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

Templates for a technical description of the PVSITES BIPV products portfolio - Second version-

Project report

BEAR TECNALIA, FLISOM, NOBATEK, ONYX, CEA

March 2017

Summary

The present document constitutes the second deliverable on PVSITES BIPV products portfolio. All the products and families of products demonstrated in the project will form part of a BIPV products portfolio which will be available in different formats. A first implementation will consist in an online matrix whose elements will be each product and its related information. Secondly, each product will be turned into a BIM object (WP7 BIPV software tool) and will constitute an input data for the BIPV software tool to be developed in WP7. Third, the collection of products and product information will be the basis for dissemination materials (physical catalogues, flyers, etc.), to be developed in WP9 Dissemination and communication. This deliverable gathers the necessary contents about the products, after a first deliverable (D2.6 Templates for a technical description of the PVSITES BIPV products portfolio - First version) in which the structure of the portfolio was established. This gathering will be progressively updated if new information becomes available. This document will be further updated in D2.8 (Month 36). The actual implementation of the online tool will take place as part of WP9 between months 36 and 42.

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.

The present report was mainly prepared by PVSITES project partner BEAR, with additional contributions from TECNALIA, FLISOM, NOBATEK, ONYX and CEA The report was originally submitted to the European Commission as Project Deliverable D2.7 in March 2017.

Disclaimer

About the PVSITES project

PVSITES is an international collaboration co-funded by the European Union under the Horizon 2020 Research and Innovation program. It originated from the realisation that although building-integrated photovoltaics (BIPV) should have a major role to play in the ongoing transition towards nearly zero energy buildings (nZEBs) in Europe, the technology in new constructions has not yet happened. The cause of this limited deployment can be summarised as a mismatch between the BIPV products on offer and prevailing market demands and regulations.

The main objective of the PVSITES project is therefore to drive BIPV technology to a large market deployment by demonstrating an ambitious portfolio of building integrated solar technologies and systems, giving a forceful, reliable answer to the market requirements identified by the industrial members of the consortium in their day-to-day activity.

Coordinated by project partner Tecnalia, the PVSITES consortium started work in January 2016 and will be active for 3.5 years, until June 2019. This document is part of a series of public reports summarising the consortium's activities and findings, available for download on the project's website at www.pvsites.eu.

The PVSITES consortium:

Tecnalia Research & Innovation	**CTCV**	**FormatD2**
Onyx Solar	**Flisom**	**Vilogia**
BEAR-iD	**Cricursa**	**R2M Solution Research to Market**
Nobatek	**CEA**	**CADCAMation**
Film Optics	**Acciona Infraestructuras**	**WIP - Renewable Energies**

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1 EXECUTIVE SUMMARY

1.1 Description of the deliverable content and purpose

The present document constitutes the second deliverable on PVSITES BIPV products portfolio. All the products and families of products demonstrated in the project will form part of a BIPV products portfolio which will be available in different formats. A first implementation will consist in an online matrix whose elements will be each product and its related information. Secondly, each product will be turned into a BIM object (WP7 BIPV software tool) and will constitute an input data for the BIPV software tool to be developed in WP7. Third, the collection of products and product information will be the basis for dissemination materials (physical catalogues, flyers, etc.), to be developed in WP9 Dissemination and communication. This deliverable gathers the necessary contents about the products, after a first deliverable (D2.6 Templates for a technical description of the PVSITES BIPV products portfolio - First version) in which the structure of the portfolio was established. This gathering will be progressively updated if new information becomes available. This document will be further updated in D2.8 (Month 36). The actual implementation of the online tool will take place as part of WP9 between months 36 and 42.

This first document contains the relevant information about the BIPV products (modules and inverters) provided by the partners with a basis on the templates set in D2.6.

1.2 Relation with other activities in the project

Table 1.1 depicts the main links of this deliverable to other activities (work packages, tasks, deliverables, etc.) within PVSITES project. The table should be considered along with the current document for further understanding of the deliverable contents and purpose.

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

Project activity	Relation with current deliverable
WP2	D2.6 established the relevant templates for the information gathering performed in this document.
WP3, WP4, WP5	The direct information about the products comes from the development and simulation phases in WP3 and WP4 (for c-Si and thin film products respectively) and WP5 (for inverters).
WP7	The information collected will also fed the creation of BIM objects within WP7.
WP9	Within WP9, the actual implementation of the portfolio tool will be performed.

1.3 Reference material

Grant Agreement PVSITES project, 691768

D2.1: Technical specifications for BIPV modules

D2.5: Specifications for energy conversion and management systems

D2.6: Structure, contents and operation mechanisms of BIPV products portfolio

1.4 Abbreviation list

BIPV: Building-integrated photovoltaics

CIGS: Copper Indium Gallium (di) Selenide

C-Si: Crystalline silicon

PV: Photovoltaics

WP: Work Package

Bc: Bare cell

Tz: Transparent zone

Cz: Cell zone

2 INTRODUCTION

2.1 BIPV products portfolio online tool

As explained above, all the products and families of products demonstrated in the project will form part of a BIPV products portfolio which will be available on different formats. A first implementation will consist in an online matrix whose elements will be each product and all its related information. Secondly, each product will be turned into a BIM object (WP7) and will constitute an input data for the BIPV software tool to be developed in WP7. Third, the collection of products and product information will be the basis for dissemination materials to be developed in WP9.

The portfolio contains all the information available on the product: PV technology, nominal power, possible architectural applications, customization, life cycle, price, etc. As for operation mechanisms, it will implement a search tool in order to select the optimum product at project design level; it will perform preliminary production estimates as a function of location, orientation, tilt, etc. to facilitate a first evaluation of economic viability (though more accurate, project specific predictions will be available through BIPV software tool, WP7). This tool will also contribute to the labour of the installation professionals by means of setting up maintenance and dismantling guidelines within the portfolio. Task 2.1, as well as work packages focused on BIPV systems technology (WP 3, 4, 5 and 6), lifecycle analysis and demonstration activities (WP8) will feed from this portfolio and self-consistently provide feedback to it.

The online portfolio and the BIPV software tool to be developed in WP7 are highly complementary in the sense that the portfolio will provide general information, data sheets and some degree of optimization and customization by the user (project design architects), while the BIPV software will allow detailed calculations on the performance of both the BIPV systems and the building in specific integration works, together with detailed analysis of economic viability. Final users of the software are design architects, thermal engineers, installers, construction products manufacturers, etc.

Protocols will be defined in order to add, correct, delete and comment information in the portfolio to improve contents and search methods. The selection of structure, contents and operational protocols will be performed by BEAR, Onyx, Flisom, Nobatek and TECNALIA. The specific gathering of information to be fed into the tool has been the responsibility of TECNALIA. A further report on operation mechanisms will be issued (D2.8, month 36). The specific implementation of the online portfolio will be made by in WP9, as part of dissemination & communication activities.

3 PRODUCTS AND TEMPLATES

3.1 Structure

The technical templates for the BIPV modules (products X1 to X12) are structured in 11 groups of information:

- General description, design and materials of BIPV modules.
- Mechanical performance of BIPV modules.
- Architectural integration of BIPV modules.
- Electrical performance of BIPV modules.
- Thermal performance of BIPV modules.
- Optical performance of BIPV modules.
- Estimation of PV production of BIPV modules.
- Simulation of passive performance of BIPV modules.
- Maintenance and dismantling.
- Life cycle assessment.
- Economical evaluation of BIPV products.

For inverters (X13 and X14), 6 different templates have been generated:

- General description and design.
- Installation.
- Electrical performance.
- Monitoring and control.
- Maintenance and dismantling.
- Life cycle assessment.

Each template has been filled with the most relevant information about PVSITES BIPV modules and inverters. This information will be updated in the M25-M36 period and the operation mechanisms for the portfolio will be defined (D2.8).

Table 3.1 depicts the BIPV products within PVSITES project which are covered by this document. Note that during the development process X2 and X4 were combined. To avoid misunderstanding, the numbers already given to the products have not been changed.

Table 3.1: Overview of PVSITES products

Code	Product	Manufacturer	Demo site	Implementation	Test bench
X1a	eRoof - CIGS roofing shingle on metal substrate	Flisom	Demonstrated in a single-detached dwelling – Belgium (D1)	Roof	
X1b	eCarport - CIGS roofing module on metal substrate	Flisom	Demonstrated on a carport – Zürich, Switzerland (D3)	Roof	

X2	eFacade - CIGS large area flexible roofing membrane and bendable elements	Flisom	Demonstrated in a façade – Geneva, Switzerland (D2)	Façade	
X3	eFlex-HiLo - CIGS for building roofs and vehicle integration	Flisom		Roof	NEST
X4	eRoof - Industrial - CIGS large area flexible roofing membrane and bendable elements	Flisom	Demonstrated in an industrial roof in Barcelona, Spain (D4)	Roof (façade)	
X5	C-Si glazed products with hidden bus bars and L interconnections	Onyx	Demonstrated in a residential building – Lille, France (D5)	Facade	
X6	Glass-glass products with back contact c-Si cells	Onyx	Demonstrated in an office building – San Sebastian, Spain (D6)	Facade	
X7	Curved glass-glass, CIGS technology	Onyx			CEA
X8	Framing system for c-Si large area glass	Onyx			CEA
X9	C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration	Onyx, Tecnalia, Film Optics		Roof	CEA
X10	This product is discarded.				
X11	C-Si semitransparent low concentration and Solar control BIPV system – shading element configuration	Onyx, Tecnalia, Film Optics	-	Facade	ACCIONA
X12	Glazed modules treated for improved passive properties	Onyx	-		-
X13	Inverter with storage system and DC coupling	Tecnalia	Demonstrated in FD2 and Vilogia buildings.		
X14	SiC based inverter	CEA	Demonstrated in Tecnalia and Cricursa buildings.		

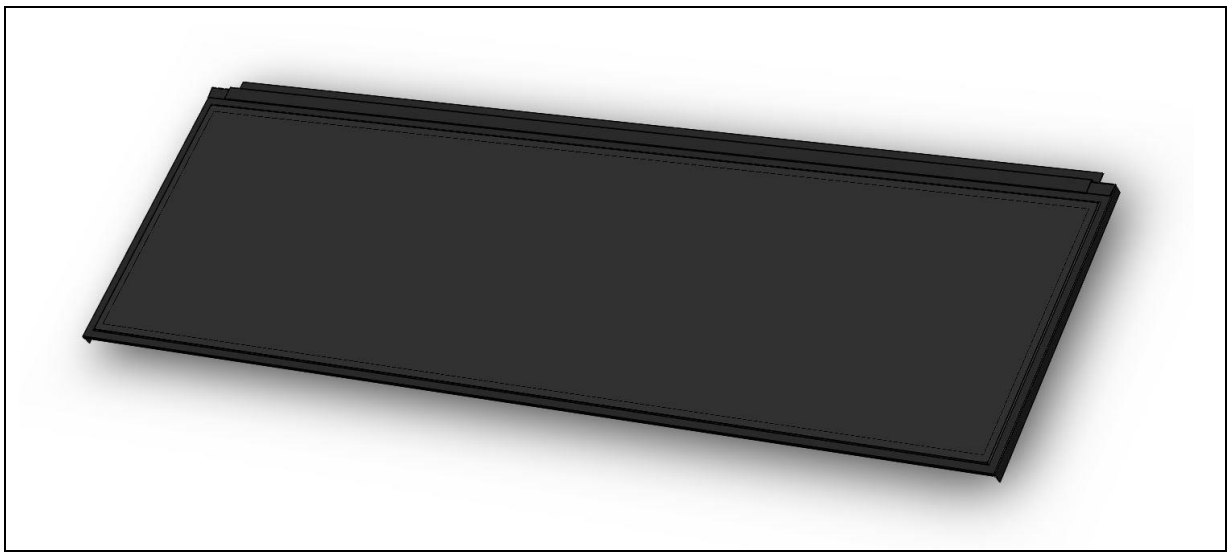
4 X1a - CIGS ROOFING SHINGLE ON METAL SUBSTRATE (eRoof)

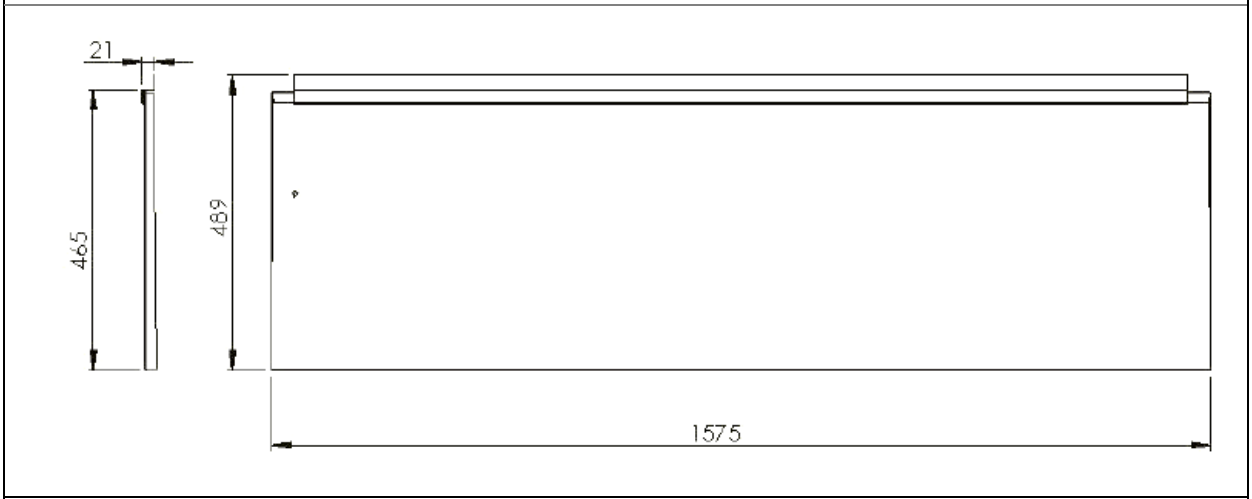
4.1 General Description, Design and Materials – X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

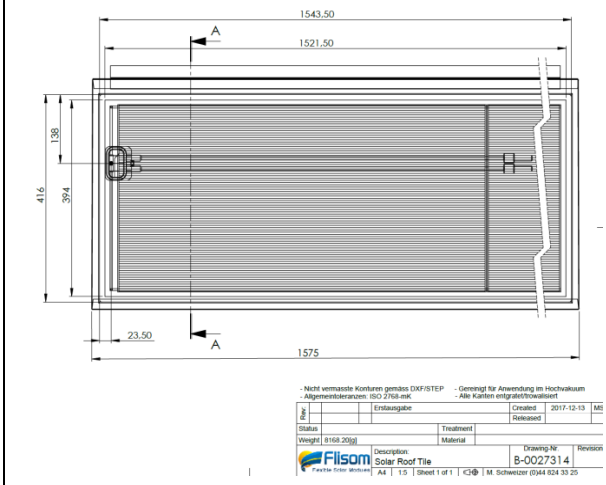
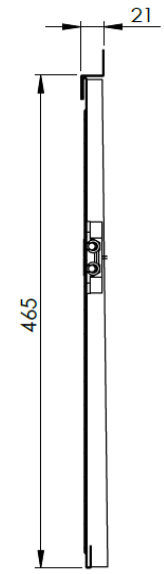
PRODUCT CODE	
Project	PVSITES. Task 2.6. BIPV products portfolio
Category	Roofing shingle
Denomination	X1a-eRoof-Tile
Partner/s	Flisom

PICTURES
REALISTIC DRAWING



Observations:
Semi-flexible and lightweight solar panel designed for BIPV roof tile installations

DESIGN PLANS	
	 SCHNITT A-A

DETAILED DESCRIPTION	
Definition	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations
Construction unit	Roofing shingle
Architectural location	Roof
Geometrical design	Rectangular
Dimensions	1575 x 489 x 21 mm
Geometrical shape	Rectangular
Materials	Descriptive value
Configuration	Monolithic unit
Layers	Layers from backsheet to frontsheet in order of application: Mild steel backsheet with PVDF coating, black RAL 9005 / Encapsulant TPO 0.4 mm /PV film CIGS grown on polyimide with Mo and ZnO electrical contacts / Encapsulant TPO 0.4 mm / Barrier film 0.4 mm. the module is sealed with edge seal ~1cm width
Frame structure	Frameless
PV technology	CIGS (Thin film)
TPO	TPO

Surface treatments	Surface textured
Thermal insulation	none
Acoustic insulation	none
Physical features	Semi-flexible and lightweight solar panel
Weight	6 Kg / unit
Rigidity	Semi-flexible
Opacity	Opaque
Active energy features	Electricity production
Photovoltaic power	50-60 Wp/unit
Optical transmittance	Opaque

4.2 Mechanical Performance – X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Denomination	X1 - eRoof-Tile

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations					
Manufacturer	Flisom					
Model	Roofing shingle – Format D2					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1575	mm	489	mm	22	mm
Weight	6	kg			-	-

4.3 Architectural Integration– X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	BEAR / Flisom
Author	Tjerk Reijenga / Julian Perrenoud

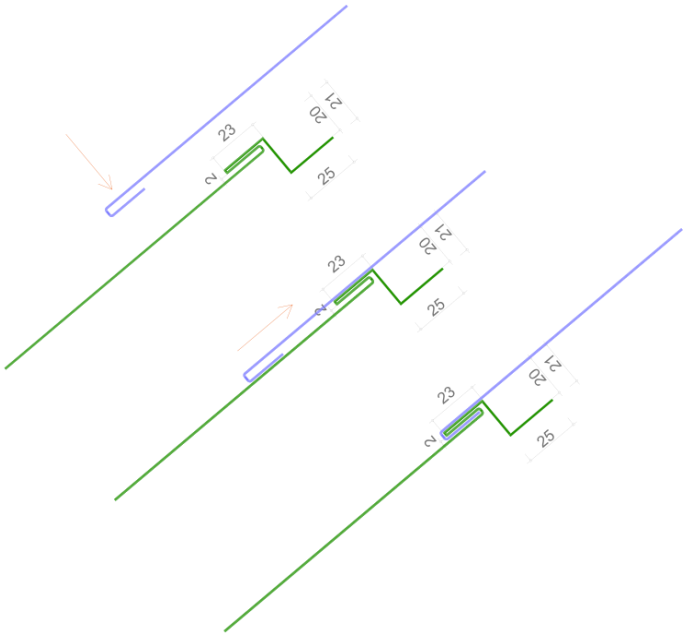
PRODUCT CODE	
Denomination	X1 - eRoof-Tile

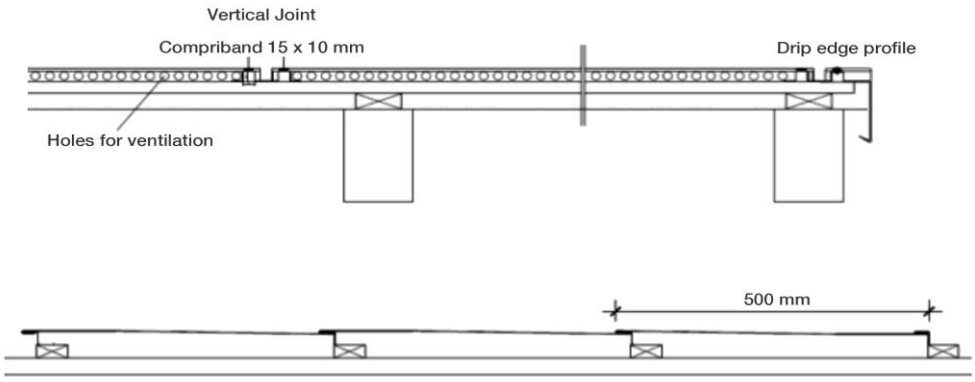
DEFINITION AND LOCATION	
Definition	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations
Construction unit	Roofing shingle
Location	Grandglise (Belgium)
Architectural location	Roof

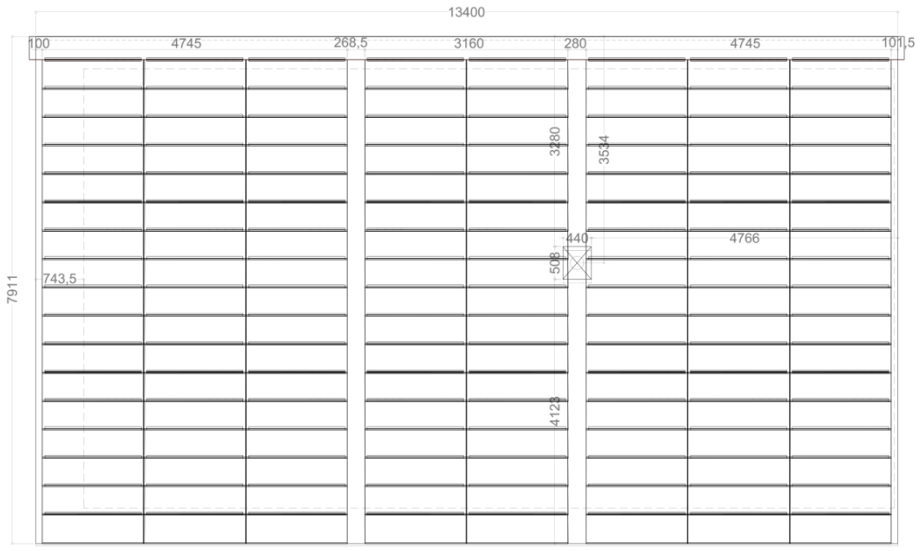
CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1575	mm	489	mm	21	mm
Weight	6	kg				
Materials and devices	Bended steel sheet with glued cells on top					
Configuration	Steel sheet					
Frame structure	Frameless					
PV technology	CIGS (Thin film)					
Thermal bridge	No					
Aesthetical features	Descriptive value					
Opacity	Opaque					
Cells colour	Very dark blue / black					
Background colour	Black RAL 9005					

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	The roof structure is made of wood. The modules will 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.
New construction permits needed	Part of building permit. Based on local regulation.
Retrofitting permits needed	Building permit needed
Maintenance	Cleaning depending on location.
Inspection	Physical inspection
Sequence of inspection	Yearly

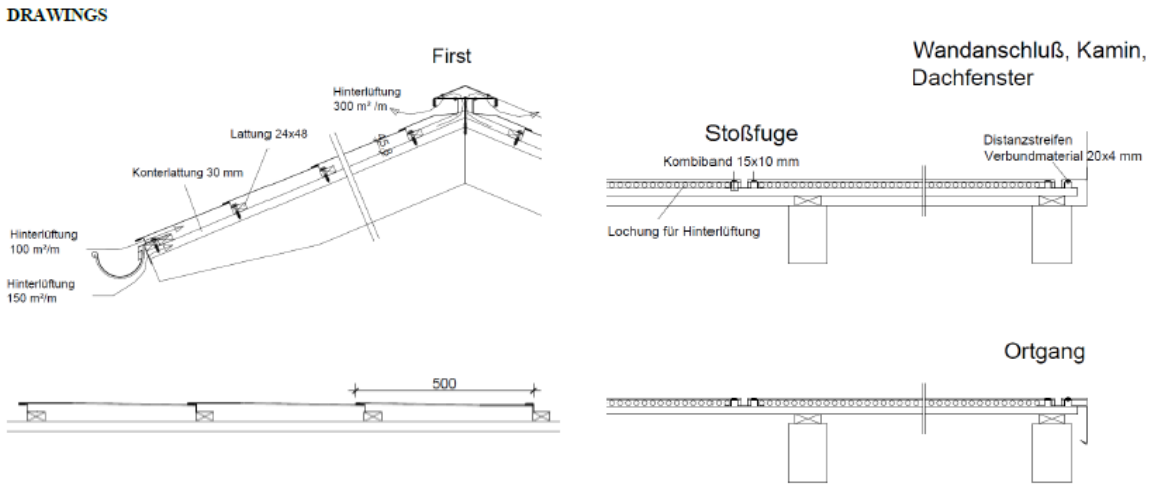
PICTURES
Integration method







Installation steps:
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.



