

An aerial photograph of a densely packed town with numerous terracotta-tiled roofs. The roofs are in various shades of red, orange, and brown, creating a textured, repetitive pattern. Some buildings have small windows or skylights visible on their roofs. The overall scene is bright and sunny, with shadows cast by the buildings.

S **TTILE**

SOLAR TECHNOLOGICAL TILE

TECHNICAL DATASHEET

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1 Concept

SOTTILE is a play on words between the acronym for Solar Technological Tile and the lightness of a practical, efficient and innovative component intended for building integration of photovoltaic systems. The concept is led by the logic of Sustainable Architecture and Circular Economy, and its application makes it possible to easily transform a traditional roof into a solar electricity generator, in combination with virtually any type of tile.

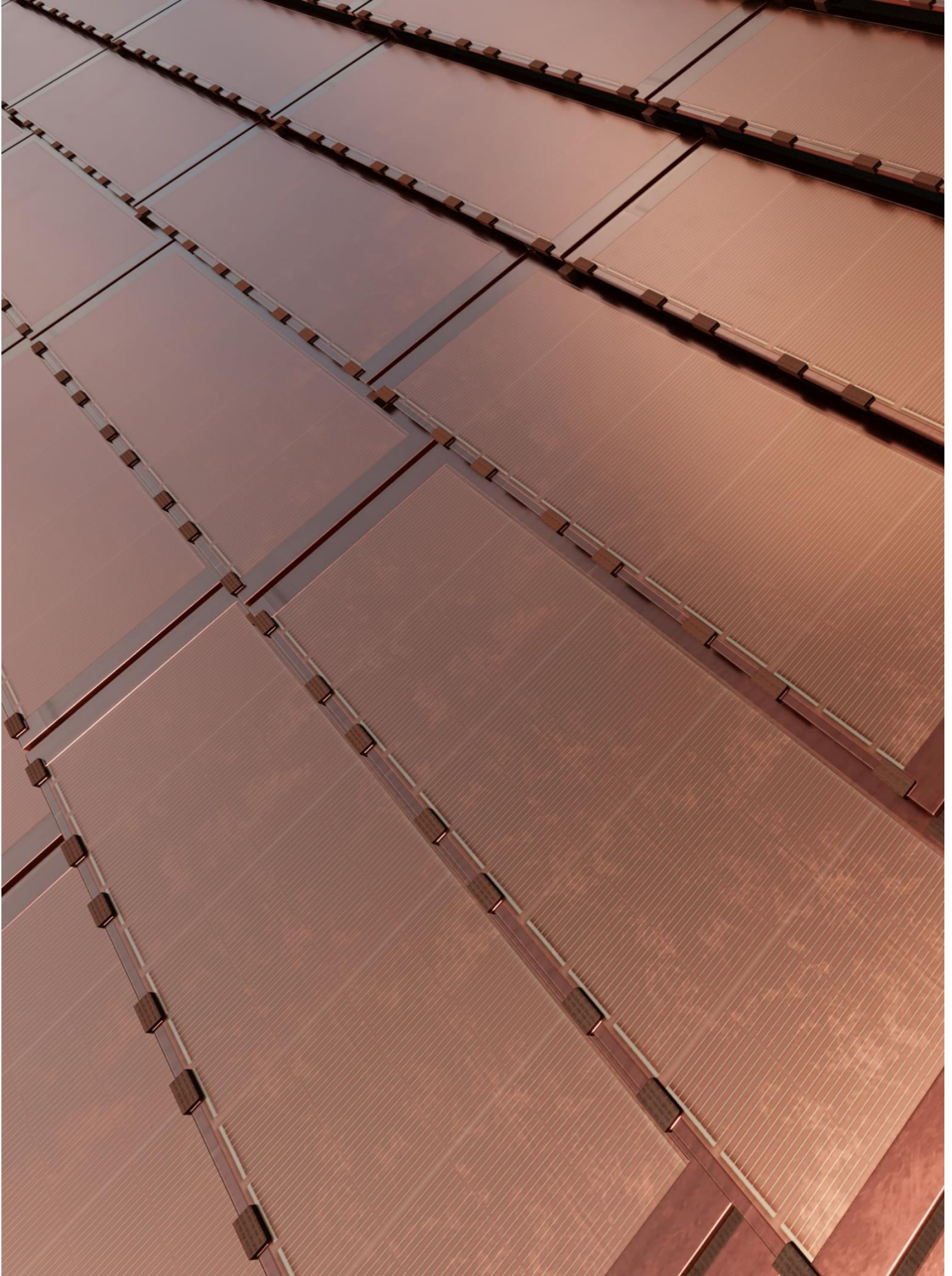


SOTTILE is a complete system, consisting of modular elements according to the desired geometry and dimensions and specially designed for installation on pitched roofs, in combination with virtually any type of tile. In fact, it can be used in place of clay roofing exclusively in the portions intended for the solar system, while the remaining portions of the roof can be covered with traditional elements.

SOTTILE was developed as part of the HEART (Holistic Energy and Architectural Retrofit Toolkit) project, coordinated by the Politecnico di Milano as part of the Horizon2020 Research and Innovation Program sponsored by the European Union.

Each element of SOTTILE consists of a 4 singular modular supports made of recycled plastic, on which the photovoltaic laminate with crystalline silicon cells, is connected. The entire system and its sub-components are designed to be quickly assembled and disassembled, greatly facilitating installation, maintenance and decommissioning practices.

The color of the modular support, as the photovoltaic laminate, can be customized in order to increase the integration with existing context.



2 Technical information

2.1 PV laminates

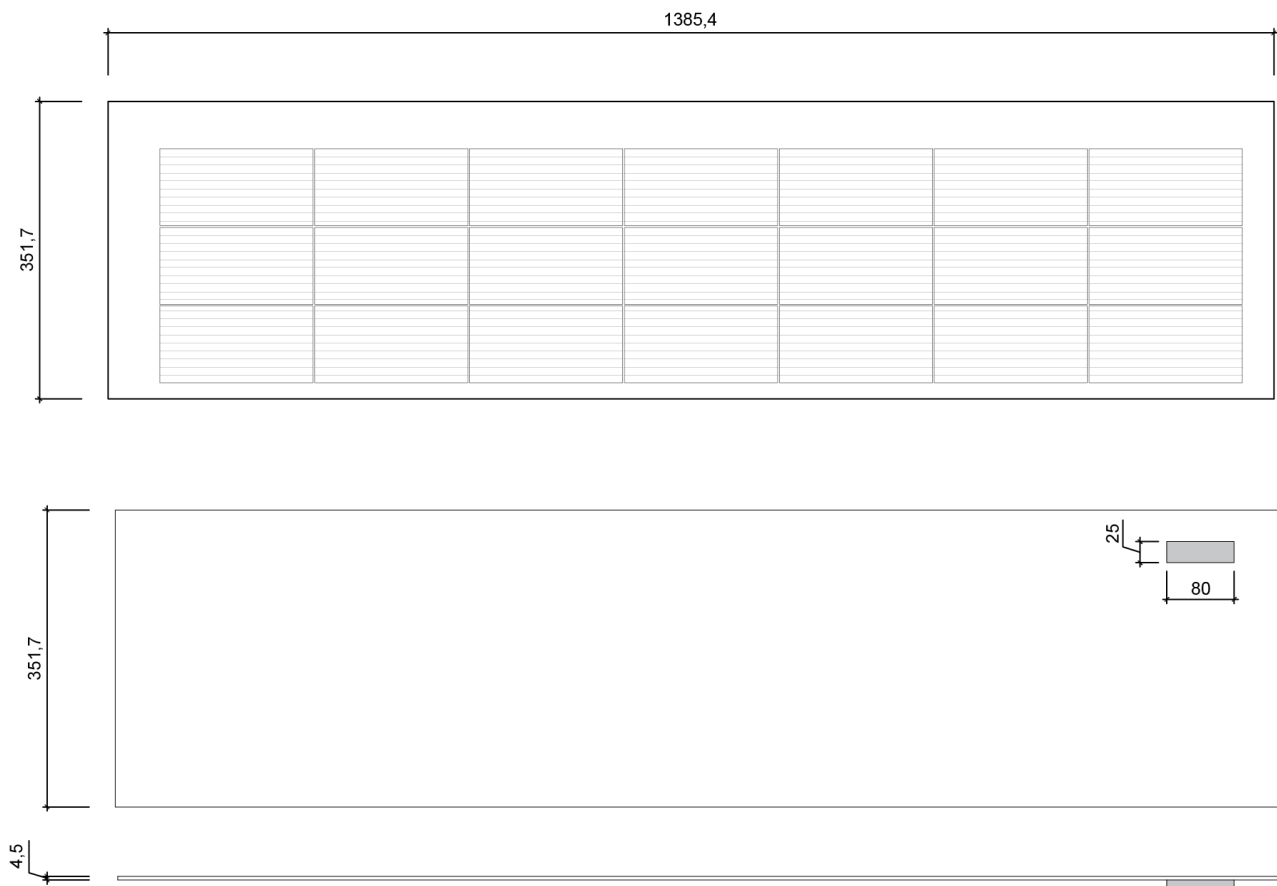
The PV module is manufactured with monocrystalline cells connected in series, laminated between an antireflective glass (3 mm thick) and a backsheet layer. Each module is able to provide a power of 77 Wp at STC. The detailed electrical features of the module are reported in the following table.

Efficiency [%]	P _{mpp} [W]	V _{oc} [V]	I _{sc} [A]	V _{mpp} [V]	I _{mpp} [A]
18~20	77	14.4	6.85	11.97	6.43

Main electrical features of the PV laminate

The laminate is (L x W) 1385,4 mm x 351,7 mm, as shown in the following figure. The junction box, completely watertight (IP 67), is placed in the corner on the back side attached with silicon adhesive. It encapsulates solar bypass diodes that keep solar power flowing in one direction and prevent it from feeding back to the solar PV laminate and integrate a power optimizer with MPPT function.

