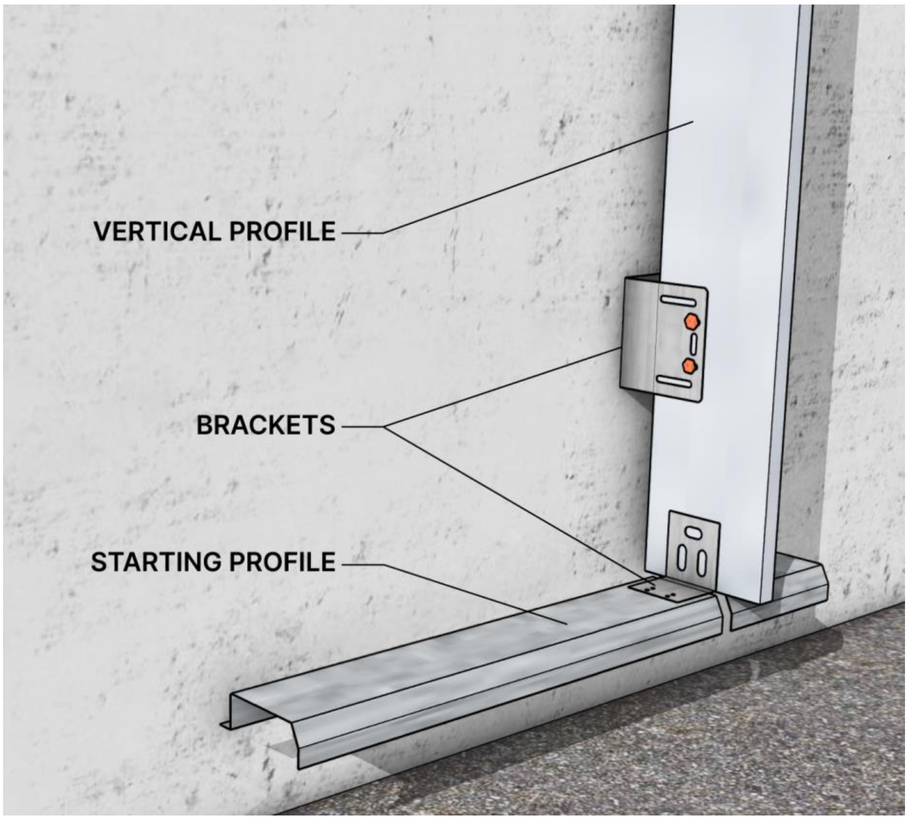


Figure 22. 3D view of horizontal starting profile of the system

2.1.3. Fixing elements

The fixing elements include various types of screws, interior and exterior spacers, and pop rivets. The installation instructions specify the locations where screws and structural rivets are applied. Based on the pull-off test results (guide outlined in Annex I of D5.3) mechanical anchoring is used when the supporting walls demonstrate sufficient tensile strength. If the walls do not meet the required strength, chemical anchoring is employed. This method involves injecting resin into a specially designed plug within a pre-drilled hole. The resin then expands and hardens around the screw, forming a strong bond with the substrate for secure attachment.

Figure 23. Self-tapping screw

Figure 24. Structural rivets

Figure 25. HILTI HRD or similar fastening screw with insulated plastic anchor

Figure 26. Screw secured using chemical anchoring

Figure 27. Interior spacer

Figure 28. Exterior spacer

2.2. Sandwich panels

As detailed in deliverable D5.3 Manufacturing Design of the Multifunctional Façade Cladding III, the sandwich panels consist of a GreenCoat sustainable steel from SSAB, and bio-based polyurethane (BioPUR) foam core from project partner INDRES. The panels are installed in rows, aligned with the vertical profiles that ensure they remain perfectly vertical. They are positioned from bottom to top, secured to the existing wall using brackets and plugs, see Figures 27 and 28. The panels are joined via a tongue-and-groove system as described in Chapter 2.1.1, which covers the substructure and fixing elements.

The manufacturable thickness of the panels ranges from 60 to 250 mm, with 100 mm chosen for the façade in all demonstration cases of the project. The panel width is standardized at 1000 mm to match the standard steel coil width, while the length is adjustable from 250 to 6000 mm based on project requirements. Panels can be produced up to 6000 mm long, but for façade installation, it is advisable to limit their length to 4000 mm. This helps prevent problems with expansion, dimensional stability, and strength. As demonstrated by tests conducted by LATTONEDIL. The tests confirmed that panels within the recommended length maintained stable mechanical properties, including tensile strength, thermal conductivity, and dimensional stability, ensuring suitability for the intended façade application (refer to Annex 4.1 for detailed test results).

At the time of writing this deliverable, the sandwich panels are in production. Upon receipt, GAR will handle the necessary machining for assembly, after which the panels will be dispatched to the first demonstration case in Milan. Additionally, a mock-up will be sent to DTI for testing and validation.

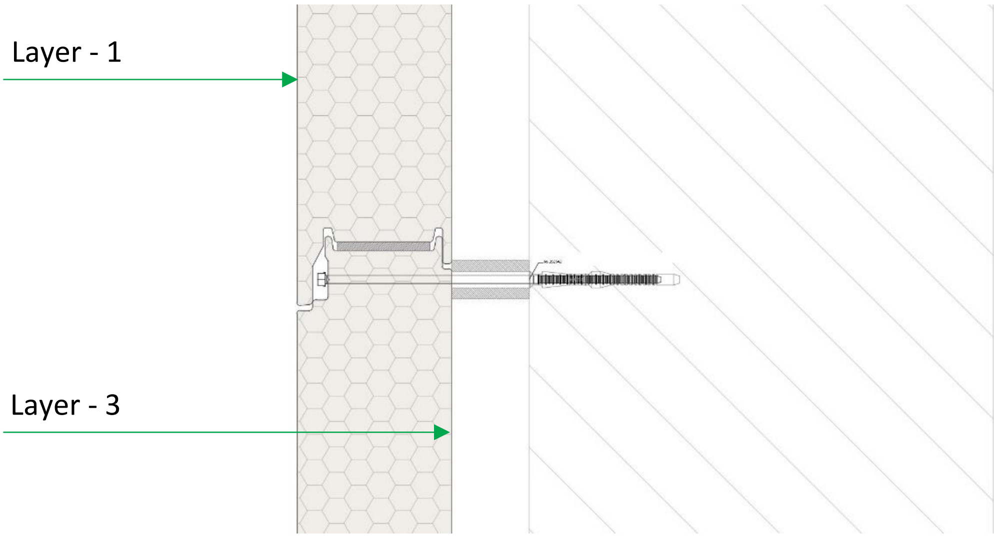


Figure 29. Preliminary sandwich panel design [drawing created using AutoCAD]

The GreenCoat outer steel layer, produced by SSAB, is a 0.7 mm thick sustainable steel coated with rapeseed oil-based paint, enhancing sustainability by replacing fossil oils. This steel is also used for manufacturing finishing elements around corners, windows, and doors. The inner steel layer, 0.45 mm thick, is not exposed to external conditions, and therefore not coated. The sandwich panel provides both thermal insulation and weatherproofing, utilizing BioPUR foam, a versatile bio-based insulation material, as described in deliverable D5.2 Manufacturing Design of the Multifunctional Façade Cladding II.

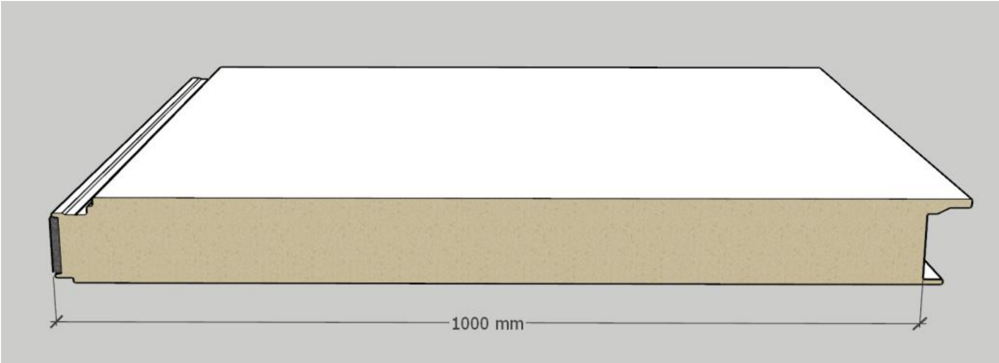


Figure 30. Sandwich panels made from BioPUR [drawing created using SketchUp]

2.2.1. Finishing elements

Steel veneer sheets are applied as the final covering at singular points, such as windows, corners, and at the bottom and top of the system. The metallic sheets will be sent to GAR facilities for machining customised lintels and jambs for doors and windows, as well as windowsills, eaves, gables, and rain gutters, all tailored to each pilot building.

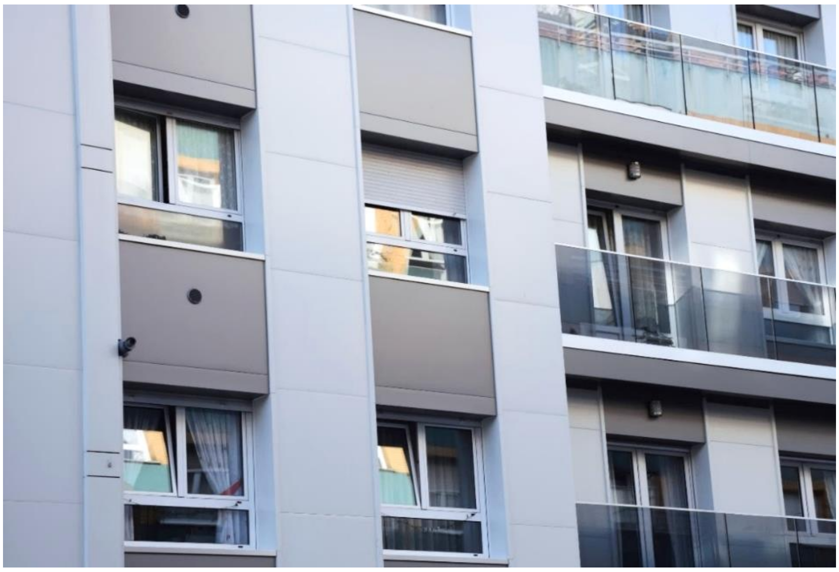


Figure 31. Several finishing elements on a completed façade installation by GAR (Image source: GAR)

2.2.2. Auxiliary elements

The installation of the façade system requires several additional components, including various sealing and rubber strips for connections at windows and doors.

Figure 32. Insulation and waterproofing layer on a window perimeter

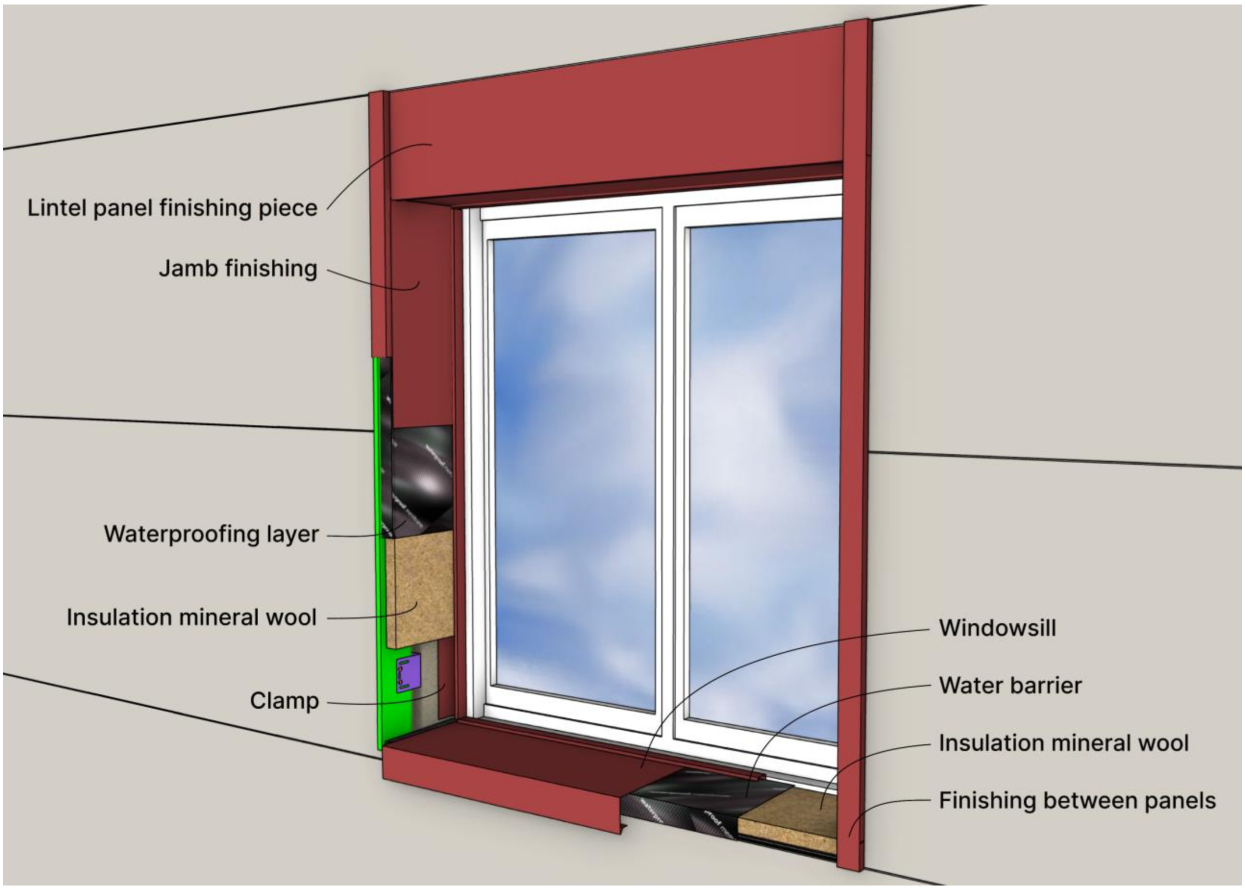


Figure 33. 3D view of window components

Manually operable round ventilation grilles with damper, 125 mm in diameter, and made from stainless steel, will be integrated at both the base and the top of the façade as part of the adaptable sealed chamber solution to enhance airflow and thermal performance in warmer seasons. The grilles are commercially available products and ensure effective air intake and exhaust, while also preventing water ingress and debris. For further details on the adaptable sealed chamber, see deliverable D5.3.

Additionally, coupling duct components will be incorporated into the air chamber to facilitate the routing of wires and pipes within the system. A drainage grid will be installed at the base of the system, along with mineral wool. The mineral wool will assist in water drainage while also minimizing heat loss and thermal bridging.