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

4.4 Electrical Performance – X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Melani Schweizer / Daniel Valencia

PRODUCT CODE	
Denomination	X1 - eRoof-Tile

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations					
Manufacturer	Flisom					
Cell type	Flexible CIGS					
Shape	Rectangular					
Colour	Dark blue/ Black					
Frame	None					
Connection Box	Back side					
Connectors	MC4					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1575	mm	489	mm	21	mm
Other						
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Vpm: max. power voltage	34-36	V		-		-
Ipm: max. power current	1.47-1.66	A		-		-
Voc: open circuit voltage	46-48	V		-		-
Isc: short circuit current	1.72-1.91	A		-		-

Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	0.01	%/ºC				-
Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range						
Temperature	-40 – 85	ºC				
Maximum System Voltage	1000	V				
Maximum Wind /Snow Load	2400	Pa				

Observations:

For elevated areas irradiation can be higher than at STC. Therefore, multiply ISC- and VOC- 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.

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.

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

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.

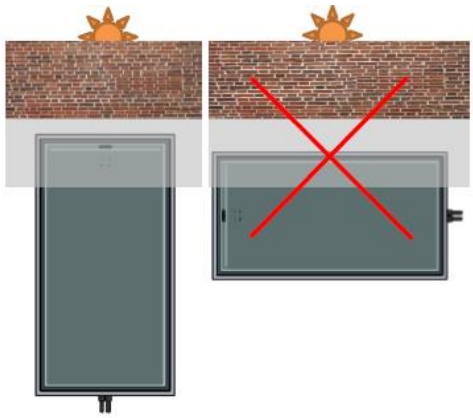


Fig 2: parallel shade *Fig 3: series shade*

Suitable inverter configurations are: central inverters, string inverters, multi-string inverters, inverters on single module level.

4.5 Optical Performance – X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado/ Daniel Valencia

PRODUCT CODE	
Denomination	X1 - eRoof-Tile

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations					
Manufacturer	Flisom					
Model	eRoof module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1575	mm	489	mm	21	mm
Weight	…	kg	5.9	kg/m^2	-	-
PV ratio (PVR)	~100	%	-	-	-	-
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5.0	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95	%	-	-	-	-

Solar absorptance (cz)	91.1	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

4.6 Maintenance and Dismantling – X1a

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Maintenance and dismantling of products and installations
Partner	Flisom
Author	Julian Perrenoud

PRODUCT CODE	
Denomination	X1 - eRoof-Tile

MAINTENANCE		
BY THE USER	Periodicity (months)	Description
Action 1	3	Visual check
Action 2	When required	Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface
Action 3	3	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.
Action 4	3	Check if the Junction Box is securely attached and that no deep scratches are penetrating the frontsheet
Observations.		

DISMANTLING
Description of dismantling 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

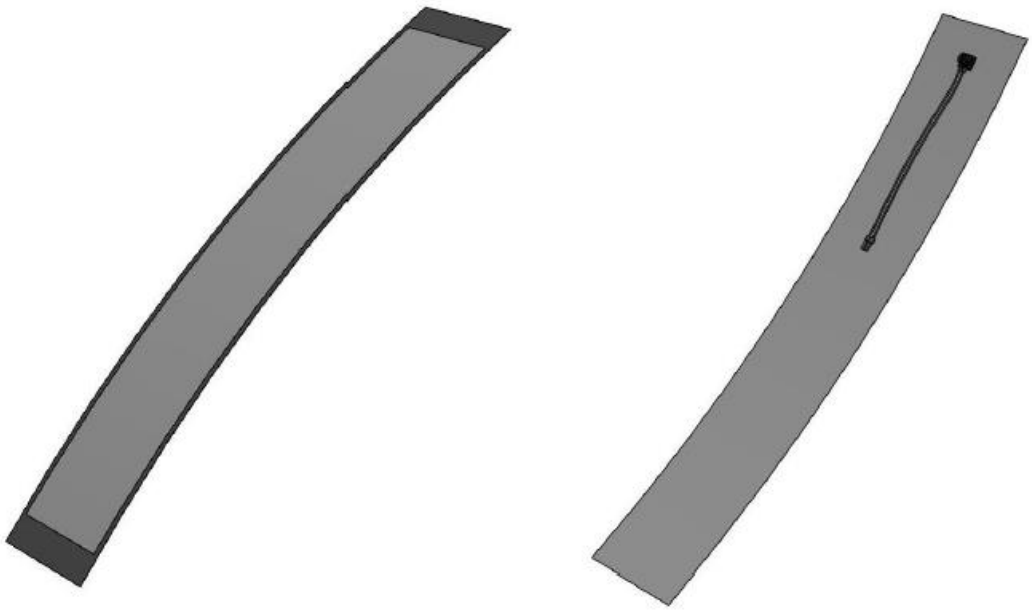
5 X1b - CIGS ROOFING MODULE ON METAL SUBSTRATE (eCarport)

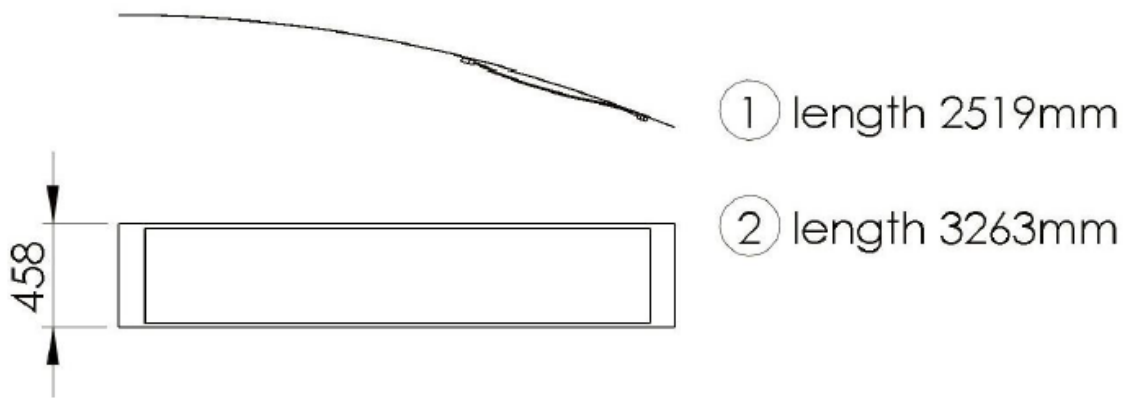
5.1 General Description, Design and Materials – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Project	PVSITES. Task 2.6. BIPV products portfolio
Category	Ventilated façade/ Curtain wall/ Skylight/ Roofing shingle/ Shading system
Denomination	X1 – eCarport
Partner/s	Flisom

PICTURES
REALISTIC DRAWING

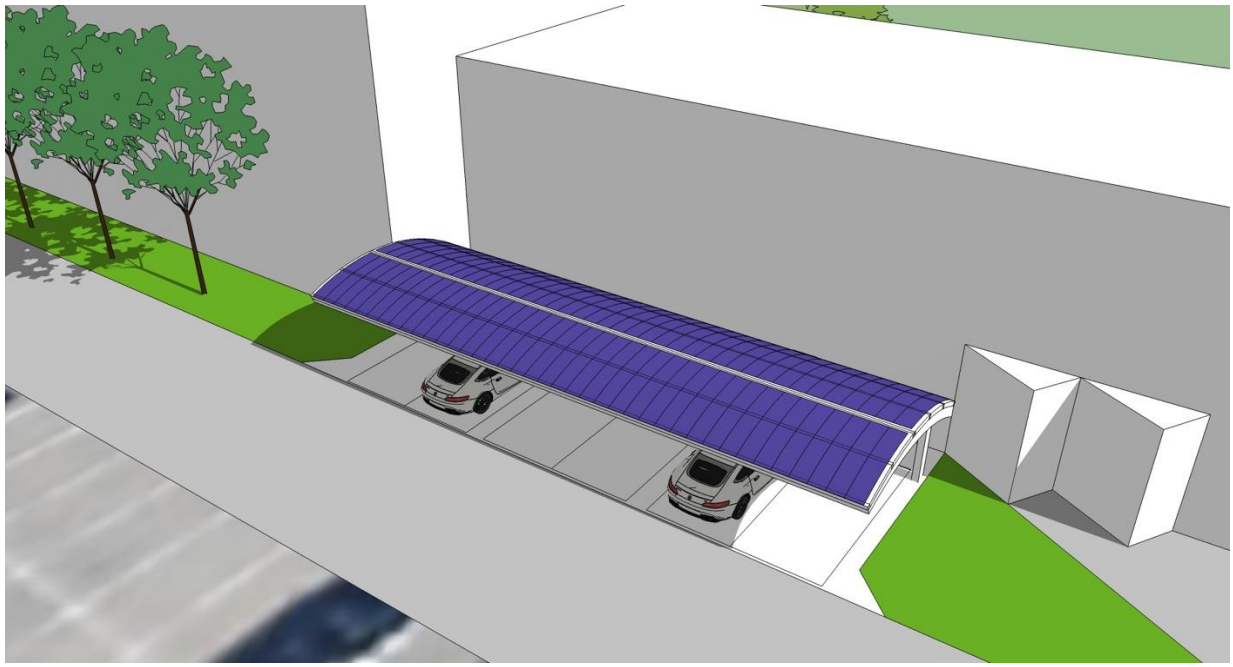




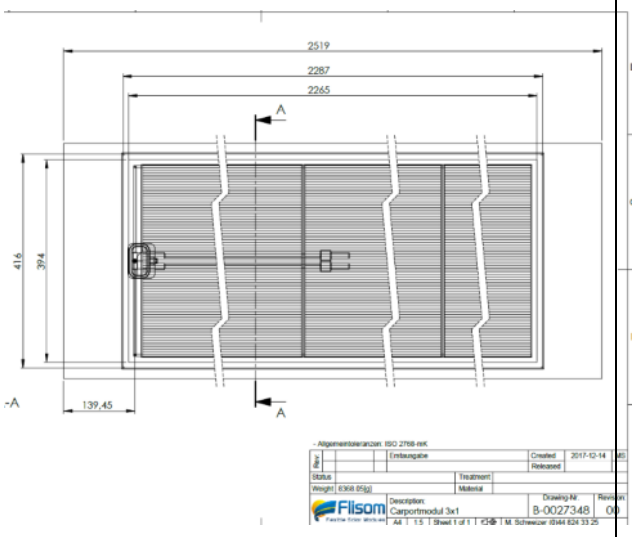
Observations:

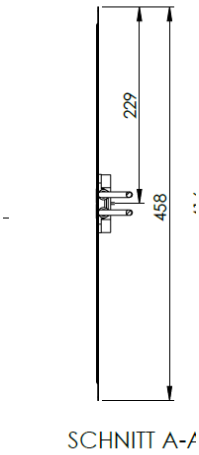
Carport module is a semi-flexible and lightweight solar panel designed for a carport installation

EXPLODED DRAWING



DESIGN PLANS





SCHNITT A-A

DETAILED DESCRIPTION	
Definition	The carport module is a semi-flexible and lightweight solar panel designed for a carport installation
Construction unit	Ventilated façade/ Curtain wall/ Skylight/ Roofing shingle/ Shading system/ Other
Architectural location	Façade/ Roof/ Other
Geometrical design	Rectangular
Dimensions	2519-3263 x 458 x 21 mm
Geometrical shape	Rectangular
Materials	Descriptive value
Configuration	Monolithic unit
Layers	Layers from backsheet to frontsheet in order of application: Mild steel backsheet with PVDF coating, black RAL 9005 / Encapsulant TPO 0.4 mm /PV film CIGS grown on polyimide with Mo and ZnO electrical contacts / Encapsulant TPO 0.4 mm / Barrier film 0.4 mm. the module is sealed with edge seal ~1cm width
Frame structure	Frameless
PV technology	CIGS (Thin film)
Encapsulation material	TPO
Surface treatments	Surface structured
Thermal insulation	none
Acoustic insulation	none
Physical features	Semi-flexible and lightweight solar panel
Weight	5.9 Kg/m^2
Rigidity	Flexible
Opacity	Opaque
Active energy features	Electricity production
Photovoltaic power	84 – 110 Wp/m^2 (2519 - 3263 mm version)
Optical transmittance	Opaque

5.2 Mechanical Performance – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Denomination	X1 – eCarport

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	The carport module is a semi-flexible and lightweight solar panel designed for a carport installation					
Manufacturer	Flisom					
Model	Carport module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	2519-3263	mm	458	mm	22	mm
Weight	-	-	5.9	kg/m2	-	-
Mechanical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Max. mechanical load	2400	Pa				

Observations:

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 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

5.3 Architectural Integration – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	BEAR / Flisom
Author	Tjerk Reijenga / Julian Perrenoud

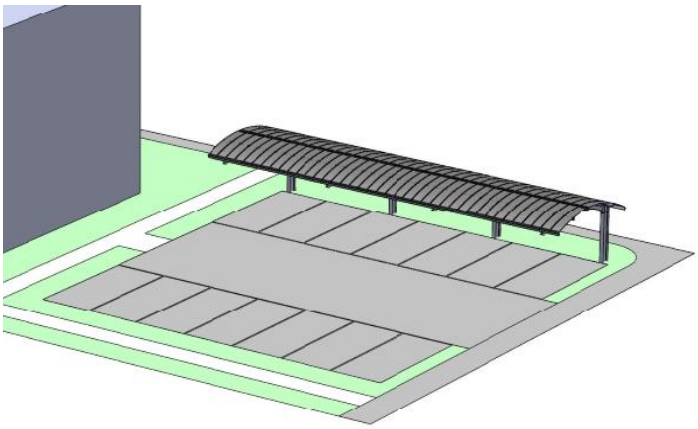
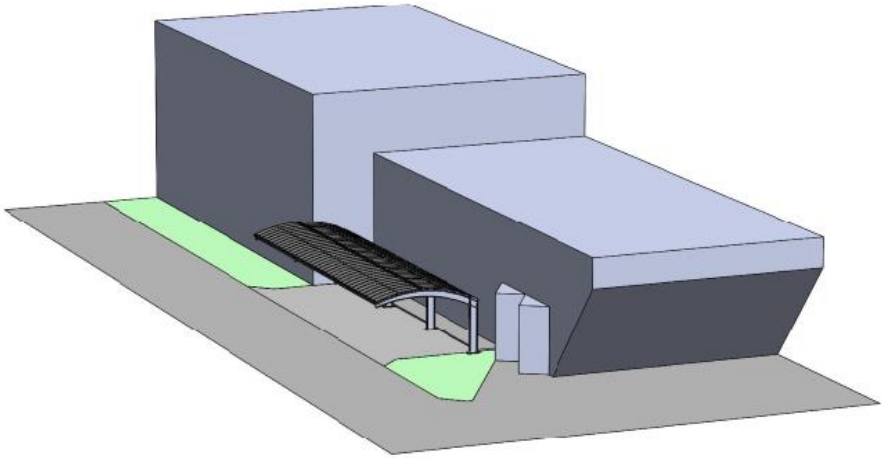
PRODUCT CODE	
Denomination	X1 – eCarport

DEFINITION AND LOCATION	
Definition	The carport module is a semi-flexible and lightweight solar panel designed for a carport installation
Construction unit	Carport module
Location	Zurich
Architectural location	Roof

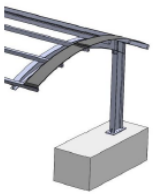
CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	2519-3263	mm	458	mm	21	mm
Weight	…	kg	5.9	kg/m^2		
Materials and devices	Bended steel sheet with glued cells on top					
Configuration	Steel sheet					
Frame structure	Frameless					
PV technology	CIGS (Thin film)					
Thermal bridge	no					
Opacity	Opaque					
Cell colour	Very dark blue / black					
Background colour	RAL 9005					

INTEGRATION AND MAINTENANCE MEASURES

New construction permits needed	Part of building permit. Based on local regulation.
Retrofitting permits needed	Building permit needed
Maintenance	Cleaning depending on location.
Inspection	Physical inspection
Sequence of inspection	Yearly

PICTURES
Integration method

EKZ demonstration

EMPA demonstration

Mounting			
1. Build foundation and mount pillars	2. Mount stiffening profiles	3. Install first row of modules	4. Install rest of modules

Observations:

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

5.4 Electrical performance – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	M. Schweizer / Daniel Valencia

PRODUCT CODE	
Denomination	X1 – eCarport

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	The carport module is a semi-flexible and lightweight solar panel designed for a carport installation					
Manufacturer	Flisom					
Cell type	Flexible CIGS					
Shape	Rectangular					
Colour	Dark blue/ Black					
Frame	Frameless					
Connection Box	Back side					
Connectors	MC4					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	2519-3263	mm	458	mm	21	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power			84-110	Wp/m^2		-
Vpm: max. power voltage	34-38	V		-		-
Ipm: max. power current	2.22-3.16	A		-		-
Voc: open circuit voltage	46-50	V		-		-
Isc: short circuit current	2.47-3.40	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	0.01	%/ºC				-

Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range	Descriptive value					
Temperature	-40 – 85	ºC				
Maximum System Voltage	1000	V				
Maximum Wind /Snow Load	2400	Pa				

Observations:

For elevated areas irradiation can be higher than at STC. Therefore, multiply ISC- and VOC- 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.

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.

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

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.

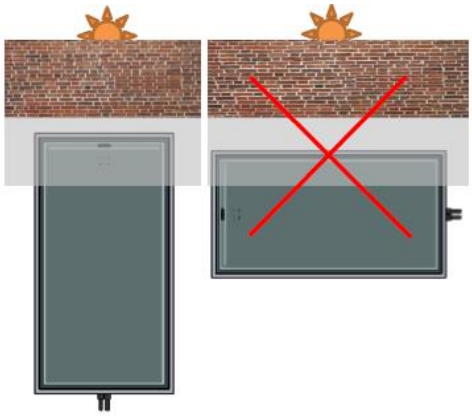


Fig 2: parallel shade *Fig 3: series shade*

Suitable inverter configurations are: central inverters, string inverters, multi-string inverters, inverters on single module level.

5.5 Optical Performance – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado/ Daniel Valencia

PRODUCT CODE	
Denomination	X1 – eCarport

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	The roofing shingle module is a semi-flexible and lightweight solar panel designed for BIPV roof tile installations					
Manufacturer	Flisom					
Model	Carport module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	2519-3263	mm	458	mm	21	mm
Weight	…	kg	5.9	kg/m^2	-	-
PV ratio (PVR)	~100	%	-	-	-	-
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5.0	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95	%	-	-	-	-

Solar absorptance (cz)	91.1	%	-	-	-	-
Emissivity	-	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

5.6 Maintenance and Dismantling – X1b

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Maintenance and dismantling of products and installations
Partner	Flisom
Author	Julian Perrenoud

PRODUCT CODE	
Denomination	X1 – eCarport

MAINTENANCE		
BY THE USER	Periodicity (months)	Description
Action 1	3	Visual check
Action 2	When required	Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface
Action 3	3	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
Action 4	3	Check if the Junction Box is securely attached and that no deep scratches are penetrating the frontsheet
Observations.		

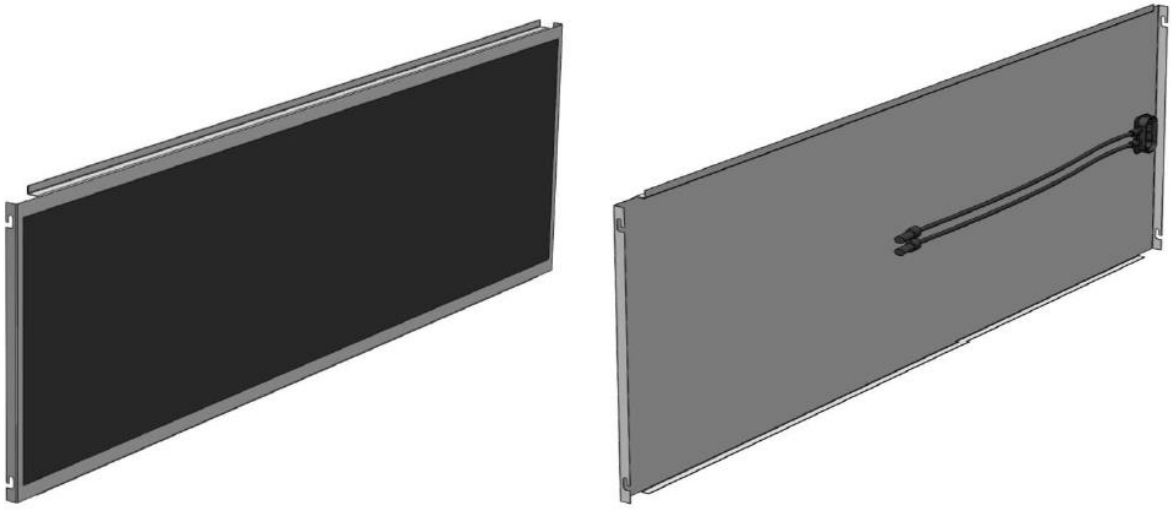
DISMANTLING
Description of dismantling Do not use aggressive cleaning agents or scrubbing materials for cleaning Do not use steam blasting for cleaning Use soft water to avoid chalk stains Soft sponges can be used

6 X2 CIGS large area flexible roofing membrane and bendable elements (eFacade)

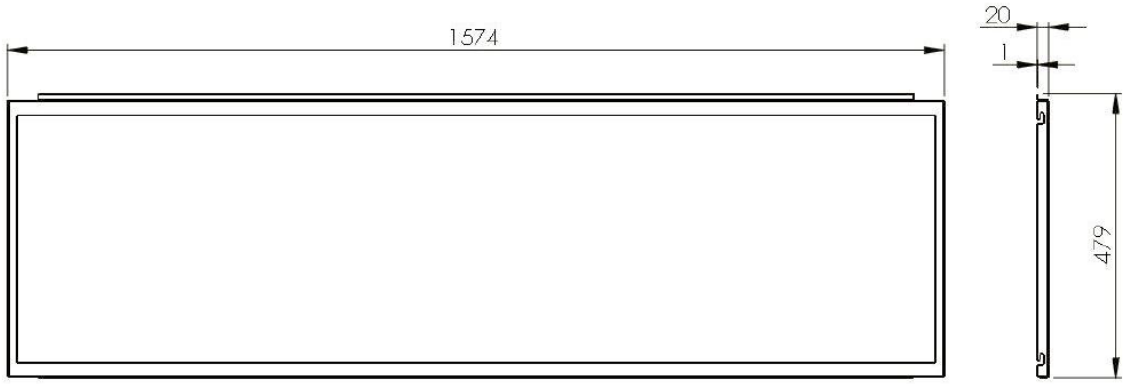
6.1 General Description, Design and Materials – X2

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Flisom/ Tecnalia
Author	Julian Perrenoud/ Daniel Valencia

PRODUCT CODE	
Project	PVSITES. Task 2.6. BIPV products portfolio
Category	Façades
Denomination	X2 - eFacade
Partner/s	Flisom

PICTURES
REALISTIC DRAWING

Observations: The EHG module is a semi-flexible and lightweight solar panel designed for BIPV facade installations

DESIGN PLANS



DETAILED DESCRIPTION	
Definition	Semi-flexible and lightweight solar panel designed for BIPV installations on facades
Construction unit	Module for façade
Architectural location	Façade
Geometrical design	Rectangular
Dimensions	1574 x 479 x 22 mm
Geometrical shape	Rectangular
Materials	Descriptive value
Configuration	Monolithic unit
Layers	Layers from backsheet to frontsheet in order of application: Aluminum black elox / Encapsulant TPO 0.4 mm /PV film CIGS grown on polyimide with Mo and ZnO electrical contacts / Encapsulant TPO 0.4 mm / Barrier film 0.4 mm. the module is sealed with edge seal ~1cm width
Frame structure	No frame
PV technology	CIGS (Thin film)
Encapsulation material	TPO
Surface treatments	Surface textured
Thermal insulation	None
Acoustic insulation	none
Physical features	Descriptive value
Weight	2.5 Kg / unit

Rigidity	Semi-flexible
Opacity	Opaque
Mobility	Fixed
Active energy features	Descriptive value
Photovoltaic power	50-60 Wp / unit

6.2 **Mechanical Performance – X2**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Denomination	X2 - eFacade