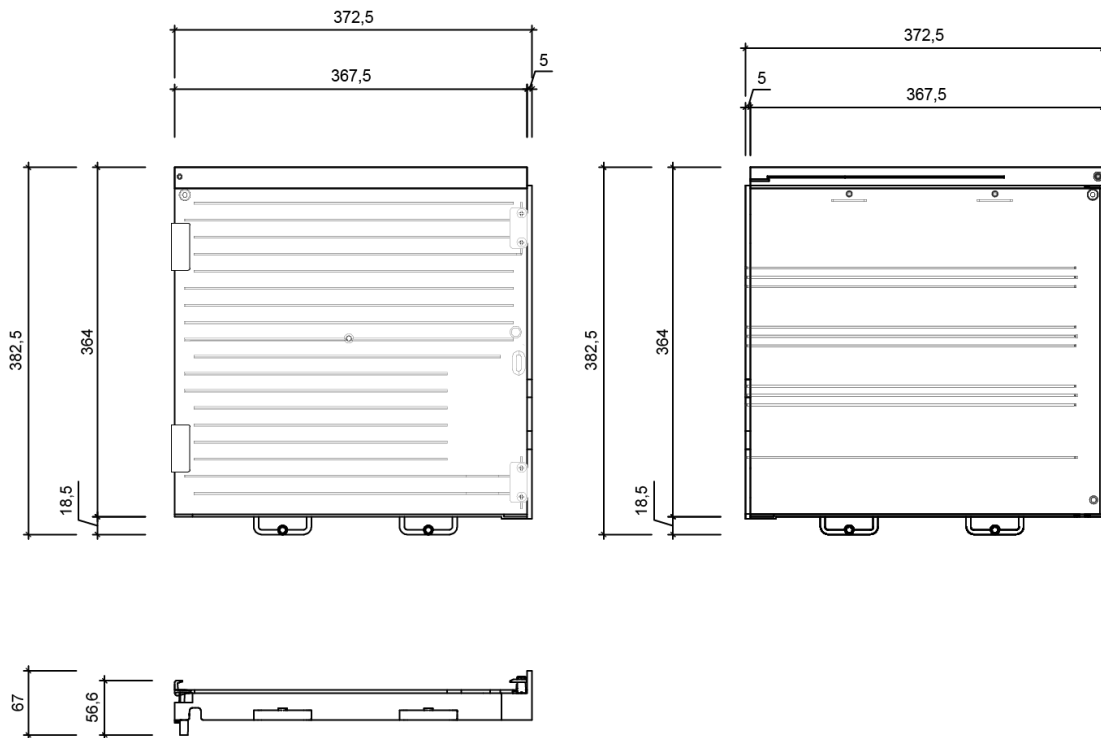
Besides, such component allows the installation of Multi-Contac connectors (MC4) with 6 mm² cables.



Front, back and side views of the PV laminate (all measures are reported in mm)

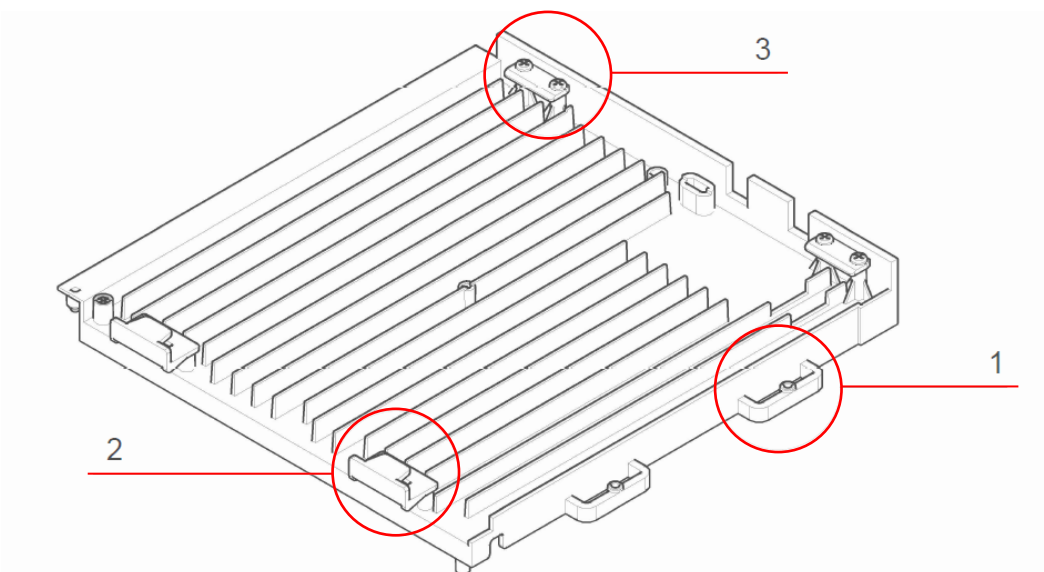
2.2 Modular supporting frame

The supporting frame which hold one PV laminate is made up by 4 recycled plastic modular elements, designed to be light-weighted, easy to handle and characterized by a snap-in connection. Each element in fact is a sort of a square, smaller than 0.16 m², easy to handle by only one worker and linked to the other elements through easy plug-snaps. In the following figure the main views of the supporting frame are reported.



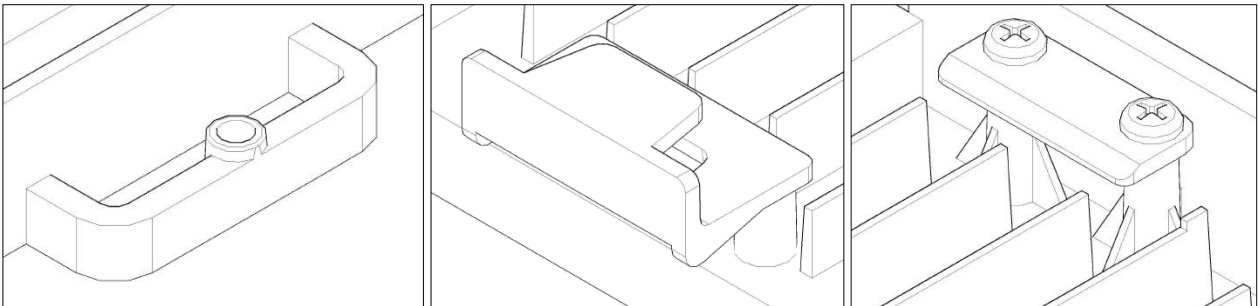
Front, back and sides views of one modular supporting frame (all the measures are reported in mm)

Both sides of each modular element are stiffened with ribs (16 mm high and 2 mm thick) that guarantees mechanical resistance avoiding the bending of the surface. In the main front the ribs are interrupted in correspondence of the location of the PV laminate's junction box, in order to ensure its flatness.



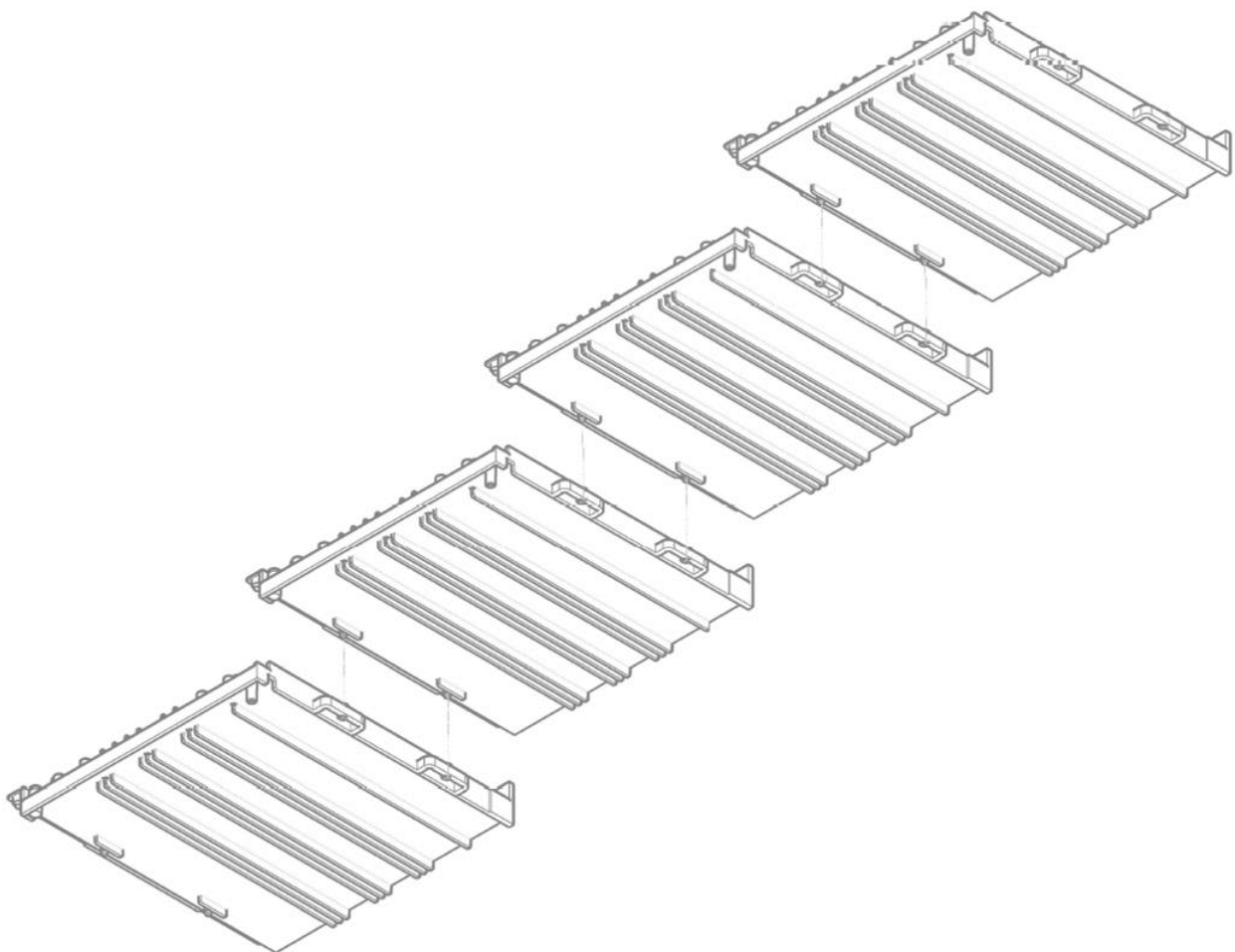
Isometric view of the frame (the numbers are related to the details reported in the next figures)

The link among frames of the same row is provided by tongue and groove joint protruding on the external side of the frame as shown in the next figure (detail 1). Moreover, thanks to the specific designed shape, such joints absorb effectively the geometrical expansion of the material due to temperature.