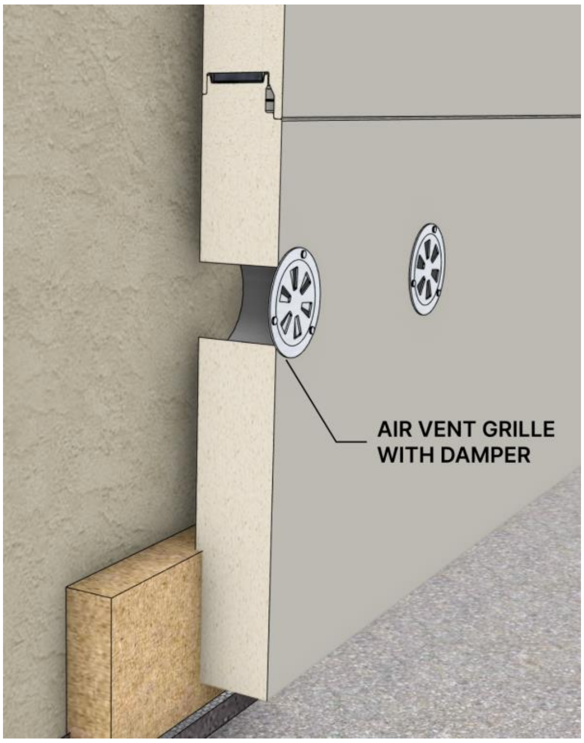


Figure 34. 3D view of air vent grilles with damper [SketchUp]

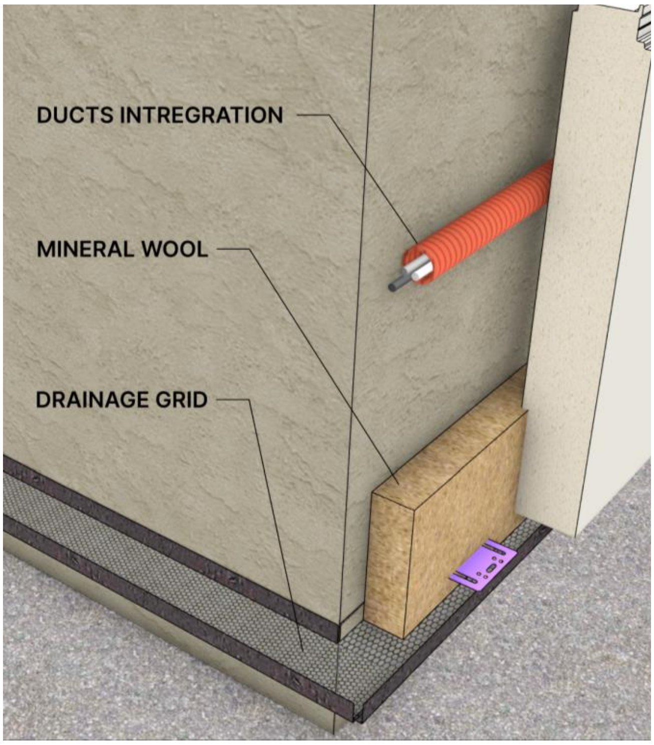


Figure 35. 3D view of the façade system start [SketchUp]

The following section provides a table with a detailed inventory of all components comprising the multifunctional façade cladding system, accompanied by their respective technical specifications.

2.3. List of façade system elements

Below is the list of components comprising the system that will be shipped and provided to the demonstration buildings.

To facilitate assembly, the installation process is divided into different stages. Each stage is clearly numbered in the installation guide drawings to help quickly identify components by their corresponding zones, making the installation process more efficient. For detailed installation instructions specific to the Milan demonstration case, please refer to the installation manual provided in Annex 4.4. The dimensions provided in the installation manuals are approximate, as adjustments may need to be made on-site to match the actual dimensions by the installers.

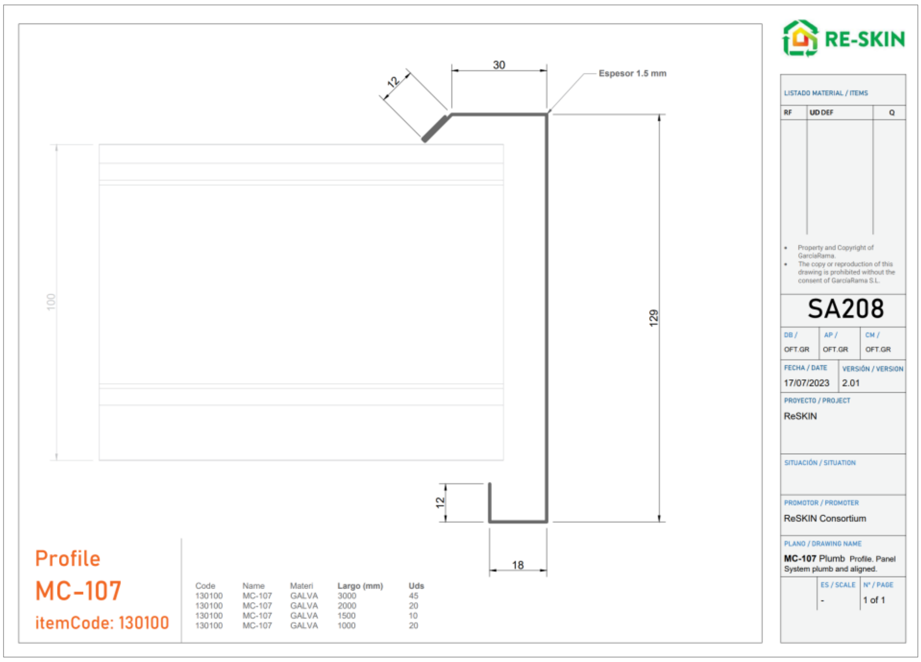


Figure 36. Example of numbering code on vertical profile for manufacturing

1	Panel	
item	*Name*	*Description*
1.1	Layer - 1	GreenCoat sustainable steel base with protective zinc layer and bio-based colour coating for external layer.
1.2	Layer - 2	100 mm BioPUR insulation. Lambda (λ) 0.022 W/mK
1.3	Layer - 3	Steel layer with protective primer for galvanic neutrality and adhesion
1.4	Spacers	Galvanised steel Z275 of 1 mm, shaped

2	Substructure	
item	*Name*	*Description*
2.1	Upright profile for plumb	Galvanised steel Z275 of 1.5 mm perforated sheet metal (3000mm)

2.2	Upright profile for junction	Galvanised steel Z275 of 1.5 mm perforated sheet metal (3000mm)
2.3	Upright profile for clipped junction	Recycled aluminium 6063, 2 mm. Length on demand.
2.4	Stop piece for panels	Recycled aluminium of 1.5 mm
2.5	Initial Profiles	Galvanized steel Z275 of 1.5mm.
2.6	Connection initial Profiles	Galvanized steel Z275 of 1.5mm.
2.7	Fixings	Galvanised steel screws, M8 and length on demand up to 230 mm.
2.8	Adjustable washer for fixings	Polypropylene
2.9	Underlay of fixing brackets	Polyamide or polyethylene
2.10	Structural pop rivets	Ø4.8 mm. Aluminium or steel, on demand.
2.11	Supporting brackets	Galvanised steel Z275 of 1.5 mm shaped. Length on demand, up to 230 mm.
2.12	Reinforcement brackets	Galvanised steel Z275 of 1.5 mm shaped. Length on demand, up to 230 mm.
2.13	'U' shaped brackets	Recycled aluminium 6063 2 mm. Length on demand, up to 230 mm.
2.14	Snap-caps, plugs and washers	Steel, aluminium, polypropylene, polyamide
2.15	Joints	EDPM, polyamide
2.16	Auxiliary material	Steel, aluminium, polypropylene, polyamide

3	**Finishing trims, covers and sealings**	
item	*Name*	*Description*
3.1	Jambs	Steel base with protective zinc layer and bio-based colour coating.
3.2	Windowsill	Natural anodised aluminium 20-30 microns.
3.3	Lintels	Steel base with protective zinc layer and bio-based colour coating.
3.4	Cover for vertical grooves, panel connection.	Steel base with protective zinc layer and bio-based colour coating.
3.5	Clamp receiver-regulator	Steel base with protective zinc layer and bio-based colour coating.

3.6	Finishing trim at start	Steel base with protective zinc layer and bio-based colour coating.
3.7	Finishing trim at sides	Steel base with protective zinc layer and bio-based colour coating.
3.8	Finishing trim at corners	Steel base with protective zinc layer and bio-based colour coating.
3.9	Finishing trim at top	Steel base with protective zinc layer and bio-based colour coating.
3.10	Auxiliary supports	Aluminium 6063 1.8 mm, length on demand up to 120 mm.
3.11	Fixings	Screws with striking system. Galvanised steel, M (Metric) Ø5.5 mm x 65 mm and polyamide anchor.
3.12	Structural pop rivets	Ø4.8 mm. Aluminium or steel, on demand.
3.13	Neutral silicone	Silicone sealing, neutral type, high range.
3.14	Structural silicone	Silicone of structural joints, high range.
3.15	Insulation on windows	Mineral wool boards 40mm for window perimeter
3.16	Draining barrier	Mineral wool 50mm

4	**Auxiliary**	
item	*Name*	*Description*
4.1	Supporting ducts strip	Supporting strip with clips for ducts of various installation. Z275 galvanised steel.
4.2	Holder	Supports for auxiliary installations and probes. Galvanised steel or aluminium.
4.3	Ventilation extensions	Aluminium, polypropylene, polyethylene.
4.4	Air Vent Grille	Stainless steel ⌀125mm with damper for facade ventilation
4.5	Drainage grid	Galvanised steel Z275 of 1.5 mm perforated sheet metal (3000mm)
4.6	Auxiliary profile for drainage grid	Galvanized steel Z275 of 1.5mm. Shaped.

2.4. Fire reaction

The façade system consists of sandwich panels and a substructure, primarily made from steel or aluminium, both classified as A1 (EN 13501-1) for non-flammability. Construction solutions and connections have been optimized for faster installation without altering material composition.

All GreenCoat components (steel layers for the sandwich panels) are fire-rated A1 s1 d0.

The sandwich panel manufacturer performed internal fire tests (Piccola Fiamma test) on RE-SKIN roof panels, similar in composition to façade panels but differing in thickness and joint design. These tests, while not standardized, align with UL94 standards for flammability. For further information, see deliverable D5.3.

Key findings include:

- The panels generally self-extinguish quickly, aligning with UL 94 V-0.
- Variations in smoke and flame height correspond to UL 94 classifications (V-0, V-1, V-2).

These tests are performed for characterization, not certification. Future façade panels incorporating more fire retardant in the BioPUR formulation, will undergo standardized testing, aiming for a B-s1-d0 Euroclass rating. Already performed flammability tests on BioPUR foam at INDRES achieved a V-0 classification. Full fire reaction testing of the panels will be conducted during the next manufacturing run, which is currently in progress.

2.5. Panel Distribution and Façade Aesthetics

The façade layout was finalized by taking into account all relevant factors, including material specifications, installation logistics, and stakeholder input.

A 3D interactive model was developed using SketchUp to facilitate communication between the partners and the installation company, enhancing understanding and streamlining the installation process. The finalized façade layout for the Milan demonstration building can be found in Annex 4.2. This layout was refined through close collaboration with ZH, POLIMI, and CdM, ensuring that both functional and architectural standards were met. Feedback from the building's owner and users was actively integrated into the decision-making process.

As previously described, the outer layer of the sandwich panel is composed of GreenCoat sustainable steel, manufactured by SSAB. SSAB provides a colour chart with 29 available options, with further details provided in deliverable D5.14. It is important to note that placing an order typically requires meeting a minimum quantity. This factor was considered when designing the façade layout and selecting the colours for the Milan demonstration case.

To achieve an optimal balance between architectural aesthetics and energy performance, POLIMI and GAR collaborated to select the appropriate palette and colour combinations, based on the specific aesthetic-architectural requirements and the context of the four case studies. The façade colour distribution for the Milan demonstration building is also outlined in Annex 4.2.

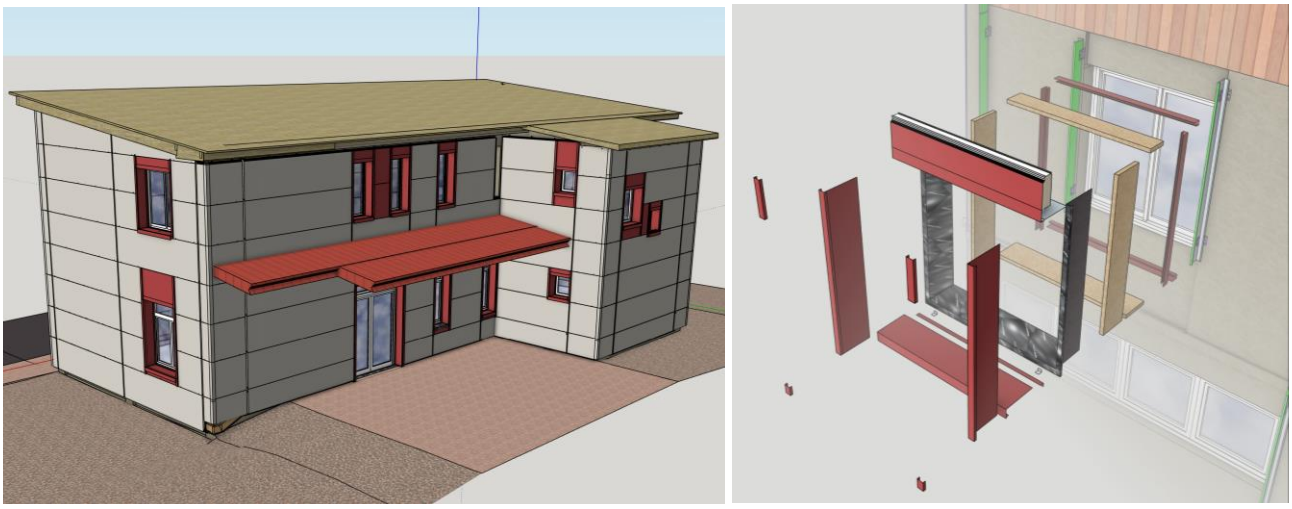


Figure 37. Images of the 3D interactive model [SketchUp]

3. BIPVT roofing system

As outlined in deliverable D5.10 Manufacturing design of the BIPVT roof system II, the BIPVT (Building Integrated Photovoltaic-Thermal) system is designed for installation on various types of sloped roofs, involving the covering of the pre-existing roof structure with the BIPVT system.

The BIPVT system's modular structure is designed to accommodate various types of refurbished PV modules. However, for each building, it requires the selection of one specific type of PV module width between each set of mullions. While different widths can be used between separate mullions, all PV modules within the same section must maintain the same width to ensure compatibility. Recycled aluminium profiles (mullions) serve as the building interface structure, housing and fixing the PV modules to the existing slab or roof framework. Positioned beneath the PV modules are the RE-SKIN sandwich panels made of BioPUR and SSAB steel, which increase radiant heat absorption and provide thermal insulation. In areas where PV modules are not intended for installation, a sandwich panel of the same thickness as the PV modules, referred to as blind panel, will be integrated into the aluminium profiles. Waterproofing is ensured by the photovoltaic modules, the blind panels, and the gaskets. An air gap is formed between the PV modules and the insulation panels. The airflow within this 80 mm gap can be generated through forced-flow or natural convection, contributing to improved electrical conversion efficiency of the PV modules by lowering the cells' operating temperature and to increase the heat pump efficiency during the winter season. In warm seasons, the ventilation also removes part of the heat load from the roof.

