This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 691768

Design pack for every PVSITES demo site

Project report

ACCIONA, TECNALIA, ONYX, BEAR, FLISOM, CRICURSA, CEA, FD2, VILOGIA

March 2019

Summary

This report includes a complete characterization of the final modules and demo-systems design through a descriptive definition in the core document and a detailed “design pack” consisted of a Module Datasheet and several Technical Guidelines per demo.

Acknowledgements

The work described in this publication has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement Nº 691768.

Disclaimer

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1 EXECUTIVE SUMMARY

Deliverable D8.3 gathers all the information generated during the design works of the BIPV modules and demo-systems planned in the project.

The current version is an update of the original "Final version" submitted on 19th December, 2017 and contains all the changes applied over the modules and demo-systems designs since then until now (31th March, 2019).

The complex requirements of some demo-buildings has caused an intense debate about certain technical issues aimed to achieve the most effective integration in the buildings, according to the customer necessities and the objectives referred in the project.

Successful designs have been finally achieved, as a result of the efforts; in such a way that, although some of them have been highly influenced by the boundary conditions of the building areas where they will be placed, final designs can be used or easily adapted to other buildings or applications. In this sense, new BIPV elements developed in PVISTES project will be able to be considered, after being demonstrated under real operating conditions, as potential commercial items for BIPV applications with a TRL 7.

Module designs are showed in the data-sheets attached to this document. It can be seen how the geometrical conception of the product meet, for each demo-case, the requirements related to the demo-building and the use intended; and how their characteristics could allow their installation in other buildings and with similar uses for which they have been initially thought.

D8.3 also includes technical guidelines for the implementation of the demo-systems. The architectural and electrical guideline are, however, more specific of the particular case of each demo. Anyway, they can be considered as classic technical guidelines of a typical BIPV project based on the use of the PVSITES BIPV elements.

1.1 Description of the deliverable content and purpose

Deliverable D8.3 and its annexes (design pack) basically present the final design of the BIPV modules and demo-systems which will be installed in the selected demo-site. The information gathered includes:

- Physical and electrical definition of the BIPV modules developed by ONYX and FLISOM.
- Technical specifications for installing and connecting the BIPV modules in their respective demo-buildings.
- Other useful information, regarding the operation & control strategies, the commissioning and maintenance rules and the health, safety and security guidelines.

All this information is gathered and detailed in the Module Datasheets and Technical Guidelines annexed to this deliverable. A descriptive definition of every demo-system is included in the core document.

The main purpose of deliverable D8.3 is to provide technical support for the future manufacturing of prototypes and installation of demo-systems in the demo-buildings. This intention is complementary to that of the deliverable "D8.2. Result of modelling and BIPV strategies for every demo site", which it is aimed to simulate, in advance, the foreseen behaviour of the systems in their respective demo-buildings.

1.2 Relation with other activities in the project

The challenges undertaken in the Task "T8.1 Design of demonstration installations", which finish with this deliverable, have been distributed in 4 subtasks:

- Subtask 8.1.1. Current performance assessment: where a technical and energy pre-auditory of the initial status of each demo-building has been carried out. (Deliverable "D8.1. Energy audit of buildings and identification of BIPV possibilities in every demo site").
- Subtask 8.1.2. Pre-dimensioning of BIPV systems for every demo site: where several demo options have been considered and power estimated for each demo-site, and one preliminary design of the chosen option has been proposed in each case. (Deliverable "D8.1. Energy audit of buildings and identification of BIPV possibilities in every demo site").
- Subtask 8.1.3. Modelling of the building with BIPV systems: where the final demo-system energy performance has been simulated for each demo on the basis of the final designs developed in the subtask 8.1.4. (Deliverable "D8.2. Result of modelling and BIPV strategies for every demo site").
- Subtask 8.1.4. Final design of BIPV implementation on demo sites: where the final design of the demo-system, including the BIPV module, has been developed for each demo-site from the preliminary idea suggested in the subtask 8.1.2 and considering the new requirements and constraints detected during the progress of the task, on the basis of the information coming from a more accurate exam of the final demo-buildings. (Deliverable "D8.3. Design pack for every demo site").

All these actions are previous to the manufacturing of the prototypes, addressed to testing and demonstration, and the installation and commissioning works of the demo-systems in their respective demo-sites, which will be carried out in the following tasks:

- Task 8.2. Manufacturing of prototypes.
- Task 8.3. Installation and commissioning of installations.

In this regards, modules data-sheets and technical guidelines, both included in this deliverable, become essential information to successfully undertake these works.

Table 1.1 Relation between current deliverable and other activities in the project

Project activity	Relation with current deliverable
Subtask 8.1.1	Demo-site pre-audit
Subtask 8.1.2	Pre-dimensioned BIPV systems
Subtask 8.1.3	Final demo-system modelling
Task 8.2	Manufacturing of prototypes
Task 8.3	Installation and commissioning of installations

2 DEMO DESIGN PROCEDURE

Working procedure, during the modules and demo-system design works, and measures taken to present results are commented in this chapter.

2.1 Working procedure

The working methodology followed to advance in the task "T8.1 Design of demonstration installations" includes several actions aimed to control and streamline the design procedure of the modules and the demo-systems where they will be installed. The complexity of the process, with a huge amount of information simultaneously managed and transferred by the large number of partners involved, has required fast, diversified and extended communication and reporting measures.

Main roles developed by each partner involved in this task have been the following:

- BIPV modules design: manufacturer partners (ONYX, FLISOM).
- BIPV architectural design: architecture partner (BEAR).
- Design support: demo-building owners or responsible (FORMATD2, FLISOM, CRICURSA, VILOGIA, TECNALIA).
- Work management and reporting: WP leader (ACCIONA).

Measures implemented to progress on the task are listed below:

- On-site visits to the real demo-sites: carried out from the first pre-auditory of the available demo-building to the procurement of that recently selected (carport), aimed to gather accurate information about the architectural details of the buildings, original building plans or/and in-situ measurements and pictures, and needs, constrains and possible implementation barriers detected, in each case.
- Specific chains e-mail: one per demo, 6 in total, conceived as a space for discussion on all the technical issues continuously arising about the conceptual and detailed designs of the developed modules and demo-systems, according to the demo-buildings and the project requirements.
- The written media allowed documenting the new advances, consolidating decisions and exchanging graphic information in a fast and immediate way. The setting up of an exclusive debate per demo facilitated quickly finding specific information between the great deals of data and comments transferred.
- Partial call conferences: were continuously held by the partners regarding specific details of the technical and management matters in progress, for a more direct communication aimed to clarify the toughest issues and to take decisions.
- General call conferences: were periodically held by all the partners involved in a certain demo-system in order to assess, in general terms, the global advances achieved in the last weeks and to detect possible future obstacles.
- Although technical issues were also treated in these conversations, they used to be more focused on organizational, financial, legislative and permitting issues, as the case may be.
- Follow-up reports: a common follow-up report template was elaborated to gather all the relevant information concerning each demo-system. The specific per demo follow-up reports have been periodically updated, not only by the WP leader but also the partners involved, after the important milestones happened and the general call conferences in order to gather the last design details and final decisions concerning the management issues.

- Deliverable “D8.3. Design pack for every demo site”, Modules Data-sheets and Technical Guidelines: have been elaborated as the works develops and updated as final designs advances. The present document corresponds to the final version.
- Common folders, one per demo and subject, were created in the Partners Area of the project’s web-site to upload and share the generated information. The tasks’ progress is documented through the Follow-up reports mentioned above. The updated versions of the associated deliverable “D8.3. Design pack for every demo site” has been periodically uploaded, together with the modules data-sheets and the technical guidelines. Additional folders are available to include updated building, modules and demo-systems drawings, 3D models for simulations, demo-site pictures and other technical information.
- These platforms will continue to be available to go on with the works, if some changes or corrections are needed in the future.

As a result of the implementation of these measures and the individual contributions of each partner, final designs of modules and demo-systems have been achieved and some decisions regarding the manufacturing and installing works have been taken. Possible future changes and corrections will be documented in next versions, as foreseen in the project’s Description Of Activities (DOA).

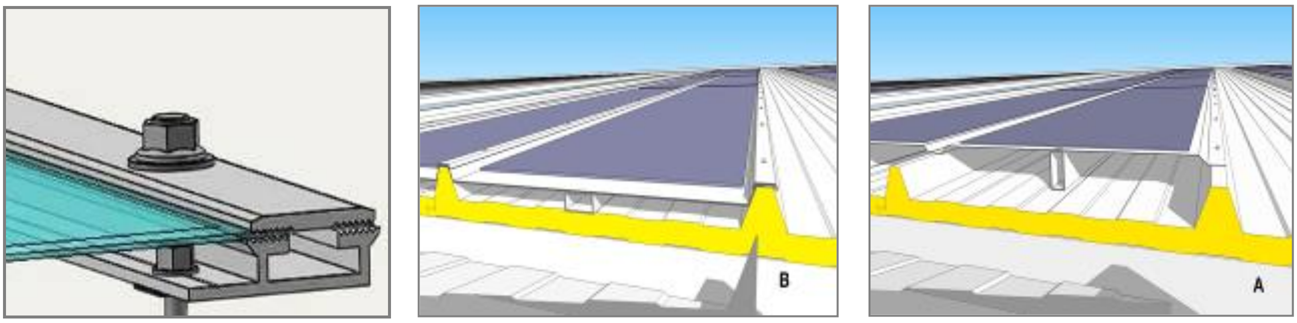


Figure 2.1: Different concepts of design of the BIPV module for industrial buildings (Demo 4)

2.2 Module Data-sheets and Technical Guidelines

As explained in the previous point, Module Datasheets and Technical Guidelines have been elaborated to document the technical details of the developed products and facilitate the integration and operation works in the project’s demo-sites.

The work distribution between the partners involved in the preparation of this deliverable (D8.3) and the annexed Module Datasheets and Technical Guidelines has been the following:

CODE	TITTLE	PARTNER								
		TEC	ONYX	BEAR	FLISOM	CRICURSA	CEA	ACCIONA	FD2	VILOGIA
MDS	**BIPV Modules Data-Sheets**									
MDS1	Demo 1 BIPV Module data-sheet				√					
MDS2	Demo 2 BIPV Module data-sheet				√					
MDS3	Demo 3 BIPV Module data-sheet				√					
MDS4	Demo 4 BIPV Module data-sheet				√					
MDS5	Demo 5 BIPV Module data-sheet		√							
MDS6	Demo 6 BIPV Module data-sheet		√							
MDS	**BIPV Demo-system descriptions**									
MDS1	Demo 1 description: Single house in Mons, Belgium			√	√			√	√	
MDS2	Demo 2 description: Educational building in Genève, Switzerland			√	√			√		
MDS3	Demo 3 description: Carport in Zurich, Switzerland			√	√			√		
MDS4	Demo 4 description: Industrial building in Barcelona, Spain			√	√	√		√		
MDS5	Demo 5 description: Apartments building in Lille, France		√	√				√		√
MDS6	Demo 6 description: Office building in San Sebastian, Spain	√	√	√				√		
GA	**Architectural Integration Guidelines**									
GA1	Demo 1 Architectural Integration Guideline			√	√				√	
GA2	Demo 2 Architectural Integration Guideline			√	√					
GA3	Demo 3 Architectural Integration Guideline			√	√					
GA4	Demo 4 Architectural Integration Guideline			√	√	√				
GA5	Demo 5 Architectural Integration Guideline		√	√						√
GA6	Demo 6 Architectural Integration Guideline	√	√	√						
GB	**Electrical Design, Operation and Control Strategies Guidelines**									
GB1	Demo 1 Electrical Design, Operation and Control Strategies Guideline				√		√			
GB2	Demo 2 Electrical Design, Operation and Control Strategies Guideline				√		√			
GB3	Demo 3 Electrical Design, Operation and Control Strategies Guideline				√		√			
GB4	Demo 4 Electrical Design, Operation and Control Strategies Guideline				√		√			
GB5	Demo 5 Electrical Design, Operation and Control Strategies Guideline		√				√			
GB6	Demo 6 Electrical Design, Operation and Control Strategies Guideline		√				√			
GC	**Installation, Commissioning and Maintenance Guidelines**									
GC1	Demo 1 Installation, Commissioning and Maintenance Guideline			√	√				√	
GC2	Demo 2 Installation, Commissioning and Maintenance Guideline			√	√					
GC3	Demo 3 Installation, Commissioning and Maintenance Guideline			√	√					
GC4	Demo 4 Installation, Commissioning and Maintenance Guideline			√	√	√				
GC5	Demo 5 Installation, Commissioning and Maintenance Guideline		√	√						√
GC6	Demo 6 Installation, Commissioning and Maintenance Guideline	√	√	√						
GD	**Health, Safety and Security Guidelines**									
GD1	Demo 1 Health, Safety and Security Guideline			√	√					
GD2	Demo 2 Health, Safety and Security Guideline			√	√					
GD3	Demo 3 Health, Safety and Security Guideline			√	√					
GD4	Demo 4 Health, Safety and Security Guideline			√	√					
GD5	Demo 5 Health, Safety and Security Guideline		√	√						
GD6	Demo 6 Health, Safety and Security Guideline		√	√						

√	Main responsible
√	Support

Figure 2.2: Distribution of works for the preparation of D8.3 and its annexes

A common template has been used for the Technical Guidelines with the aim to give the project's documents consistency in format and make easy the dissemination and exploitation tasks. The designer and manufacturer's criteria have been respected, regarding the Module Datasheets format. Thus, they have been presented in a way similar than used for their commercial items.

2.2.1 Module Datasheets

Modules datasheets have been elaborated by the designer and manufacture partners (FLISOM and ONYX). Main physical and electrical properties have been detailed in order to make possible the electrical configuration of the entire system and the architectural integration of the modules in the demo-buildings. The modules datasheets will be useful besides to estimate the expected power generation in the demo-sites or any other location with the desired operating conditions, as the case may be.


PVsites DEMO 1 Flisom Flexible Solar Modules

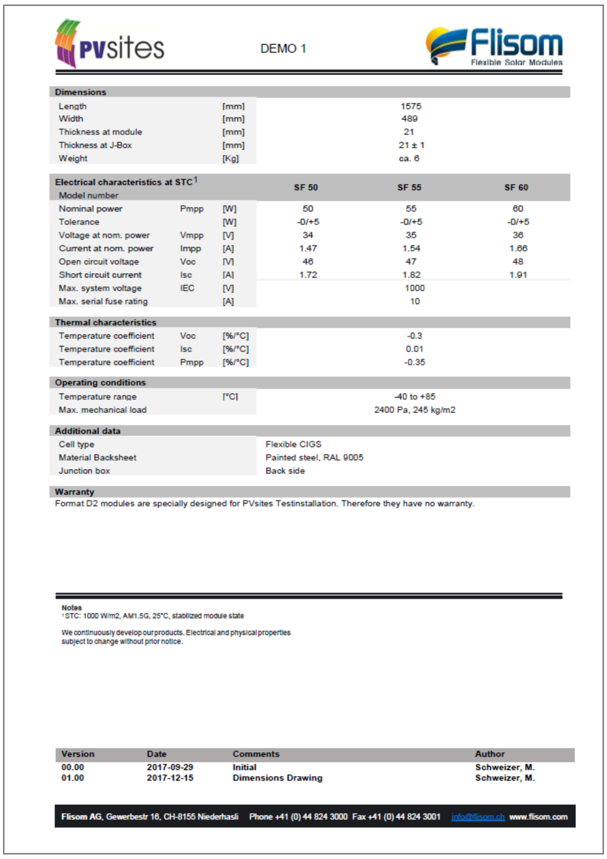
PVsites module – for Stambruges BE

SWISS MADE

Description

The Format D2 module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations.

Flisom AG, Gewerbestr 16, CH-8155 Niederhasli Phone +41 (0) 44 824 3000 Fax +41 (0) 44 824 3001 info@flisom.ch www.flisom.com


PVsites DEMO 1 Flisom Flexible Solar Modules

Dimensions					
Length		[mm]		1575	
Width		[mm]		489	
Thickness at module		[mm]		21	
Thickness at J-Box		[mm]		21 ± 1	
Weight		[Kg]		ca. 6	
Electrical characteristics at STC[1] Model number			**SF 50**	**SF 55**	**SF 60**
Nominal power	Pmpp	[W]	50	55	60
Tolerance		[W]	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	34	35	36
Current at nom. power	Impp	[A]	1.47	1.54	1.66
Open circuit voltage	Voc	[V]	46	47	48
Short circuit current	Isc	[A]	1.72	1.82	1.91
Max. system voltage	IEC	[V]		1000	
Max. serial fuse rating		[A]		10	
Thermal characteristics					
Temperature coefficient	Voc	[%/°C]		-0.3	
Temperature coefficient	Isc	[%/°C]		0.01	
Temperature coefficient	Pmpp	[%/°C]		-0.35	
Operating conditions					
Temperature range		[°C]		-40 to +85	
Max. mechanical load				2400 Pa, 245 kg/m2	
Additional data					
Cell type			Flexible CIGS		
Material Backsheet			Painted steel, RAL 9005		
Junction box			Back side		

Warranty

Format D2 modules are specially designed for PVsites Testinstallation. Therefore they have no warranty.

Notes

[1] STC: 1000 W/m2, AM1.5G, 25°C, stabilized module state

We continuously develop our products. Electrical and physical properties subject to change without prior notice.

Version	Date	Comments	Author
00.00	2017-09-29	Initial	Schweizer, M.
01.00	2017-12-15	Dimensions Drawing	Schweizer, M.

Flisom AG, Gewerbestr 16, CH-8155 Niederhasli Phone +41 (0) 44 824 3000 Fax +41 (0) 44 824 3001 info@flisom.ch www.flisom.com

Figure 2.3: Belgian demo-system's module datasheet, by FLISOM

Every module datasheets have been gathered in Annexes 1-6, one per demo, and coded with the acronym "MDSn", where "n" is the numerical code assigned to each demo.

2.2.2 Technical Guidelines

In the same way, several technical guidelines have been edited in order to make possible the physical and electrical integration of each module in its demo-building. Operation, maintenance and security aspects have also been dealt. In this regards, 4 different technical guidelines have been implemented:

- GAn: Demo n Architectural Integration Guideline.
- GBn: Demo n Electrical Design, Operation & Control Strategies Guideline.
- GCn: Demo n Installation, Commissioning and Maintenance Guideline.
- GDn: Demo n Health, Safety and Security Guideline.

All of them have been fulfilled for each demo and gathered in Annexes 1-6, coded with their correspondent acronyms: "GAn", "GBn", "GCn" and "GDn", where "n" is the numerical code assigned to each demo.

Guideline GAN: Architectural Integration, Demo D3 Switzerland, Zürich.

PVsites

SPECIFICATIONS

Description:
The FLISOM modules are produced and will be installed at two locations. One location is at EMPA in Zurich-Dubendorf and the other location is at Utility EKZ in Zürich.
The cells are laminated on the thin steel back sheet. The sheets are bended during installation

Dimension:
Module dimensions: 3000 x 1000 mm.
Working dimensions: 3000 x 1000 mm.
Materials:
Steel sheets

Colours:
The metal sheet is black.

Mounting system:
The carport structure is made of steel.
Modules are mounted on the steel profiles. During the installation the modules will be bended to fit the half round shape of the structure.

EU Standard:
Not applicable.
The carport is not a building according to the European Standard EN50583-2016 "Photovoltaics in buildings".

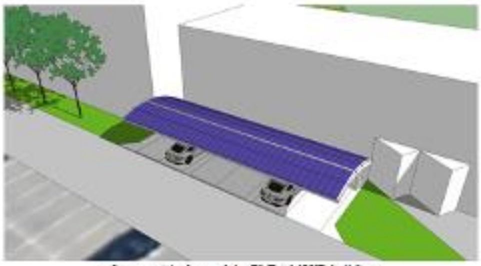
Procedure:
Building permit is needed for the structure but not in special for the roof modules.

Check of BIPV quality and definition:
Good points that increase the aesthetical quality are:

- The structure is clear and simple
- The whole roof is covered with modules

Points of attention are:
- The colour of the modules and the other parts of the structure.

PICTURES



Carport A in front of the EMPA-MOVE building

Carport B at the EKZ-site

Figure 2.4: Carport demo-system's Architectural Integration Guideline (GA1), by BEAR

2.3 Update report

From the submitting of the "Final version" of this deliverable (19th December, 2017) up to now (31th March, 2019) modules and demo-systems designs have been subjected to change. The current D8.3 version gathers all these changes and results from the update of the descriptions, tables and figures included in the document. Modules Data-sheets and Technical Guidelines annexed to the document have also been updated in the same way.

3 BIPV DEMO-SYSTEMS DESCRIPTIONS

This chapter includes a descriptive definition of the final BIPV elements developed in the project for the implementation of the planned demo-systems. Additional technical details can be found in the Module datasheets and the Technical Guidelines gathered in the Annex.

3.1 Demo 1 description: Single house in Mons, Belgium

3.1.1 Demo-building description

PVSITES Demo-Building 1, provided by the partner the partner FORMAT D2, is a residential building for private and professional use. The main location data are:

- Address: Rue du Banc de Sable, 22, Stambruges (Belgium).
- Geographical coordinates: 50° 29' 58,7" N // 3° 42' 52,9" E.
- Elevation: 68 m.

Figure 3.1: Demo 1. FORMAT D2 residential and professional building in Belgium

The demo-system will consist on a BIPV roof composed by CIGS on steel modules designed and manufactured by FLISOM. The module design has been specially conceived to facilitate the installation of the BIPV tiles on the sloped roof structure, to efficiently resolve the boundary areas and to contribute to the waterproofing and the thermal performance of the roof as a whole. The constructive and energy passive functionalities of the BIPV roof will come to further improve the energy performance of a building, already designed on the basis of the sustainable architecture, environmental friendly and according to the local style and uses.

The new BIPV roof system will be SSW oriented, with 30º tilt; total occupied area, 106,0 m^2; and PV area 99,6 m^2.

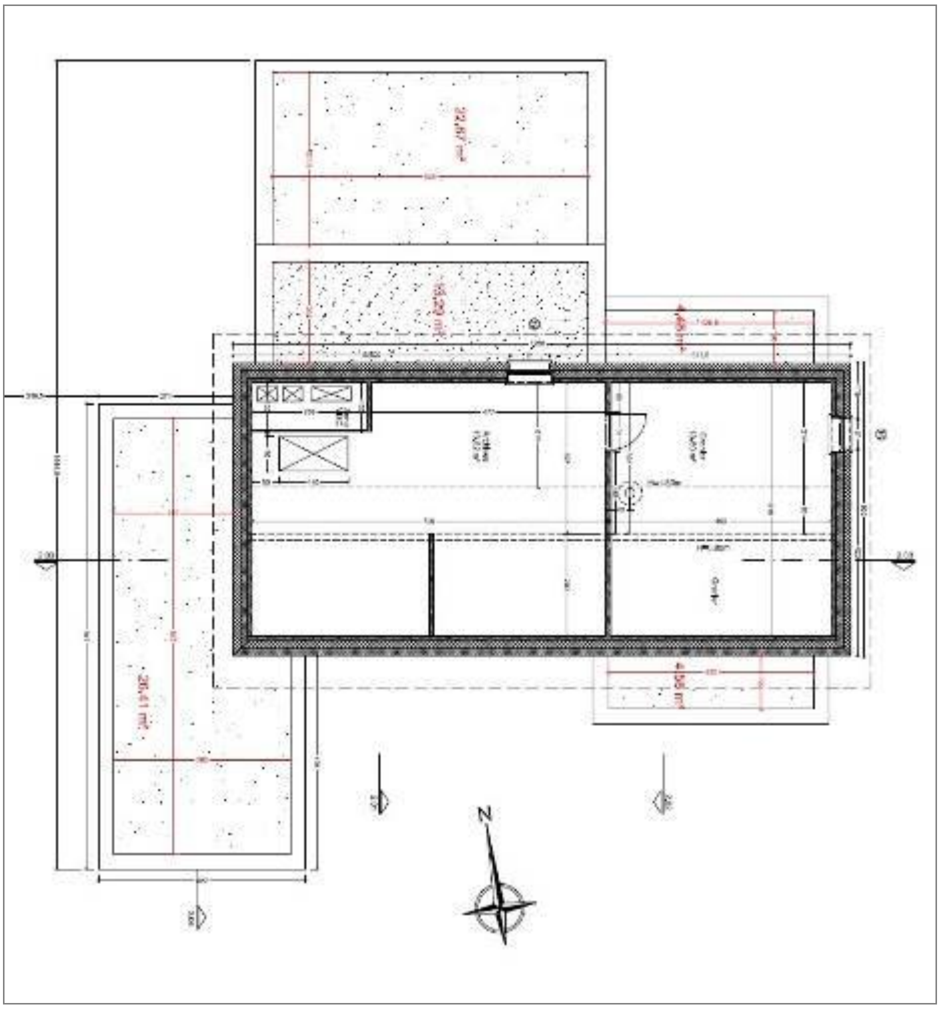


Figure 3.2: Floor plan of the Belgian Demo-building

3.1.2 BIPV system definition

BIPV tiles developed by FLISOM for the FORMAT D2 demo-site are semi-flexible and lightweight elements designed to be directly assembled to each other, in order to get a compact roof with, at least, similar mechanical properties than a conventional roofing system. Series connectivity has already been thought to be carried out during the installation works; in such a way that the presence of connection boxes and cables do not disturb the handling and fastening of the elements. The modules' size and aspect ratio also will facilitate the roof construction, providing at the same time electrical characteristics easily to combine in a series-parallel array compatible with the most common solar inverters in the market.

The final dimensions of the modules are:

- Module height: 465 mm.
- Module length: 1.575 mm.
- Module thickness: 21 mm.

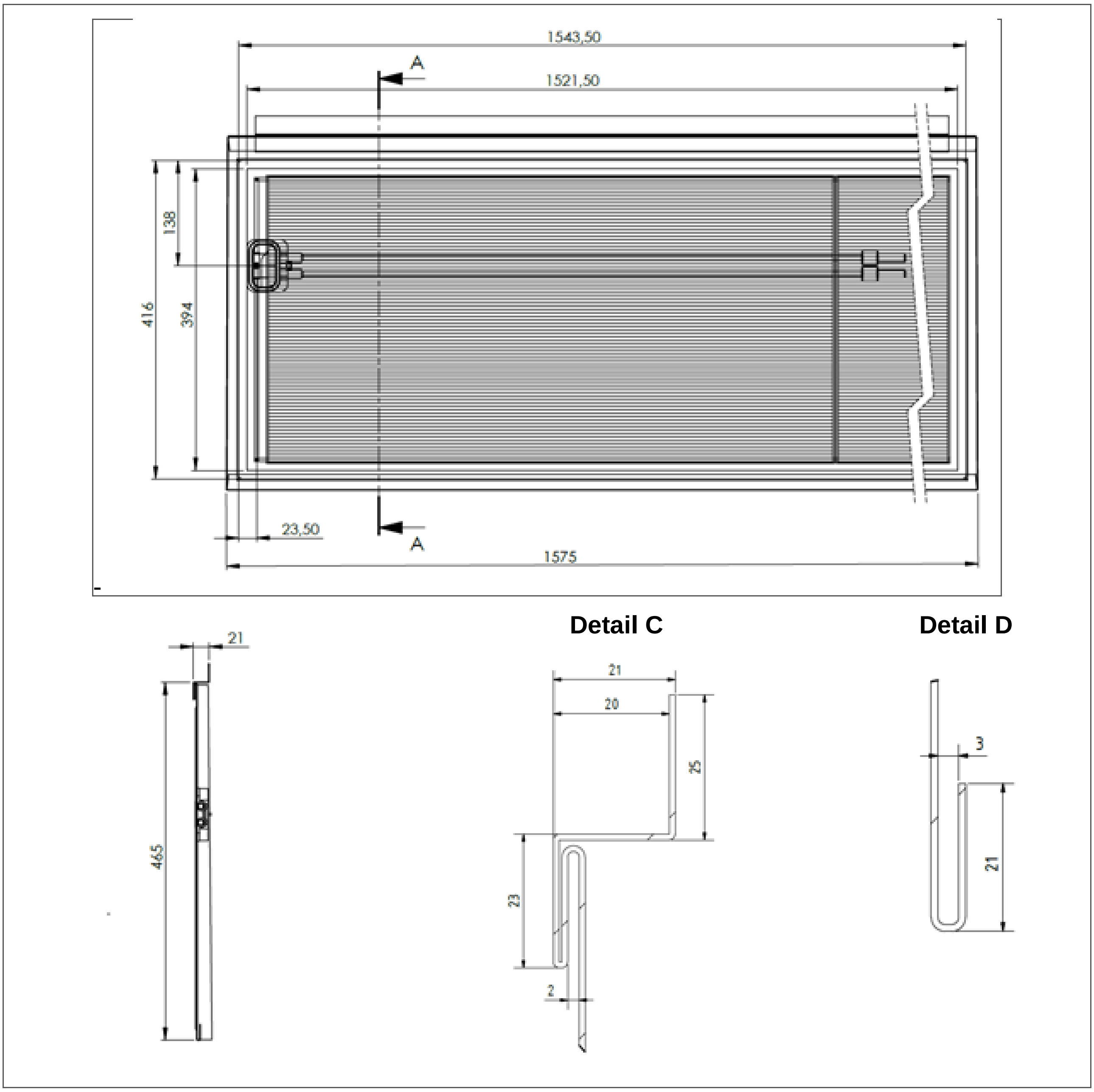


Figure 3.3: Geometrical details of the BIPV tile for the FORMAT D2 demo

The Belgian BIPV roof system will have 136 tiles. The PV solar field will not occupy the entire roof area, since end-pieces of the overhang will be installed along the perimeter. In the other hand, there will not be BIPV modules in the "vertical" strip in which the existing chimney is located. Tiles installed in this area will be non-active, in order to avoid as possible the adverse effects of shadows.

Figure 3.4: BIPV tile designed by FLISOM for the FORMAT D2 demo-site

Two options have been proposed regarding the layout of the modules in the roof, in order to resolve the integration of the chimney in an aesthetic way. Option 1 considers just one vertical non-active strip. Option 2 considers two non-active strips in order to give symmetry to the roof as a whole. The second solutions seem to be the more esthetical one.

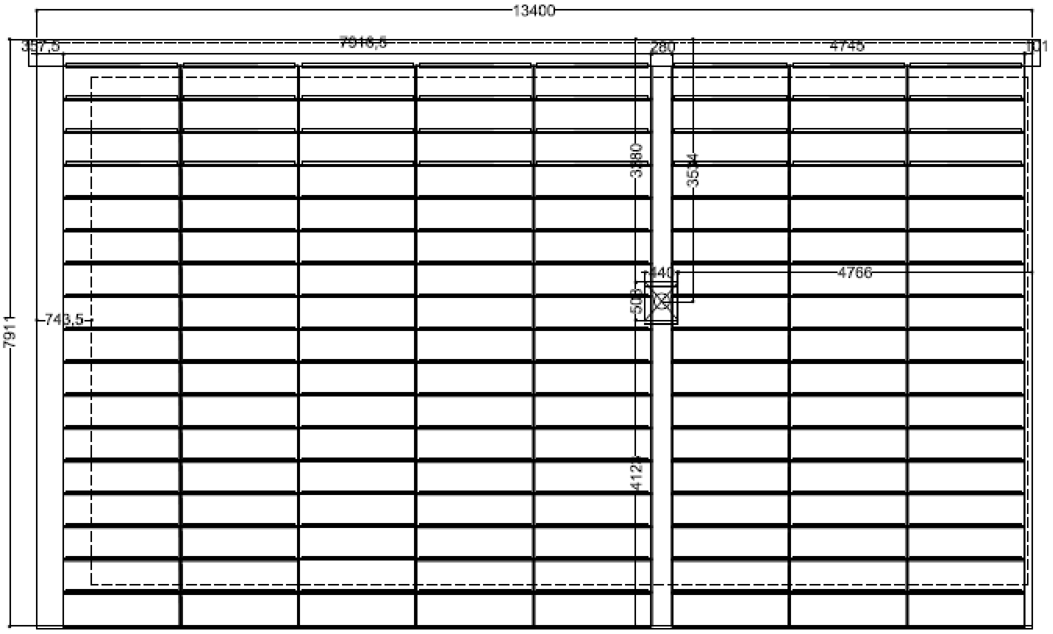


Figure 3.5: Option 1. Asymmetric layout of BIPV modules

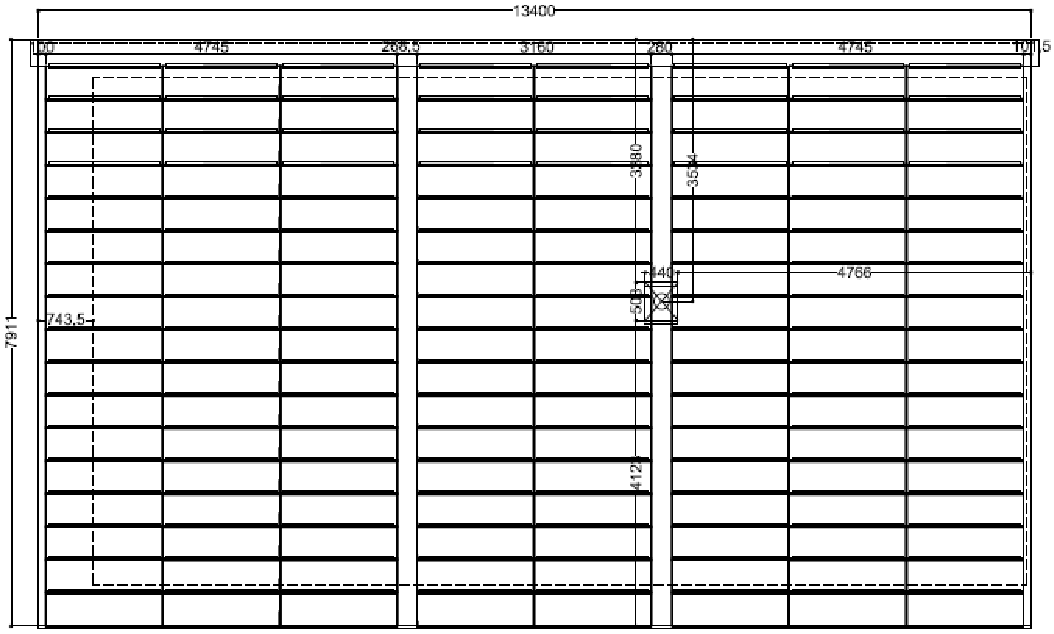


Figure 3.6: Option 2. Symmetric layout of BIPV modules

Finally, cabling will be hidden under the tiles and boundary elements and conducted to the solar inverter, provided by TECNALIA, which will have a DC coupled storage system.

Table 3.1 Demo PV System definition

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 1	Roof	CSF	14	30	8	17	136	99,6	8,7

The power management strategy will correspond to the following diagram, where the black lines represent energy flows, red lines are power supply lines and dotted lines are monitoring and control signals.

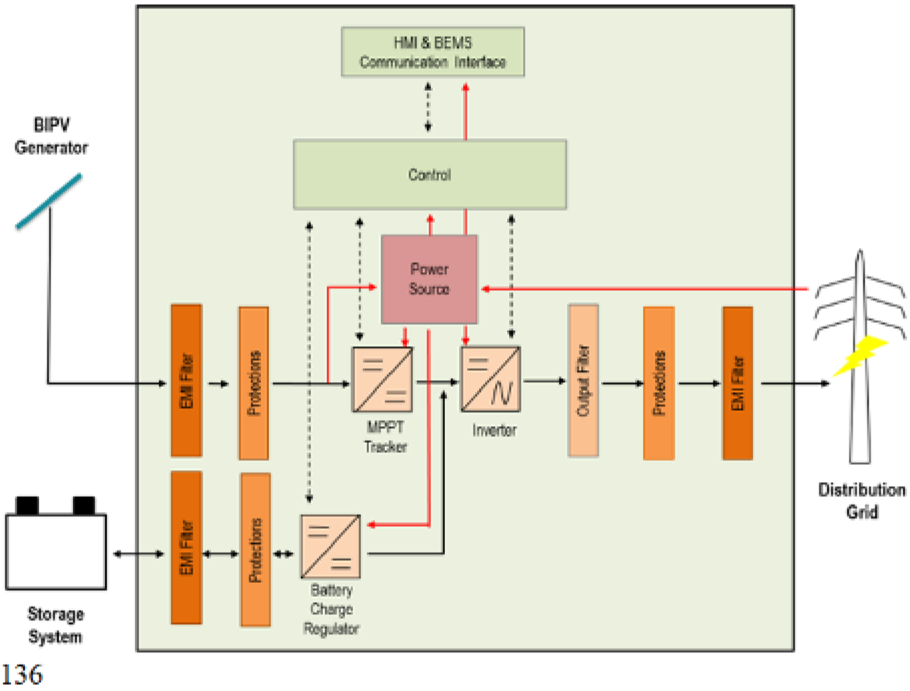


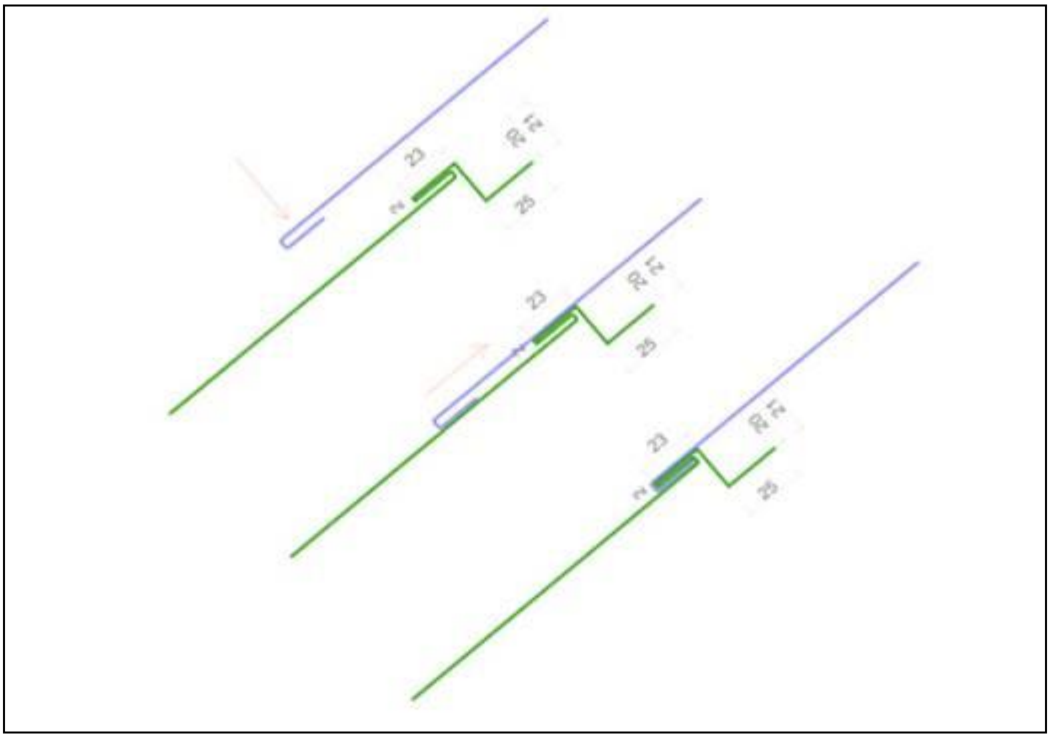
Figure 3.7: Block diagram of DC-coupled storage inverter

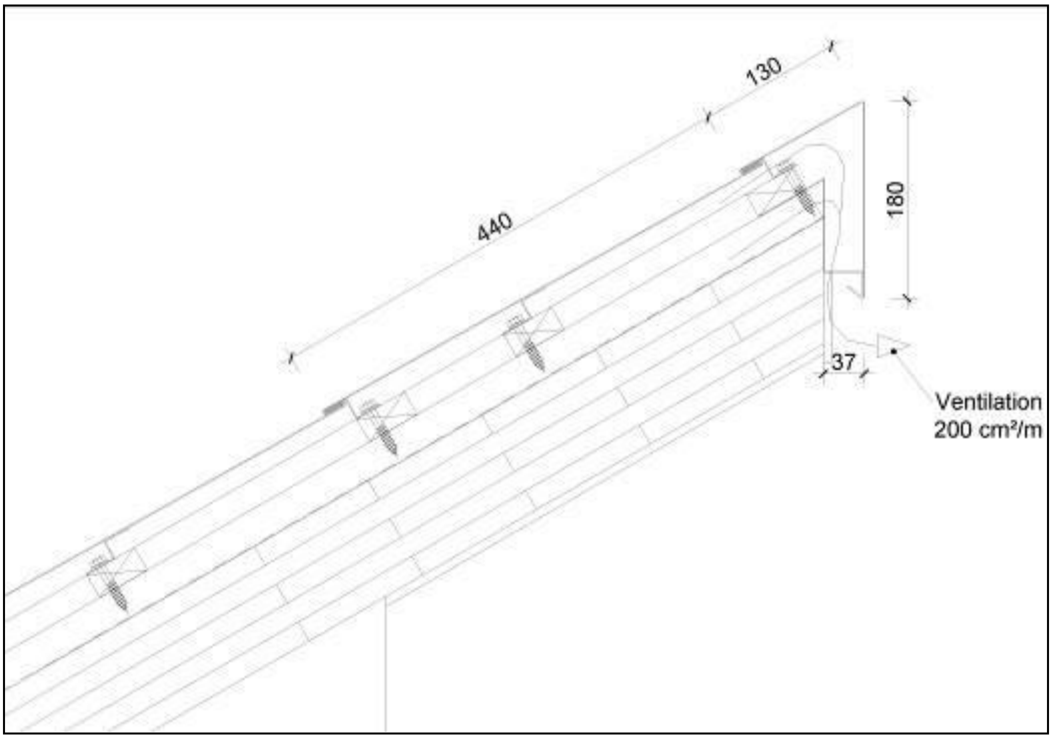
3.1.3 Building integration design

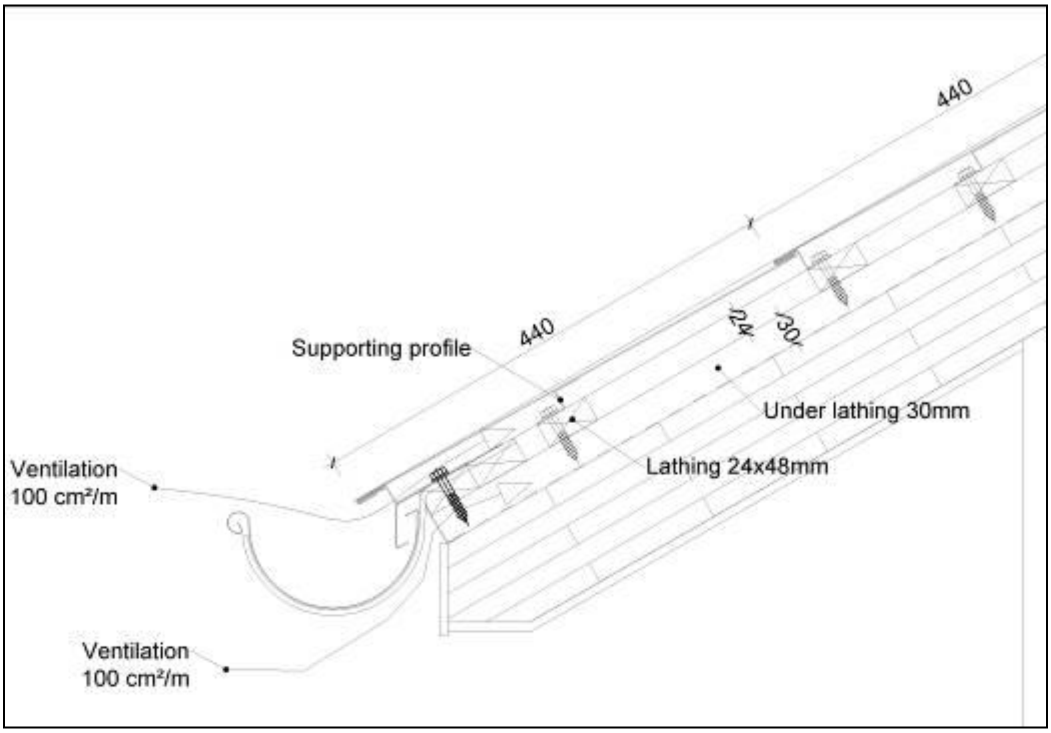
As explained in the previous point, the specific geometrical design of the modules has been conceived to achieve a good building integration, according to the common technical requirements of a sloped roof.

Aesthetical quality of a BIPV roof is highly conditioned to the size and shape of the modules, joints between modules, fixing elements, roof edge, rims and other adjacent elements and material, textures and colour of each part. The Belgian roof design takes into account all these factors in order to achieve a great aesthetical impact (more details about the aesthetic criteria applied can be found in the Architectural Integration Guideline “GA1”).

The roof structure is made of wood. This makes mounting easy, as the modules can be screwed on horizontal bats. Each module will have a 25 mm overlap with the next one in the vertical direction. Modules will be connected with a click-connection.




130
440
180
37
Ventilation
200 cm²/m



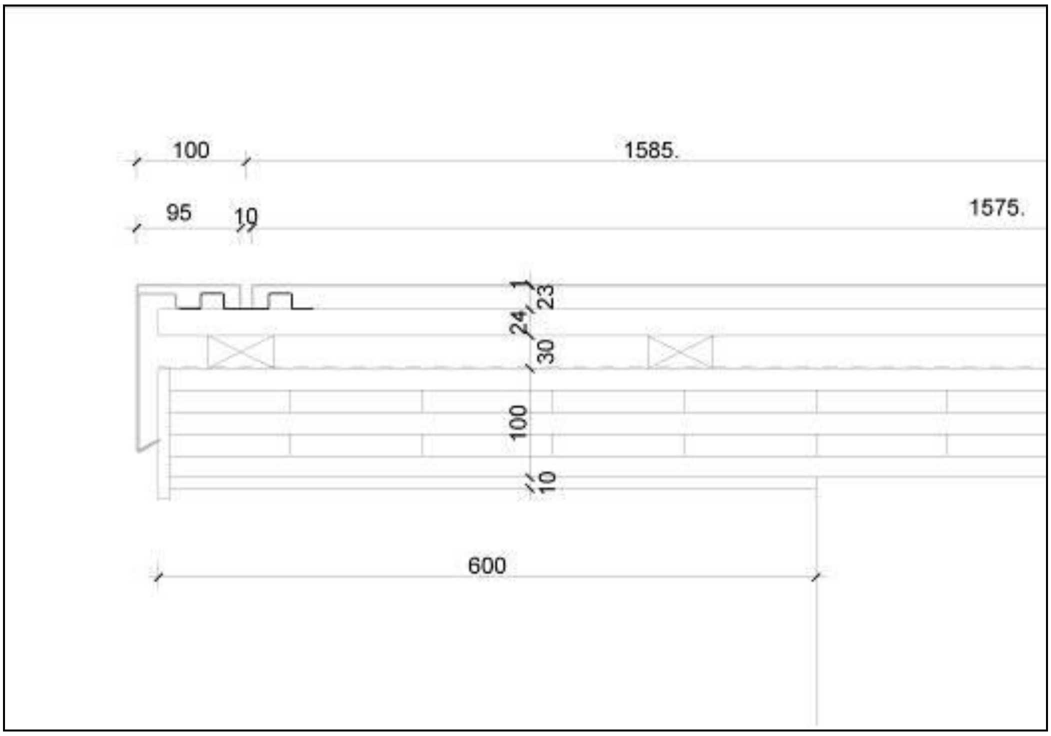


Figure 3.8: Modules assembly procedure and sections of the roof

Mounting must start with the lowest module and then go up to the ridge. The lower edge of the tiles, provided with an upper overlap bracket and a set of small halls in the side, will allow to assembly the module to the below one, which has a coincident set of male anchors in the upper edge. The result will be a stepped overlapping system of tiles, matched each other, and laid out form the top to the bottom of the roof.

This design, which includes the use of end-pieces (ridge, drip edges, etc.) with exclusive construction functionality, will allow protecting the modules from standing water, snow or extreme soiling, as well as increase the power production by means the optimal inclination of the modules.

The entire roof will work as a ventilated roof, thanks to an air gap between the PV modules and the roof structure around 50 mm. The air flow throughout this gap, natural forced, will reduce the temperature behind the modules due to the retained air and the heat dissipated from the back side of the PV cells in operation.

As an aesthetic measure, steel parts of the BIPV tiles will have the most similar colour to that of the CIGS cells: RAL 9005, close to black. This will be also applied to the gutters, any other adjacent element and sealing of the chimney.

3.2 Demo 2 description: Educational building in Genève, Switzerland

3.2.1 Demo-building description

The PVSITES Demo-site 2, provided by the partner FLISOM, is a set of buildings which houses the hotel school EHC (École Hôtelière de Genève). The main location data are:

- Address: Avenue de la Paix 12, 1202, Genève (Switzerland).
- Geographical coordinates: 46°13'36.8"N // 6°08'17.4"E.
- Elevation: 431 m.

Figure 3.9: École Hôtelière de Genève (school facilities and students hotel)

The BIPV system foreseen in the École Hôtelière de Genève consists of several ventilated façades built with PV modules laminated on metal piece, designed and manufactured by FLISOM. The pavilions 1 and 2 of the complex will host the systems.

The east façade of the Pavilion 1 has two rows of windows in the ends of the building and a central curtain wall in the middle, from the top to the ground. The BIPV systems will be installed in the 2 available areas between them.

The west façade of the pavilion 2 has two centred vertical rows of windows, also from the top of the building to the ground. The BIPV systems will be installed in the 3 available areas between them.

Figure 3.10: East and West façades of the Pavilions 1 and 2, respectively

3.2.2 BIPV system definition

The BIPV modules have been specifically designed for the demonstration. The geometry of the metal pieces, used as substrate for the lamination of the PV layer, allows matching modules each other in order to easily construct a ventilated façade. The final dimensions of the modules are:

- Module height: 479 mm.
- Module length: 1.574 mm.
- Module thickness: 20 mm.

CIGS cell colour is close to black (RAL 9005). The developed product is quite tested (certified), as it is close to a commercial BIPV element.

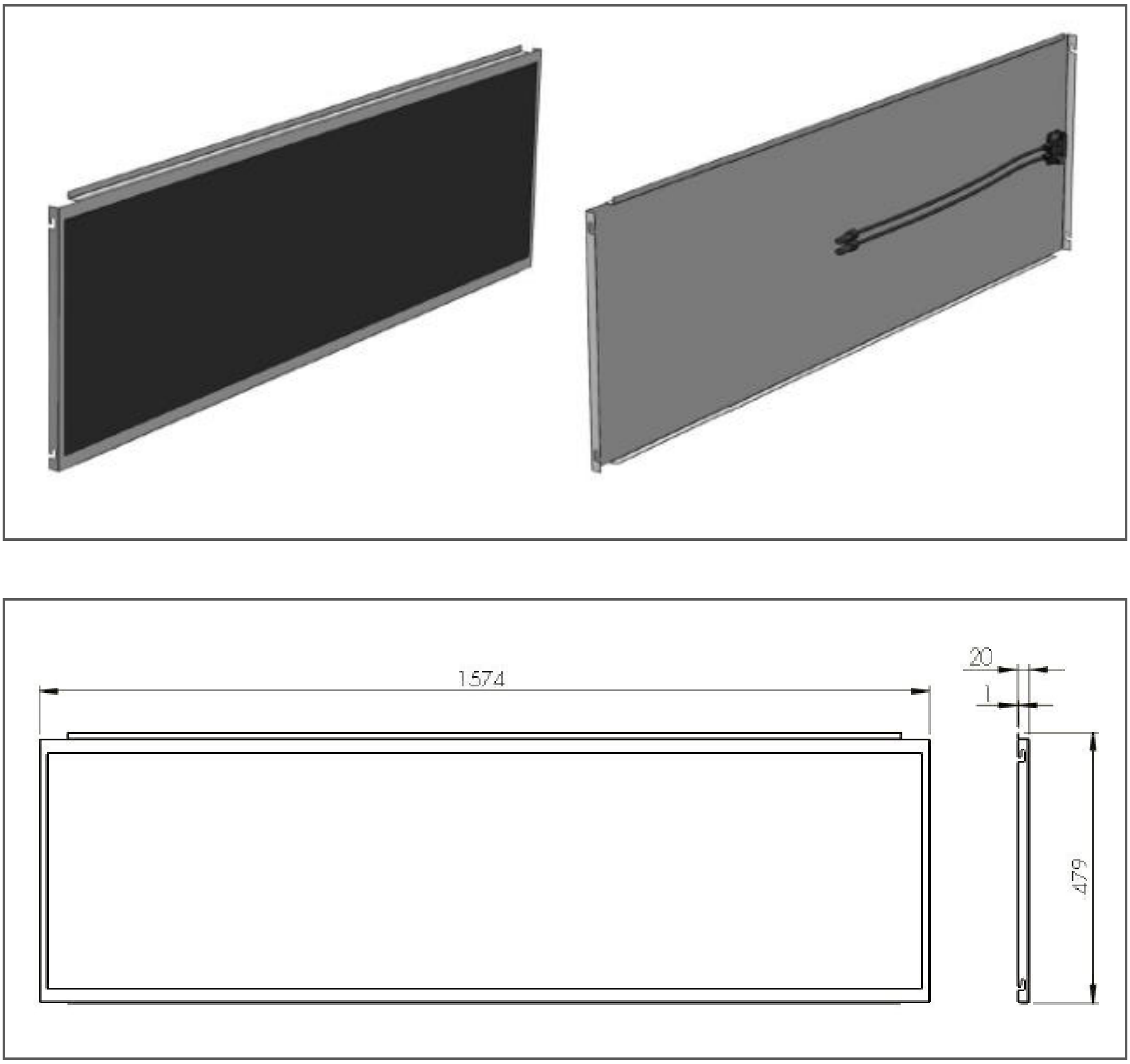


Figure 3.11: BIPV module for the EHG demo-site

As said before, 2 different solar field must be considered:

- E façade of the Pavilion 1 (orientation -80°, tilt 90°); composed of 2 sub-systems: SF-E1 (south section) and SF-E2 (north section).
- W façade of the Pavilion 2 (orientation +100°, tilt 90°); composed of 3 sub-systems: SF-W1 (north section) and SF-W2 (middle section) and SF-W3 (south section).