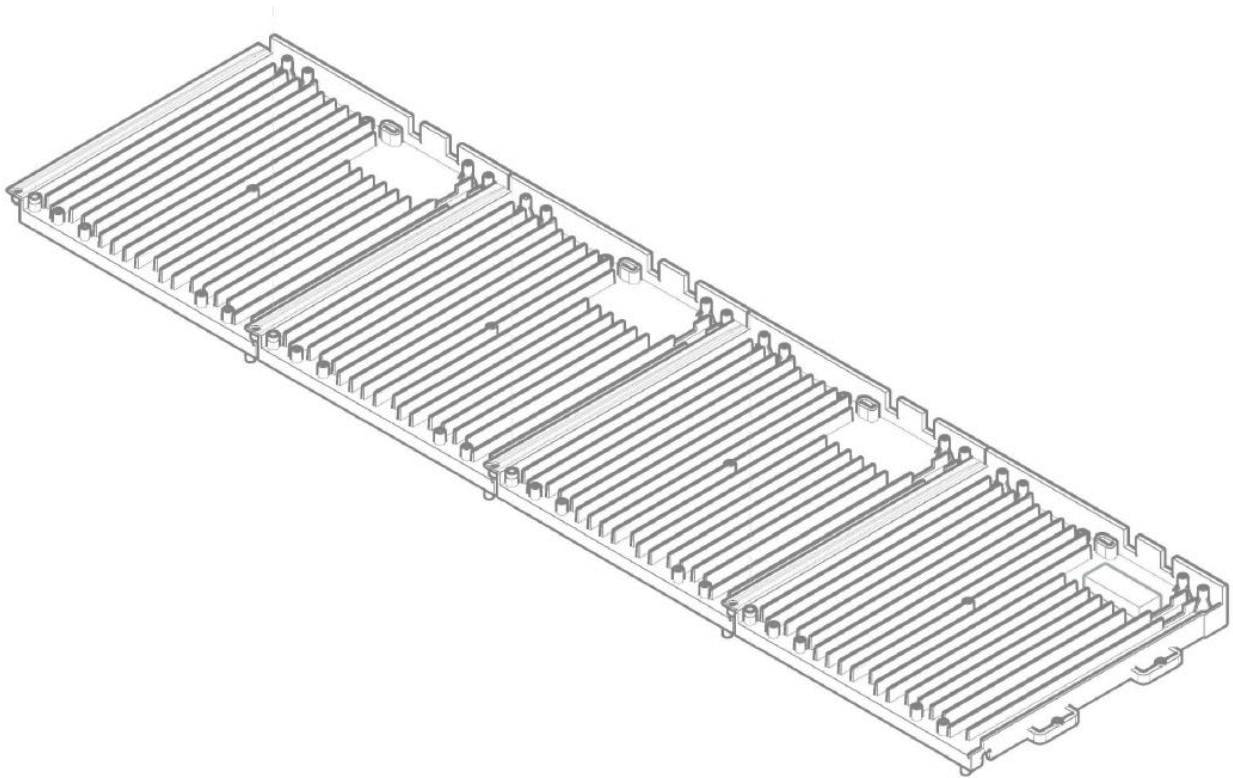


Isometric view of the joint connection between modules detail 1(left) and anchor profiles detail 2 (center) and 3 (right)

The coupling of each supporting frame with the PV laminate is obtained with 4 cramps (anchor profiles): 2 snapped in the lower part (detail 2) and 2 screwed in the upper part of the frame (detail 3). On the opposite side compared to the joints, a protruding lag covers the gap between frames, providing hence the waterproofing among frames in the same row.



Isometric backside view of the 4 supporting frames



Isometric front view of the 4 linked supporting frames

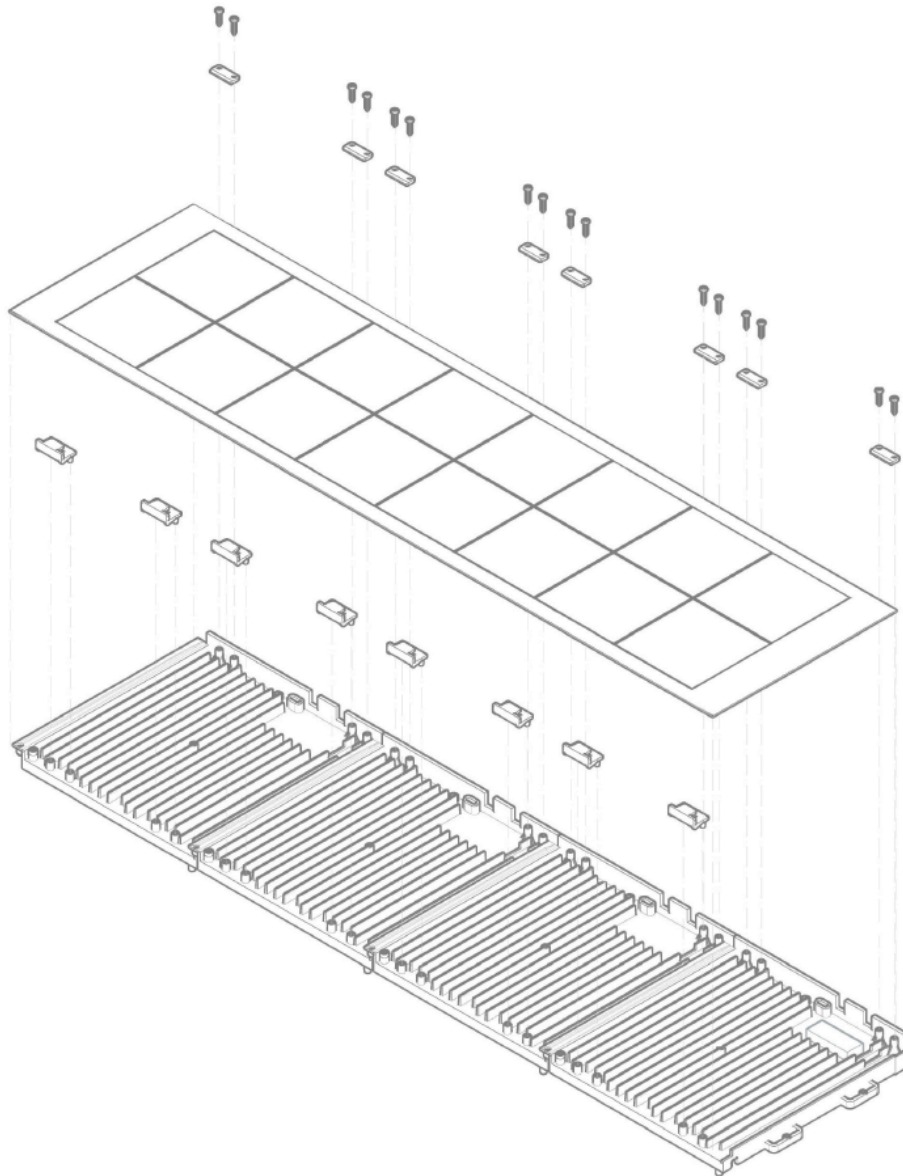
It should be noted that the waterproofing of the roof is provided by the connection of the supporting frame, without the need to add additional layers, as described in the next section.



Laboratory testing of connections on prototypes

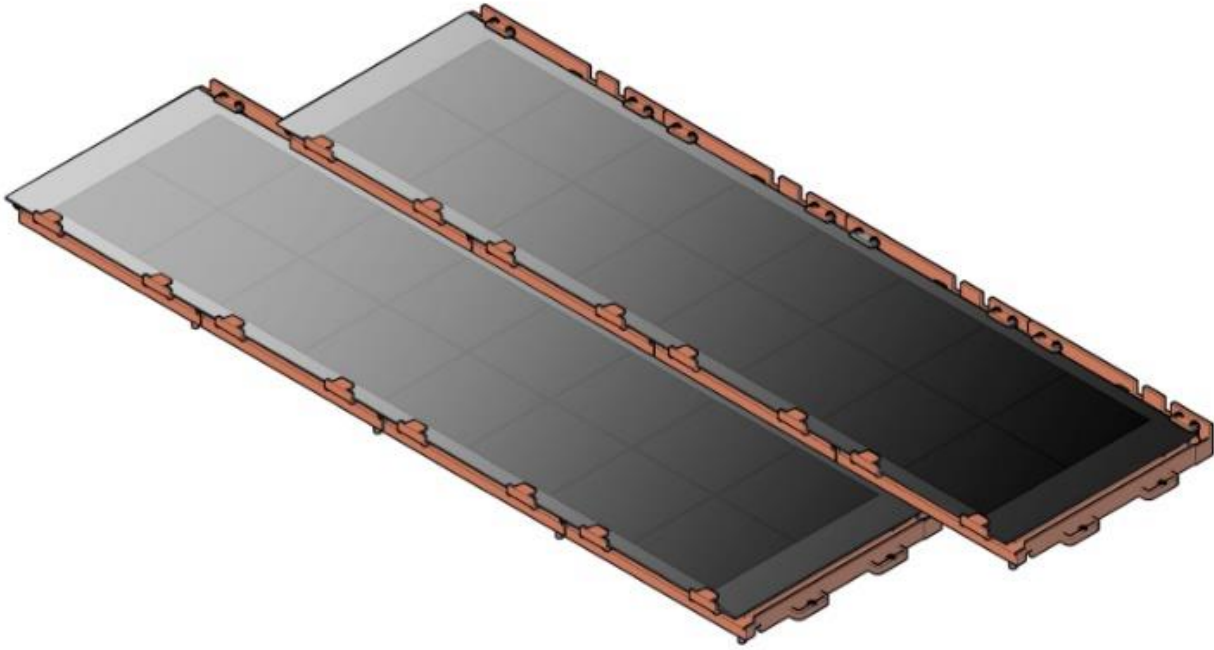
2.3 Overall component and connections

As already mentioned, the coupling of the 4 supporting frames with the PV laminate is fulfilled with 16 cramps (anchor profiles); in such respect, when the 4 frames are placed next to each other, the snap joints can be added, the PV laminate is overlapped to the frames and finally the screwed joints mechanically secure the PV module. The assembly steps are shown in the next figure.