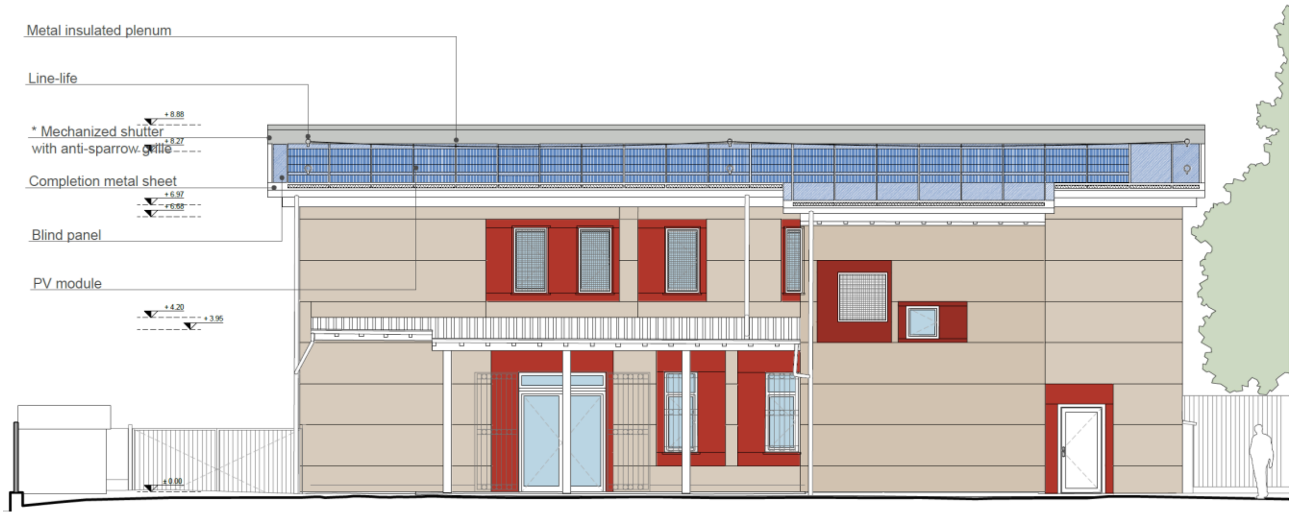


Figure 38. Elevation view of the BIPVT system installed in the Milan demonstration case.

3.1. System components

The BIPVT system consists of the following components/sections (see Figure 39):

1. Recycled aluminium mullion profiles.
2. Refurbished PV modules.
3. Air gap.
4. BioPUR thermal insulation panels.
5. Joining, sealing, finishings and fixing elements.
6. Thermal break insulation between the recycled aluminium mullion profile and the existing roof structure.

For further details, refer to deliverable D5.10 Manufacturing design of the BIPVT roof system II.

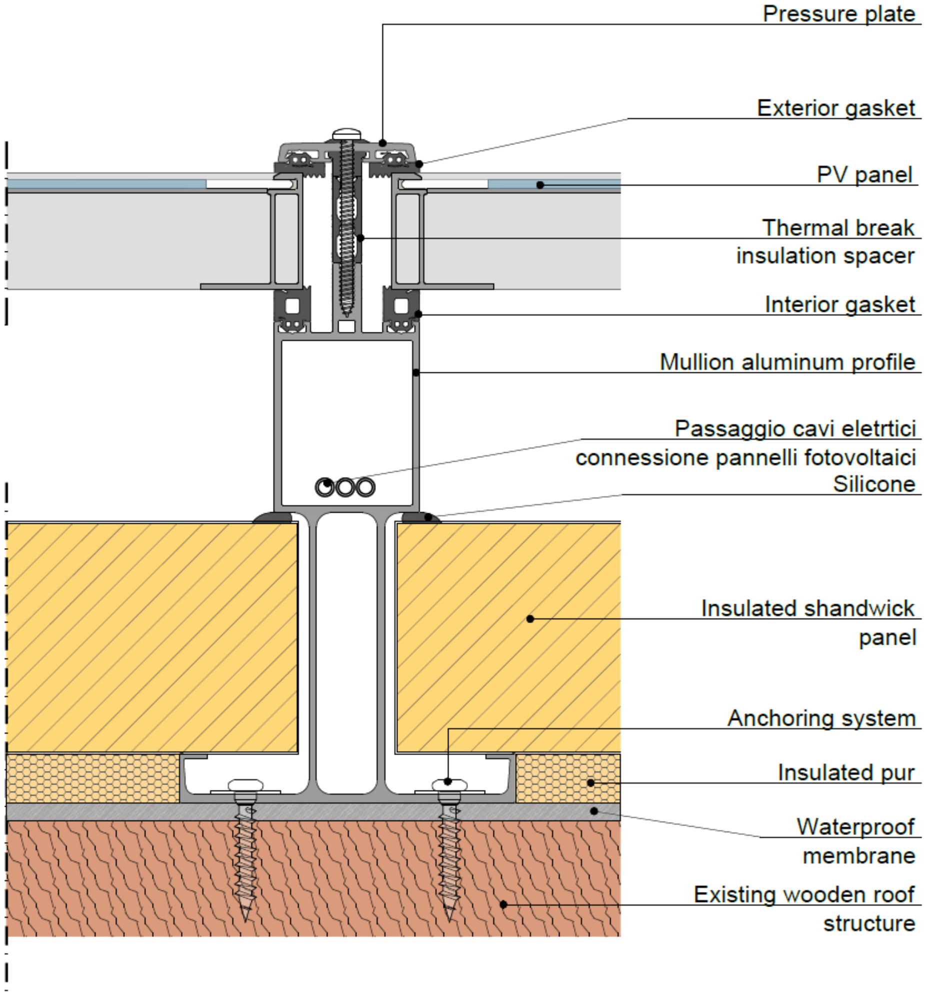


Figure 39. Cross-section of the BIPVT roof system with insulation panel [drawing created using AutoCAD]

3.1.1. Aluminium profile

The system incorporates specially manufactured recycled aluminium profiles (mullions) that serve both as support and as building-interface structure. These profiles house the PV modules, similar to curtain wall glass façades, while also providing protective enclosure for the electrical wiring. The profiles are designed with a cup-shaped cross-section and are manufactured as a single extruded piece, enabling PV module placement in the upper part, installation of insulating panels at the base, and creating an intermediate ventilated air gap. The versatile configuration of the profiles can accommodate different PV module types, allowing adjustments in width spacing, length and thickness. For fastening, various elements are employed based on the underlying structure, including self-tapping screws for wood, chemical dowels for concrete, and nuts and bolts for steel frames. The table presented in chapter 3.2 of this document outlines the specific elements intended for use in the Milan demonstration case. Further research will explore solutions tailored to the remaining specific case study applications.

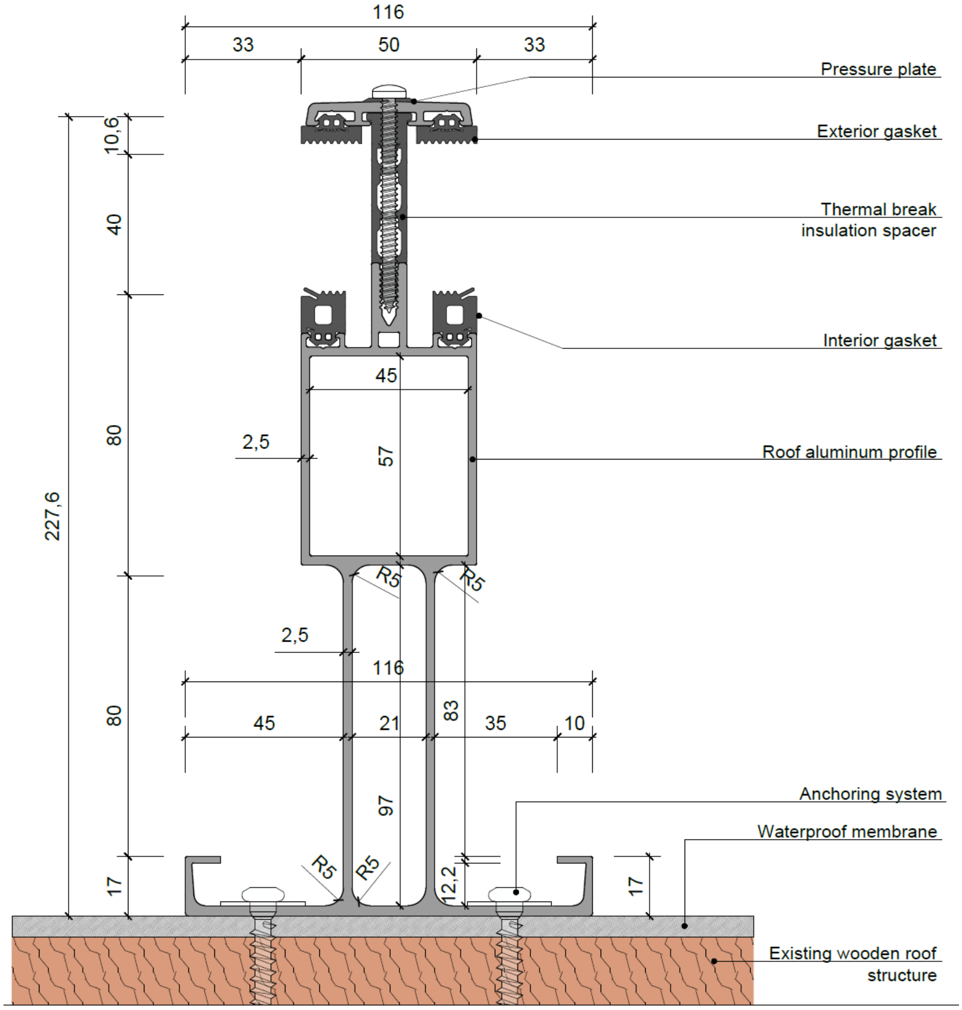


Figure 40. Cross-section of aluminium profile [drawing created using AutoCAD]

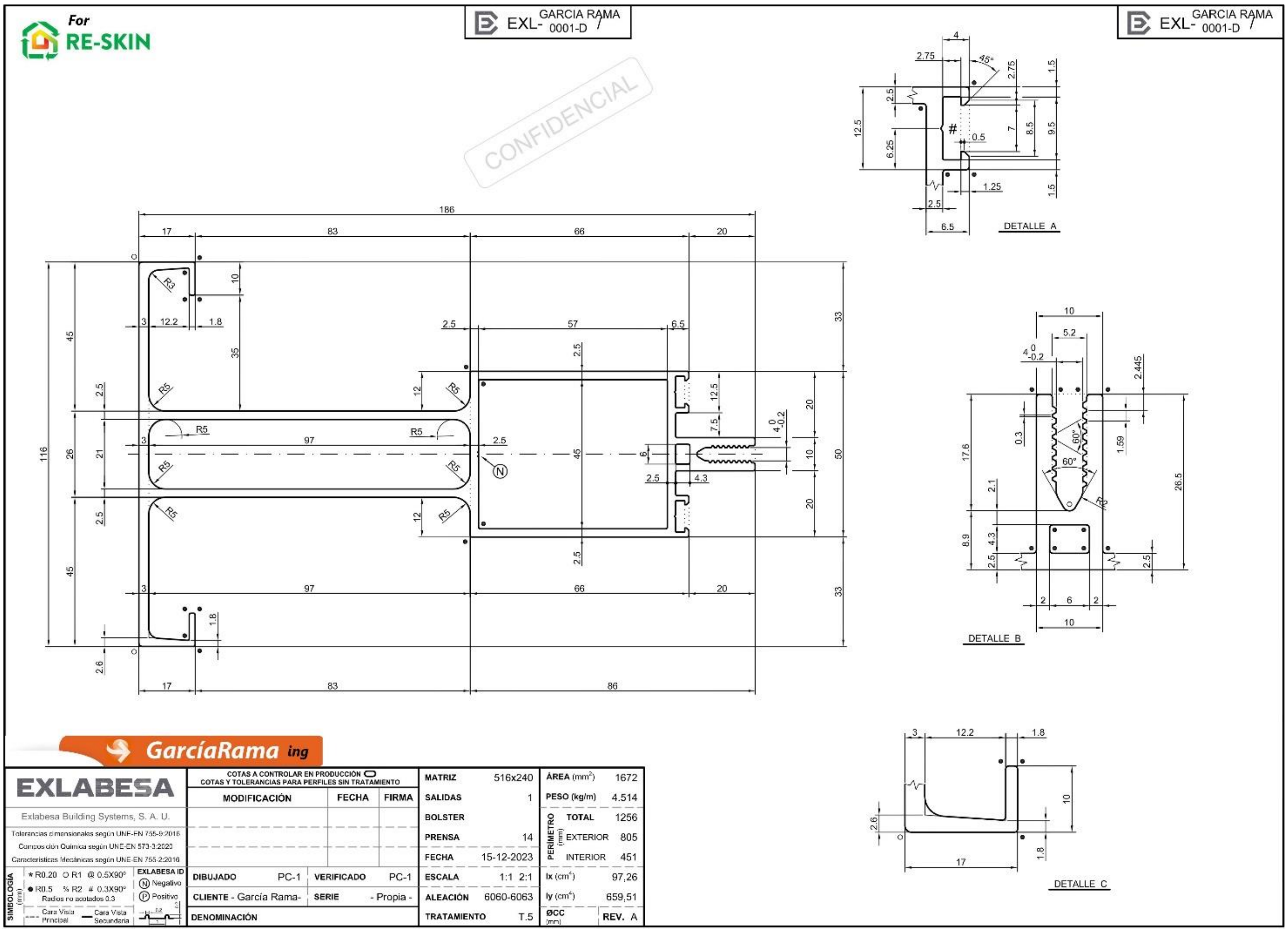


Figure 41. Drawing of the roof profile with specifications produced by the manufacturer (Source: Exlabesa)

The extrusion die for the mullion aluminium profiles was produced by manufacturer Exlabesa. The profiles were extruded accordingly and dispatched to both DTI for roof testing and the Milan demonstration case.

Figure 42. Image showing the test extrusion of the roof aluminium profile.

3.1.2. PV module

Following the circular economy approach of the RE-SKIN project, refurbished photovoltaic modules will be used. Due to the nature of reusing components, specific standard products cannot be defined. Generally, glass-tedlar laminates with mono- or polycrystalline cells and anodised aluminium perimeter frames will be employed. Commonly available PV module sizes on the market today are referred to, such as approximately 165 cm by 100 cm for residential installations and 195 cm by 100 cm for commercial applications. The module depth typically ranges from 8mm (for glass-glass PV laminate) to 45mm, with a deeper frame providing better structural stability. Weight also varies, with residential modules weighing around 18 kg and larger commercial modules about 22 kg. Prior to installation, a structural analysis is essential to assess roof capacity to support the additional weight of the PV system and its components. The BIPVT system can accommodate virtually any type of commercial module, with smaller sizes offering greater flexibility for rooftop installation. For the Milan demonstration case, refurbished backsheet modules will be used. Flash tests were performed to determine their peak power, showing a 5-10% decrease compared to the peak power specified in the technical datasheet. See Annex 4.5 for the test report on the PV module examination.

The datasheet for the original performance of the PV modules that will be installed in the Milan demonstration building can be found in the Annex 4.6.

3.1.3. Thermal insulation panel

The thermal insulation layer consists of a sandwich panel comprising a bio-based polyurethane (BioPUR) foam core, manufactured by project partner INDRES, and an outer layer made of sustainable steel sourced from SSAB. The panel's thickness is 80 mm to meet the specific thermal insulation needs for all the demonstration cases. Placed into the grooves located at the base of the profiles, the sandwich panels are joined together through tongue-and-groove connections, applying tape between the joints, ensuring effective waterproofing and insulation continuity.

Outer layer

The external steel layer is made of GreenCoat sustainable steel produced by SSAB with a thickness of 0.7 mm. This metallic sheet will also be used for manufacturing and machining of finishing trims.

Inner layer

The inner finishing layer also consists of steel sourced from SSAB. For the inner layer, as it is not exposed to external environmental conditions, a primer that ensures galvanic neutrality and adhesion is used according to specification from the manufacturer. The thickness of the sandwich panel’s inner steel layer is 0.45 mm.