Figure 3.12: Solar fields of the EHG demo system: Pavilion 1 (west) and Pavilion 2 (east)

The following pictures show the modules layout on the E façade of the Pavilion 1 and the W façade of the Pavilion 2:

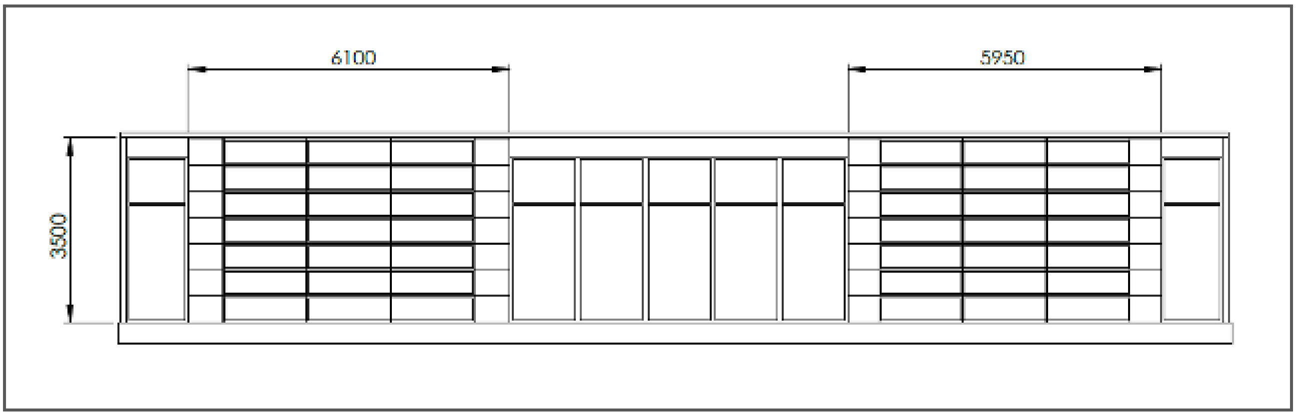


Figure 3.13: E facade Pavilion 1 modules layout

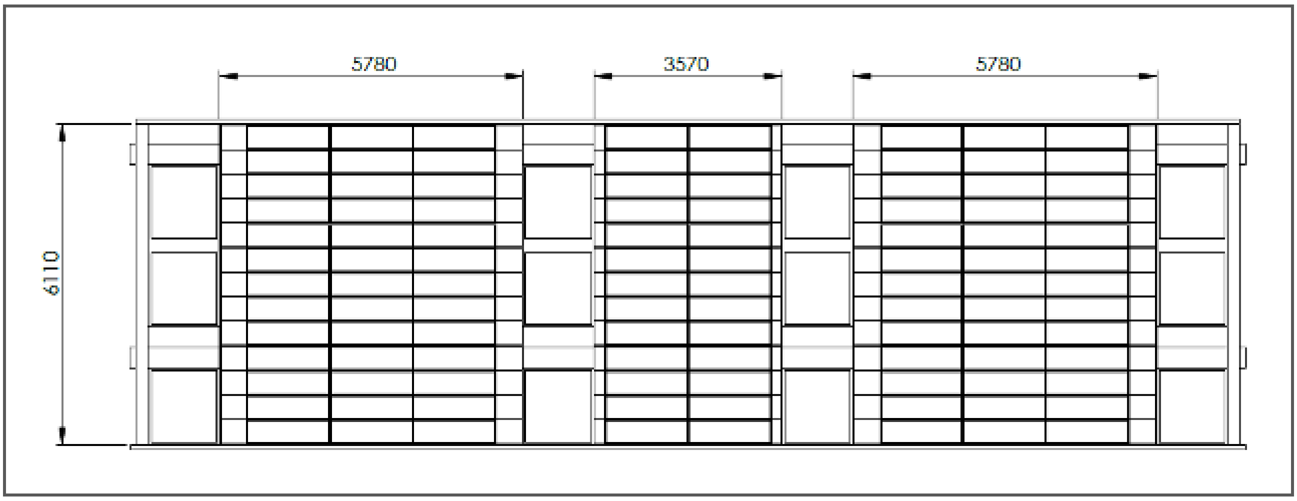


Figure 3.14: W facade Pavilion 2 modules layout

Final peak power, occupied area and estimated production of each subsystem and the complete system are listed in the table below:

Table 3.2 Demo 2 PV System definition

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 2	E façade Pavilion 1	SF-E1	100	90	3	7	21	15,8	1,2
		SF-E2	100	90	3	7	21	15,8	1,2
	W façade Pavilion 2	SF-W1	-80	90	3	13	39	29,4	2,1
		SF-W2	-80	90	2	13	26	19,6	1,4
		SF-W3	-80	90	3	13	39	29,4	2,1
	E&W Façades	**CSF**					**146**	**110,1**	**8,0**

The power systems have been chosen among commercial items and the storage system will be dimensioned according to the power production and the demand profiles:

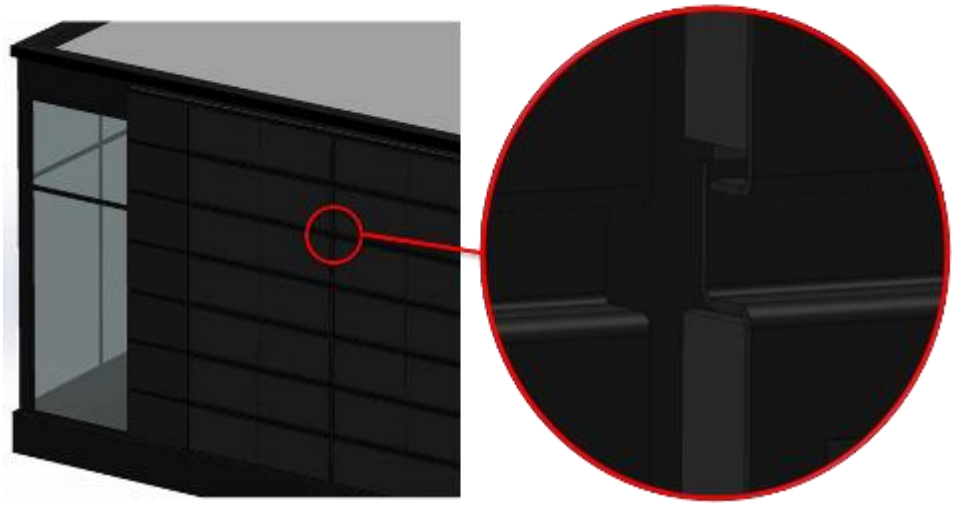
- Pavilion 1: inverter SolarEdge SE2200H, with optimizer P405.
- Pavilion 2: inverter SolarEdge SE6000H, with optimizer P405 (3 strings).

Each building has its own electricity delivery point located into the basement of the principal building. In the other hand, there are also divisional distribution electricity boards into each floor of the buildings.

3.2.3 Building integration design

The BIPV ventilated façades will be attached to the existing brick walls. The facade cladding is done with the facade technology from "Schweitzer Metalbau". The system is based on vertical profiles with pins that can hold the horizontal cladding.

Overlapping between adjacent modules



West facade Pavilion 1

East facade Pavilion 2

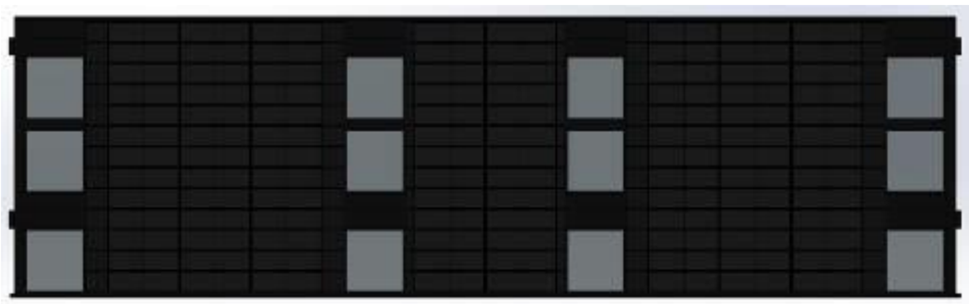


Figure 3.15: Foreseen aesthetic appearance for the EHG BIPV systems

The BIPV units will be hung from the structure using the lateral hooks located in modules' edge. A minimum distance of 5 mm must be kept between the edges of adjacent module to assume the thermal expansion of the metal sheets. Module size and mounting mechanism have been thought to make easy the installation and maintenance works. Modules will be overlapping to each other, and the existing brick walls will be totally hidden. All back rails, holders and edge elements will be anodized black, in order to have a uniform façade.

Additionally, specific edge pieces have been designed for the solar field's perimeter to achieve a functional and aesthetical finishing of the building integrated systems.

CIGS cell colour is close to black (RAL 9005). It is aesthetically advisable to apply the same colour to the front and back metal sheets and adjacent construction elements. Other measures aimed to improve aesthetic are: to use of the same cladding system for the whole facade, to cover adjacent areas with similar black tailor-made panels and to hide cladding and power connection between modules. Connection of the BIPV system with windows and at ground level should be well resolved.

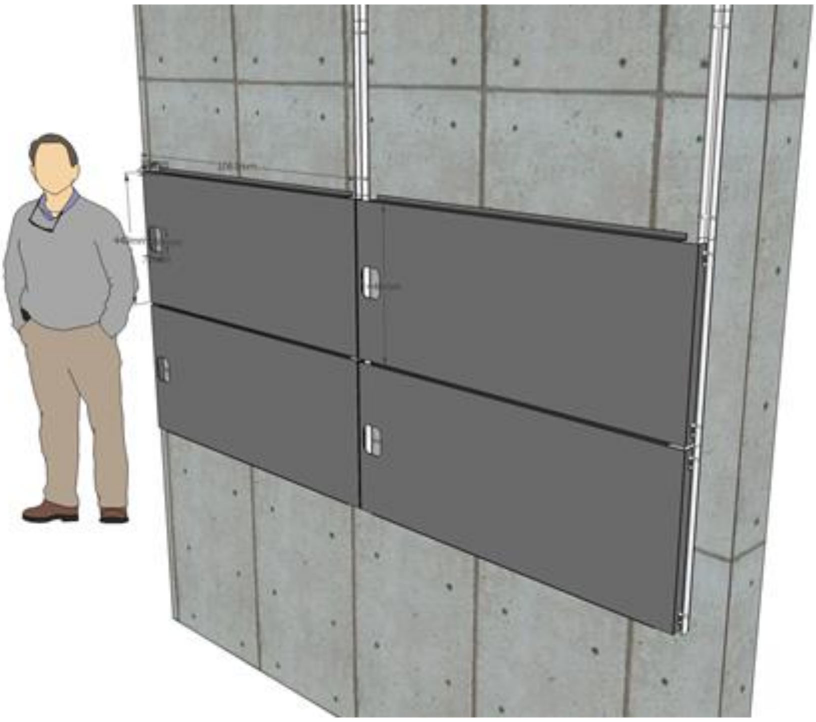


Figure 3.16: Façade hang in solution

As a ventilated façade, there will be an open-air chamber between the PV modules and the brick walls aimed to dissipate the heat generated by the PV cells in operation.

Connection in series between modules is possible during the installation works.

3.3 Demo 3 description: Carport in Zurich, Switzerland

3.3.1 Demo-building description

The Demo 3 will consist in a PV carport system, with modules made of CIGS laminated on a thin steel back sheet, designed and manufactured by FLISOM.

The initially selected Demo-site 3, an existing carport pending of a retrofitting located in the parking of EMPA Campus, in Dübendorf (Switzerland), has been finally discarded because of several reasons:

- The asbestos covering should be removed, issue not considered in the budget
- The carport use is private, and the project would not compensate the operating losses during the installation works.
- The system would be shadowed by nearby trees, reducing the power production.
- Visibility form the street is not good, reducing the dissemination impact.

With the opening of the EMPA mobility demonstrator (MOVE, https://www.empa.ch/web/move) on the EMPA campus a much more prominent location came up and FLISOM reached an agreement with EMPA to allow a construction of a PV carport in this platform. While the negotiations with EMPA were ongoing FLISOM looked for alternative solutions. With EKZ, the local electricity provider for about 1 million people in the canton of Switzerland, FLISOM found an excellent collaboration opportunity. EKZ is interested in building a PV carport in front of their building in Seuzach.

Hence, two PV carports will be installed in the following locations:

- EMPA Campus.
  - Address: Überlandstrasse 129, 8600, Dübendorf, Zurich (Switzerland).
  - Geographical coordinates: 47° 24' 08.9" N // 8° 36' 40.0" E.
  - Elevation: 433 m.

Figure 3.17: Location of one of the demonstrative PV carports in EMPA Campus, Switzerland

- EKZ facilities.
  - Address: Deisrütistrasse 12, 8472 Seuzach, Switzerland.
  - Geographical coordinates: 47° 32' 0" N // 8° 44' 0" E

- Elevation: 450 m.

Figure 3.18: Location of one of the demonstrative PV carports in EKZ facilities, Switzerland

3.3.2 BIPV system definition

The modules used in the Demo-sites 3 will consist of a semi-flexible and lightweight CIGS solar panels designed and manufactured by FLISOM. They have been conceived to be integrated in the new carport design, aimed to a future commercialization. Two modules of different sizes will be used for the carport implementation; the shortest one (2519 mm) will be installed in the lower zone of the carport and the longest (3263 mm) in the upper. Regarding the module’s power, it might be achieved different values depending of the manufacturing conditions (medium values detailed in the modules data-sheet have been taken as a reference for calculations). The metal back sheet will be black.

- Module 1:
    - Power: 85 Wp.
    - Dimensions: 2519 x 458 mm.
- Module 2:
    - Power: 110 Wp.
    - Dimensions: 3263 x 458 mm.

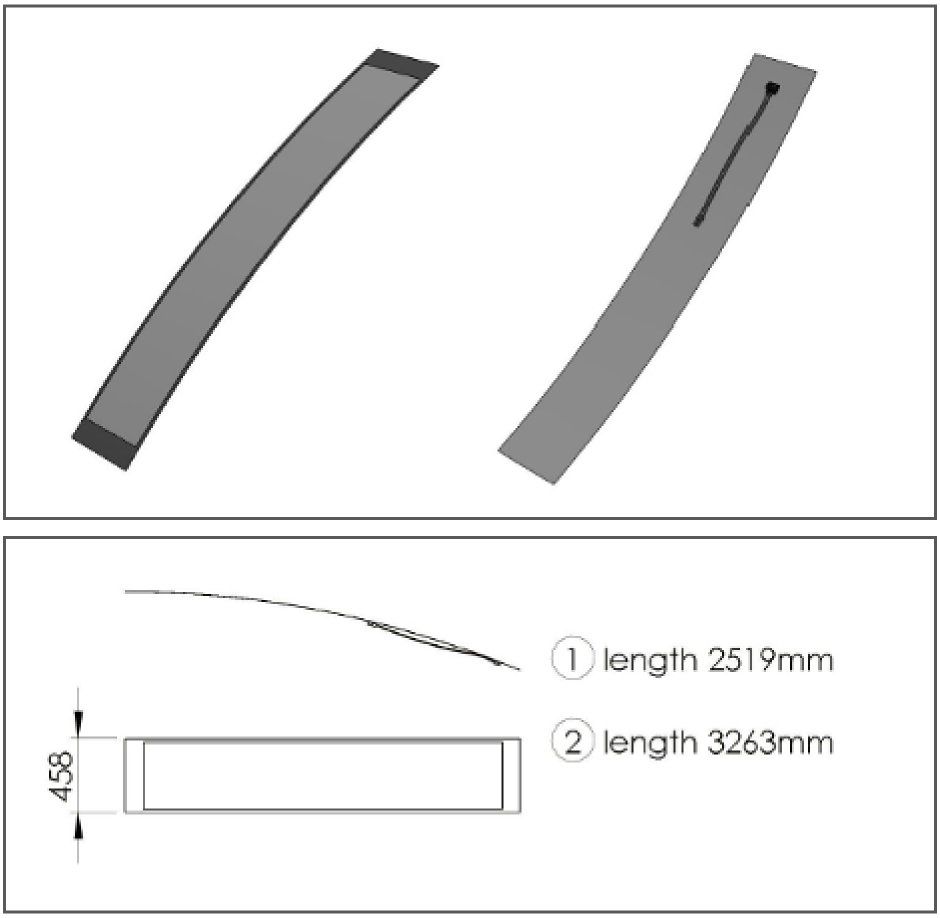


Figure 3.19: PV module for the carports implemented in EMPA and EKZ demo-sites

The modules will be installed on the carport as showed below, presenting a variable inclination along the curved section.

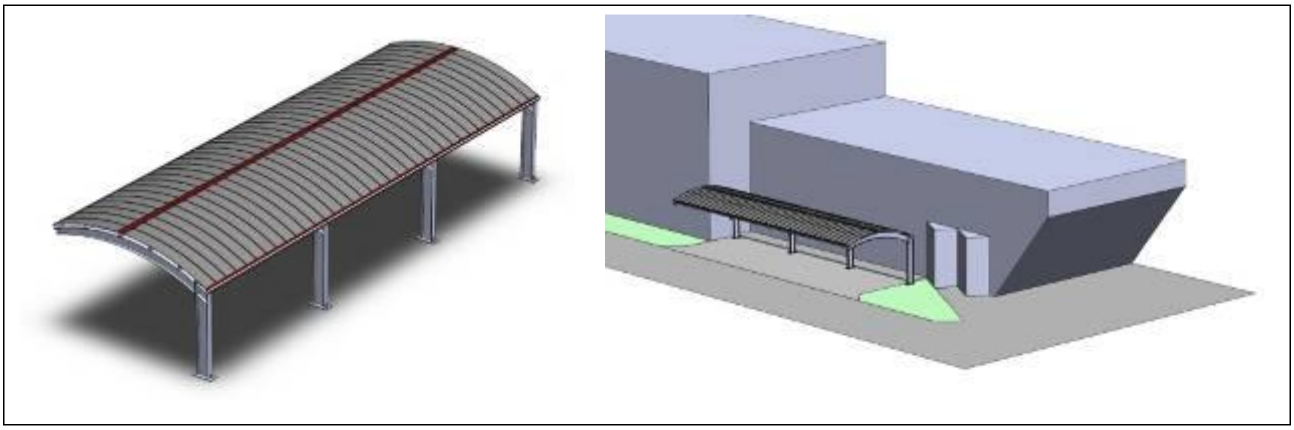


Figure 3.20: Infographics of the carport foreseen for the EMPA Campus

In the other hand, there is a difference in total length, and consequently number of modules, between the carports planned for each demo-site. The EMPA carport will be able to host 5 cars; the EKZ's one, 6 cars. The PV systems planned for each carport are defined as follow:

- EMPA Campus.
  - Power: 7,2 kWp. Occupied area: 98,0 m^2.
  - No. of modules: 74 (37 modules “model 1” and 37 modules “model 2”).

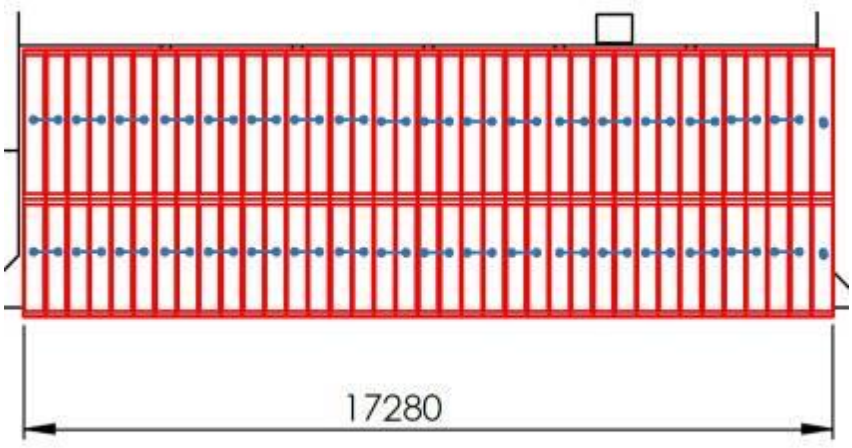


Figure 3.21: String concept for EMPA’s carport

- EKZ Facilities.
  - Power: 7.6 kWp. Occupied area: 103,3 m^2.
  - No. of modules: 78 (39 modules “model 1” and 39 modules “model 2”).

Figure 3.22: String concept for EKZ’s carport

The main system data will be the following:

Table 3.3 Demo 3 PV System definition

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 3	EMPA Carport	SF-EMPA-1			37	1	37	42,7	3,1
		SF-EMPA-2			37	1	37	55,3	4,1
		CSF-EMPA					**74**	**98,0**	**7,2**
	EKZ Carport	SF-EKZ-1			39	1	39	45,0	3,3
		SF-EKZ-2			39	1	39	58,3	4,3
		CSF-EKZ					**78**	**103,3**	**7,6**
	EMPA & EKZ Carports	**CSF**					**152**	**201,3**	**14,8**

Regarding the power conditioning, a "Solaredge SE 9 kW" inverter with "P300 MPP trackers" will be used for these demo-systems. Thus, connection of modules must be carried out in pairs, together with a common MPP tracker.

The generated power will be used to cover the EV charging stations' demands. The EMPA demo-site has already an Electric Vehicle (EV) charging station; a new one will be shortly installed in EKZ facilities. There will be batteries in the EMPA carport. The consumption profile of the current EV car charges is required to determinate the batteries sizing.

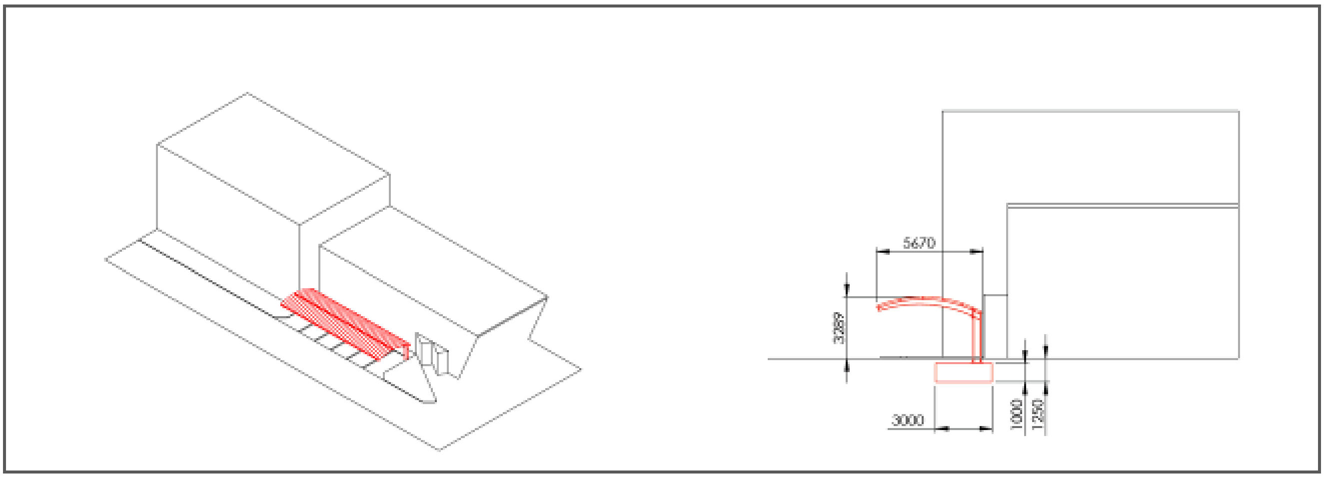
3.3.3 Building integration design

The structural component which will host the PV systems the Demo-sites 3 is, in reality, an urban furniture element; thus, the challenge is slightly different from a building integrated application. The carports will perform as a protection against rain, hail, snow, frost and the direct sun rays, besides a power generator. The PV modules will totally cover the complete carports.

The carport has been designed as a premium product, which will provide the consumer the maximum energy functionality and use comfort. In this regard, the minimum amount of pillars has been planned in order to facilitate the driving in & out. This decision entails, however, a massive fundament to take over the huge momentum in case of snow load. In the other hand, the colour of the covering will be black (as the cells and free areas of the laminate) and the pillars will be able to be selected.

The carport structure will be made of steel. Modules will be mounted on the steel profiles. During the installation the modules will be bended to fit the half round shape of the structure.

Below are showed the plans of the EMPA and EKZ carports:



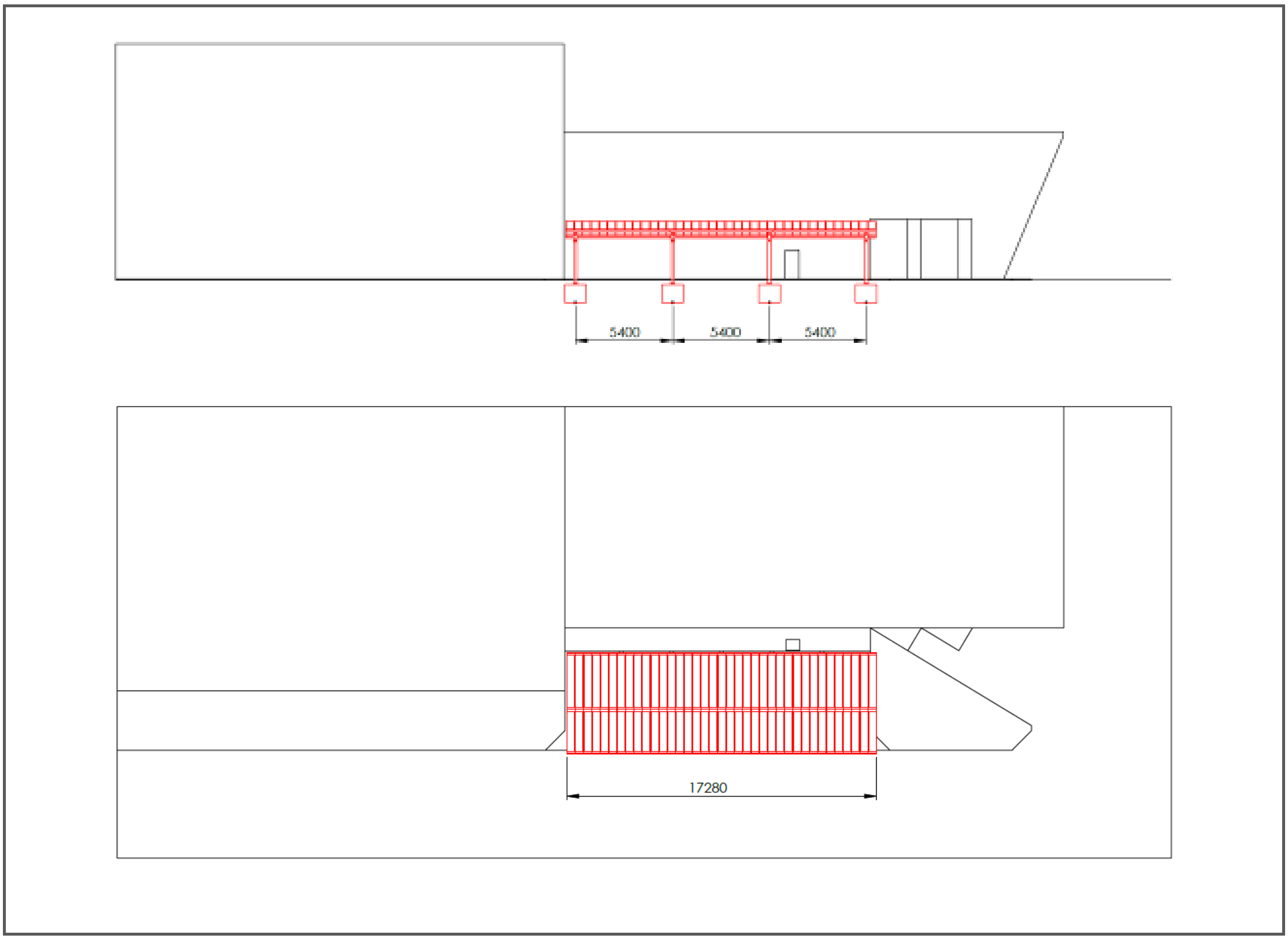
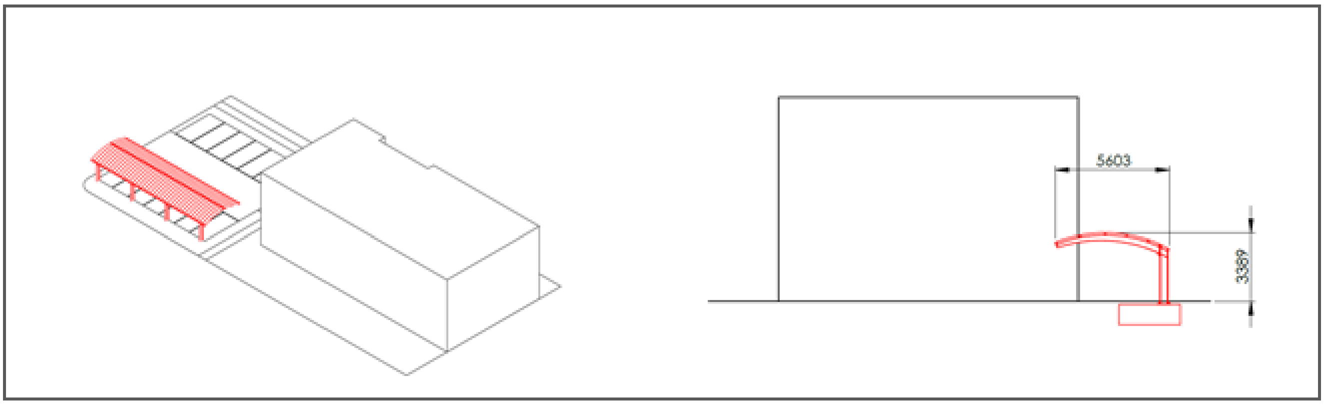


Figure 3.23: Drawings of the EMPA carport



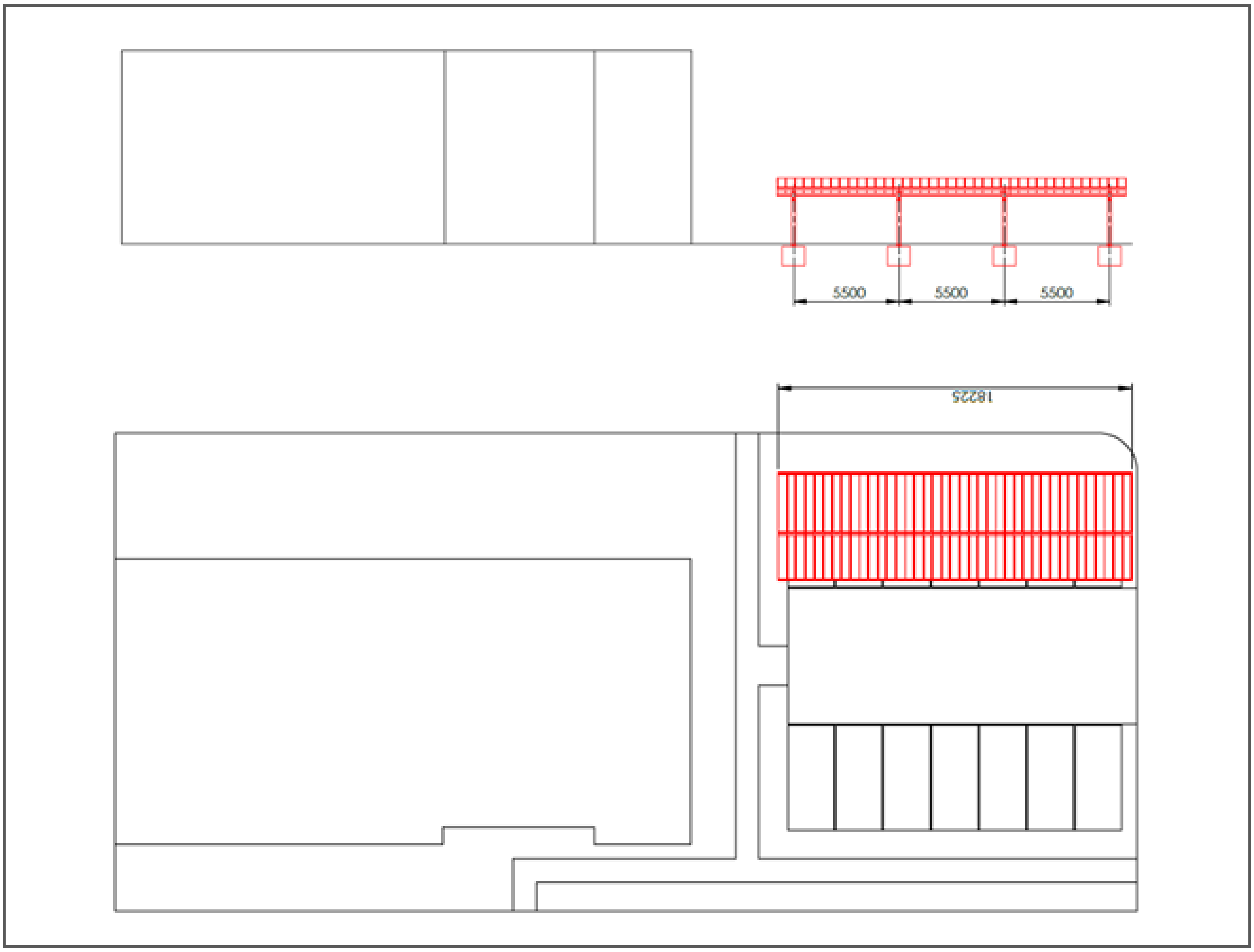
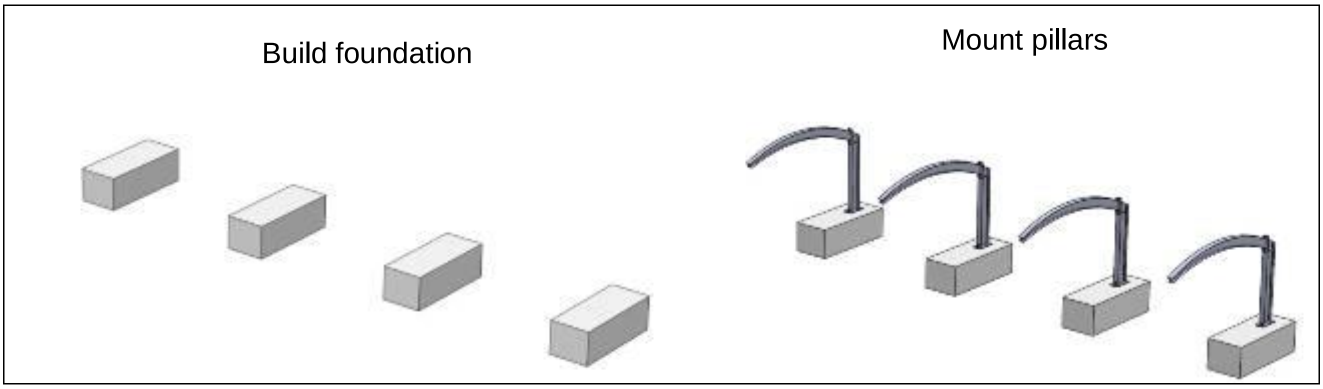


Figure 3.24: Drawings of the EKZ carport

Figure below graphically explains, step by step, the mounting procedure of the PV carports:



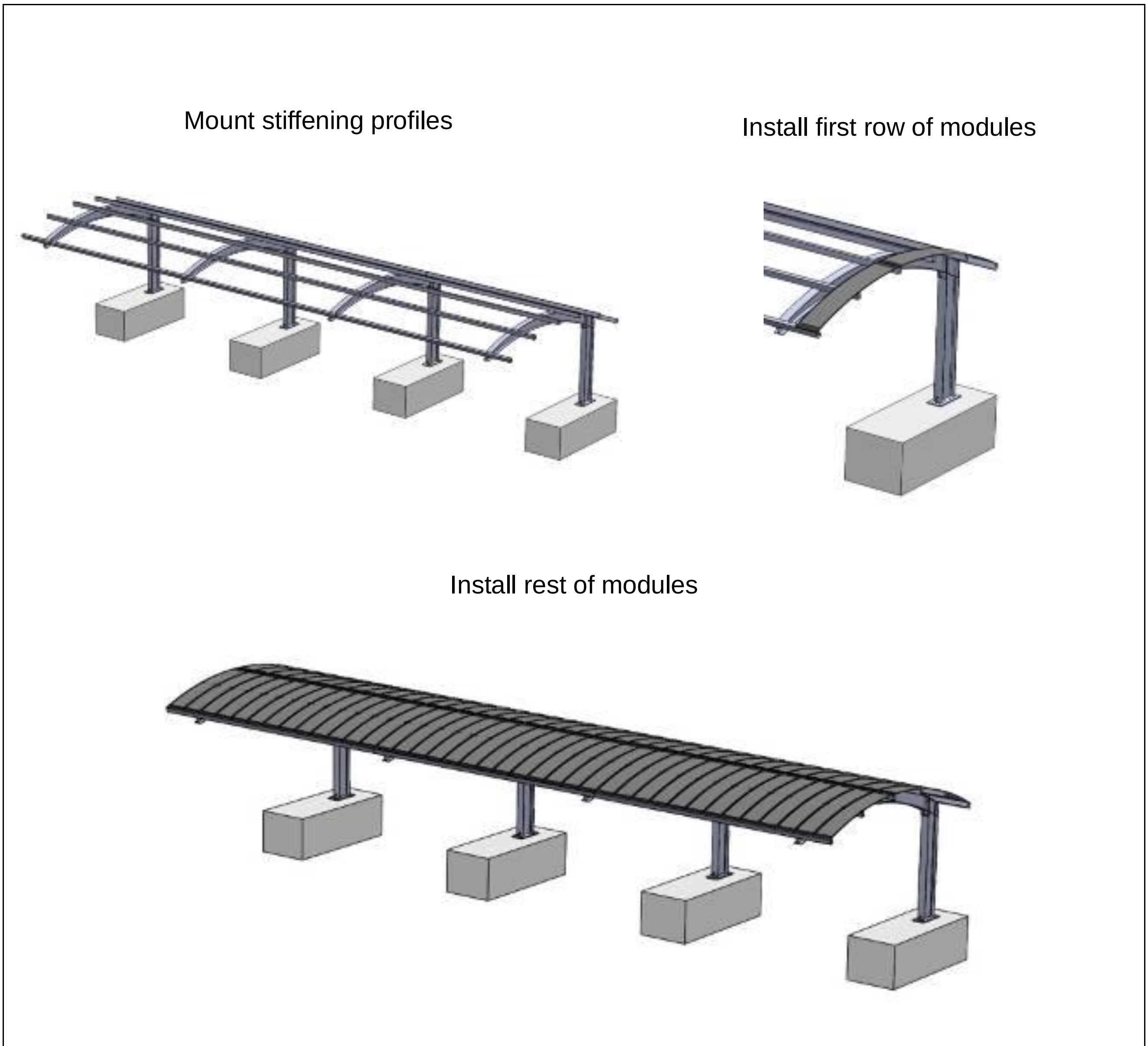


Figure 3.25: PV Carports' installation procedure

The final appearance of the designed carports in the available demo-site will be the following:

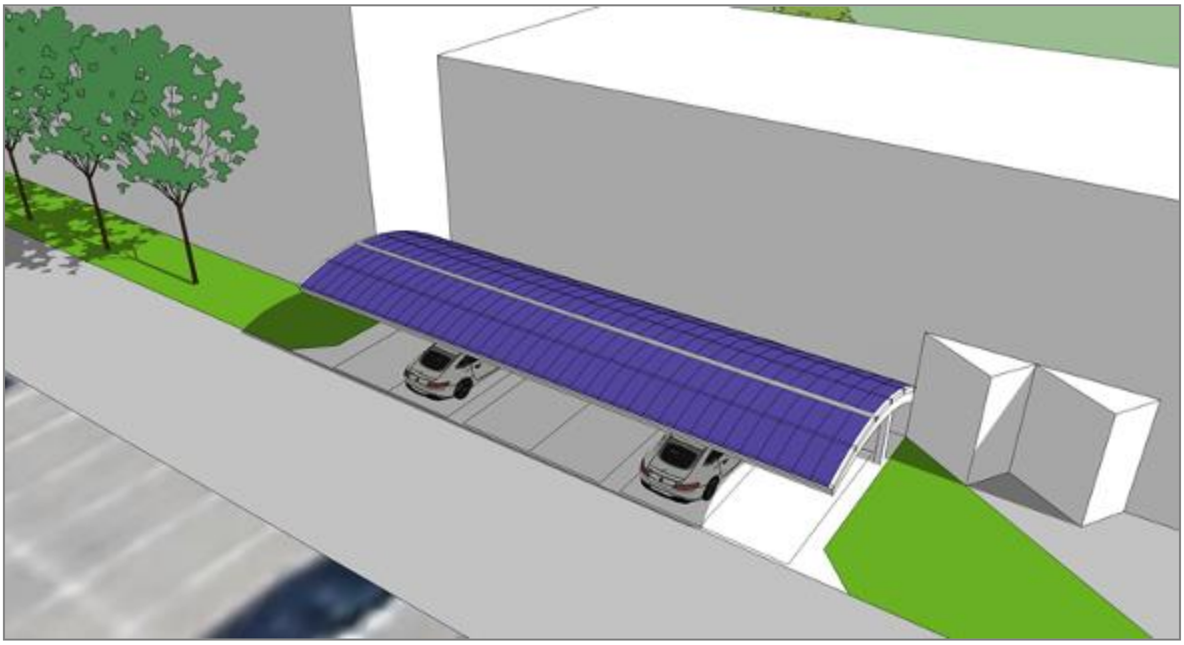


Figure 3.26: PV carport at EMPA Campus

Figure 3.27: PV carport at EKZ facilities

3.4 Demo 4 description: Industrial building in Barcelona, Spain

3.4.1 Demo-building description

PVSITES Demo-Building 4, provided by the partner CRICURSA, is an industrial and office building complex. The main location data are:

- Address: PL Coll de la Manya, Camí de Can Ferran s/n, 08403, Granollers (Spain).
- Geographical coordinates: 41° 35' 14.9'' N // 2° 16' 01.7'' E
- Elevation: 153 m.

Figure 3.28: Demo 4. CRICURSA Industrial and office building complex in Spain

The BIPV roof system will be placed in the south face of a double-sloped roof of a recently built pavilion (orientation: +2°; tilt 6°). The final location allows avoiding the nearly shadows projected by the roof parapet on the front and back façades.

The new building’s roof is divided into 10 sections made up of polyurethane panel *AIS-3G of 50 mm* of different width separated by transversal skylight elements *Arcoplus 1000 flat*.

Some undesirable shadows from the parapet might affect the PV modules performance. This inconvenient has been assessed through the simulations carried out by CADCAMation on the basis of a 3D model of the demo building and system. For this reason, the PV modules will be able to be slightly moved away from the roof edges.

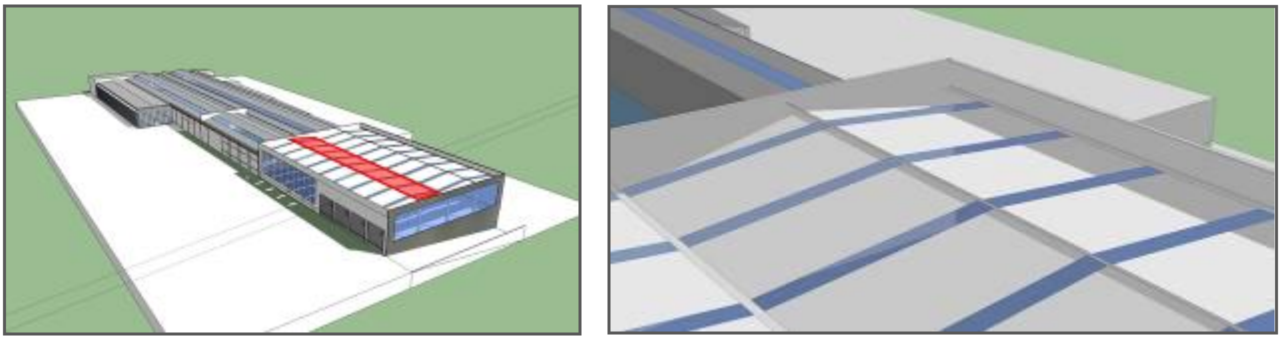


Figure 3.29: Chosen area chosen for the BIPV system and roof parapet shadowing effect

3.4.2 BIPV system definition

The BIPV system proposed for this demo-site consists of a PV integrated roof based on CIGS cells laminated on semi-flexible and lightweight steel modules, designed and manufactured by FLISOM, with a double functionality as a constructive roofing solution and a renewable energy generation system. The edges of the steel sheet are bended to increase stiffness and the possibilities to mount the modules. Cells colour is very dark black-blue and metal sheet is white (RAL 9010).

The BIPV modules will be placed on the existing roof sandwich-panels. Thus, the module has been designed in order to perfectly match with the sandwich panel geometry. Two options have been proposed in this regards (see figure 3.30); the second one has been chosen:

- Option 1: the module positioned below the highest point of the roof sandwich panels. In this case the production process for FLISOM is more complicated, as the cells have to be laminated before the sheets are bended in the right shape.
- Option 2: the module is positioned higher than the highest point of the roof sandwich-panels. This is easier for FLISOM as the sheets can be produced, painted and bended before the cells are laminated. Another advantage is that, in this way, the cavity between the modules and the sandwich-panels is larger and good ventilation of the air chamber is possible. This option has been chosen.

Option 1 | Option 2

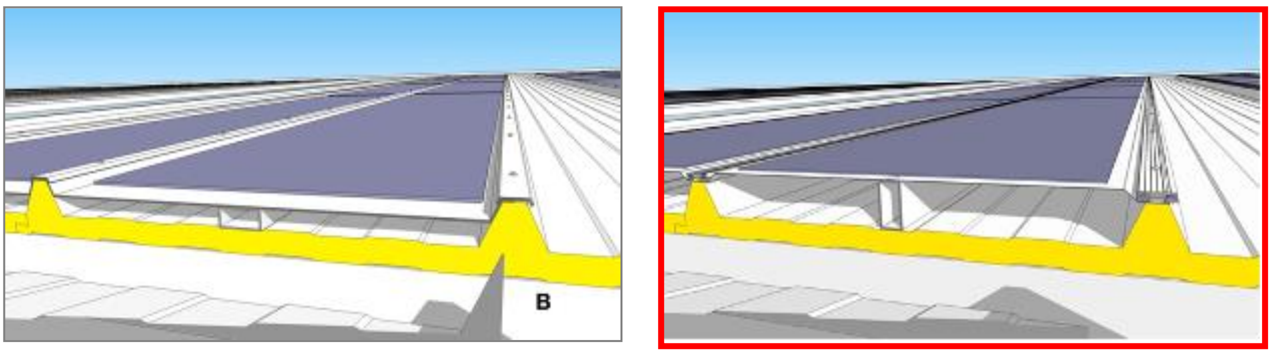


Figure 3.30: Module design options

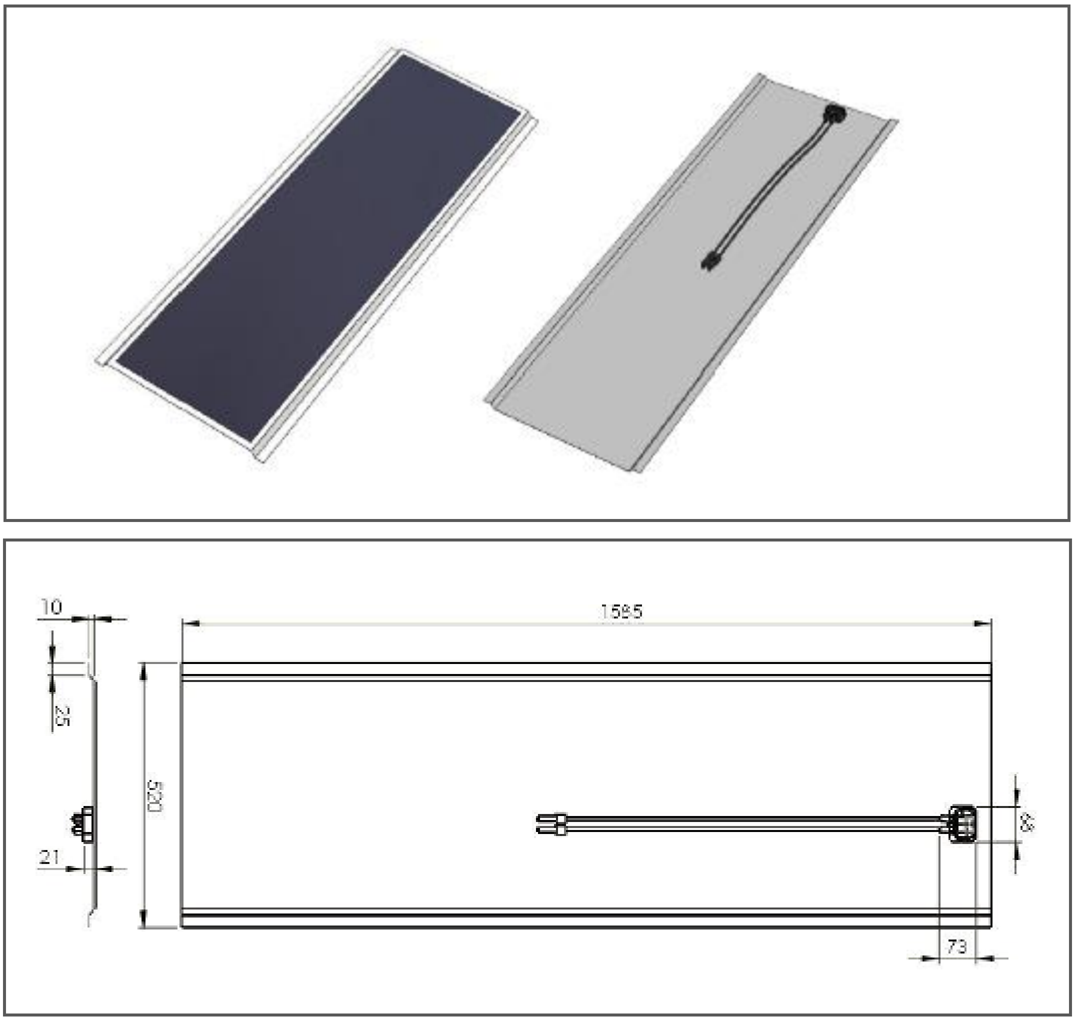


Figure 3.31: Industrial roofing element module by FLISOM

The BIPV system will be placed in the south face of the north pavilion's sloped roof, with orientation +2°and tilt 6°. It will be composed of 336 PV modules of, approximately, 60 Wp (real module power will range between 56-62 Wp, depending on the production lot). The total power will be 20,2 kWp, and the total occupied area will reach 276,9 m^2. The modules layout in the solar field finally proposed is the following:

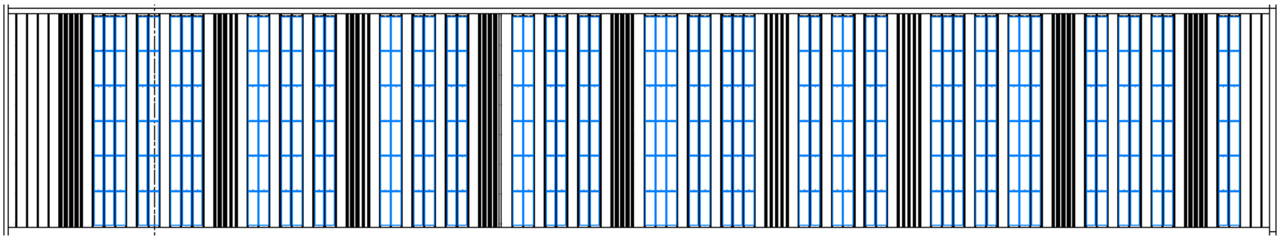


Figure 3.32: Solar field of the CRICURSA's demo-system

The solar field will be divided in 9 sections separated by the existing transversal skylights. Every section will consist of several rows of modules, arranged in pairs or trios; each of them will constitute an electrical string managed by the same *Solar Edge* MPP trackers micro-converter. The number of rows and modules per section are listed below:

Complete system: (56 x 6) = 336

- Section 1: (3 x 6) + (2 x 6) + (3 x 6) = 8 x 6 = 48
- Section 2: (2 x 6) + (2 x 6) + (2 x 6) = 6 x 6 = 36
- Section 3: (2 x 6) + (2 x 6) + (2 x 6) = 6 x 6 = 36
- Section 4: (2 x 6) + (2 x 6) + (2 x 6) = 6 x 6 = 36
- Section 5: (3 x 6) + (2 x 6) + (3 x 6) = 8 x 6 = 48
- Section 6: (2 x 6) + (2 x 6) + (2 x 6) = 6 x 6 = 36
- Section 7: (3 x 6) + (2 x 6) + (3 x 6) = 8 x 6 = 48
- Section 8: (2 x 6) + (2 x 6) + (2 x 6) = 6 x 6 = 36
- Section 9: (2 x 6) = 12

The main system data will be the following:

Table 3.4 Demo 4 PV System definition (2 options)

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 4	Roof	CSF	2	6	56	6	336	276,9	20,2

The proposed PV system would have 20,2 kWp (Table above). There is an alternative option, that will be not selected, consisting of the same system with 2 last rows left out and 19,4 kWp.