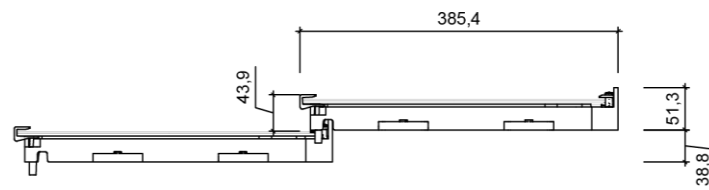


Assembly of the 4 frames with the PV laminate

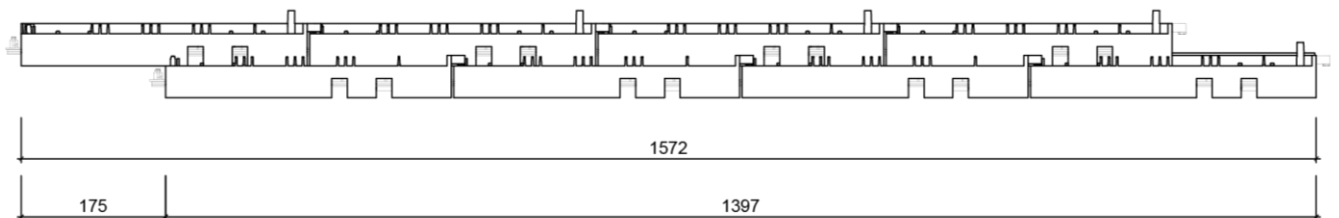
The figure of the final PV tile is reported below. It should be noted that the whole component must be assembled directly on the roof.



Axonometric view of 2 PV tiles

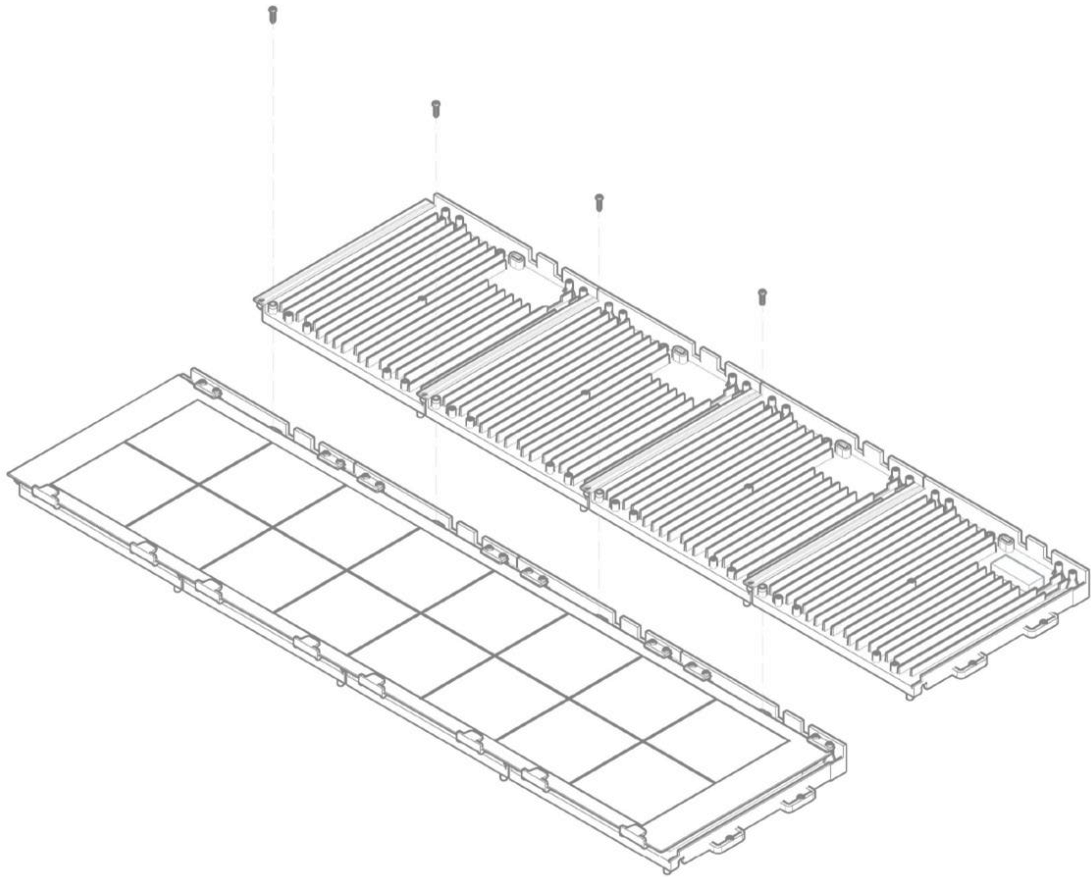


Transversal of 2 PV tiles (sizes in mm)



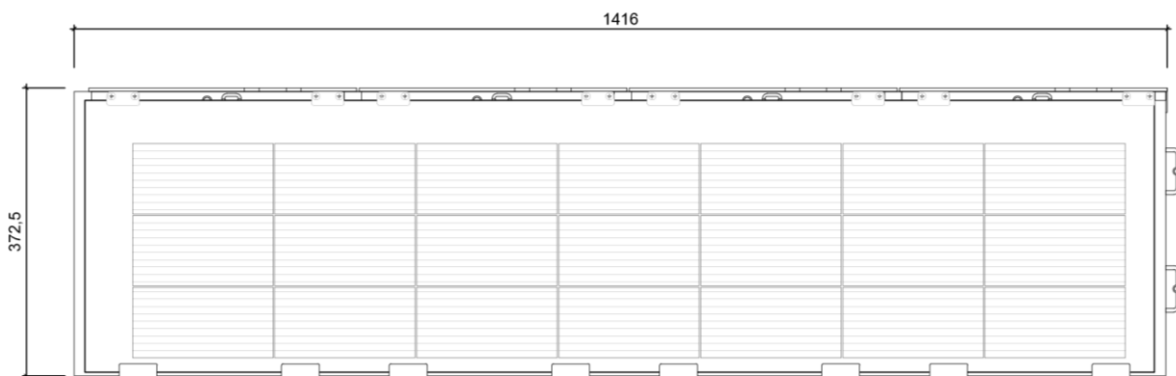
Longitudinal of 2 PV tiles (sizes in mm)

PV tiles in the same row could be easily installed through the joint connections already shown in detail 1. When the first row is completed, the second one must be overlapped on the upper edge and screwed in the specific slots (4 for each PV tile), as shown in following figure.



Final layout of 2 overlapped PV tiles in different row

The holes and the screws are finally covered with the PV laminate which further guarantee the waterproofing.



Top view of the PV tile

2.4 Summary of the technical information

Dimensional features

Size of the PV laminate (Width, Length, Thickness) [mm]: 351.7 x 1385.4 x 4.0

Weight of the PV laminates [kg]: ≈6 kg

Size of the a modular supporting frame (Width, Length, Thickness) [mm]: 372.5 x 382.5 x 67

Weight of the modular Supporting frame [kg]: ≈1 kg

Power output features

Power output in STC [W_p]: 77

Voltage at MPP [V]: 11.97

Current at MPP [A]: 6.43

Open circuit voltage [V]: 14.4

Short circuit current [A]: 6.85

Installation and operation features

Minimum operating temperature [°C]: -40°C

Maximum operating temperature [°C]: +80°C

Minimum operating relative humidity (at min. temperature) [%]: 0

Maximum operating relative humidity (at max. temperature) [%]: 100%



SOTTILE on-site assembly test

3 Installation procedure

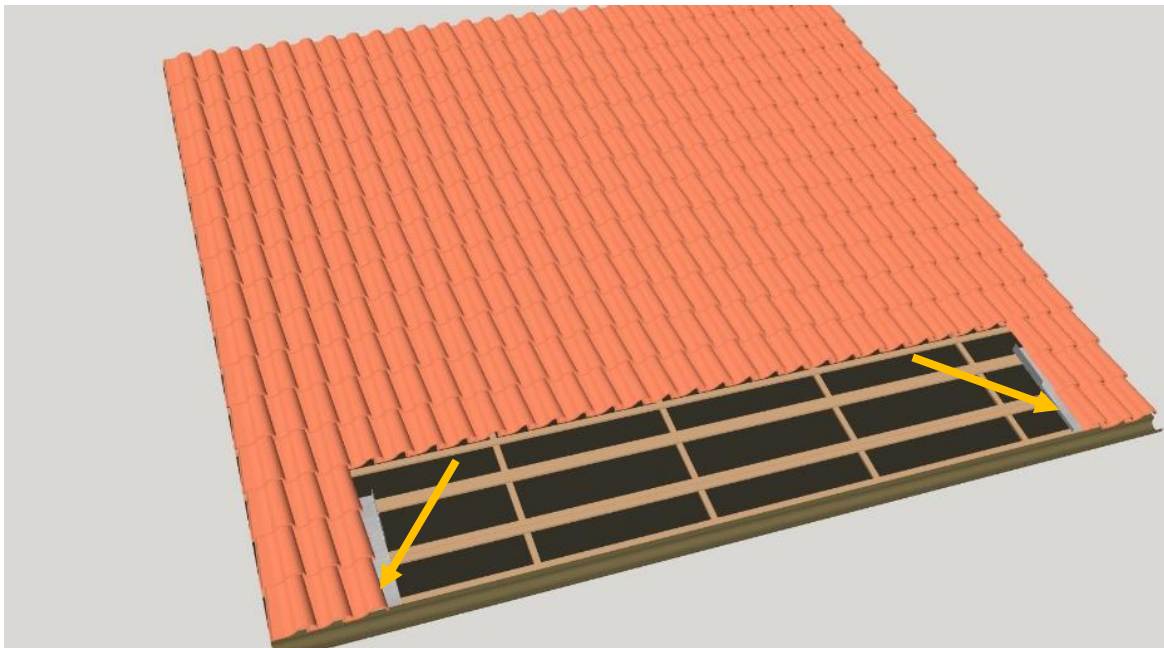


Once the size and geometry of the SOTTILE system has been established, the corresponding space within the traditional roofing system must be left free. In the case of existing roofs, before starting the installation of SOTTILE, it is necessary to carry out an inspection of the roof in order to check the anchoring system features. In fact, the PV tiles should be anchored above aluminium or wooden profiles 35 cm far; if they are not already installed, it is necessary to provide with the integration of these supports.