Insulation

The sandwich panel serves a dual purpose, acting as both a thermal insulation element and as a second weatherproof protective outer layer in direct contact with the exterior.

An initial trial manufacturing run of the roof sandwich panel was performed at Lattonedil, producing a first batch of 80 mm panels with BioPUR core and GreenCoat steel, featuring a basic tongue-and-groove connection, see Fig. 43. These panels were used for internal testing at Lattonedil and INDRES, as well as for roof mock-up testing in WP3 at DTI.

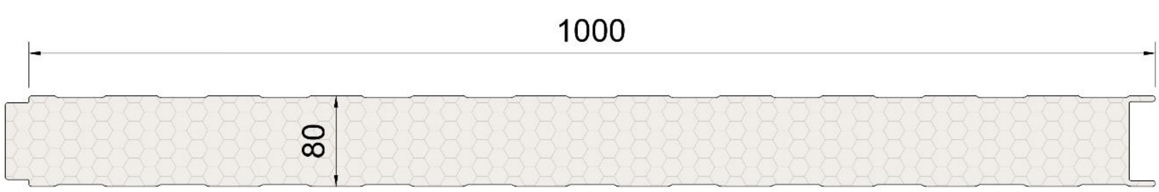


Figure 43. Detail drawing of the RE-SKIN roof sandwich panel with basic tongue-and-groove design [AutoCAD]

Figure 44. RE-SKIN sandwich panels manufactured for the roof

Following the manufacturing trial, it was determined that the panel connection could be improved, prompting a change in the profile. The final design of the roof sandwich panel will use the more advanced tongue-and-groove connection used for the façade panels (see Fig. 45). As a result, both roof and façade panels will share a unified design, differing only in thickness—80 mm for the roof panels and 100 mm for the façade panels. This will streamline the manufacturing process, allowing both types of panels to be produced on a single production line.

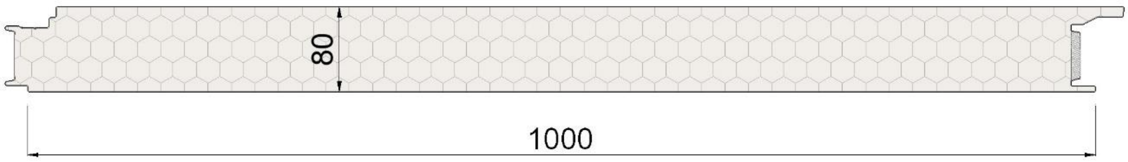


Figure 45. Detail drawing of the finalised design RE-SKIN roof sandwich panel with the advanced tongue-and-groove connection [AutoCAD]

3.1.4. Auxiliary elements

The installation of the BIPVT system requires additional components, including fixings (screws, pop-rivets), auxiliary profiles, lateral finishings and several sealings like silicone and tape.
Additionally, the areas where the PV modules are not installed will be covered with blind panels of the same thickness as the PV modules. These blind panels consist of a steel casing with a BioPUR core.

3.1.5. Ventilation complementary components

To allow ventilation within the air gap in order to recover warm air for thermal purposes while also preventing debris infiltration, a specific air intake and recovery system is being developed.

Air intake grilles from outside at the eaves line and extraction channels at the ridge are currently being studied. The Milan case study will be the test bed for the development of the related technological solutions. For further details, refer to D5.10 Manufacturing deign of the BIPVT roof system.

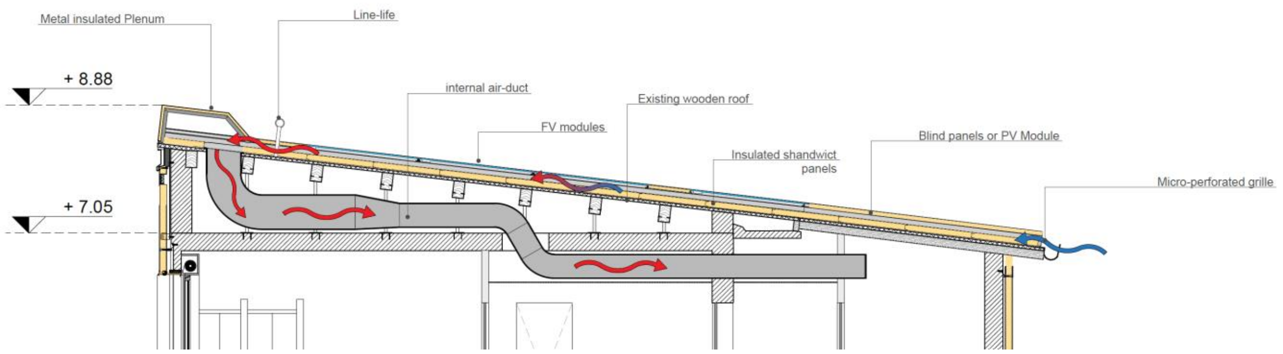


Figure 46. Section of the BIPVT roof and rear-ventilation.

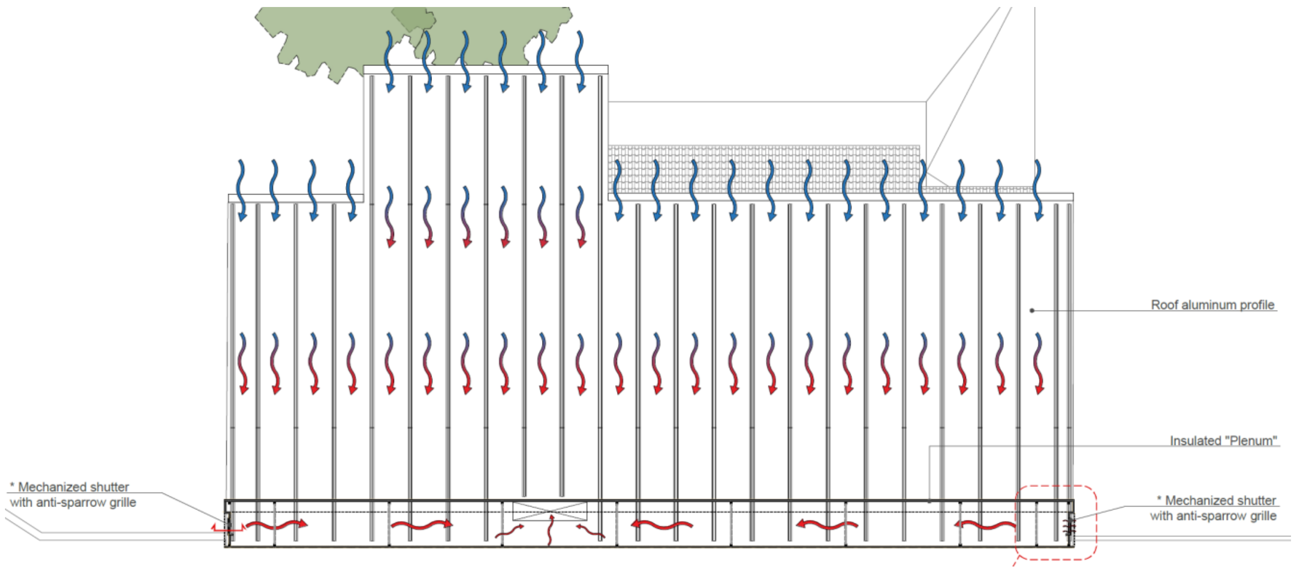


Figure 47. BIPVT roof layout for the Milan demonstration case with ventilation airflow diagram.

The table in the following section presents a comprehensive inventory of all components comprising the BIPVT roof system, along with their corresponding technical characteristics.

3.2. List of BIPVT elements

1	Roof Sandwich Panel	
item	*Name*	*Description*
1.1	Layer - 1	GreenCoat sustainable steel base with protective zinc layer and bio-based colour coating for external layer, 0.70 mm thick.
1.2	Layer - 2	80 mm BioPUR insulation. Lambda (λ) 0.022 W/mk.
1.3	Layer - 3	GreenCoat sustainable steel base with protective zinc layer and bio-based coating for internal layer, 0.55 mm thick.

2	Substructure	
item	*Name*	*Description*
2.1	Roof mullion profile	Recycled aluminium, 2.5 mm in thickness, with a length of 6000 mm.
2.2	Interior gaskets	EDPM, polyamide
2.3	Spacer	EDPM, polyamide
2.4	Exterior gaskets	EDPM, polyamide
2.5	Pressure plate	Recycled aluminium
2.6	Auxiliary brackets	Galvanised steel Z275 of 1.5 mm shaped. Length on demand, up to 230 mm.
2.8	Fixings	Self-tapping galvanised steel screws. Length on demand up to 230 mm.
2.9	Insulation for thermal bridge break	EDPM, polyamide

3	Finishing trims, covers and sealings	
item	*Name*	*Description*
3.1	Finishing trim at bottom	Steel base with protective zinc layer and bio-based colour coating, 0.70 mm thick.
3.2	Finishing trim at sides	Steel base with protective zinc layer and bio-based colour coating, 0.70 mm thick.

3.3	Finishing trim at corners	Steel base with protective zinc layer and bio-based colour coating, 0.70 mm thick.
3.4	Finishing trim at top	Steel base with protective zinc layer and bio-based colour coating, 0.70 mm thick.
3.5	Metallic ventilation grid profile	Aluminium
3.6	L-shaped profile	Galvanised steel Z275, 1.5 mm thick.
3.7	Fixings	Self-tapping galvanised steel screws. Length on demand up to 230 mm.
3.8	Adhesive tape	Polyethylene tape with adhesive for exterior applications
3.9	Neutral silicone	Silicone sealing, neutral type, high range.
3.10	Pop rivets	Aluminium or steel, on demand.
3.11	Auxiliary wooden elements	Structural wood.
3.12	Adjustable washer for fixings	Polypropylene

4	**PV module**	
item	*Name*	*Description*
4.1	PV module	Refurbished PV modules
4.2	T-profile	Galvanised steel Z275. Length on demand.
4.3	Perimeter profile	Galvanised steel Z275. Length on demand.

The components for the BIPVT system solution in the Milan demonstration case have been designed and manufactured. If improved solutions are identified during the implementation phase or through further testing at DTI, they will be incorporated.

4. Annex

4.1. Test results on sandwich panel

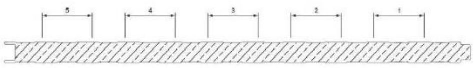
M 06-11 Rev 6 Protocollo di prova

LATTONEDIL

Protocollo di Prova

Tipo Pannello:	Isopar HP 80
Data produzione:	22/01/2024
Ora produzione:	12:00:00
Poliolo:	Indresmat
Linea di produzione:	Linea 2
Numero ordine:	Test

Sezione pannello Lattonedil Spa Milano
modello ISOPAR



	Unità di misura [SI]	Punti Norma UNI EN 14509	Posizione Provino: Maschio 1	2	Centro 3	4	Femmina 5	Valori di riferimento	Valori medio
Densità:	[Kg/m³]	A.8	44,77	43,96	44,22	43,87	43,71	≥ 36	44,10
Res. Trazione:	[N/mm²]	A.1	0,103	0,077	0,080	0,110	0,072	> 0,084	0,088
Mod. Trazione:	[N/mm²]	A.1	2,56	2,18	2,24	2,57	2,49	> 1,62	2,41
Res. Compressione:	[N/mm²]	A.2	0,090	0,089	0,096	0,093	0,091	> 0,110	0,092
Mod. Compressione:	[N/mm²]	A.2	2,13	2,13	2,41	2,40	2,17	> 1,25	2,25
Res. Taglio:	[N/mm²]	A.3	0,090	0,129	0,128	0,124	0,122	> 0,086	0,119
Mod. Taglio:	[N/mm²]	A.3	2,380	2,354	2,339	2,156	2,337	> 2,209	2,313
Conducibilità Termica:	[W/MK]	A.10.2.1.1			0,02222			≤ 0,023	0,02222
Piccola Fiamma:	[mm]		170	165	175	180	170	< 150	172,0
Spessore:	[mm]	D.2.1	80,62	81,03	80,70	81,21	80,63	±2 ≤100;2%Sp>100	80,84

Rilievo dimensionale

Bm	Bf	ds1	p1	ds2	p2	ds3	p3	dc	Wp	W	Curv.
20,18	22,93							80,84	1002	1001	1

Rintracciabilità lamierati

Interno	N° Coil		Materiale	Acciaio	Ral	9006	Spessore	0,55	Fornitore	
Esterno				Acciaio		9006		0,70		

Firma Compilatore

LATTONEDIL **Trazione** 24.01.2024

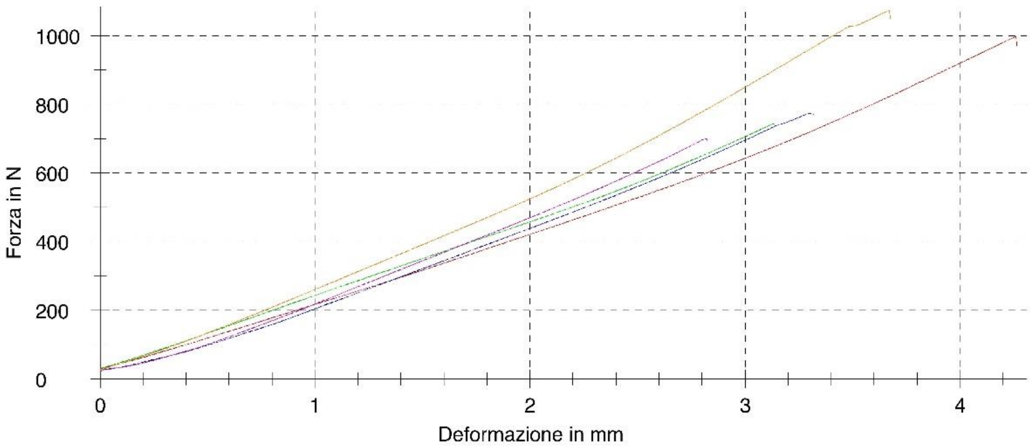
Tabella parametro:

Tipo di Pannello	:	**Isopar HP 80**	**Data di Produzione**	:	**22/01/24**
Tipo di Materiale	:	**Indresmat**	**Ora di Produzione**	:	**12:00**
Operatore:	:	**Gastaldo**	**Data della Prova**	:	**24/01/24**

Risultati:

No.	Larghezza mm	Lunghezza mm	Spessore mm	S_0 mm²	E_{mod} N/mm²	F_m N	R_m N/mm²	εF_{max} mm	W_u mm	Tipo di Rottura
1	97,51	99,35	81,23	9687,62	2,56	998	0,103	4,3	4,25	Interno 100%
2	97,45	99,79	81,5	9724,54	2,18	744	0,077	3,1	3,17	Interno 100%
3	97,75	99,38	81,94	9714,40	2,24	774	0,080	3,3	3,31	Interno 100%
4	98,27	99,3	82,2	9758,21	2,57	1070	0,110	3,7	3,82	Interno 100%
5	98,56	98,75	82,11	9732,80	2,49	701	0,072	2,8	2,83	Interno 100%

Grafico della serie:



Statistiche:

Series n = 5	Larghezza mm	Lunghezza mm	Spessore mm	S_0 mm²	E_{mod} N/mm²	F_m N	R_m N/mm²	εF_{max} mm	W_u mm
min	97,45	98,75	81,23	9687,62	2,18	701	0,072	2,8	2,83
$\bar{x}$	97,91	99,31	81,8	9723,51	2,41	858	0,088	3,4	3,48
max	98,56	99,79	82,2	9758,21	2,57	1070	0,110	4,3	4,25
s	0,4872	0,371	0,4155	25,80	0,184	167	0,017	0,6	0,56
ν [%]	0,50	0,37	0,51	0,27	7,66	19,43	19,39	16,07	16,20