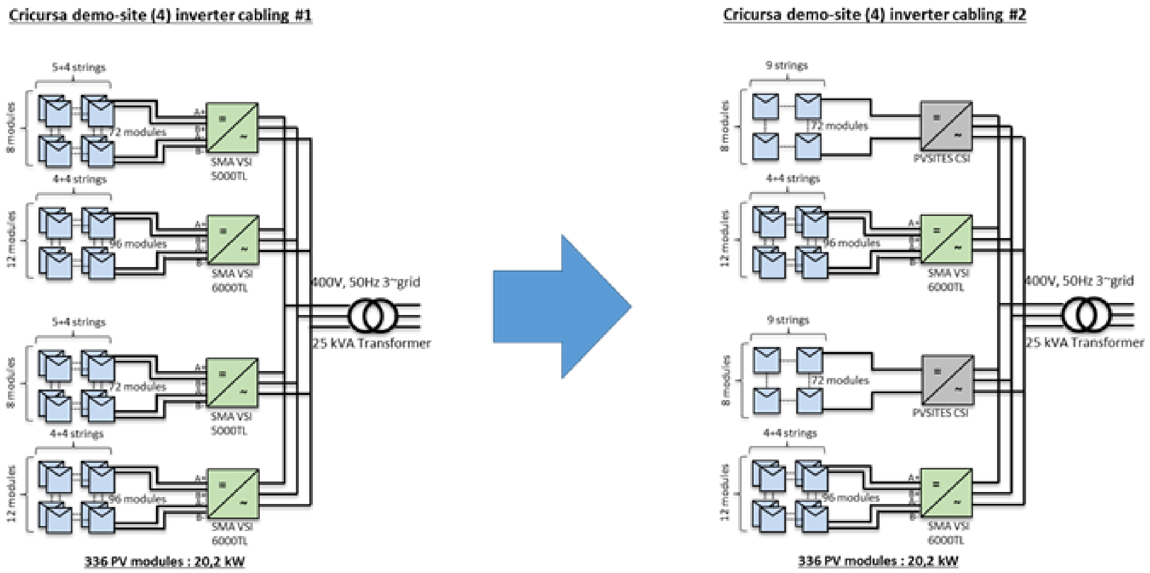
Figure 3.33: Possible location of the inverter in the roof

The cable-laying will be carried out avoiding obstacles to make easy the installation, connection and maintenance works on the roof. The electrical conversion will be probably done following the Solar Edge strategy, consisting on an array of DC/DC micro-converters connected to an AC/DC central inverter. The generated energy will be injected into the distribution grid through the connection to the low voltage panel.

Regarding the grid connection some issues has still to be clarified:

- If the excess of energy is intended to be injected into the grid, the electricity distribution company (ENDESA) has to make a previous study about the state of the network considering the new installed power. This would be a slow process which might cause unacceptable delays in the project. In order to solve meanwhile this inconvenient, a certified device preventing the discharge of energy to the distribution network could be installed.
- Selection of the most suitable inverter and batteries system. The final selection is this regard has been a monophasic battery LGChem RESU10 5KW, 63Ah, and 10Kwh; The inverter of battery will be the SMA SUNNY ISLAND 6.0H which is remotely controllable via communications protocol MODBUS Rs-485.

Here bellow it is attached the cabling configuration at the beginning of the project which means the installation of two commercial inverters SMA 5000TL and another commercial inverters SMA 6000TL. Later on, when the CEA inverters are ready to be installed in CRICURSA, the two 5KW inverters SMA 5000LT will be replaced for these CEA ones.



Electrical DC characteristic for 1 inverter	SMA VSI (5000TL)	SMA VSI (6000TL)
PV modules in series	8	12
PV modules in parallel	5 (A) + 4 (B)	4 (A) + 4 (B)
Number of PV modules	72	96
DC maximum power	4,32 kW	5,76 kW
DC maximum voltage	384 V	576 V
DC maximum current	9,55 A (A) + 7,64 A (B)	7,64 A (A) + 7,64 A (B)

Electrical DC characteristic for 1 inverter	PVSITES CSI	SMA VSI (6000TL)
PV modules in series	8	12
PV modules in parallel	9	4 (A) + 4 (B)
Number of PV modules	72	96
DC maximum power	4,32 kW	5,76 kW
DC maximum voltage	384 V	576 V
DC maximum current	17,19 A	7,64 A (A) + 7,64 A (B)

Figure 3.34: Cabling configuration at the beginning and at the end of project

This is the recommended configuration of the electrical map of panels per inverter proposed by the Engineering of CRICURSA.

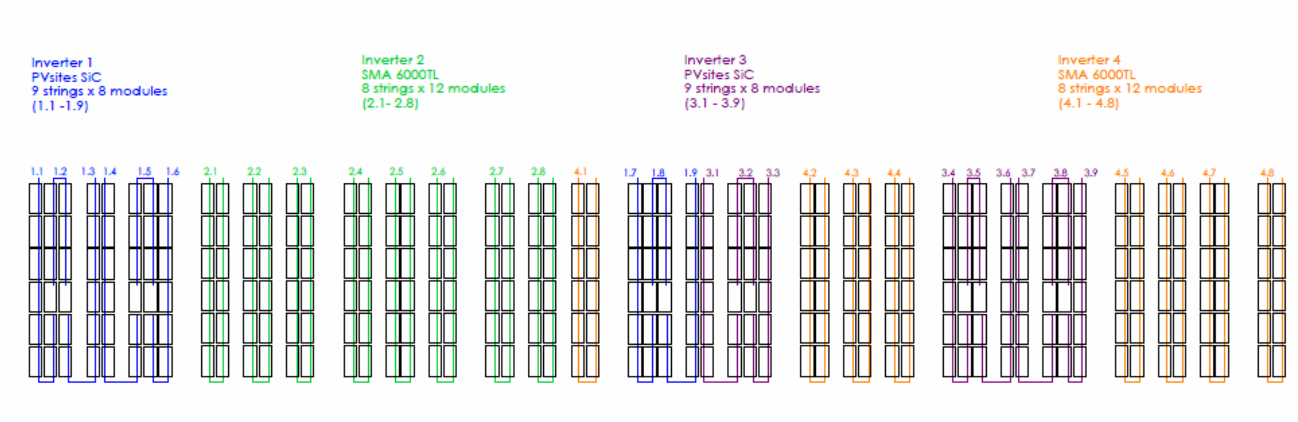


Figure 3.35: electrical map of the distribution per inverter

3.4.3 Building integration design

As said above, the PV module designed and manufactured by FLISOM consists on a steel sheet of inverted-U-shaped section with the edges bended and the CIGS cells laminated in the middle.

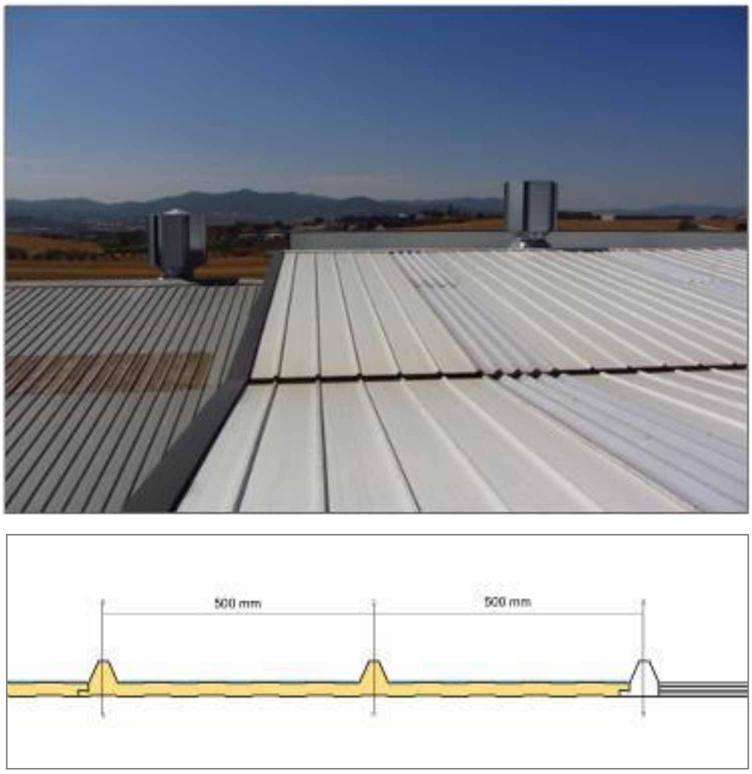


Figure 3.36: Standard sandwich-panel section currently installed in the CRICURSA roof

The modules will be screwed aligned, on the ribs, with the roof sandwich-panels currently installed on the underlying construction. The roof sandwich-panels have three ribs with a width of 500 mm between them. Total roof sandwich-panel width is 1000 mm. In between are transparent areas with plastic panels every 6 sandwich-panels units (Arcoplus 1000 flat skylight elements).

Roof length is about 9.940 mm, so that 6 modules can be mounted in a row.

There will be a 50 mm gap between the modules and the sandwich-panels, in such a way that natural rear ventilation would be possible between both elements. The BIPV module designed by FLISOM considers all this requirements and constraints in order to make possible the integration.

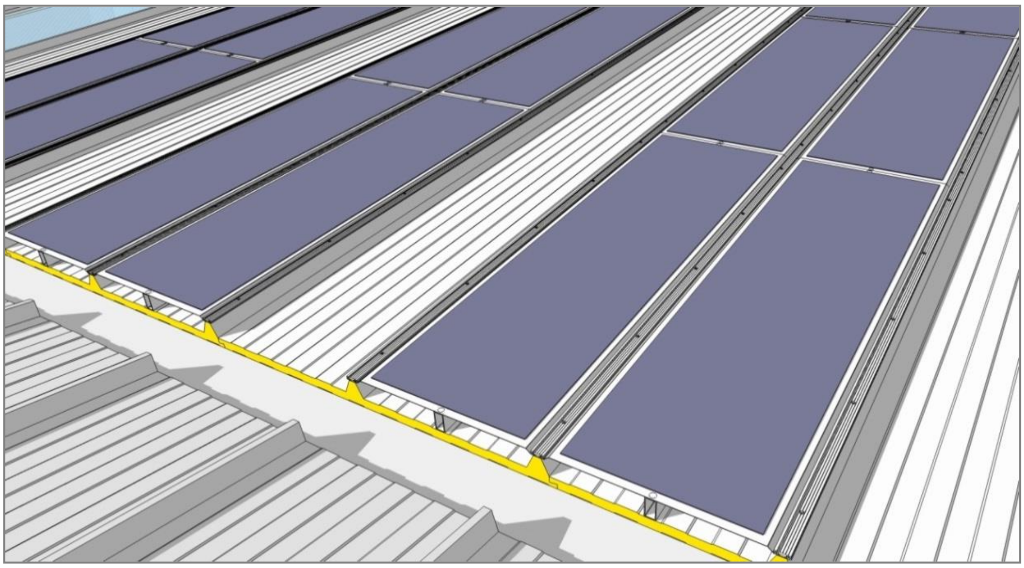


Figure 3.37: Mechanical integration strategy of the PV roof element

The original idea was to screw the modules on the sandwich panels. Because of the possibility for expansion, a better solution is to add a profile with rubber on top before screwing. The rubbers will guarantee that no water can come in and with oval holes the modules can expand.

The vertical connection between modules and the roof construction will be hidden and the horizontal connection to the roof will be done with a hidden gutter/profile under the modules. Regarding the colours, it is preferred to give the steel sheets a colour close to the roof colour RAL 9010 (matt white). The same should also be used for the profiles, ridge and edges. All these measures would guarantee aesthetic.

As said before, the PV system will be located in the south face of the north pavilion's sloped roof. PV modules will be distributed in sections separated by the existing transversal skylights.

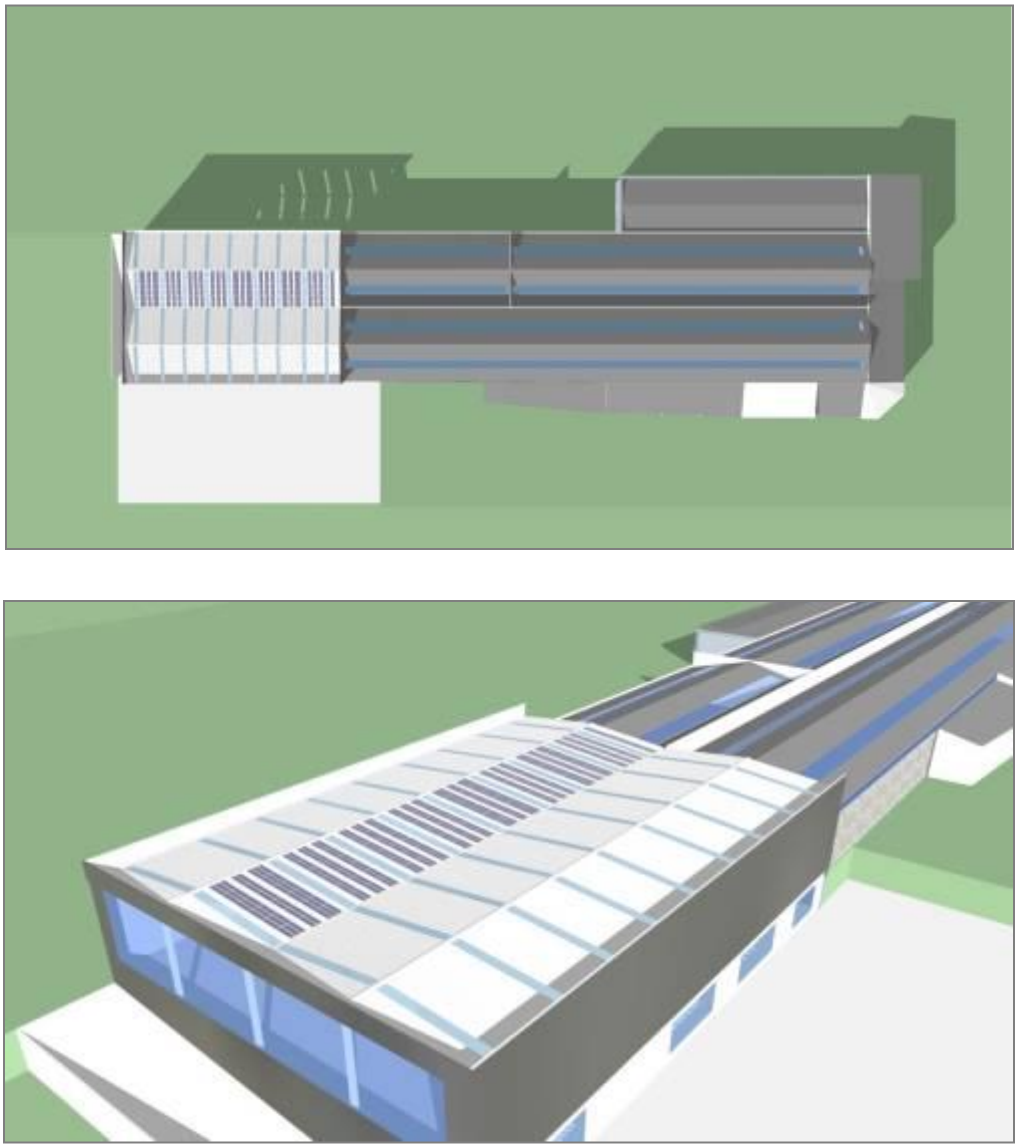


Figure 3.38: Architectural integration of the PV demo-system

The figure below graphically explains, step by step, the mounting procedure of the BIPV system in the CRICURSA's demo-site:

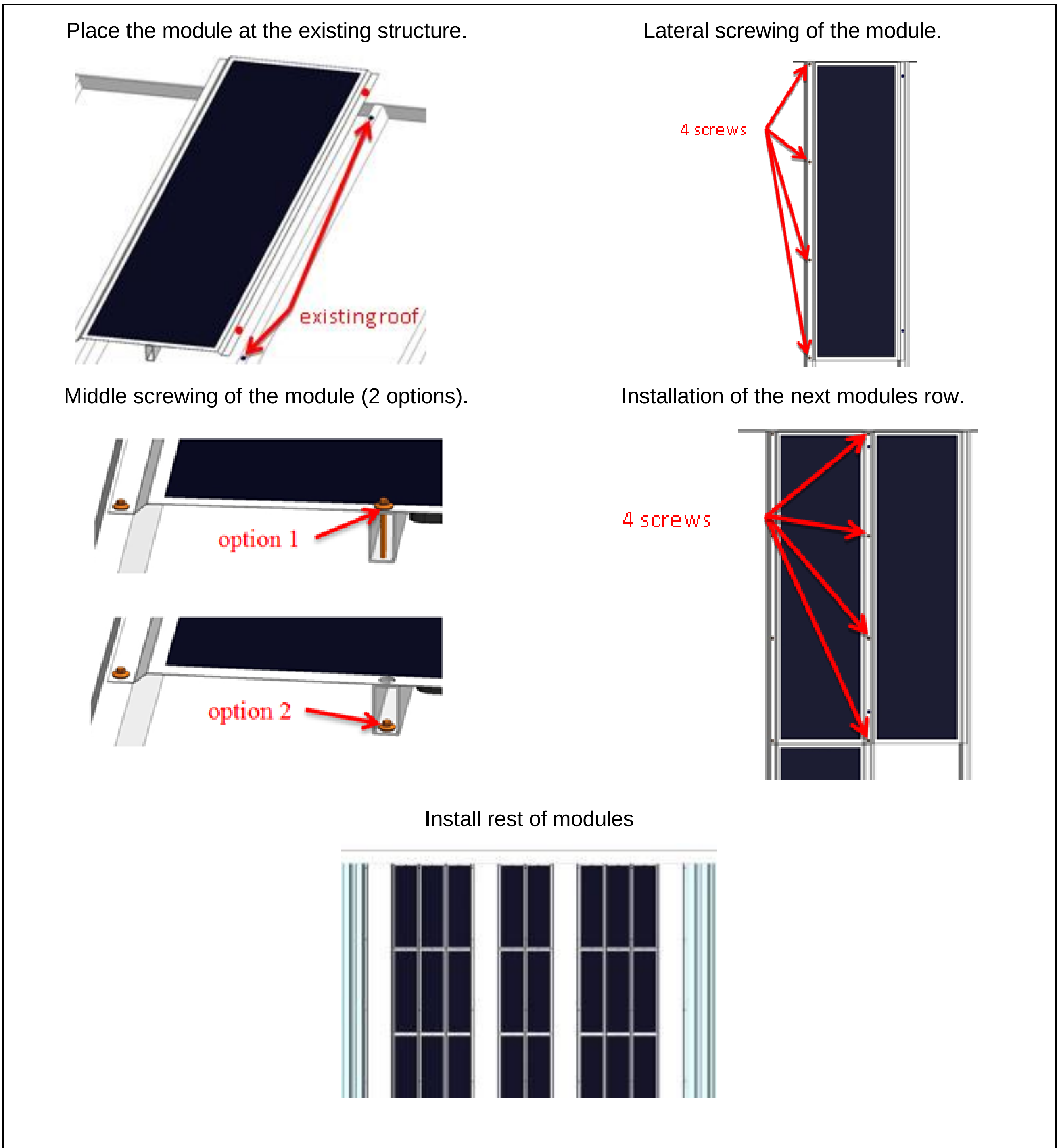


Figure 3.39: Installation procedure of the BIPV industrial roof system

From the architectural point of view, it will perform as a tropical roof, based on a double layer concept. In this regard, modules will work not only as a power production unit but also providing extra passive energy benefits, as a building element, consisting on the thermal dissipation of the heat retained in the open-air gap between the PV modules and the roofing units, in part generated by the PV cells in operation.

3.5 Demo 5 description: Apartments building in Wattignies, France

3.5.1 Demo-building description

PVSITES Demo-Building 5, provided by the partner VILOGIA, is a residential storey block, and it is currently in a retrofitting process.

- Address: 12-14, rue du Docteur Laennec, 59139, Wattignies (France).
- Geographical coordinates (sexagesimal): 41° 35' 14.9" N // 2° 16' 01.7" E.
- Elevation: 153 m.

Figure 3.40: Demo 5. Residential 8-storey building, provided by VILOGIA

The BIPV ventilated façade system will be placed in SSE façade, which is currently made from the top to the ground by a brick cladding and include a vertical windows row in the west side. Roofs are provided with foam glass insulation, a bituminous sealing and a gavel protection. Brick wall includes polystyrene insulation and air chamber throughout the air can flow. Originally the openings were made of wood, but some of them were replaced by PVC double glazing units. All of them will be replaced in order to improve the thermal insulation during the retrofitting works which will happen later.

The SSE façade brick cladding will be removed almost in their entirety, as part of the retrofitting works, leaving the inner concrete wall exposed. The foreseen BIPV system will be installed on this wall. The project will have to provide a complete façade solution that not only introduce PV but also ensure thermal insulation and waterproofing.

On the other hand, in order to avoid shadows over the PV modules from the high trees existing in front of the façade will be pruned.

3.5.2 BIPV system definition

The BIPV system will consist of a BIPV ventilated façade made with fully opaque glass-glass Si-crystalline modules, 151 Wp, with hidden bus bars and L-interconnections (model X5, 1st generation, by ONYX) to improve its aesthetical appearance. After having considered various configurations and modules dimensions, the final system's features will be the following: the orientation will be -16° and tilt 90°, occupying an area of 130,5 m^{2}, and with 17,0 kWp total power. The chronology of the different proposals and the different options considered are detailed below:

Figure 3.41: BIPV glass-glass module with hidden bus bars (1st generation), by ONYX

The module colour is black. The visible parts of the mounting system will also be black. A second colour will be chosen for adjacent elements, as the whole building will be renovated and will need a new cladding.

BIPV system initial design

In any case, the chosen option would cover a large portion of the SSE facade, leaving the solar field at a certain distance to the windows row and the ground to make it difficultly accessible for malicious acts.

At the beginning, several options related to the modules layout have been considered in order to fulfil with the requirements of the building property and the power and occupied area planned in the DOA. At first, two options have been studied with the following module dimensions (a vertical configuration and a horizontal configuration, see Figure 3.40):

- Module length: 1700 mm.
- Module width: 1000 mm.
- Module thickness: 13,8 mm.

Figure 3.42: Horizontal and vertical options (1st proposals) related to the layout of the modules

With the initial module dimensions, the solar field for the vertical option would include a total of 77 BIPV modules, vertically positioned and distributed in 7 vertical rows with 11 modules each one.

The main system data would be the following:

Table 3.5 Demo 5 preliminary PV System definition

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 5	S façade	CSF	-16	90	7	11	77	130,9	20,0

Nevertheless, as commented before a retrofitting process is planned for the next year, so the following proposal has been considered and is the final one.

BIPV system final design

Considering the retrofitting design of the north facade, an updated module layout has been proposed with a vertical distribution (8 vertical rows of 14 modules each one, 112 in total) of modules with new dimensions (see below) and the introduction of random-ordered vertical windows similar to the north facade.

The module:

- Module length: 1300 mm, changed to 1280 mm during the detailed design phase.
- Module width: 910 mm.
- Module thickness: 13,8 mm.

This choice has been made to ensure consistency between the façades after the retrofitting works, for a unique architectural design.

This option will imply a lower power installed around 17,0 kWp (lower that planned in the DOA) and is requiring:

- An extra horizontal profile to mount the modules.
- A fixing system compatible, in size and look, to that used for the new cladding, in order to make possible to fit together.
- A mounting system for the PV with a deep equal to that of the new cladding and a suitable watertight solution for the edges.

The main system data is the following:

Table 3.6 Demo 5 final PV System definition

System definition					System data				
System	Solar field	SubSystem	Orient (º)	Tilt (º)	N. mod H	N. mod V	Total N. mod	Total area (m2)	Total power (kWp)
Demo 5	S façade	CSF	0	0	8	14	112	132,5	17,0

Cabling will be planned aimed to facilitate installation and maintenance and to ensure invisibility. The 2 solar inverters will be provided by TECNALIA. They will be placed, together with the 2 batteries and the monitoring system, in a separated room on the ground floor, not accessible for tenants. Regarding the connection scheme, the most favourable energy management scenario will be adopted, considering technical and economic factors under the current legislative framework in France.

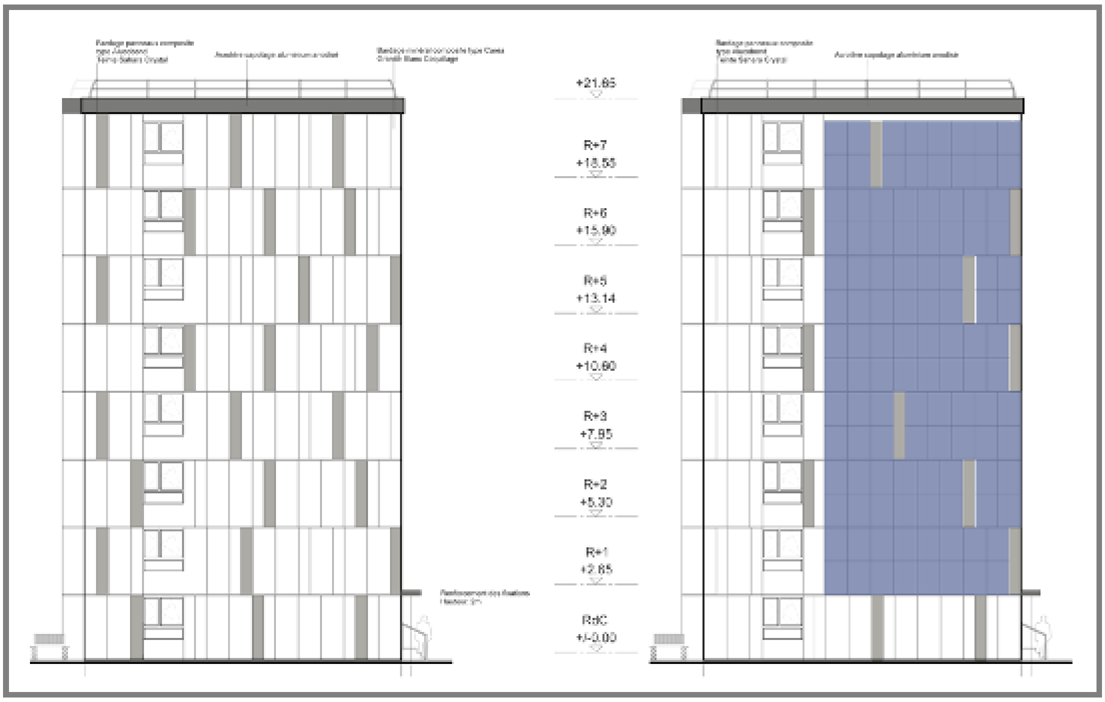


Figure 3.43: Final modules layout inspired in the renovation design

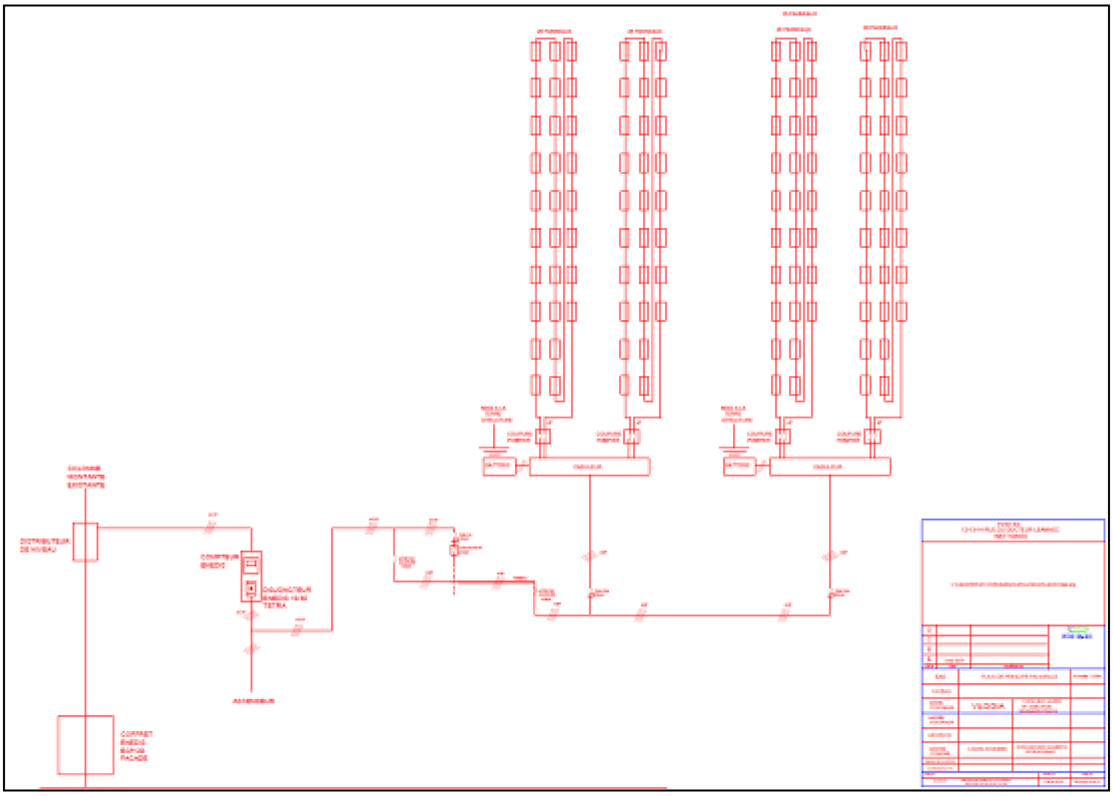


Figure 3.44: "SB fijaciones" clip system and real application for a glass-panels facade Single-line scheme of the PV system implemented in the Demo 5

3.5.3 Building integration design

The BIPV system implementation will be included in the planned retrofitting works, in such a way that it will meet the common purposes, together with other measures, related to the improvement of the building energy performance. This means that the detailed construction project of the BIPV system will be able to guaranty thermal insulation and waterproofing all along the façade. In this regard, installation of thermal insulation panels behind the PV modules and well executed joining to the boundary elements is planned.

The main points to take into account in order to do a good integration are the following:

- Original brick cladding will be taken out. So, the new BIPV cladding will be mounted on the concrete construction. The concrete roof edge would stay. If possible, the first few meters of bricks would stay to maintain the PV modules inaccessible from the ground. If not possible due to field constraints, this area would have to be protected.
- As the retrofitting works come later and include the replacement of the existing windows, some space would be left between the existing windows and the PV modules. This is also done for security reasons.
- The BIPV system design should have into account the thermal insulation intended to be installed and should effectively resolve the thermal bridges in the fixations and the edges.
- Characteristics of the conventional cladding close to the PV area should be chosen technically and aesthetically compatible to the BIPV system.

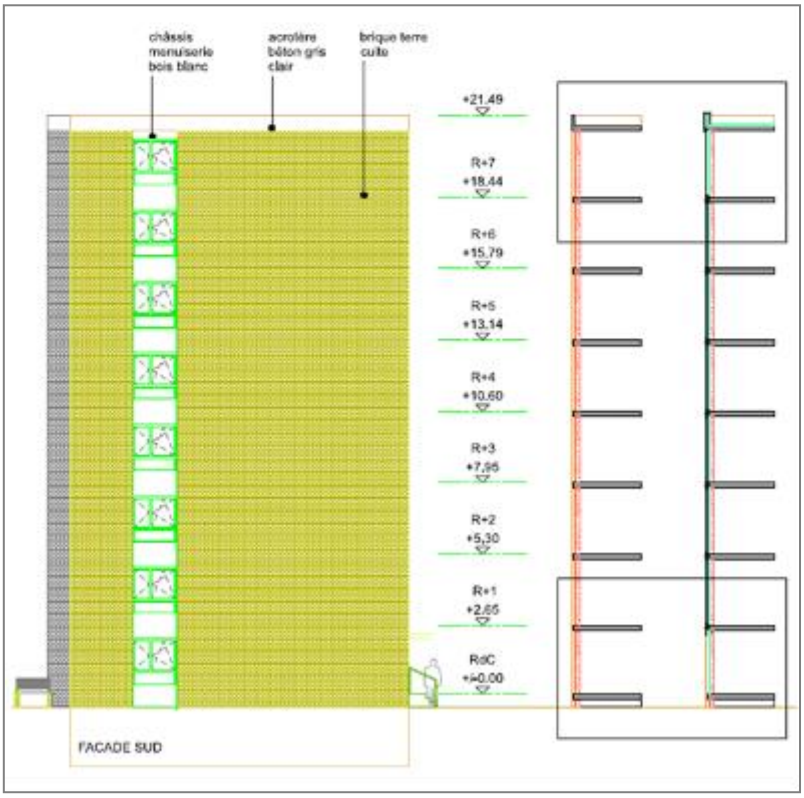


Figure 3.45: Closed ventilated façade system with thermal insulation and waterproofing

Regarding the mounting system, a fixing system based on vertical profiles and removable fixations is proposed. Horizontal position of the modules is preferable from the structural safety point of view, although vertical position would also be viable if some specific measures are applied.

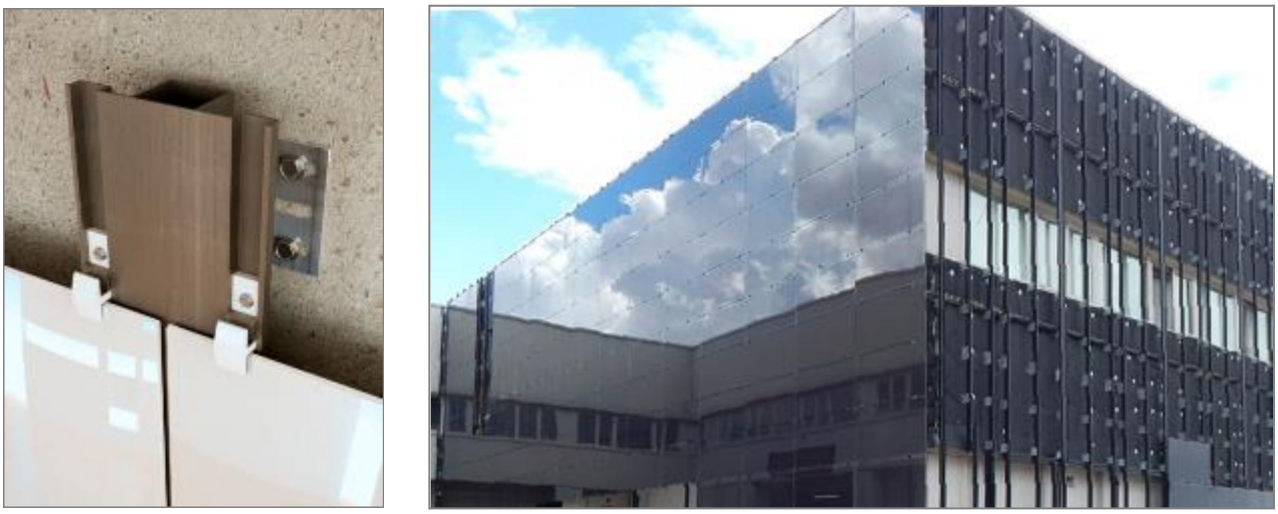


Figure 3.46: "SB fijaciones" clip system and real application for a glass-panels facade

The building owner insisted to have removable fixations in order to ease future maintenance.

The mounting system also have to be compliant with the local regulations, including physical separations every two levels for firefighting.

3.6 Demo 6 description: Office building in San Sebastian, Spain

3.6.1 Demo-building description

PVSITES Demo-Building 6, provided by the partner TECNALIA, is an office building with engineering and chemical laboratories.

- Address: Paseo Mikeletegi 2, San Sebastian (Spain).
- Geographical coordinates (sexagesimal): 43° 17' 10.9" N // 1° 59' 05.6" W.
- Elevation: 132 m.

Figure 3.47: TECNALIA offices and labs in San Sebastian

The BIPV system addressed to be installed in TECNALIA will consist on a double-skin over the existing curtain walls with c-Si back contact laminated glass modules, by ONYX.

The chosen façades, SSE & S, are composed of large curtain walls; each one divided in two zones corresponding to the office areas of the first and the second floors. Both façades have a polygonal section made up of 6 vertical windows rows with different orientations and an extra one facing east.

The entire curtains walls will be covered by PV, with the exception of the seventh rows which present an inappropriate orientation. The curtain walls are composed of an aluminium structure with clear double-glazing units. There is one horizontal windows row per floor with openable windows; all the others are closed elements.

Figure 3.48: Existing curtain wall in the SE façade and constructive details

3.6.2 BIPV system definition

The design of the BIPV system has been performed considering several aspects, such as: mechanical feasibility of proposed architectural integrations, installed power, daylight, ventilation and aesthetical appearance, besides other specific technical requirements of the demo-building.

The module chosen for TECNALIA's demo-site will be the *Model X6*, by ONYX, based on glass-glass back-contact c-Si cells technology for semi-transparent curtain walls and ventilated façades applications. The module will have a total of 64 mono-crystalline back-contact cells and will provide 191.5 Wp of power with 61% of active area (39% of transparency). Thanks to the foreseen transparency degree, the module will allow the entrance of natural light into the building. The cell colour will be black and the module will be frameless.

The dimensions of the module have been chosen based on the glass construction units of the existing curtain walls. After verifying the exact dimensions, it was observed that the two facades were not identical, being one of them slightly bigger than the other one. For this reason, in order to reproduce the exact skin in each façade, the use of two BIPV modules was decided. The final dimensions are

- Module height: 760 / 765 mm.
- Module length: 2250 / 2212mm.
- Module thickness: 13.8 mm.

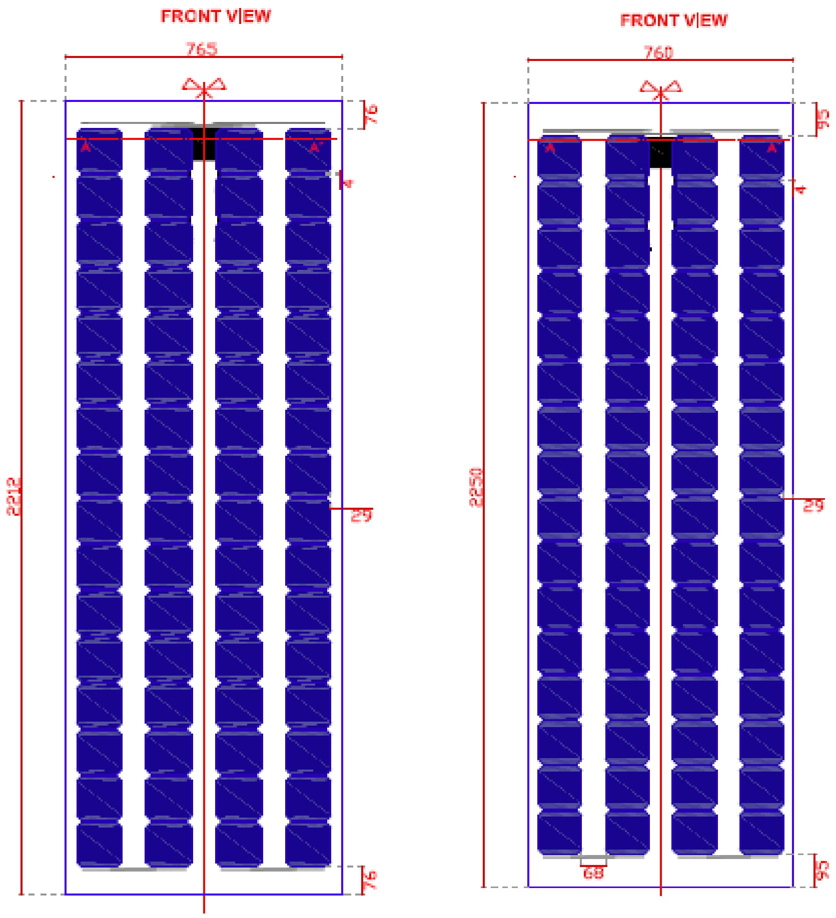


Figure 3.49: BIPV glass-glass modules for Demo 6, by ONYX

A total of 96 modules with 64 cells each are needed to fulfil the project's requirements. In this case, the whole curtain wall's surface is occupied, providing a highly homogenous visual aspect. There's a lateral part that was left uncovered due to its different orientation, which made difficult finding and optimal electrical solution.

Another option consisting of 76 modules with 80 cells and geometrically compatible with the curtain wall structure was also considered. In this case, the higher cells density of the modules would allow taking out one row of at each floor for a clear outside view. The required power would also be fulfilled with this configuration. However, the first option was preferred by the building property.

The complete system will consist of two sub-systems, one per façade (SSE & S). Each BIPV system will be located, configured and dimensioned according to the existing curtain wall on which it will be installed. In such a way that the modules layout will exactly reproduce its same geometrical composition, as can be seen in Figure 3.54Figure 3.54.

In the same way, orientations of the different faces which comprise each PV system correspond to the curtain walls' ones:

- SSE polygonal façades orientations: -31°, -32°, -33°, -34°, -35°, -36°; tilt 90°.
- S polygonal façade's orientations: -1°, 0°, +1°, +2°, +3°, +4°; tilt 90°.

The main system data will be the following:

Table 3.7 Demo 6 PV System definition

System definition					System data				
System	**Solar field**	**SubSystem**	**Orient (º)**	**Tilt (º)**	**N. mod H**	**N. mod V**	**Total N. mod**	**Total area (m2)**	**Total power (kWp)**
Demo 6	SE façade	SEF	Several	90	6	8	48	81,0	9,2
	S façade	SF	Several	90	6	8	48	81,0	9,2
	SE&S façades	CF	Several	90			**96**	**162,0**	**18,4**

Regarding the power management a conventional inverter will be used, instead of CEA's originally considered solution for the grid connection. All the equipment will be placed together in order to reduce electrical losses and facilitate the maintenance labours.

The BIPV system will be connected to the inner grid of the building under a self-consumption regime without storage following the basic scheme showed in the figure below.

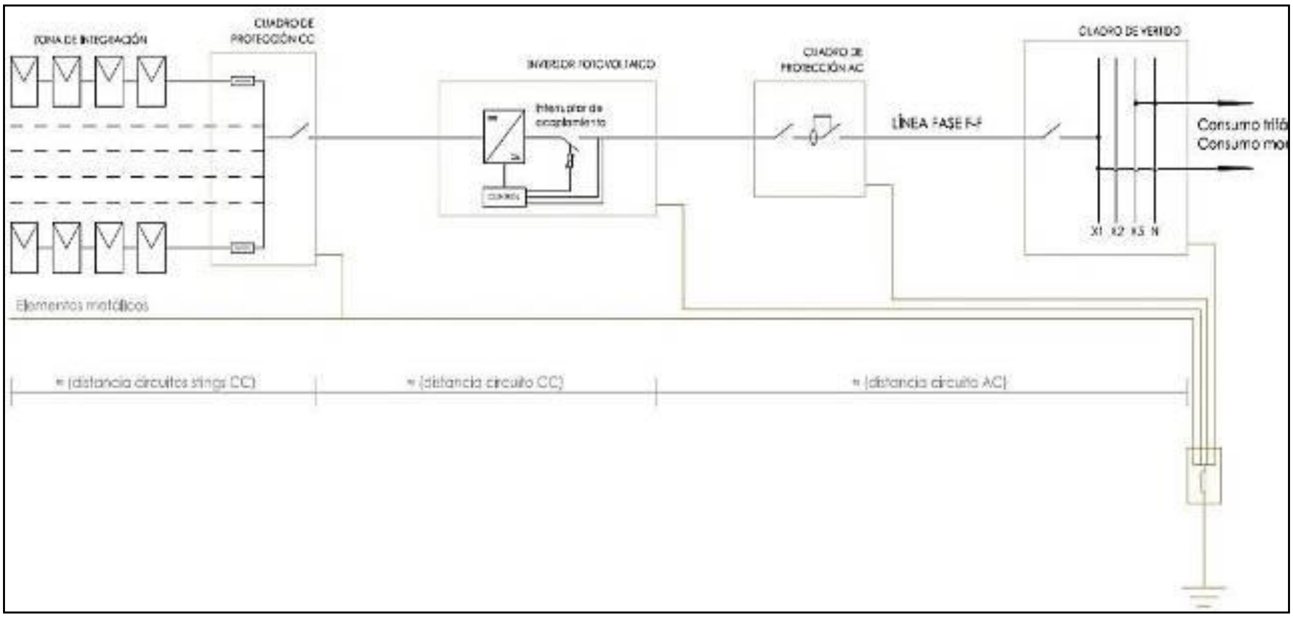


Figure 3.50: Direct connection to building inner grid for self-consumption and without storage

3.6.3 Building integration design

The BIPV systems planned for TECNALIA's demo-site will work as a ventilated façade, since the original curtain wall will not be removed. Therefore, a ventilated façade mounting system will be used to install the modules. As said before, the geometrical design of the BIPV modules reproduces the existing curtain walls' configuration.

The proposed mounting system is based on HILTI's façade solution 's2s' (slab to slab), using three 'T' vertical profiles per module. Unfortunately, HILTI does not have a valid fixation system for the glass BIPV modules, and following ONYX's advice, TECNALIA contacted "SB Fijaciones", who could provide a fixation solution applicable in this case. The main reason why this solution was chosen was that it was the fixation system used for the ETAG 034 wind load and impact tests performed in the project, which were successfully passed.

In order to maximise the ventilation of the PV modules, brackets of 180 mm were chosen, leading to a ventilated cavity behind the modules of about 20-25 cm. The vertical profiles and clips will be anodized in black in order to match the colour of the solar cells and improve the aesthetical solution.

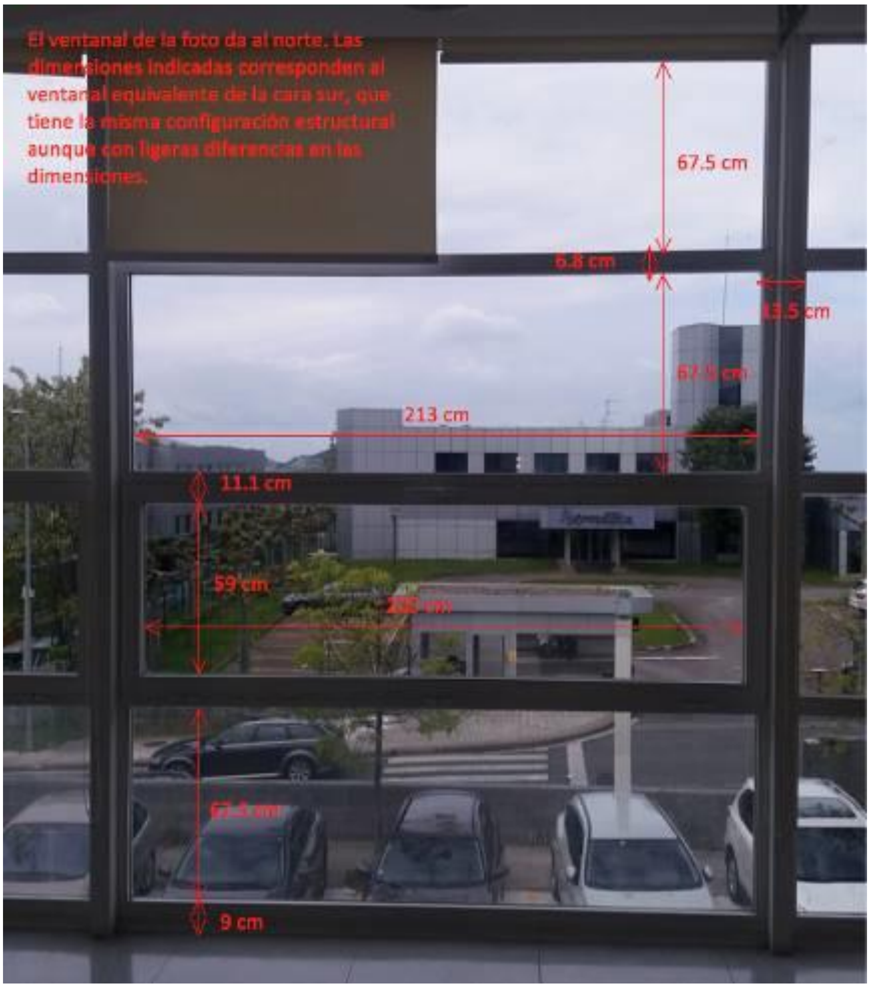


Figure 3.51: Dimensions of the existing curtain wall facade

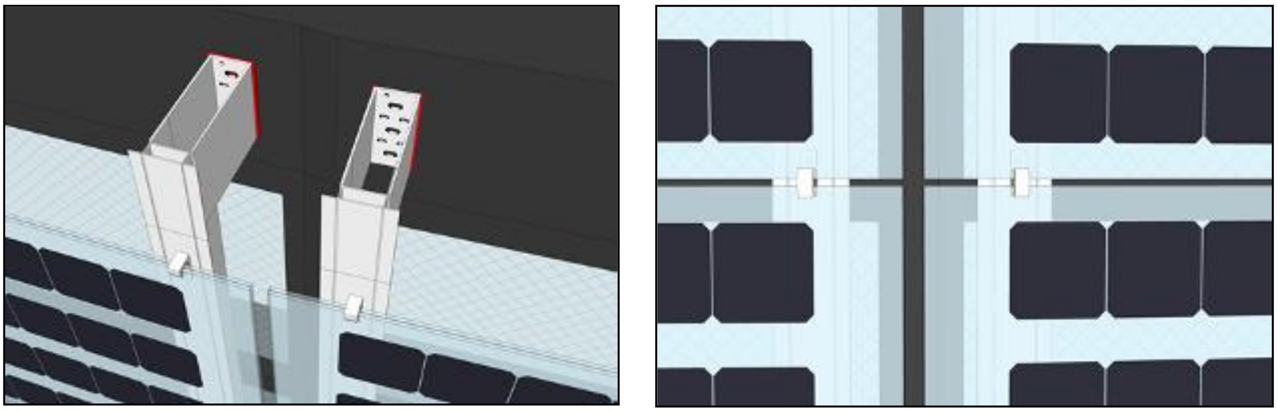


Figure 3.52: Skin facade based on mounting with SB Fijaciones clips

SB Fijaciones' clip is compatible with 13 and 17 mm glass components. ONYX's module is 13.8 mm thick so using the 17 mm clip was decided. The existing gap will be filled with a 3 mm PVC piece, adhesive to the EPDM joint of the clip. A scheme is shown below.

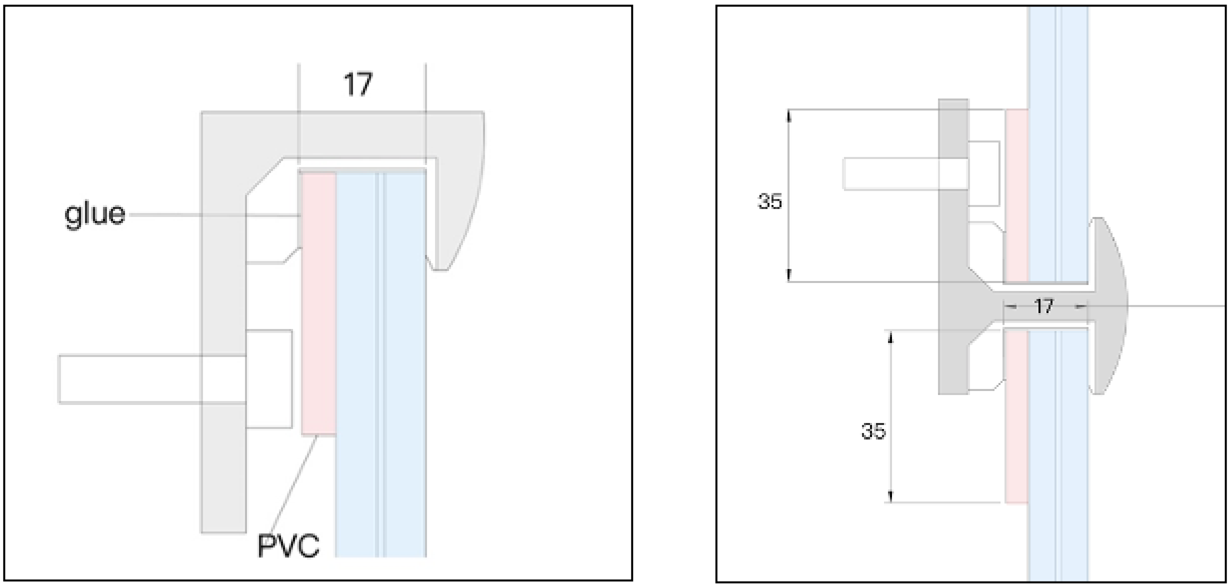
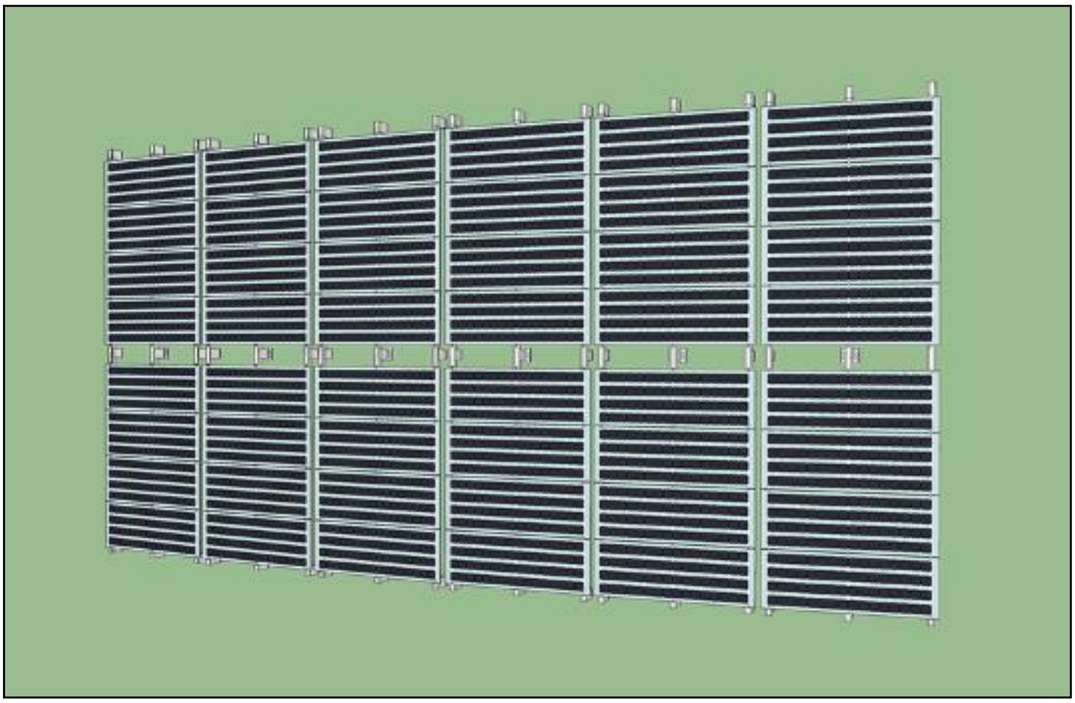


Figure 3.53: Detail of the 17 mm start/final and intermediate clip. A PVC part is used to fill the gap between the glass and the EPDM joint

The use of clips has a problem that couldn't be solved for this demo. The modules need at least 6 supports (3 on top and 3 at the bottom), for opaque applications it is simple to add an extra vertical profile in the middle. Since the BIPV system is semi-transparent, avoiding the central vertical profile would have been preferred but HILTI's mechanical analysis proved that a central vertical profile was structurally indispensable.