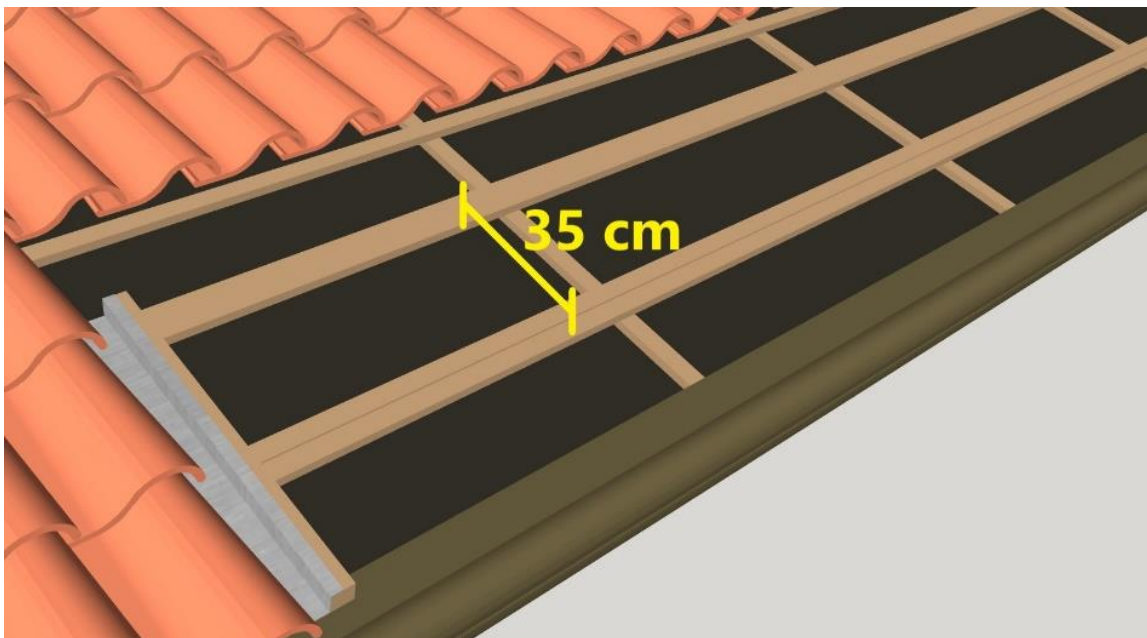
Mounting phase 1

In case of existing roof, first of all it is needed to remove the existing tiles that will be replaced by SOTTILE system, as shown in figure (Mounting phase 1). It is advisable to start with the installation of the modular supporting frame from the bottom-left side of the roof.



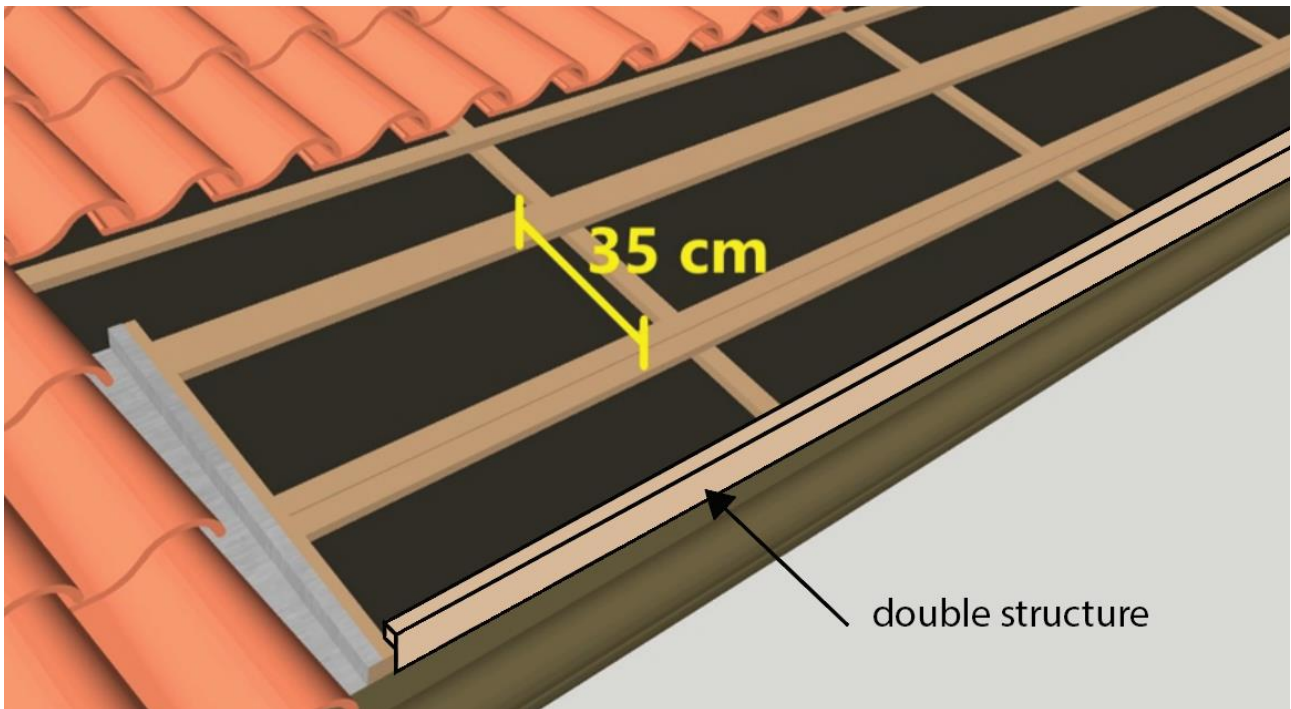
Mounting phase 2

After that, two C-profile channels are positioned on the right and left sides of the selected area (Mounting phase 2), which are essential for lateral water drainage.



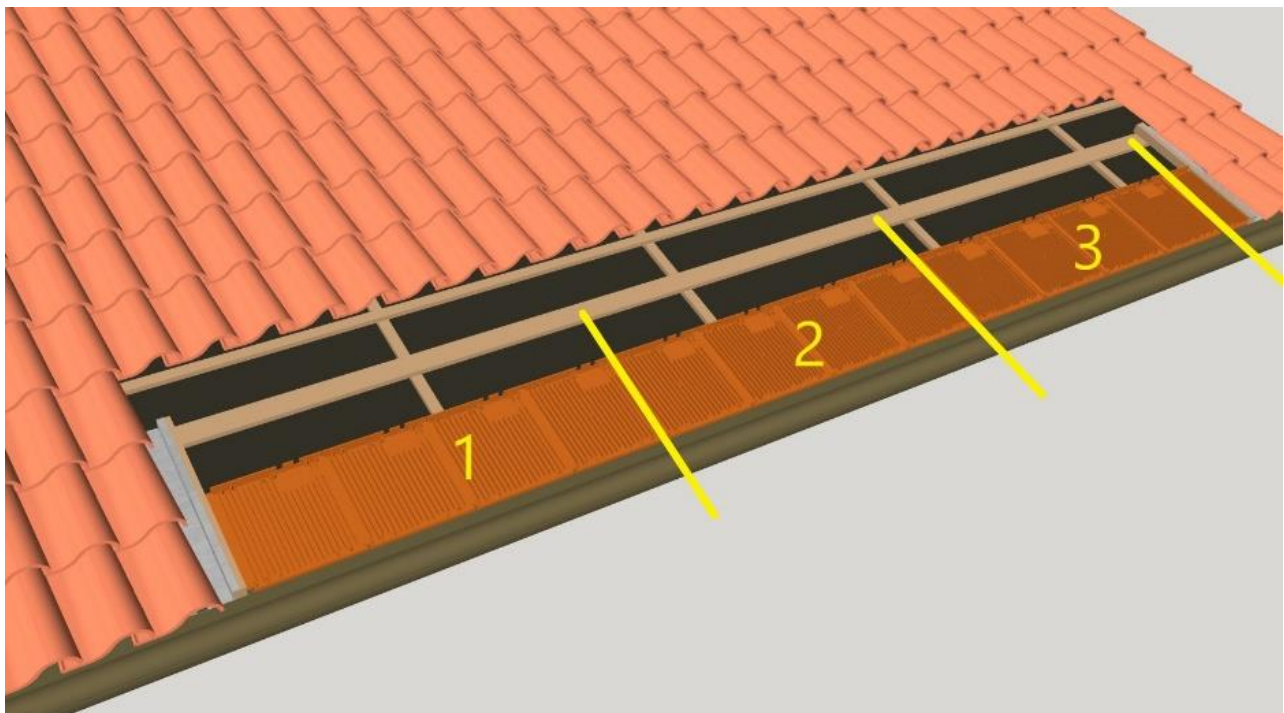
Mounting phase 3

The ideal distance between the center of each batten profile, to properly fix the modular supporting frame, should be 35 cm. Then proceed fixing the batten profile before positioning the modular supporting frame (Mounting phase 3).