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installations on facades					
Manufacturer	Flisom					
Model	EHG module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1574	mm	479	mm	22	mm
Weight	2.5	kg	3.32	kg/m2	-	-
Mechanical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Max. mechanical load	2400	Pa				

6.3 Architectural Integration – X2

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	BEAR / Flisom
Author	Tjerk Reijenga / Julian Perrenoud

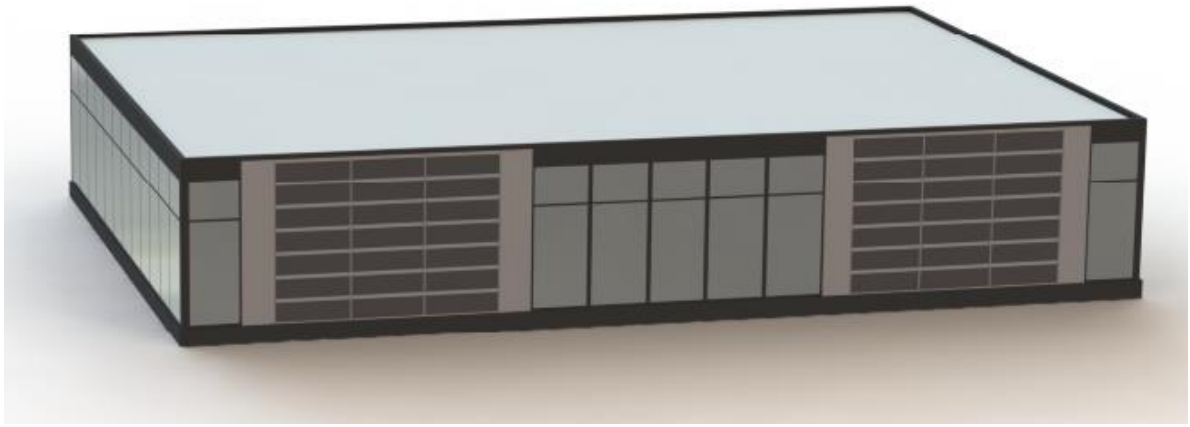
PRODUCT CODE	
Denomination	X2- eFacade

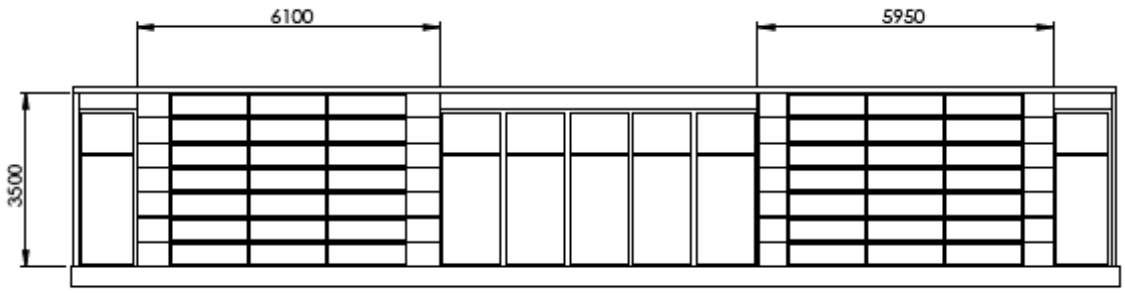
DEFINITION AND LOCATION	
Definition	Semi-flexible and lightweight solar panel designed for BIPV installations on facades
Construction unit	Ventilated façade
Location	Geneva
Architectural location	Façade

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1574	mm	479	mm	22	mm
Weight	2.5	kg	3.32	kg/m^2		
Materials and devices	Bended aluminium/steel sheet with laminated cells on top					
Configuration	Other					
Frame structure	none					
PV technology	CIGS					
Location of pipes, diameters	Dimensions, drawing					
Thermal bridge	No					
Aesthetical features	Modules are tailor made and can fit the whole area. This increase the aesthetics and added value.					
Opacity	Opaque					
Cell colour	Very dark blue / black					
Background colour	Black					

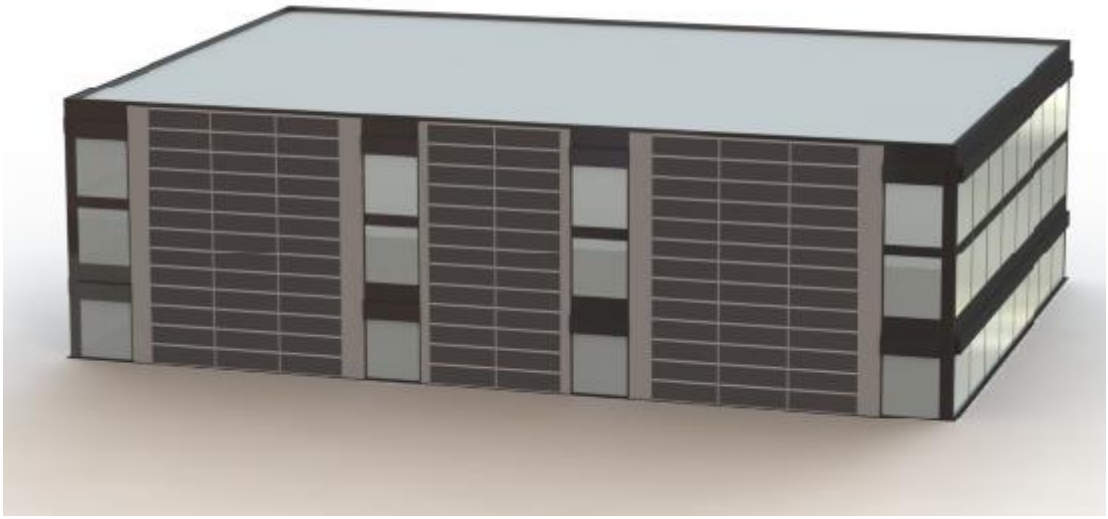
INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Hanging on an aluminium back frame system
Secondary construction	A secondary construction is needed to connect modules to the wall.
New construction permits needed	Part of building permit. Based on local regulation.
Retrofitting permits needed	Building permit needed
Maintenance	Cleaning depending on location.
Inspection	Physical inspection
Sequence of inspection	Yearly

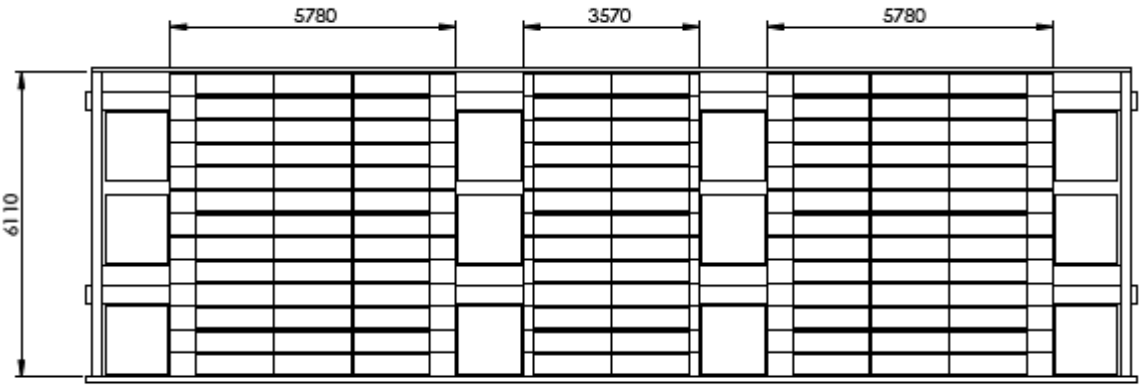
PICTURES
Integration method
Integration proposal for EHG. Pavillon 1

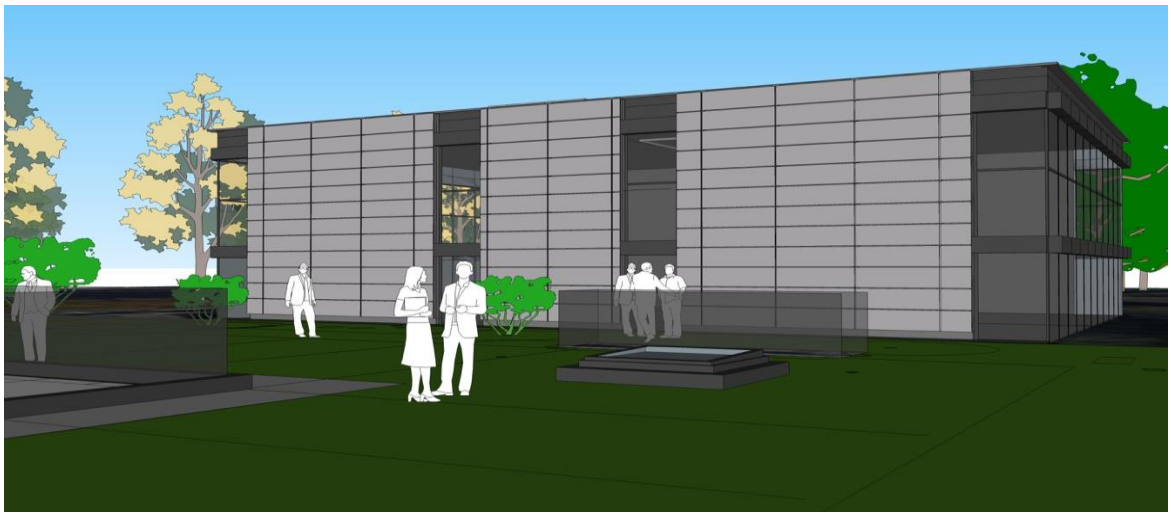


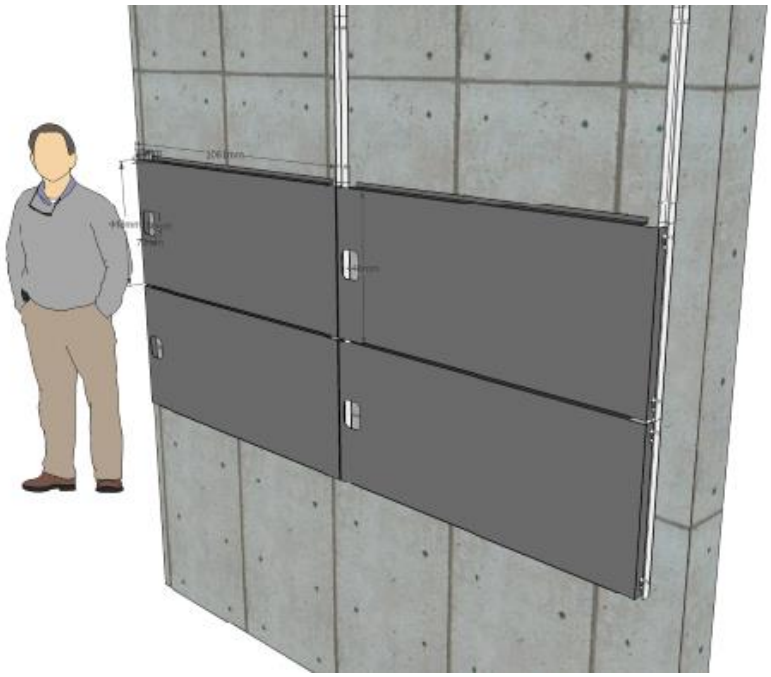


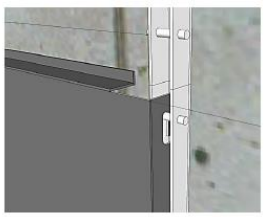
Integration proposal for EHGeneve. Pavillon 2









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	4. Install all modules and the side covers
			

6.4 Electrical Performance – X2

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	M. Schweizer / Daniel Valencia

PRODUCT CODE	
Denomination	X2- eFacade

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installations on facades					
Manufacturer	Flisom					
Cell type	Flexible CIGS					
Shape	Rectangular					
Colour	Black					
Front layer	ETFE					
Frame	none					
Connection Box	Back side					
Connectors	MC4					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1574	mm	479	mm	22	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	50-60	Wp	66-80	Wp/m^2		-
Vpm: max. power voltage	34-36	V		-		-
Ipm: max. power current	1.47-1.66	A		-		-
Voc: open circuit voltage	46-48	V		-		-
Isc: short circuit current	1.72-1.91	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3

Isc (α) Temp. coefficient	0.01	%/ºC				-
Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range						
Temperature	-40 – 85	ºC				
Maximum System Voltage	1000	V				

Observations:

For elevated areas irradiation can be higher than at STC. Therefore, multiply ISC- and VOC- 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.
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.

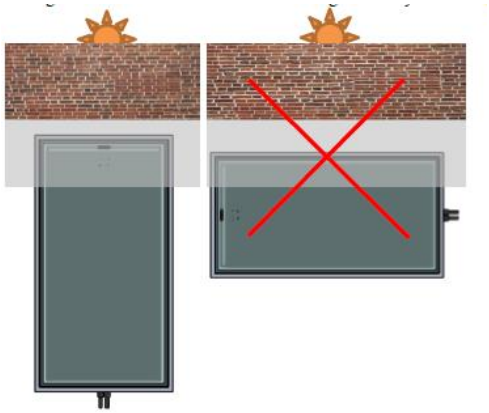


Fig 2: parallel shade *Fig 3: series shade*

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

Suitable inverter configurations are: Central inverters, String inverters, Multi-String inverters, Inverters on single module level.

6.5 Optical Performance – X2

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X2 - eFacade

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installations on facades					
Manufacturer	Flisom					
Model	EHG module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1574	mm	479	mm	22	mm
PV ratio (PVR)	~100	%	-	-	-	-
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5.0	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95.0	%	-	-	-	-
Solar absorptance (cz)	91.1	%	-	-	-	-
Observations: Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone						

6.6 **Maintenance and Dismantling – X2**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Maintenance and dismantling of products and installations
Partner	Flisom
Author	Julian Perrenoud

PRODUCT CODE	
Denomination	X2 - eFacade

MAINTENANCE		
	Periodicity (months)	Description
Action 1	4	Visual check
Action 2	When required	Remove dust and dirt (sediments, leaves, pollen, bird droppings, etc.) from the surface
Action 3	4	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
Action 4	4	Check if the Junction Box is securely attached and that no deep scratches are penetrating the frontsheet

Observations.
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

7 X3 Experimental/Innovative Flexible CIGS alternatives

7.1 General Description, Design and Materials – X3

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Flisom/ Tecnalia
Author	Julian Perrenoud/ Daniel Valencia

PRODUCT CODE	
Project	PVSITES. Task 2.7. BIPV products portfolio
Category	Building roofs and vehicle integration
Denomination	eFlex - HiLo
Partner/s	Flisom

PICTURES
REALISTIC DRAWING

Junction box will move to the back, drawing not yet available

Observations:

eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications

DETAILED DESCRIPTION	
Definition	eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications
Construction unit	Flexible rectangular module
Architectural location	Building roofs, vehicle integration and others
Geometrical design	Rectangular
Dimensions	1617 x 411 x 21 mm (800, 2300, 3100 mm length available too)
Geometrical shape	Rectangular
Configuration	Monolithic unit
Layers	Fluoropolymer front sheet / plastic back sheet
Frame structure	Frameless
PV technology	CIGS (Thin film)
Encapsulation material	TPO
Thermal insulation	none
Acoustic insulation	none
Weight	1.3 Kg / unit; <2 Kg/m^2

Rigidity	Flexible
Opacity	Opaque
Mobility	Fixed
Photovoltaic power	50-60 Wp / unit
Optical transmittance	Opaque

7.2 Mechanical Performance – X3

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Denomination	X3 – eFlex-HiLo

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications					
Manufacturer	Flisom					
Model	eFlex-HiLo 1.6					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Length/ Height/ Thickness	1617	mm	411	mm	22	mm
Weight	1.3	kg	<2	kg/m2	-	-
Others length values	800	mm	2300	mm	3100	mm
Mechanical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Max. mechanical load	2400	Pa				

7.3 **Architectural Integration – X3**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	BEAR / Flisom
Author	Tjerk Reijenga / Julian Perrenoud

PRODUCT CODE	
Denomination	X3 – eFlex-HiLo

DEFINITION AND LOCATION	
Definition	eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications
Location	Zurich

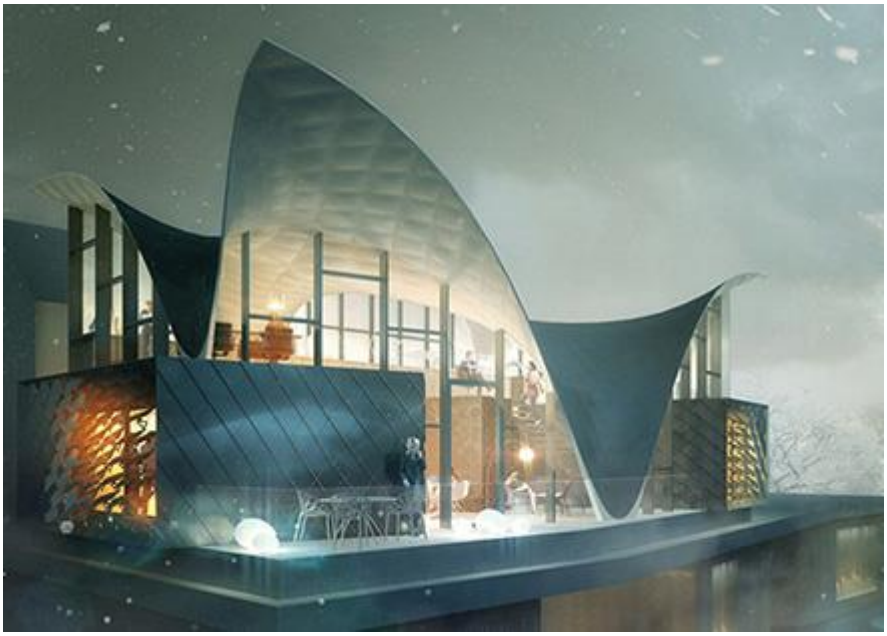
CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1617	mm	411	mm	22	mm
Other standardized lenghts	~800	mm	~2300	mm	~3100	mm
Weight	1.3	kg	<2	kg/m^2		
Materials and devices	Bended aluminium/steel sheet with laminated cells on top					
Frame structure	frameless					
PV technology	CIGS					
Location of pipes, diameters	Dimensions, drawing					
Thermal bridge	No					
Aesthetical features	Modules are tailor made and can fit the whole area. This increase the aesthetics and added value. Applicable for curved surfaces – bendable					
Opacity	Opaque					
Cell colour	Very dark blue / black					

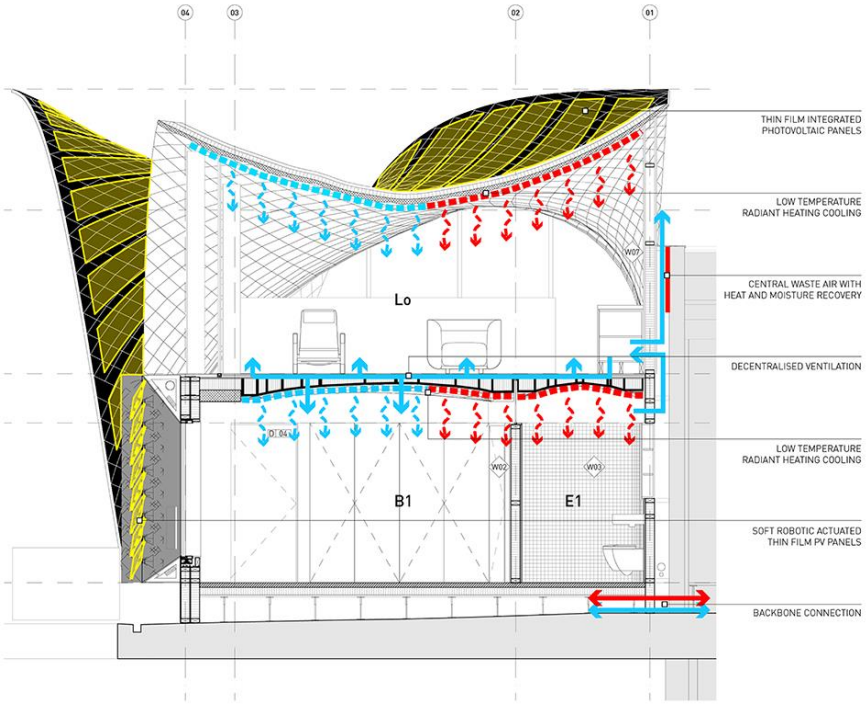
Background colour	Black

INTEGRATION AND MAINTENANCE MEASURES	
New construction permits needed	Part of building permit. Based on local regulation.
Retrofitting permits needed	Building permit needed
Maintenance	Cleaning depending on location.
Inspection	Physical inspection
Sequence of inspection	Yearly

PICTURES

Integration method





7.4 **Electrical Performance – X3**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	M. Schweizer / Daniel Valencia

PRODUCT CODE	
Denomination	X3 – eFlex-HiLo

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications					
Manufacturer	Flisom					
Cell type	Flexible CIGS					
Shape	Rectangular					
Colour	Black					
Front layer	Fluoropolymer					
Frame	none					
Connection Box	Back side					
Cables	700 mm long, 4 mm^2 section					
Connectors	MC4					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1617	mm	411	mm	22	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	50-60	Wp	66-80	Wp/m^2		-
Vpm: max. power voltage	34-36	V		-		-
Ipm: max. power current	1.47-1.66	A		-		-
Voc: open circuit voltage	46-48	V		-		-

Isc: short circuit current	1.72-1.91	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	0.01	%/ºC				-
Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range						
Temperature	-40 – 85	ºC				
Maximum System Voltage	1000	V				
Protection	IP67					
Maximum Wind /Snow Load	2400	Pa				

7.5 Optical Performance – X3

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X3 – eFlex-HiLo

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	eFlex-HiLo is a flexible and lightweight solar panel designed for integration into roofs, structures with limited load bearing capacity, mobility applications on trailers, RVs, boats and many more demanding applications					
Manufacturer	Flisom					
Model	eFlex-HiLo 1.6					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1617	mm	411	mm	22	mm
PV ratio (PVR)	~100	%	-	-	-	-
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5.0	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95.0	%	-	-	-	-

Solar absorptance (cz)	91.1	%	-	-	-	-

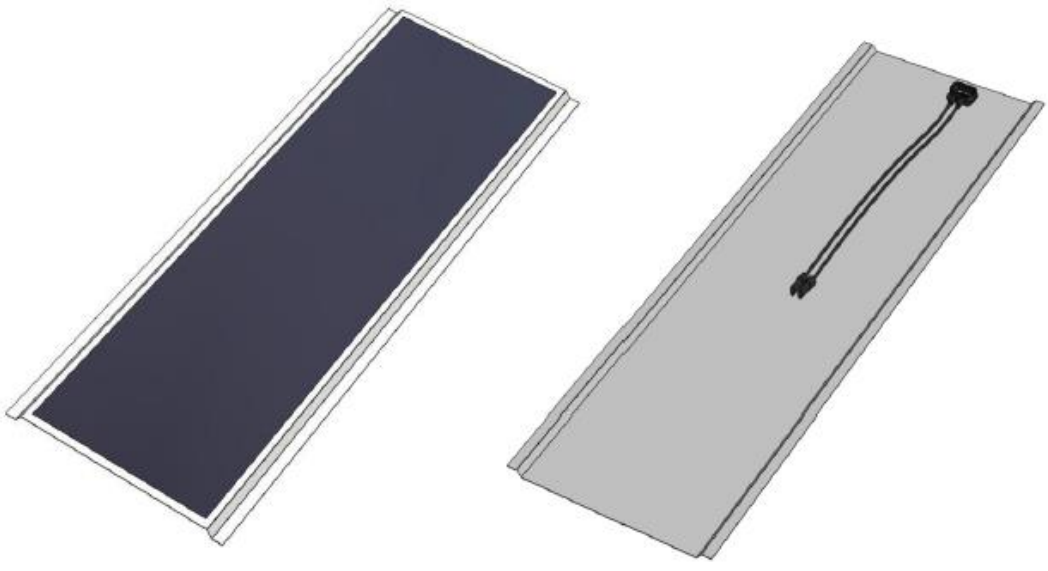
Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