An alternative integration solution based on a horizontal substructure system was evaluated and later discarded after verifying that its applicability in the building was not possible due to the need of anchoring points over the existing curtain wall structure, which wasn't designed for that purpose. In addition, this solution was also more expensive. In any case, the conceptual solution is shown in the figures below and a detailed description can be found in the Architectural Integration Guideline (GA6) which could be of interest for other building typologies. The aesthetical solution is indeed better than the previous solution.



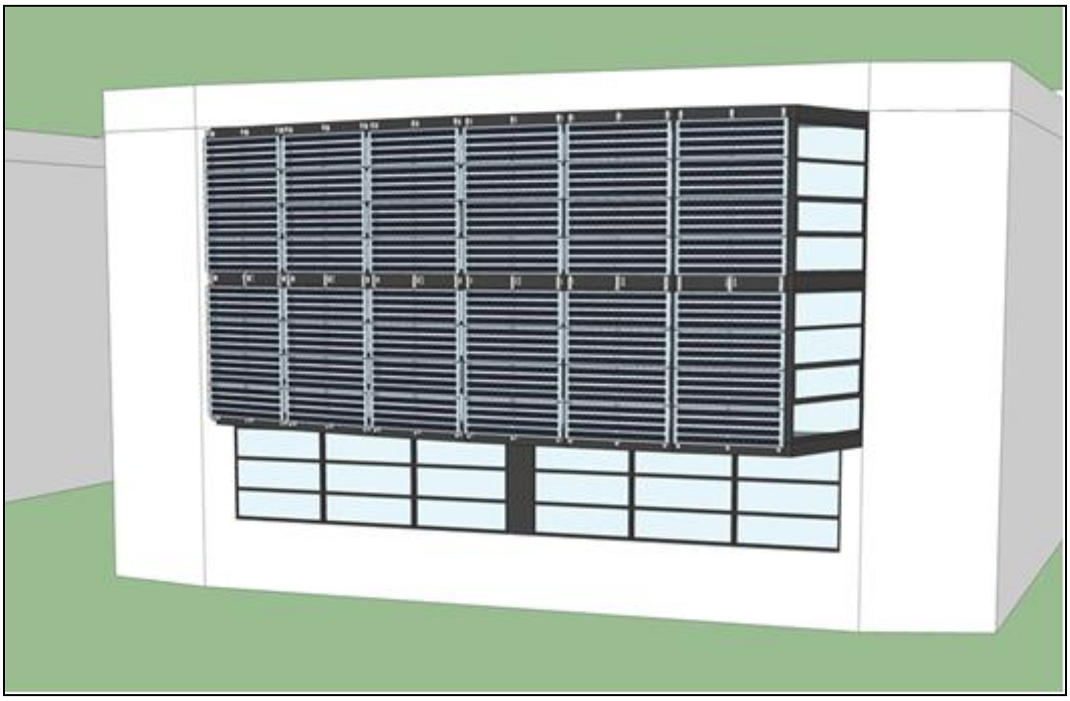


Figure 3.54: Final solution with SB fijaciones clips

As an alternative, a mounting system based on full profiles all around by “Reynolds” could also be suitable (see Architectural Integration Guideline, GA6). It would consist of a visible mounting structure attached to the upper, intermediate and lower floor slabs with vertical and horizontal profiles fixing the modules. However, some additional fixing points to the curtain walls’ structure might be needed, which was not feasible in TECNALIA’s office building. Air gap between the BIPV ventilated façade and the curtain wall would be around 40-50 mm, behind the horizontal profiles, sufficient to rightly develop its potential as a thermal passive element. The visual appearance would correspond to a conventional glass cladding, similar to the existing curtain walls.

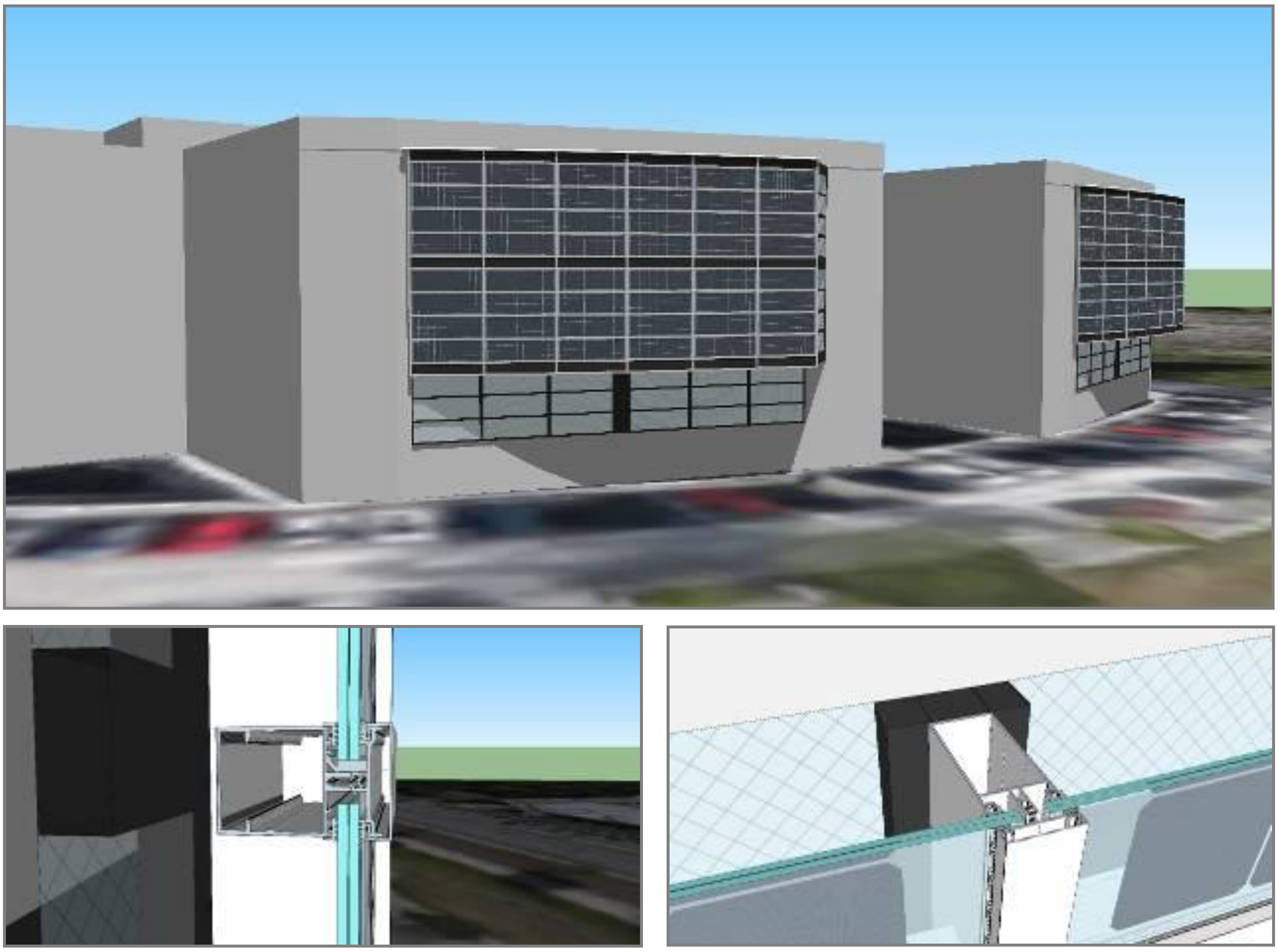
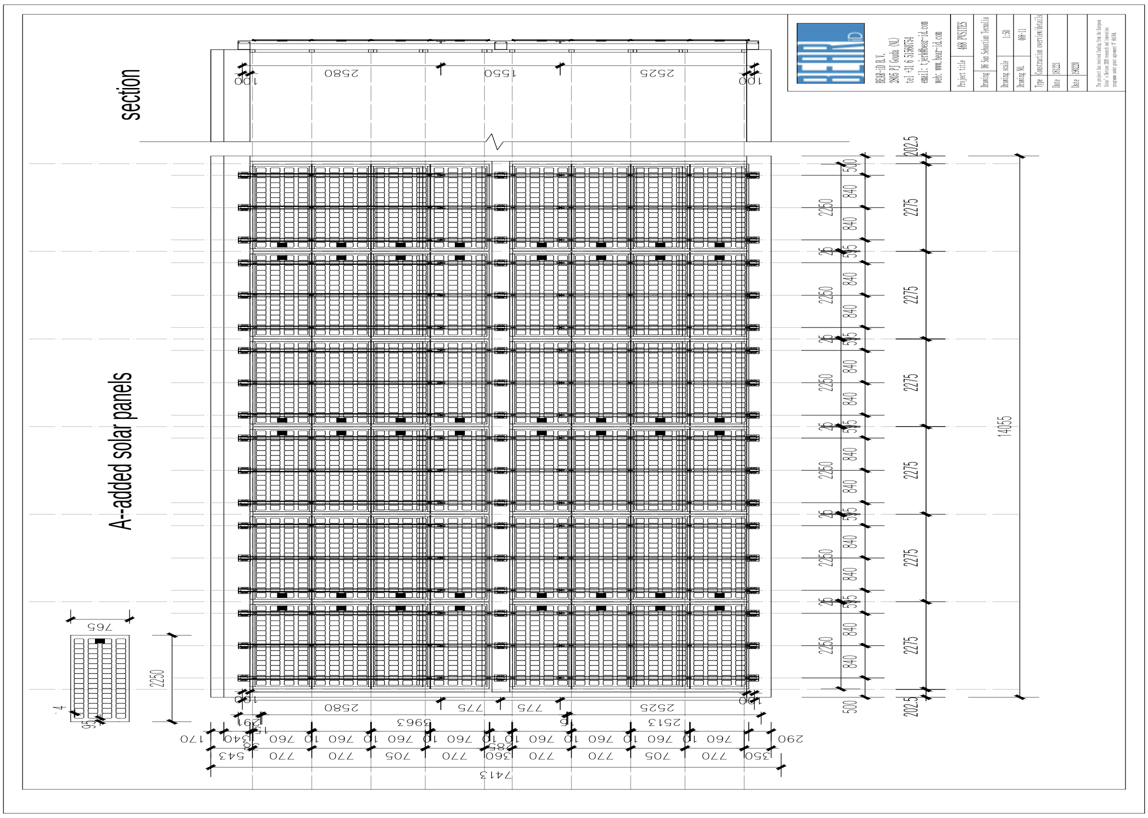


Figure 3.55: Reynolds' mounting structure

Due to the integration limitations offered by the existing curtain wall, the use of the combined solution provided by HILTI and SB Fijaciones was finally preferred. The PV installation layout is shown in the next figures:



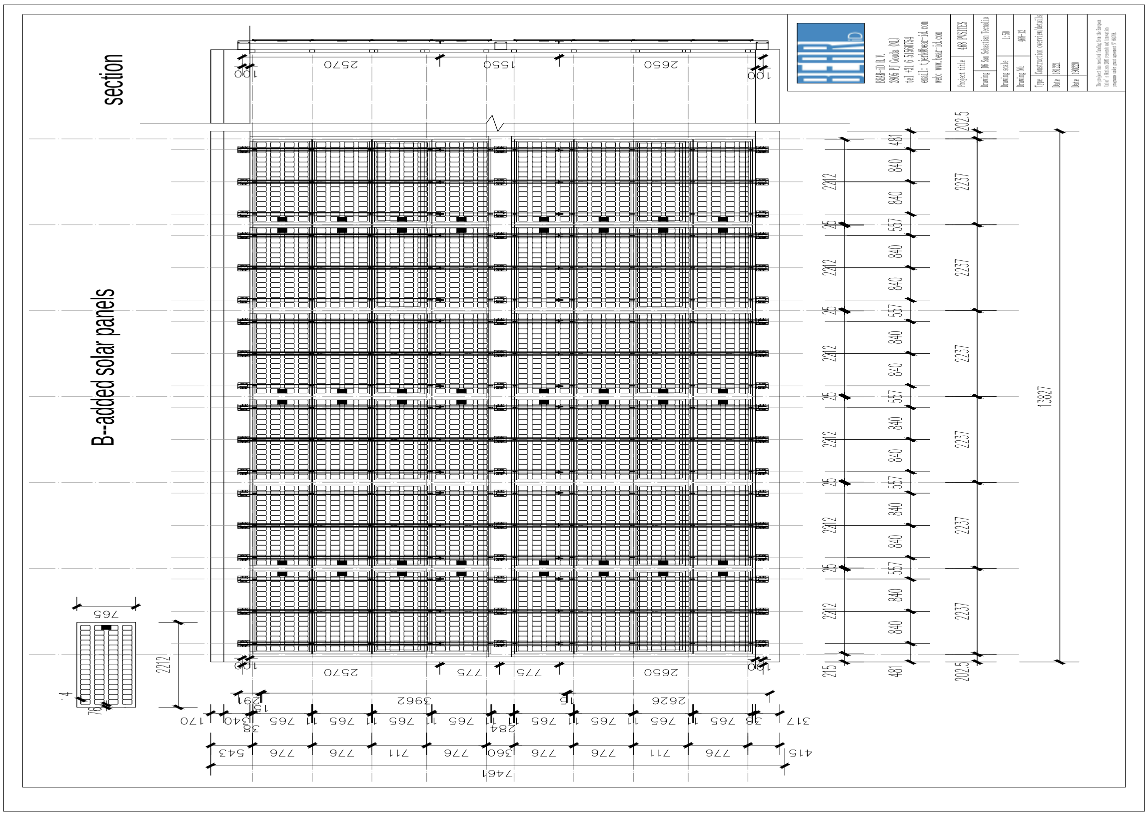


Figure 3.56: PV layout for Façade A and B of Demo 6

ANNEX 1. DEMO 1 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS1: Demo 1 BIPV Module data-sheet

GA1: Demo 1 Architectural Integration Guideline

GB1: Demo 1 Electrical Design, Operation & Control Strategies Guideline

GC1: Demo 1 Installation, Commissioning and Maintenance Guideline

GD1: Demo 1 Health, Safety and Security Guideline

ANNEX 2. DEMO 2 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS2: Demo 2 BIPV Module data-sheet

GA2: Demo 2 Architectural Integration Guideline

GB2: Demo 2 Electrical Design, Operation & Control Strategies Guideline

GC2: Demo 2 Installation, Commissioning and Maintenance Guideline

GD2: Demo 2 Health, Safety and Security Guideline

ANNEX 3. DEMO 3 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS3: Demo 3 BIPV Module data-sheet

GA3: Demo 3 Architectural Integration Guideline

GB3: Demo 3 Electrical Design, Operation & Control Strategies Guideline

GC3: Demo 3 Installation, Commissioning and Maintenance Guideline

GD3: Demo 3 Health, Safety and Security Guideline

ANNEX 4. DEMO 4 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS4: Demo 4 BIPV Module data-sheet

GA4: Demo 4 Architectural Integration Guideline

GB4: Demo 4 Electrical Design, Operation & Control Strategies Guideline

GC4: Demo 4 Installation, Commissioning and Maintenance Guideline

GD4: Demo 4 Health, Safety and Security Guideline

ANNEX 5. DEMO 5 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS5: Demo 5 BIPV Module data-sheet

GA5: Demo 5 Architectural Integration Guideline

GB5: Demo 5 Electrical Design, Operation & Control Strategies Guideline

GC5: Demo 5 Installation, Commissioning and Maintenance Guideline

GD5: Demo 5 Health, Safety and Security Guideline

ANNEX 6. DEMO 6 MODULE DATASHEET & GUIDELINES

This annex contents the complete characterization of the BIPV module used for this demo-system and the building integration and installation guidelines.

MDS6: Demo 6 BIPV Module data-sheet

GA6: Demo 6 Architectural Integration Guideline

GB6: Demo 6 Electrical Design, Operation & Control Strategies Guideline

GC6: Demo 6 Installation, Commissioning and Maintenance Guideline

GD6: Demo 6 Health, Safety and Security Guideline

D8.3 Design pack for every demo site

ANNEX 1. DEMO 1 BIPV MODULES DATA-SHEETS AND GUIDELINES

- **MDS1: Demo 1 BIPV Module data-sheet**
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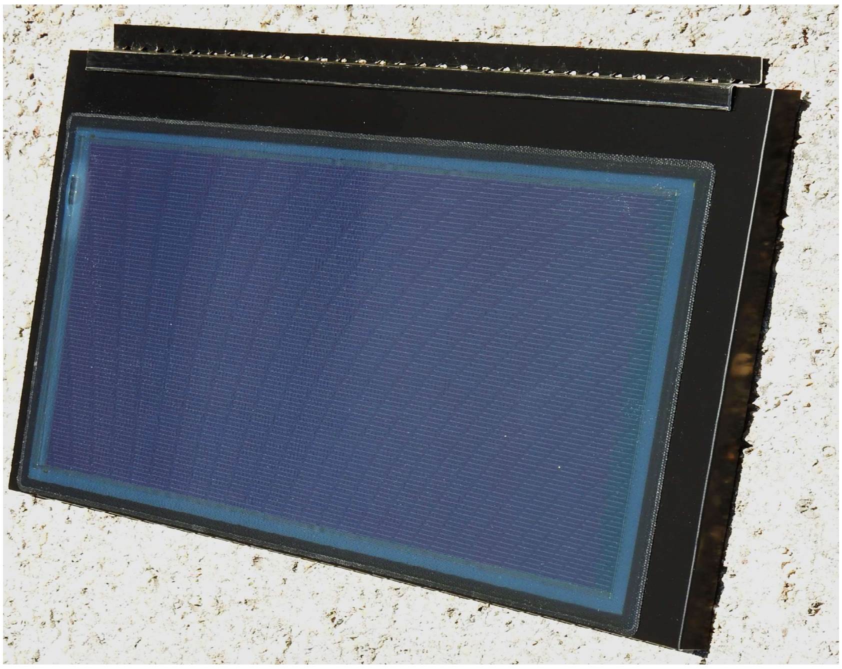
- **GC1: Demo 1 Installation, Commissioning and Maintenance Guideline**
- **GD1: Demo 1 Health, Safety and Security Guideline**

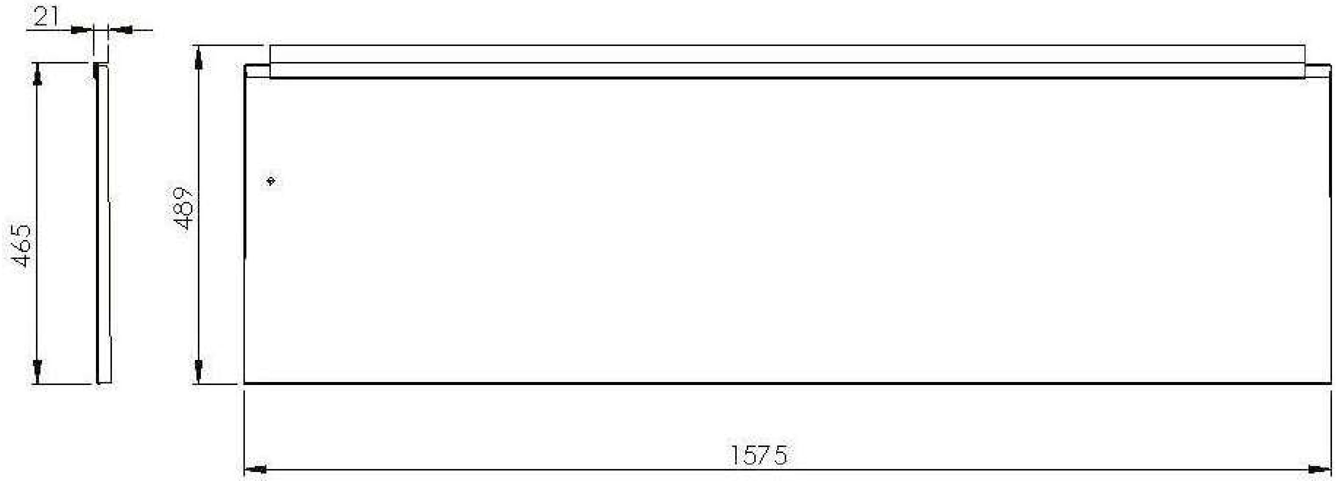
PVsites module – for Stambruges BE

SWISS MADE



Description

The Format D2 module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations.



Dimensions					
Length		[mm]	1575		
Width		[mm]	489		
Thickness at module		[mm]	21		
Thickness at J-Box		[mm]	21 ± 1		
Weight		[Kg]	ca. 6		

Electrical characteristics at STC[1] Model number			SF 50	SF 55	SF 60
Nominal power	Pmpp	[W]	50	55	60
Tolerance		[W]	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	34	35	36
Current at nom. power	Impp	[A]	1.47	1.54	1.66
Open circuit voltage	Voc	[V]	46	47	48
Short circuit current	Isc	[A]	1.72	1.82	1.91
Max. system voltage	IEC	[V]		1000	
Max. serial fuse rating		[A]		10	

Thermal characteristics			
Temperature coefficient	Voc	[%/°C]	-0.3
Temperature coefficient	Isc	[%/°C]	0.01
Temperature coefficient	Pmpp	[%/°C]	-0.35

Operating conditions		
Temperature range	[°C]	-40 to +85
Max. mechanical load		2400 Pa, 245 kg/m2

Additional data	
Cell type	Flexible CIGS
Material Backsheet	Painted steel, RAL 9005
Junction box	Back side

Warranty

Format D2 modules are specially designed for PVsites Testinstallation. Therefore they have no warranty.

Notes

[1] STC: 1000 W/m2, AM1.5G, 25°C, stabilized module state

We continuously develop our products. Electrical and physical properties subject to change without prior notice.

Version	Date	Comments	Author
00.00	2017-09-29	Initial	Schweizer, M.
01.00	2017-12-15	Dimensions Drawing	Schweizer, M.

SPECIFICATIONS

Project : Demo 1 – BIPV Roof Modules

Location : Belgium, Stambruges

Owner/Architect : FORMAT D2, Dominique Deramaix

Introduction to aesthetics of the roof:

The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".

Integration of Photo-voltaic systems has the achievement:

to combine technical functions;

the improvement of the usability;

to follow the proportions of the envelope or the shape of the building;

to visual integrate this in the 'concept of the design'.

Aesthetical quality is measured by:

1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.

The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.

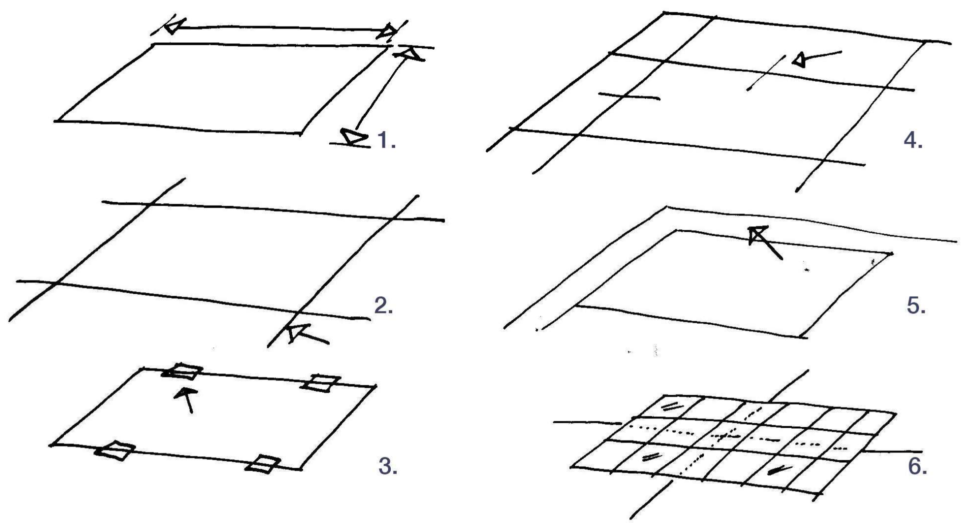
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.

2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more than the total dimensions of the facade or roof.

3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.

4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the

adjacent material should be chosen within the same range of material, dimensions and colour.
5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general a roof is a simple, homogenous surface. This can also be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.
6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Description :
The FLISOM modules are produced and will be installed by Wittenauer, Dach- und Fassadenbau.

The cell is laminated on the steel sheet. The edges of the sheet are bended to increase stiffness and possibilities to mount. At the top and bottom the bended metal is perforated to let air flow behind the module.

Dimension :
Module dimensions are 1575 x 465 mm (?)
Working dimensions are 1590 x 450 mm (?)

Materials :
Steel sheet with bended edges.

Colours :
The cell colour is close to black (RAL 9005).
The metal sheet will be painted in the same colour, black (RAL 9005).

Mounting system :
The roof structure is made of wood. This makes mounting easy as the modules can be screwed on horizontal bats. Each module has a 25 mm overlap with the next module. Modules are connected in vertical direction with a click-connection.
Mounting start with the lowest module and then goes up to the ridge.

EU Standard :
The roof modules are BIPV products according to the European Standard EN50583-2016 “Photovoltaics in buildings”.
The application is according to the mounting Category A “Sloped, roof-integrated, not accessible from within the building” (EN50583-2-2016 “Photovoltaics in buildings – Part 2: BIPV systems”.
Note: This standard does not take in consideration the aesthetical aspects of BIPV.

Procedure :

Building permit is needed for this type of roof modules. Can be difficult in sensitive or historical context.

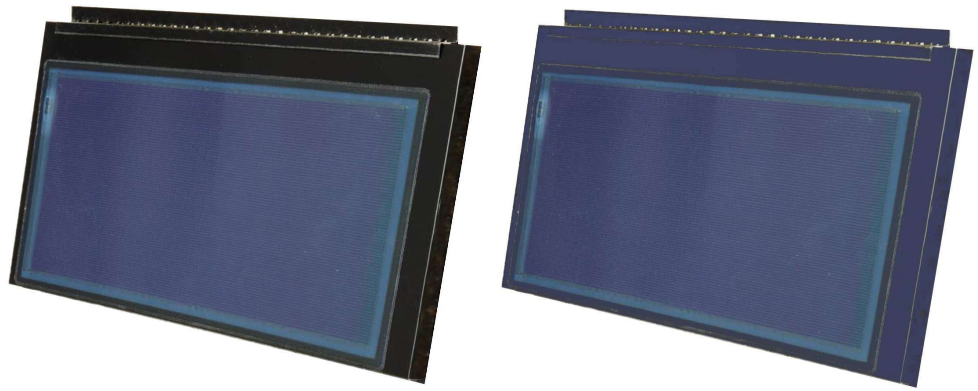
Check of BIPV quality and definition :
Good points that increase the aesthetical quality are:
- the whole roof is covered with modules
- the vertical connection between modules and the roof construction is hidden
- the horizontal connection to the roof is done with a hidden gutter/profile under the modules.

Points of attention are :
- the colour of the modules. It is preferred to give the steel sheets a colour close to the module colour. This colour should also be used for the profiles, ridge and edges.
- the chimney ask for two tailor made modules. Another solution is to make one or two strips/zones where the chimney will fit in. See the two proposals

According to the EU standard EN50583-2016 “Photovoltaics in buildings” this product is a BIPV product.

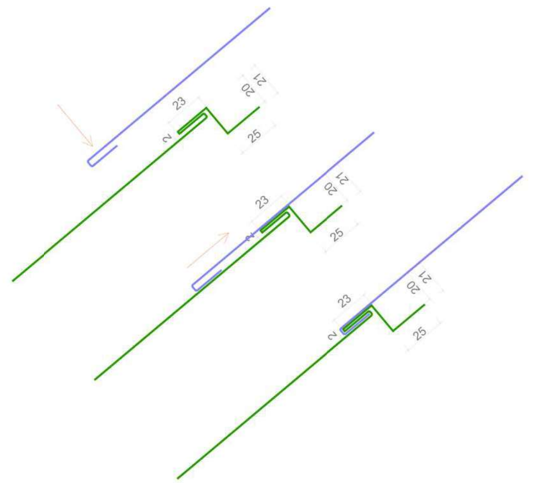
PICTURES

Prototype of the FLISOM Roof tile (picture FLISOM).

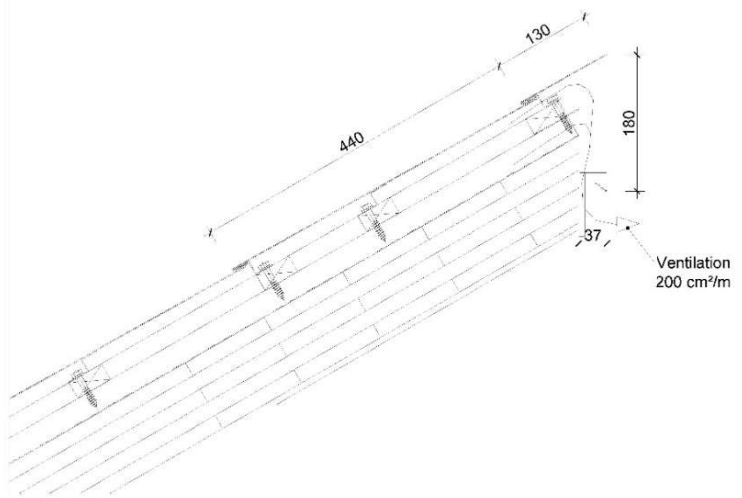


Left the prototype and right the suggested colour.

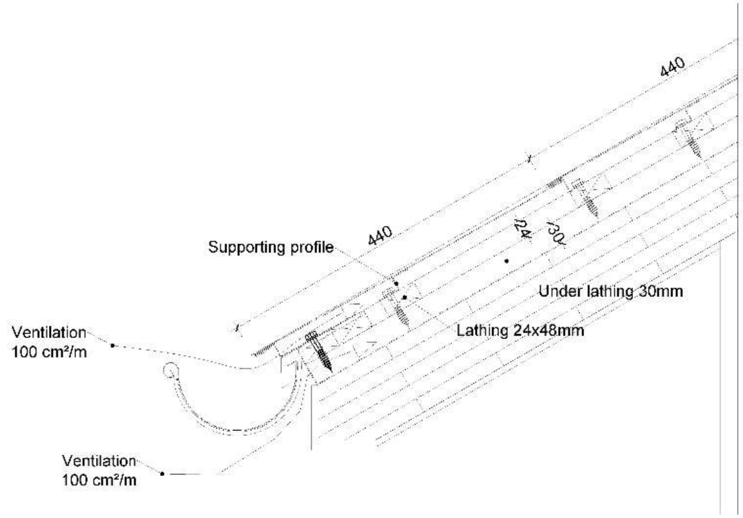
DRAWINGS



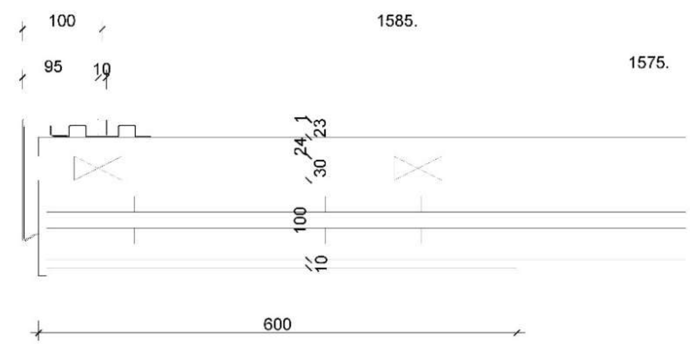
Top and bottom edge details. The bottom of the upper module connects with the top of the lower module by sliding the module up.



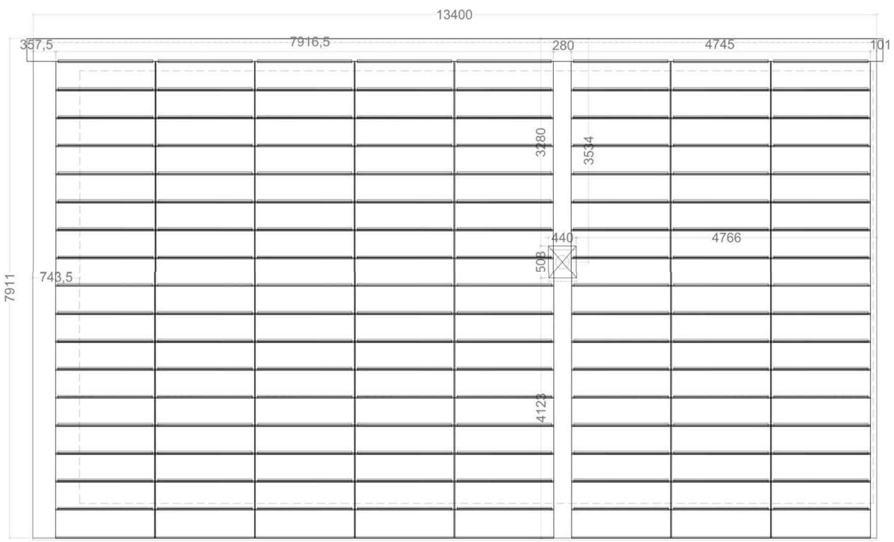
Concept drawing of roof mounting system.
(Upper roof part)



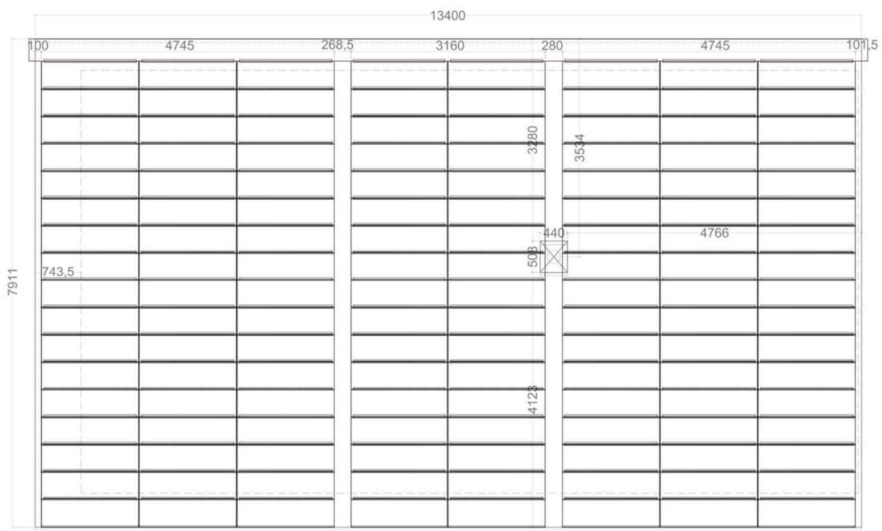
Concept drawing of roof mounting system.
(Bottom of the roof)



Concept drawing of roof mounting system.
(Edges roof part)



Proposal 1 to solve the chimney connection.



Proposal 2 to solve the chimney connection.

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 1. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[GB1] Electrical design, operation and control strategies guideline.

[GC1] Installation, commissioning and maintenance guideline.

[GD1] Health, safety and security guideline.

SPECIFICATIONS

Electrical

For elevated areas irradiation can be higher than at STC. Therefore, multiply I_{SC}- and V_{OC}- values with a factor of 1.25 for the electrical layout of cables, fuses and converters (worst case scenario). For a serial connection the voltage of a single module is multiplied by the number of modules to calculate the system voltage. Make sure that you are always within the limits of the maximum system voltage. Use an adequate device for overcurrent protection (fuse, blocking diode). Maximum Isc multiplied by a factor of 1.56 to protect a string in parallel configuration.

The maximum number of modules connectable in series is calculated by adding Voc of each single module multiplied by 1.25 up to the maximum system voltage which you can find on the label.

Back-sheet of Flisom PVSITES modules are made of metal and have to be connected to the ground. Also ground the support structure and arrange an adequate lightning protection. Do not use materials which can cause corrosion. The hole for the grounding cable can be drilled anywhere in the edges of the module frame as in fig. 1. If the back-sheet of the module and the support structure/clamps are conductive it is not necessary to ground every module. The grounding of the support structure is sufficient. Make sure that you do not damage the edge seal or front-sheet.

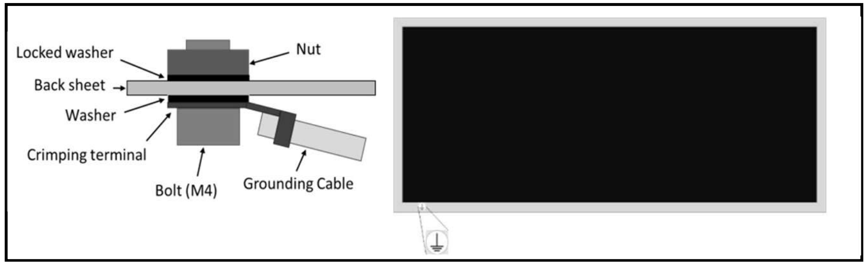


Fig. 1: Recommended grounding connection

Do not use PV modules of different power classes or configurations in the same PV system. Flisom tile modules use MC4 connectors. Only use these connectors or compatible connector types which are authorised from both producers.

Use solar cables for outside use (ø 2.5 to 4mm² and min. 90 °C).

Secure all electrical connections and use stress relief appliances. Do not go below the minimum bending radius of the cables. Use cable guides to prevent connectors and cables from lying in excess water, snow or dirt.

The junction box is not to be opened. The diode cannot be repaired.

Module Orientation and Shading

In general the modules can be mounted either in portrait or in landscape mode, depending on different limiting factors:

Casting shadow on the panels should be avoided.

- Always install the Flisom modules in a location that has good sun exposure throughout the year. Less power is generated in shaded locations.

- Plan the installation in such a way, that the Flisom modules receive the same amount of direct sunlight within the same string (taking in account their orientation and shadowing).

If direct shadow on active surface could not be avoided:

- Orientation of the shadow on the active surface is crucial: the panel may only be installed as in fig 2 (Parallel shade). To compare, fig 3 shows a series shade - shading the complete length of several full cells. This type of casting shadow will negatively affect the power generation of the module and can cause degradation by overheating.

Fig 2: parallel shade

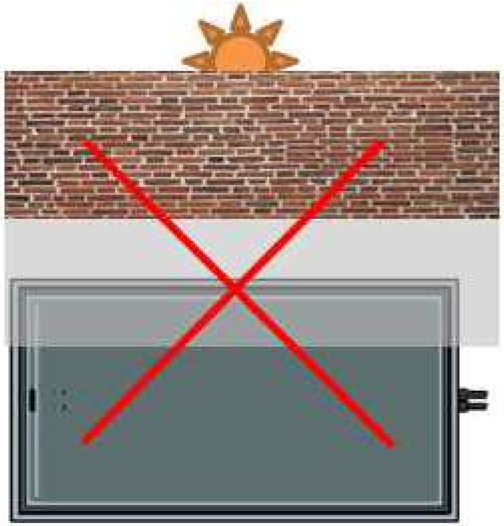


Fig 3: series shade

Negative impact on the system performance from full or partial shading from rooftop equipment, structural elements of a building and nearby trees, poles power lines or nearby buildings should be avoided. A professional shading analysis prior to installation is recommended by Flisom.

Inverter General

Inverters convert direct current into alternating current. Inverters of the latest generation, with MPPT (Maximum Power Point Tracker), optimize the production, even in situations of weather changes or variable sunlight.

Suitable inverter configurations are:

- Central inverters
- String inverters
- Multi-String inverters
- Inverters on single module level

Parameters Inverter Demo 1

For Demo 1 a three-phase DC-coupled PV storage inverter will be used. The inverter is developed by Technalia and CEA.

ELECTRICAL CHARACTERISTICS	
AC active power	10 kW
Grid voltage, frequency and phases	400 V ±10 %, 50 Hz ±5 %, 3~
Power factor	> 0.99 at rated power
Grid current distortion (THD)	< 3 % at rated power
Battery voltage range	250-750 V
Maximum Battery DC current	20A
PV MPPT voltage range	200-800V
Maximum PV MPPT DC current	20A
PV-to-Grid Peak Conversion Efficiency	> 96 % at rated power
Battery-to-Grid Peak Conversion Efficiency	> 96 % at rated power
PV-to-Grid Overall Efficiency (EN 50530)	>95%

CONTROL	
DC control strategies	Advanced MPPT techniques (GMPPT, MPRT)
	Battery DC current/voltage regulation
Grid-connected Operation	Active and Reactive AC power regulation
Off-Grid Operation	Drop control (P-f and Q-V with virtual impedance)
PROTECTIONS	
General protections	Reverse polarity
	AC and DC short-circuits
	AC and DC over/sub-voltage
	Over/Sub-frequency
	Array residual current detector
Grid-connected operation protections	LVRT capability
	Islanding detection based on frequency shift method
BEMS INTERFACE	
Communication protocol	ModBus RTU
Output monitoring data	Output active and reactive AC power
	Status (operation mode/alarms)
	Input BIPV power
	Input/Output battery power
	State of Charge of the battery
Input commands	Active and reactive AC power
	Battery Charging/Discharging power
	Operation mode

POWER MANAGEMENT STRATEGY

In the block diagram in Figure 4 the black lines represent energy flows, red lines are power supply lines and dotted lines are monitoring and control signals.

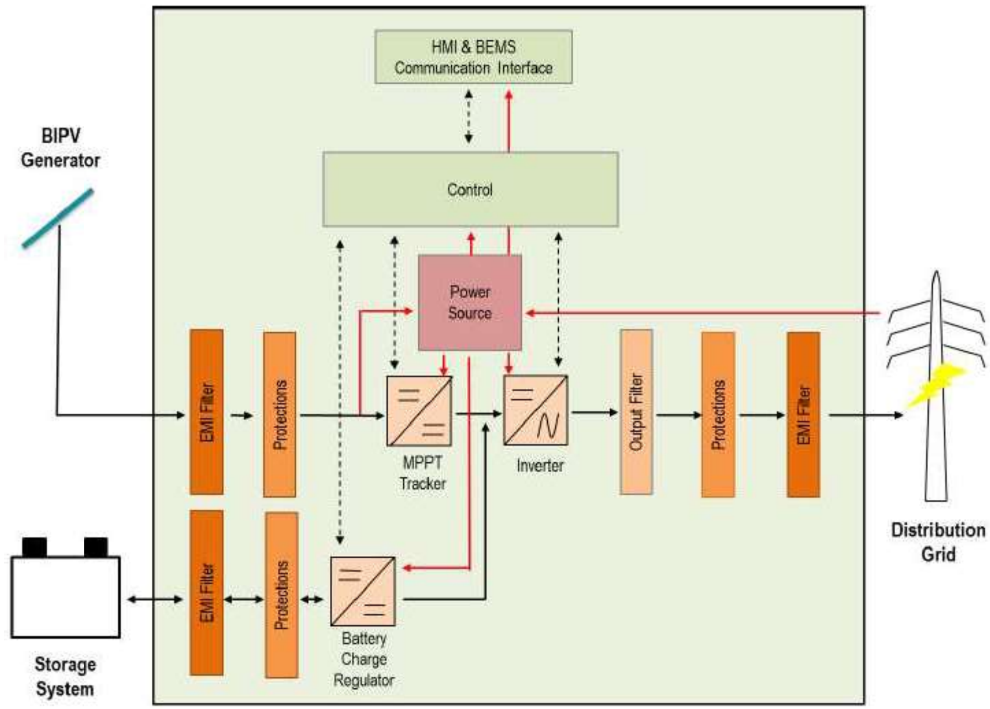


Fig. 4: Block diagram of DC-coupled storage inverter

The EMS strategy will be showed in the figure below.

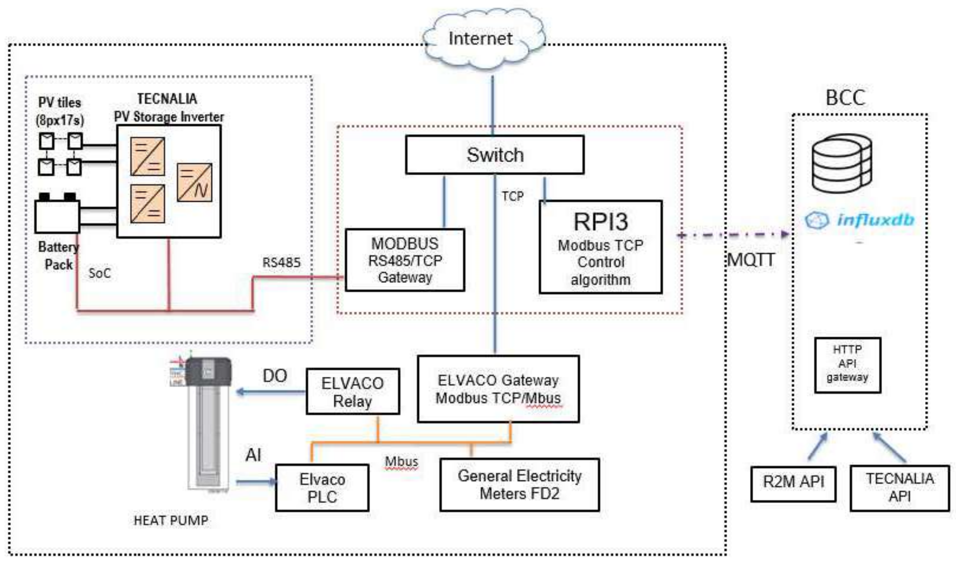


Fig. 4: Energy Management System (EMS)

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 1. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS1] Module data-sheet

[GA1] Architectural integration guideline

[GC1] Installation, commissioning and maintenance guideline

[GD1] Health, safety and security guideline

SPECIFICATIONS

Environment

Flisom modules can be operated in the range of -40°C to 85°C. Depending on the area it is necessary to protect the modules from standing water, snow or extreme soiling. At consistent solar radiation Flisom PV modules generate more power at lower temperatures. To improve the energy yield of the plant increasing cooling or ventilation is an option.

Handling

Flisom PVSITES modules use thin metal sheets as back-sheet. Hence they can bend by applying forces while installation (e.g. dropping on the corner). Please handle with care. Modules must be stored modules in a dry place. Do not transport modules without packaging. Do not put modules on top of each other to avoid small scratches (this can accelerate module degradation by environmental factors). Do not use JB cables as handles to carry or lift the modules. Be cautious when front-sheet is wet since the surface could lose grip. Do not apply solvents, adhesives, paint or stickers on the front-sheet. Do not place the modules face-down in direct contact to abrasive surfaces.

Mechanical

Keep a minimum distance of 5mm between the edges of single modules to take thermal expansion into account. Only use compatible materials.

Installation

1. All old tiles have to be removed.
2. Place the roof battens according to the drawing of the tile manufacturer.
3. Install the tiles and connect the cables according to the string plan.

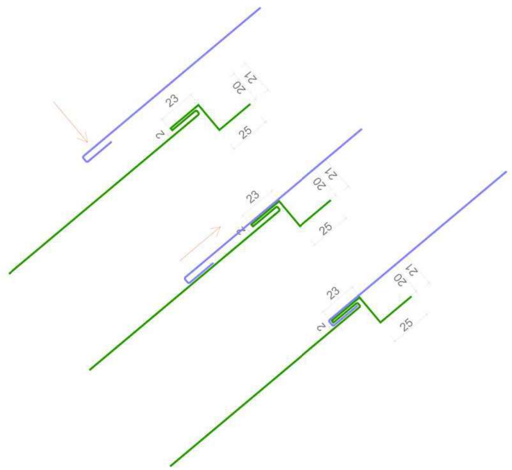
   (See drawings for more details).

Inspection and Maintenance

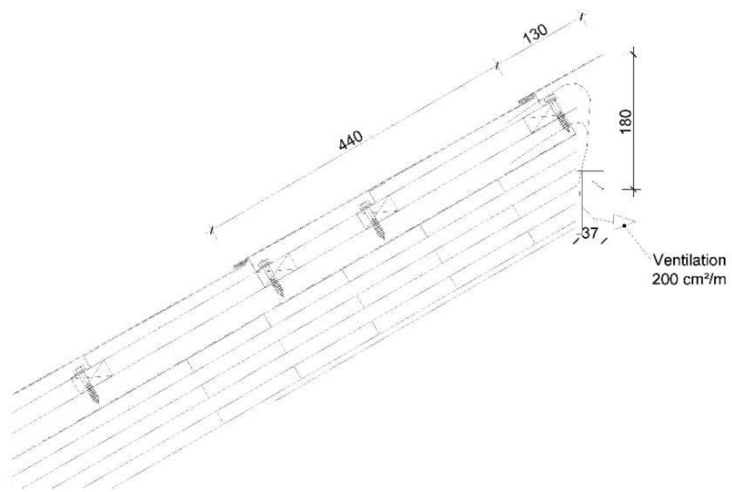
It is recommended to have a visual check on a regular basis (quarterly). Plan check-ups according to the given environmental and safety conditions and regulations.

- Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface.
- Do not use aggressive cleaning agents or scrubbing materials for cleaning
- Do not use steam blasting for cleaning.
- Use soft water to avoid chalk stains
- Soft Sponges can be used
- Check if connectors and grounding are tight and without corrosion and if the insulation is not damaged also check for loose mechanical or electrical contacts.
- Check if the Junction Box is securely attached and that no deep scratches are penetrating the front sheet

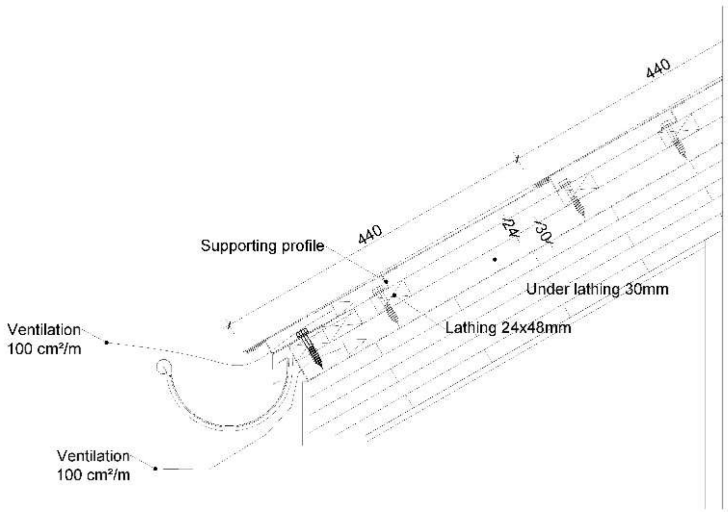
DRAWINGS



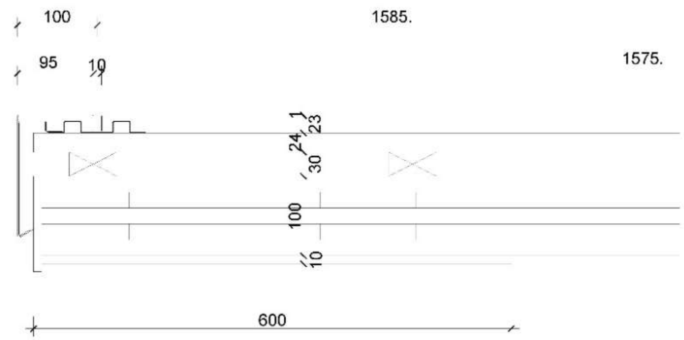
Top and bottom edge details. The bottom of the upper module connects with the top of the lower module by sliding the module up.



Concept drawing of roof mounting system.
(Upper roof part)



Concept drawing of roof mounting system.
(Bottom of the roof)



Concept drawing of roof mounting system.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 1. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS1] Module data-sheet

[GA1] Architectural integration guideline

[GB1] Electrical design, operation and control strategies guideline

[GD1] Health, safety and security guideline

SPECIFICATIONS

Danger

Electrical shock

The generated current of a module under illumination is dangerous. Modules should be connected only if the system is covered and thus potential and current free. Do not modify the module, the junction box or the connectors. Make sure that you work with dry tools and under dry working conditions. Current has a linear behaviour with incoming radiation and can exceed the mentioned current if the illumination is higher than under Standard Test conditions (STC). Fix issues in the grounding immediately.

Working on live parts

When working on wiring use safety equipment (insulating gloves, shoes, etc) and appropriate tools (insulating tools, etc). Make sure that you have grounded the modules and the mounting construction. Do not use damaged or broken modules. Repair or replace damaged modules or cables immediately. Do not dismantle modules or the junction box.

High Voltage

In a PV system the voltage is multiplied by the number of modules in series up to the stated system voltage. Do not allow the system to exceed the stated system voltage.

Be aware that almost the same voltage stated on the label is present under low light conditions.

Arcing

PV modules generate direct current when exposed to light. When disconnected a dangerous arc between the wires may be generated which will not extinguish on its own. Do not disconnect under load.

Fire Protection

Do not use PV modules in explosive atmospheres. Check the local regulations for fire protection

Warning

Do not use aggressive solvents or scrubbing materials for cleaning the modules. Do not use sharps objects. Do not walk on the panels if there is any risk that sharp stones under the soles, or sharp shoe elements would damage the panel.

The safety instructions for other system components apply. Local standards, building norms and accident prevention regulations must be followed. Disregarding the warnings can cause serious injuries or even death.

Keep a minimum distance of 5m1 to a burning PV system. Inform the public authorities about the PV installation.

Attention

Do not concentrate light on the modules. Modules and insulations can be destroyed by concentrated light.

[1] *Source: www.arbeit-und-gesundheit.de/2/2349*

Do not remove the label or use modules without labels attached by the manufacturer.

Reverse currents may damage modules. To avoid reverse currents, maintain an equivalent voltage in each parallel connected string of the circuit.

Storage and Transportation

Do not stand or step on the modules or their packaging. Do not accept modules delivered in damaged packaging. Do not put pressure on the modules. Do not bend the modules to a radius of less than 50cm.

Installation

Before installing modules, contact the appropriate authorities to obtain any required building permits and to determine installation and inspection requirements that apply to the installation. Make sure that unauthorised people have no access to the construction place. Do not install when it is raining, snowing, windy or the ground is slippery. Flisom recommends to use personal protective equipment such as safety gloves and safety boots etc. Respect general safety rules.