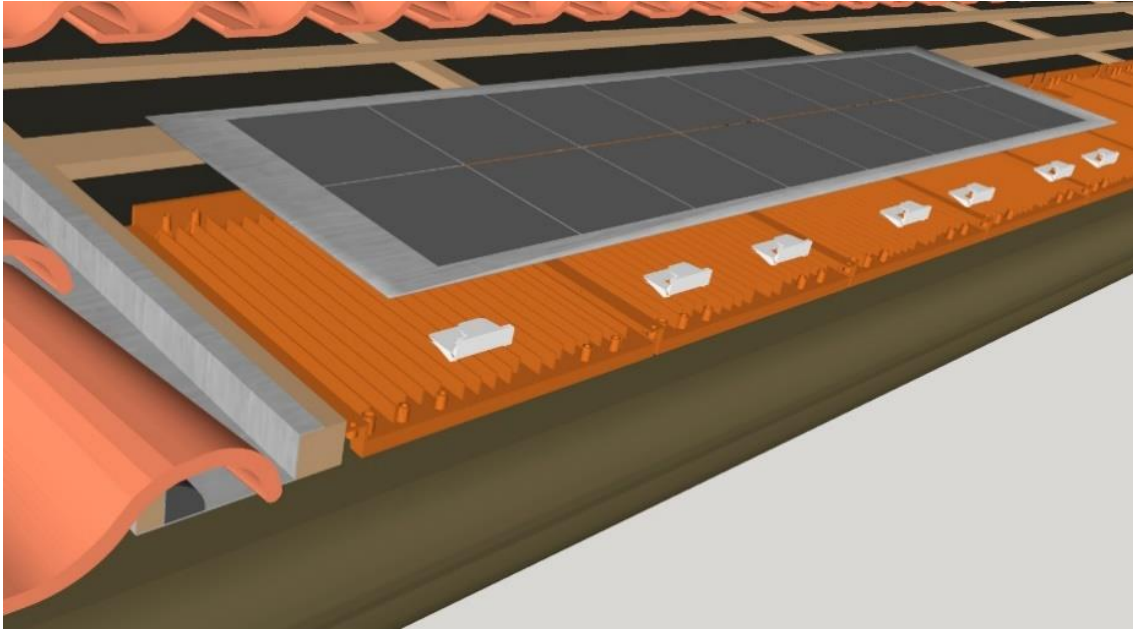
Mounting phase 4

It is important to note that the first batten is characterized by a double height (Mounting phase 4).



Mounting phase 5

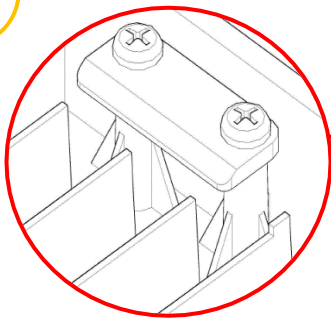
After positioned and fixed the first 4 modular supporting frames, it is possible to repeat the operation with the other frames until the entire row is completed (Mounting phase 5).



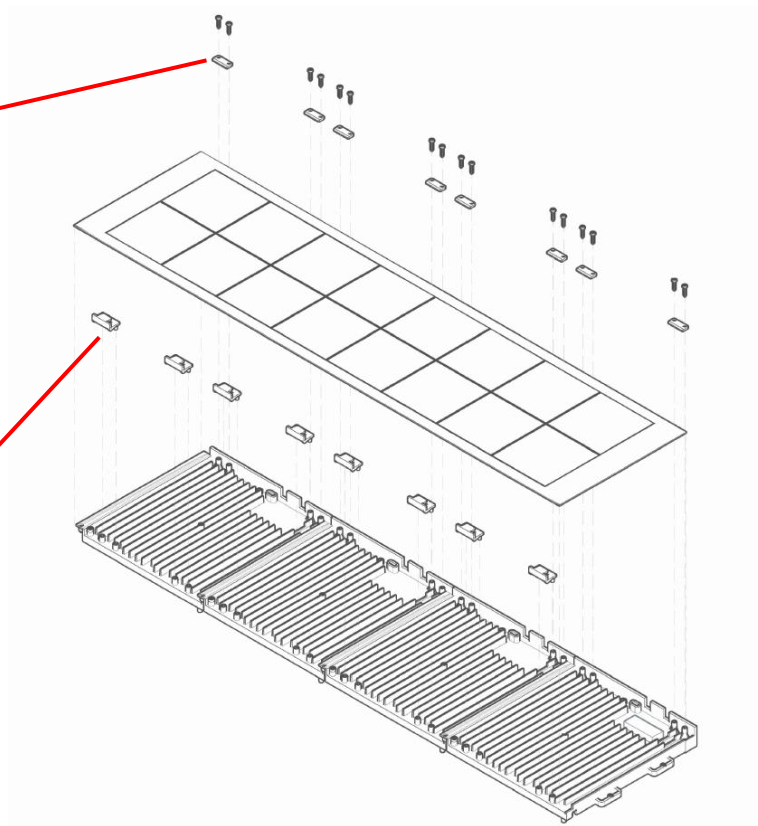
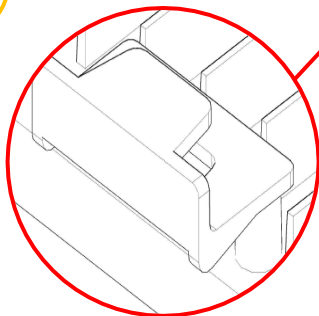
Mounting phase 6

Once all the modular support frames have been fixed, it is possible to proceed with the application of the photovoltaic laminates, always starting from the lower left corner (Mounting phase 6). The mounting of the PV module is divided in two different phases.

B

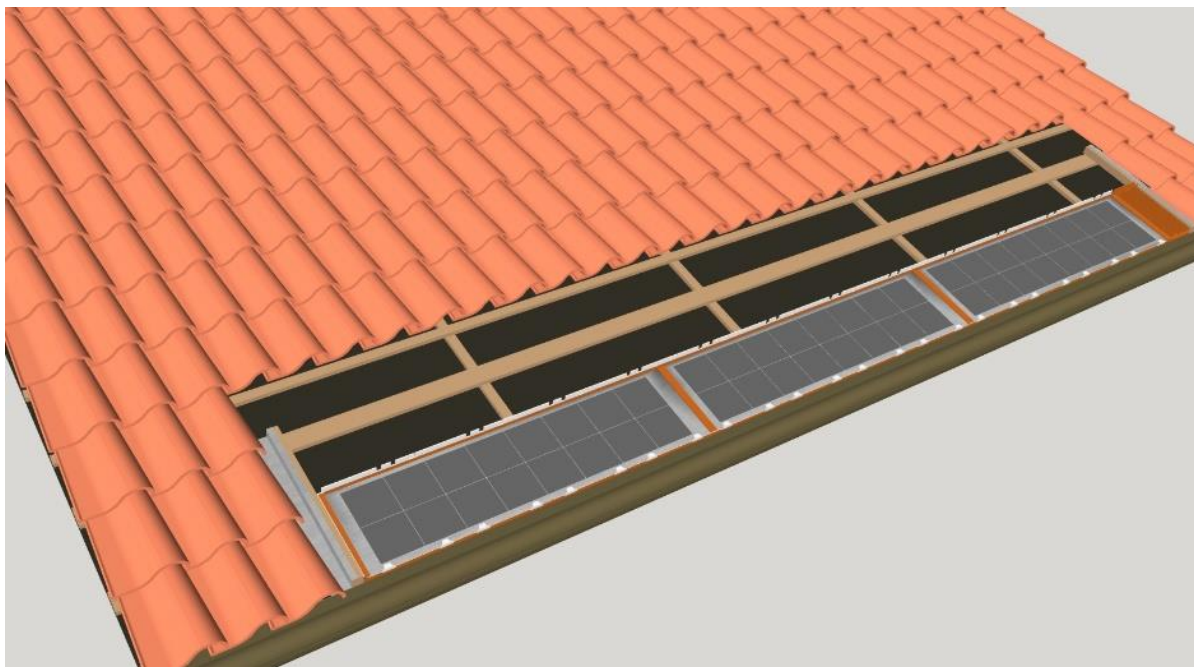


A



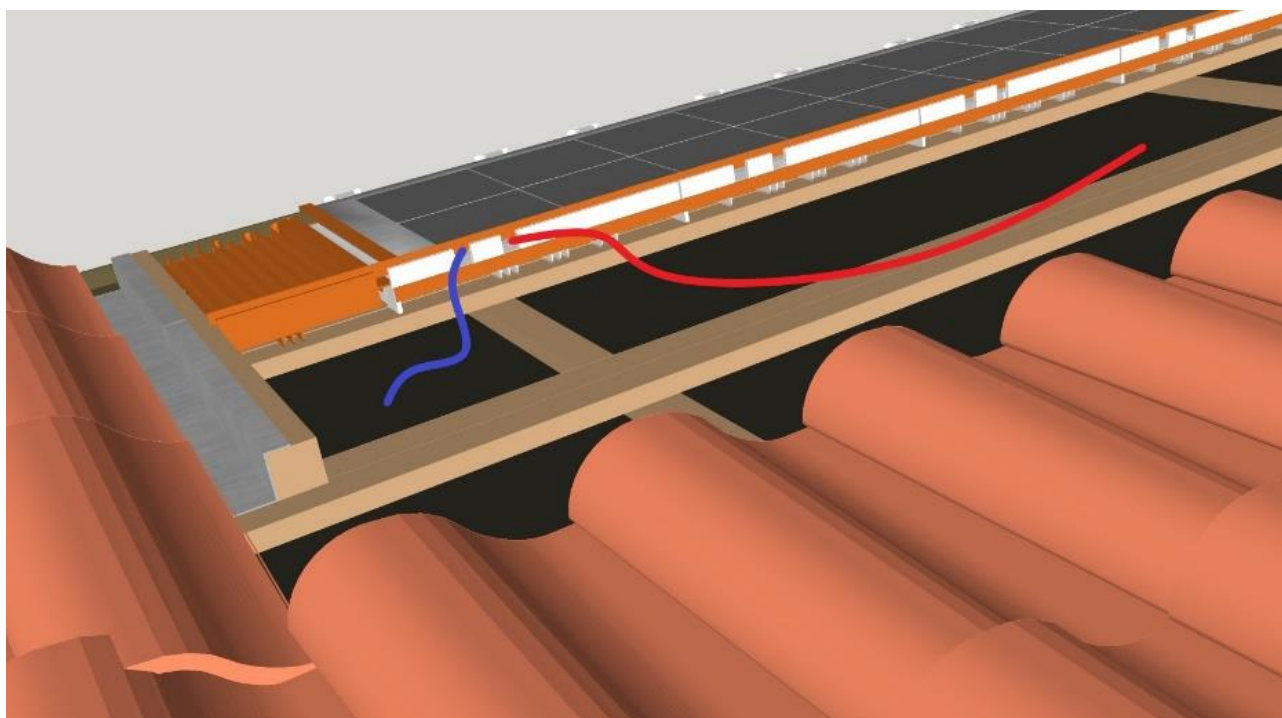
Mounting phase 7

First of all, it is necessary to fix the clips on the plastic frames in the holes provided at the bottom of the supporting frame, that are used to anchor the photovoltaic panel in the bottom part; in fact, once these clips are fixed (Mounting phase 7 - A), the panel can be positioned by tilting it into the rent in the clips, lying it down. After that, a second row of clips with screw is used to fasten of the photovoltaic modules in the upper part. As shown in the above, the clips are fixed with screws in the holes provided at the top of the supporting frame (Mounting phase 7 - B).