8 X4 - eRoof - Industrial

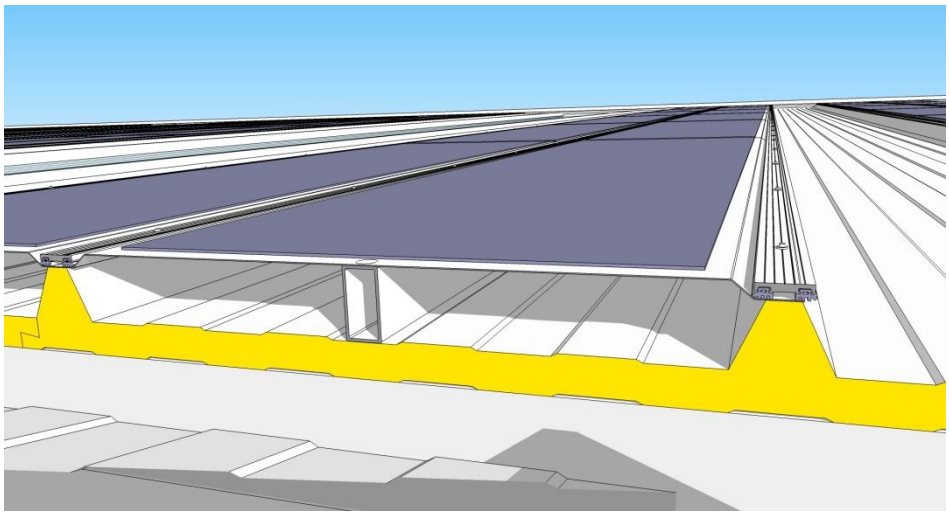
8.1 General Description, Design and Materials – X4

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Flisom/ Tecnalia
Author	Julian Perrenoud/ Daniel Valencia

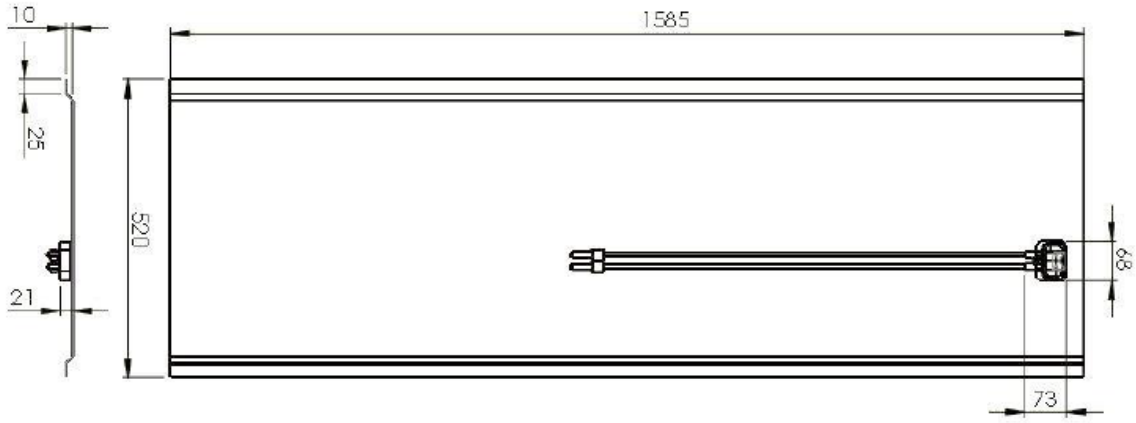
PRODUCT CODE	
Project	PVSITES. Task 2.7. BIPV products portfolio
Category	Roof
Denomination	X4 - eRoof-Industrial
Partner/s	Flisom

PICTURES
REALISTIC DRAWING

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

EXPLODED DRAWING



DESIGN PLANS



DETAILED DESCRIPTION	
Definition	Semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures
Construction unit	Module for roof
Architectural location	Roof
Geometrical design	Rectangular
Dimensions	1585 x 520 x 21 mm
Geometrical shape	Rectangular

Configuration	Monolithic unit
Frame structure	Aluminium
PV technology	CIGS (Thin film)
Physical features	Descriptive value
Weight	5.8 Kg / unit
Rigidity	Semi-flexible
Opacity	Opaque
Mobility	Fixed
Photovoltaic power	50-60 Wp / unit
Optical transmittance	Opaque

8.2 **Mechanical Performance – X4**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	Julian Perrenoud / Daniel Valencia

PRODUCT CODE	
Denomination	X4 - eRoof-Industrial

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures					
Manufacturer	Flisom					
Model	Cricursa module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1585	mm	520	mm	21	mm
Weight	5.8	kg				
Mechanical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Max. mechanical load	2400	Pa				

Architectural Integration – X4

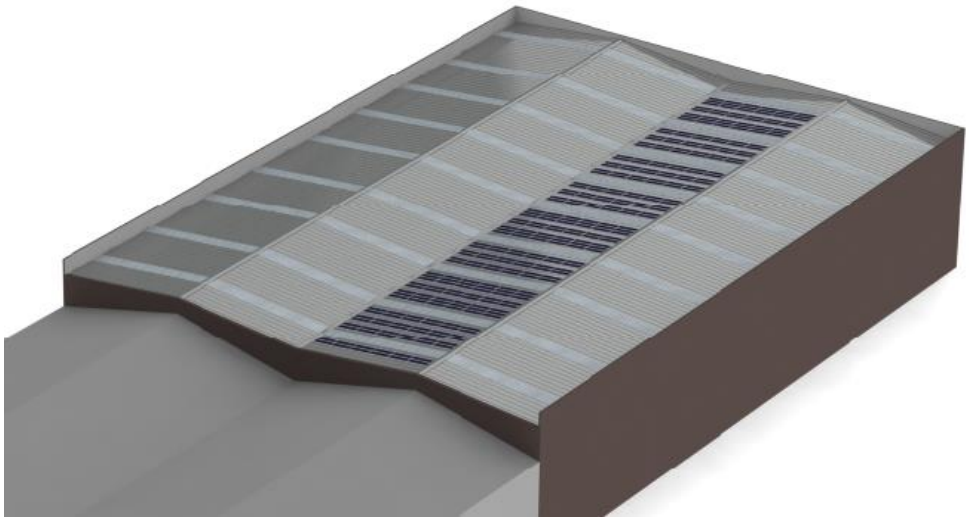
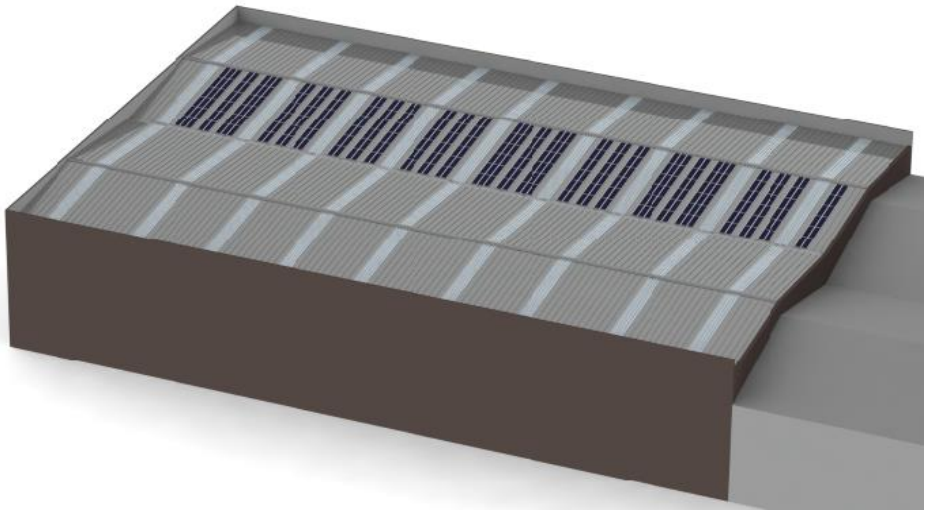
TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	BEAR / Flisom
Author	Tjerk Reijenga / Julian Perrenoud

PRODUCT CODE	
Denomination	X4 - eRoof-Industrial

DEFINITION AND LOCATION	
Definition	Semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures
Construction unit	Roofing module
Location	Barcelona
Architectural location	Roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1574	mm	479	mm	22	mm
Weight	2.5	kg	3.32	kg/m^2		
Materials and devices	Bended aluminium/steel sheet with laminated cells on top					
PV technology	CIGS					
Location of pipes, diameters	Dimensions, drawing					
Thermal bridge	No					
Aesthetical features	Modules are tailor made and can fit the whole area. This increase the aesthetics and added value.					
Opacity	Opaque					
Cell colour	Very dark blue / black					
Background colour	Black					

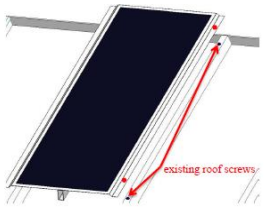
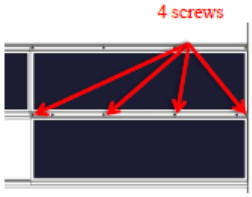
INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Mounted on the underlying (steel) structure or roof structure
New construction permits needed	Part of building permit. Based on local regulation.
Retrofitting permits needed	Building permit needed
Maintenance	Cleaning depending on location.
Inspection	Physical inspection
Sequence of inspection	Yearly

PICTURES
Integration method



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.

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 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.

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.

1. Position the first module and mark the position of the existing screws	2. Stamp out holes on the marked positions. Screw the module 4 times on one side on the roof	3. Screw the middle of the module on the roof (2 options)	4. Start the next module row and screw them together with the first row module on the roof
			

8.3 **Electrical Performance – X4**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Flisom / Tecnalia
Author	M. Schweizer / Daniel Valencia

PRODUCT CODE	
Denomination	X4 - eRoof-Industrial

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures					
Manufacturer	Flisom					
Cell type	Flexible CIGS					
Shape	Rectangular					
Colour	Black					
Front layer	ETFE					
Frame	none					
Connection Box	Back side					
Connectors	MC4					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1585	mm	520	mm	21	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	50-60	Wp	66-80	Wp/m^2		
Vpm: max. power voltage	34-36	V				
Ipm: max. power current	1.47-1.66	A				
Voc: open circuit voltage	46-48	V				
Isc: short circuit current	1.72-1.91	A				
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3

NOCT: stand. oper. temp.		ºC				-
Isc (α) Temp. coefficient	0.01	%/ºC				-
Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range						
Temperature	-40 – 85	ºC				
Maximum System Voltage	1000	V				

Observations:

For elevated areas irradiation can be higher than at STC. Therefore, multiply ISC- and VOC- 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. 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.

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.

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.

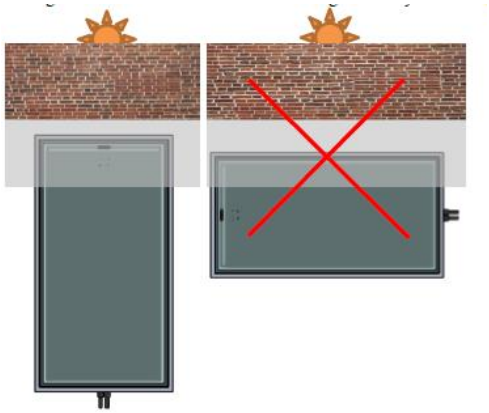


Fig 2: parallel shade *Fig 3: series shade*

Suitable inverter configurations are: Central inverters, String inverters, Multi-String inverters, Inverters on single module level

8.4 **Optical Performance – X4**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X4 - eRoof-Industrial

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	Semi-flexible and lightweight solar panel designed for BIPV installation on trapezoidal roof structures					
Manufacturer	Flisom					
Model	Cricursa module					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1585	mm	520	mm	21	mm
PV ratio (PVR)	~100	%				
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95	%	-	-	-	-
Solar absorptance (cz)	91.1	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

9 X5 C-Si glazed products with hidden bus bars and L interconnections

9.1 General Description, Design and Materials – X5

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Ventilated façade/ Curtain wall
Denomination	X5 - C-Si glazed products with hidden bus bars and L interconnections
Partner/s	Onyx Solar

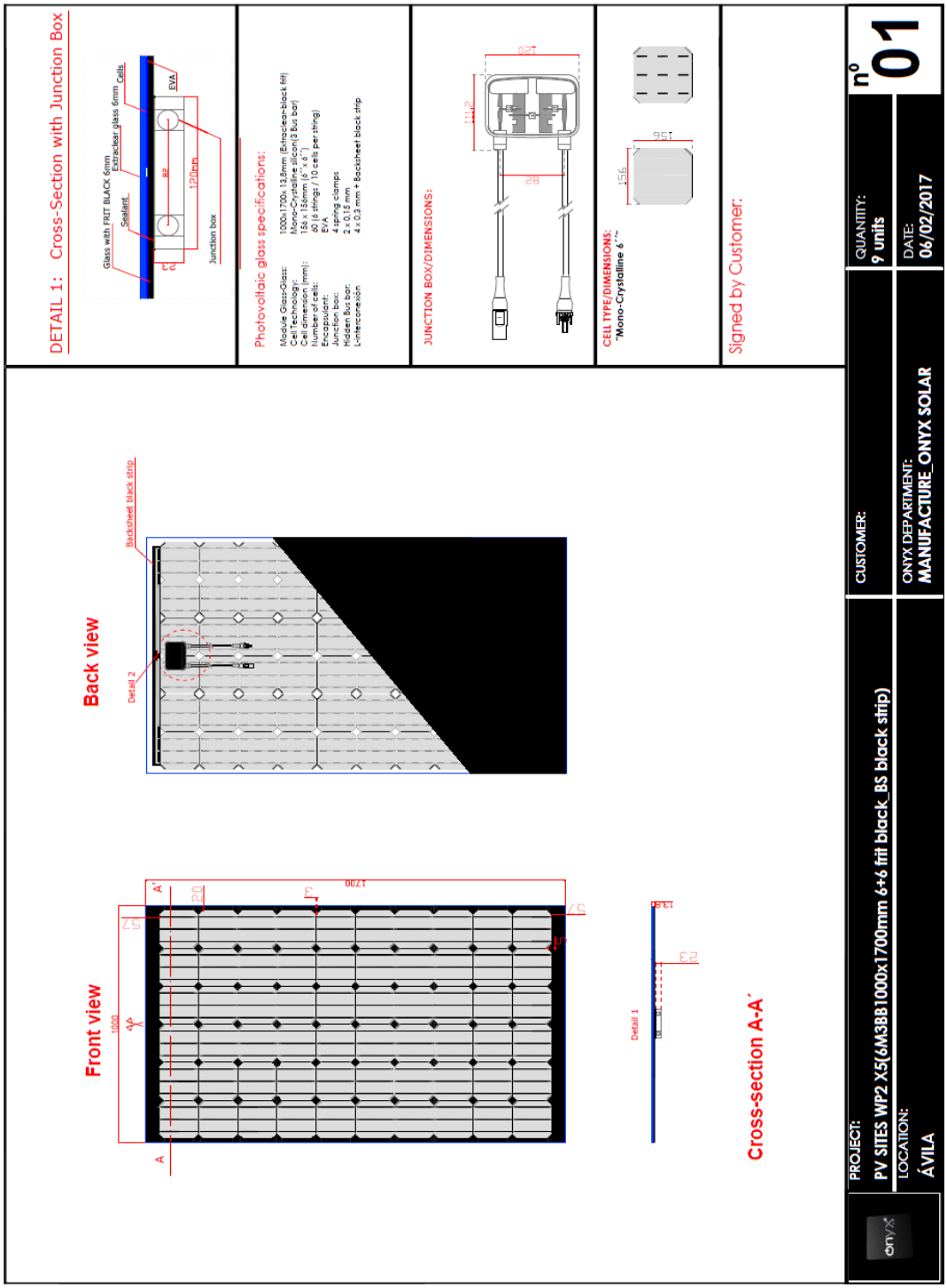
PICTURES

REALISTIC DRAWING

Observations:

Final appearance of PV rectangular C-Si opaque modules with hidden busbars and L-interconnections (front and back views)

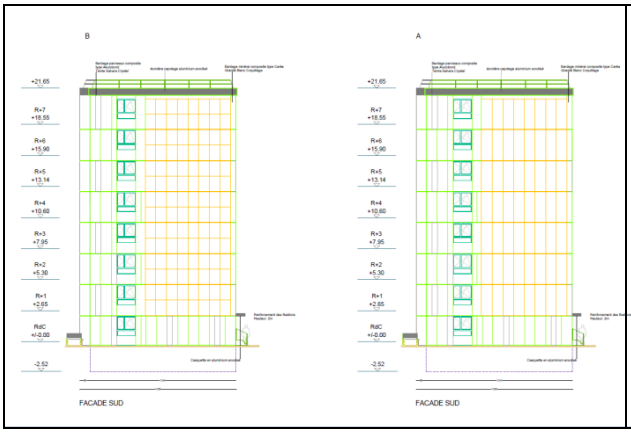
EXPLODED DRAWING



Observations:

Manufacturing drawings of product X5-1

DESIGN PLANS



DETAILED DESCRIPTION	
Definition	PV rectangular C-Si opaque modules with Hidden busbars and L-interconnections
Construction unit	Ventilated façade/Curtain wall
Architectural location	Façade
Geometrical design	Rectangular opaque module
Dimensions	Height: 480-2000 mm, Length: 1245-4000 mm Width: 9.80-17.80
Geometrical shape	Rectangular/Customizable
Materials	PV glazing (Extraclear tempered glass, EVA, C-Si cells, Black frit patterned glass, black plastic sheet)
Configuration	Double glazing or simple laminated glass
Layers	From top to bottom: Extraclear tempered glass EVA, C-Si solar cells, EVA Black frit patterned glass
Frame structure	Frameless
PV technology	Si-monocrystalline
Encapsulation material	EVA
Surface treatments	Rear glass with black frit / Customizable
Thermal insulation	Common glazing technologies can be used (double/triple glazing, low-E coatings, etc)
Acoustic insulation	Double/triple glazing can be used.
Physical features	Similar to classic C-Si modules
Weight	20 to 60 kg/m^2 (glazing)
Rigidity	Rigid
Opacity	Opaque

Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	153 Wp/m^2. Variable depending on cell density (PVR)
Thermal transmittance (U value)	Defined by glazing system used

9.2 **Mechanical Performance – X5**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Denomination	X5 - C-Si glazed products with hidden bus bars and L interconnections

DESIGN/DATASHEET VALUES		
BIPV UNIT		
General characteristics	PV rectangular C-Si opaque modules with Hidden busbars and L-interconnections	
Manufacturer	Onyx Solar	
Model	C-Si Opaque PV glazing with hidden busbars and L-interconnections	
Shape	Rectangular	
Physical characteristics	PV glazing	Unit
Height/ Length/ Thickness	480-2000/ 1245-4000/ 9.80-17.80	mm
Weight	20-60	Kg/ m^2
Mechanical characteristics	Glass mechanical properties	
Tensile strength	120-200 (tempered); 40 (float)	MPa
Tensile modulus	~70	GPa
Poisson coefficients	0.22	-

Observations:

Mechanical characteristics are the ones from the glass layers, which are the main mechanical material of the PV glazing

9.3 Architectural Integration – X5

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Onyx Solar / BEAR
Author	Léo Staccioli / Tjerk Reijenga

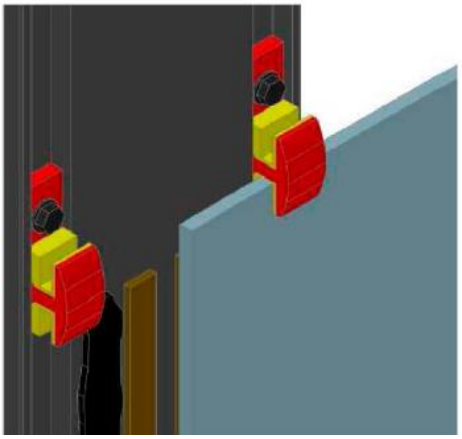
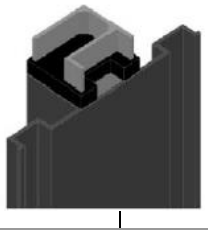
PRODUCT CODE	
Denomination	X5 - C-Si glazed products with hidden bus bars and L interconnections

DEFINITION AND LOCATION	
Definition	PV rectangular C-Si opaque modules with hidden busbars and L-interconnections
Construction unit	Ventilated façade/Curtain wall
Architectural location	Façade

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1245-4000	mm	9.80-17.80	mm	480-2000	mm
Weight			20-60	kg/m^2		
Materials and devices	PV glazing (double or simple). Includes junction box at the back					
Configuration	Double glazing					
Frame structure	Frameless					
PV technology	Si-mono-crystalline 156x156mm solar cells					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	No					
Aesthetical features	Hidden solar cells interconnections. Fully black appearance.					
Opacity	Opaque (Black rear frit patterned glass)					
Cell colour	Dark blue					
Background colour	Black					

Surface treatments	Surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common ventilated façade/curtain wall systems
Maintenance	Cleaning periodic activities, in order to avoid performance losses
Inspection	Remote monitoring / Physical inspection
Sequence of inspection	N/A
Maintenance for the system	N/A
Sequence of maintenance	Cleaning activities depending on the environmental conditions
Accessibility of system	PV modules are accessible from the exterior.
Safety procedure	Glazing system should comply with standards (f.i. CWCT note 67 or ETAG 034) in order to guarantee safety accessibility
Removal	Same removal process than normally façade elements, take care of disconnecting cables

PICTURES	
Integration method	
Horizontal lay-out	Vertical lay-out
	
Ventilated façade mounting system	
  	

9.4 **Electrical Performance – X5**

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Denomination	X5 - C-Si glazed products with hidden bus bars and L interconnections

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Si-mono-crystalline PV glazing					
Manufacturer	Not specific cell provider required					
Cell type	Mono-crystalline silicon. 156x156 mm solar cell with three BB					
Module Shape	Rectangular					
Colour	Dark Blue					
Front layer	Extraclear tempered glass					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection	Non-parallel connection within one module					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1000	mm	1700	mm	13.8	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	260	Wp	153	Wp/m^2		-
Efficiency	16	%		-		-
Vpm: max. power voltage	31.5	V		-		-
Ipm: max. power current	8.28	A		-		-
Voc: open circuit voltage	40.6	V		-		-

Isc: short circuit current	8.45	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	+0.08	%/ºC				-
Voc (β) Temp. coefficient	-0.361	%/ºC				-
P (γ) Temp. coefficient	-0.451	%/ºC				-
Operating range						
Temperature	-40 - +85	ºC				
Maximum System Voltage	1000	V				

9.5 Optical Performance – X5

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X5 - C-Si glazed products with hidden bus bars and L interconnections

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	PV laminated glass with rows of solar cells every 3 mm					
Manufacturer	Onyx Solar					
Model	C-Si glazed products with hidden bus bars and L interconnections					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1000	mm	1700	mm	13.8	mm
Weight	51	kg	30	kg/m2		
PV ratio (PVR)	Variable					
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	89.8	%	-	-	-	-
Solar transmittance	81.9	%	-	-	-	-
Visible reflectance (tz)	8.5	%	-	-	-	-
Solar reflectance (tz)	7.8	%	-	-	-	-
Visible reflectance (cz)	5.9	%	-	-	-	-
Solar reflectance (cz)	10.1	%	-	-	-	-
Visible absorptance (tz)	1.7	%	-	-	-	-
Solar absorptance (tz)	10.3	%	-	-	-	-
Visible absorptance (cz)	98.3	%	-	-	-	-
Solar absorptance (cz)	89.7	%	-	-	-	-

Emissivity	83.7	%	-	-	-	-
Observations: Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.						