Disposal

Flisom modules must be disposed of in a responsible manner. Please contact your local supplier or disposal company for further information. For health and safety reasons, Flisom modules should not be disposed of with household garbage, and must be dealt with in accordance with local codes and regulations.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 1. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS1] Module data-sheet

[GA1] Architectural integration guideline

[GB1] Electrical design, operation and control strategies guideline

[GC1] Installation, commissioning and maintenance guideline

PVsites

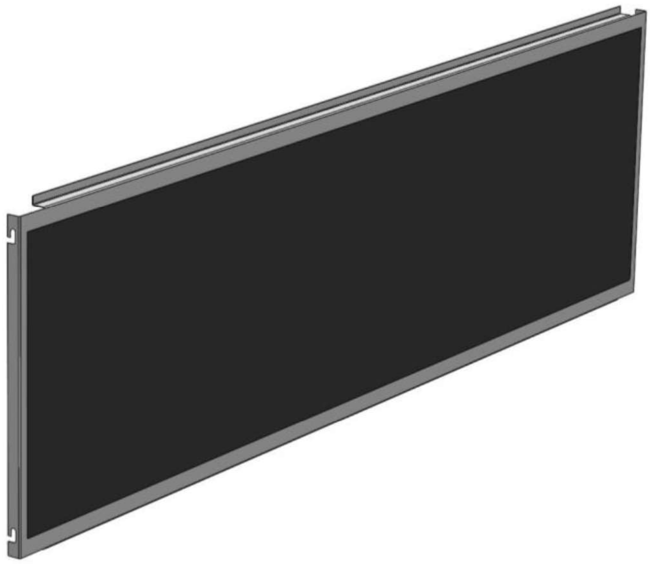
D8.3 Design pack for every demo site

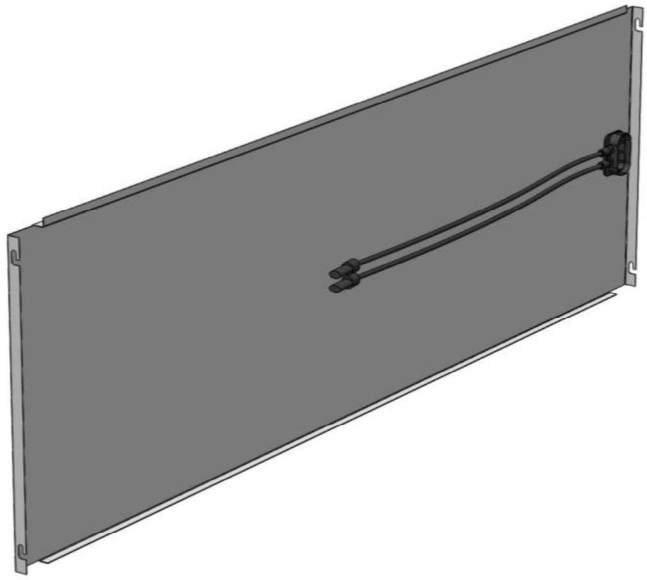
ANNEX 2. DEMO 2 BIPV MODULES DATA-SHEETS AND GUIDELINES

- **MDS2: Demo 2 BIPV Module data-sheet**
- **GA2: Demo 2 Architectural Integration Guideline**
- **GB2: Demo 2 Electrical Design, Operation & Control Strategies Guideline**
- **GC2: Demo 2 Installation, Commissioning and Maintenance Guideline**
- **GD2: Demo 2 Health, Safety and Security Guideline**

PVsites module – for EHG facade

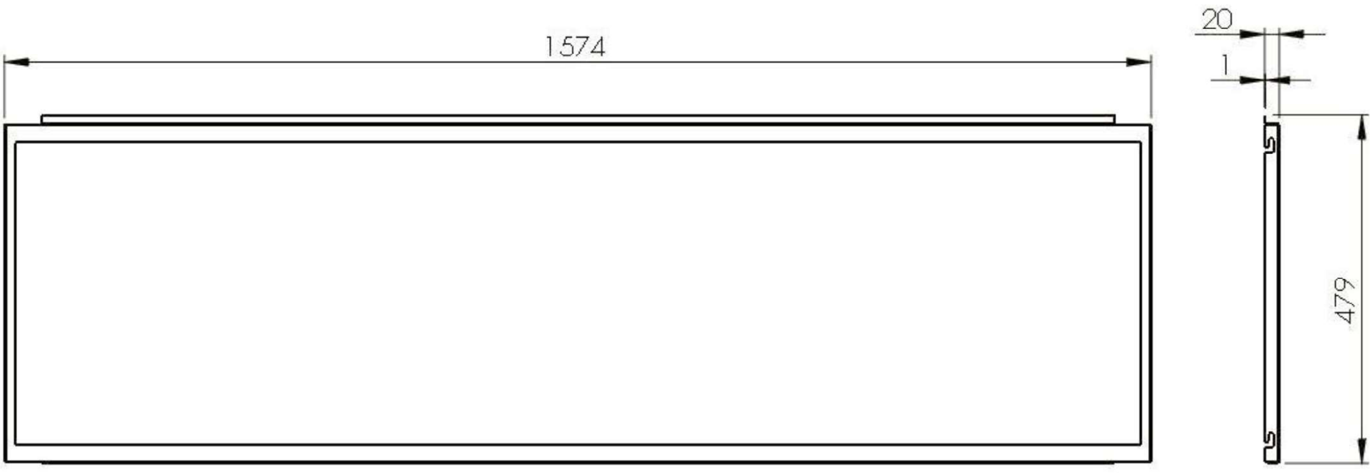
SWISS MADE





Description

The EHG module is a semi-flexible and lightweight solar panel designed for BIPV installations on facades.



Flisom AG, Gewerbestr 16, CH-8155 Niederhasli Phone +41 (0) 44 824 3000 Fax +41 (0) 44 824 3001 info@flisom.ch www.flisom.com

Dimensions

Length		[mm]	1574
Width		[mm]	479
Thickness at module		[mm]	22.2
Thickness at J-Box		[mm]	21 ± 1
Weight		[Kg]	2.5

Electrical characteristics at STC[1]

Model number			SF 50	SF 55	SF 60
Nominal power	Pmpp	[W]	50	55	60
Tolerance		[W]	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	34	35	36
Current at nom. power	Impp	[A]	1.47	1.54	1.66
Open circuit voltage	Voc	[V]	46	47	48
Short circuit current	Isc	[A]	1.72	1.82	1.91
Max. system voltage	IEC	[V]		1000	
Max. serial fuse rating		[A]		10	

Thermal characteristics

Temperature coefficient	Voc	[%/°C]	-0.3
Temperature coefficient	Isc	[%/°C]	0.01
Temperature coefficient	Pmpp	[%/°C]	-0.35

Operating conditions

Temperature range	[°C]	-40 to +85
Max. mechanical load		2400 Pa, 245 kg/m2

Additional data

Cell type	Flexible CIGS
Material Backsheet	Aluminium
Junction box	Back side

Warranty

EHG modules are specially designed for PVsites Testinstallation. Therefore they have no warranty.

Notes
[1] STC: 1000 W/m2, AM1.5G, 25°C, stabilized module state

We continuously develop our products. Electrical and physical properties subject to change without prior notice.

Version	Date	Comments	Author
00.00	**2017-09-29**	**Initial**	**Schweizer, M.**

Flisom AG, Gewerbestr 16, CH-8155 Niederhasli Phone +41 (0) 44 824 3000 Fax +41 (0) 44 824 3001 info@flisom.ch www.flisom.com

SPECIFICATIONS

Project : Demo 2 – BIPV Facade

Location : Switzerland, Geneva

Owner : EHG (contact Julian Perrenoud)

Introduction to aesthetics of the facade:
The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".
Integration of Photo-voltaic systems has the achievement:

- to combine technical functions;
- the improvement of the usability;
- to follow the proportions of the envelope or the building shape;
- to visual integrate this in the 'concept of the design'.

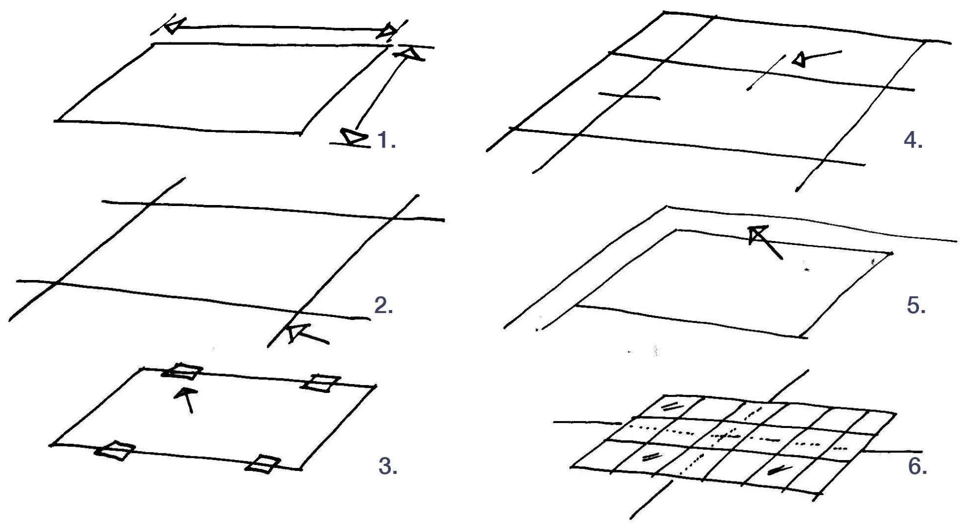
Aesthetical quality is measured by:

1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.
The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.
2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more then the total dimensions of the facade or roof.
3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.
4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the adjacent material should be chosen within the same range of material, dimensions and colour.

5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general a roof is a simple, homogenous surface. This can also be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.

6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Description :
The modules will be produced by FLISOM.
The technology is CIGS on aluminium facade element

Dimension :
Module dimensions are 1574x 479 mm.

Working dimensions are 1600 x 500 mm.

Materials :
Aluminium facade element.
Colours :
The cell colour and back sheet is black.

Mounting system :
The facade cladding is done with the facade technology from Schweitzer Metalbau. The system is based on vertical profiles with pins that can hold the horizontal cladding.

EU Standard :
The modules are BIPV products according to the European Standard EN50583-2016 “Photovoltaics in buildings”.
The application is according to the mounting Category C “Non-sloped (vertically) mounted not accessible from within the building” (EN50583-2-2016 “Photovoltaics in buildings – Part 2: BIPV systems”.
Note: This standard does not take in consideration the aesthetical aspects of BIPV.

Procedure :
Building permit is needed for this type of facade modules. Can be difficult in sensitive or historical context.

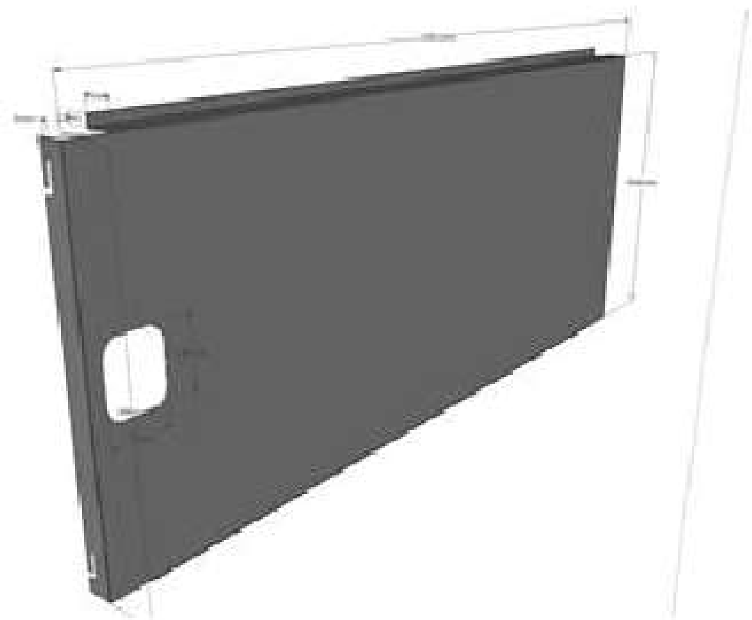
Check of BIPV quality and definition :
Good points that increase the aesthetical quality are:
- the whole facade use the same cladding system (material and mounting system);
- the adjacent areas are also covered with black tailor made panels;
- the connection between modules/cladding is hidden.

Points of attention are :

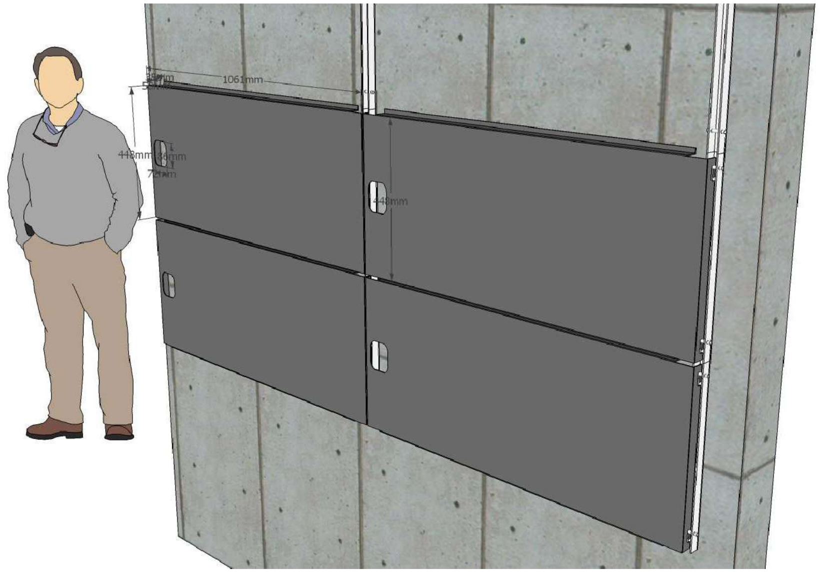
- the connection with windows and at ground level, will the red bricks be visible?.

According to the EU standard EN50583-2016 "Photovoltaics in buildings" this product is a BIPV product.

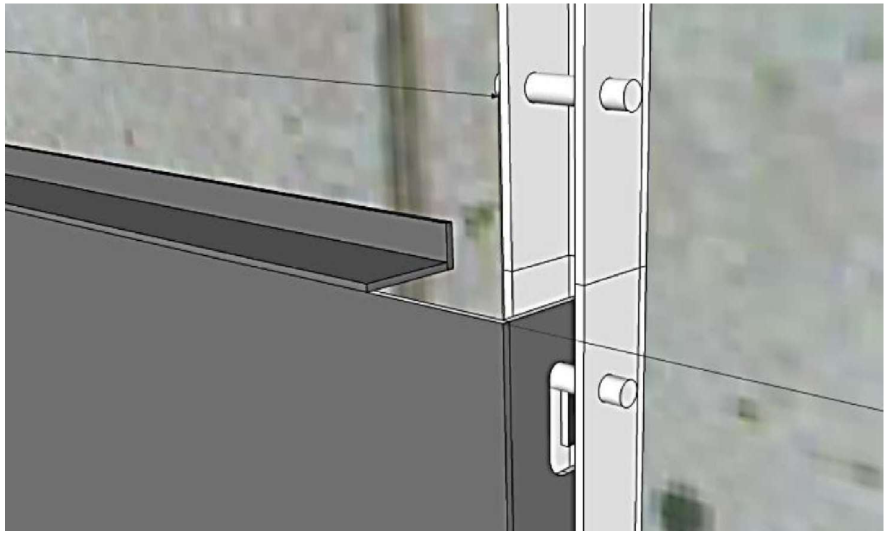
PICTURES



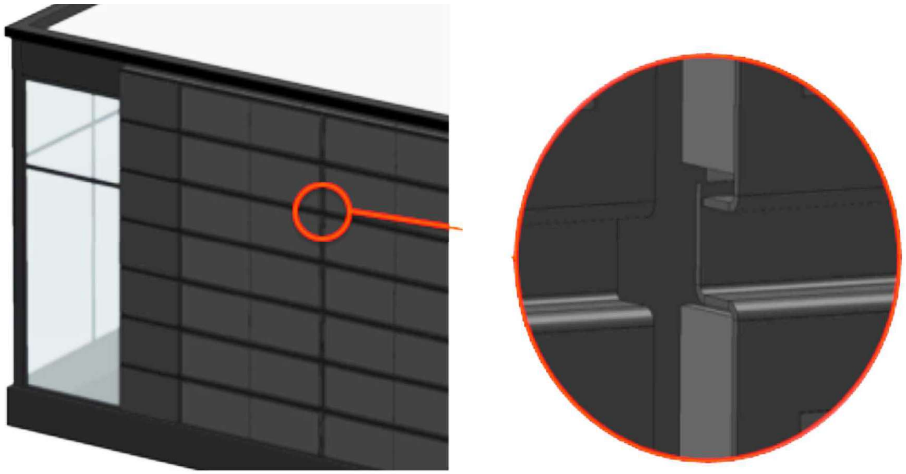
Basic module.



Mounting system proposed by Schweitzer



Application of profiles on the facade



Picture of the installed system (rendering).

Picture of the west pavilion with east facing facade.

Picture of the east pavilion with west facing facade.

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 2. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[GB2] Electrical design, operation and control strategies guideline

[GC2] Installation, commissioning and maintenance guideline

[GD2] Health, safety and security guideline

SPECIFICATIONS

Electrical

For elevated areas irradiation can be higher than at STC. Therefore, multiply I_{SC}- and V_{OC}- values with a factor of 1.25 for the electrical layout of cables, fuses and converters (worst case scenario). For a serial connection the voltage of a single module is multiplied by the number of modules to calculate the system voltage. Make sure that you are always within the limits of the maximum system voltage. Use an adequate device for overcurrent protection (fuse, blocking diode). Maximum Isc multiplied by a factor of 1.56 to protect a string in parallel configuration.

The maximum number of modules connectable in series is calculated by adding Voc of each single module multiplied by 1.25 up to the maximum system voltage which you can find on the label.

Backsheet of Flisom PVsites modules are made of metal and have to be connected to the ground. Also ground the support structure and arrange an adequate lightning protection. Do not use materials which can cause corrosion. The hole for the grounding cable can be drilled anywhere in the edges of the module frame as in fig. 1. If the backsheet of the module and the support structure/clamps are conductive it is not necessary to ground every module. The grounding of the support structure is sufficient. Make sure that you do not damage the edge seal or frontsheet.

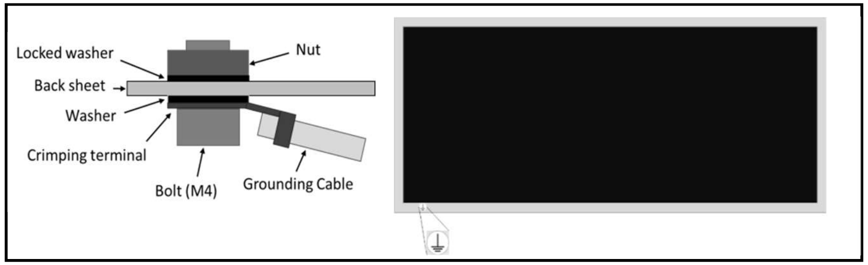


Fig. 1: Recommended grounding connection

Do not use PV modules of different power classes or configurations in the same PV system. Flisom facade modules use MC4 connectors. Only use these connectors or compatible connector types which are authorised from both producers.

Use solar cables for outside use (ø 2.5 to 4mm² and min. 90 °C).

Secure all electrical connections and use stress relief appliances. Do not go below the minimum bending radius of the cables. Use cable guides to prevent connectors and cables from lying in excess water, snow or dirt.

The junction box is not to be opened. The diode cannot be repaired.

Module Orientation and Shading

In general the modules can be mounted either in portrait or in landscape mode, depending on different limiting factors:

Casting shadow on the panels should be avoided.

- Always install the Flisom modules in a location that has good sun exposure throughout the year. Less power is generated in shaded locations.

- Plan the installation in such a way, that the Flisom modules receive the same amount of direct sunlight within the same string (taking in account their orientation and shadowing).

If direct shadow on active surface could not be avoided:

- Orientation of the shadow on the active surface is crucial: the panel may only be installed as in fig 2 (Parallel shade). To compare, fig 3 shows a series shade - shading the complete length of several full cells. This type of casting shadow will negatively affect the power generation of the module and can cause degradation by overheating.

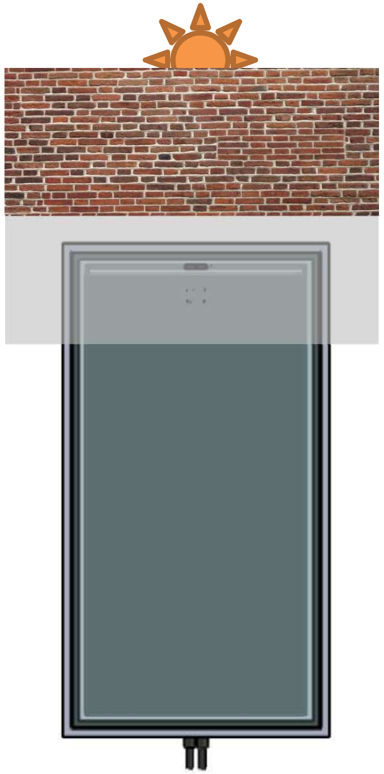


Fig 2: parallel shade

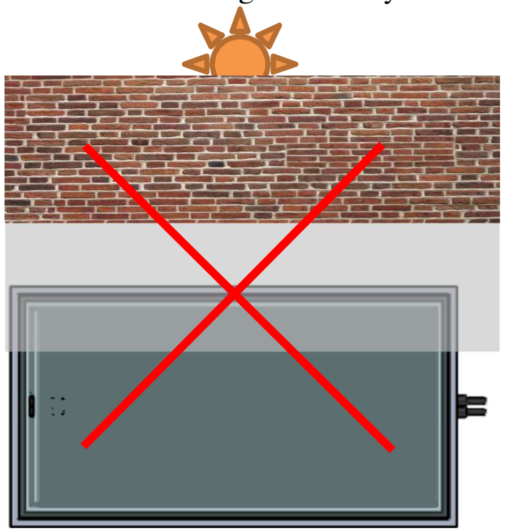


Fig 3: series shade

Negative impact on the system performance from full or partial shading from rooftop equipment, structural elements of a building and nearby trees, poles power lines or nearby buildings should be avoided. A professional shading analysis prior to installation is recommended by Flisom.

POWER MANAGEMENT STRATEGY

Inverter General

Inverters convert direct current into alternating current. Inverters of the latest generation, with MPPT (Maximum Power Point Tracker), optimize the production, even in situations of weather changes or variable sunlight.

Suitable inverter configurations are:

- Central inverters
- String inverters
- Multi-String inverters
- Inverters on single module level

Parameters Inverters Demo 2

Inverter Pavilion 1 (west):

Type:	ABB UNO-2.5-I-OUTD-S
Stringconcept:	7 strings of 6 modules in series

Inverter Pavilion 2 (east):

Type:	ABB TRO-5.8_TL_OUTD-S-400
Stringconcept:	6 strings of 18 modules in series

Energy management

The power generated will be entirely injected to the grid; so that, an EMS will not be needed.

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 2. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS2] Module data-sheet

[GA2] Architectural integration guideline

[GC2] Installation, commissioning and maintenance guideline

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SPECIFICATIONS

Environment

Flisom modules can be operated in the range of -40°C to 85°C. Depending on the area it is necessary to protect the modules from standing water, snow or extreme soiling. At consistent solar radiation Flisom PV modules generate more power at lower temperatures. To improve the energy yield of the plant increasing cooling or ventilation is an option.

Handling

Flisom PVsite modules use thin metal sheets as backsheet. Hence they can bend by applying forces while installation (e.g. dropping on the corner). Please handle with care. Store modules in a dry place. Do not transport modules without packaging. Do not put modules on top of each other to avoid small scratches (this can accelerate module degradation by environmental factors). Do not use JB cables as handles to carry or lift the modules. Be cautious when frontsheet is wet since the surface could lose grip. Do not apply solvents, adhesives, paint or stickers on the frontsheet. Do not place the modules face-down in direct contact to abrasive surfaces.

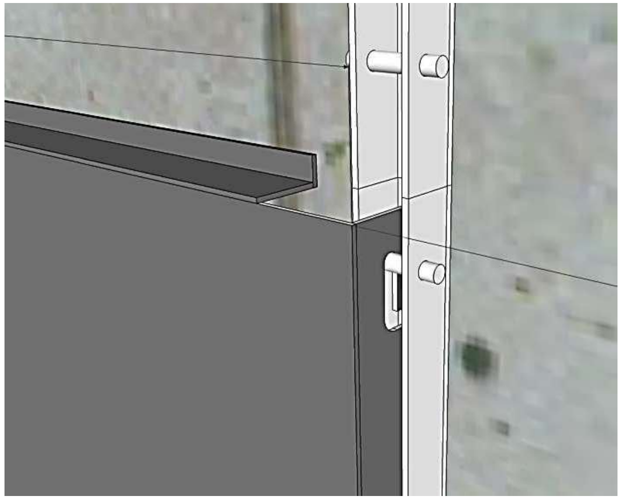
Mechanical

Keep a minimum distance of 5mm between the edges of single modules to take thermal expansion into account. Only use compatible materials.

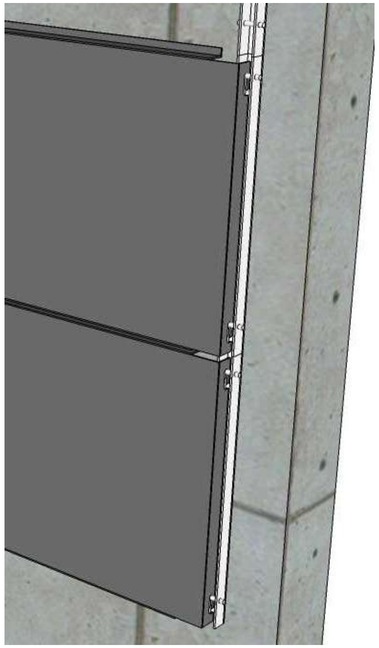
Installation

1. Mount the vertical rails and check that all are parallel.

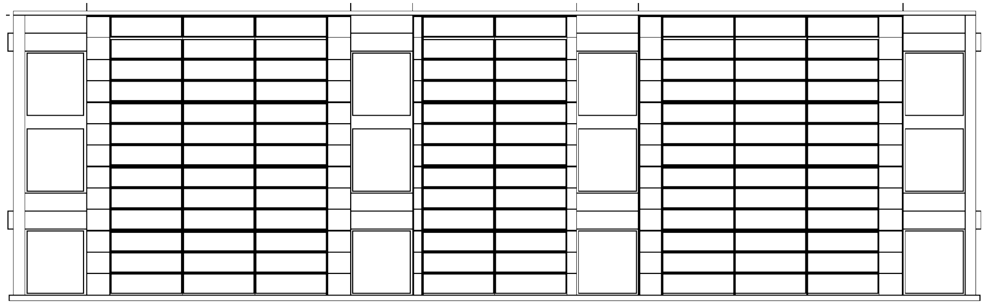
2. Hang in the first module at the bottom of the row.



3. Hang in the second module and connect the cables according to the string plan.

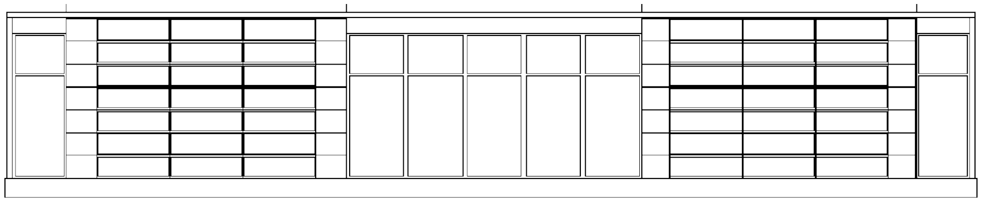


Pavilion 2



4. Install all modules and the side covers

Pavilion 1



Inspection and Maintenance

It is recommended to have a visual check on a regular basis (quarterly). Plan check-ups according to the given environmental and safety conditions and regulations.

- Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface.
- Do not use aggressive cleaning agents or scrubbing materials for cleaning
- Do not use steam blasting for cleaning.
- Use soft water to avoid chalk stains
- Soft Sponges can be used
- Check if connectors and grounding are tight and without corrosion and if the insulation is not damaged also check for loose mechanical or electrical contacts.
- Check if the Junction Box is securely attached and that no deep scratches are penetrating the frontsheet

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 2. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS2] Module data-sheet

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[GB2] Electrical design, operation and control strategies guideline

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SPECIFICATIONS

Danger

Electrical shock

The generated current of a module under illumination is dangerous. Modules should be connected only if the system is covered and thus potential and current free. Do not modify the module, the junction box or the connectors. Make sure that you work with dry tools and under dry working conditions. Current has a linear behaviour with incoming radiation and can exceed the mentioned current if the illumination is higher than under Standard Test conditions (STC). Fix issues in the grounding immediately.

Working on live parts

When working on wiring use safety equipment (insulating gloves, shoes, etc) and appropriate tools (insulating tools, etc). Make sure that you have grounded the modules and the mounting construction. Do not use damaged or broken modules. Repair or replace damaged modules or cables immediately. Do not dismantle modules or the junction box.

High Voltage

In a PV system the voltage is multiplied by the number of modules in series up to the stated system voltage. Do not allow the system to exceed the stated system voltage.

Be aware that almost the same voltage stated on the label is present under low light conditions.

Arcing

PV modules generate direct current when exposed to light. When disconnected a dangerous arc between the wires may be generated which will not extinguish on its own. Do not disconnect under load.

Fire Protection

Do not use PV modules in explosive atmospheres. Check the local regulations for fire protection

Warning

Do not use aggressive solvents or scrubbing materials for cleaning the modules. Do not use sharps objects. Do not walk on the panels if there is any risk that sharp stones under the soles, or sharp shoe elements would damage the panel.

The safety instructions for other system components apply. Local standards, building norms and accident prevention regulations must be followed. Disregarding the warnings can cause serious injuries or even death.

Keep a minimum distance of 5m[1] to a burning PV system. Inform the public authorities about the PV installation.

Attention

Do not concentrate light on the modules. Modules and insulations can be destroyed by concentrated light.

[1] *Source: www.arbeit-und-gesundheit.de/2/2349*

Do not remove the label or use modules without labels attached by the manufacturer.

Reverse currents may damage modules. To avoid reverse currents, maintain an equivalent voltage in each parallel connected string of the circuit.

Storage and Transportation

Do not stand or step on the modules or their packaging. Do not accept modules delivered in damaged packaging. Do not put pressure on the modules. Do not bend the modules to a radius of less than 50cm.

Installation

Before installing modules, contact the appropriate authorities to obtain any required building permits and to determine installation and inspection requirements that apply to the installation. Make sure that unauthorised people have no access to the construction place. Do not install when it is raining, snowing, windy or the ground is slippery. Flisom recommends to use personal protective equipment such as safety gloves and safety boots etc. Respect general safety rules.

Disposal

Flisom modules must be disposed of in a responsible manner. Please contact your local supplier or disposal company for further information. For health and safety reasons, Flisom modules should not be disposed of with household garbage, and must be dealt with in accordance with local codes and regulations.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 2. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS2] Module data-sheet

[GA2] Architectural integration guideline

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[GC2] Installation, commissioning and maintenance guideline

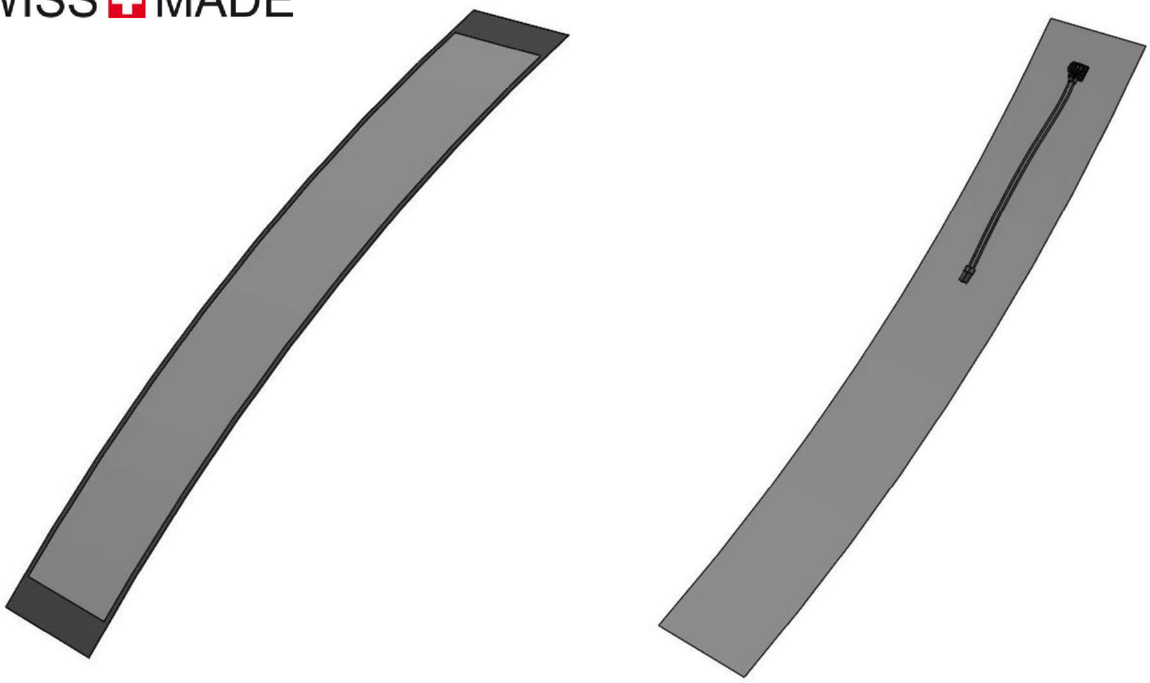
D8.3 Design pack for every demo site

ANNEX 3. DEMO 3 BIPV MODULES DATA-SHEETS AND GUIDELINES

- **MDS3: Demo 3 BIPV Module data-sheet**
- **GA3: Demo 3 Architectural Integration Guideline**
- **GB3: Demo 3 Electrical Design, Operation & Control Strategies Guideline**
- **GC3: Demo 3 Installation, Commissioning and Maintenance Guideline**
- **GD3: Demo 3 Health, Safety and Security Guideline**

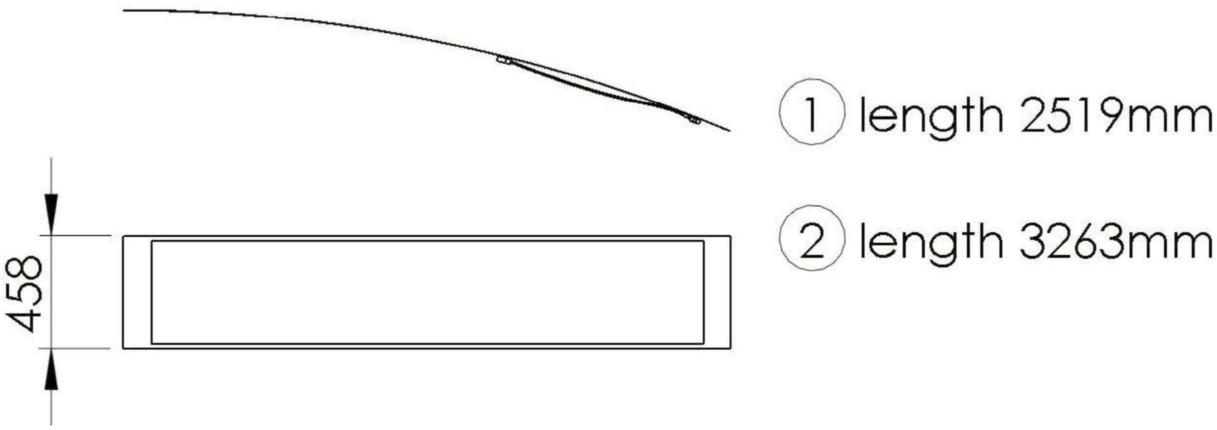
PVsites module – for Carport

SWISS MADE



Description

The carport module is a semi-flexible and lightweight solar panel designed for a carport installation.



Flisom AG, Gewerbestr 16, CH-8155 Niederhasli Phone +41 (0) 44 824 3000 Fax +41 (0) 44 824 3001 info@flisom.ch www.flisom.com

Dimensions

		1	2
Typ		1	2
Length	[mm]	2519	3263
Width	[mm]	458	
Thickness at module	[mm]	2	
Thickness at J-Box	[mm]	21 ± 1	
Weight	[Kg]	6.7	8.8

Typ 1 Electrical characteristics at STC[1]

Model number			SF 80	SF 85	SF 90
Nominal power	Pmpp	[W]	80	85	90
Tolerance		[W]	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	36	37	38
Current at nom. power	Impp	[A]	2.22	2.29	2.37
Open circuit voltage	Voc	[V]	48	49	50
Short circuit current	Isc	[A]	2.47	2.53	2.62
Max. system voltage	IEC	[V]		1000	
Max. serial fuse rating		[A]		10	

Typ 2 Electrical characteristics at STC[1]

Model number			SF 100	SF 105	SF 110	SF 115	SF 120
Nominal power	Pmpp	[W]	100	105	110	115	120
Tolerance		[W]	-0/+5	-0/+5	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	34	35	36	37	38
Current at nom. power	Impp	[A]	2.94	3.00	3.06	3.11	3.16
Open circuit voltage	Voc	[V]	46	47	48	49	50
Short circuit current	Isc	[A]	3.20	3.25	3.30	3.35	3.40
Max. system voltage	IEC	[V]			1000		
Max. serial fuse rating		[A]			10		

Thermal characteristics

Temperature coefficient	Voc	[%/°C]	-0.3
Temperature coefficient	Isc	[%/°C]	0.01
Temperature coefficient	Pmpp	[%/°C]	-0.35

Operating conditions

Temperature range	[°C]	-40 to +85
Max. mechanical load		2400 Pa, 245 kg/m2

Additional data

Cell type	Flexible CIGS
Material Backsheet	Painted steel, RAL 9005
Junction box	Back side

Warranty

Carport modules are specially designed for PVsites Testinstallation. Therefore they have no warranty.

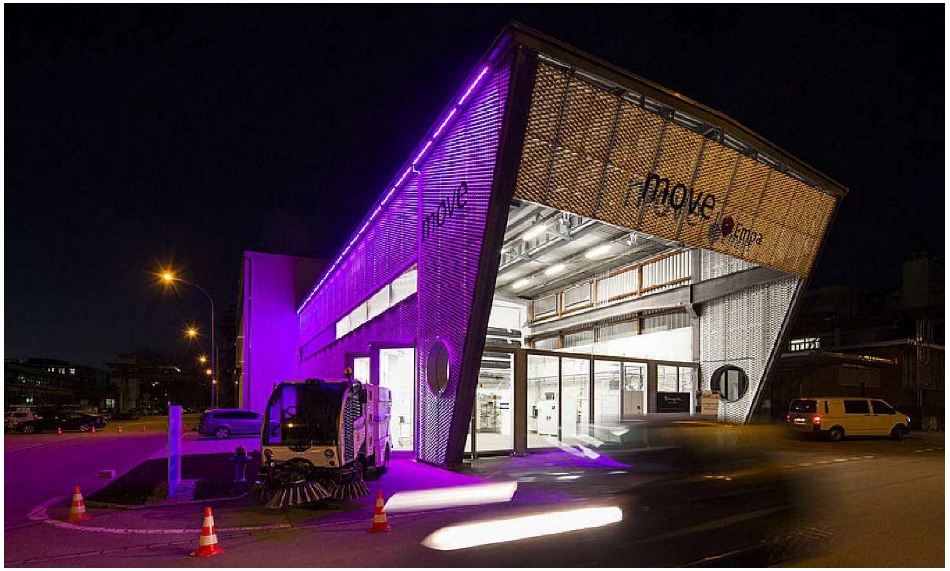
Notes

[1] STC: 1000 W/m2, AM1.5G, 25°C, stabilized module state

We continuously develop our products. Electrical and physical properties subject to change without prior notice.

Version	Date	Comments	Author
00.00	**2017-09-29**	**Initial**	**Schweizer, M.**

SPECIFICATIONS



Project : Demo 3 – BIPV Roof Modules

Location : Switzerland, Zürich (Dübendorf)

Owner : EMPA (contact Julian Perrenoud)

Introduction to aesthetics of the roof:
The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".
Integration of Photo-voltaic systems has the achievement:

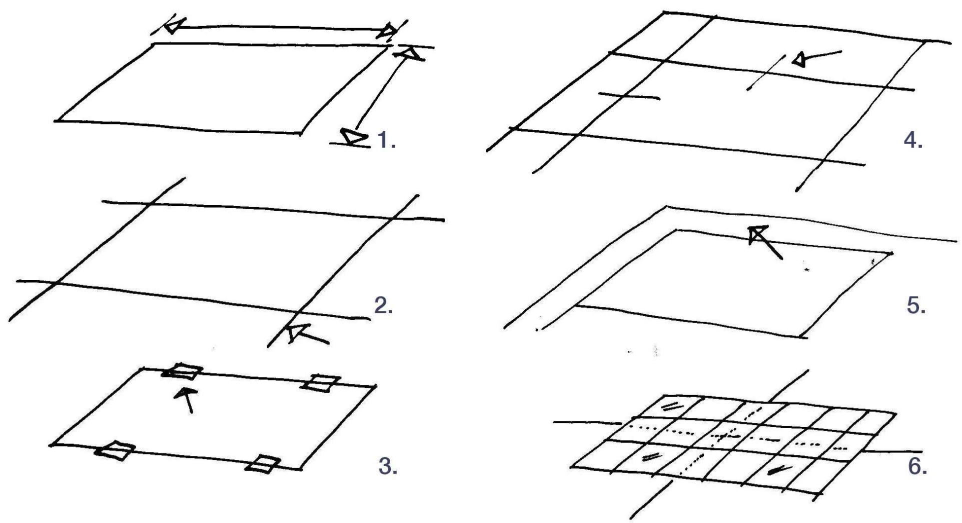
- to combine technical functions;
- the improvement of the usability;
- to follow the proportions of the envelope or the shape of the building;
- to visual integrate this in the 'concept of the design'.

Aesthetical quality is measured by:

1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.
The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.
2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more then the total dimensions of the facade or roof.
3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.
4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the adjacent material should be chosen within the same range of material, dimensions and colour.

5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general a roof is a simple, homogenous surface. This can also be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.
6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Description:
The FLISOM modules are produced and will be installed at two locations. One location is at EMPA in Zürich-Dübendorf and the other location is at Utility EKZ in Zürich. The cells are laminated on the thin steel back sheet. The sheets are bended during installation. Two different sized modules will be used.

Dimension:
Module 1:
- Power: 85 Wp. Dimensions: 2519 x 458 mm.

Module 2:
- Power: 110 Wp. Dimensions: 3263 x 458 mm.

Materials :
Steel sheets.

Colours:
The metal sheet is black.

Mounting system:
The carport structure is made of steel.
Modules are mounted on the steel profiles. During the installation the modules will be bended to fit the half round shape of the structure.

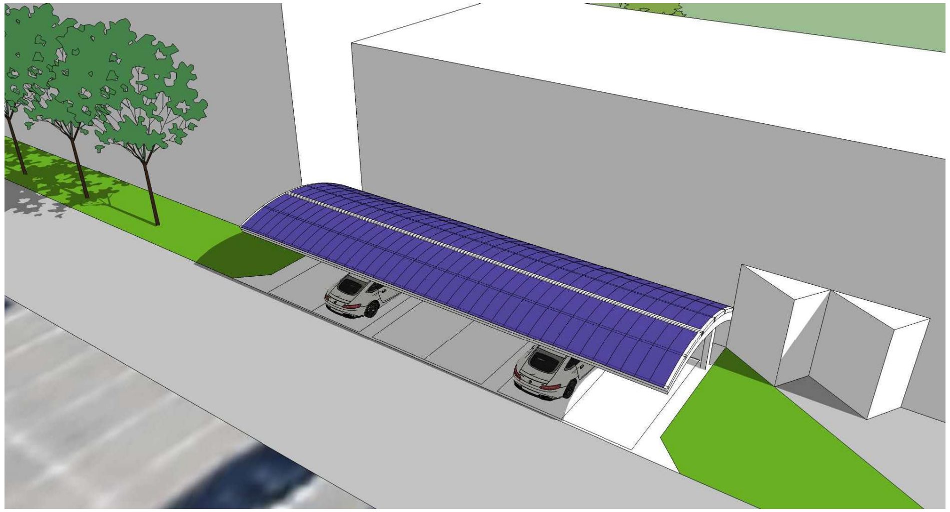
EU Standard:
Not applicable.
The carport is not a building according to the European Standard EN50583-2016 “Photovoltaics in buildings”.

Procedure:
Building permit is needed for the structure but not in special for the roof modules.

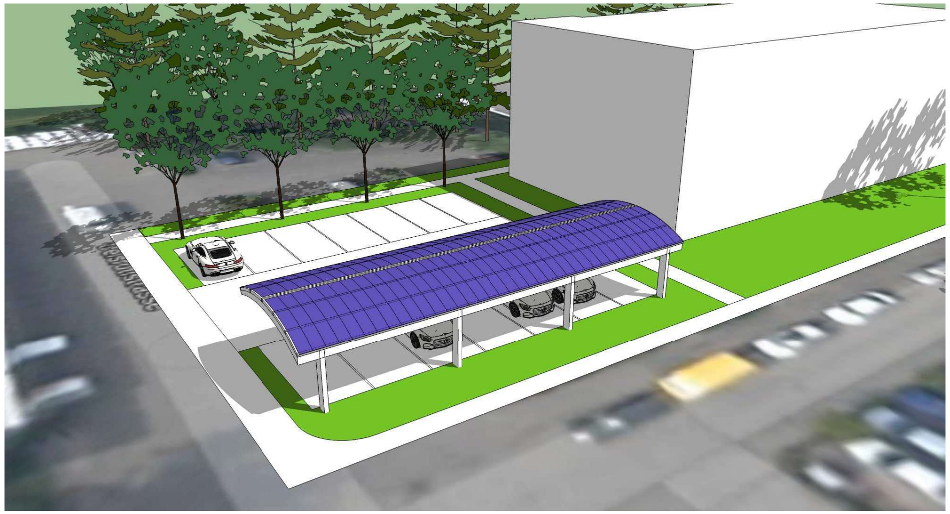
Check of BIPV quality and definition:
Good points that increase the aesthetical quality are:
- the structure is clear and simple
- the whole roof is covered with modules

Points of attention are:
- the colour of the modules and the other parts of the structure.

PICTURES



Carport A in front of the EMPA-MOVE building



Carport B at the EKZ-site

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For elevated areas irradiation can be higher than at STC. Therefore, multiply I_{SC}- and V_{OC}- values with a factor of 1.25 for the electrical layout of cables, fuses and converters (worst case scenario). For a serial connection the voltage of a single module is multiplied by the number of modules to calculate the system voltage. Make sure that you are always within the limits of the maximum system voltage.

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Back-sheet of Flisom PVSITES modules are made of metal and have to be connected to the ground. Also ground the support structure and arrange an adequate lightning protection. Do not use materials which can cause corrosion. The hole for the grounding cable can be drilled anywhere in the edges of the module frame as in fig. 1. If the back-sheet of the module and the support structure/clamps are conductive it is not necessary to ground every module. The grounding of the support structure is sufficient. Make sure that you do not damage the edge seal or front-sheet.

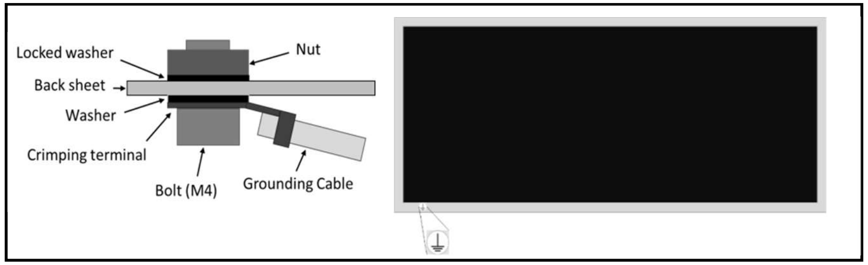

Fig. 1: Recommended grounding connection

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Secure all electrical connections and use stress relief appliances. Do not go below the minimum bending radius of the cables. Use cable guides to prevent connectors and cables from lying in excess water, snow or dirt.

The junction box is not to be opened. The diode cannot be repaired.

Module Orientation and Shading

In general the modules can be mounted either in portrait or in landscape mode, depending on different limiting factors:

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- Plan the installation in such a way, that the Flisom modules receive the same amount of direct sunlight within the same string (taking in account their orientation and shadowing).

If direct shadow on active surface could not be avoided:

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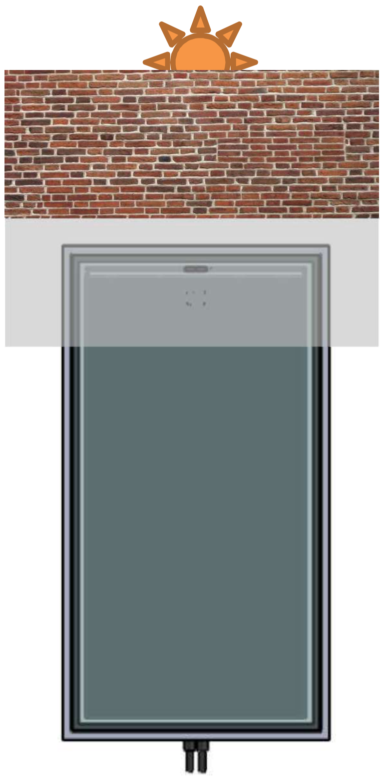

Fig 2: parallel shade

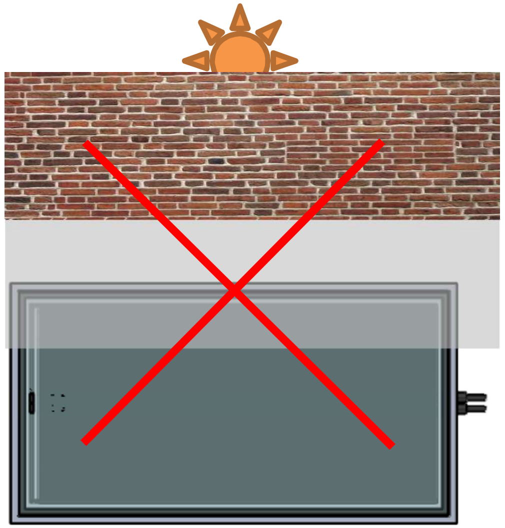

Fig 3: series shade

Negative impact on the system performance from full or partial shading from rooftop equipment, structural elements of a building and nearby trees, poles power lines or nearby buildings should be avoided. A professional shading analysis prior to installation is recommended by Flisom.

POWER MANAGEMENT STRATEGY

Inverter General

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Suitable inverter configurations are:

- Central inverters
- String inverters
- Multi-String inverters
- Inverters on single module level

Recommended Inverter for Carport EMPA and EKZ

"Solaredge SE 9 kW inverters with MPP tracker P300" will be used as power equipment for this demo-system.

Connect always two neighbouring modules along long side together to one MPP tracker (see drawing string concept).

Energy management

In the EKZ carport, the power generated will be entirely injected to the grid; so that, an EMS will not be needed.

In the EMPA carport, an EMS will be needed to manage power production and storage in the batteries.

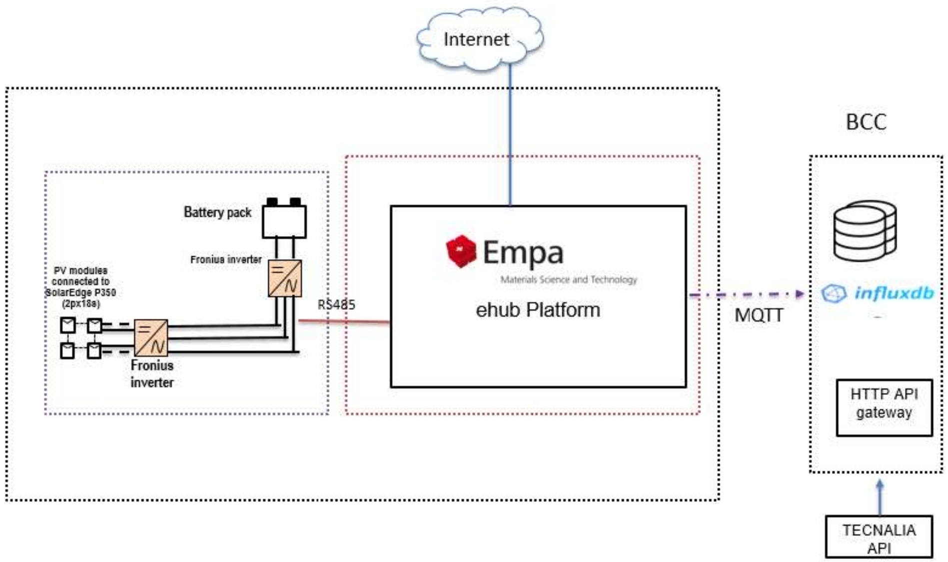
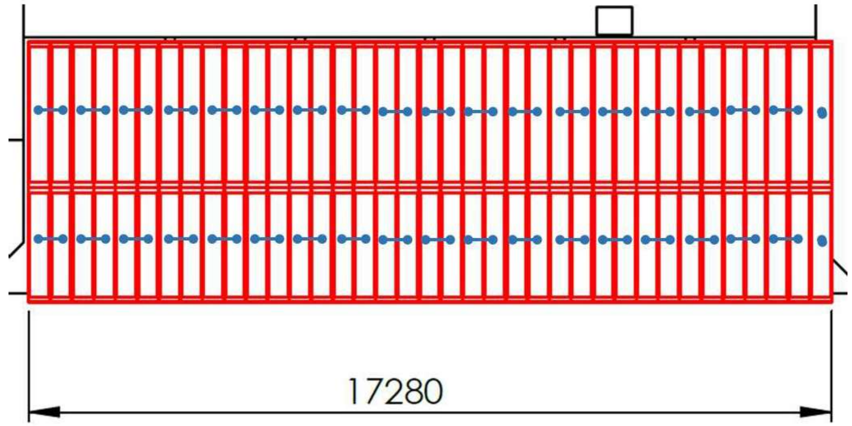


Fig. 4: Energy Management System (EMS)

DRAWINGS

String concept carport EMPA



String concept carport EKZ

RELATED DATA-SHEET AND GUIDELINES

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SPECIFICATIONS

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Flisom modules can be operated in the range of -40°C to 85°C. Depending on the area it is necessary to protect the modules from standing water, snow or extreme soiling. At consistent solar radiation Flisom PV modules generate more power at lower temperatures. To improve the energy yield of the plant increasing cooling or ventilation is an option.