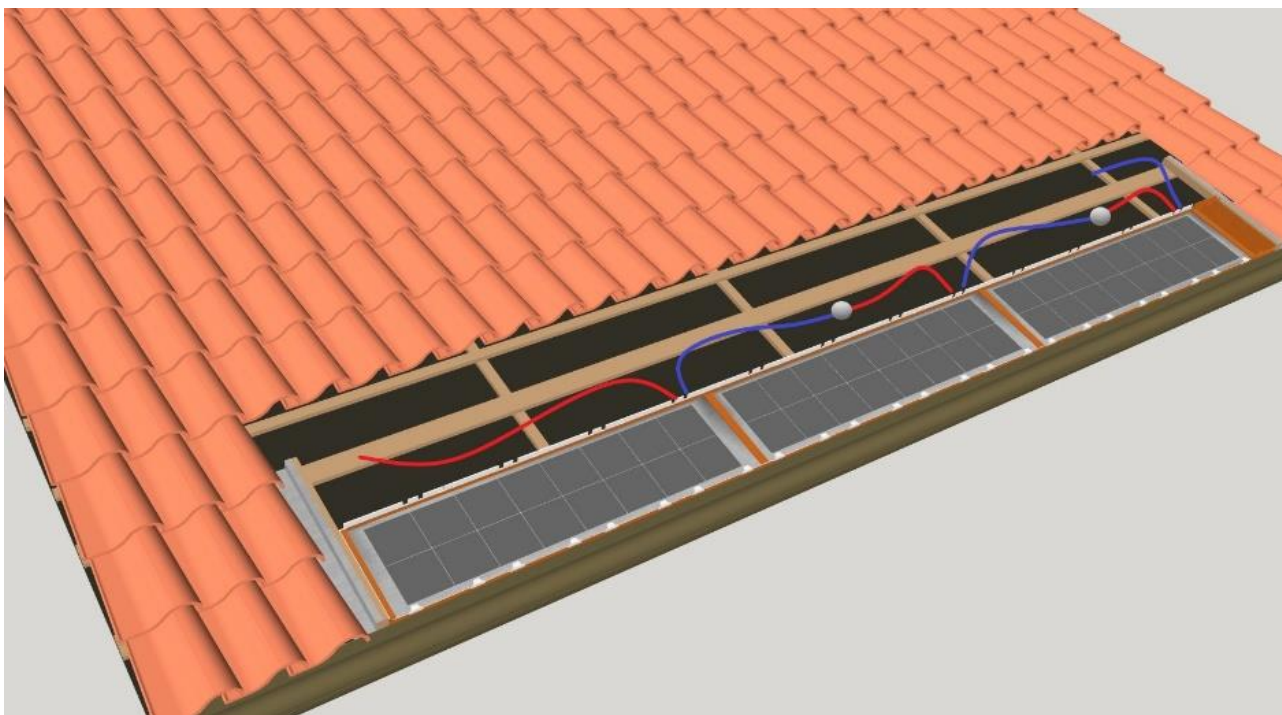


Mounting phase 8

After that it is possible to proceed with the connection of the other photovoltaic panels in order to complete the entire row (Mounting phase 8) and then to continue with the installation of the second string.

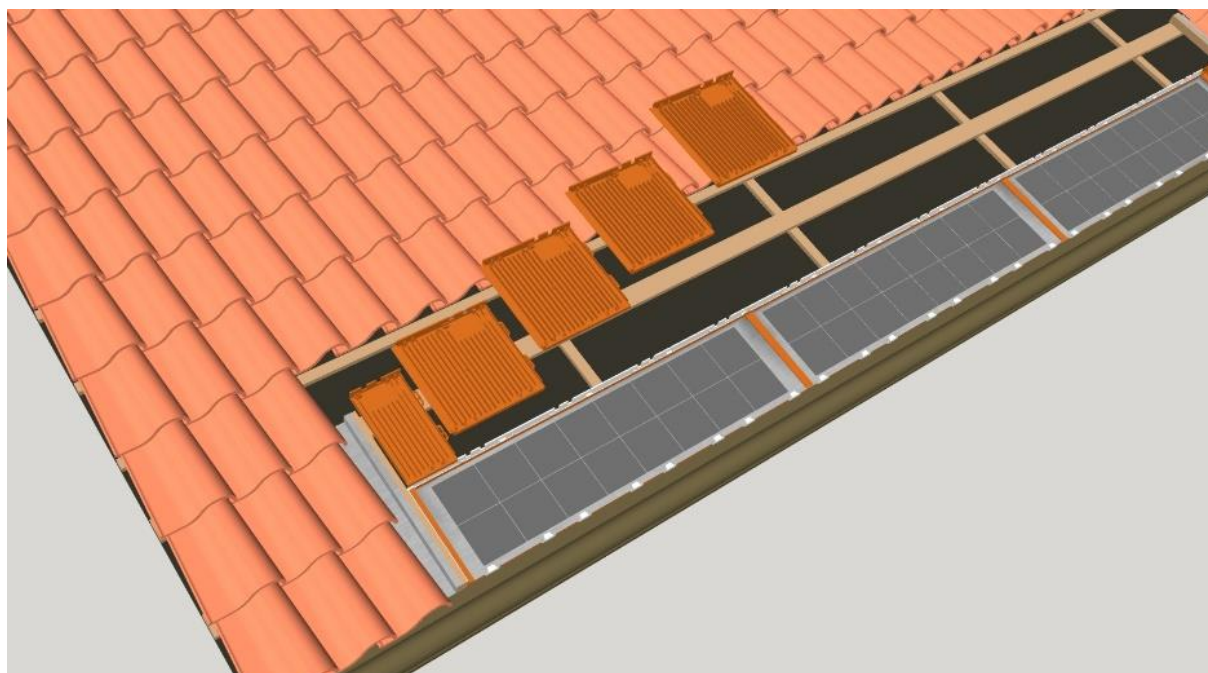


Mounting phase 9



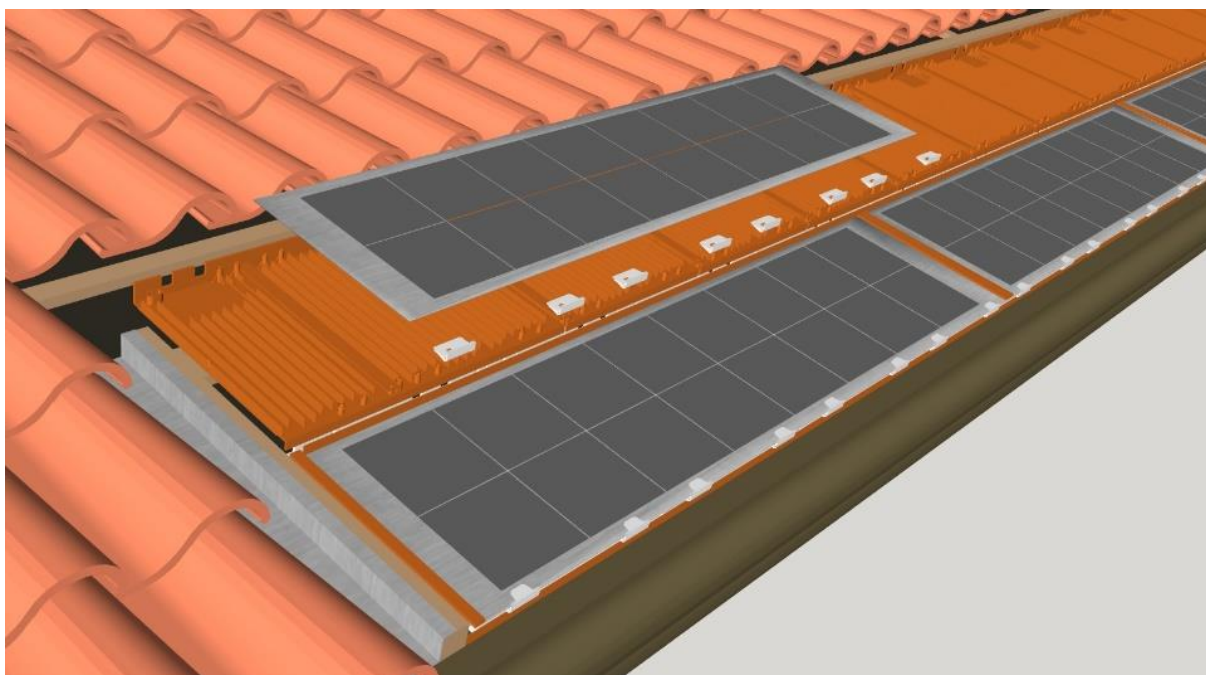
Mounting phase 10

Each photovoltaic panel is provided with two cables (Mounting phase 9) that must be correctly connected to the other modules in order to create the electrical circuit. In particular, starting from the right, the red cable of the first module will be connected with the cable coming from the upper string while the blue cable will be connected with the red cable of the adjacent module (Mounting phase 10) and so on until the first module at the bottom left from which only one blue cable will come out that will be connected to the inverter (see Mounting phase 13 for further details). It should be noted that the maximum system voltage must not exceed 900 V, so a maximum number of 60 laminates can be connected in series.