Zwick/Roell **Pagina1/1**

LATTONEDIL

Compressione

24.01.2024

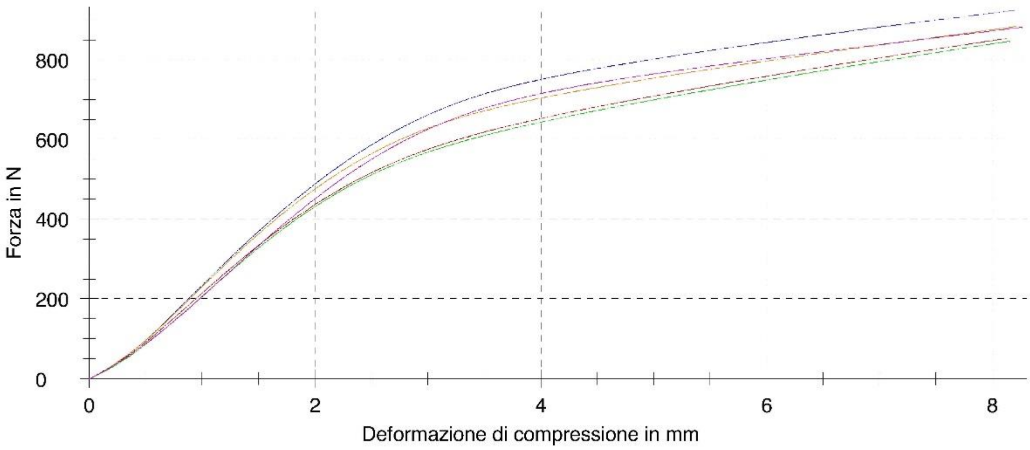
Tabella parametro:

Tipo di Pannello	:	Isopar HP 80	Data di Produzione	:	22/01/24
Tipo di Materiale	:	Indresmat	Ora di Produzione	:	12:00
Operatore:	:	Gastaldo	Data della Prova	:	24/01/24

Risultati:

No.	Lunghezza mm	Larghezza mm	Spessore mm	S_0 mm²	E_{mod} N/mm²	W_u mm	F_{max} N	R_{max} N/mm²
1	97,75	97,27	80,87	9508,14	2,13	3,56	854	0,090
2	97,43	97,79	81,15	9527,68	2,13	3,57	847	0,089
3	97,86	97,99	81,54	9589,30	2,41	3,44	924	0,096
4	97,8	97,52	81,74	9537,46	2,40	3,34	883	0,093
5	97,93	98,89	82,23	9684,30	2,17	3,64	882	0,091

Grafico della serie:



Statistiche:

Series n = 5	Lunghezza mm	Larghezza mm	Spessore mm	S_0 mm²	E_{mod} N/mm²	W_u mm	F_{max} N	R_{max} N/mm²
min	97,43	97,27	80,87	9508,14	2,13	3,34	847	0,089
$\bar{x}$	97,75	97,89	81,51	9569,38	2,25	3,51	878	0,092
max	97,93	98,89	82,23	9684,30	2,41	3,64	924	0,096
s	0,1932	0,6207	0,5271	70,91	0,144	0,12	30	0,003
ν [%]	0,20	0,63	0,65	0,74	6,42	3,47	3,47	3,20

Zwick Roell

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RE-SKIN

LATTONEDIL

Flessione/Taglio 24.01.2024

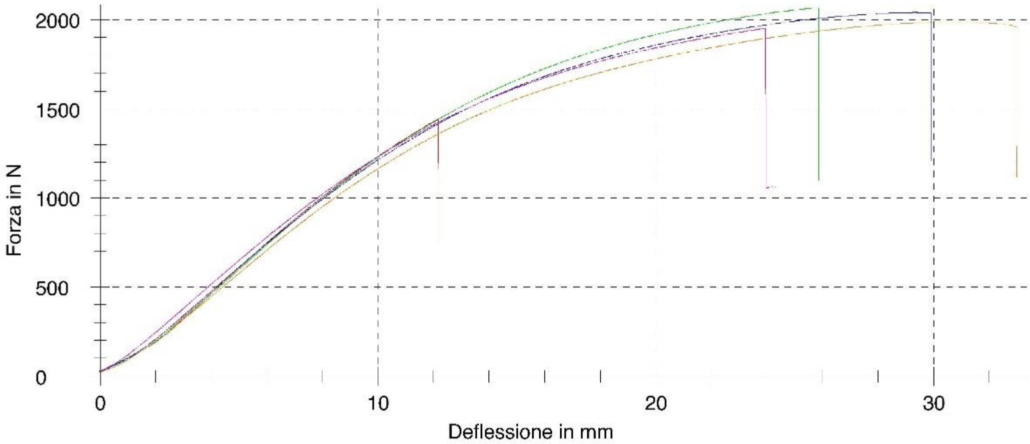
Tabella parametro:

Tipo di Pannello	:	Isopar HP 80	Data di Produzione	:	22/01/24
Tipo di Materiale	:	Indresmat	Ora di Produzione	:	12:00
Operatore:	:	Gastaldo	Data della Prova	:	24/01/24

Risultati:

	Spessore	Larghezza	$S_{0\ Sup}$	$S_{0\ Inf}$	$\Delta F/\Delta w$	F_{max}	εF_{max}	R_{taglio}	G_c	B_s
No.	mm	mm	mm²	mm²	N/mm	N	mm	N/mm²	N/mm²	Nm²
1	82,28	98,41	68,89	54,13	138,151	1440	12,17	0,090	2,380	42439,945
2	82,2	98,35	68,85	54,09	136,468	2070	25,86	0,129	2,354	42331,001
3	82,32	97,95	68,57	53,87	135,270	2040	29,28	0,128	2,339	42282,962
4	82,42	97,81	68,47	53,8	124,926	1990	30,68	0,124	2,156	42325,957
5	82,4	97,67	68,37	53,72	134,904	1950	23,95	0,122	2,337	42244,707

Grafico della serie:



Statistiche:

Series	Spessore	Larghezza	$S_{0\ Sup}$	$S_{0\ Inf}$	$\Delta F/\Delta w$	F_{max}	εF_{max}	R_{taglio}	G_c	B_s
n = 5	mm	mm	mm²	mm²	N/mm	N	mm	N/mm²	N/mm²	Nm²
min	82,2	97,67	68,37	53,72	124,926	1440	12,17	0,090	2,156	42244,707
$\bar{x}$	82,32	98,04	68,63	53,92	133,944	1900	24,39	0,119	2,313	42324,914
max	82,42	98,41	68,89	54,13	138,151	2070	30,68	0,129	2,380	42439,945
s	0,08989	0,3282	0,2297	0,1805	5,198	258	7,33	0,016	0,090	73,252
ν [%]	0,11	0,33	0,33	0,33	3,88	13,61	30,06	13,72	3,88	0,17

Zwick Roell

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M 01-11 Rev 5 Calcolo Densità

LATTONEDIL

CALCOLO DENSITÀ

Tipo Pannello : Isopar HP 80
Data produzione: 22/01/2024
Ora produzione: 12:00:00
Poliolo: Indresmat
Linea produzione: Linea 2
Ordine: 0,55+0,7
Data prova: 24/01/2024
Operatore: Gastaldo

Provino	D1	D2	D3	D4	D5	
Peso (grammi)	33,15	32,63	33,04	32,83	33,31	
Larghezza A (mm)	97,26	97,11	97,39	98,12	98,75	
Lunghezza B (mm)	99,27	99,29	99,28	99,14	99,39	
Larghezza C (mm)	97,06	97,16	96,81	97,22	98,70	
Lunghezza D (mm)	99,34	99,21	99,51	99,08	99,59	
Spessore A (mm)	76,62	77,22	77,60	77,55	77,95	
Spessore B (mm)	76,80	77,03	77,38	77,23	77,58	
Spessore C (mm)	76,65	76,63	77,27	77,24	77,39	
Spessore D (mm)	76,89	77,10	77,43	77,24	77,44	
Media Larghezza	97,16	97,14	97,10	97,67	98,73	
Media Lunghezza	99,31	99,25	99,40	99,11	99,49	
Media Spessore	76,74	77,00	77,42	77,32	77,59	**Media Densità**
Densità (Kg/m^3)	**44,77**	**43,96**	**44,22**	**43,87**	**43,71**	**44,10**

LATTONEDIL

M 12-11 Rev 0 Conducibilità termica

CONDUCIBILITA' TERMICA

Wednesday, January 24, 2024, Time 09:32

Wintherm32v3 Version 3.32.116 Uni
Instrument: F200
Instrument Program Version 296
Instrument Serial Number: 999

Sample Name: test1 1
Thickness: 29.01mm

Rear Left :	28.60 mm	Rear Right :	28.80 mm
Front Left:	29.21 mm	Front Right:	29.44 mm

[Isopar HP 80 22/01/24 12:00]
[Indresmat]
Thickness obtained : from instrument

TEST RUN

Calibration used : User Type
Calibration File Id: IMMR-440_Usertype_Calibration3

Number of transducers per plate: 1
Number of transducers used per plate: 1

Number of Setpoints: 1

Setpoint duration: 63 min

Block Averages for setpoint 1 in SI units

	Tupper [°C]	Tlower [°C]	Qupper [µV]	Qlower [µV]	Lambda [W/mK]
-se-	0.01	20.01	-684	712	0.02214
-se-	0.01	20.01	-685	713	0.02215
-se-	0.01	20.01	-685	713	0.02217
-se-	0.01	20.01	-685	713	0.02216
-se-	0.01	20.01	-685	715	0.02219
-se-	0.01	20.01	-686	715	0.02220
-se-	0.01	20.01	-686	715	0.02220
-se-	0.01	20.01	-685	717	0.02223
-se-	0.01	20.01	-688	714	0.02223
-se-	0.01	20.01	-689	713	0.02224

Wednesday, January 24, 2024, Time 10:36

Setpoint No. 1
Setpoint Upper: 0.00 °C
Setpoint Lower: 20.00 °C
Temperature Upper: 0.01 °C
CalibFactor Upper: 0.022501
Results Upper: 0.02242 W/mK
Temperature Lower: 20.01 °C
CalibFactor Lower: 0.021239
Results Lower: 0.02202 W/mK
Percent Difference: 1.79%

Thermal Equilibrium Criteria:
Temperature Equilibrium: 0.20
Between Block HFM Equil.: 40
HFM Percent Change: 0.00
Min Number of Blocks: 10
Calculation Blocks: 5

Results Table -- SI Units

Mean Temp	Upper Cond	Lower Cond	Average Cond
10.01	0.02242	0.02202	0.02222

M 03-11 Rev 5 Piccola Fiamma

LATTONEDIL

Piccola Fiamma

Tipo Pannello:	*Isopar HP 80*
Data Produzione:	*22/01/2024*
Ora Produzione:	*12:00:00*
Poliolo:	*Indresmat*
Linea produzione:	*Linea 2*
Ordine:	-
Data Prova:	*24/01/2024*
Operatore:	*Gastaldo*

MATERIALE	FORMULAZIONE
Isocianato	
Poliolo	
Pentano	
Catalizzatore	
Add. 1	
Add. 2	
Totale	**0**

N°	H Fiamma [mm]	Tempo [s]	Colore Fumi	Intesità Fumi
1	**170**	4	Grigio	Alta
2	**165**	4	Grigio	Alta
3	**175**	5	Grigio	Alta
4	**180**	5	Grigio	Alta
5	**170**	4	Grigio	Alta

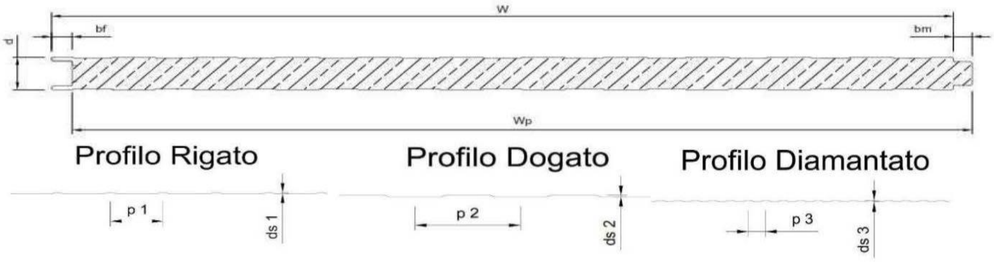
Note:

LATTONEDIL

M 05-11 Rev 7 Verifica misure Pareti

Rilievo dimensionale

Sezione pannello Lattonedil Spa Milano
modello ISOPAR



DESCRIZIONE	DATO RILEVATO						VALORE (mm)	MEDIA
	LATO INTERNO			LATO ESTERNO				
PROFONDITA' LATO MASCHIO **bm**	19,82			20,53			20.0 ±1.0	20,18
PROFONDITA' LATO FEMMINA **bf**	22,71			23,15			22.5 ±1.0	22,93
PROFONDITA' RIGATO **ds1**							1.0 ±0.3	
PASSO RIGATO **p1**							47.5 ±1.0	
PROFONDITA' DOGATO **ds2**							0.9 ±0.27	
PASSO DOGATO **p2**							90.9 ±1.0	
PROFONDITA' DIAMANT. **ds3**							1.1 ±0.3	
PASSO DIAMANTATO **p3**							16.0 ±1.0	
SPESSORE PANNELLO **d**	80,63	81,21	80,70	81,03	80,62		±2 (d≤100); ±2%d (d>100)	80,84
PASSO POLIURETANO **Wp**	1002						1000 ±2	1002
LARGHEZZA UTILE **W**	1001			1001			1000 ±2	1001
CURVATURA	1,0						≤8.5	1

Operatore:	Battaglia		Linea di produzione:	2
Pannello:	Isopar HP		Spessore:	80
Data e ora produzione:	22/01/2024	12:00:00	Data Prova:	24/01/2024

4.2. Preliminary Layout of the Façade for the Milan Demonstration Building

4.3. Detail drawings of façade connections in the Milan demo

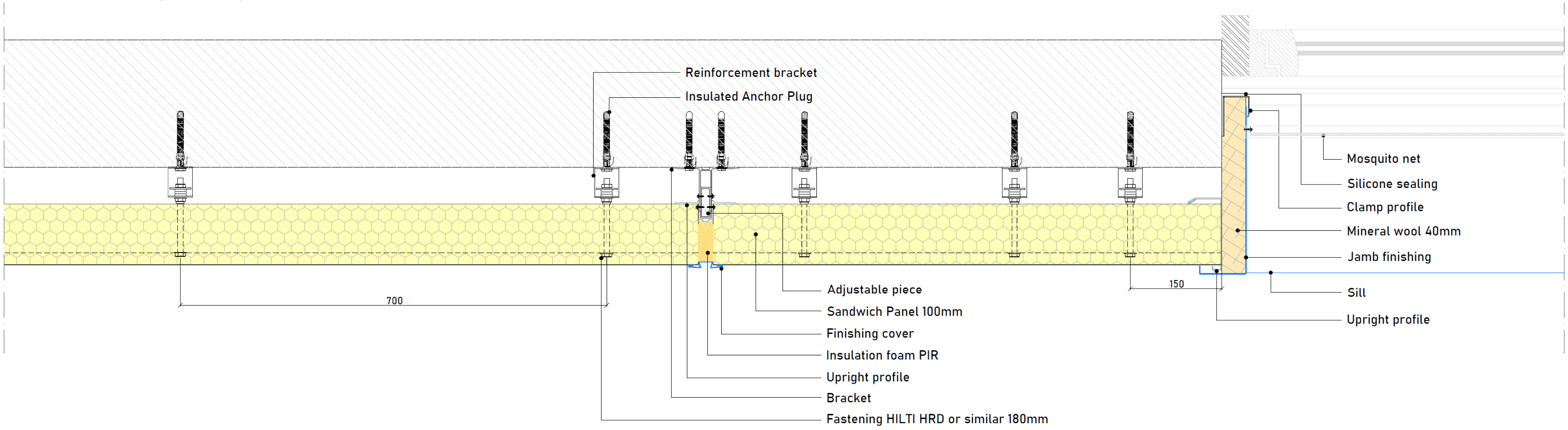


Figure 48. Horizontal section detail of Milan demo window [drawing created using AutoCAD]