10 X6 Glass-Glass product with back-contacts c-Si cells

10.1 General Description, Design and Materials – X6

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Onyx Solar
Author	Héctor Zamora

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Ventilated façade/ Curtain wall/ Skylight/ Shading system
Denomination	X6 - Glass-glass products with back contact c-Si cells
Partner/s	Onyx

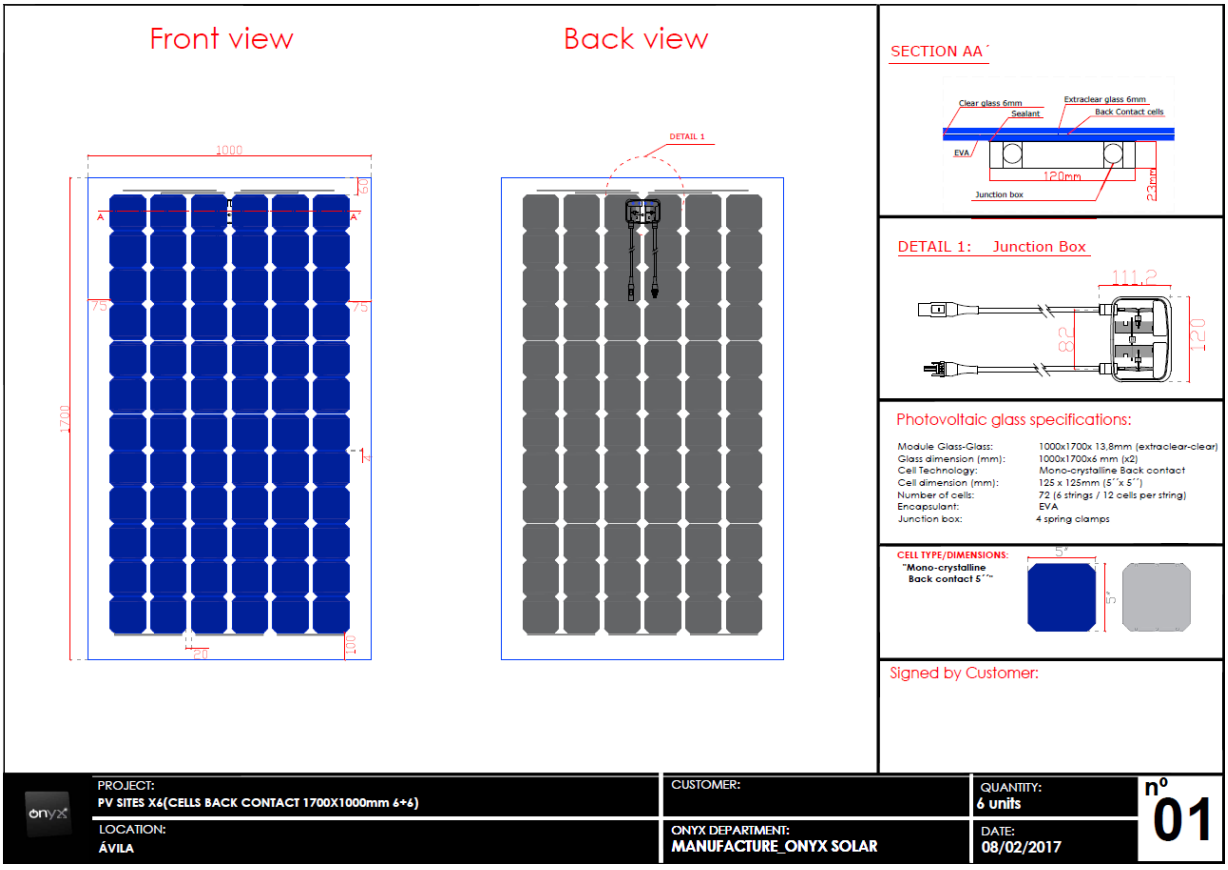
PICTURES

REALISTIC DRAWING

Observations:

Semi-transparent Photovoltaic module based on back contact cells, allowing an improved aesthetics of the product and higher performances due to the absence of front bus bars.

EXPLODED DRAWING



Observations:

CAD Drawing of X6 product

DESIGN PLANS

DETAILED DESCRIPTION	
Definition	Semi-transparent PV rectangular glazing based on back contact 5” c-Si solar cells
Construction unit	Ventilated façade/ Curtain wall/ Skylight/ Shading system
Architectural location	Façade/ Roof
Geometrical design	Rectangular semi-transparent glazing
Dimensions	Length: 1245 – 4000 mm, Height: 480 – 2000 mm
Geometrical shape	Rectangular / Customizable
Materials	Glass, EVA, back contact solar cells
Configuration	Simple laminated glass
Layers	From top to bottom: Extraclear tempered glass, EVA, back contact solar cells, EVA, Cleartempered glass
Frame structure	Frameless/ Aluminium
PV technology	Si-mono crystalline
Encapsulation material	EVA
Surface treatments	May be included on PV glazing
Thermal insulation	Common glazing technologies can be used (double/triple glazing, low-e coatings, etc)
Acoustic insulation	Double/triple glazing can be used.
Physical features	Similar to other glazing skylights/glazing façade elements
Weight	20-60 kg/m^2
Rigidity	Rigid
Opacity	68%
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	126 Wp/m^2
Passive energy features	Same as other BIPV glazing solutions, depending on the specific application (shading effect, reducing cooling/heating needs) and the additional treatments on the glazing (low-e, etc)
Optical transmittance	27%
Thermal transmittance (U value)	Defined by glazing system used

10.2 Mechanical Performance – X6

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Onyx Solar
Author	Héctor Zamora

PRODUCT CODE	
Denomination	X6 - Glass-glass products with back contact c-Si cells

DESIGN/DATASHEET VALUES		
BIPV UNIT		
General characteristics	Semi-transparent PV rectangular glazing based on back contact 5” c-Si solar cells	
Manufacturer	Onyx Solar	
Model	See-through Back contact solar cells glass glass BIPV	
Shape	Rectangular / Customizable	
Physical characteristics	Value 1	Unit 1
Height/ Length/ Thickness	1245-4000/ 480-2000/ 9.8-17.8	mm
Weight	20-60	kg/m^2
Mechanical characteristics	Glass mechanical properties	
Tensile strength	120-200	MPa
Tensile modulus	~70	GPa
Poisson coefficients	0.22	-

Observations:

Mechanical properties are the ones for the glass layers, which are the main mechanical material of the PV glazing.

10.3 Architectural Integration – X6

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Onyx Solar
Author	Héctor Zamora

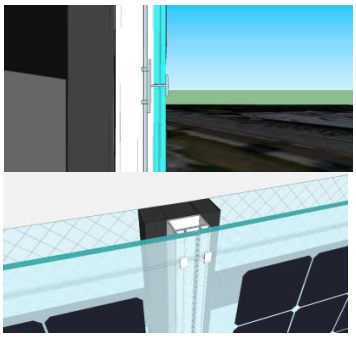
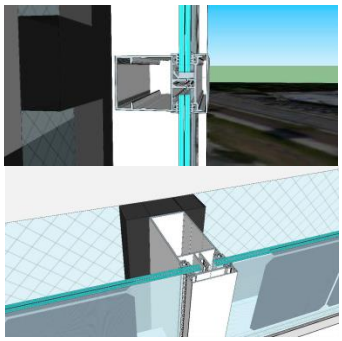
PRODUCT CODE	
Denomination	X6 - Glass-glass products with back contact c-Si cells

DEFINITION AND LOCATION	
Definition	Semi-transparent PV rectangular glazing based on back contact 5” c-Si solar cells
Construction unit	Ventilated façade/ Skylight/ Curtain wall/ Shading element
Location	Better performance in locations with high direct radiation
Architectural location	Façade/ roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1245-4000	mm	480-2000	mm	9.8-17.8	mm
Weight	50.63	kg	27	kg/m^2		
Materials and devices	PV glazing. Includes junction box at the back					
Configuration	Double glazing					
Frame structure	Frameless/ aluminium					
PV technology	Si-mono-crystalline					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure.					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	Determined by structure					
Aesthetical features	Structure appearance can be customized					
Opacity	Transparent glazing with opaque PV cells (32% transparency)					
Cell colour	Dark blue (front), Grey (back)					
Background colour	Customizable					

Frame colour	Customizable
Surface treatments	Colour or surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common façade/skylight/curtain wall systems
Maintenance	Cleaning periodic activities, in order to avoid performance losses
Inspection	Remote monitoring
Sequence of inspection	N/A
Maintenance for the system	N/A
Sequence of maintenance	Cleaning activities depending on the environmental conditions
Accessibility of system	PV modules are accessible from the exterior.
Safety procedure	Glazing system should comply with standards (f.i. CWCT note 67 or ETAG 034) in order to guarantee safety accessibility
Removal	Same removal process than normally applied in skylight or façade elements, taken care of disconnecting cables

PICTURES		
Integration method		
Integration as ventilated façade	Invisible framing system	Visible framing system
		
Observations: Pictures correspond with the overseen integration options for the		

10.4 Electrical Performance – X6

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Onyx Solar
Author	Héctor Zamora

PRODUCT CODE	
Denomination	X6 - Glass-glass products with back contact c-Si cells

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Back contact mono crystalline PV glazing					
Manufacturer	Not specific provider required					
Cell type	Mono-crystalline silicon. 125x125 mm back contact solar cell					
Module Shape	Rectangular					
Module Colour	Dark blue solar cells. Transparent non-coloured glazing					
Front layer	Low iron tempered glass					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection	Non-parallel connection within one module					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1700	mm	1000	mm	13.8	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	215	Wp	126	Wp/m^2		-
Efficiency	20	%		-		-
Tolerance	±10	%		-		-
Vpm: max. power voltage	39.24	V		-		-
Ipm: max. power current	5.5	A		-		-

Voc: open circuit voltage	46.80	V		-		-
Isc: short circuit current	5.7	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	3.5	mA/ºC				-
Voc (β) Temp. coefficient	-1.74	mV/ºC				-
P (γ) Temp. coefficient	-0.3	%/ºC				-
Operating range						
Temperature	-40 - +85	ºC				
Maximum System Voltage	1000	V				
Protection	IP65					

10.5 Optical Performance – X6

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X6 - Glass-glass products with back contact c-Si cells

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	Back contact mono crystalline PV glazing					
Manufacturer	Onyx Solar					
Model	See-through Back contact solar cells glass glass BIPV					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	2250	mm	750	mm	13.8	mm
Weight	50.63	kg	27	kg/m2		
PV ratio (PVR)	Variable	%				
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	89.8	%	-	-	-	-
Solar transmittance	81.9	%	-	-	-	-
Visible reflectance (tz)	8.5	%	-	-	-	-
Solar reflectance (tz)	7.8	%	-	-	-	-
Visible reflectance (cz)	4.8	%	-	-	-	-
Solar reflectance (cz)	8.3	%	-	-	-	-
Visible absorptance (tz)	1.7	%	-	-	-	-
Solar absorptance (tz)	10.3	%	-	-	-	-
Visible absorptance (cz)	95.2	%	-	-	-	-
Solar absorptance (cz)	91.7	%	-	-	-	-

Emissivity	83.7	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

11 X7 Curved glass-glass, CIGS technology

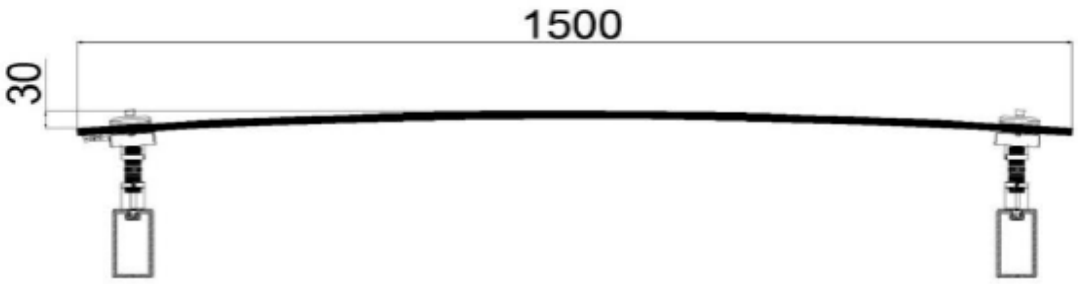
11.1 General Description, Design and Materials – X7

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Onyx Solar, FLISOM
Author	Héctor Zamora

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Ventilated façade/ Curtain wall/ Skylight/ Roofing shingle/ Shading system
Denomination	X7 - Curved glass-glass, CIGS technology
Partner/s	Onyx, FLISOM

PICTURES

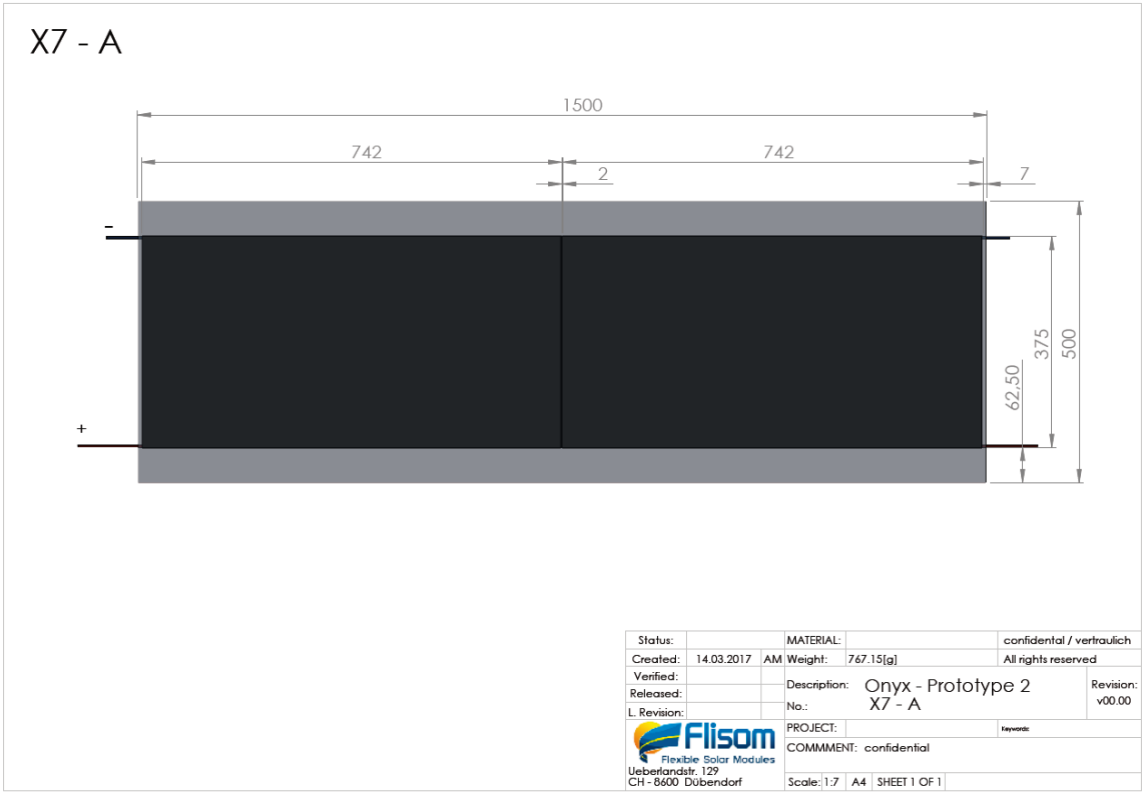
REALISTIC DRAWING



Observations:

Curved glass-glass opaque CIGS module

EXPLODED DRAWING



Observations:

Drawings of X7 product

DETAILED DESCRIPTION	
Definition	Opaque curved glass-glass CIGS PV module
Construction unit	Ventilated façade/ Curtain wall/ Skylight
Architectural location	Façade/ Roof
Geometrical design	Rectangular curved glass glass module based on CIGS technology
Dimensions	1500mm/500mm/11mm. Higher thicknesses can be used, but the cold bending process takes more time.
Geometrical shape	Rectangular, curved
Materials	Tempered glass, CIGS sub-module, encapsulant
Configuration	Simple laminated
Layers	From top to bottom: 4mm Front clear tempered glass, encapsulant, CIGS pre encapsulated module, encapsulant, 4mm rear tempered glass
Frame structure	Frameless
PV technology	Thin film (CIGS)
Surface treatments	May be included in front/rear side
Thermal insulation	Double glazing. Depending on the curvature required, additional technologies could be used.
Acoustic insulation	Double glazing. Depending on the curvature required, additional technologies could be used.
Physical features	Similar to other curved glazing skylights/glazing façade elements
Weight	20-60 kg/m^2
Rigidity	Rigid
Opacity	Opaque
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with sun radiation.
Photovoltaic power	67 Wp/m^2
Additional gain	Other gains (concentration, etc.)
Passive energy features	Descriptive value
Optical transmittance	Opaque
Thermal transmittance (U value)	Defined by glazing system used

11.2 Mechanical Performance – X7

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Onyx, FLISOM
Author	Héctor Zamora

PRODUCT CODE	
Denomination	X7 - Curved glass-glass, CIGS technology

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	Opaque curved glass glass CIGS PV module					
Manufacturer	Onyx					
Model	Curved CIGS glass elements					
Shape	Rectangular, Curved					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	500	mm	1500	mm	11	mm
Weight			20-60	kg/m2	-	-
Mechanical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Tensile strength	120-200	MPa				
Tensile modulus	~70	GPa				
Poisson coefficients	0.22	-				
Observations: Mechanical properties are the ones for the glass layers, which are the main mechanical material of the PV glazing.						

11.3 Architectural Integration – X7

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Onyx, FLISOM
Author	Héctor Zamora

PRODUCT CODE	
Denomination	X7 - Curved glass-glass, CIGS technology

DEFINITION AND LOCATION	
Definition	Opaque curved glass glass CIGS PV module
Construction unit	Ventilated façade/ Curtain wall/ Skylight/ Shading system
Location	Due to their curved shape, it can be used in designs with non-linear shapes (irregular roofings, curved canopies, etc)
Architectural location	Façade/ Roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular/ curved					
Dimensions	1500	mm	11	mm	500	mm
Weight			20-60	kg/m^2		
Materials and devices	PV glazing. Includes junction box at the back					
Configuration	Simple laminated					
Frame structure	Frameless					
PV technology	Thin film (CIGS)					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure.					
Thermal insulation	Common glazing thermal insulation strategies can be used, taking into account the curvature of the glass					
Thermal bridge	Determined by structure					
Aesthetical features	Appearance can be customised					
Opacity	Opaque					
Colours of sub-modules	Black (Front), Gold (rear)					

Background colour	Customisable
Frame colour	Customisable
Surface treatments	Colour or surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common façade/skylight/curtain wall applied for curved systems
Maintenance	Cleaning periodic activities, in order to avoid performance losses
Inspection	Remote monitoring
Sequence of inspection	N/A
Maintenance for the system	N/A
Sequence of maintenance	Cleaning frequency depends on environmental conditions
Accessibility of system	PV modules are accessible for the exterior
Safety procedure	Glazing system should comply with standards (f.i. CWCT note 67 or ETAG 034) in order to guarantee safety accessibility
Removal	Same removal process than normally applied in skylight or façade elements, taken care of disconnecting cables.

11.4 Electrical Performance – X7

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X7 - Curved glass-glass, CIGS technology

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Opaque curved glass glass CIGS PV module					
Manufacturer	FLISOM					
Cell type	CIGS pre encapsulated sub-module					
Shape	Rectangular/customisable					
Colour	Black PV active surface. Transparent non-coloured glazing					
Front layer	Clear tempered glass					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection						
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness (glazing)	900	mm	450	mm	11	mm
Height/ Length/ Thickness (CIGS submodule)	742	mm	372	mm	-	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	30	Wp	108.6	Wp/m^2		-
Efficiency	11	%		-		-
Tolerance	±10	%		-		-

Vmp	34	V		-		-
Imp	0.88	A		-		-
Voc	46	V		-		-
Isc	0.97	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	0.01	%/ºC				-
Voc (β) Temp. coefficient	-0.3	%/ºC				-
P (γ) Temp. coefficient	-0.35	%/ºC				-
Operating range						
Temperature	-40 - +90	ºC				
Maximum System Voltage	1000	V				
Protection	IP65					
Maximum Wind /Snow Load	2400	Pa				
Max. Reverse Current (IR)	N/A	A				

11.5 Optical Performance – X7

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Maider Machado / Daniel Valencia

PRODUCT CODE	
Denomination	X6 - Glass-glass products with back contact c-Si cells

DESIGN / DATASHEET VALUES

BIPV UNIT						
General characteristics	Opaque curved glass-glass CIGS PV module					
Manufacturer	Flisom - Onyx Solar					
Model	Curved CIGS glass elements					
Shape	Curved - Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	500	mm	1500	mm	11	mm
Weight			20-60	kg/m2	-	-
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance	0	%	-	-	-	-
Solar transmittance	0	%	-	-	-	-
Visible reflectance (tz)	-	%	-	-	-	-
Solar reflectance (tz)	-	%	-	-	-	-
Visible reflectance (cz)	5	%	-	-	-	-
Solar reflectance (cz)	8.9	%	-	-	-	-
Visible absorptance (tz)	-	%	-	-	-	-
Solar absorptance (tz)	-	%	-	-	-	-
Visible absorptance (cz)	95	%	-	-	-	-
Solar absorptance (cz)	91.1	%	-	-	-	-
Emissivity	83.7	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

12 X8 - Framing system for c-Si large area glass

12.1 General Description, Design and Materials – X8

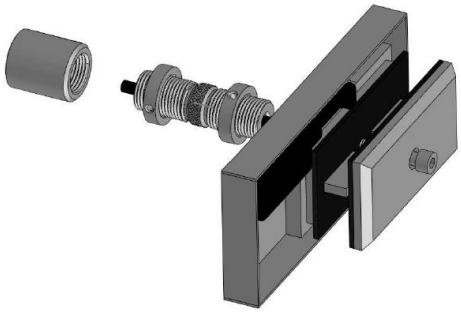
TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Onyx Solar
Author	Léo Staccioli, Héctor Zamora

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Ventilated façade/ Curtain wall/ Skylight/ Roofing shingle/ Shading system
Denomination	X8 - Framing system for c-Si large area glass

PICTURES

REALISTIC DRAWING

1.



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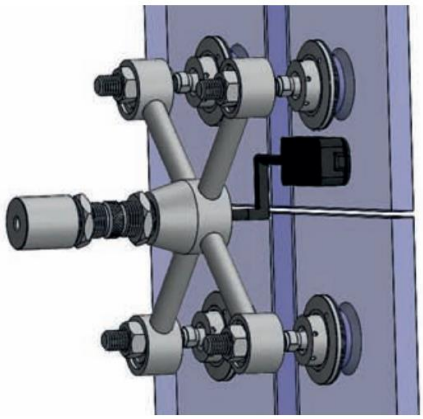
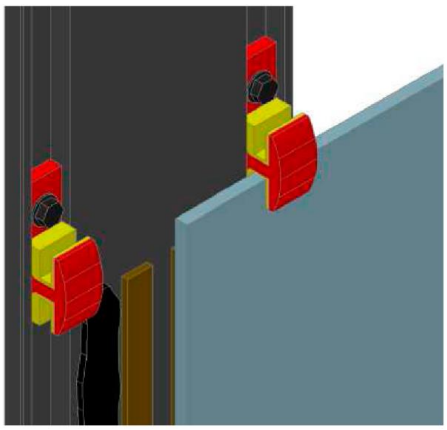
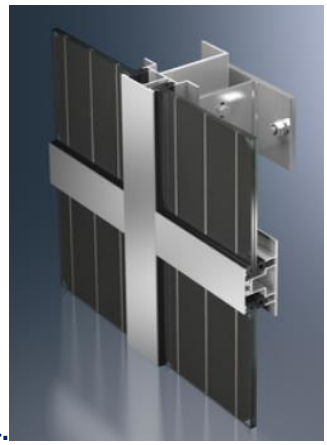


3. 