Handling

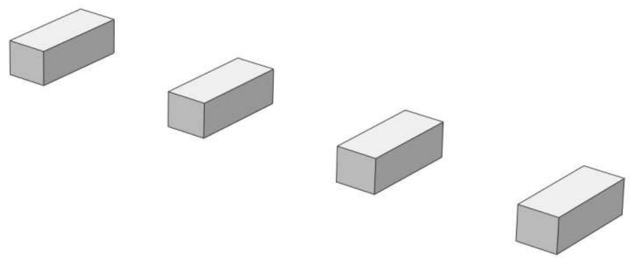
Flisom PVSITES modules use thin metal sheets as backsheet. Hence they can bend by applying forces while installation (e.g. dropping on the corner). Please handle with care. Store modules in a dry place. Do not transport modules without packaging. Do not put modules on top of each other to avoid small scratches (this can accelerate module degradation by environmental factors). Do not use JB cables as handles to carry or lift the modules. Be cautious when front sheet is wet since the surface could lose grip. Do not apply solvents, adhesives, paint or stickers on the front sheet. Do not place the modules face-down in direct contact to abrasive surfaces.

Mechanical

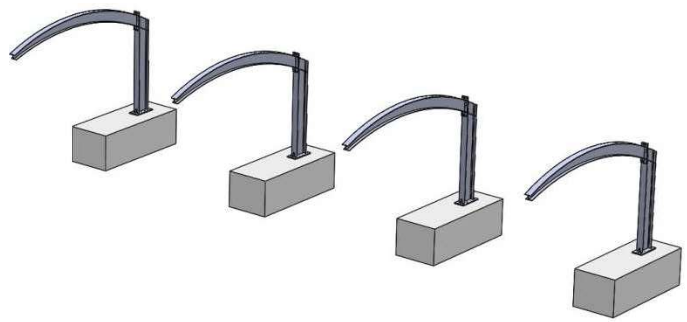
Keep a minimum distance of 5mm between the edges of single modules to take thermal expansion into account. Only use compatible materials.

Installation

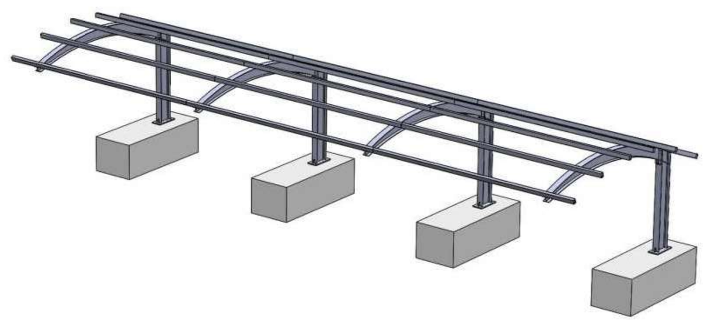
1. Build foundation



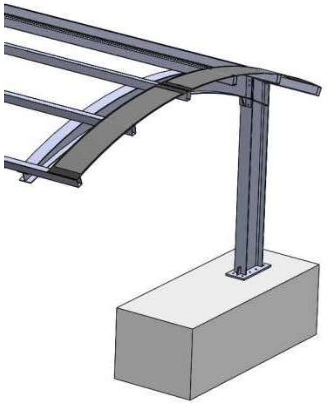
2. Mount pillars



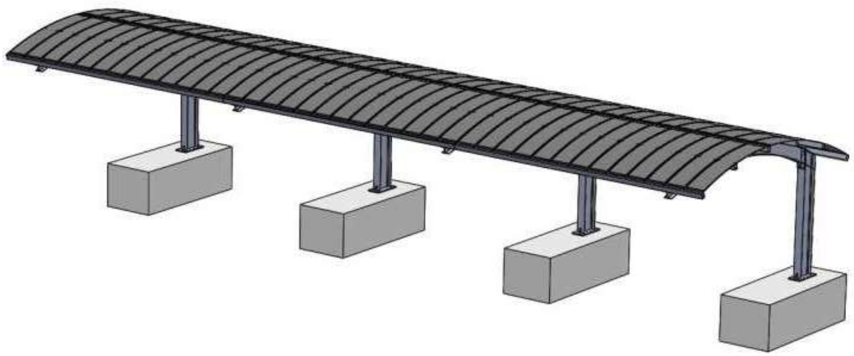
3. Mount stiffening profiles



4. Install first row of modules



5. Install rest of modules



Inspection and Maintenance
It is recommended to have a visual check on a regular basis (quarterly). Plan check-ups according to the given environmental and safety conditions and regulations.

- Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface.
- Do not use aggressive cleaning agents or scrubbing materials.
- Do not use steam blasting for cleaning.
- Use soft water to avoid chalk stains
- Soft Sponges can be used
- Check if connectors and grounding are tight and without corrosion and if the insulation is not damaged also check for loose mechanical or electrical contacts.
- Check if the Junction Box is securely attached and that no deep scratches are penetrating the front sheet

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 3. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS3] Module data-sheet

[GA3] Architectural integration guideline

[GB3] Electrical design, operation and control strategies guideline

[GD3] Health, safety and security guideline

SPECIFICATIONS

Danger

Electrical shock

The generated current of a module under illumination is dangerous. Modules should be connected only if the system is covered and thus potential and current free. Do not modify the module, the junction box or the connectors. Make sure that you work with dry tools and under dry working conditions. Current has a linear behaviour with incoming radiation and can exceed the mentioned current if the illumination is higher than under Standard Test conditions (STC). Fix issues in the grounding immediately.

Working on live parts

When working on wiring use safety equipment (insulating gloves, shoes, etc) and appropriate tools (insulating tools, etc). Make sure that you have grounded the modules and the mounting construction. Do not use damaged or broken modules. Repair or replace damaged modules or cables immediately. Do not dismantle modules or the junction box.

High Voltage

In a PV system the voltage is multiplied by the number of modules in series up to the stated system voltage. Do not allow the system to exceed the stated system voltage.

Be aware that almost the same voltage stated on the label is present under low light conditions.

Arcing

PV modules generate direct current when exposed to light. When disconnected a dangerous arc between the wires may be generated which will not extinguish on its own. Do not disconnect under load.

Fire Protection

Do not use PV modules in explosive atmospheres. Check the local regulations for fire protection

Warning

Do not use aggressive solvents or scrubbing materials for cleaning the modules. Do not use sharps objects. Do not walk on the panels if there is any risk that sharp stones under the soles, or sharp shoe elements would damage the panel.

The safety instructions for other system components apply. Local standards, building norms and accident prevention regulations must be followed. Disregarding the warnings can cause serious injuries or even death.

Keep a minimum distance of 5m[1] to a burning PV system. Inform the public authorities about the PV installation.

Attention

Do not concentrate light on the modules. Modules and insulations can be destroyed by concentrated light.

Do not remove the label or use modules without labels attached

[1] *Source: www.arbeit-und-gesundheit.de/2/2349*

by the manufacturer.

Reverse currents may damage modules. To avoid reverse currents, maintain an equivalent voltage in each parallel connected string of the circuit.

Storage and Transportation

Do not stand or step on the modules or their packaging. Do not accept modules delivered in damaged packaging. Do not put pressure on the modules. Do not bend the modules to a radius of less than 50cm.

Installation

Before installing modules, contact the appropriate authorities to obtain any required building permits and to determine installation and inspection requirements that apply to the installation. Make sure that unauthorised people have no access to the construction place. Do not install when it is raining, snowing, windy or the ground is slippery. Flisom recommends to use personal protective equipment such as safety gloves and safety boots etc. Respect general safety rules.

Disposal

Flisom modules must be disposed of in a responsible manner. Please contact your local supplier or disposal company for further information. For health and safety reasons, Flisom modules should not be disposed of with household garbage, and must be dealt with in accordance with local codes and regulations.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 3. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

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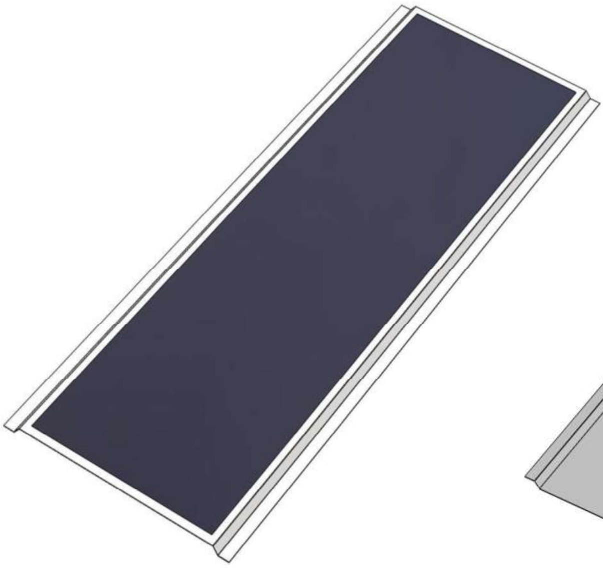
D8.3 Design pack for every demo site

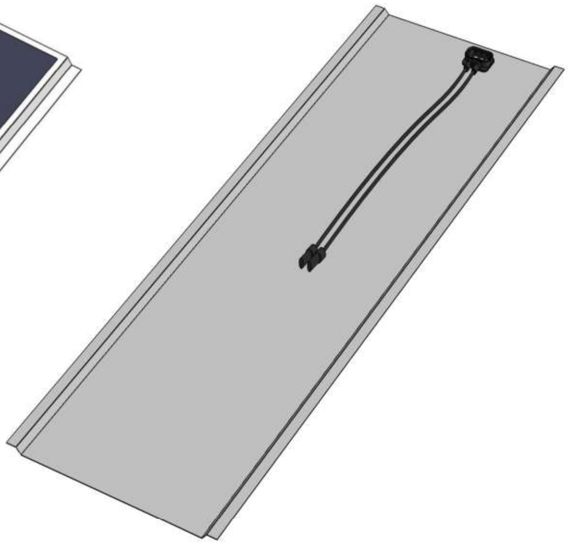
ANNEX 4. DEMO 4 BIPV MODULES DATA-SHEETS AND GUIDELINES

- **MDS4: Demo 4 BIPV Module data-sheet**
- **GA4: Demo 4 Architectural Integration Guideline**
- **GB4: Demo 4 Electrical Design, Operation & Control Strategies Guideline**
- **GC4: Demo 4 Installation, Commissioning and Maintenance Guideline**
- **GD4: Demo 4 Health, Safety and Security Guideline**

PVsites module – for Cricursa Building

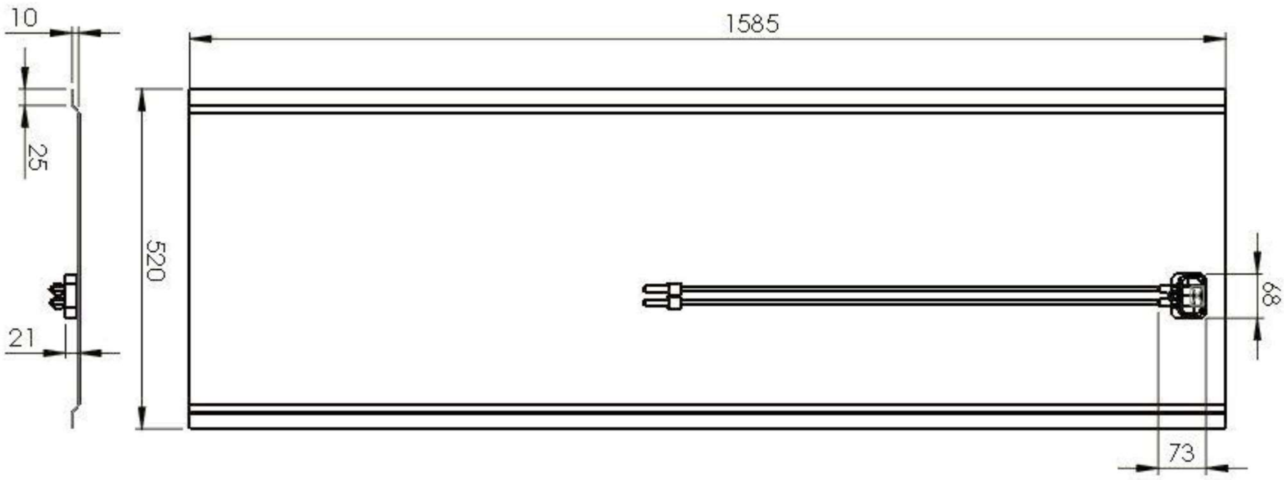
SWISS MADE





Description

The Cricursa module is a semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures.



DEMO 4

Dimensions			
Length		[mm]	1585
Width		[mm]	520
Thickness at module		[mm]	12.2
Thickness at J-Box		[mm]	21 ± 1
Weight		[Kg]	5.8

Electrical characteristics at STC[1] Model number			SF 50	SF 55	SF 60
Nominal power	Pmpp	[W]	50	55	60
Tolerance		[W]	-0/+5	-0/+5	-0/+5
Voltage at nom. power	Vmpp	[V]	34	35	36
Current at nom. power	Impp	[A]	1.47	1.54	1.66
Open circuit voltage	Voc	[V]	46	47	48
Short circuit current	Isc	[A]	1.72	1.82	1.91
Max. system voltage	IEC	[V]		1000	
Max. serial fuse rating		[A]		10	

Thermal characteristics			
Temperature coefficient	Voc	[%/°C]	-0.3
Temperature coefficient	Isc	[%/°C]	0.01
Temperature coefficient	Pmpp	[%/°C]	-0.35

Operating conditions		
Temperature range	[°C]	-40 to +85
Max. mechanical load		2400 Pa, 245 kg/m2

Additional data	
Cell type	Flexible CIGS
Material Backsheet	Painted steel, RAL 9010
Junction box	Back side

Warranty

Cricursa modules are specially designed for PVsites Testinstallation. Therefore they have no warranty.

Notes

[1] STC: 1000 W/m2, AM1.5G, 25°C, stabilized module state

We continuously develop our products. Electrical and physical properties subject to change without prior notice.

Version	Date	Comments	Author
00.00	2017-09-29	Initial	Schweizer, M.

SPECIFICATIONS

Project : Demo 4 – BIPV Roof Modules

Location : Spain, Granollers

Owner : CRICURSA. Contact: Henry Delgado Betancourt

Introduction to aesthetics of the roof:
The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".
Integration of Photo-voltaic systems has the achievement:

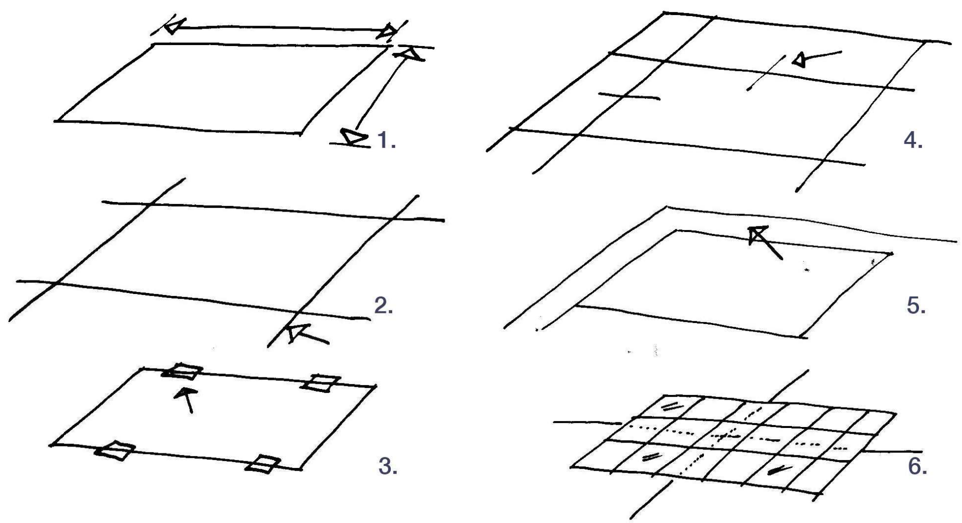
- to combine technical functions;
- the improvement of the usability;
- to follow the proportions of the envelope or the shape of the building;
- to visual integrate this in the 'concept of the design'.

Aesthetical quality is measured by:

1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.
The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.
2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more than the total dimensions of the facade or roof.
3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.
4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the

adjacent material should be chosen within the same range of material, dimensions and colour.
5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general a roof is a simple, homogenous surface. This can also be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.
6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Design description:
The cells will be laminated on steel sheets. The steel sheets will be screwed in the same line where the roof sandwich-panels are mounted on the underlying construction.

The roof sandwich-panels are produced by panelais and have three ribs with a width of 500 mm. Total roof sandwich-panel width is 1000 mm. In between are transparent areas with plastic panels.
The modules produced by FLISOM need to follow these dimensions for an easy construction.
In the design phase there are two options for the section of the modules.
Option 1. The module is below the highest point of the roof sandwich panels. In this case the production process for FLISOM is more complicated as the cells have to be laminated before the sheets are bended in the right shape.
Option 2. In this option the sheets are higher than the highest point of the roof sandwich-panels. This is easier for FLISOM as the sheets can be produced, painted and bended before the cells are laminated. Another advantage is that in this way the cavity is larger and good ventilation of the cavity is possible. This option is chosen.

To demonstrate the function of the second skin roof it is needed to make the modules the same length of the roof. Because of the limitations in the production process, 6 modules will cover the length of the roof.
The original idea was to screw the modules on the sandwich panels. Because of the possibility for expansion, a better solution is to add a profile with rubber on top before screwing. The rubbers will guarantee that no water can come in and with oval holes the modules can expand.

Module description:
The FLISOM cells will be laminated on steel sheets. The edges of the sheet are bended to increase stiffness and the possibilities to mount the sheets.

Dimension :
Module dimensions are about 1585 x 520 mm.

Horizontal overlap is 18 mm. The weight is 5.4 Kg/module that means 6.5 Kg/m^2. Roof length is about 9940 mm so that 6 modules can be mounted in a row.

Materials :
Steel sheet with bended edges.

Colours :
The cell colour is very dark black-blue. The metal sheet is White (RAL 9010).

Mounting system :
Modules are screwed in vertical direction on the ribs (edges) of the roof sandwich-panels.

EU Standard :
The roof modules are BIPV products according to the European Standard EN50583-2016 "Photovoltaics in buildings".
The application is according to the mounting Category A "Sloped, roof-integrated, not accessible from within the building" (EN50583-2-2016 "Photovoltaics in buildings – Part 2: BIPV systems".
Note: This standard does not take in consideration the aesthetical aspects of BIPV.

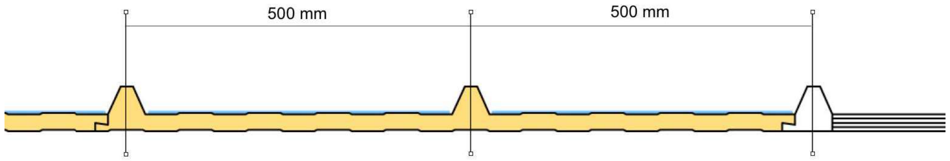
Procedure :
No building permit is needed for this type of application.

Check of BIPV quality and definition :
Good points that increase the aesthetical quality are:
- the whole roof is covered with modules;
- the vertical connection between modules and the roof construction is hidden
- the horizontal connection to the roof is done with a hidden gutter/profile under the modules.

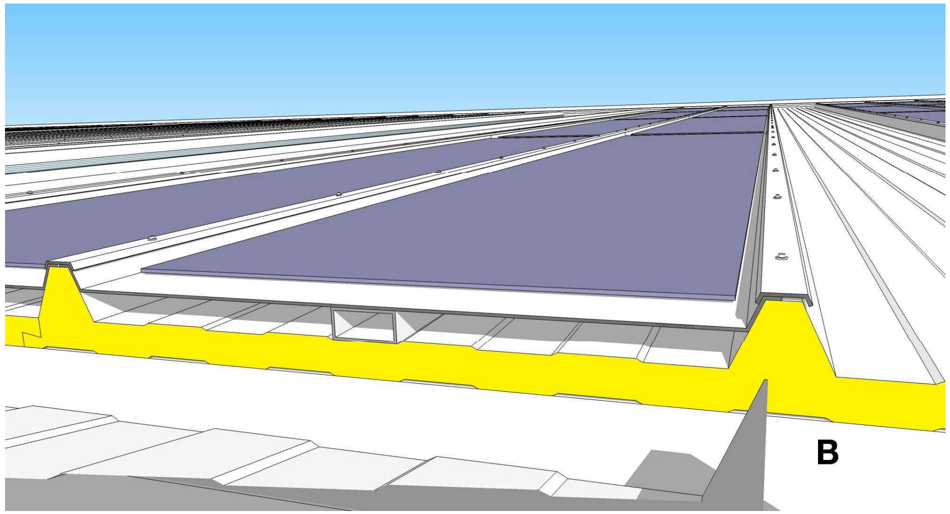
Points of attention are:
- the colour of the modules. It is preferred to give the steel sheets a colour close to the roof colour RAL9010 (matt white). This colour should also be used for the profiles, ridge and edges.
-

According to the EU standard EN50583-2016 "Photovoltaics in buildings" this product is a BIPV product.

PICTURES

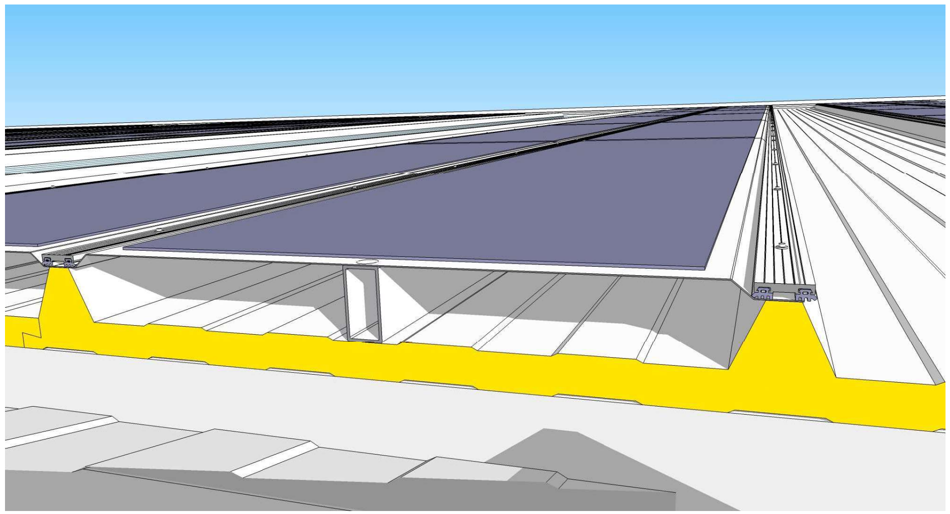


Standard roof sandwich-panel section.

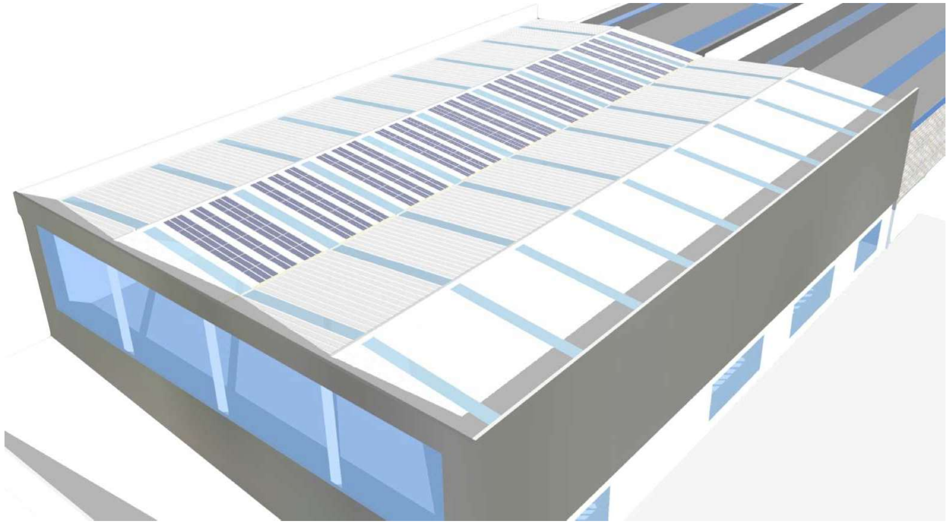


Proposed section with option 1.

CRICURSA roof with the sandwich-panels.



Proposed section with option 2.



Available roof area roof.

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 4. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[GB4] Electrical design, operation and control strategies guideline.

[GC4] Installation, commissioning and maintenance guideline.

[GD4] Health, safety and security guideline.

SPECIFICATIONS

Electrical

For elevated areas irradiation can be higher than at STC. Therefore, multiply I_{SC}- and V_{OC}- values with a factor of 1.25 for the electrical layout of cables, fuses and converters (worst case scenario). For a serial connection the voltage of a single module is multiplied by the number of modules to calculate the system voltage. Make sure that you are always within the limits of the maximum system voltage. Use an adequate device for overcurrent protection (fuse, blocking diode). Maximum Isc multiplied by a factor of 1.56 to protect a string in parallel configuration.

The maximum number of modules connectable in series is calculated by adding Voc of each single module multiplied by 1.25 up to the maximum system voltage which you can find on the label.

Back-sheet of Flisom PVSITES modules are made of metal and have to be connected to the ground. Also ground the support structure and arrange an adequate lightning protection. Do not use materials which can cause corrosion. The hole for the grounding cable can be drilled anywhere in the edges of the module frame as in fig. 1. If the back-sheet of the module and the support structure/clamps are conductive it is not necessary to ground every module. The grounding of the support structure is sufficient. Make sure that you do not damage the edge seal or front-sheet.

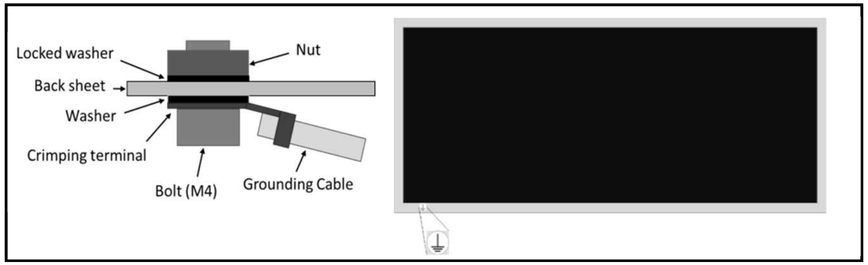


Fig. 1: Recommended grounding connection

Do not use PV modules of different power classes or configurations in the same PV system. Flisom CRICURSA modules use MC4 connectors. Only use these connectors or compatible connector types which are authorised from both producers.

Use solar cables for outside use (ø 2.5 to 4mm² and min. 90 °C).

Secure all electrical connections and use stress relief appliances. Do not go below the minimum bending radius of the cables. Use cable guides to prevent connectors and cables from lying in excess water, snow or dirt.

The junction box is not to be opened. The diode cannot be repaired.

Module Orientation and Shading

In general the modules can be mounted either in portrait or in landscape mode, depending on different limiting factors:

Casting shadow on the panels should be avoided.

- Always install the Flisom modules in a location that has good sun exposure throughout the year. Less power is generated in shaded locations.
- Plan the installation in such a way, that the Flisom modules receive the same amount of direct sunlight within the same string (taking in account their orientation and shadowing).

If direct shadow on active surface could not be avoided:

- Orientation of the shadow on the active surface is crucial: the panel may only be installed as in fig 2 (Parallel shade). To compare, fig 3 shows a series shade - shading the complete length of several full cells. This type of casting shadow will negatively affect the power generation of the module and can cause degradation by overheating.

Fig 2: parallel shade

Fig 3: series shade

Negative impact on the system performance from full or partial shading from rooftop equipment, structural elements of a building and nearby trees, poles power lines or nearby buildings should be avoided. A professional shading analysis prior to installation is recommended by Flisom.

POWER MANAGEMENT STRATEGY

Inverter General

Inverters convert direct current into alternating current. Inverters of the latest generation, with MPPT (Maximum Power Point Tracker), optimize the production, even in situations of weather changes or variable sunlight.

Suitable inverter configurations are:

- Central inverters
- String inverters
- Multi-String inverters
- Inverters on single module level

Inverter for Cricursa

The final electrical scheme of the demo-system will include:

- 2 commercial inverters SMA 6000TL and another commercial inverters SMA 6000TL.
- 2 CEA 5000W inverters are ready to be installed in CRICURSA.

Fig 4: possible location of the inverters

Energy management

The EMS strategy will be showed in the figure below.

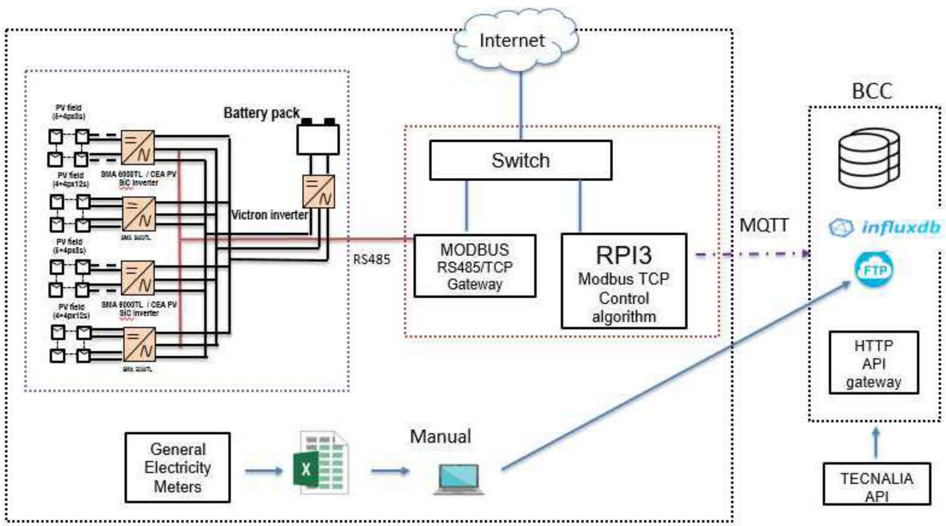
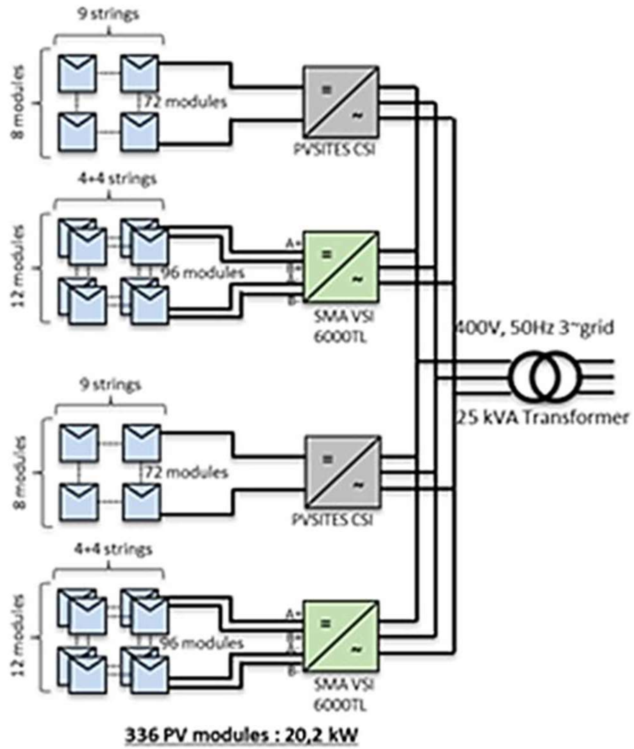


Fig. 4: Energy Management System (EMS)

ELECTRICAL DIAGRAM



Electrical DC characteristic for 1 inverter		
	PVSITES CSI	SMA VSI (6000TL)
PV modules in series	8	12
PV modules in parallel	9	4 (A) + 4 (B)
Number of PV modules	72	96
DC maximum power	4,32 kW	5,76 kW
DC maximum voltage	384 V	576 V
DC maximum current	17,19 A	7,64 A (A) + 7,64 A (B)

Fig. 5: Final one-line diagram of the PV system implemented in the Demo 4

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 4. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS4] Module data-sheet

[GA4] Architectural integration guideline

[GC4] Installation, commissioning and maintenance guideline

[GD4] Health, safety and security guideline

SPECIFICATIONS

Environment

Flisom modules can be operated in the range of -40°C to 85°C. Depending on the area it is necessary to protect the modules from standing water, snow or extreme soiling. At consistent solar radiation Flisom PV modules generate more power at lower temperatures. To improve the energy yield of the plant increasing cooling or ventilation is an option.

Handling

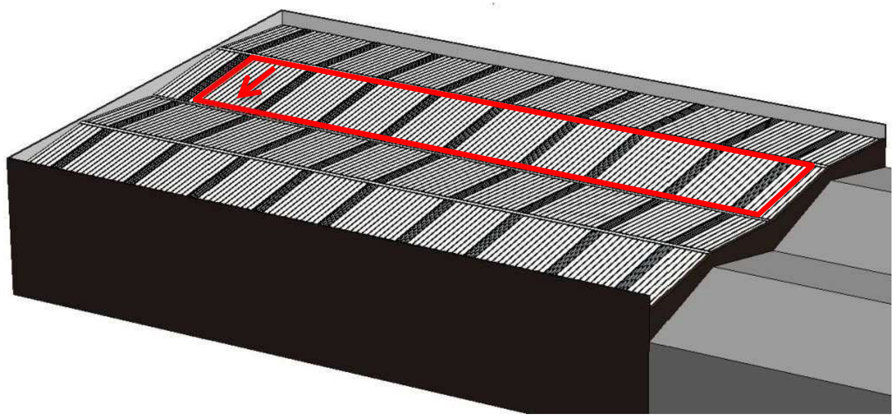
Flisom PVSITES modules use thin metal sheets as backsheet. Hence they can bend by applying forces while installation (e.g. dropping on the corner). Please handle with care. Store modules in a dry place. Do not transport modules without packaging. Do not put modules on top of each other to avoid small scratches (this can accelerate module degradation by environmental factors). Do not use JB cables as handles to carry or lift the modules. Be cautious when front sheet is wet since the surface could lose grip. Do not apply solvents, adhesives, paint or stickers on the front sheet. Do not place the modules face-down in direct contact to abrasive surfaces.

Mechanical

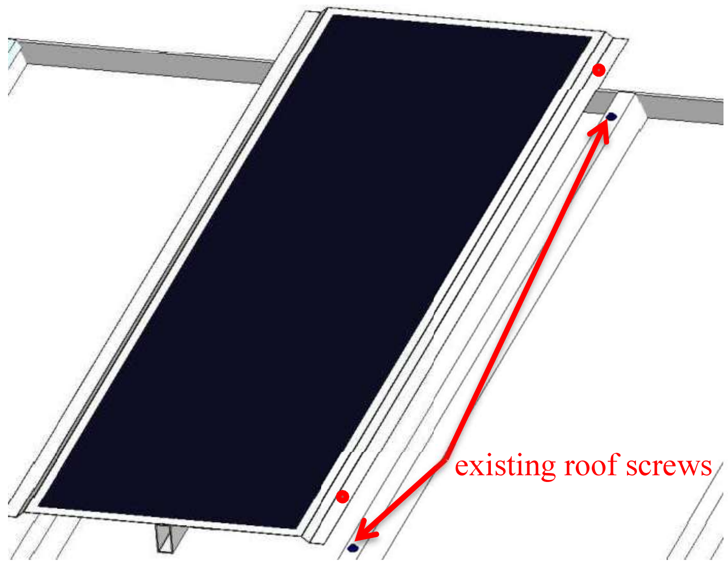
Keep a minimum distance of 5mm between the edges of single modules to take thermal expansion into account. Only use compatible materials. Use special roof screws and EPDM sealing to ensure a waterproof roof.

Installation

Cricursa installation has to be done in the marked area. Start with installation from the roof top.

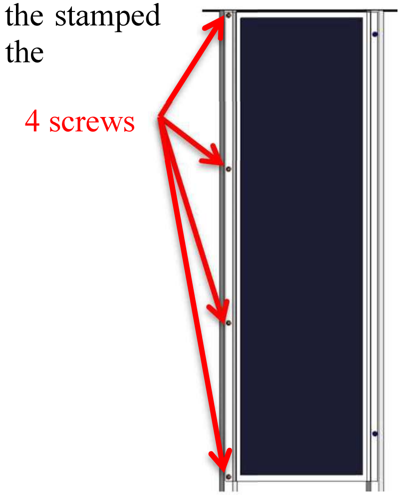


1. Position the first module and mark the positon of the existing screws

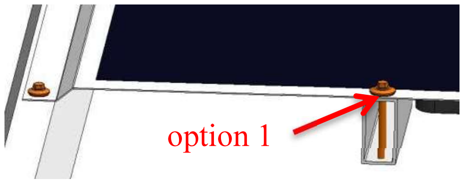


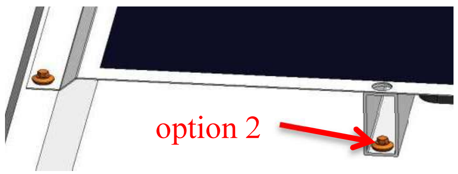
2. Stamp out holes on the marked positons. The holes should be bigger than the screws diameter to have enough tolerances.

3. Place the module and check that the stamped out holes are placed over the existing roof screws. Screw the module 4 times on one side on the roof.



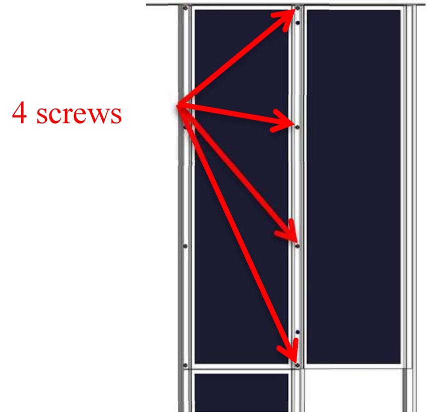
4. Screw the middle of the module on the roof (2 options)





5. Install the rest of the modules in this row and connect the cables according to the string planning.

6. Start the next module row and screw them together with the first row module on the roof



7. Repeat point 1 to 6 until all modules are installed

Inspection and Maintenance

It is recommended to have a visual check on a regular basis (quarterly). Plan check-ups according to the given environmental and safety conditions and regulations.

- Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface.
- Do not use aggressive cleaning agents or scrubbing materials for cleaning
- Do not use steam blasting for cleaning.
- Use soft water to avoid chalk stains
- Soft Sponges can be used
- Check if connectors and grounding are tight and without corrosion and if the insulation is not damaged also check for loose mechanical or electrical contacts.
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SPECIFICATIONS

Danger

Electrical shock

The generated current of a module under illumination is dangerous. Modules should be connected only if the system is covered and thus potential and current free. Do not modify the module, the junction box or the connectors. Make sure that you work with dry tools and under dry working conditions. Current has a linear behaviour with incoming radiation and can exceed the mentioned current if the illumination is higher than under Standard Test conditions (STC). Fix issues in the grounding immediately.

Working on live parts

When working on wiring use safety equipment (insulating gloves, shoes, etc) and appropriate tools (insulating tools, etc). Make sure that you have grounded the modules and the mounting construction. Do not use damaged or broken modules. Repair or replace damaged modules or cables immediately. Do not dismantle modules or the junction box.

High Voltage

In a PV system the voltage is multiplied by the number of modules in series up to the stated system voltage. Do not allow the system to exceed the stated system voltage.

Be aware that almost the same voltage stated on the label is present under low light conditions.

Arcing

PV modules generate direct current when exposed to light. When disconnected a dangerous arc between the wires may be generated which will not extinguish on its own. Do not disconnect under load.

Fire Protection

Do not use PV modules in explosive atmospheres. Check the local regulations for fire protection

Warning

Do not use aggressive solvents or scrubbing materials for cleaning the modules. Do not use sharps objects. Do not walk on the panels if there is any risk that sharp stones under the soles, or sharp shoe elements would damage the panel.

The safety instructions for other system components apply. Local standards, building norms and accident prevention regulations must be followed. Disregarding the warnings can cause serious injuries or even death.

Keep a minimum distance of 5m[1] to a burning PV system. Inform the public authorities about the PV installation.

Attention

Do not concentrate light on the modules. Modules and insulations can be destroyed by concentrated light.

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Do not remove the label or use modules without labels attached by the manufacturer.

Reverse currents may damage modules. To avoid reverse currents, maintain an equivalent voltage in each parallel connected string of the circuit.

Storage and Transportation

Do not stand or step on the modules or their packaging. Do not accept modules delivered in damaged packaging. Do not put pressure on the modules. Do not bend the modules to a radius of less than 50cm.

Installation

Before installing modules, contact the appropriate authorities to obtain any required building permits and to determine installation and inspection requirements that apply to the installation. Make sure that unauthorised people have no access to the construction place. Do not install when it is raining, snowing, windy or the ground is slippery. Flisom recommends to use personal protective equipment such as safety gloves and safety boots etc. Respect general safety rules.

Disposal

Flisom modules must be disposed of in a responsible manner. Please contact your local supplier or disposal company for further information. For health and safety reasons, Flisom modules should not be disposed of with household garbage, and must be dealt with in accordance with local codes and regulations.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 4. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS4] Module data-sheet

[GA4] Architectural integration guideline

[GB4] Electrical design, operation and control strategies guideline

[GC4] Installation, commissioning and maintenance guideline

D8.3 Design pack for every demo site

ANNEX 5. DEMO 5 BIPV MODULES DATA-SHEETS AND GUIDELINES

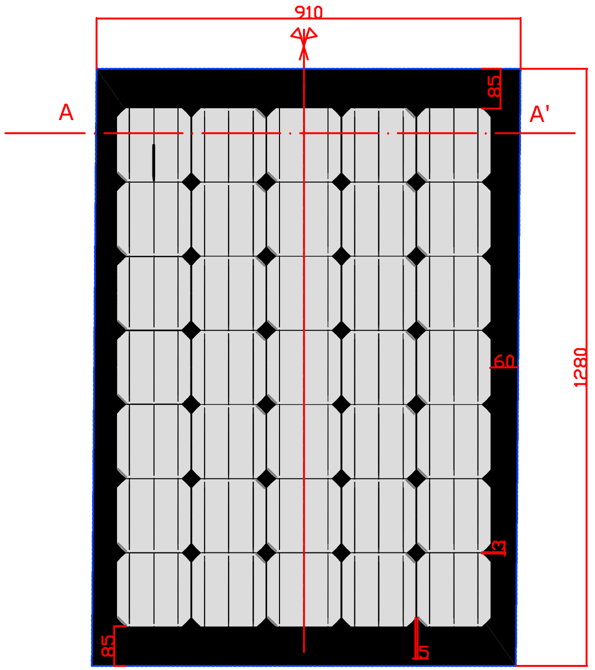
- **MDS5: Demo 5 BIPV Module data-sheet**
- **GA5: Demo 5 Architectural Integration Guideline**
- **GB5: Demo 5 Electrical Design, Operation & Control Strategies Guideline**
- **GC5: Demo 5 Installation, Commissioning and Maintenance Guideline**
- **GD5: Demo 5 Health, Safety and Security Guideline**

PVSITES module by – for VILOGIA Building (FR)

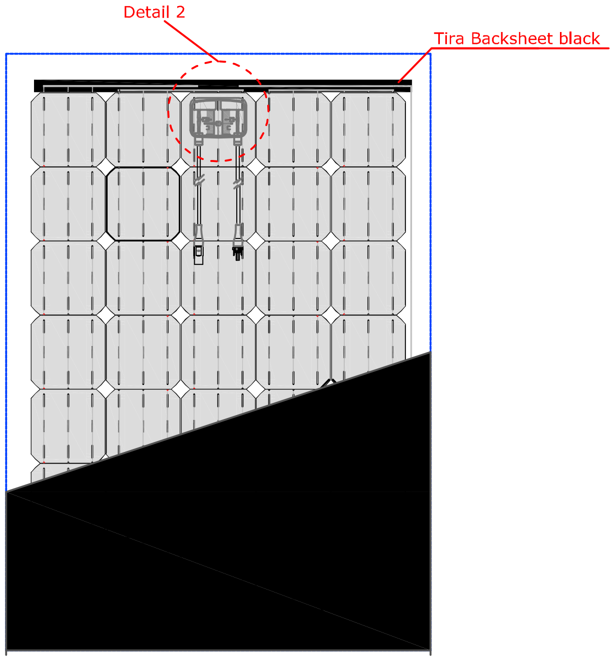
Hidden busbars and L-interconnections (1st generation) module

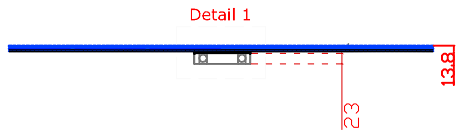
Front and back appearance of sample X5-1 and details of black ribbon and plastic sheets

Front view



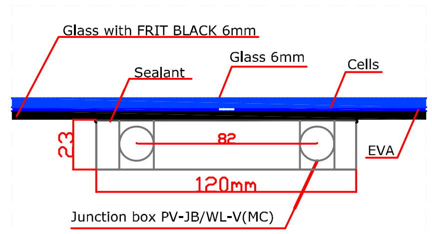
Back view





Cross-section A-A´

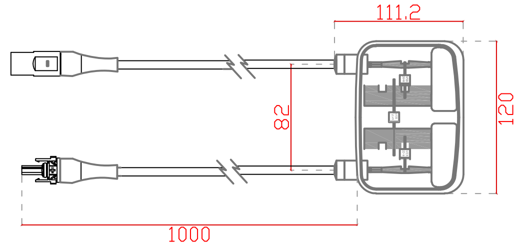
DETAIL 1: Cross-Section with Junction Box



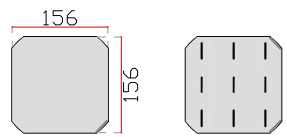
Photovoltaic glass specifications:

Module Glass-Glass:	910x1280x 13,8mm
Cell Technology:	Mono-Crystalline silicon(3 Bus bar)
Cell dimension (mm):	156 x 156mm (6´´x 6´´)
Number of cells:	35 (5 strings / 7 cells per string)
Encapsulant:	EVA
Junction box:	PV-JB/WL-V MC (4 spring clamps) junction box
Hidden Bus bar:	2 x 0,15 mm black colour
L-interconexión	4 x 0,3 mm + tira Backsheet black

DETAIL 2:Junction box/Dimensions:



Cell type/Dimensions:
"Mono-Crystalline 6´´"



Signed by Customer:

PROJECT: **PV SITES (6M3BB 910x1300mm 6+6 frit black_tira BS black)**	CUSTOMER:	QUANTITY: **N/A**	**n°01**
LOCATION: **ÁVILA**	ONYX DEPARTMENT: **MANUFACTURE_ONYX SOLAR**	DATE: **09/01/2019**	**rev1**

PHOTOVOLTAIC GLASS	1280 x	910
	6" Mono	Crystalline
Electrical data test conditions (STC)		
Nominal peak power	151	P_{mpp} (Wp)
Open-circuit voltage	22,22	V_{oc} (V)
Short-circuit current	9,05	I_{sc} (A)
Voltage at nominal power	18,34	V_{mpp} (V)
Current at nominal power	8,26	I_{mpp} (A)
Power tolerance not to exceed	±10	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, stabilized module state.		
Mechanical description		
Length	1280	mm
Width	910	mm
Thickness	13,8	mm
Surface area	1,16	sqm
Weight	34,94	Kgs
Cell type	6" Mono	Crystalline
No PV cells / Transparency degree	35	0% opaque
Front Glass	6 mm	PPI black connections
Rear Glass	6 mm	Tempered glass + black frit
Thickness encapsulation	1,80 mm	EVA Foils
Category / Color code		
Junction Box		
Protection	IP65	
Wiring Section	$2{,}5\ mm^2$ or	$4{,}0\ mm^2$
Limits		
Maximum system voltage	1000	Vsys (V)
Operating module temperature	-40…+85	°C
Temperature Coefficients		
Temperature Coefficient of Pmpp	-0,451	%/°C
Temperature Coefficient of Voc	-0,361	%/°C
Temperature Coefficient of Isc	+0,08	%/°C

global leader in building integrated photovoltaic glass

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SPECIFICATIONS

Project : Demo 5 – BIPV Facade

Location : France, Lille

Owner : VILOGIA (contact Agnieszka Bogucka)

Introduction to aesthetics of the facade:
The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".
Integration of Photo-voltaic systems has the achievement:

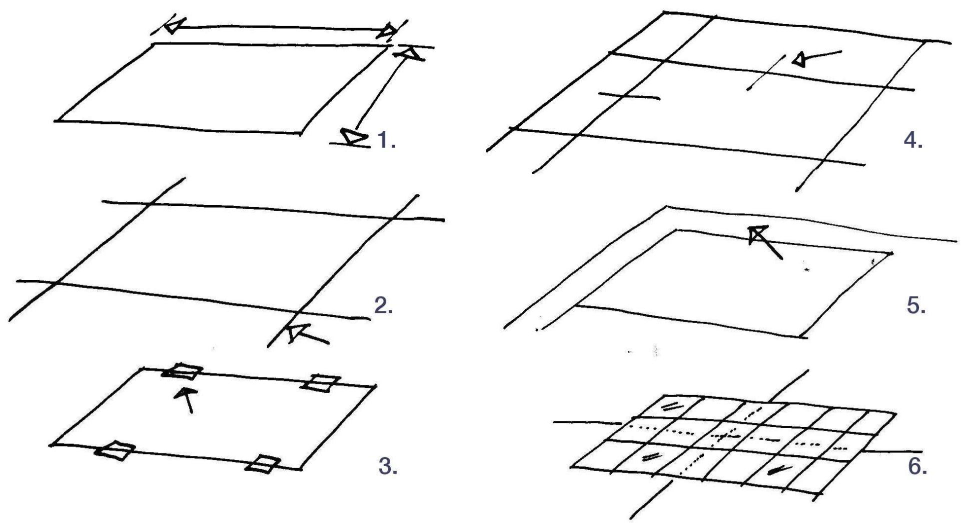
- to combine technical functions;
- the improvement of the usability;
- to follow the proportions of the envelope or the shape of the building;
- to visual integrate this in the 'concept of the design'.

Aesthetical quality is measured by:

1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.
The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.
2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more than the total dimensions of the facade or roof.
3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.
4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the adjacent material should be chosen within the same range of material, dimensions and colour.

5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general a roof is a simple, homogenous surface. This can also be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.
6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Description :
The modules will be produced by ONYX.
The technology is glass-glass with Si-crystalline cells with hidden bus bars

Dimension :
Module dimensions are 1280 x 910 mm (?)

Materials :
Glass-glass modules.
Colours :
The module colour is black. The visible parts of the mounting system will also be black. A second colour will be chosen for adjacent elements, as the whole building will be renovated and will need a new cladding.

Mounting system :
The facade cladding has been designed by the installer to ensure ease of later maintenance. The system is based on vertical profiles and removable fixations that can hold the horizontal cladding.

EU Standard :
The modules are BIPV products according to the European Standard EN50583-2016 "Photovoltaics in buildings".
The application is according to the mounting Category C "Non-sloped (vertically) mounted not accessible from within the building" (EN50583-2-2016 "Photovoltaics in buildings – Part 2: BIPV systems".
Note: This standard does not take in consideration the aesthetical aspects of BIPV.

Procedure :
Building permit is needed for this type of facade modules. Can be difficult in sensitive or historical context.

Check of BIPV quality and definition :
Good points that increase the aesthetical quality are:
- the whole facade use the same cladding system (dimensions and mounting system);
- the connection between modules/cladding is hidden.

Points of attention are :
- the adjacent material. To give the same type of feeling about the material, glass or enamelled glass (Colorbel) or any other shiny material should be used. However, in this context, the adjacent material would be chosen according to the future retrofitting works architectural choices.
- dimensions and way of mounting of the adjacent material should be the same as for the PV modules.
- the clips or other fixations are very visible. Coating of the clips in the same colour of the cladding or of the modules will make it less obvious. It means one colour for the PV modules and a second colour for the other cladding panels.

According to the EU standard EN50583-2016 "Photovoltaics in buildings" this product is a BIPV product.

Prototype of the ONYX Module (picture ONYX).

PICTURES

Colour chart from Colorbel enamelled glazing

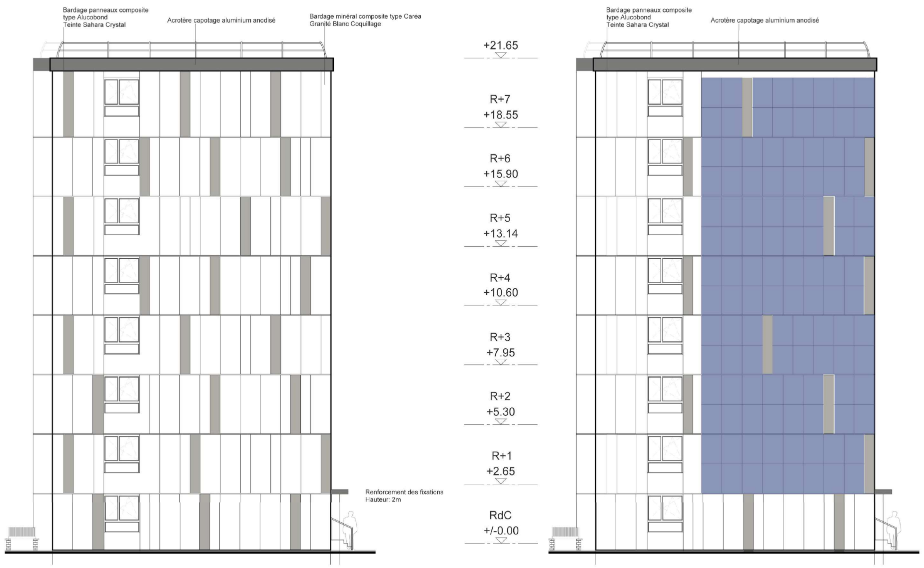
SB fixing clip system (example of mounting system).

Application of profiles on the facade.

Application of a glasspanels at the facade with SB fijaciones clip system.