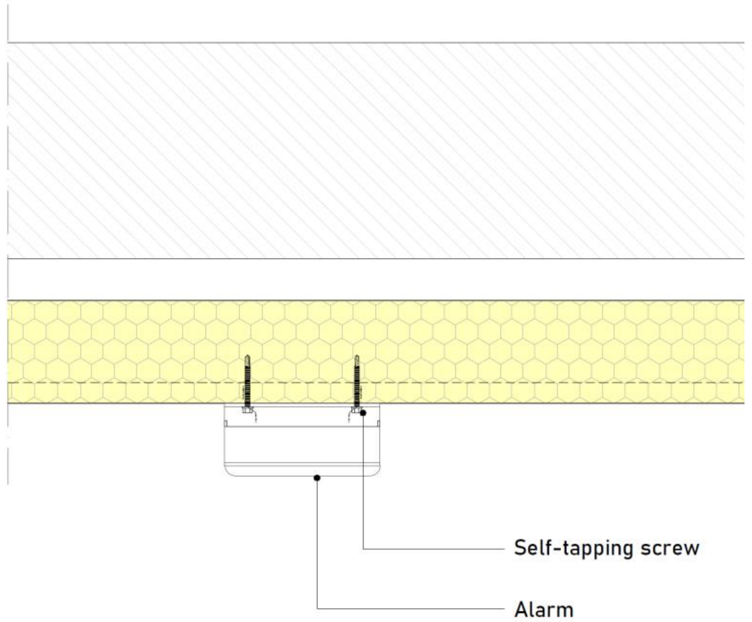


Figure 49. Horizontal section of alarm fixing

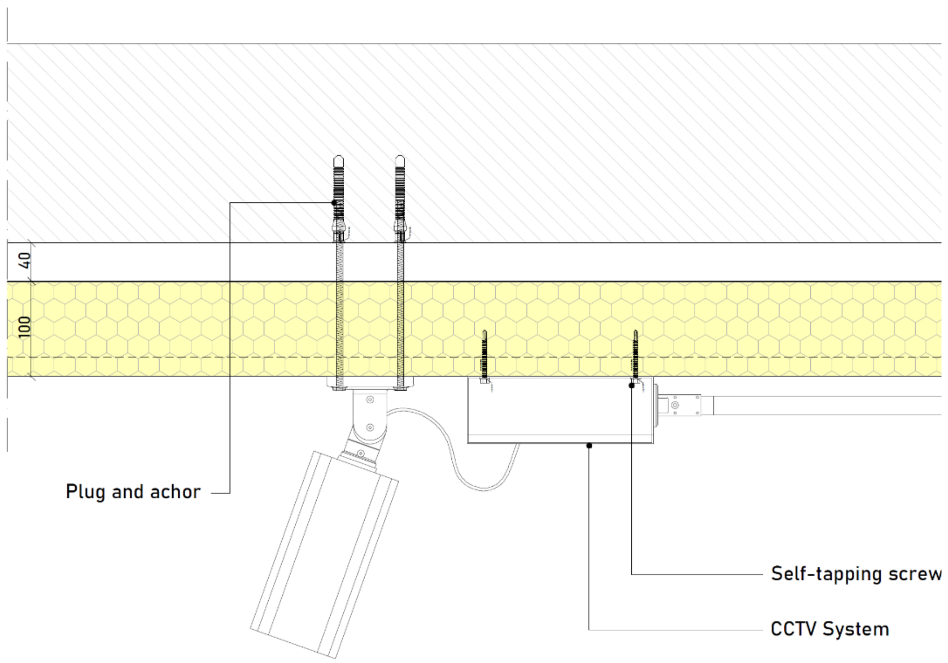


Figure 50. Horizontal section of CCTV fixing

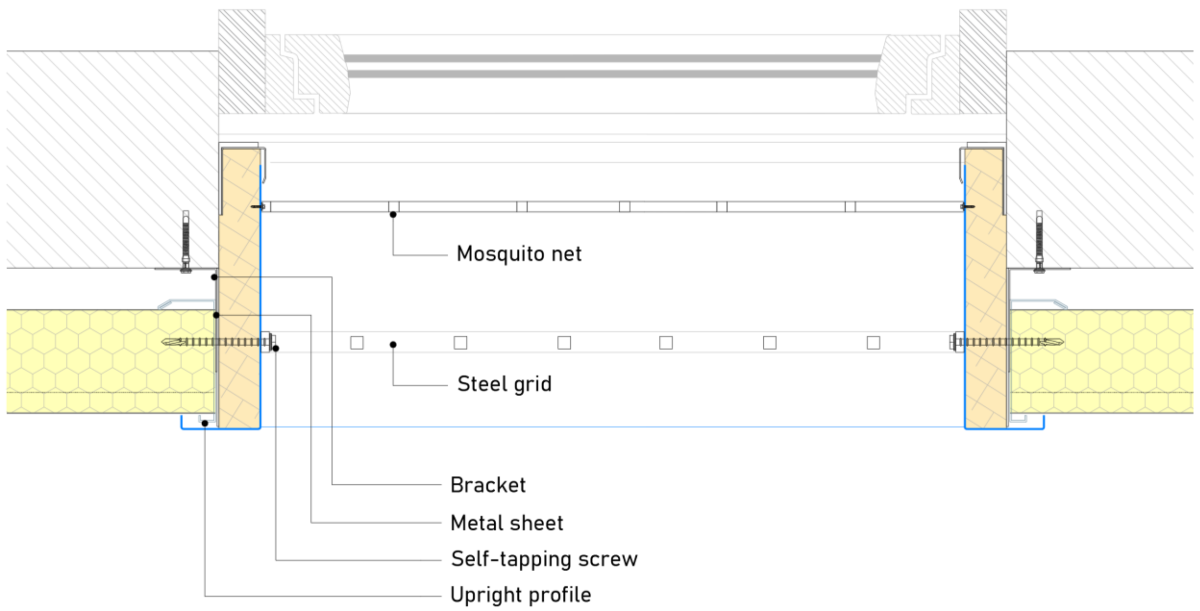


Figure 51. Horizontal section of bars and mosquito nets fixed to a window

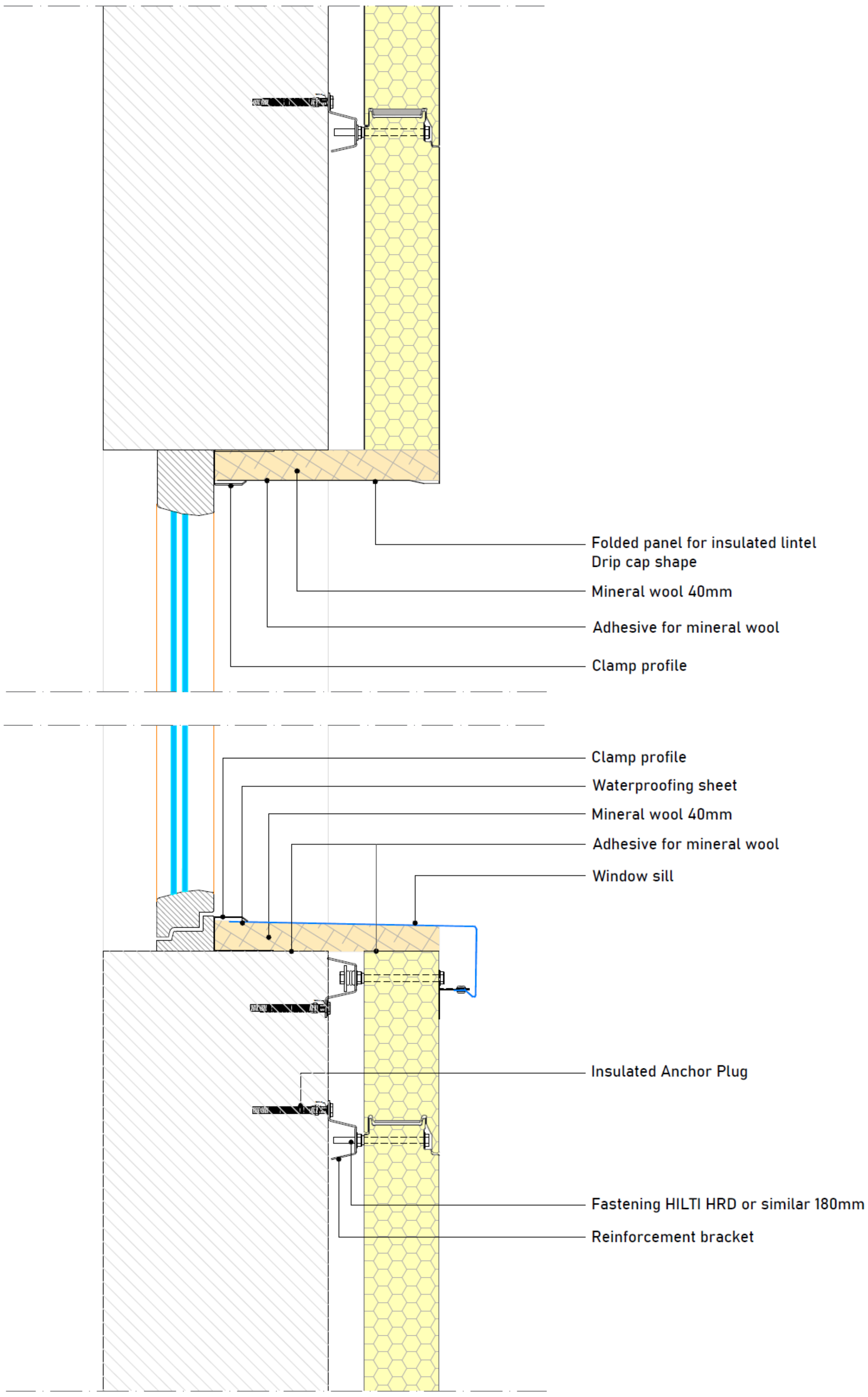


Figure 52. Vertical section detail of Milan demo window [drawing created using AutoCAD]

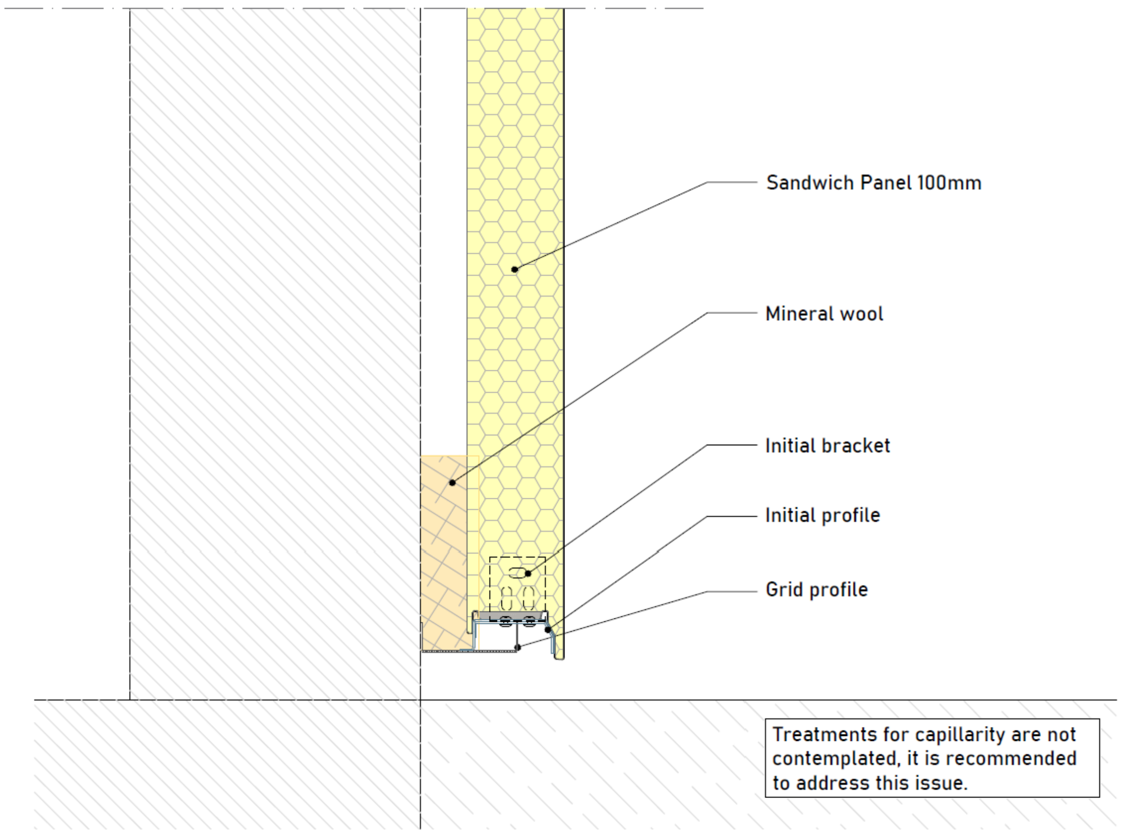


Figure 53. Detail drawing of the façade system's starting point [drawing created using AutoCAD]