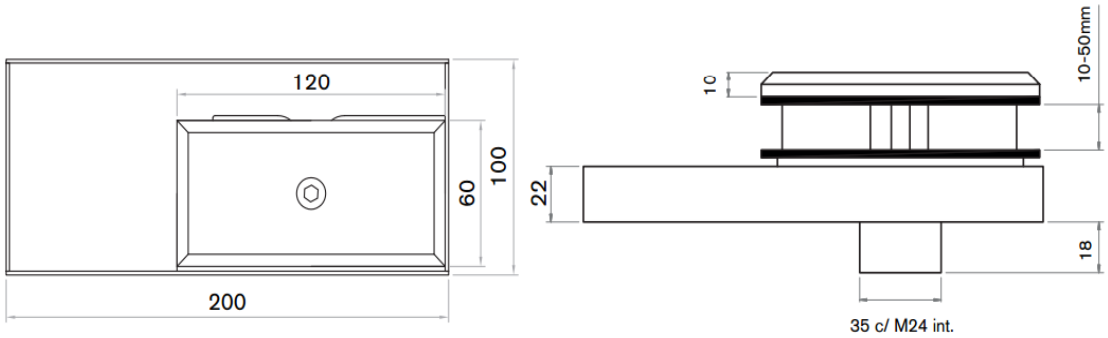
4. 

Observations:

1. Mounting system for ventilated façades (picture will follow)
2. Mounting system for PV skylights and curtain walls (picture will follow)
3. Mounting system for ventilated façades (picture will follow)
4. Mounting system for ventilated façade

DESIGN PLANS

1.



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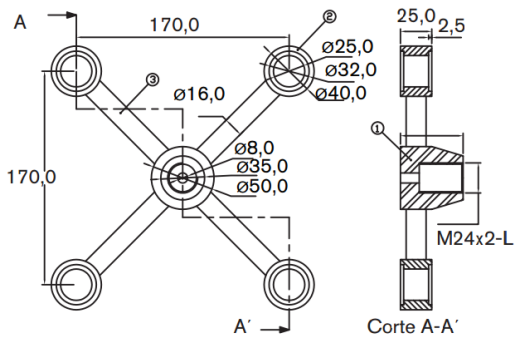

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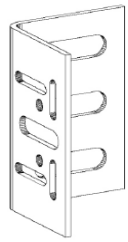
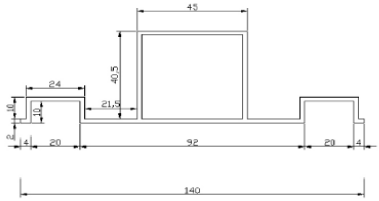
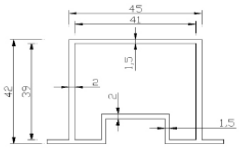


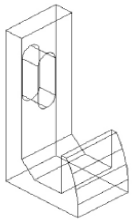
Ménsulas Sustentación



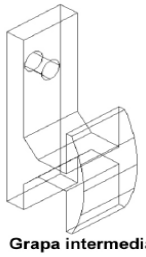


Perfiles verticales

Ménsulas Retención



Grapa arranque



Grapa intermedia

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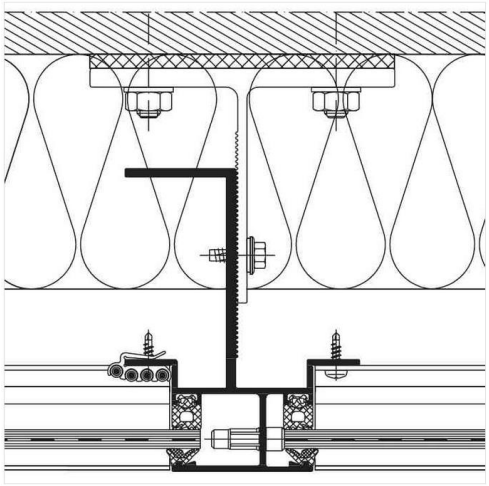


DETAILED DESCRIPTION	
Definition	Framing system for c-Si large area glass
Construction unit	Ventilated façade/ Curtain wall/ Skylight
Architectural location	Façade/ Roof
Geometrical design	Depends on the glazing
Dimensions	Height: up to 2400 mm, Length: up to 5100 mm (dimensions of the glazing)
Geometrical shape	Depends on the glazing
Materials	Aluminium/ Stainless steel/ PV glazing
Frame structure	1. Mounting system for ventilated façades 2. Mounting system for PV skylights and curtain walls 3. Mounting system for ventilated façades 4. Mounting system for ventilated façade
PV technology	c-Si large area glass
Encapsulation material	EVA
Weight	Total weight will depend on the glazing
Rigidity	Rigid
Opacity	Depends on the glazing
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	Depends on the glazing
Optical transmittance	Depends on the glazing
Thermal transmittance (U value)	Defined by glazing system used

12.2 Mechanical Performance – X8

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Denomination	X8 - Framing system for c-Si large area glass

DESIGN/DATASHEET VALUES		
BIPV UNIT		
General characteristics	Framing system for c-Si large area glass	
Physical characteristics	1. Mounting sytem for ventilated façades (Example)	Unit 1
Height/ Length/ Thickness	Depends on the glazing	mm
Weight	Depends on the glazing	kg
Others	-	-
Mechanical characteristics (Framing system)	Value 1	Unit 1
Ø	12-100	mm
Elastic Limit: Rp 0,2 min	200	N/mm^2
Elastic Limit: Rp 1,0 min	275	N/mm^2
Tensile strength: Rp min	500-700	N/mm^2
Elongation: AMin(Long/Trans)	40-30	**%**
HB (Brinel) max hardness	215	-

12.3 Architectural Integration – X8

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Denomination	X8 - Framing system for c-Si large area glass

DEFINITION AND LOCATION	
Definition	Framing system for c-Si large area glass
Construction unit	Ventilated façade/ Curtain wall/ Skylight
Location	Demonstrator in Chambery (France)
Architectural location	Façade/ Roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular/Customizable					
Dimensions (glazing)	Up to 5100	mm	-	mm	Up to 2400	mm
Materials and devices	Aluminium/Stainless steel + PV glazing					
Configuration	Depends on the glazing					
Frame structure	Aluminium/Stainless steel					
PV technology	c-Si large area glass					
Location of pipes, diameters	Depends on the glazing					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	Determined by structure					
Opacity	Depends on the glazing					
Cell colour	Dark blue/Blue					
Background colour	Depends on the glazing					
Frame colour	Grey (aluminium/stainless steel)					
Surface treatments	Colour or surface technologies for glass can be used					

INTEGRATION AND MAINTENANCE MEASURES

Mounting system	Façade/Curtain wall/Skylight
Maintenance	N/A
Inspection	Remote monitoring
Maintenance for the system	N/A
Sequence of maintenance	N/A
Accessibility of system	Depends on the system
Safety procedure	Framing system should comply with standards ETAG 034 (Wind suction resistance) and CWCT note 67 (Impact due to maintenance activities)
Removal	Same removal process than normally façade, curtain wall and skylight elements, taken care of disconnecting cables

13 X9 - C-Si semitransparent low concentration and solar control BIPV system – skylight configuration

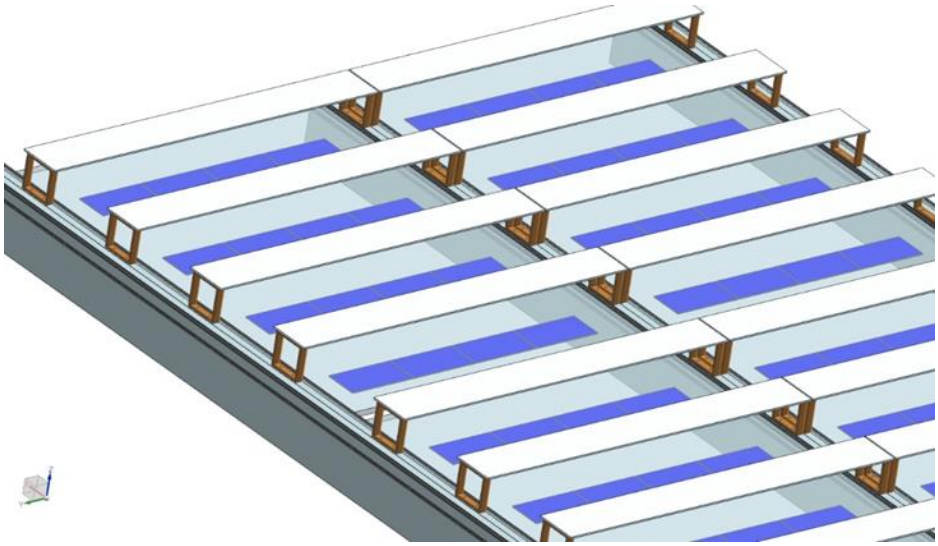
13.1 General Description, Design and Materials – X9

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Skylight
Denomination	X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration
Partner/s	Tecnalia, Film Optics, Bear, Nobatek, Onyx

PICTURES

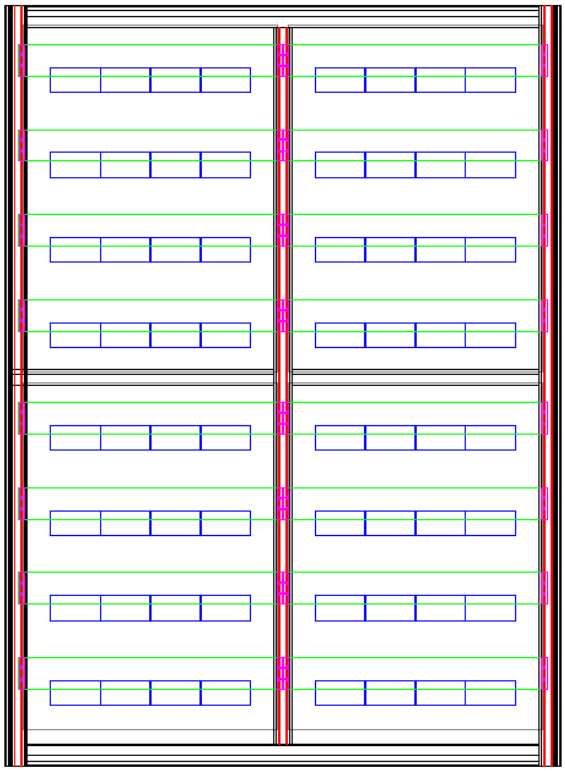
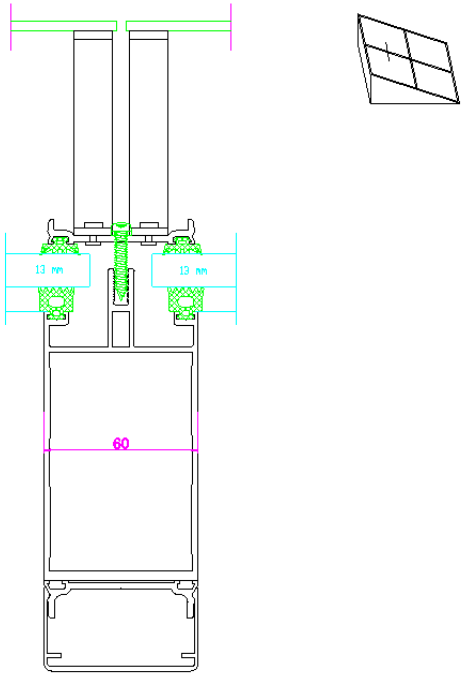
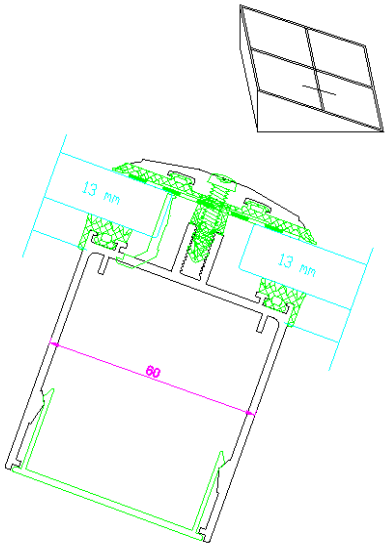
REALISTIC DRAWING



Observations:

Photovoltaic skylight system including lenses to concentrate solar radiation onto the solar cells during the central part of the year and allow light passing towards the interior of the building during the winter.

DESIGN PLANS

Front view	Intermediate vertical section with simple glazing
	
Intermediate horizontal section	
	

DETAILED DESCRIPTION	
Definition	PV rectangular glazing combined with optical system anchored to the skylight structure
Construction unit	Skylight
Architectural location	Roof
Geometrical design	Rectangular glazing combined with optical systems
Dimensions	Height: 700-3000 mm, Length: 350-1000 mm.
Geometrical shape	Rectangular
Materials	PV glazing (glass, EVA, silicon solar cells) + Optical system (glass, PMMA), structural system (aluminium, EPDM)
Configuration	Double glazing or simple laminated glass
Layers	From top to bottom: Optical system: Extraclear glass, PMMA; PV glazing: Extraclear glass glass, EVA, Solar cells, EVA, glass, junction box Additional layers maybe added in case of double glazing Glass layers maybe tempered depending on safety requirements
Frame structure	Aluminium. Others may be used
PV technology	Si-polycrystalline
Encapsulation material	EVA
Surface treatments	May be included on PV glazing back side
Thermal insulation	Common glazing technologies can be used (double/triple glazing, low-E coatings, etc)
Acoustic insulation	Double/triple glazing can be used. Especial encapsulants should be studied
Physical features	Similar to other glazing skylights
Weight	20 to 60 kg/m^2 (glazing) + 5 kg/m^2 (optical system) + 8 kg/m^2 (aluminium structure)
Rigidity	Rigid
Opacity	Transparent, with opaque solar cells
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	40 Wp/m^2 with standard config. It can be customized
Additional gain	Peak power may be multiplied up to 2.3X due to concentration effects
Passive energy features	Variable optical properties depending on the season

Optical transmittance	~39% in summer and ~47% in winter (for simple PV glazing, Latitude 45º, 20º tilted)
Thermal transmittance (U value)	Defined by glazing system used

13.2 Mechanical Performance – X9

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration

DESIGN/DATASHEET VALUES				
BIPV UNIT				
General characteristics	PV rectangular glazing combined with optical system anchored to the skylight structure			
Manufacturer	Onyx Solar			
Model	Low-C Skylight			
Shape	Rectangular			
Physical characteristics	PV glazing	Unit	Optical system	Unit
Height/ Length/ Thickness	700-3000/ 350-1000/ 8-40	mm	100/ 360-1020/ 4-6	mm
Weight	20 - 60	kg/m^2	~5	kg/m^2
Mechanical characteristics	Glass mechanical properties			
Tensile strength	120-200 (tempered); 40 (float)	MPa	120-200 (tempered); 40 (float)	MPa
Tensile modulus	~70	GPa	~70	GPa
Poisson coefficients	0.22	-	0.22	-

Observations:

Mechanical characteristics are the ones from the glass layers, which are the main mechanical material of the PV glazing and the optical system

13.3 Architectural Integration – X9

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Tecnalia
Author	Daniel Valencia

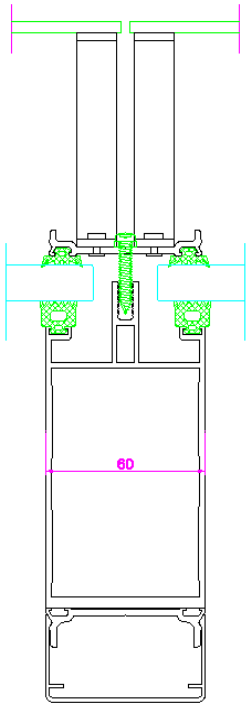
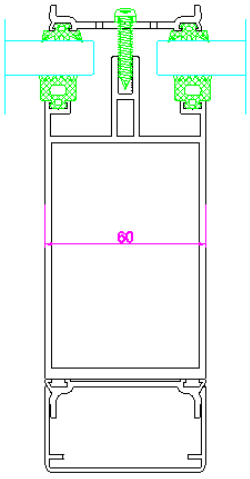
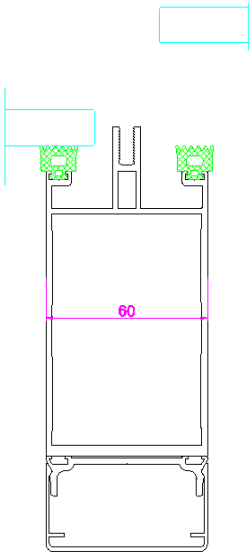
PRODUCT CODE	
Denomination	X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration

DEFINITION AND LOCATION	
Definition	PV rectangular glazing combined with optical system anchored to the skylight structure
Construction unit	Skylight
Location	Especially useful in latitudes range +/-20º - +/- 50º. Better in locations with high direct radiation
Architectural location	Roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Height	Unit 1	Length	Unit 2	Thickness	Unit 3
Shape	Rectangular					
Dimensions	700-3000	mm	350-1000	mm	200-256*	mm
Standardized variations	312	mm	156	mm	1-2	mm
Weight	33-73*	kg/m^2	Depend on glazing configuration			
	** Including structure, PV glazing and optical system*					
Materials and devices	PV glazing (double or simple). Includes junction box at the back and optical system above glazing anchored to the skylight structure					
Configuration	Double glazing or simple laminated					
Frame structure	Aluminium skylight structure (others materials can be possible)					
PV technology	Si-poly-crystalline. 78x156 mm solar cells					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	Determined by structure					

Aesthetical features	Structure appearance can be customized
Opacity	Transparent glazing with opaque PV cells covering 20-30% of the area
Cell colour	Dark blue (front), grey (back)
Background colour	Customizable
Frame colour	Customizable
Surface treatments	Colour or surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common skylight structural system
Secondary construction	Additional supports for optical system are required. Specific holes in skylight structure are needed
Maintenance	N/A
Inspection	Remote monitoring
Sequence of inspection	N/A
Maintenance for the system	N/A
Accessibility of system	Optical elements can be easily removed to access any area of the system
Safety procedure	Glazing system should comply with standards (f.i. CWCT note 67) in order to guarantee safety accessibility
Glazing removal	1) Remove optical elements 2) Remove structure pressure plate 3) Remove glass as normally done in skylight, taken care of disconnecting cables
Accessibility for removal	If required, optical lamellas can be removed to reach the working area. They can be easily dismounted by removing bolts

PICTURES		
Integration method		
Initial	Remove optical elements	Remove structure pressure plate and glass
		

13.4 Electrical perfomance– X9

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Si-poly-crystalline PV glazing					
Manufacturer	Not specific cell provider required					
Cell type	Poly-crystalline silicon. 78x156 mm solar cell with two BB					
Module Shape	Rectangular					
Module Colour	Dark blue solar cells. Transparent non-coloured glazing					
Front layer	Extra-clear glass plate					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection	Non-parallel connection within one module					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1100	mm	800	mm	13	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	32	Wp	40	Wp/m^2		-
Efficiency	16.4	%	-	-		-
Vmp: max. power voltage	8.10	V		-		-
Imp: max. power current	3.91	A		-		-

Voc: open circuit voltage	10.2	V		-		-
Isc: short circuit current	4.15	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	+0.08	%/ºC				-
Voc (β) Temp. coefficient	-0.361	%/ºC				-
P (γ) Temp. coefficient	-0.451	%/ºC				-
Operating range						
Temperature	-40 - +85	ºC				
Maximum System Voltage	600	V				

13.5 Optical Performance – X9

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration

DESIGN/DATASHEET VALUES						
BIPV UNIT						
General characteristics	PV laminated glass with rows of solar cells every 156 mm					
Manufacturer	Onyx Solar					
Model	Low-C Skylight. Prototype 01					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1100	mm	800	mm	13	mm
Weight	31	kg	35.2	kg/m^2	-	-
PV ratio (PVR)	22.1	%				
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance (tz)	89.8	%	-	-	-	-
Solar transmittance (tz)	81.9	%	-	-	-	-
Visible reflectance (tz)	8.5	%	-	-	-	-
Solar reflectance (tz)	7.8	%	-	-	-	-
Visible reflectance (cz)	10.1	%	-	-	-	-
Solar reflectance (cz)	5.9	%	-	-	-	-
Visible absorptance (tz)	1.7	%	-	-	-	-
Solar absorptance (tz)	10.3	%	-	-	-	-

Visible absorptance (cz)	89.9	%	-	-	-	-
Solar absorptance (cz)	94.1	%	-	-	-	-
Emissivity	83.7	%	-	-	-	-

Observations:
Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

This data does not consider the effect of redirection of light by the optical system as it varies strongly with latitude, tilt, PV occupancy ratio of glazing and diffuse light ratio. This effect will affect to operational solar factor and light transmittance.

14 X11 - C-Si semitransparent low concentration and solar control BIPV system – shading element configuration

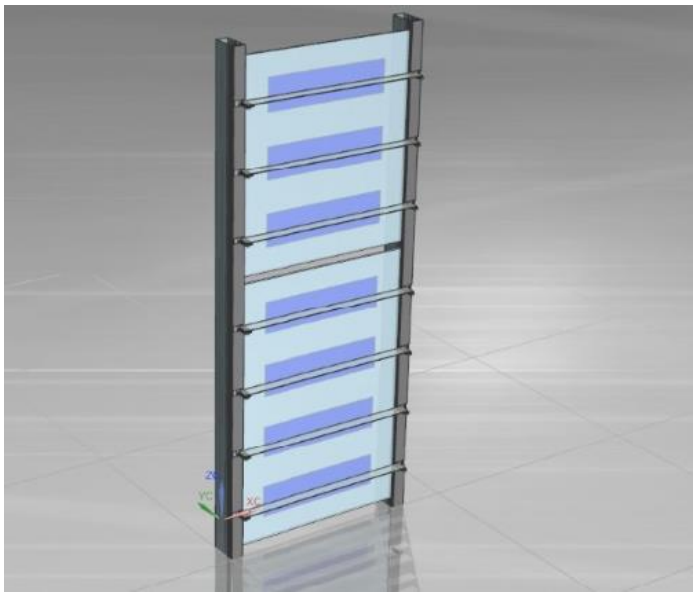
14.1 General Description, Design and Materials – X11

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Facade
Denomination	X11 - C-Si semitransparent low concentration and Solar control BIPV system – shading element configuration
Partner/s	Tecnalia, Film Optics, BEAR, Nobatek, Onyx

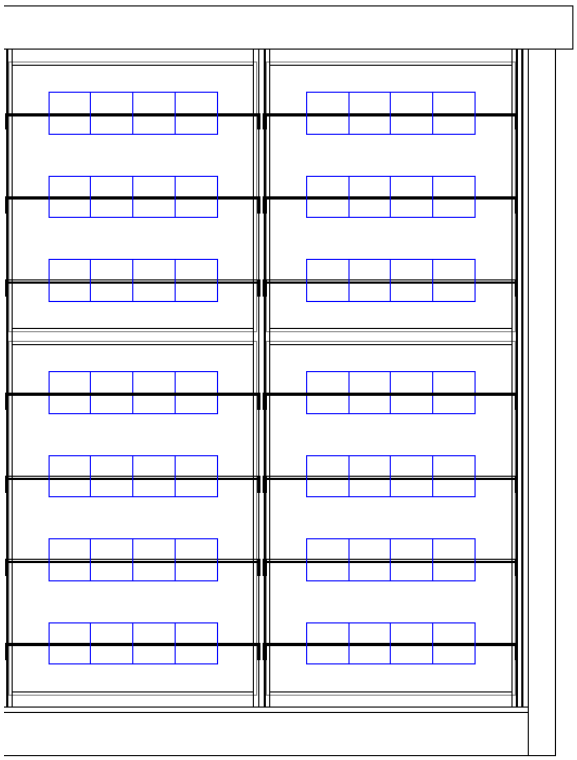
PICTURES

REALISTIC DRAWING



Observations:

Photovoltaic façade system including lenses to concentrate solar radiation onto the solar cells during the central part of the year and allow light passing towards the interior of the building during the winter.