Initial proposal with horizontal (1700x1000 mm) or vertical modules (1000 x 1700 mm)

Initial proposal with horizontal modules (1700 x 1000 mm)



Final design based on the renovation design (May 2017)
Not:e module dimensions are 1280 x 910 mm.

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 5. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[GB5] Electrical design, operation and control strategies guideline

[GC5] Installation, commissioning and maintenance guideline

[GD5] Health, safety and security guideline

SPECIFICATIONS

Modules are classified at the production line depending on their power. They are already prepared to be connected in series or in parallel.

Series or parallel assembly

- The configuration will depend on the voltage required. If a high voltage is required we will connect the modules in series because final voltage will be $V = V1 + V2 + (\ldots) Vn$, and the intensity value $I = I1 = I2 = (\ldots) = In$.
- If on the other hand we are interested in obtaining high current intensities we will go for a connection in parallel: $I = I1 + I2 + (\ldots) + In$, and final voltage $V = V1 = V2 = (\ldots) = Vn$.
- The maximum recommended configuration for modules connected in series is 1000V voltage (600V for USA). Isolation is guaranteed up to this voltage.
- In a parallel connection you can connect as many modules as the gadget to which it is connected admits (i.e.: inverter, combiner box, regulator or other suitable equipment).
- Always use suitable cables: high voltages or currents can produce short-circuit and degrade them by overheating. Please follow local/national electrical codes.
- Please read carefully the manual of all additional equipment needed in a PV system such as inverters, regulator, batteries, etc. Recommendations of the manufacturers must be followed.
- Protections: For certain BOS and applications (especially BOS for thin film technology) it would be necessary the integration of short-circuit current limiting fuses per a given number of strings to increase electrical safety and optimized maintenance.

BIPV units must be connected and interconnected by an electrical installer with proven experience in PV installations and low-voltage systems. The PV installation design must be certified by a registered professional electrical engineer. The PV BOS design and installation procedure must comply with local codes and requirements from all relevant authorities.

PV systems, as any electrical devices, require good ventilation ensuring proper thermal dispersion. Any solution preventing the aforementioned as: as silicone sealed of wiring, wrong cabling tubing de-ratio values, improper wiring tubing sections, etc. must be avoided.

Junction Box

Onyx Solar PV glasses are designed allowing different Junction Box (JB) implementation depending on each product type, standard or customized. JB can be placed at any point in the rear glass, can be welding or no-potting compatible, and can hold a variable number of by-pass diodes.

In the case of edge junction boxes, the Junction Boxes are designed to be run within a structure as aluminium/steel frames allowing both, good ventilation and absence of moisture. Direct exposure to external outdoors conditions should be avoided.

As general characteristics it should be pointed out that any JB system used by Onyx shows IP-65 protection grade.

In the case of crystalline technologies, Onyx Solar usually uses the following junction box:

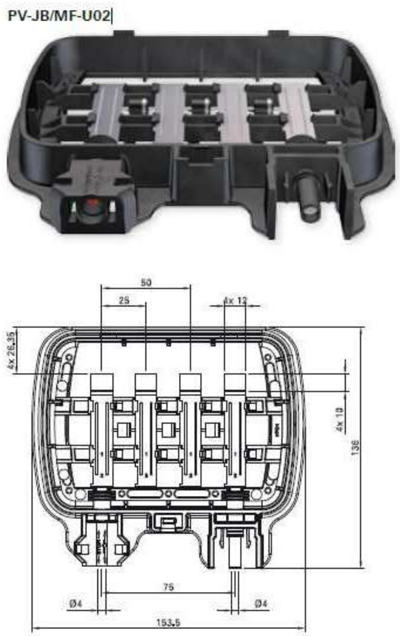


Fig. 1: Multi-contact Junction Box

Wiring

Onyx Solar uses wiring classified as solar wiring with variable length, and sections from 2,5 to 4mm2 (AWG 14, 12). These sections allow:

- Nominal current: 42 A.
- Nominal voltage: 600/ 1000 VAC 1800 VDC.
- Max Acceptable Operating Temperature: from -40 to 85 ºC

Module Orientation tilt and layout

Location Analysis: the access and security of the location where the PV glass are to be installed and the surface must be analysed in detail, specially orientation and shadows that may appear over the surface must be studied in order to design an installation that offers the highest output.

In order to maximize the energy production, the Solar PV array should be orientated between south-east and south-west. It is not absolutely necessary for the array to face due south. There will be only a small percentage power loss, as a result of moving a few degrees east or west of south. In many cases, the proposed Solar PV array orientation and tilt are determined by the design and location of the building.

The modules layout can be either vertical or horizontal, depending on different factors (mounting system, surface, etc.).

The performance of PV panels is also affected by the shading effect due to trees, passing of clouds, neighbouring buildings and any other means. So there is a need to install the modules where they can receive an adequate sun exposure.

Orientation, tilt and layout of the module in the PVSITES Demo-system 5:

- Location: south façade
- Tilt: 90°
- Orientation: -16°
- Position: vertical.

Electrical diagram

The following one-line diagram (Figure 2) shows the final electric configuration of the Demo site 5 in France. The main characteristics are described below:

- Cells array: 35 cells (one PV glass/Module).
- Solar layout: 4 strings with 28 PV glasses C-Si (112 modules).
- Dimensions: 1280 x 910 mm.
- Module power = 151 Wp.
- System power = 17kWp.

ELECTRICAL DIAGRAM

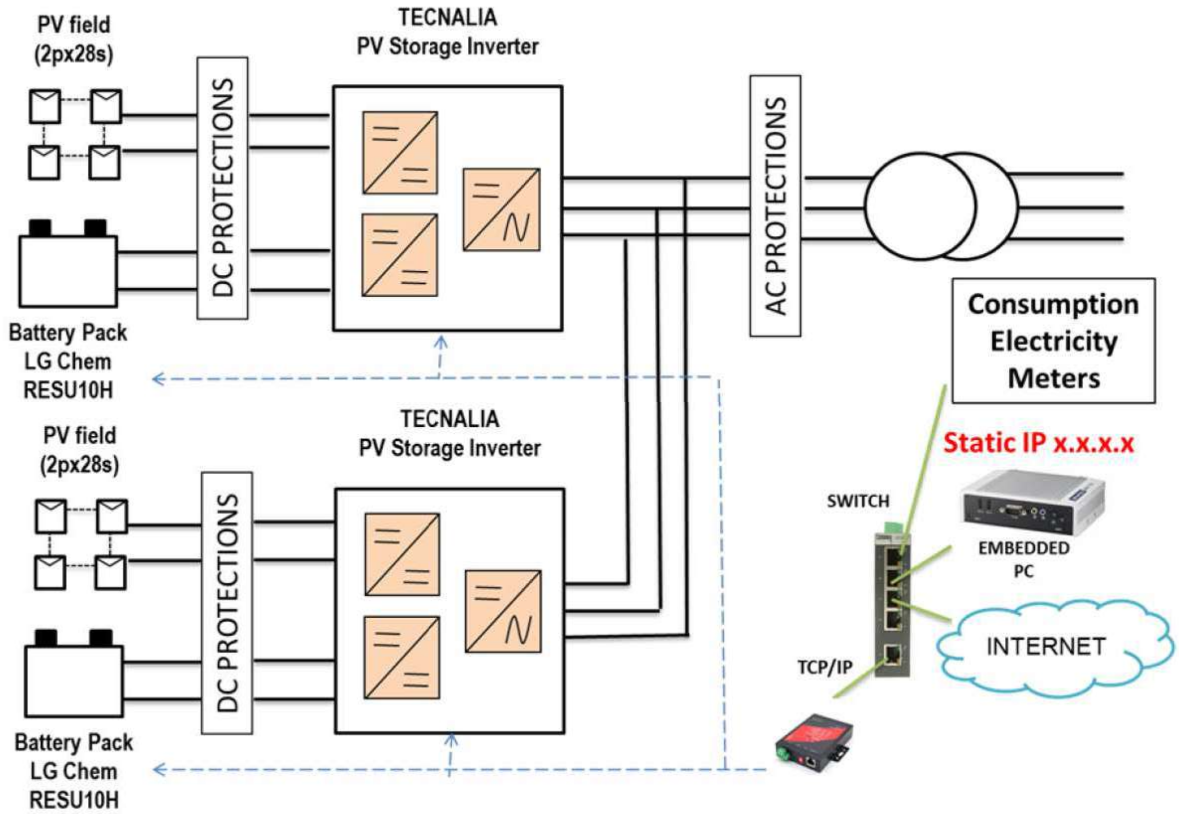


Fig. 2: Basic scheme of the PV system implemented in the Demo 5

ELECTRICAL DIAGRAM

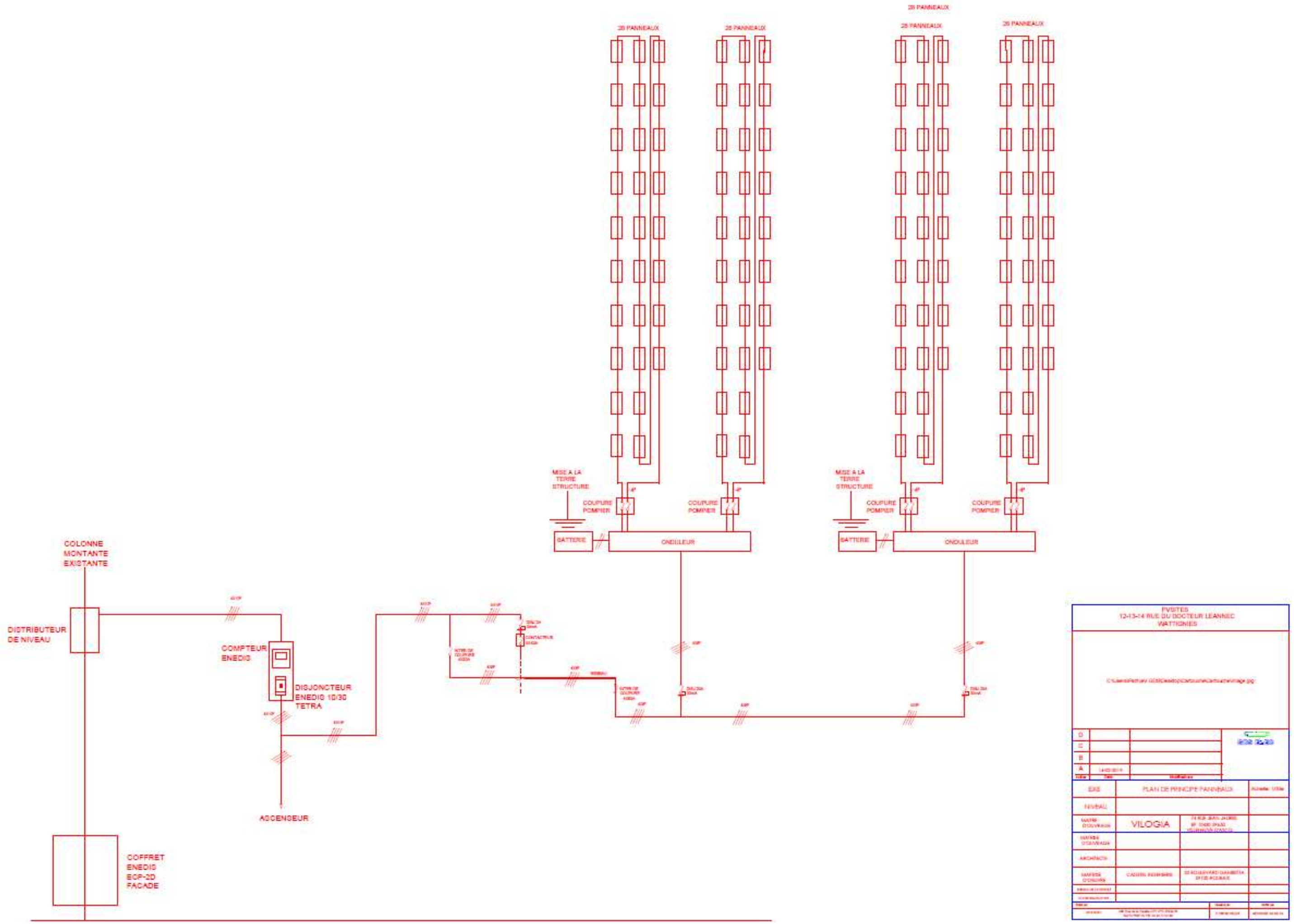


Fig. 3: Single-line scheme of the PV system implemented in the Demo 5

POWER MANAGEMENT STRATEGY

The EMS strategy will be showed in the figure below.

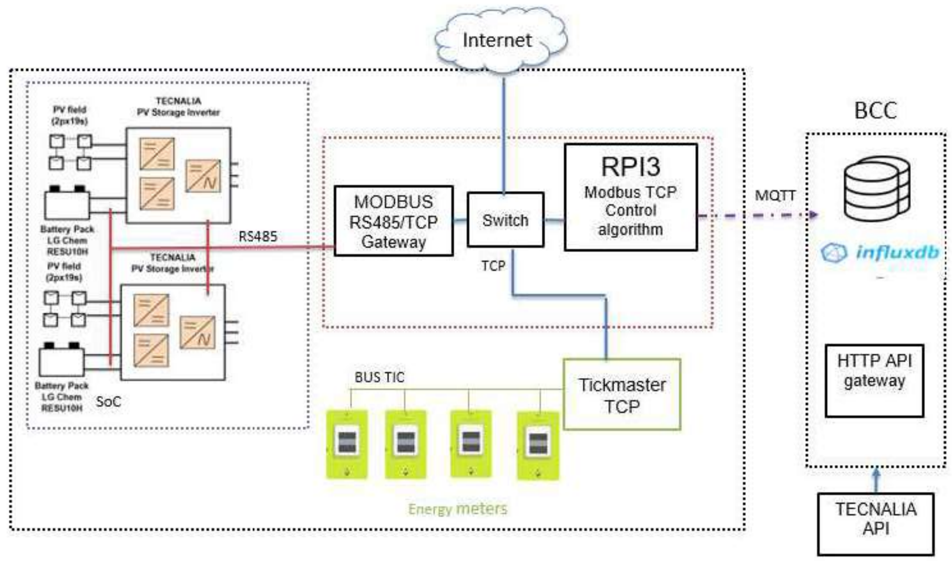


Fig. 4: Energy Management System (EMS)

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 5. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS5] Module data-sheet

[GA5] Architectural integration guideline

[GC5] Installation, commissioning and maintenance guideline

[GD5] Health, safety and security guideline

SPECIFICATIONS

Installation

- The support structure must bear all possible mechanical loads (wind, snow…), calculated according to the region where it would be located and satisfying the local Building Codes. Both structure and supports must be of a very resistant material such as stainless steel, galvanized iron or anodized aluminium.
- Structural systems to integrate the PV glass in façades, canopies and skylights: for this type of installation it is required fixing structures in stainless steel, galvanized iron or anodized aluminium adapted to allow an easy fixing and maintenance over any main structure being wooden, tailed or made of steel. Typically used structural systems consist in primary and secondary structures are shown below:
  - Profile of galvanized steel with frame, presser, adaptable excluder and aluminium lid. EPDM Joints in contact with triple or double laminated BIPV glass units.
  - Profile with anodized aluminium frame. EPDM joints and dividers for the laminated glass and structural silicon for waterproof.
  - Profile with anodized aluminium frame. EPDF joints and dividers for the laminated glass and screwed anodized aluminium lid with silicon for waterproof.
  - Profile with anodized aluminium frame of rectangular tube. EPDF joints and metallic divides for the glass and structural silicon.
  - Profiles designed in galvanized steel or aluminium for IGU (insulating Glass Units) and adapted by means of offset to hold the connections of the PV glass.
  - Vertical structure for PV ventilated façades

Commissioning

The main aspects to be considered can be summarized as follows:

- A minimum power installed capacity must be achieved in order to get the proper performance of the solar inverter or solar controller, or what is the same, a minimum surface of integration is needed in order to build up a technically effective system. This active surface will vary depending on the technology used and the building integration conditions (tilt, orientation, shadows/shades, building surround).
- It is mandatory that the BIPV connected to a single investor or regulator, share the same technology showing identical electrical characteristics although slight difference in dimensions (note:*there may be a possibility of compatibility even while not being the equal when the electrical parameters are proportional between each other).
- Photovoltaic elements connected to the same solar inverter or solar controller should have the same orientation and tilt angle in order to work all of them in similar conditions and not having some penalized by others.

Failure to meet any of these points implies a highly complex installation design analysis to in order to be able to provide minimum operation guarantees. Each of these cases should be managed independently. For instance, depending on the power installed two frames of design can be selected:

- For large installed power PV system: several three-phase inverters showing each one several independent entries allows to perform and manage energy of different powers coming from highly different strings of PV modules with different power rate, orientation, or tilted position.

- For small BIPV integrations: there are low power inverters, however as lower as the installed power is the harder it gets to find a suitable solution that can meet the ranges of operation.

Mainly there are three ways of connecting a photovoltaic system to other utilities. This will conditioned the way the generated energy is managed: direct connection to building inner grid for self-consumption and without storage, grid-connected PV system feeding energy to the utility grid, stand-alone/Self consumption with battery storage of the generated energy.

The minimum parameters required are determined by the type of installation, since depending on this, the key equipment and elements might vary (from inverter to a charge controller/regulator, type of protections, etc.).

- Direct connection to building inner grid for self-consumption and without storage (see the electrical diagram of the Figure 1). The purpose of this kind of PV system installation is to consume in the building instantly the energy that is generated in the PV system. The basic elements that form it are the photovoltaic modules, the solar power inverter and the AC protection switchboard where the energy generated is poured. The inner grid to which the solar installation will be connected will always be of alternating nature (AC) so the connection can be performed in single or three phase system depending on the needs of use.
- Grid-connected PV system feeding energy to the utility grid. In this kind of photovoltaic installation, the generated energy is not directly consumed, but it is feed into the Utility Grid regardless of the energy consumed and the incentives or compensations that the Utility Company/Local Government can provide (feed-in tariffs). The basic elements that form this installation are the photovoltaic modules, the solar inverter and the measurement equipment to control the energy balance (net metering) with which you want to pour the energy generated. (The one-line schematic design is essentially similar to the previous case).
- Stand-alone/Self consumption with battery storage of the generated energy (see the electrical diagram of the Figure 2). The purpose of the installation with is to store the energy produced during a given time of the day to be able to use it when it is needed regardless of the instantaneous production. The basic elements that form this installation are the photovoltaic modules, the charge controller, the battery or UPS system, the solar inverter and the AC protection switchboard. If the final energy use is to be performed in DC, you can disregard the inverter.

In Demo5 case, a combination of these three types of connections has been chosen, as the system includes self-consumption, storage and grid-connection.

To understand the simplicity of the elements composing the PV system it should be noted that the BIPV units , regardless of its kind, is an element that should be treated as any conventional building element since its structural characteristics do not differ from any other type of glazing. As for the electrical part is concerned, any qualified electric installer can do following a wiring diagram and a one-line electrical scheme, being the BOS similar to other low-voltage electrical installations.

The steps to integrate a photovoltaic system are the following; you must first make a study based on the needs and requirements of the client to create an economic and technically feasible integration solution, second you should have a preliminary study to see if the place which is going to support the installation is the right one, then the interconnection of glasses and number of strings are designed leading to final and appropriate voltages and currents to be connected to the inverter, the solar inverters are chosen according to the electrical values, parameters and operating ranges. The wiring sections and protections are selected on the bases of local codes and calculated over-currents values. After all the elements are selected on the basis of design, the performance of work on-site is like any other electrical installation. Finally, once all elements are interconnected to the grid/consumption point, ramping-up can take place and all the needed tests and commissioning process can be carried out.

Maintenance

Preventive maintenance should take place at least twice a year. Key elements should be checked and verified. The minimum actions to be considered are:

- Checking system connections.
- Checking cable system especially if it has been in the sun or in bad weather conditions that can produce corrosion; cracks may appear on the covering which can produce energy loss.
- Checking the sealing of the j-boxes, even if there is a time lapse they should still be sealed and no corroded due to water.
- Checking all structural pieces in the structure that supports the photovoltaic modules to search for losses.
- Checking if any glass may be fractured. If so contact the supplier and change the module.
- Checking all segments of the BOS.
- Checking all earth connections

Cleaning of the PV glazing is similar to equivalent glazing systems. Nevertheless, special care should be taken not to affect the PV sealants or connections.

Mainly rain eliminates the necessity to clean de panels. If needed, clean the surfaces with a mixture of neutral detergent and water. It is recommended using dissolution in water and neutral detergent with 3% of ammonia and a surfactant.

Typical cleaning tool for glass as rubber brush could be used in order to clean the PV module avoiding any scratch on the glass.

ELECTRICAL DIAGRAMS

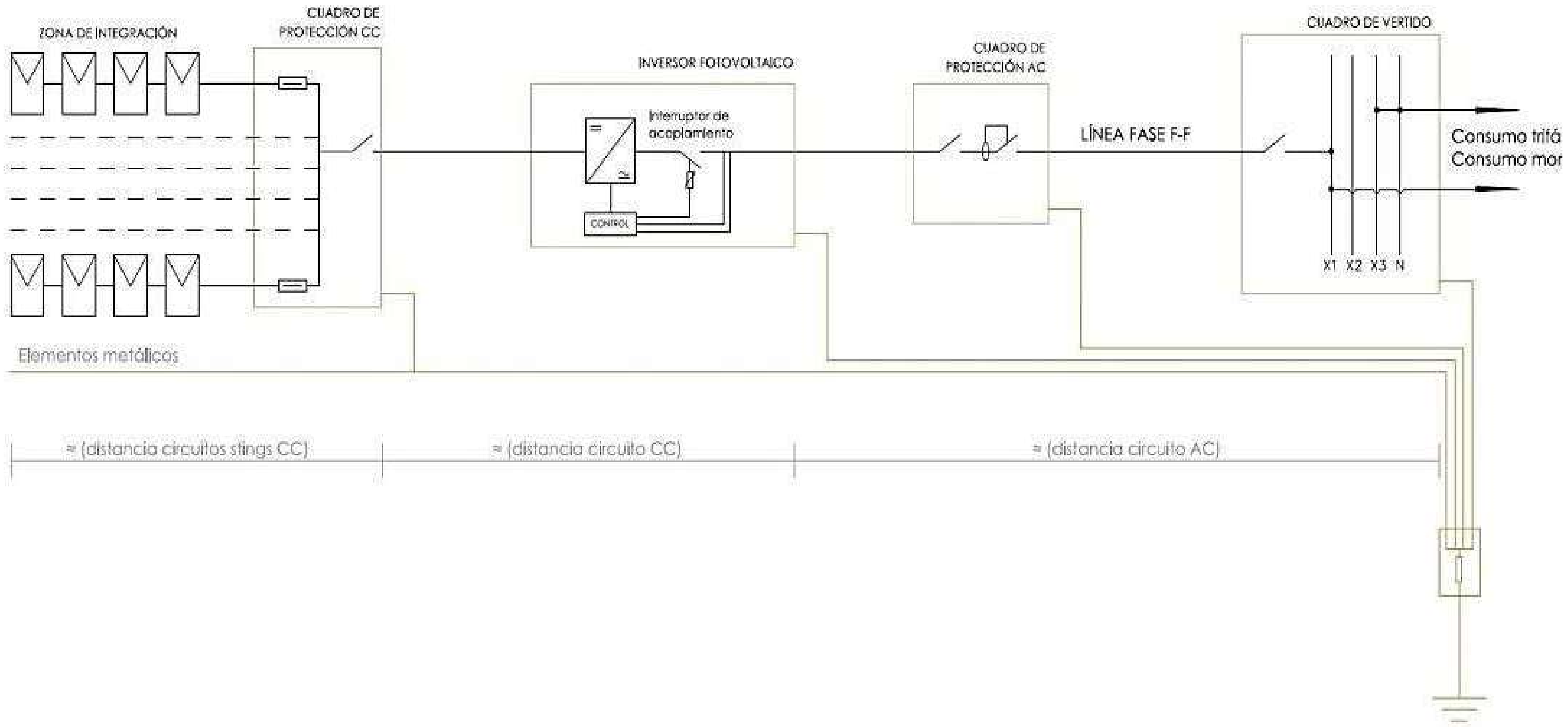


Fig. 1: Direct connection to building inner grid for self-consumption and without storage

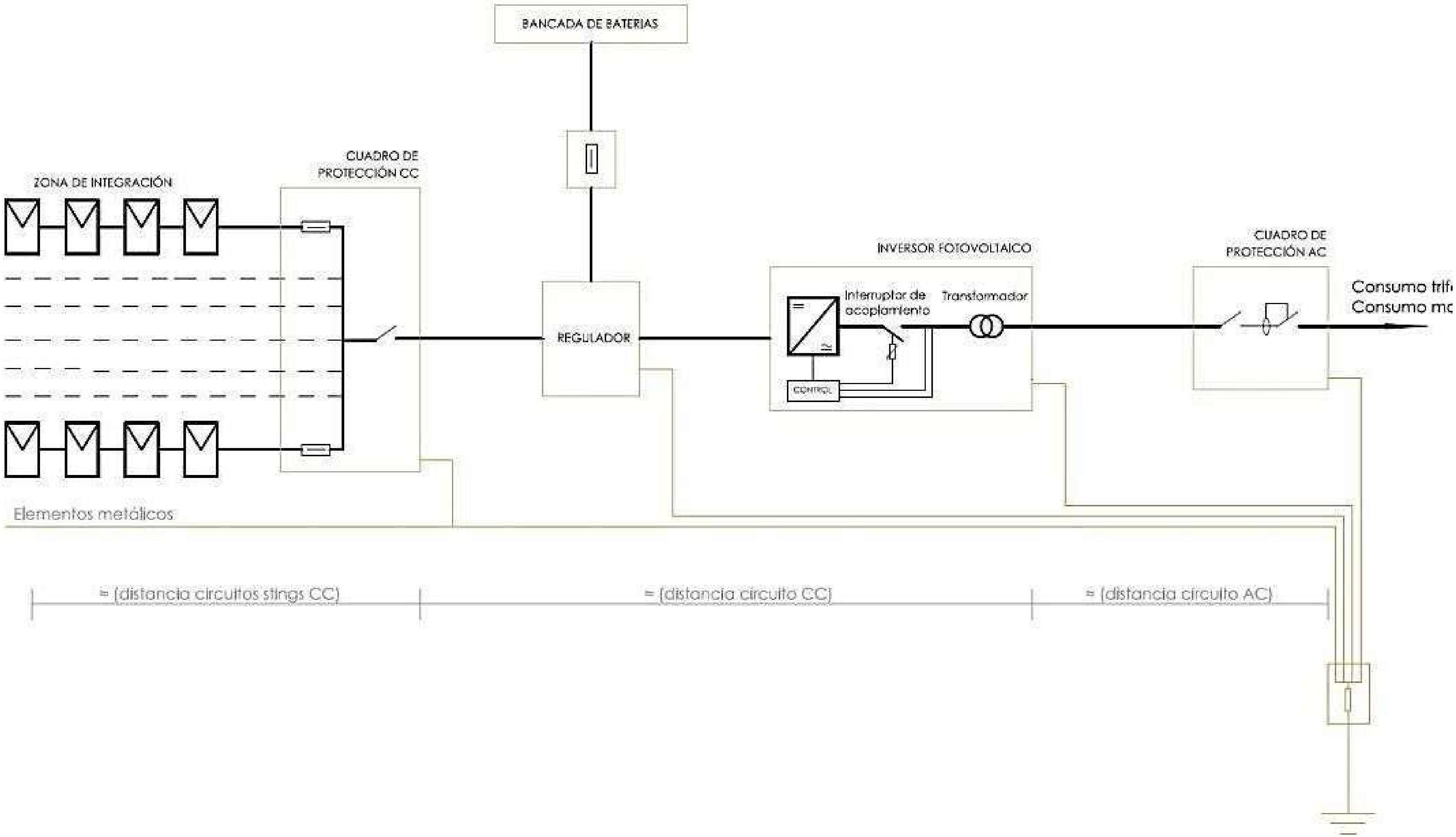


Fig. 2: Stand-alone/Self consumption with battery storage of the generated energy

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 5. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS5] Module data-sheet

[GA5] Architectural integration guideline

[GB5] Electrical design, operation and control strategies guideline

[GD5] Health, safety and security guideline

SPECIFICATIONS

Mechanical and electrical recommendations

Photovoltaic glasses as solar panels produce direct current. If one of them is exposed to the light of sun it may produce electric shock or burns. This risk increases when various modules are interconnected. For this it is mandatory to handle with care, always use suitable protection equipment using gloves and pole detection. Other equipment that form the final group of a photovoltaic installation such as batteries, inverters and photovoltaic regulators can also mean risk. Photovoltaic glasses can weigh up to 120 Kg/sqm and must be replaced following a suitable safety plan and in the same way they were installed: lifted one by one with the support of assistant machinery and a suction cup (vacuum lifter system) as rigging system. From these statements can be formulated the following general recommendations:

- Cover the front side of the modules with opaque material and stick with adhesive tape. This way voltage in the cells will be suppressed. Never eliminate voltage of the modules by short-circuit.
- Installation and future connection of modules must be done by a qualified electrician or under supervision of a authorized person.
- The installation must take place under suitable weather conditions (avoid rain, snow…) in order to avoid electric shocks.
- Only use suitable tools to work on electrical installations, covered with insulating material.
- As values of the electrical characteristic have been calculated under standard measuring conditions according to UNE- EN 61215 Norm (1000W/m2, AM 1.5, 25°C), there may be the case that a higher voltage with respect to the stipulated can be produced. For this reason equipment such as regulators or cables must be prepared to support this possible increase. For limit temperature cases the limit value for the correction factor is 1,25.
- All equipment, junction boxes, cables must be suitable for photovoltaic installations. Never touch bare wires. If cables are not to be connected immediately insulate them for protection. Never manipulate junction boxes extracting for instance the diodes placed by the manufacturer.
- Never try modifying the electronic set up of the junction boxes or take out for example the protection diodes.
- Modules must never be installed or manipulated near places where flammable gases are easily developed, sparks can be produced.
- Keep children away from the photovoltaic modules.
- The Photovoltaic glass must be fully disconnected from its next modules before any replacement.
- You must pay special attention to the packaging, storage and posterior transportation, following these manual recommendations.
- There is risk of fall while installing the modules on the structure, for these reason workers must wear the necessary security

systems such as harness, gloves or adequate footwear.

To avoid any type of risk while assembling the system, whether isolated or for grid connection, all elements, including structure, must be earth connected. It is installer's responsibility to find the most suitable earth system based in washers/screws system, clamps, etc. Any galvanization effect should be avoided.

Use specific connectors for photovoltaic panels.

Never disconnect nor connect while the circuit is loaded.

Disconnected connectors should be protected from filth and water.

Handling and packaging recommendations

You must pay special attention to the packaging, storage and posterior transportation, well tying the modules up because the glass could fracture and it would become useless. To avoid any torsion, modules must be packaged in vertical position.

First and last module in the crate must have their front side looking out.

The rest of modules must be back to back.

If rear JBs, they must be alternated one up one down in the package. The rest of the back side of the module must be covered by a sheet of polystyrene with an adequate thickness.

The front sides of the modules facing the inside will be separated by polystyrene or plastic in order to protect the glass..

All modules must be covered with polystyrene and positioned between woods.

The boxes and or crates can be wooden and/or cardboard based.

Do not dismantle the module in any case, nor extract any incorporated component.

Do not walk on the module.

The panel is a physical body that supports certain voltage, distortion, torsion…regulated by the competent norms but during installation and without acknowledge of these norms it is recommendable to take certain precautions. The panel must be transported being held from the longest sides to avoid non desirable torsion effects.

Never bang the panel on any of its sides, especially the angles.

Maintenance and cleaning recommendations

Never clean the glass with pressurized water nor abrasives that can damage the panel.

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 5. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS5] Module data-sheet

[GA5] Architectural integration guideline

[GB5] Electrical design, operation and control strategies guideline

[GC5] Installation, commissioning and maintenance guideline

D8.3 Design pack for every demo site

ANNEX 6. DEMO 6 BIPV MODULES DATA-SHEETS AND GUIDELINES

- **MDS6: Demo 6 BIPV Module data-sheet**
- **GA6: Demo 6 Architectural Integration Guideline**
- **GB6: Demo 6 Electrical Design, Operation & Control Strategies Guideline**
- **GC6: Demo 6 Installation, Commissioning and Maintenance Guideline**
- **GD6: Demo 6 Health, Safety and Security Guideline**

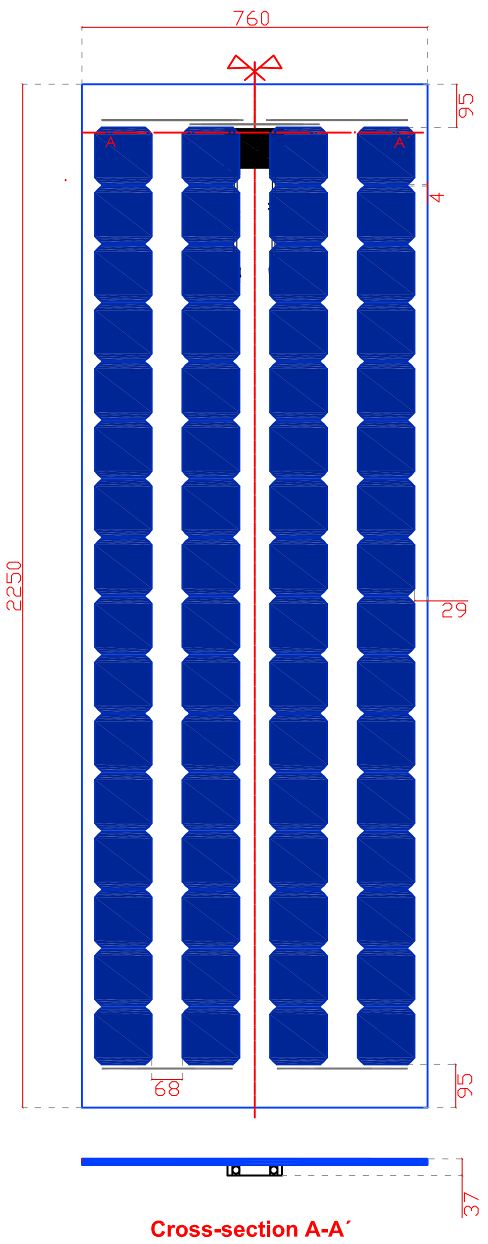
PVSITES module by – for TECNALIA Office building (SP)

Back contact cells BIPV module by ONYX

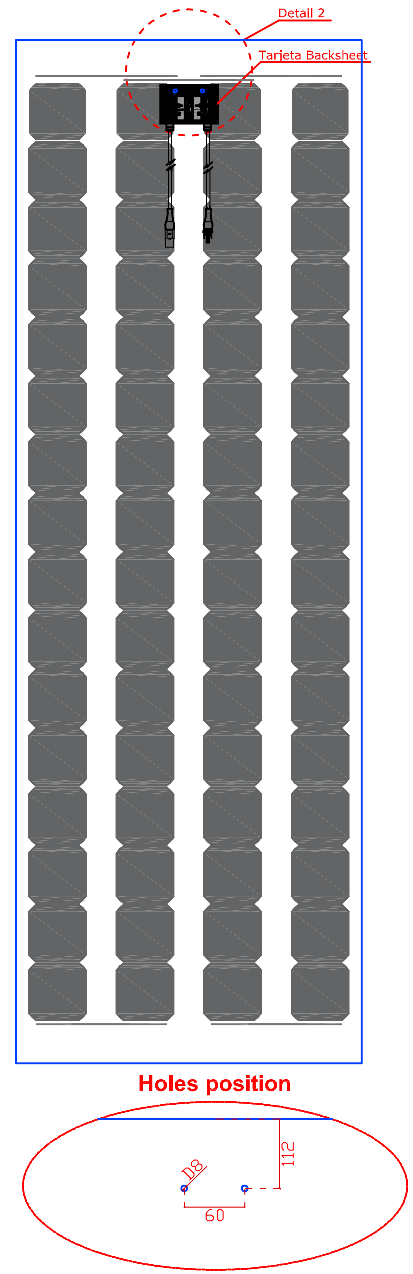
Front and back uniform appearance of the back contact cells BIPV prototypes and details.

Note: It is needed to highlight that modules dimensions and cells configuration (4strings of 16 cells) for Demo 6 will be slightly different.

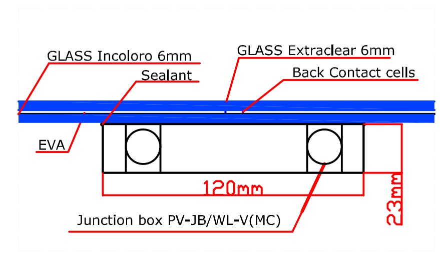
FRONT VIEW



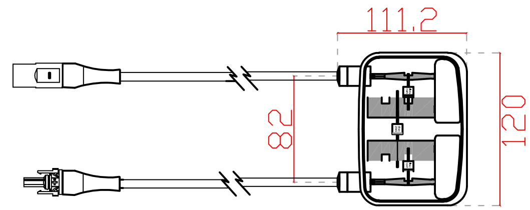
REAR VIEW



Detail 1: Cross section A-A´



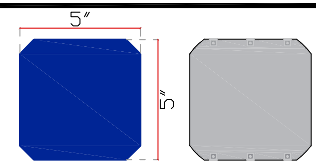
Detail 2: Junction Box



Photovoltaic glass specifications:

Module Glass-Glass:	760 x 2250 x 13,8mm
Glass dimension (mm):	760 x 2250 x 6 mm (x2)
Cell Technology:	Mono-crystalline Back contact
Cell dimension (mm):	125 x 125mm (5´´x 5´´)
Number of cells:	64 (4 strings / 16 cells per string)
Encapsulant:	EVA
Junction box:	PV-JB/WL-V MC (4 spring clamps)

CELL TYPE/DIMENSIONS:
"Mono-crystalline Back contact 5´´"



Signed by Customer:

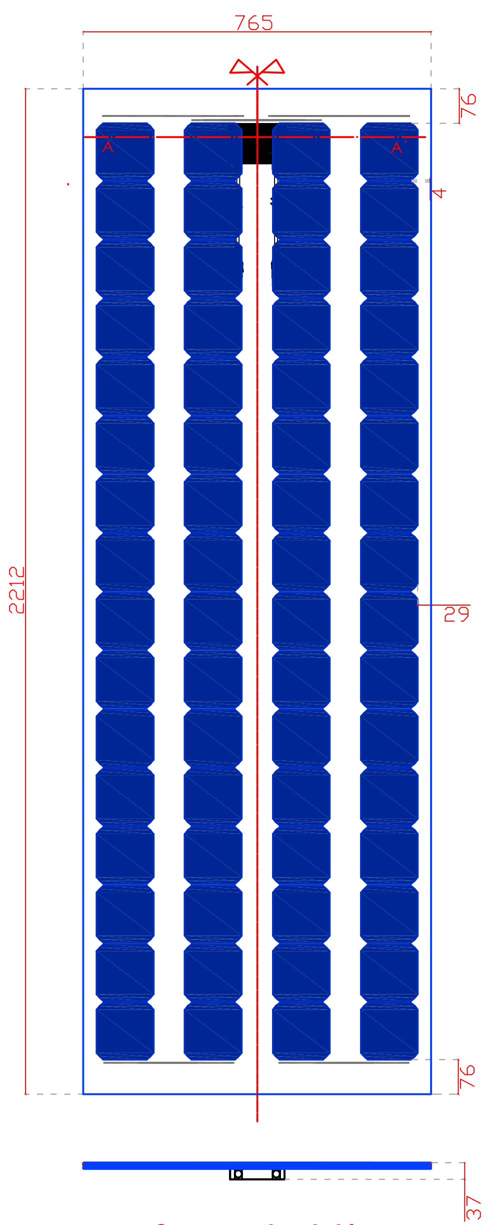
PROJECT: **PV SITES X6(CELLS BACK CONTACT 2250X760mm 6+6)**	CUSTOMER:	QUANTITY: **48 units**	nº **01**
LOCATION: **ÁVILA**	ONYX DEPARTMENT: **MANUFACTURE_ONYX SOLAR**	DATE: **12/03/2018**	

PHOTOVOLTAIC GLASS

PHOTOVOLTAIC GLASS 5" Mono		2250 x 760 Crystalline Back contact
Electrical data test conditions (STC)		
Nominal peak power	192	P_{mpp} (Wp)
Open-circuit voltage	41,60	V_{oc} (V)
Short-circuit current	5,70	I_{sc} (A)
Voltage at nominal power	34,88	V_{mpp} (V)
Current at nominal power	5,49	I_{mpp} (A)
Power tolerance not to exceed	±10	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, stabilized module state.		
Mechanical description		
Minimum active length	2250	mm
Minimum active width	760	mm
Thickness	13,8	mm
Surface area	1,71	sqm
Weight	51	Kgs
Cell type	5'' Mono	Crystalline
No PV cells / Transparency degree	64	40%
Front Glass	6 mm	Tempered Glass Low-Iron
Rear Glass	6 mm	Tempered Glass
Thickness encapsulation	1,80 mm	EVA Foils
Category / Color code		
Junction Box		
Protection	IP65	
Wiring Section	$2{,}5\ mm^2$ or	$4{,}0\ mm^2$
Limits		
Maximum system voltage	1000	Vsys (V)
Operating module temperature	-40…+85	°C
Temperature Coefficients		
Temperature Coefficient of Pmpp	-0,30	%/°C
Temperature Coefficient of Voc	-1,74	%/°C
Temperature Coefficient of Isc	3,50	%/°C

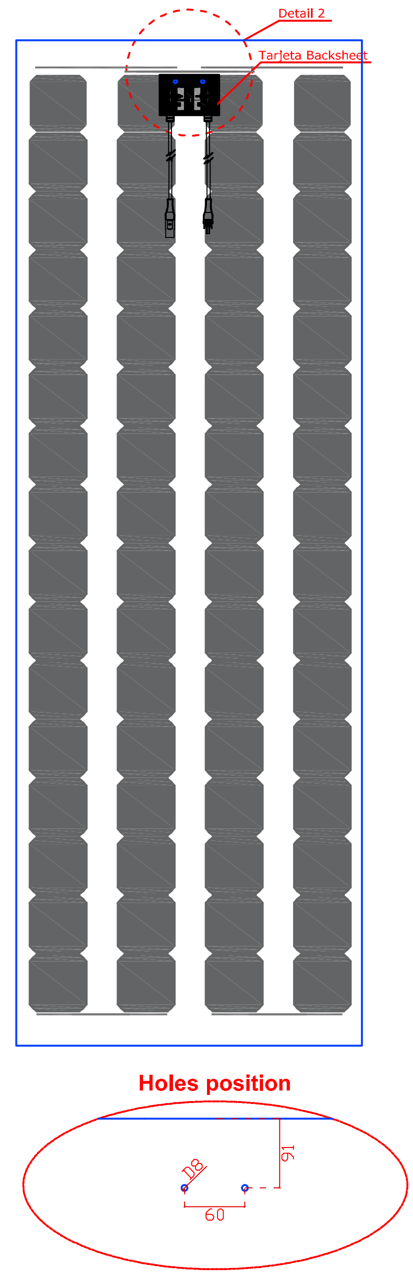
* All technical specifications are subject to change without notice by Onyx Solar

FRONT VIEW



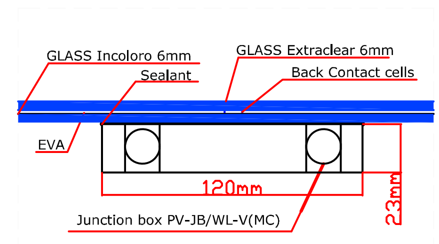
Cross-section A-A´

REAR VIEW

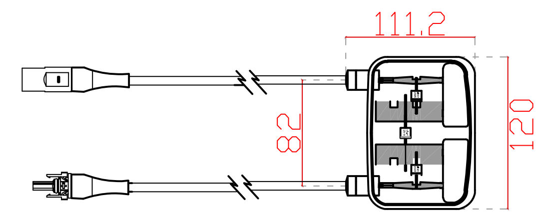


Holes position

Detail 1: Cross section A-A´



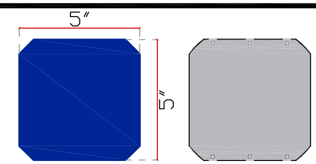
Detail 2: Junction Box



Photovoltaic glass specifications:

Module Glass-Glass:	765 x 2212 x 13,8mm
Glass dimension (mm):	765 x 2212 x 6 mm (x2)
Cell Technology:	Mono-crystalline Back contact
Cell dimension (mm):	125 x 125mm (5´´x 5´´)
Number of cells:	64 (4 strings / 16 cells per string)
Encapsulant:	EVA
Junction box:	PV-JB/WL-V MC (4 spring clamps)

CELL TYPE/DIMENSIONS:
"Mono-crystalline Back contact 5´´"



Signed by Customer:

PROJECT: **PV SITES X6(CELLS BACK CONTACT 2212X765mm 6+6)**	CUSTOMER:	QUANTITY: **48 units**
LOCATION: **ÁVILA**	ONYX DEPARTMENT: **MANUFACTURE_ONYX SOLAR**	DATE: **13/03/2018**

nº **02**

PHOTOVOLTAIC GLASS	5" Mono	2212 x 765 Crystalline Back contact
Electrical data test conditions (STC)		
Nominal peak power	192	P_{mpp} (Wp)
Open-circuit voltage	41,60	V_{oc} (V)
Short-circuit current	5,70	I_{sc} (A)
Voltage at nominal power	34,88	V_{mpp} (V)
Current at nominal power	5,49	I_{mpp} (A)
Power tolerance not to exceed	±10	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, stabilized module state.		
Mechanical description		
Minimum active length	2212	mm
Minimum active width	765	mm
Thickness	13,8	mm
Surface area	1,69	sqm
Weight	51	Kgs
Cell type	5'' Mono	Crystalline
No PV cells / Transparency degree	64	0%
Front Glass	6 mm	Tempered Glass Low-Iron
Rear Glass	6 mm	Tempered Glass
Thickness encapsulation	1,80	EVA Foils
Category / Color code		
Junction Box		
Protection	IP65	
Wiring Section	2,5 mm^2 or	4,0 mm^2
Limits		
Maximum system voltage	1000	Vsys (V)
Operating module temperature	-40…+85	°C
Temperature Coefficients		
Temperature Coefficient of Pmpp	-0,30	%/°C
Temperature Coefficient of Voc	-1,74	%/°C
Temperature Coefficient of Isc	3,50	%/°C

* All technical specifications are subject to change without notice by Onyx Solar

SPECIFICATIONS

Project: Demo 6 – BIPV Facade

Location: Spain, San Sebastian

Owner: Tecnalia (contact: Maider Machado Garcia)

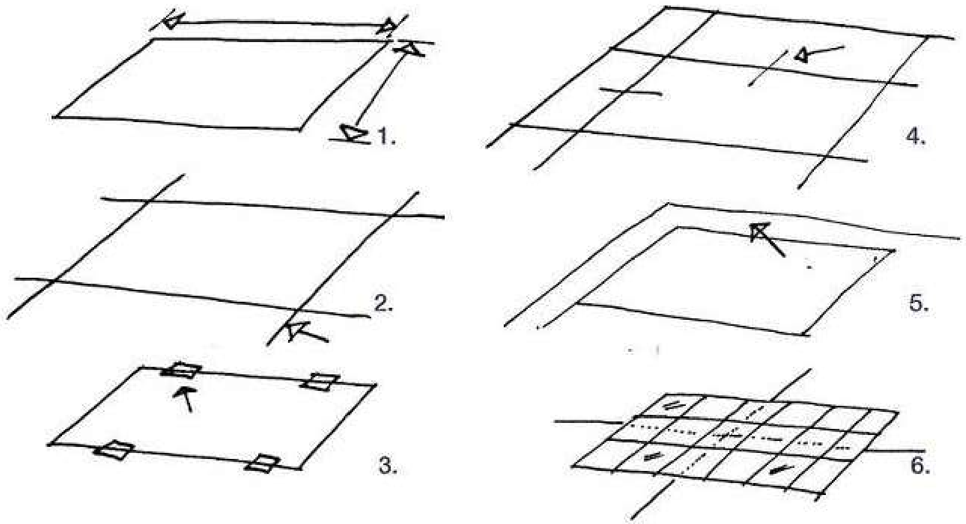
Introduction to aesthetics of the facade:
The architectural aspects of BIPV are explained in D 2.4 "Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project".
Integration of Photo-voltaic systems has the achievement:
- to combine technical functions;
- the improvement of the usability;
- to follow the proportions of the envelope or the shape of the building;
- to visual integrate this in the 'concept of the design'.

Aesthetical quality is measured by:
1. size and shape
2. joints
3. fixings
4. combination with adjacent building products
5. detailing of edges and rims
6. transparency

1. Size and shape. In general a facade or roof is seen as one large area that loose on aesthetical quality when it is randomly disturbed.
The range of module dimensions is limited. As, in general, the construction industry works on a 300 mm grid, it will be useful to choose dimensions of BIPV modules that fit to this grid.
Note: For roofs the horizontal dimensions are less flexible. Vertical dimensions have a little more flexibility.
2. Joints. The profiles (or lack of profiles) between modules are an important visual aspect. Less obvious joints or no joints will have a better aesthetical quality then contrasting profiles that emphasize the dimensions of the module more than the total dimensions of the facade or roof.
3. Fixings. The way the modules are fixed can be visible or non-visible. In general non-visible fixing will give a better aesthetical quality.
4. Combination of products. Combination with other adjacent building materials is probably the most critical aesthetical aspect. Roof modules that are combined with a strong contrasting material like red ceramic tiles have a negative impact on the aesthetical quality. The same is for facades where the adjacent material is contrasting in colour, shape, texture and dimensions. Even with the same colour, the texture or dimensions of the materials, it will have a big contrast. In general the adjacent material should be chosen within the same range of material, dimensions and colour.
5. Detailing of edges and rims. The perimeter of a roof is an important detail. In general, a roof is a simple, homogenous surface. This can also

be achieved with PV modules. But it asks for a simple detailing in the same style as the modules. Same material, same colour, same level of quality etc are essential. For the facade the connection with the roof, the edges and the wall openings are essential details.

6. Transparency. For most roofs or facades this is not an issue. But it is possible to make semi-transparent areas that combine a BIPV-roof or facade with daylight into the building.



Main aesthetical subjects

Design description:

To design a second skin for this existing facade, there are several options. The design has to balance between aspects as daylight, ventilation, view and installed power.

To reach the required capacity of 20 kWp we need around 96 modules with 64 cells each or 76 modules with 80 cells. Both are possible within the dimensions of the existing windows (2265 x 743 mm).

With higher density modules (80 cells) we can take out one row of modules at each floor for a clear outside view. With the less dense modules (64 cells) we need the full surface but there will be more equal daylight coming inside.

Besides the modules, we designed several options for the integration of the modules. Basically there are two directions:

a. Reynolds full profiles all around (see 3D drawings);

b. No profiles but a clip system (see 3D drawings with as reference the clips from SB fijaciones).

The second option looks more integrated and is chosen to go to the next step. Final installer and system is not decided.

The use of the clips has one problem to solve. The modules need at least 6 supports (3 on top and 3 at the bottom). For opaque applications it is simple to add an extra vertical profile in the middle. Because of the existing windows this is not preferred so another option is needed. This result in two possibilities:

a. horizontal profile and another type of clips. Or

b. vertical profiles like blocks that can be mounted on the existing window frames.

Both options can be found in the drawings section below.

Module description:

The modules (X6) will be produced by ONYX.

The technology is glass-glass with Si-crystalline cells and hidden bus bars.

Dimension:

Module dimensions are 2250 x 760 mm and 2212 x 765 mm for Façade A and B, respectively

Working dimensions are about 2265 x 743 mm (This are the dimensions of the existing window frames).

Materials:
Semi-transparent glass-glass modules.

Colours:
The cell colour is black and the module is semi-transparent.

Mounting system:
The mounting of the modules is done with the facade technology from HILTI and SB Fijaciones for the main metal substructure and glass anchoring elements, respectively. The substructure is based on the use of three vertical anodized aluminium profiles per module and fixing clips that hold the modules horizontally at six points. The open 'rain screen' has a space between the modules and the existing façade of approximately 20 cm. In horizontal direction the space is 25 mm and in vertical direction the space is 10 mm (clip thickness), plus 2-3 mm extra to allow the vertical thermal dilatation.

EU Standard:
The modules are BIPV products according to the European Standard EN50583-2016 "Photovoltaics in buildings".
The application is according to the mounting Category E "Externally integrated, accessible or not accessible from within the building" (EN50583-2-2016 "Photovoltaics in buildings – Part 2: BIPV systems".
Note: This standard does not take in consideration the aesthetical aspects of BIPV.

Procedure:
Building permit is needed for this type of facade.