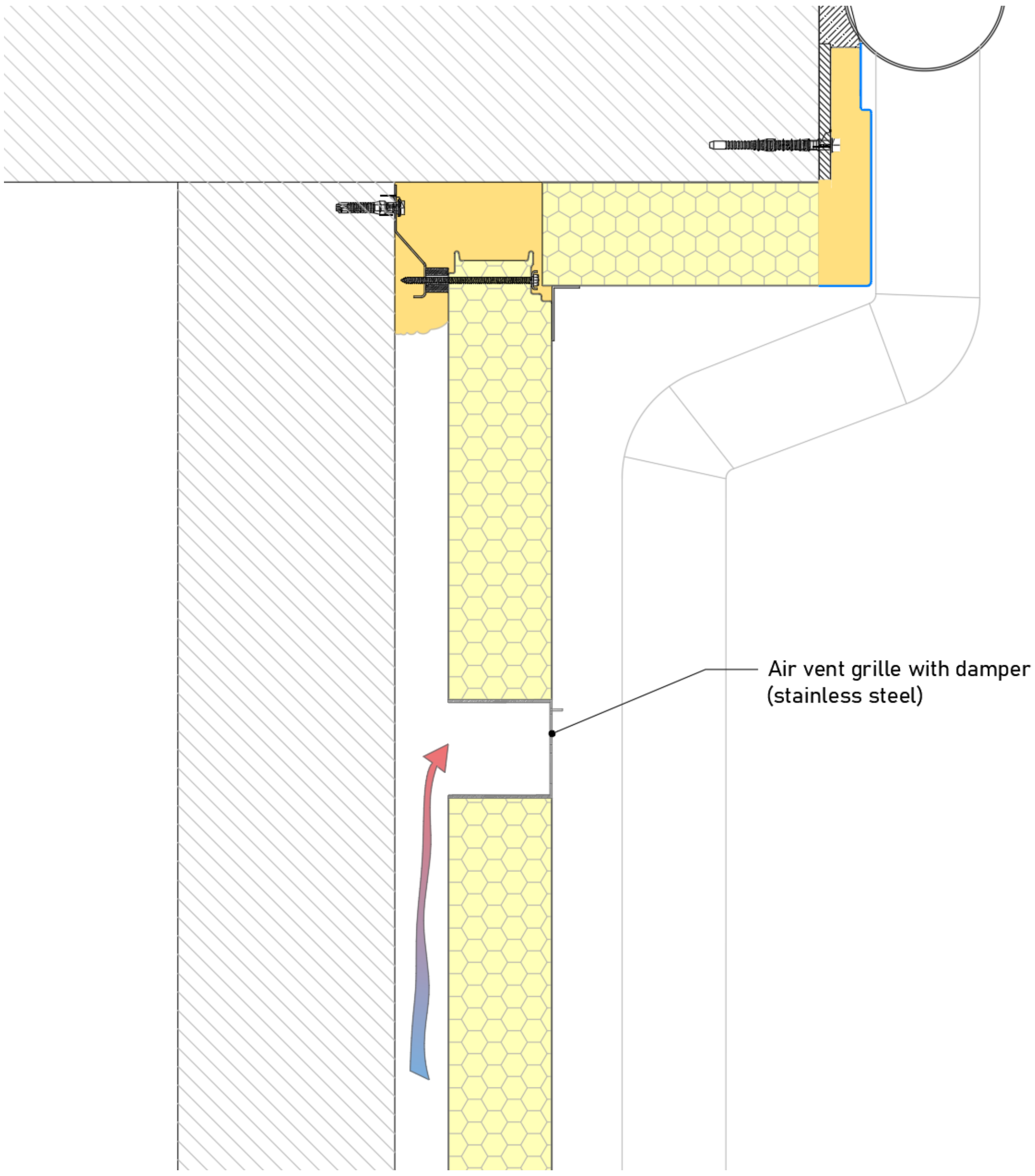


Figure 54. Top ventilation grille for air outtake [drawing created using AutoCAD]

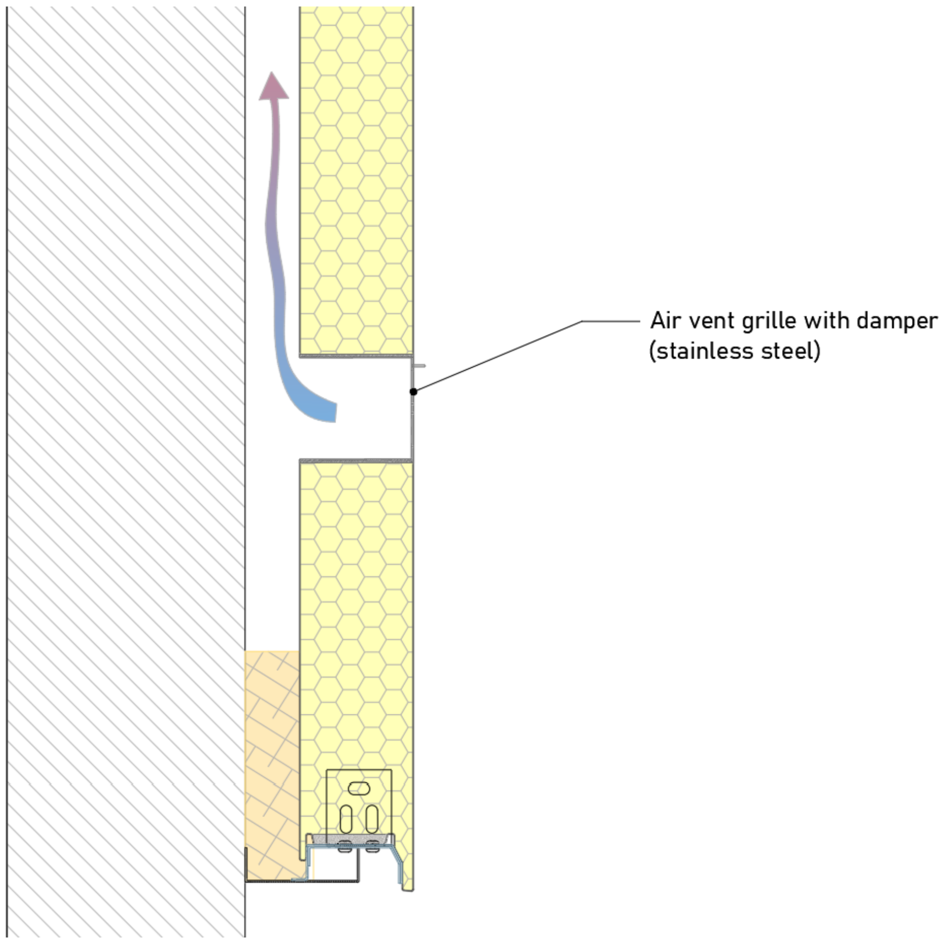
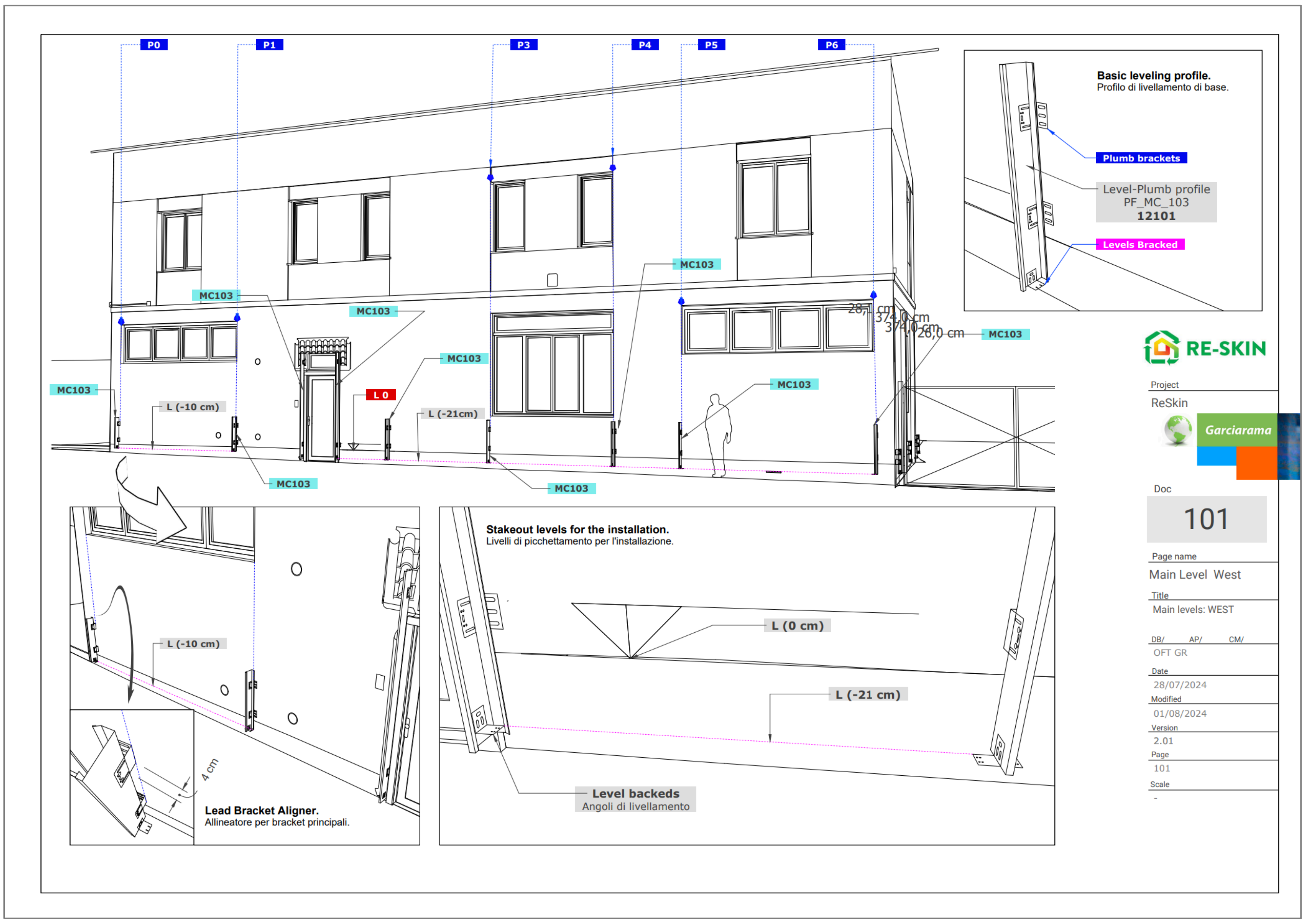
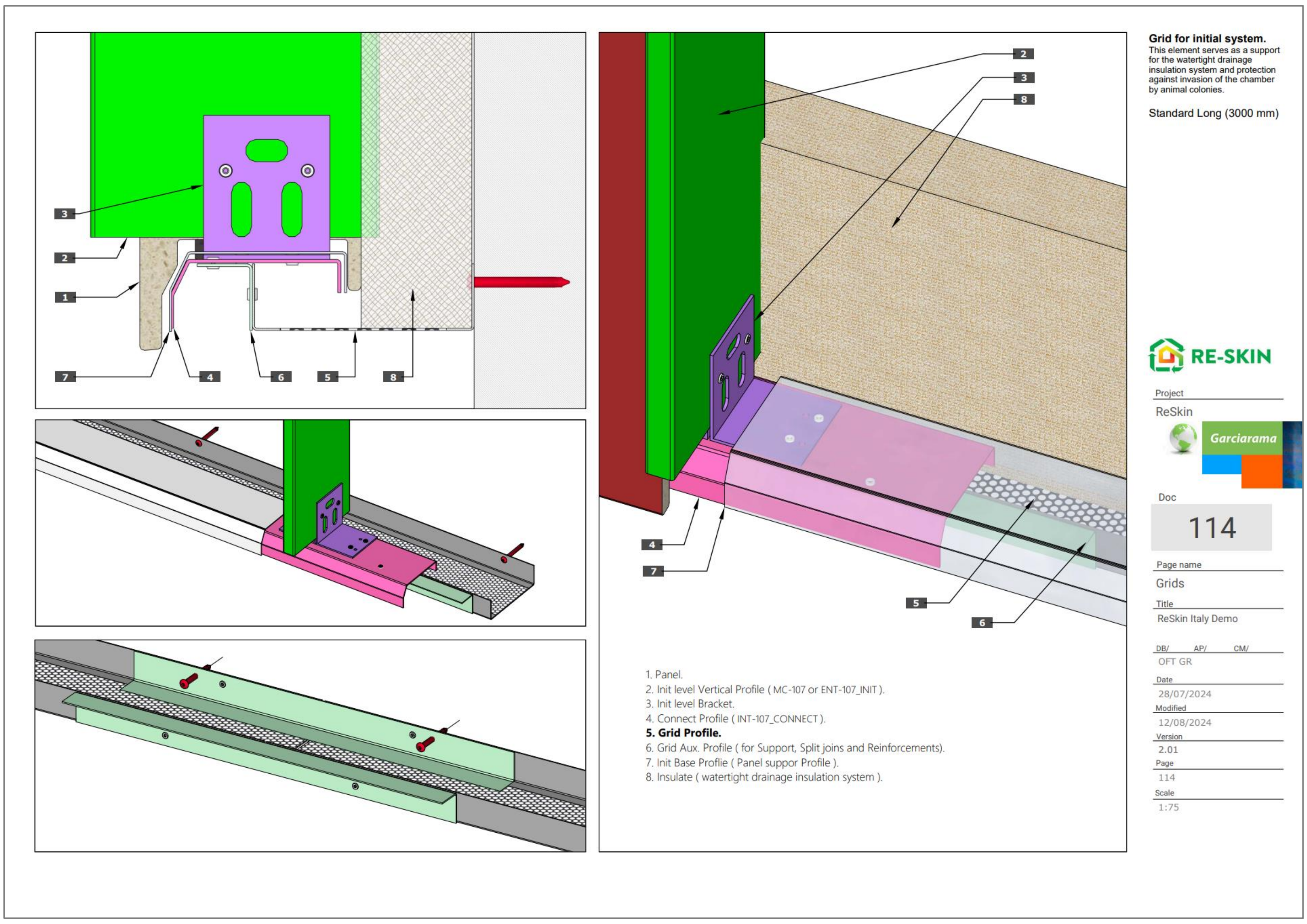


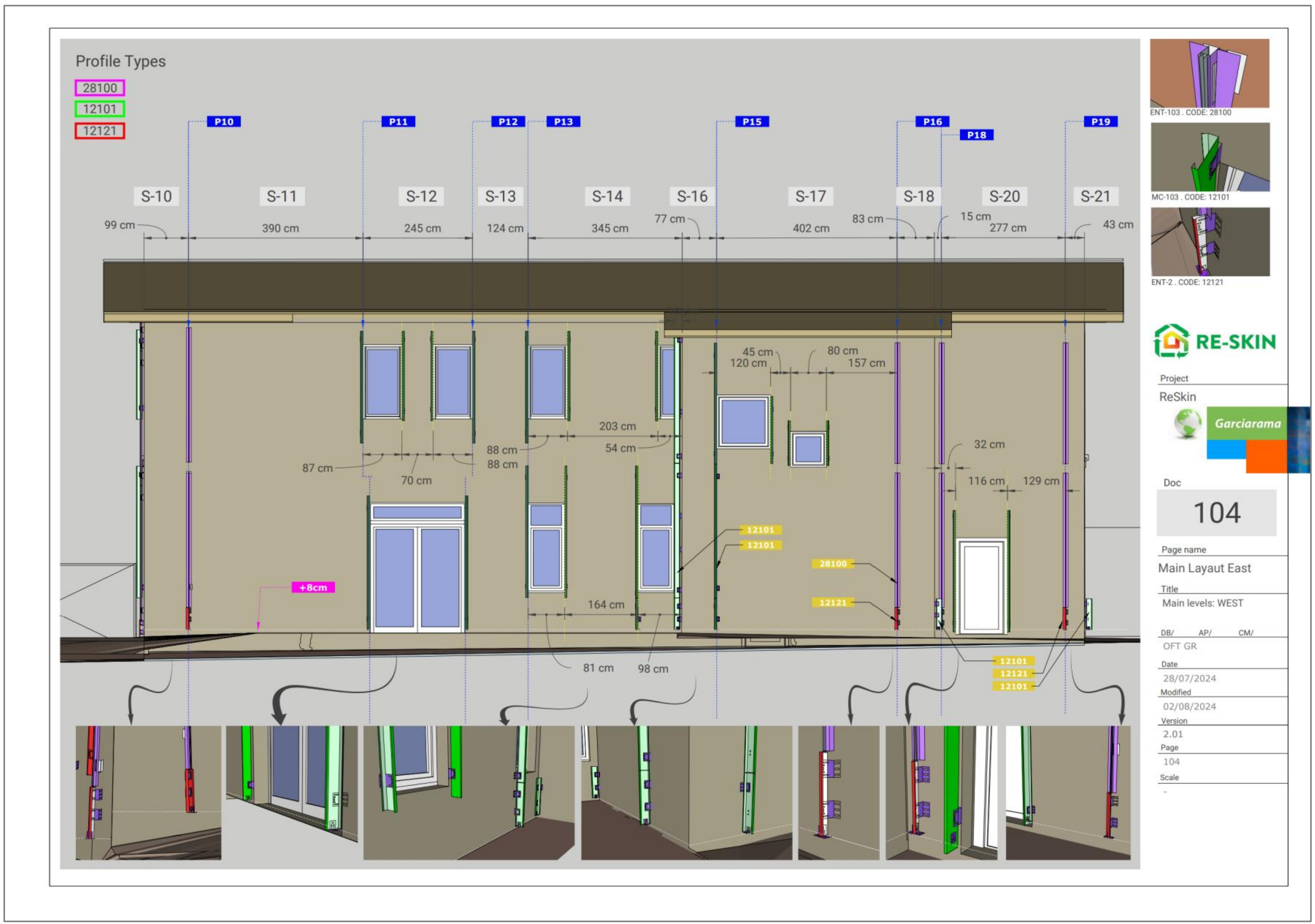
Figure 55. Bottom ventilation grille for air intake [drawing created using AutoCAD]

Figure 56.