DESIGN PLANS
Front view


DETAILED DESCRIPTION	
Definition	PV rectangular glazing combined with optical system anchored to the façade structure
Construction unit	Curtain wall/ Shading system
Architectural location	Façade
Geometrical design	Rectangular glazing combined with optical systems
Dimensions	Height: 700-3000 mm, Length: 350-1000 mm.
Geometrical shape	Rectangular
Materials	PV glazing (glass, EVA, silicon solar cells) + Optical system (glass, PMMA), structural system (aluminium, EPDM)
Configuration	Double glazing or simple laminated glass

Layers	From exterior to interior: Optical system: Extraclear glass, PMMA; PV glazing: Extraclear glass glass, EVA, Solar cells, EVA, glass, junction box Additional layers maybe added in case of double glazing Glass layers maybe tempered depending on safety requirements
Frame structure	Aluminium. Others may be used
PV technology	Si-polycrystalline
Encapsulation material	EVA
Surface treatments	May be included on PV glazing back side
Thermal insulation	Common glazing technologies can be used (double/triple glazing, low-E coatings, etc)
Acoustic insulation	Double/triple glazing can be used. Special encapsulants should be studied
Physical features	Similar to other glazed façades
Weight	20 to 60 kg/m^2 (glazing) + 5 kg/m^2 (optical system) + 8 kg/m^2 (aluminium structure)
Rigidity	Rigid
Opacity	Transparent, with opaque solar cells
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	40 Wp/m^2 with standard config. It can be customized
Additional gain	Generated power may be multiplied up to 2X due to concentration effects during spring-summer
Passive energy features	Variable optical properties depending on the season
Thermal transmittance (U value)	Defined by glazing system used

14.2 Mechanical Performance – X11

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X11 - C-Si semitransparent low concentration and Solar control BIPV system – shading element configuration

DESIGN/DATASHEET VALUES				
BIPV UNIT				
General characteristics	PV rectangular glazing combined with optical system anchored to the façade structure			
Manufacturer	Onyx Solar			
Model	Low-C Façade			
Shape	Rectangular			
Physical characteristics	PV glazing	Unit	Optical system	Unit
Height/ Length/ Thickness	700-3000/ 350-1000/ 8-40	mm	100/ 360-1020/ 4-6	mm
Weight	20 - 60	kg/m^2	~5	kg/m^2
Mechanical characteristics	Glass mechanical properties			
Tensile strength	120-200 (tempered); 40 (float)	MPa	120-200 (tempered); 40 (float)	MPa
Tensile modulus	~70	GPa	~70	GPa
Poisson coefficients	0.22	-	0.22	-

Observations:

Mechanical characteristics are the ones from the glass layers, which are the main mechanical material of the PV glazing and the optical system

14.3 Architectural Integration – X11

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X11 - C-Si semitransparent low concentration and Solar control BIPV system – shading element configuration

DEFINITION AND LOCATION	
Definition	PV rectangular glazing combined with optical system anchored to the façade structure
Construction unit	Façade/ Curtain wall glazing
Location	Especially useful in latitudes range +/-20º - +/- 50º. Better in locations with high direct radiation
Architectural location	Façade

CONSTRUCTION UNIT FEATURES						
Physical properties	Height	Unit 1	Length	Unit 2	Thickness	Unit 3
Shape	Rectangular					
Dimensions	700-3000	mm	350-1000	mm	200-256*	mm
Standardized variations	312	mm	156	mm	1-2	mm
Weight	33-73*	kg/m^2	Depend on glazing configuration			
	** Including structure, PV glazing and optical system*					
Materials and devices	PV glazing (double or simple). Includes junction box at the back and optical system above glazing anchored to the skylight structure					
Configuration	Double glazing or simple laminated					
Frame structure	Aluminium (others can be possible)					
PV technology	Si-poly-crystalline. 156x156 mm solar cells					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	Determined by structure					
Aesthetical features	Structure appearance can be customized					

Opacity	Transparent glazing with opaque PV cells covering 30-40% of the area
Cell colour	Dark blue (front), grey (back)
Background colour	Customizable
Frame colour	Customizable
Surface treatments	Colour or surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common skylight structural system
Secondary construction	Additional supports for optical system are required. Specific holes in skylight structure are needed
Maintenance	N/A
Inspection	Remote monitoring
Accessibility of system	Similar to other façade systems. Optical elements can be easily removed if required
Safety procedure	Glazing system should comply with standards in order to guarantee safety accessibility
Glazing removal	1) Remove optical elements and disconnect module cables 2) Remove structure pressure plate 3) Remove glass as normally done in curtain walls
Accessibility for removal	If required, optical lamellas can be removed to reach the working area. They can be easily dismounted by removing bolts

14.4 Electrical Performance – X11

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X11 - C-Si semitransparent low concentration and Solar control BIPV system – shading element configuration

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Si-poly-crystalline PV glazing					
Manufacturer	Not specific cell provider required					
Cell type	Poly-crystalline silicon. 156x156 mm solar cell					
Module Shape	Rectangular					
Module Colour	Dark blue solar cells. Transparent non-coloured glazing					
Front layer	Extraclear glass plate					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection	Non-parallel connection within one module					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1100	mm	800	mm	13	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	32	Wp	40	Wp/m^2		-
Efficiency	16.4	%	-	-		-
Vmp: max. power voltage	8.10	V		-		-
Imp: max. power current	3.91	A		-		-
Voc: open circuit voltage	10.2	V		-		-

Isc: short circuit current	4.15	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	+0.08	%/ºC				-
Voc (β) Temp. coefficient	-0.361	%/ºC				-
P (γ) Temp. coefficient	-0.451	%/ºC				-
Operating range						
Temperature	-40 - +85	ºC				
Maximum System Voltage	600	V				
Maximum Wind /Snow Load	N/A	Pa				
Max. Reverse Current (IR)	N/A	A				

14.5 Optical Performance – X11

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Optical performance of BIPV modules
Partner	Tecnalia
Author	Daniel Valencia

PRODUCT CODE	
Denomination	X11 - C-Si semitransparent low concentration and Solar control BIPV system – façade configuration

DESIGN/DATASHEET VALUES

BIPV UNIT						
General characteristics	PV laminated glass with rows of solar cells every 312 mm					
Manufacturer	Onyx Solar					
Model	Low-C Façade. Prototype 01					
Shape	Rectangular					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1059	mm	922	mm	13	mm
Weight	31	kg	35.2	kg/m^2		
PV ratio (PVR)	30	%				
Optical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Visible transmittance (tz)	89.8	%	-	-	-	-
Solar transmittance (tz)	81.9	%	-	-	-	-
Visible reflectance (tz)	8.5	%	-	-	-	-
Solar reflectance (tz)	7.8	%	-	-	-	-
Visible reflectance (cz)	10.1	%	-	-	-	-
Solar reflectance (cz)	5.9	%	-	-	-	-
Visible absorptance (tz)	1.7	%	-	-	-	-
Solar absorptance (tz)	10.3	%	-	-	-	-
Visible absorptance (cz)	89.9	%	-	-	-	-

Solar absorptance (cz)	94.1	%	-	-	-	-
Emissivity	83.7	%	-	-	-	-

Observations:

Absorptance is calculated from transmittance and reflectance values. Acronym (tz): transparent zone. Acronym (cz): cell zone.

This data does not consider the effect of redirection of light by the optical system as it varies strongly with latitude, tilt, PV occupancy ratio of glazing and diffuse light ratio. This effect will affect to operational solar factor and light transmittance.

15 X12 - Glazed modules treated for improved passive properties (Dark blue mass coloured glass)

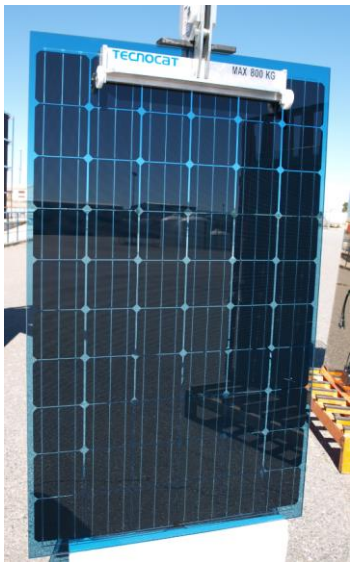
15.1 General Description, Design and Materials – X12

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description, design and materials of BIPV modules.
Partner	Onyx Solar
Author	Léo Staccioli, Héctor Zamora

PRODUCT CODE	
Project	PVSITES. Task 2.3. BIPV products portfolio
Category	Ventilated façade/ Curtain wall/ Skylight/ Shading system
Denomination	X12 - Glazed modules treated for improved passive properties (Dark blue mass coloured glass)
Partner/s	Onyx

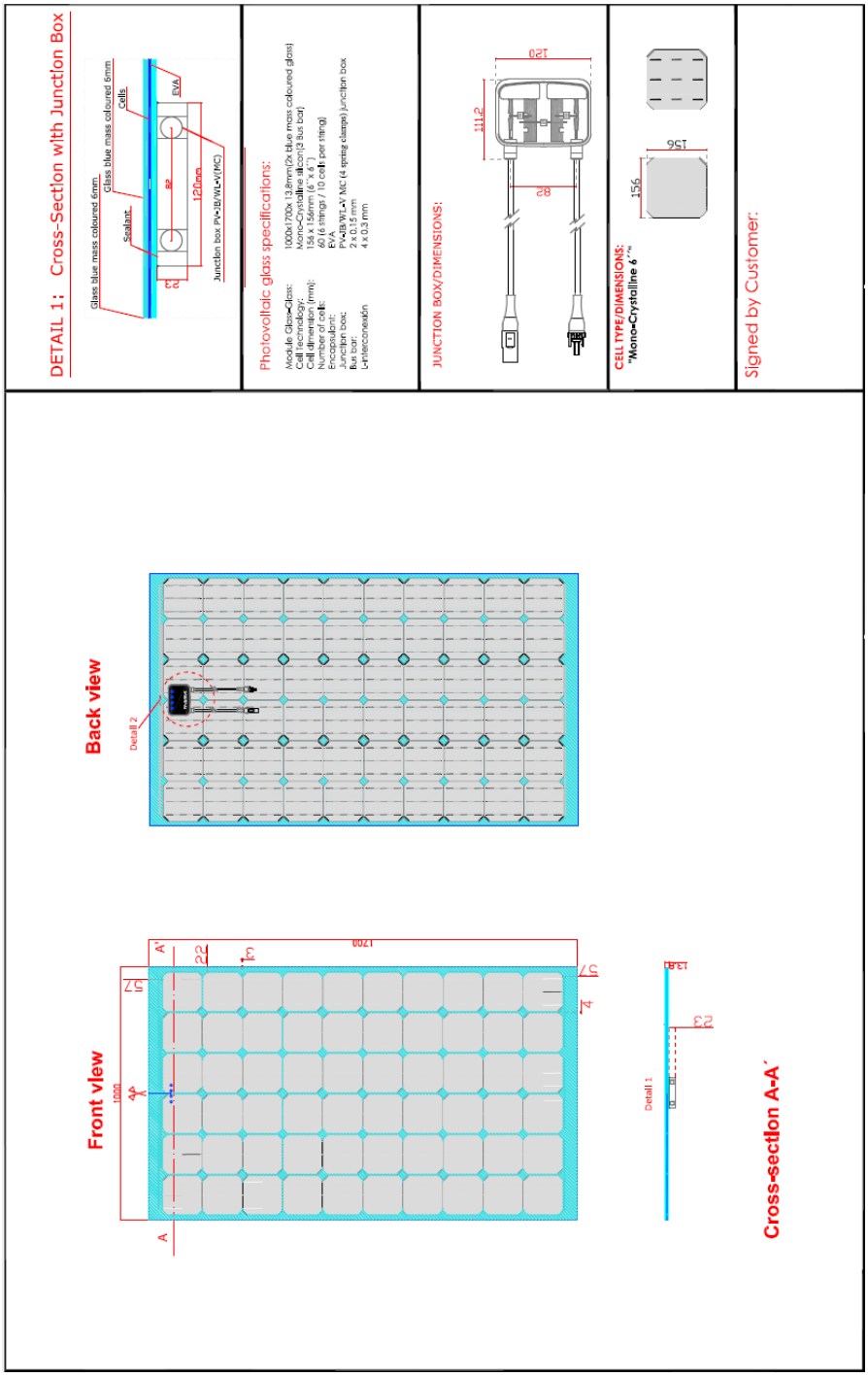
PICTURES

REALISTIC DRAWING



Observations:
Final appearance of PV rectangular C-Si module with tempered dark blue mass coloured glass

EXPLODED DRAWING



Observations:
Manufacturing drawings of sample X12 (front and back views)

DETAILED DESCRIPTION

Definition	PV rectangular C-Si modules with tempered dark blue mass coloured glass
Construction unit	Ventilated façade/ Curtain wall/ Skylight
Architectural location	Façade/Roof
Geometrical design	Rectangular module / Customizable
Dimensions	Height: 480-2000 mm, Length: 1245-4000 mm, Width: 9.80-17.80
Geometrical shape	Rectangular/Customizable
Materials	PV glazing (Dark blue mass coloured glass, EVA, C-Si cells)
Configuration	Double glazing or simple laminated glass
Layers	From top to bottom: Tempered dark blue mass coloured glass EVA, c-Si solar cells, EVA Tempered dark blue mass coloured glass
Frame structure	Frameless
PV technology	Si-monocrystalline
Encapsulation material	EVA
Surface treatments	May be included
Thermal insulation	Common glazing technologies can be used (double/triple glazing, low-E coatings, etc)
Acoustic insulation	Double/triple glazing can be used.
Physical features	Similar to classic c-Si modules
Weight	20 to 60 kg/m^2 (glazing)
Rigidity	Rigid
Opacity	81%
Mobility	No mobile parts
Active energy features	Photovoltaic glazing that generates electricity with Sun radiation
Photovoltaic power	65 Wp/m^2
Thermal transmittance (U value)	Defined by glazing system used

15.2 Mechanical Performance – X12

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Mechanical performance of BIPV modules
Partner	Onyx Solar
Author	Léo Staccioli, Héctor Zamora

PRODUCT CODE	
Denomination	X12 - Glazed modules treated for improved passive properties

DESIGN/DATASHEET VALUES		
BIPV UNIT		
General characteristics	PV rectangular c-Si modules with tempered dark blue mass coloured glass	
Manufacturer	Onyx Solar	
Model	c-Si modules with dark blue mass coloured glass	
Shape	Rectangular	
Physical characteristics	PV glazing	Unit
Height/ Length/ Thickness	480-2000/1245-4000/9.80-17.80	mm
Weight	20-60	Kg/ m^2
Mechanical characteristics	Glass mechanical properties	
Tensile strength	120-200 (tempered); 40 (float)	MPa
Tensile modulus	~70	GPa
Poisson coefficients	0.22	-

Observations:

Mechanical characteristics are the ones from the glass layers, which are the main mechanical material of the PV glazing

15.3 Architectural Integration – X12

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Architectural integration of BIPV products
Partner	Onyx Solar
Author	Léo STACCIOLI

PRODUCT CODE	
Denomination	X12 - Glazed modules treated for improved passive properties

DEFINITION AND LOCATION	
Definition	PV rectangular C-Si opaque modules with dark blue mass coloured glass
Construction unit	Ventilated façade/ Curtain wall/ Skylight
Location	Better performance in locations with high direct radiation
Architectural location	Façade/Roof

CONSTRUCTION UNIT FEATURES						
Physical properties	Length	Unit 1	Width	Unit 2	Height	Unit 3
Shape	Rectangular					
Dimensions	1245-4000	mm	9.80-17.80	mm	480-2000	mm
Weight	…	kg	20-60	kg/m^2		
Materials and devices	PV glazing (double or simple). Includes junction box at the back					
Configuration	Double glazing or simple laminated					
Frame structure	Frameless					
PV technology	Si-mono-crystalline 156x156mm solar cells					
Location of pipes, diameters	Each PV glazing will have two cables. Cables can be housed in the structure					
Thermal insulation	Common glazing thermal insulation strategies can be used					
Thermal bridge	Determined by structure					
Aesthetical features	Dark blue aspect					
Opacity	81%					
Cell colour	Dark blue					

Background colour	Dark blue
Surface treatments	Surface technologies for glass can be used

INTEGRATION AND MAINTENANCE MEASURES	
Mounting system	Common façade/Curtain wall/ Skylight systems
Maintenance	N/A
Inspection	Remote monitoring
Accessibility of system	PV modules are accessible from the exterior.
Safety procedure	Glazing system should comply with standards (f.i. CWCT note 67) in order to guarantee safety accessibility
Removal	Same removal process than normally used in façade elements, taking care of disconnecting cables

15.4 Electrical Performance – X12

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of BIPV modules
Partner	Onyx Solar
Author	Léo Staccioli, Héctor Zamora

PRODUCT CODE	
Denomination	X12 - Glazed modules treated for improved passive properties

DESIGN/DATASHEET VALUES						
PHOTOVOLTAIC CELL/ ARRAY						
General characteristics	Si-mono-crystalline PV glazing					
Manufacturer	Not specific cell provider required					
Cell type	Mono-crystalline silicon. 156x156 mm solar cell with three BB					
Shape	Rectangular					
Colour	Dark blue					
Front layer	Tempered dark blue mass coloured glass					
Frame	Frameless PV glass					
Connection Box	Non specific					
Cables	4 mm^2 up to 1000V					
Connectors	MC4					
Series-parallel connection	Non-parallel connection within one module					
Physical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Height/ Length/ Thickness	1000	mm	1700	mm	13.8	mm
Electrical characteristics	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Rated power	110	Wp	65	Wp/m^2		-
Efficiency	8	%		-		-
Vpm: max. power voltage	31.52	V		-		-
Ipm: max. power current	3.54	A		-		-
Voc: open circuit voltage	42.50	V		-		-

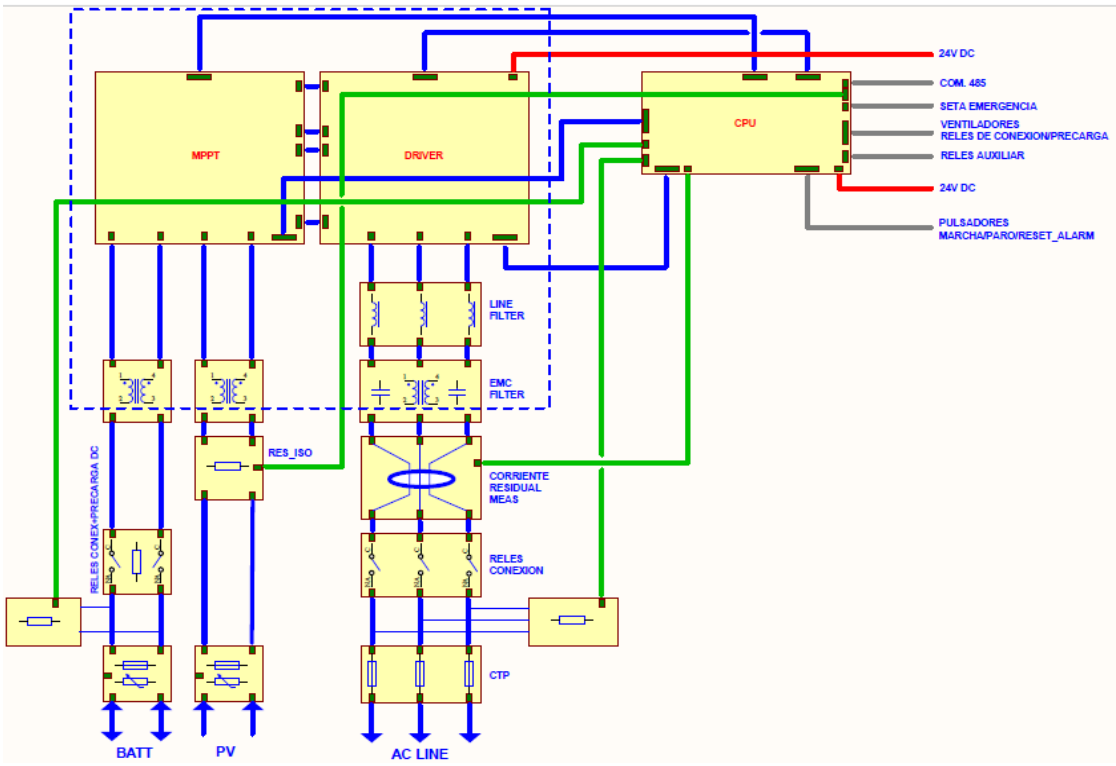
Isc: short circuit current	3.50	A		-		-
Thermal parameters	Value 1	Unit 1	Value 2	Unit 2	Value 3	Unit 3
Isc (α) Temp. coefficient	0.07	%/ºC				-
Voc (β) Temp. coefficient	-0.31	%/ºC				-
P (γ) Temp. coefficient	-0.41	%/ºC				-
Operating range						
Temperature	-40 - +85	ºC				
Maximum System Voltage	1000	V				
Maximum Wind /Snow Load	N/A	Pa				
Max. Reverse Current (IR)	N/A	A				
Observations:						

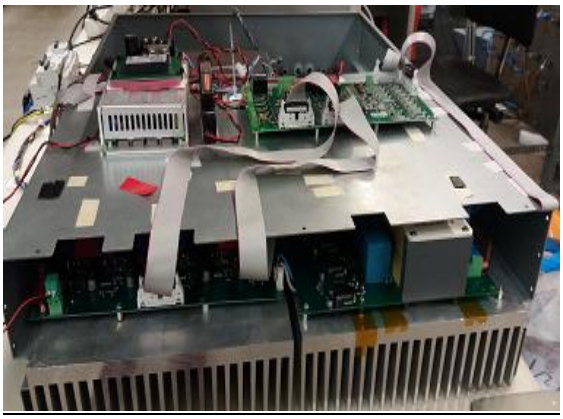
16 X13 - DC-Coupled PV Storage Inverter

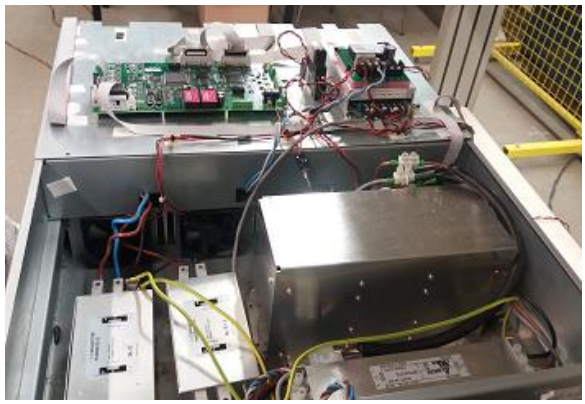
16.1 General Description and Design – X13

TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description and design of inverters
Partner	Tecnalia
Author	Iñigo Vidaurrazaga

PRODUCT CODE	
Project	PVSITES. Task 2.6. BIPV products portfolio
Denomination	X13 - DC-Coupled PV Storage Inverter
Partner/s	Tecnalia
Author/s	Ricardo Alonso

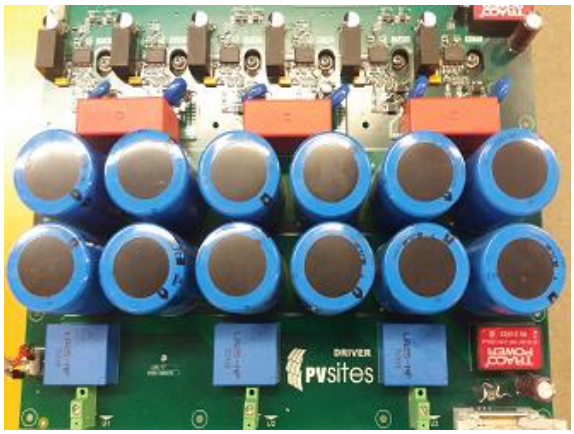
PICTURES
REALISTIC DRAWING
Brief Scheme of the PV Storage Inverter

Complete system





DC/DC Converter

DC/AC Converter



Observations:

According to the scheme showed above, the PV Inverter is composed of the following elements:

1. DC-DC Converter (MPPT and Battery Converters).
2. DC-AC Converter
3. Control Board
4. DC EMI Filters
5. PV Array Insulation Meter
6. DC Relays for Battery Connection and DC precharging
7. Battery Voltage Meter
8. DC Overvoltage and Overcurrent protection (Voltage Suppressors, fuses…)
9. Voltage Surge Protection Device (PSM3-20/400 TNC)
10. AC Voltage Meter
11. AC Connection Relay
12. Residual Current Meter
13. AC EMI Filter
14. Line Filter

Apart from these elements, the PV Inverter also contains a power source (which can be powered from PV, Battery or Grid) for providing 24V to the entire circuit. The scheme also shows signal connection between power converters and control board, to provide analog measurement or PWM driving signals among others.