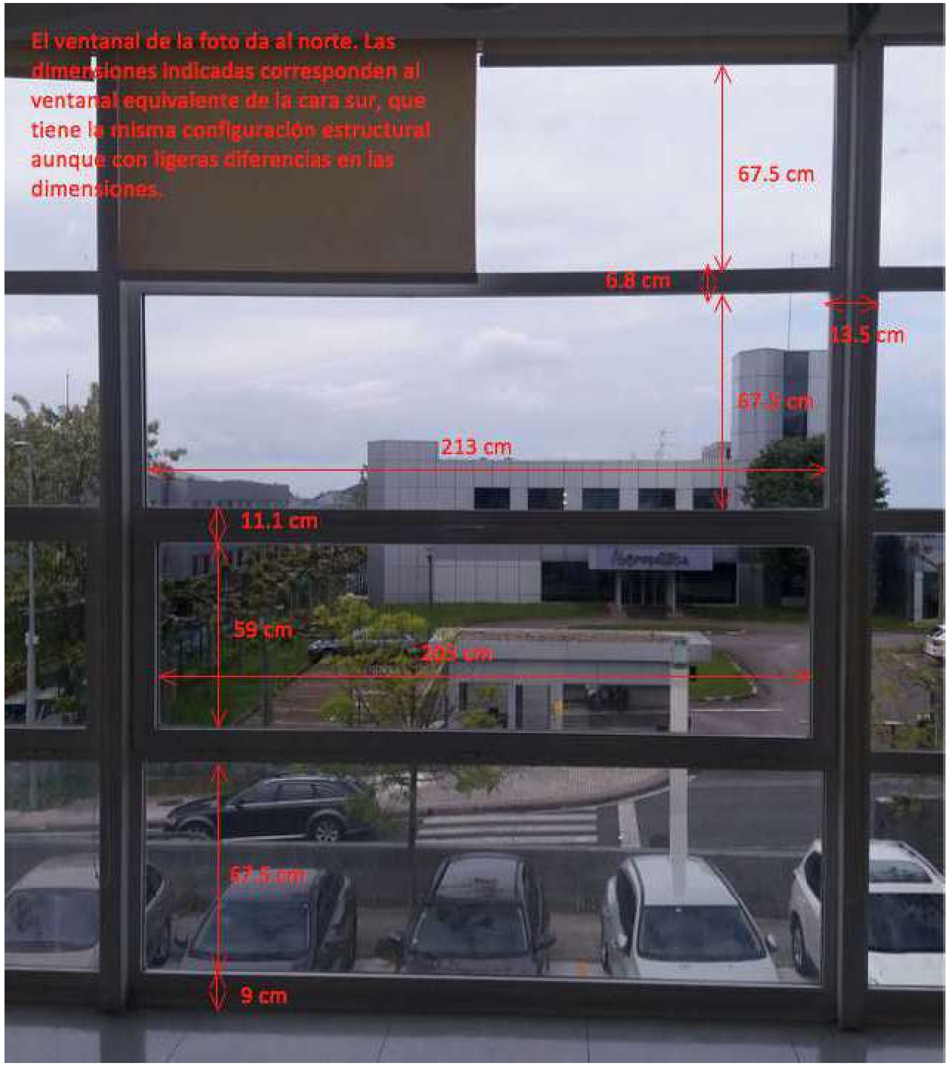
Check of BIPV quality and definition:
Good points that increase the aesthetical quality are:
- the modules form a second skin with a ventilated cavity behind the modules;
- the shape and dimensions of the modules fits to the existing window frames;
- the modules are frameless.

Points of attention are:
- the clips and substructure are very visible. Coating them in a dark colour will make them less visual.

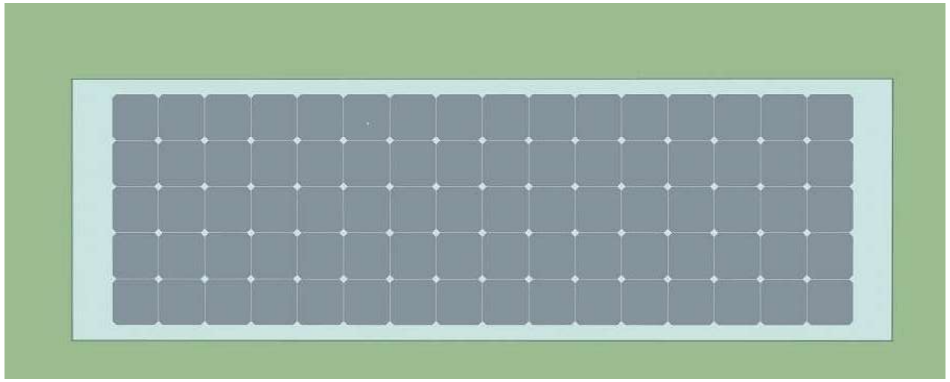
According to the EU standard EN50583-2016 "Photovoltaics in buildings" this product is a BIPV product.

PICTURES

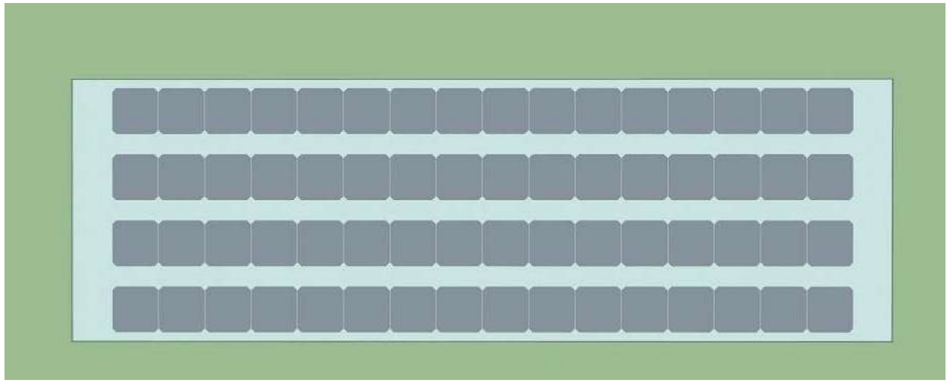
Prototype of the ONYX Module X6 (picture ONYX).



Dimensions of the existing facade

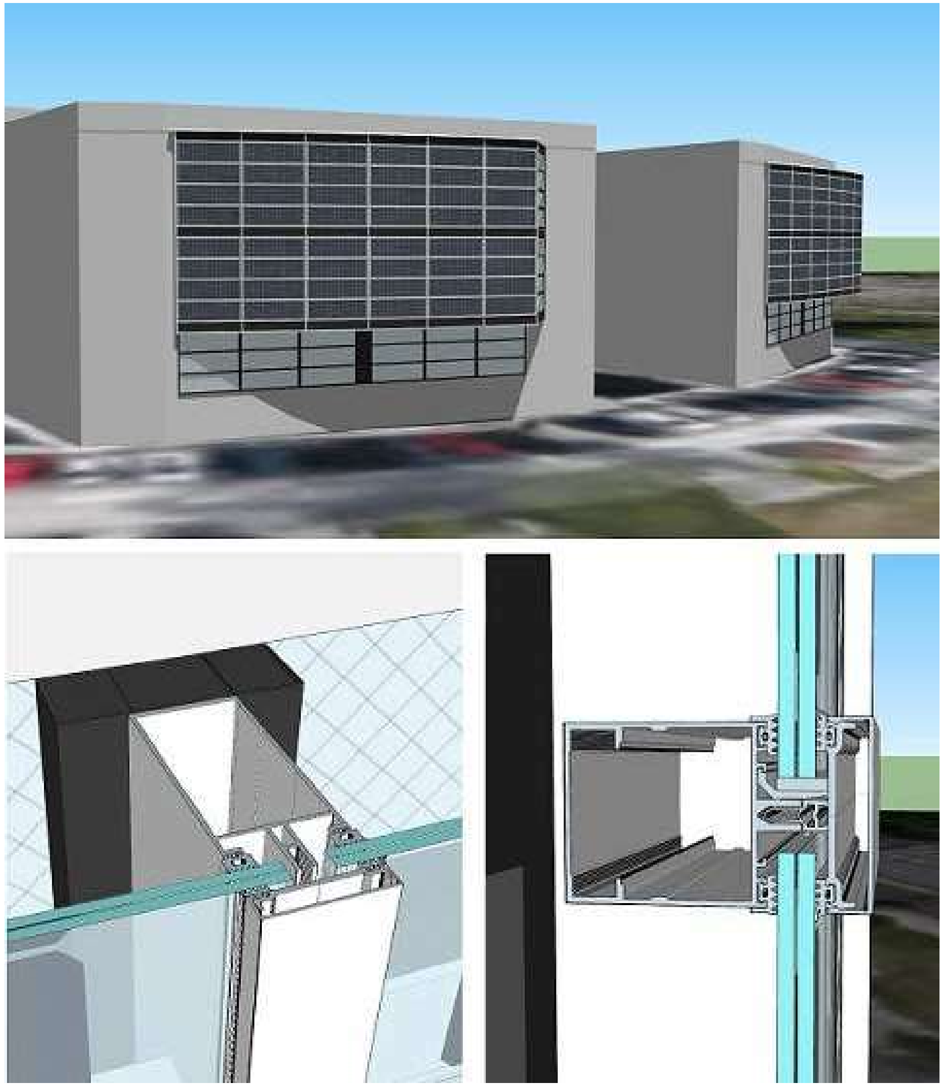


Dense module with 5 rows of 16 cells. Total of 80 cells.

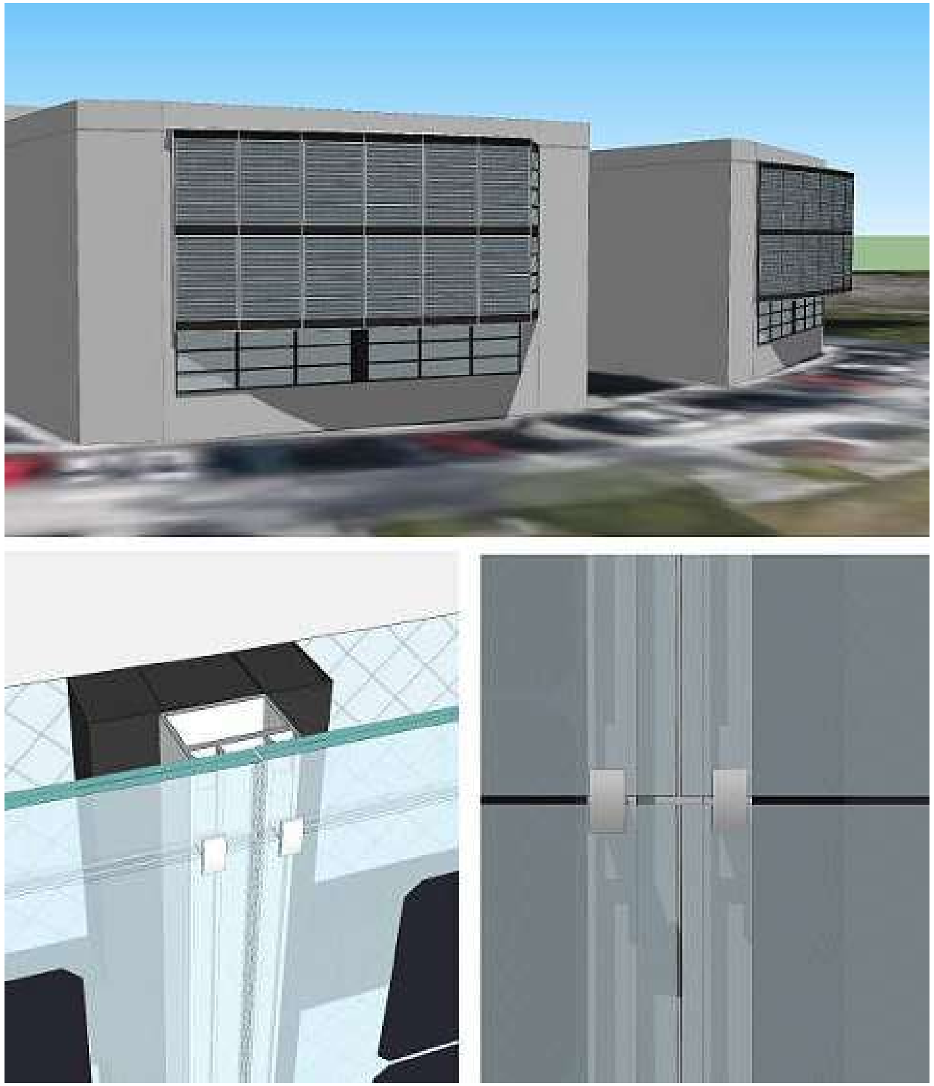


Less dense module with 4 rows of 16 cells. Total of 64 cells.

Initially considered design and installation options (finally discarded)

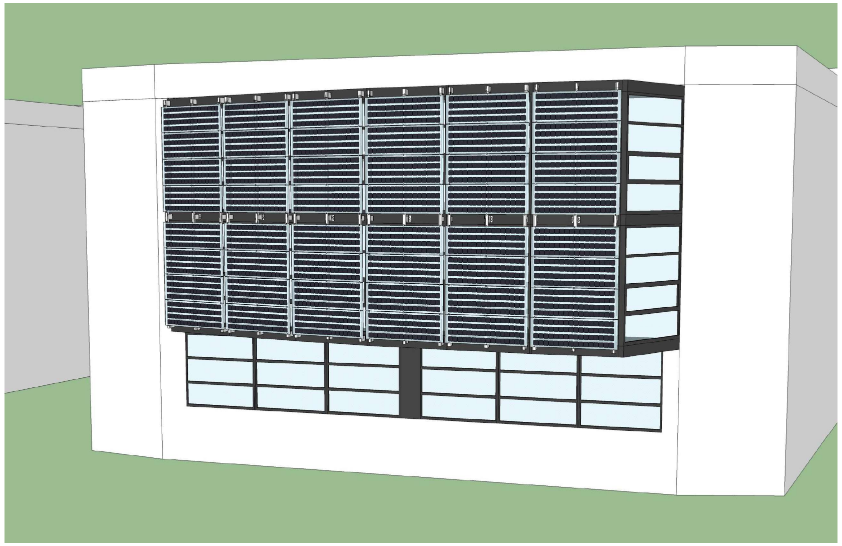


First design option (finally discarded), based on mounting with Reynolds profiles.

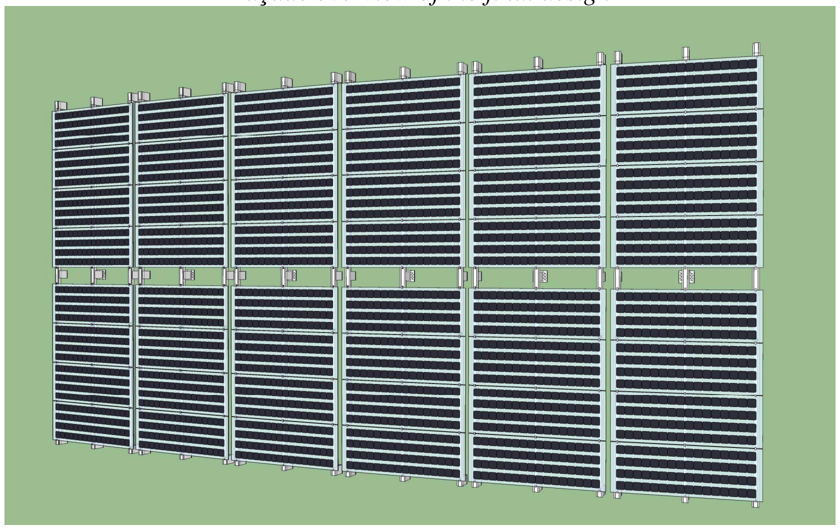


Second design option (finally discarded), based on mounting with SB Fijaciones clips.

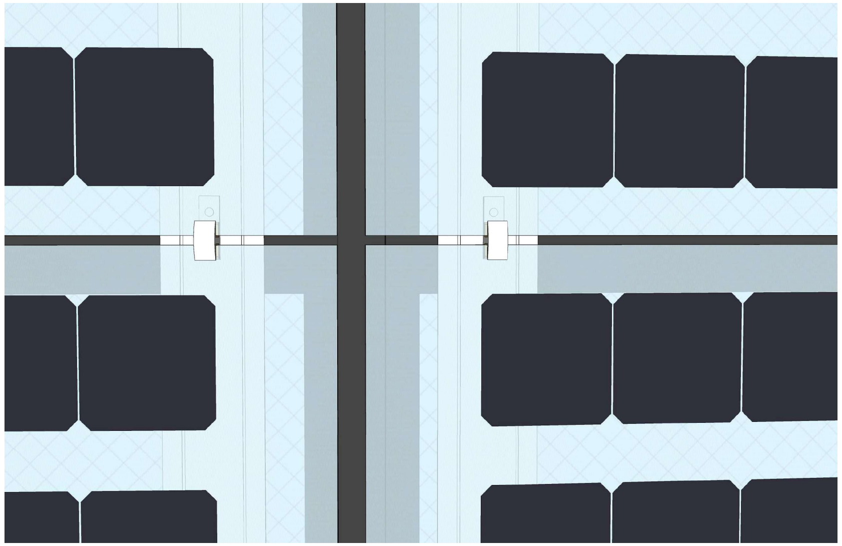
Final design and installation adopted in the real demo-building



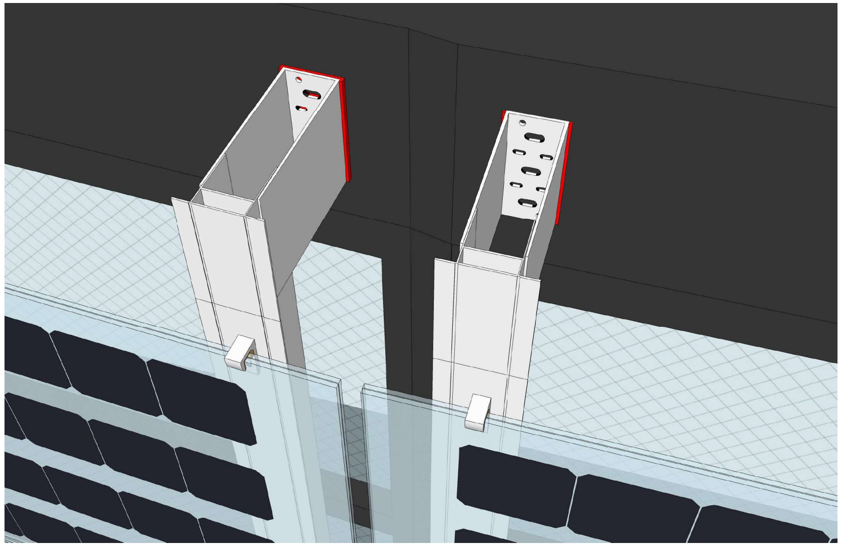
Façade overview of the final design



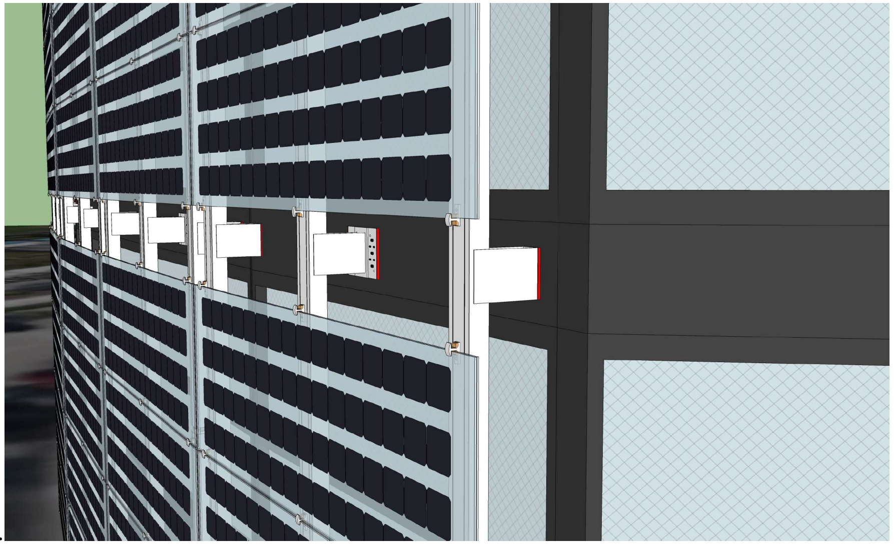
Overview with vertical profiles with SB fijaciones clips.



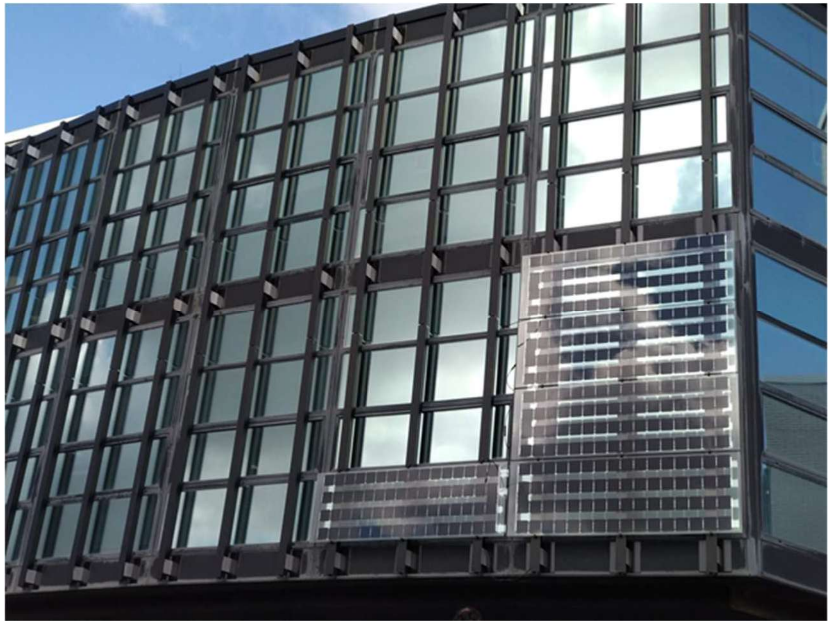
Detail with vertical profiles with SB Fijaciones clips (1)



Detail with vertical profiles with SB Fijaciones clips (2)

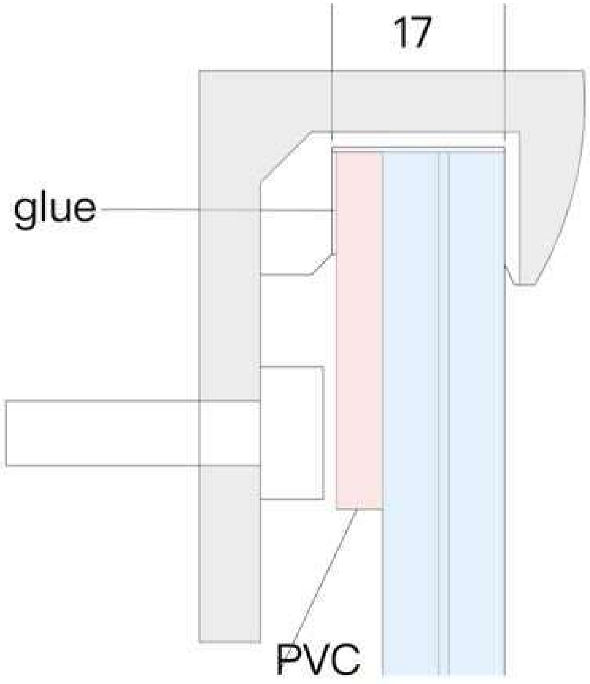


Detail with vertical profiles with SB Fijaciones clips (3)

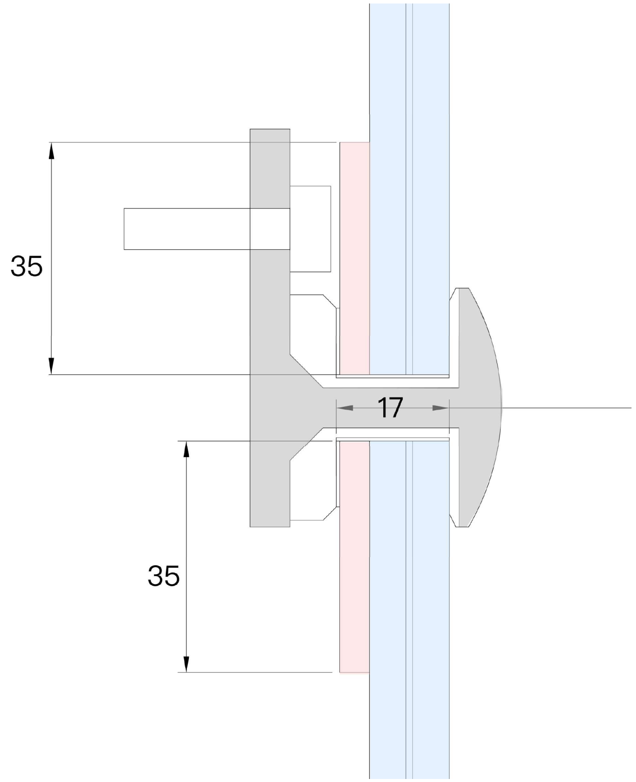


Vertical profiles with SB Fijaciones clips installed in the real demo-site

Detail of the SB Fijaciones clips installed in the vertical profiles.



Start/final SB Fijaciones clip. The use of a 3mm prop is needed to adjust the glass thickness (13.8 mm) in the clip (17 mm).



Intermediate SB Fijaciones clip. The use of a 3mm prop is needed to adjust the glass thickness (13.8 mm) in the clip (17 mm).

RELATED GUIDELINES

Guidelines related to the PVSITES modules and systems implemented in the Demo 6. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[GB6] Electrical design, operation and control strategies guideline.

[GC6] Installation, commissioning and maintenance guideline.

[GD6] Health, safety and security guideline.

SPECIFICATIONS

Modules are classified at the production line depending on their power. They are already prepared to be connected in series or in parallel.

Series or parallel assembly

- The configuration will depend on the voltage required. If a high voltage is required we will connect the modules in series because final voltage will be $V = V1 + V2 + (\ldots) Vn$, and the intensity value $I = I1 = I2 = (\ldots) = In$.
- If on the other hand we are interested in obtaining high current intensities we will go for a connection in parallel: $I = I1 + I2 + (\ldots) + In$, and final voltage $V = V1 = V2 = (\ldots) = Vn$.
- The maximum recommended configuration for modules connected in series is 1000V voltage (600V for USA). Isolation is guaranteed up to this voltage.
- In a parallel connection you can connect as many modules as the gadget to which it is connected admits (i.e.: inverter, combiner box, regulator or other suitable equipment).
- Always use suitable cables: high voltages or currents can produce short-circuit and degrade them by overheating. Please follow local/national electrical codes.
- Please read carefully the manual of all additional equipment needed in a PV system such as inverters, regulator, batteries, etc. Recommendations of the manufacturers must be followed.
- Protections: For certain BOS and applications (especially BOS for thin film technology) it would be necessary the integration of short-circuit current limiting fuses per a given number of strings to increase electrical safety and optimized maintenance.

BIPV units must be connected and interconnected by an electrical installer with proven experience in PV installations and low-voltage systems. The PV installation design must be certified by a registered professional electrical engineer. The PV BOS design and installation procedure must comply with local codes and requirements from all relevant authorities.

PV systems, as any electrical devices, require good ventilation ensuring proper thermal dispersion. Any solution preventing the aforementioned as: as silicone sealed of wiring, wrong cabling tubing de-ratio values, improper wiring tubing sections, etc. must be avoided.

Junction Box

Onyx Solar PV glasses are designed allowing different Junction Box (JB) implementation depending on each product type, standard or customized. JB can be placed at any point in the rear glass, can be welding or no-potting compatible, and can hold a variable number of by-pass diodes.

In the case of edge junction boxes, the Junction Boxes are designed to be run within a structure as aluminium/steel frames allowing both, good ventilation and absence of moisture. Direct exposure to external outdoors conditions should be avoided.

As general characteristics it should be pointed out that any JB system used by Onyx shows IP-65 protection grade.

In the case of crystalline technologies, Onyx Solar usually uses the following junction box:

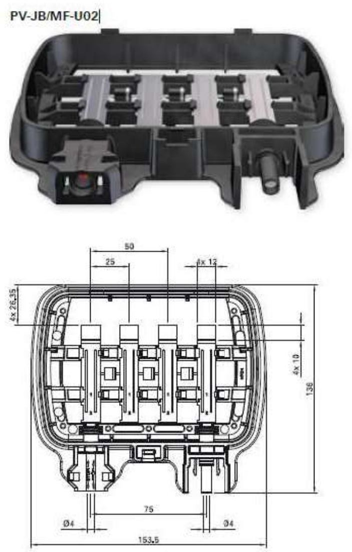


Fig. 1: Multi-contact Junction Box

Wiring

Onyx Solar uses wiring classified as solar wiring with variable length, and sections from 2,5 to 4mm2 (AWG 14, 12). These sections allow:

- Nominal current: 42 A.
- Nominal voltage: 600/ 1000 VAC 1800 VDC.
- Max Acceptable Operating Temperature: from -40 to 85 ºC.

Module Orientation, tilt and layout

Location Analysis: the access and security of the location where the PV glass are to be installed and the surface must be analysed in detail, specially orientation and shadows that may appear over the surface must be studied in order to design an installation that offers the highest output.

In order to maximize the power generation of the system, the Solar PV array should be orientated between south-east and south-west. It is not absolutely necessary for the array to face due south. There will be only a small percentage power loss, as a result of moving a few degrees east or west of south. In many cases, the proposed Solar PV array orientation and tilt are determined by the design and location of the building. The modules layout can be either vertical or horizontal, depending on different factors (mounting system, surface, etc.).

The performance of PV panels is also affected by the shading effect due to trees, passing of clouds, neighbouring buildings and any other means. So it is mandatory to ensure the installation of the modules where they can receive an adequate sun exposure.

Orientation, tilt and layout of the module in the PVSITES Demo-system 6:

- Location: south façade
- Tilt: 90°
- Orientation: S façade, -1° (...) +4°; SE façade, -31° (...) -36°
- Position: horizontal.

Electrical diagram

The following one-line diagram (Figure 2) shows the final electric configuration of the Demo site 2 in San Sebastian (Spain). The main characteristics are described below:

- Cells array: 16 x 4 cells (5″ c-Si) per module (41% transparency).
- Solar layout: 12 strings with 8 modules on E façade (96 modules).
- Dimensions: 2250 x 750 mm
- Module power = 191,5 Wp.
- System power = 18,40 kWp.

Energy management

The power generated will be injected to the grid under a self-consumption scheme with a zero grid injection equipment: so that, an EMS will not be needed.

ELECTRICAL DIAGRAMS

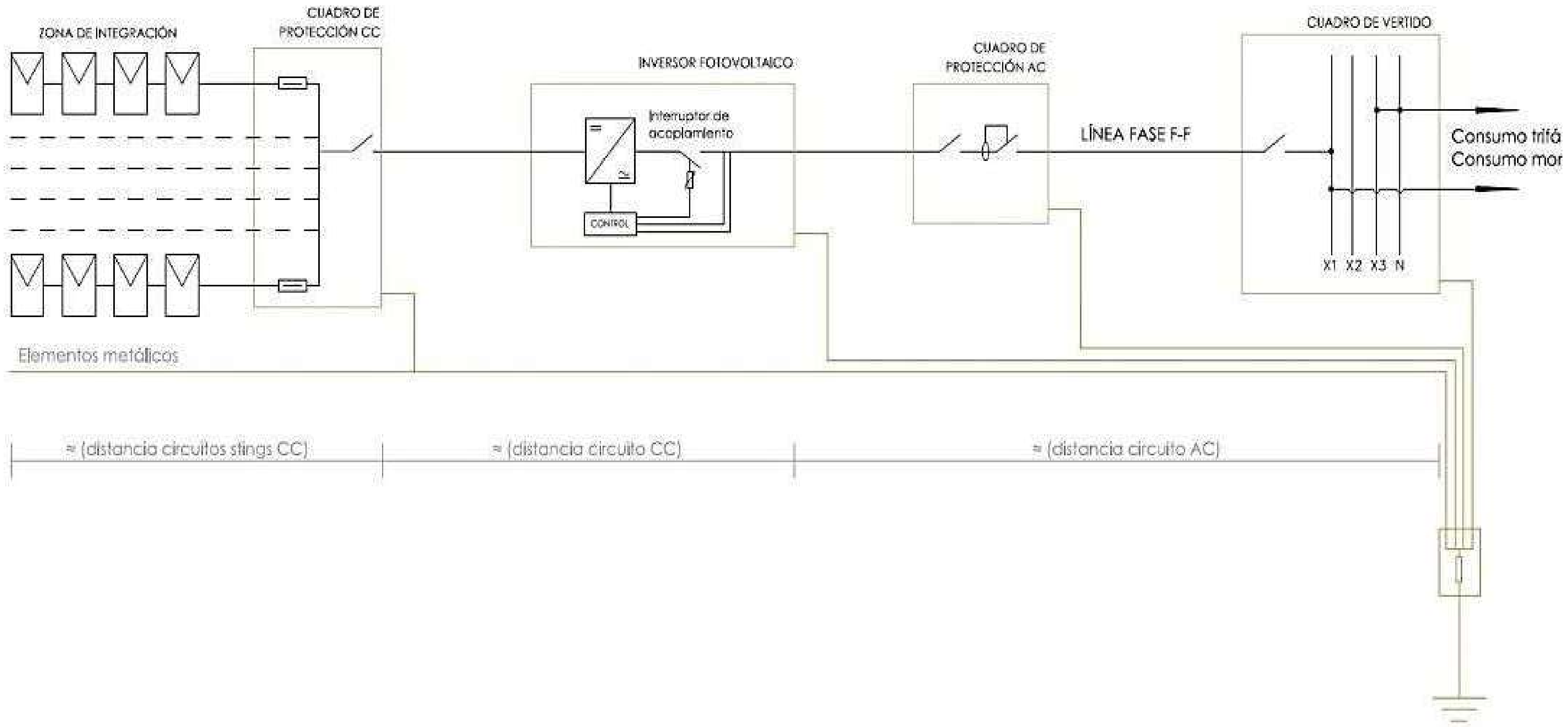


Fig. 1: Direct connection to building inner grid for self-consumption and without storage (strategy adopted for the Demo-system 6 in TECNALIA's building)

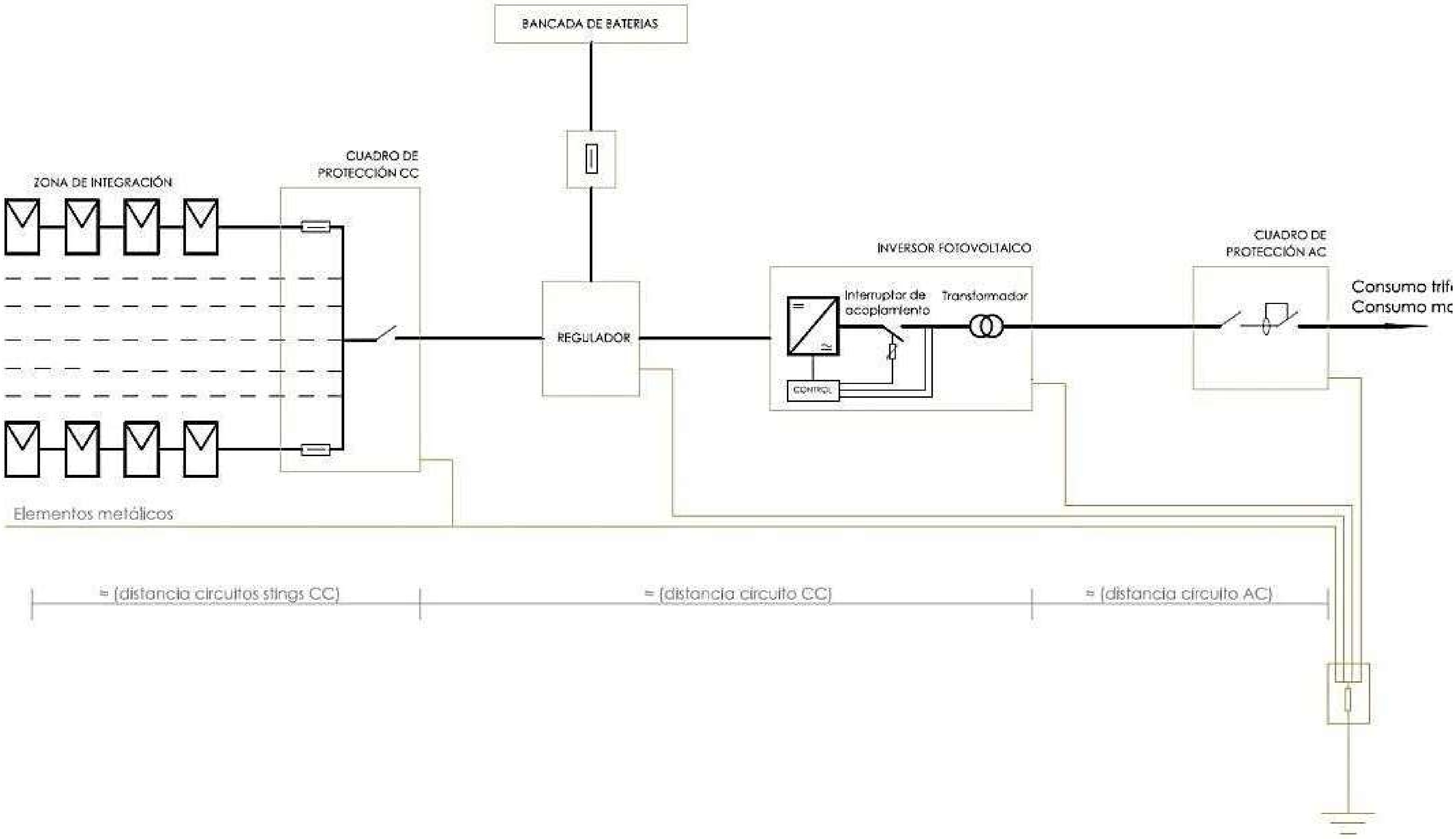


Fig. 2: Stand-alone/Self consumption with battery storage of the generated energy

RELATED DATA-SHEET AND GUIDELINES

Module data-sheet and guidelines related to the PVSITES modules and systems implemented in the Demo 6. Any system designed based on these products has to comply all these specifications in order to guarantee the project feasibility.

[DS6] Module data-sheet

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SPECIFICATIONS

Installation

- The support structure must bear all possible mechanical loads (wind, snow…), calculated according to the region where it would be located and satisfying the local Building Codes. Both structure and supports must be of a very resistant material such as stainless steel, galvanized iron or anodized aluminium.
- Structural systems to integrate the PV glass in façades, canopies and skylights: for this type of installation it is required fixing structures in stainless steel, galvanized iron or anodized aluminium adapted to allow an easy fixing and maintenance over any main structure being wooden, tailed or made of steel. Typically used structural systems consist in primary and secondary structures are shown below:
  - Profile of galvanized steel with frame, presser, adaptable excluder and aluminium lid. EPDM Joints in contact with triple or double laminated BIPV glass units.
  - Profile with anodized aluminium frame. EPDM joints and dividers for the laminated glass and structural silicon for waterproof.
  - Profile with anodized aluminium frame. EPDF joints and dividers for the laminated glass and screwed anodized aluminium lid with silicon for waterproof.
  - Profile with anodized aluminium frame of rectangular tube. EPDF joints and metallic divides for the glass and structural silicon.
  - Profiles designed in galvanized steel or aluminium for IGU (insulating Glass Units) and adapted by means of offset to hold the connections of the PV glass.
  - Vertical structure for PV ventilated façades

Commissioning

The main aspects to be considered can be summarized as follows:

- A minimum power installed capacity must be achieved in order to get the proper performance of the solar inverter or solar controller, or what is the same, a minimum surface of integration is needed in order to build up a technically effective system. This active surface will vary depending on the technology used and the building integration conditions (tilt, orientation, shadows/shades, building surround).
- It is mandatory that the BIPV connected to a single investor or regulator, share the same technology showing identical electrical characteristics although slight difference in dimensions (note:*there may be a possibility of compatibility even while not being the equal when the electrical parameters are proportional between each other).
- Photovoltaic elements connected to the same solar inverter or solar controller should have the same orientation and tilt angle in order to work all of them in similar conditions and not having some penalized by others.

Failure to meet any of these points implies a highly complex installation design analysis to in order to be able to provide minimum operation guarantees. Each of these cases should be managed independently. For instance, depending on the power installed two frames of design can be selected:

- For large installed power PV system: several three-phase inverters showing each one several independent entries allows to perform and manage energy of different powers coming from highly different strings of PV modules with different power rate, orientation, or tilted position.

- For small BIPV integrations: there are low power inverters, however as lower as the installed power is the harder it gets to find a suitable solution that can meet the ranges of operation.

Mainly there are three ways of connecting a photovoltaic system to other utilities. This will conditioned the way the generated energy is managed: direct connection to building inner grid for self-consumption and without storage, grid-connected PV system feeding energy to the utility grid, stand-alone/Self consumption with battery storage of the generated energy.

The minimum parameters required are determined by the type of installation, since depending on this, the key equipment and elements might vary (from inverter to a charge controller/regulator, type of protections, etc.).

- Direct connection to building inner grid for self-consumption and without storage (see the electrical diagram of the Figure 1). The purpose of this kind of PV system installation is to consume in the building instantly the energy that is generated in the PV system. The basic elements that form it are the photovoltaic modules, the solar power inverter and the AC protection switchboard where the energy generated is poured. The inner grid to which the solar installation will be connected will always be of alternating nature (AC) so the connection can be performed in single or three phase system depending on the needs of use.
- Grid-connected PV system feeding energy to the utility grid. In this kind of photovoltaic installation, the generated energy is not directly consumed, but it is feed into the Utility Grid regardless of the energy consumed and the incentives or compensations that the Utility Company/Local Government can provide (feed-in tariffs). The basic elements that form this installation are the photovoltaic modules, the solar inverter and the measurement equipment to control the energy balance (net metering) with which you want to pour the energy generated. (The one-line schematic design is essentially similar to the previous case).
- Stand-alone/Self consumption with battery storage of the generated energy (see the electrical diagram of the Figure 2). The purpose of the installation with is to store the energy produced during a given time of the day to be able to use it when it is needed regardless of the instantaneous production. The basic elements that form this installation are the photovoltaic modules, the charge controller, the battery or UPS system, the solar inverter and the AC protection switchboard. If the final energy use is to be performed in DC, you can disregard the inverter.

To understand the simplicity of the elements composing the PV system it should be noted that the BIPV units , regardless of its kind, is an element that should be treated as any conventional building element since its structural characteristics do not differ from any other type of glazing. As for the electrical part is concerned, any qualified electric installer can do following a wiring diagram and a one-line electrical scheme, being the BOS similar to other low-voltage electrical installations.

The steps to integrate a photovoltaic system are the following; you must first make a study based on the needs and requirements of the client to create an economic and technically feasible integration solution, second you should have a preliminary study to see if the place which is going to support the installation is the right one, then the interconnection of glasses and number of strings are designed leading to final and appropriate voltages and currents to be connected to the inverter, the solar inverters are chosen according to the electrical values, parameters and operating ranges. The wiring sections and protections are selected on the bases of local codes and calculated over-currents values. After all the elements are selected on the basis of design, the performance of work on-site is like any other electrical installation. Finally, once all elements are interconnected to the grid/consumption point, ramping-up can take place and all the needed tests and commissioning process can be carried out.

Maintenance

Preventive maintenance should take place at least twice a year. Key elements should be checked and verified. The minimum actions to be considered are:

- Checking system connections.
- Checking cable system especially if it has been in the sun or in bad weather conditions that can produce corrosion; cracks may appear on the covering which can produce energy loss.
- Checking the sealing of the j-boxes, even if there is a time lapse they should still be sealed and no corroded due to water.
- Checking all structural pieces in the structure that supports the photovoltaic modules to search for losses.
- Checking if any glass may be fractured. If so contact the supplier and change the module.
- Checking all segments of the BOS.
- Checking all earth connections

Cleaning of the PV glazing is similar to equivalent glazing systems. Nevertheless, special care should be taken not to affect the PV sealants or connections.

Mainly rain eliminates the necessity to clean de panels. If needed, clean the surfaces with a mixture of neutral detergent and water. It is recommended using dissolution in water and neutral detergent with 3% of ammonia and a surfactant.

Typical cleaning tool for glass as rubber brush could be used in order to clean the PV module avoiding any scratch on the glass.

ELECTRICAL DIAGRAMS

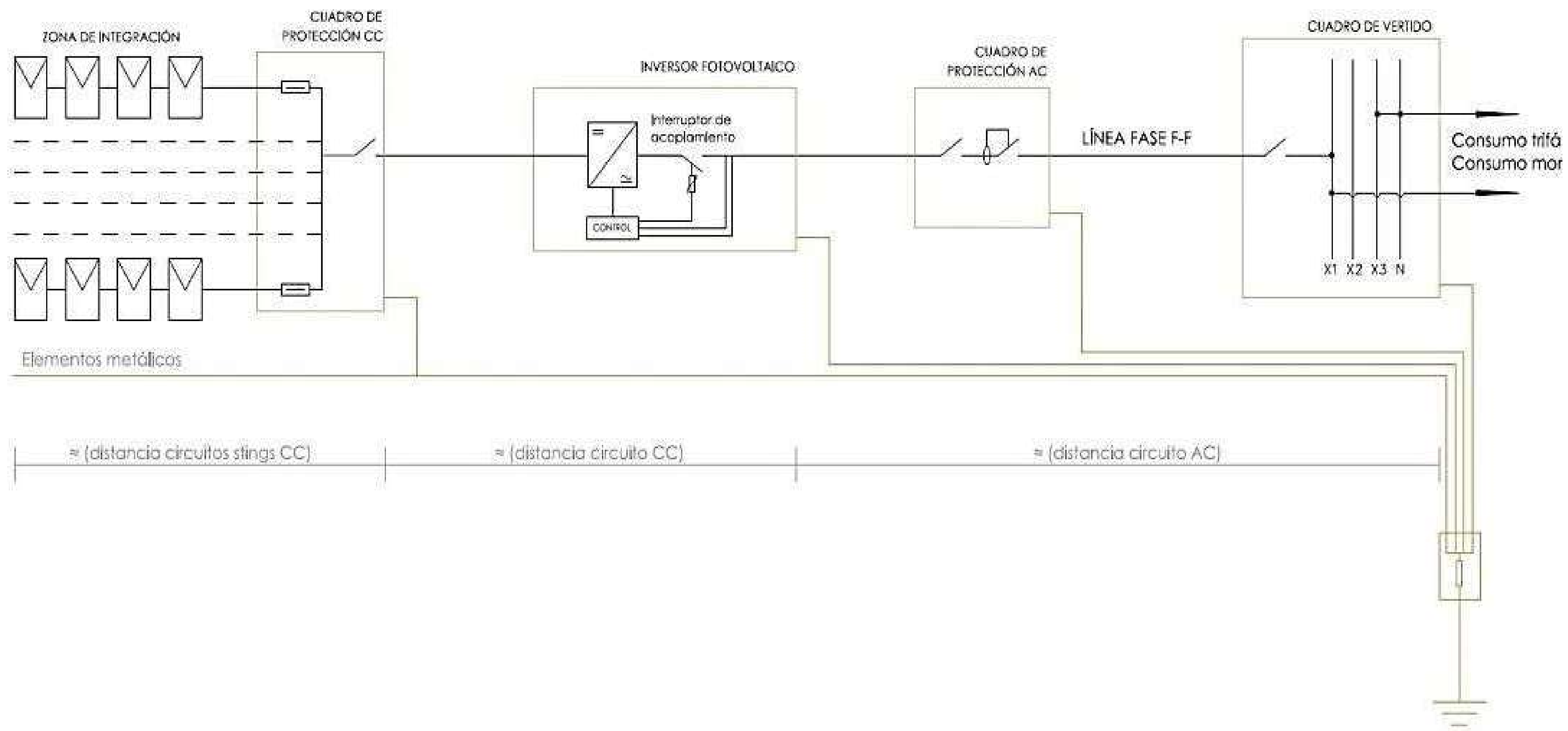

Fig. 1: Direct connection to building inner grid for self-consumption and without storage (strategy adopted for the Demo-system 6 in TECNALIA's building)

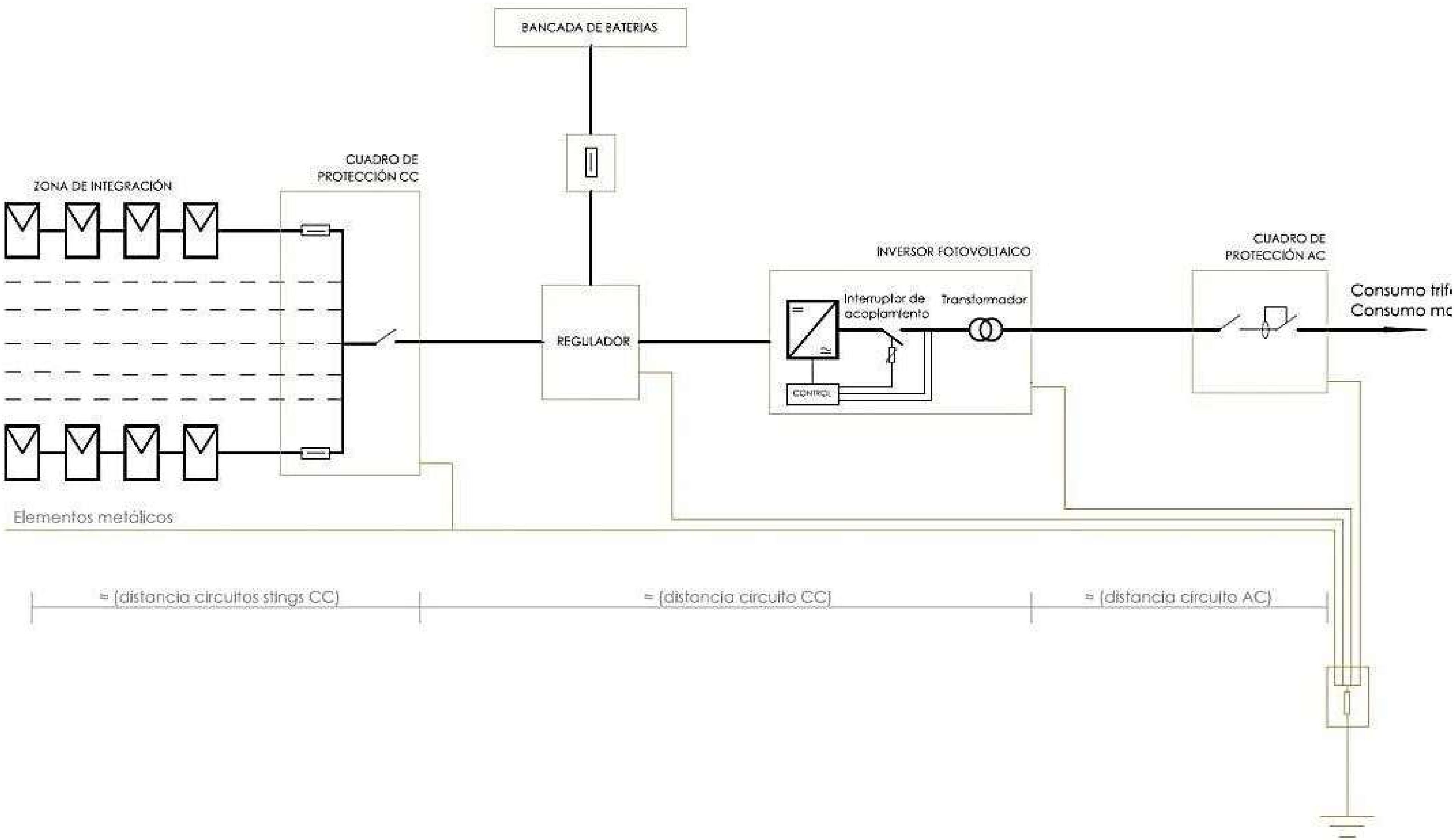

Fig. 2: Stand-alone/Self consumption with battery storage of the generated energy

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SPECIFICATIONS

Mechanical and electrical recommendations

Photovoltaic glasses as solar panels produce direct current. If one of them is exposed to the light of sun it may produce electric shock or burns. This risk increases when various modules are interconnected. For this it is mandatory to handle with care, always use suitable protection equipment using gloves and pole detection. Other equipment that forms the final group of a photovoltaic installation such as batteries, inverters and photovoltaic regulators can also mean risk. Photovoltaic glasses can weigh up to 120 Kg/sqm and must be replaced following a suitable safety plan and in the same way they were installed: lifted one by one with the support of assistant machinery and a suction cup (vacuum lifter system) as rigging system. From these statements can be formulated the following general recommendations:

- Cover the front side of the modules with opaque material and stick with adhesive tape. This way voltage in the cells will be suppressed. Never eliminate voltage of the modules by short-circuit.
- Installation and future connection of modules must be done by a qualified electrician or under supervision of a authorized person.
- The installation must take place under suitable weather conditions (avoid rain, snow…) in order to avoid electric shocks.
- Only use suitable tools to work on electrical installations, covered with insulating material.
- As values of the electrical characteristic have been calculated under standard measuring conditions according to UNE- EN 61215 Norm (1000W/m2, AM 1.5, 25°C), there may be the case that a higher voltage with respect to the stipulated can be produced. For this reason equipment such as regulators or cables must be prepared to support this possible increase. For limit temperature cases the limit value for the correction factor is 1,25.
- All equipment, junction boxes, cables must be suitable for photovoltaic installations. Never touch bare wires. If cables are not to be connected immediately insulate them for protection. Never manipulate junction boxes extracting for instance the diodes placed by the manufacturer.
- Never try modifying the electronic set up of the junction boxes or take out for example the protection diodes.
- Modules must never be installed or manipulated near places where flammable gases are easily developed, sparks can be produced.
- Keep children away from the photovoltaic modules.
- The Photovoltaic glass must be fully disconnected from its next modules before any replacement.
- You must pay special attention to the packaging, storage and posterior transportation, following these manual recommendations.
- There is risk of fall while installing the modules on the structure, for these reason workers must wear the necessary security

systems such as harness, gloves or adequate footwear.

To avoid any type of risk while assembling the system, whether isolated or for grid connection, all elements, including structure, must be earth connected. It is installer's responsibility to find the most suitable earth system based in washers/screws system, clamps, etc. Any galvanization effect should be avoided.

Use specific connectors for photovoltaic panels.

Never disconnect nor connect while the circuit is loaded.

Disconnected connectors should be protected from filth and water.

Handling and packaging recommendations

You must pay special attention to the packaging, storage and posterior transportation, well tying the modules up because the glass could fracture and it would become useless. To avoid any torsion, modules must be packaged in vertical position.

First and last module in the crate must have their front side looking out.

The rest of modules must be back to back.

If rear JBs, they must be alternated one up one down in the package. The rest of the back side of the module must be covered by a sheet of polystyrene with an adequate thickness.

The front sides of the modules facing the inside will be separated by polystyrene or plastic in order to protect the glass..

All modules must be covered with polystyrene and positioned between woods.

The boxes and or crates can be wooden and/or cardboard based.

Do not dismantle the module in any case, nor extract any incorporated component.

Do not walk on the module.

The panel is a physical body that supports certain voltage, distortion, torsion…regulated by the competent norms but during installation and without acknowledge of these norms it is recommendable to take certain precautions. The panel must be transported being held from the longest sides to avoid non desirable torsion effects.

Never bang the panel on any of its sides, especially the angles.

Maintenance and cleaning recommendations

Never clean the glass with pressurized water nor abrasives that can damage the panel.

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