4.4. Installation manual for Milan demo case



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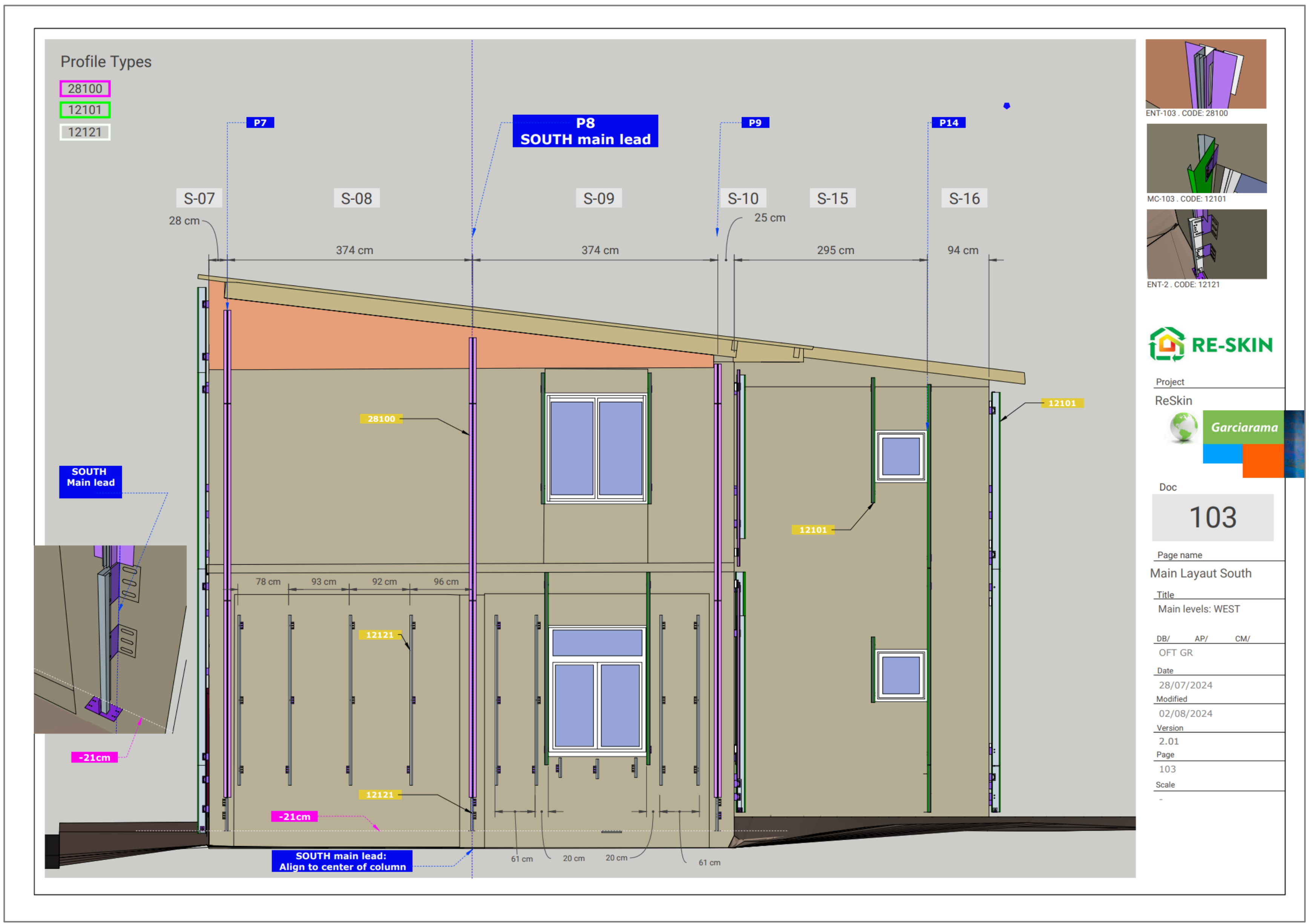
12101
12121
P10
P11
P12
P13
P15
P16
P18
P19
S-10
S-11
S-12
S-13
S-14
S-16
S-17
S-18
S-20
S-21
ENT-103 . CODE: 28100
MC-103 . CODE: 12101
ENT-2 . CODE: 12121
RE-SKIN
Project
ReSkin
Garciarama
Doc
104
Page name
Main Layaut East
Title
Main levels: WEST
OFT GR
Date
28/07/2024
Modified
02/08/2024
Version
2.01
Page
104
Scale


Profile Types
28100
12101
12121
P7
P8
SOUTH main lead
P9
P14
S-07
S-08
S-09
S-10
S-15
S-16
SOUTH Main lead
-21cm
SOUTH main lead:
Align to center of column
ENT-103 . CODE: 28100
MC-103 . CODE: 12101
ENT-2 . CODE: 12121
RE-SKIN
Project
ReSkin
Garciarama
Doc
103
Page name
Main Layaut South
Title
Main levels: WEST
OFT GR
Date
28/07/2024
Modified
02/08/2024
Version
2.01
Page
103
Scale

4.5. Test report for PV module examination

Test Report
PV Module Examination

Client:

GE4A Group B.V.

Projekt-No. 107167

Zentrum für Sonnenenergie- und

Wasserstoff-Forschung

Baden-Württemberg

Department Modules Systems Applications

MSA Solab

2023

Client	**GE4A Group B.V.** Louis Couperusplein 2 2514 Deen Haag Netherlands
Contact	Frank Lallement, GE4A Group
Offer	ANG-107446
Commissioning	Email 25.07.2023
Project No.	P-107167
Test institution	Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) Meitnerstraße 1 70563 Stuttgart Deutschland www.zsw-bw.de
Receipt of test samples	**02.08.2023**

Report written and approved

Stuttgart, 29.08.2023

Roland Einhaus Head Solab	Tim Helder Test engineer

Contents

1 Summary

The **STC-Power** measured according to IEC 61215-2:2021 of the two investigated modules is 226.9 W and 238.4 W.

2 Backround

The GE4A Group delivered two solar modules with a repaired back sheet. Due to the repairing step, which was conducted on the whole backside area, the original nameplates with the IV characteristics of the modules are covered or gone. Therefore, a classification regarding the nameplate information is not possible.

3 Applied tests

The following tests and measurements were applied to the supplied two modules:

- **STC power** measurements according to IEC 61215-2: 2021 (MQT 6)

4 Tested modules

The modules were supplied to ZSW with delivery on Friday the 02.08.2023.

Module properties:

Module type	unkown
Manufacturer	Trina Solar
Nameplate power	250 to 255 W (see e-mail from 22nd August 2023)
Cells	poly-c-Si, 60cells, 3BB
Module design	Glass/backsheet, Al-frame
Year of production	not specified
Number of samples	2 modules

5 Results

5.1 STC power measurement

With a Xenon flash-light sun simulator, class AAA, type Berger, the module power was measured under Standard Test Conditions (STC), i.e. 25°C, 1000 W/m² and AM1.5 spectrum, according to IEC 61215 with a measurement uncertainty of power measurement ±2.1%.

The modules were thoroughly cleaned before the initial power measurement.

A mono-c-Si module with precision calibration by Fraunhofer ISE was used as reference.

The characteristic values from the performance measurement at standard test conditions (STC) are listed in **Table 1**.

No.	Serial number	LK [W]	P_{MPP} [W]	ΔP [%]	U_{OC} [V]	I_{SC} [A]	U_{MPP} [V]	I_{MPP} [A]	FF [%]
M01	4120215800254	N/A	226.86	N/A	37.56	8.505	29.53	7.683	71.01
M02	4120215800492	N/A	238.37	N/A	37.10	8.431	29.84	7.987	76.21

Table 1: Overview of the STC measurements.

Due to missing nameplates of the modules, an exact rating with respect to the manufacturer's information is not possible. With respect to the value of 250 to 255 W from the e-mail correspondence on August 22nd, the measured power is significantly lower.

Furthermore, STC measurements alone cannot provide a sufficient insight into the quality of the repair solution. Further test, such as artificial aging with Damp-Heat or test of insulation under wet conditions, could reveal more information about the quality and are strongly recommended from our side.

6 Appendix

6.1 List of equipment

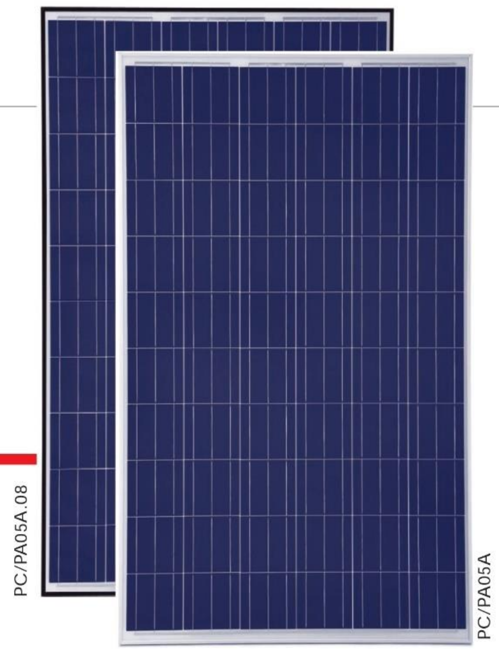
The following relevant test equipment was used for the tests applied:

– Flash sun simulator: Berger Pulsed Solar Simulator PSS 30 with PSL 8 Last (class AAA)

P-107167_GE4A-Group.docxGE4A 4/4

4.6. PV module datasheet for original performance

Mono Multi Solutions



TSM-PC05A
TSM-PA05A

THE Honey MODULE

by Trinasolar

15.9%
MAX EFFICIENCY

260W
MAX POWER OUTPUT

10 YEAR
PRODUCT WARRANTY

25 YEAR
LINEAR POWER WARRANTY

Module can bear snow loads up to **5400Pa** and wind loads up to **2400Pa**

Guaranteed power output
0~+3%

High performance under low light conditions
Cloudy days, mornings and evenings

Manufactured according to International Quality and Environment Management System Standards
ISO9001, ISO14001

MC4 photovoltaic connectors increase system reliability

Founded in 1997, Trina Solar (NYSE: TSL) has established itself as a leader in the solar community with its vertically integrated business model. Our modules and system solutions provide clean solar power in on-grid and off-grid residential, commercial, industrial and utility-scale systems.

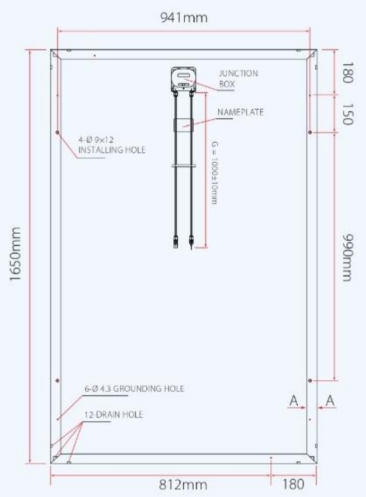
With more than 22 offices worldwide, Trina Solar has partnerships with leading installers, distributors, utilities and developers in all major PV markets. Trina Solar is committed to driving smarter energy choices.

Trina Solar Limited
www.trinasolar.com

Trinasolar
Smart Energy Together

TSM-PC05A / TSM-PA05A THE Honey MODULE

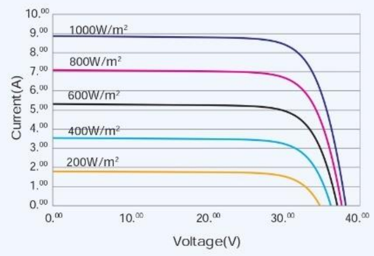
DIMENSIONS OF PV MODULE TSM-PC/PA05A



Back View

A-A

I-V CURVES OF PV MODULE TSM-255 PC/PA05A



Average efficiency reduction of 4.5% at 200W/m² according to EN 60904-1.

CERTIFICATION

ELECTRICAL DATA @ STC	TSM-250 PC/PA05A	TSM-255 PC/PA05A	TSM-260 PC/PA05A
Peak Power Watts-P_{MAX} (Wp)	250	255	260
Power Output Tolerance-P_{MAX} (%)	0/+3	0/+3	0/+3
Maximum Power Voltage-V_{MP} (V)	30.3	30.5	30.6
Maximum Power Current-I_{MPP} (A)	8.27	8.37	8.50
Open Circuit Voltage-V_{OC} (V)	38.0	38.1	38.2
Short Circuit Current-I_{SC} (A)	8.79	8.88	9.00
Module Efficiency η_m (%)	15.3	15.6	15.9

Values at Standard Test Conditions STC (Air Mass AM1.5, Irradiance 1000W/m², Cell Temperature 25°C).
Power measurement tolerance: ±3%

ELECTRICAL DATA @ NOCT	TSM-250 PC/PA05A	TSM-255 PC/PA05A	TSM-260 PC/PA05A
Maximum Power-P_{MAX} (Wp)	183	186	190
Maximum Power Voltage-V_{MP} (V)	27.3	27.4	27.5
Maximum Power Current-I_{MPP} (A)	6.70	6.79	6.91
Open Circuit Voltage (V)-V_{OC} (V)	34.8	34.9	35.0
Short Circuit Current (A)-I_{SC} (A)	6.99	7.11	7.20

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.
Power measurement tolerance: ±3%

MECHANICAL DATA	
Solar cells	Multicrystalline 156 × 156mm (6 inches)
Cell orientation	60 cells (6 × 10)
Module dimensions	1650 × 992 × 35mm (64.95 × 39.05 × 1.37 inches)
Weight	18.6kg (41.0 lb)
Glass	High transparency solar glass 3.2mm (0.13 inches)
Frame	Anodized aluminium alloy
J-Box	IP 65 rated
Cables	Photovoltaic Technology cable 4.0mm² (0.006 inches²), 1000mm (39.4 inches)
Connector	Original MC4

TEMPERATURE RATINGS	
Nominal Operating Cell Temperature (NOCT)	44°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.41%/°C
Temperature Coefficient of V_{OC}	- 0.32%/°C
Temperature Coefficient of I_{SC}	0.053%/°C

MAXIMUM RATINGS	
Operational Temperature	-40~+85°C
Maximum System Voltage	1000V DC(IEC)/ 600V DC(UL)
Max Series Fuse Rating	15A

WARRANTY
10 year Product Workmanship Warranty
25 year Linear Power Warranty

(Please refer to product warranty for details)

PACKAGING CONFIGURATION
Modules per box: 29 pieces
Modules per 40' container: 812 pieces

TSM_EN_Nov_2012

Trinasolar
Smart Energy Together

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.