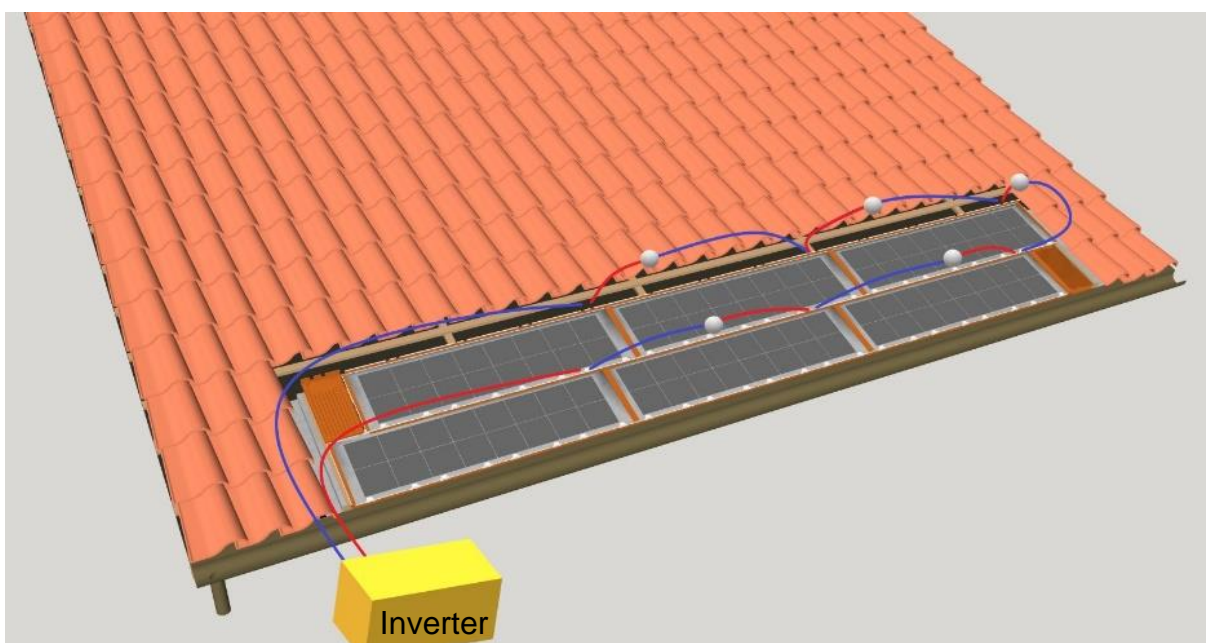
Mounting phase 11

After wiring the first string, it is possible to proceed with the installation of the second string. The procedure is similar, so starting from the left and shifting by half a module, the plastic frames of the photovoltaic cells are arranged and fixed (Mounting phase 11). Similarly, it is possible to proceed by completing the entire second string.



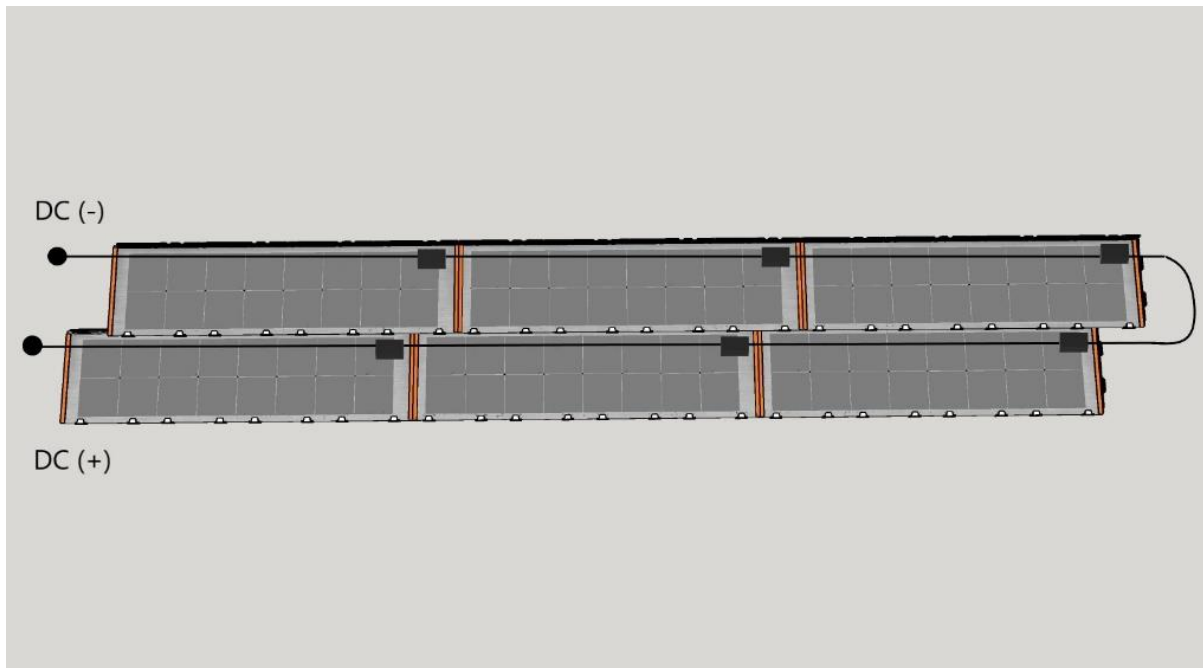
Mounting phase 12

Once the modular frames of the second string have been fixed, the photovoltaic laminates can be installed (Mounting phase 12). The procedure is identical to the one described before (Mounting phases 5-11).

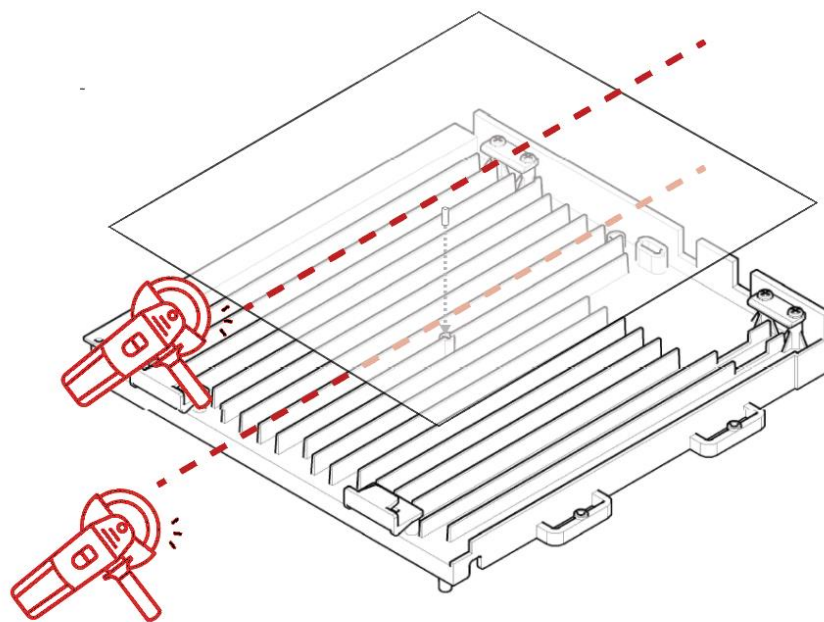


Mounting phase 13

Once the photovoltaic tiles of the second string have been fixed, it is possible to proceed with the wiring. The cables are connected following the same procedure already described: starting from the right, the red cable will connect with the red cable of the module below and the blue cable with the red of the adjacent one (Mounting phase 13). The details of PV connections are shown below.



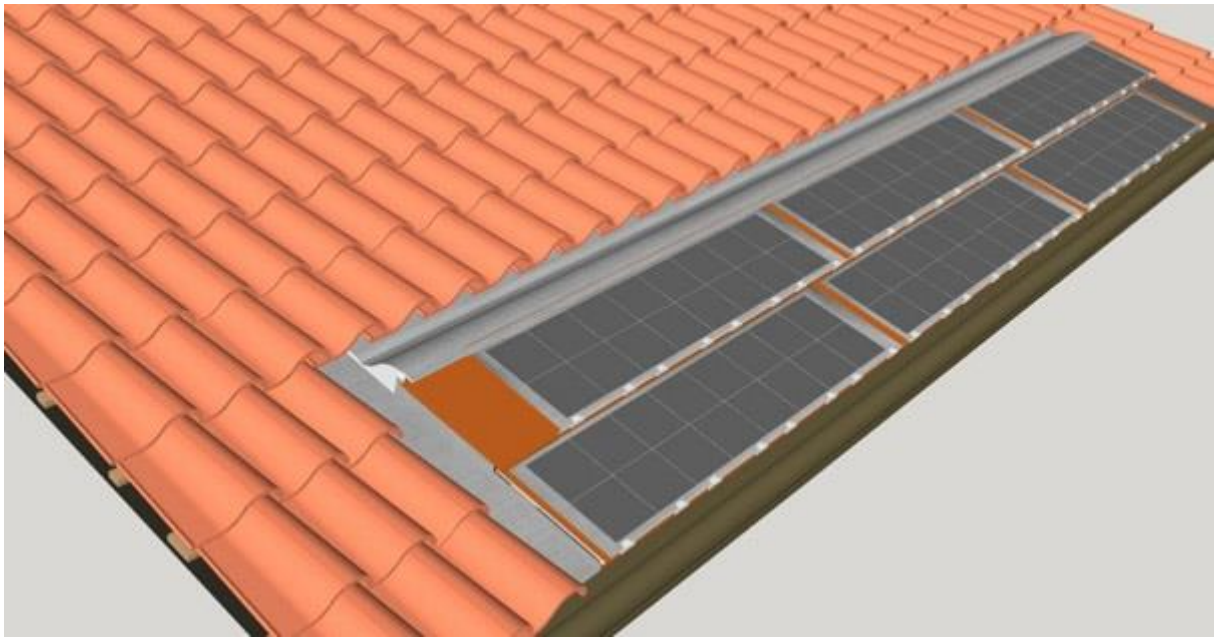
Detail of PV connection



Mounting phase 14

For completion purposes of the edge of the roof, the modular supporting frame can be cut by an angle grinder (Mounting phase 14), taking care to cut both the tile and the lid at least 1 cm beyond the central connection. To keep the half lid resting on the half tile, a perimeter carter will be required.

After connecting all the photovoltaic modules to each other and to the inverter, the last row of tiles is repositioned.



Mounting phase 17

These will rest on a metal s-shaped profile that will drain the water downward, avoiding any infiltration into the roof.



Installation of a 10 kW_p SOTTILE system



SOTTILE

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