DETAILED DESCRIPTION	
Functionality description	High efficiency, low cost and flexible 10kW three-phase DC-coupled PV storage inverter. It can be easily parallelized to make larger systems up to hundreds of kW and offers a wide DC input range to cope with different BIPV generators (even affected by mismatching effects) and battery packs. It communicates with the BEMS in order to provide monitoring data about PV storage inverter performance and receive the required commands to implement required energy management strategies.
Technology description	Multilevel symmetrical topology is used for the DC-DC Converter for battery and PV source management. Both converters and the Three-Phase DC-AC Converter are coupled in a high-voltage DC link. The control unit is composed of a DSP controller (TMS320F28335) and FPGA for managing the power transfer inside the converter and provide external communication.
Number of PV inputs	1
Number of MPP trackers	1

Battery regulator	YES
Nominal AC Power	10 kW
Maximum PV power	10 kW
Maximum Battery power	10 kW
Dimensions	700x600x210 (mm)
Weight	50 Kg
Enclosure	Metallic cabinet
Protection degree	IP65
HMI	LEDs for indicating Inverter errors/status
Communication	Serial. RS485 Communication. The Inverter provides Modbus RTU communication in slave mode to exchange data operating with the BEMS or other SW interfaces
CAPEX	2000€
OPEX	0€/year
Lifetime	10 years

16.2 Installation – X13

PRODUCT CODE	
Denomination	DC-Coupled PV Storage Inverter

INSTALLATION AND MAINTENANCE MEASUREMENTS	
Dimensions	700x600x210 (mm)
Weight	50kg
Enclosure	Metallic cabinet
Protection degree (IEC 60529)	IP65
Refrigeration	Forced ventilation
Operating temperature	0 – 40 ºC
General protections	Residual Current Detector, DC Reverse Polarity Protection, AC-DC Short Circuit Protection, AC-DC Over Voltage Protection, Grid Interface Protecction (Voltage&Frequency range), PV Array Insulation Protection.
PV connectors	Terminal wire connectors
Battery connectors	Terminal wire connectors
AC connectors	Terminal wire connectors
Communication connectors	Terminal wire connectors
HMI	LEDs for indicating errors/status

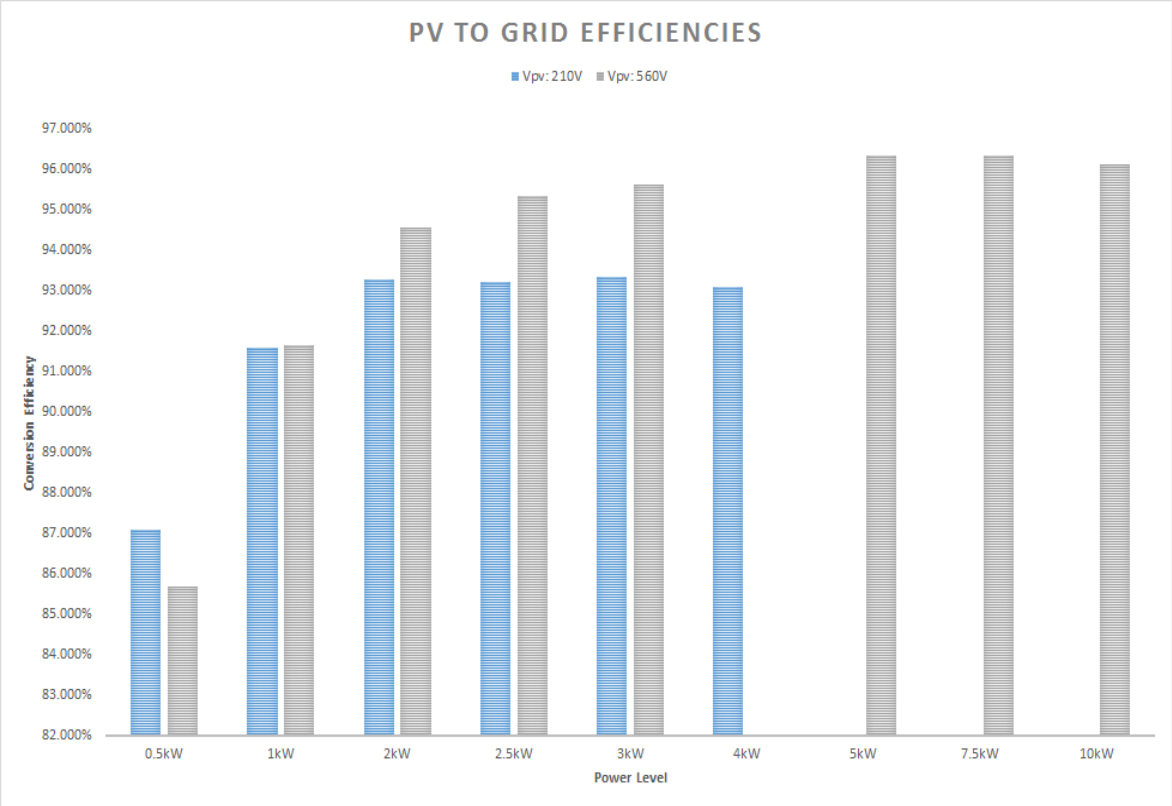
16.3 Electrical Performance – X13

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of inverters
Partner	Tecnalia
Author	Iñigo Vidaurrazaga

PRODUCT CODE	
Denomination	DC-Coupled PV Storage Inverter

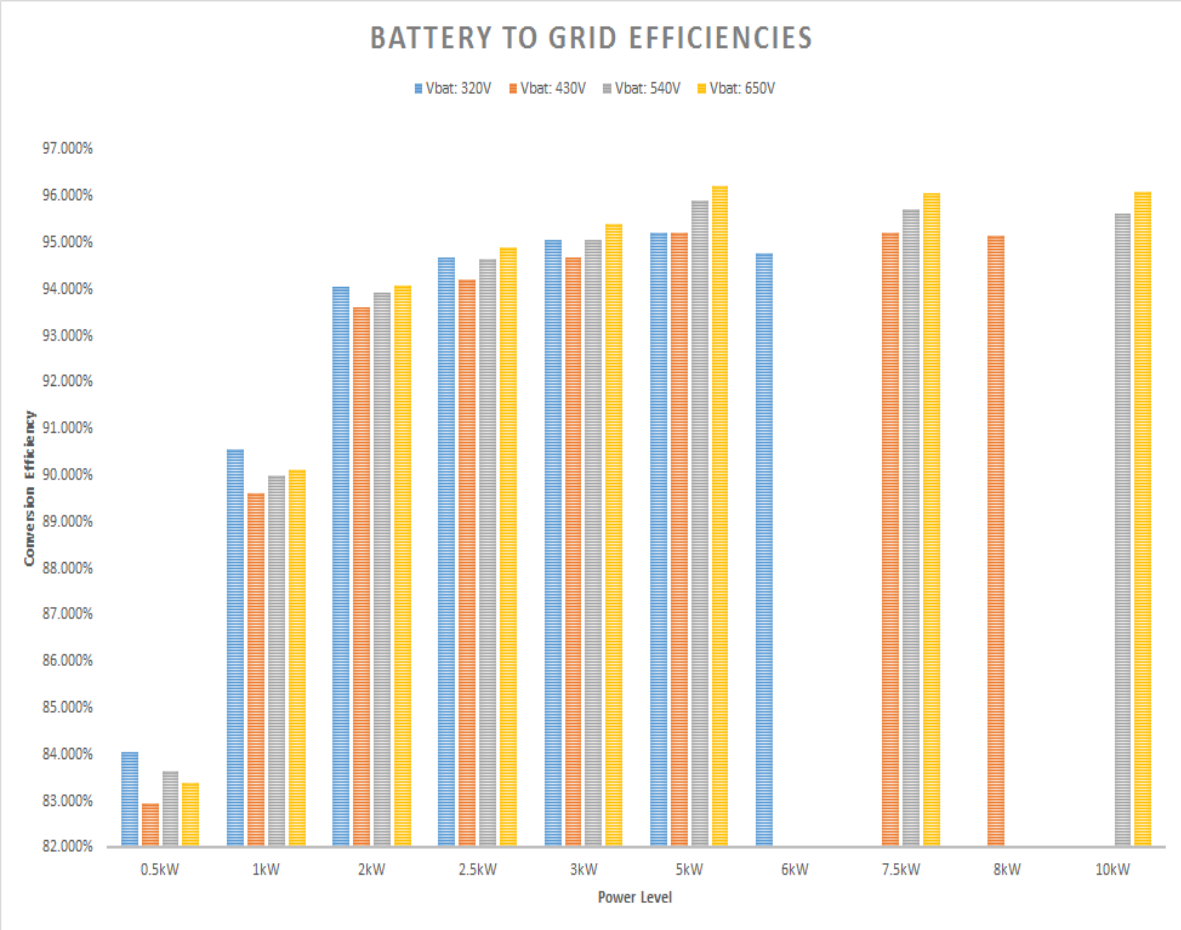
DESIGN/DATASHEET VALUES		
Maximum Efficiency (PV to Grid)	96.335% (@V_{PV}: 560V,P: 7.5kW)	
Overall efficiency (50530) (PV to Grid)	European	92.872% (@V_{PV}: 210V) 95.406% (@V_{PV}: 560V)
	CEC	93.070% (@V_{PV}: 210V) 95.978% (@V_{PV}: 560V)
Maximum Efficiency (Battery to Grid)	96.235% (@V_{BAT}: 650V, P: 5kW)	
Maximum Efficiency (PV to Battery)	97.266% (@V_{BAT}: 540V,V_{PV}: 560V,P: 5kW)	
PV voltage Range	200-1000V	
PV MPPT voltage Range	200-800V	
Max PV Input Power	10kW	
Min PV Input Power	50W	
Max PV Input Current	20A	
Bat voltage Range	250V-750V	
Max Bat Power	10kW	
Min Bat Power	50W	
Max Bat Current	20A	
Max AC Output Power	10kW	
Power factor (PF)	>0.9998 at Rated Power	
Nominal AC Voltage	230V/400V	
Max AC Output Current	15.9A / 27.6A	

Number of Phases	3
Frequency	50Hz
Reactive power control	33%
Stand-by consumption	15W
Night consumption	15W
Residual Current Detector (RCD)	YES
Low Voltage Ride through (LVRT)	YES (IEC 62910)
Anti-islanding protection	YES (UNE EN 62116)
Intended islanding operation	No Islanding Operation
Grid current distortion (THD)	Ideal Strong Grid. 0.6% (@33%Pn), 0.35%(@66%Pn), 0.32%(@100%Pn).
Direct current injection	<60mA (<0.5%In)
PV array insulation resistance detection	YES
CE conformity	Pre-Certified Yes
PV to Grid Efficiencies	



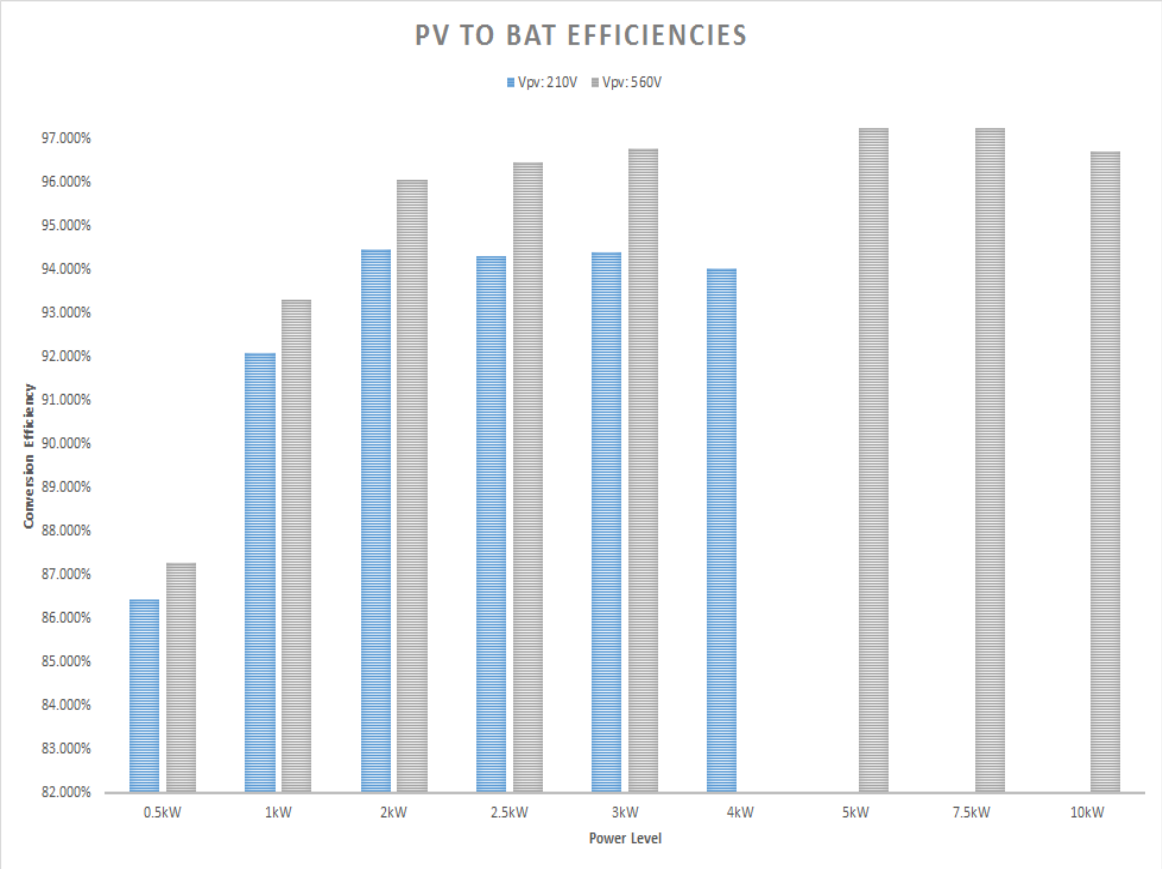
PV To Grid		Power Level								
		0.5kW	1kW	2kW	2.5kW	3kW	4kW	5kW	7.5kW	10kW
VPV	210V	87.096%	91.607%	93.297%	93.220%	93.359%	93.086%			
	560V	85.695%	91.674%	94.565%	95.364%	95.624%		96.351%	96.353%	96.150%

Battery to Grid Efficiencies



BatTo Grid		Power Level									
		0.5kW	1kW	2kW	2.5kW	3kW	5kW	6kW	7.5kW	8kW	10kW
VBAT	320V	84.050%	90.563%	94.044%	94.673%	95.050%	95.208%	94.779%			
	430V	82.946%	89.631%	93.611%	94.203%	94.695%	95.221%		95.214%	95.160%	
	540V	83.637%	89.987%	93.919%	94.652%	95.063%	95.920%		95.732%		95.630%
	650V	83.400%	90.115%	94.093%	94.892%	95.397%	96.235%		96.080%		96.102%

PV to Battery Efficiencies



PV To Bat		Power Level								
		0.5kW	1kW	2kW	2.5kW	3kW	4kW	5kW	7.5kW	10kW
VPV	210V	86.424%	92.083%	94.470%	94.325%	94.412%	94.051%			
	560V	87.263%	93.306%	96.068%	96.487%	96.797%		97.266%	97.262%	96.724%

Observations:
At low Battery and PV voltages power level is saturated when maximum current is reached (around 20A). When computing the overall efficiency (European and CEC according to EN50530), this saturated power is considered for higher power levels. The power conversion results for transfers from PV to Battery are tested at a Battery voltage of 540V.

16.4 Monitoring and control – X13

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Monitoring and control of inverters
Partner	Tecnalia
Author	Iñigo Vidaurrazaga

PRODUCT CODE	
Denomination	DC-Coupled PV Storage Inverter

DESIGN/DATASHEET VALUES	
Communication protocol	Modbus-RTU
OUTPUT MONITORING DATA	
AC Active Power	Data Type: IQ15 (32 bits), Unit: W
AC Reactive Power	Data Type: IQ15 (32 bits), Unit: VAr
AC Grid Voltage	Data Type: IQ21 (32 bits), Unit: V
Grid Frequency	Data Type: IQ21 (32 bits), Unit: Hz
AC Active Current	Data Type: IQ21 (32 bits), Unit: A
AC Reactive Current	Data Type: IQ21 (32 bits), Unit: Ar
Alarm Status	Data Type: Unsigned Integer (16 bits), Values: 1-OFF 2- Warning 3-ON 4-ACK
Alarm ACK Status	Data Type: Unsigned Integer (16 bits). Values: Boolean. 0- NO ACK, 1-ACK
Alarm Type	Data Type: Unsigned Integer (16 bits). Values: 0 - No Alarm, 1-DC Overvoltage, 2- Grid Overcurrent, 4- Unused, 8- DC Overcurrent, 16-HW Error, 32- DC/AC Driver Error, 64- DC/DC Driver Error, 128-Unused, 256- DC/AC- Overheat, 512- DC/DC Overheat, 1024- Battery Over/Under Voltage
Grid Switch Status	Data Type: Unsigned Integer (16 bits). Values: 0- Disconnected, 1-Waiting, 2 Connected
PV MPPT Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Active Power Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON

Frequency Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Power Factor Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Reactive Power Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
AC Voltage Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Start Bottom Status	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Stop Bottom Status	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Inverter Mode	Data Type: Unsigned Integer (16 bits), Values: 0- PV/Storage/Grid Mode 1- PV/Grid Mode 2- Storage/Grid Mode 3- PV/Storage Mode
PV Operating Mode	Data Type: Unsigned Integer (16 bits), Values: 0- No PV 1- Low Power Mode 2- MPPT Mode 3- Constant Power Mode 4- Constant Voltage Mode
DC Link Voltage	Data Type: IQ21 (32 bits), Unit: V
Battery Current	Data Type: IQ21 (32 bits), Unit: Hz
PV Current	Data Type: IQ21 (32 bits), Unit: A
Battery Voltage	Data Type: IQ21 (32 bits), Unit: V
PV Voltage	Data Type: IQ21 (32 bits), Unit: V
DC-AC Temperature	Data Type: IQ21 (32 bits), Unit: ºC
DC-DC Temperature	Data Type: IQ21 (32 bits), Unit: ºC
INPUT COMMANDS	
Alarm ACK	Data Type: Unsigned Integer (16 bits). Values: 4-ACK
Set/Clear Active Power Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Set/Clear Frequency Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Set/Clear Power Factor Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Set/Clear Reactive Power Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON

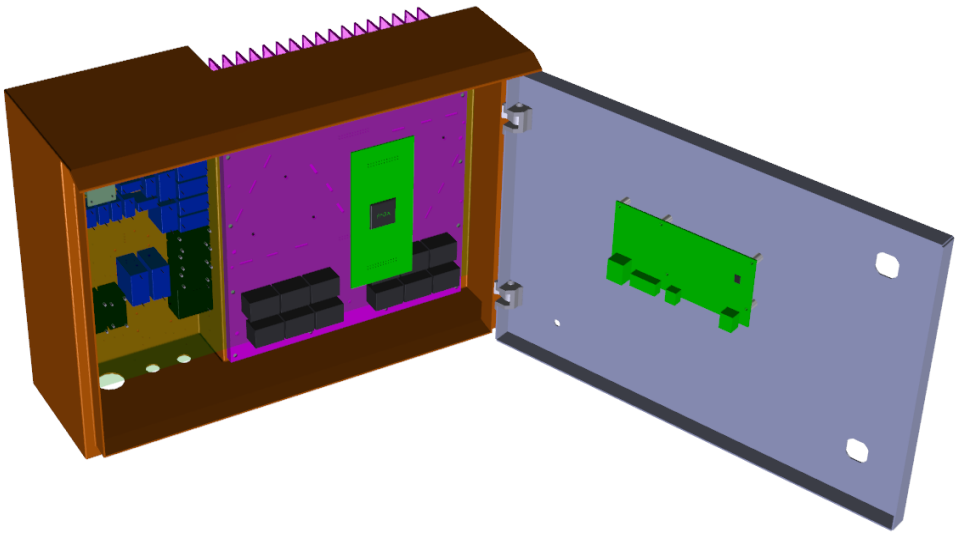
Set/Clear AC Voltage Control Operation Mode	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Set/Clear Start Bottom	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Set/Clear Stop Bottom	Data Type: Unsigned Integer (16 bits). Values: Boolean 0- OFF, 1- ON
Nominal Power	Data Type: IQ15 (32 bits), Unit: W
Max. Power Gradient	Data Type: IQ7 (16 bits), Unit: 0-100%Pn/s
Power Limited/Constant Set Point	Data Type: Signed Integer (16 bits). Unit: 0-100%Pn
K_LFSM (Constant for Limited Frequency Sensitive Mode)	Data Type: Unsigned Integer (16 bits). Values: Unit: 0-100%Pn/Hz
Frequency Threshold for LFSM	Data Type: IQ21 (32 bits), Unit: Hz
K_FSM (Constant for Frequency Sensitive Mode)	Data Type: Unsigned Integer (16 bits). Unit: 0-100%Pn/Hz
K_VAC (AC Voltage Control)	Data Type: Unsigned Integer (16 bits). Unit: 0-100%Pn/Hz
Grid Power Set Point	Data Type: IQ15 (32 bits), Unit: W
Reactive Power Set Point	Data Type: Unsigned Integer (16 bits). Unit: 0-100%Pn
Power Factor Set Point	Data Type: IQ21 (32 bits), Values: ±0.95
Set Inverter Mode	Data Type: Unsigned Integer (16 bits), Values: 0- PV/Storage/Grid Mode 1- PV/Grid Mode 2- Storage/Grid Mode 3- PV/Storage Mode

17 X14 - SiC based inverter

17.1 General Description and Design – X14

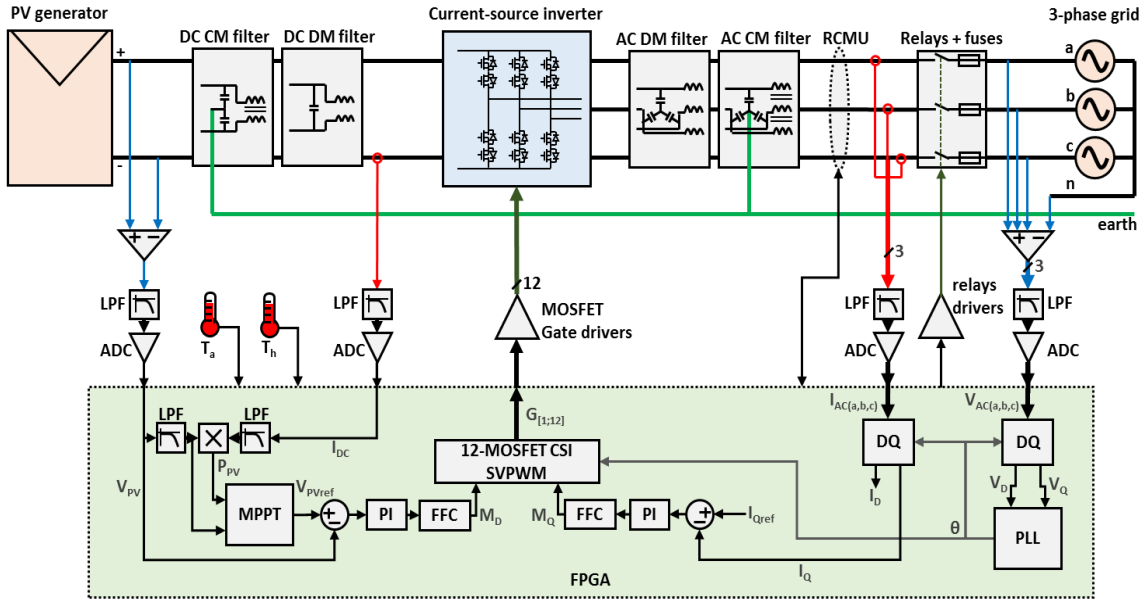
TECHNICAL TEMPLATE REFERENCE	
Technical subject	General description and design of inverters
Partner	CEA
Author	Anthony BIER

PRODUCT CODE	
Project	PVSITES. Task 5.3. BIPV products portfolio
Denomination	X14 - SiC based inverter
Partner/s	CEA
Author/s	Anthony BIER

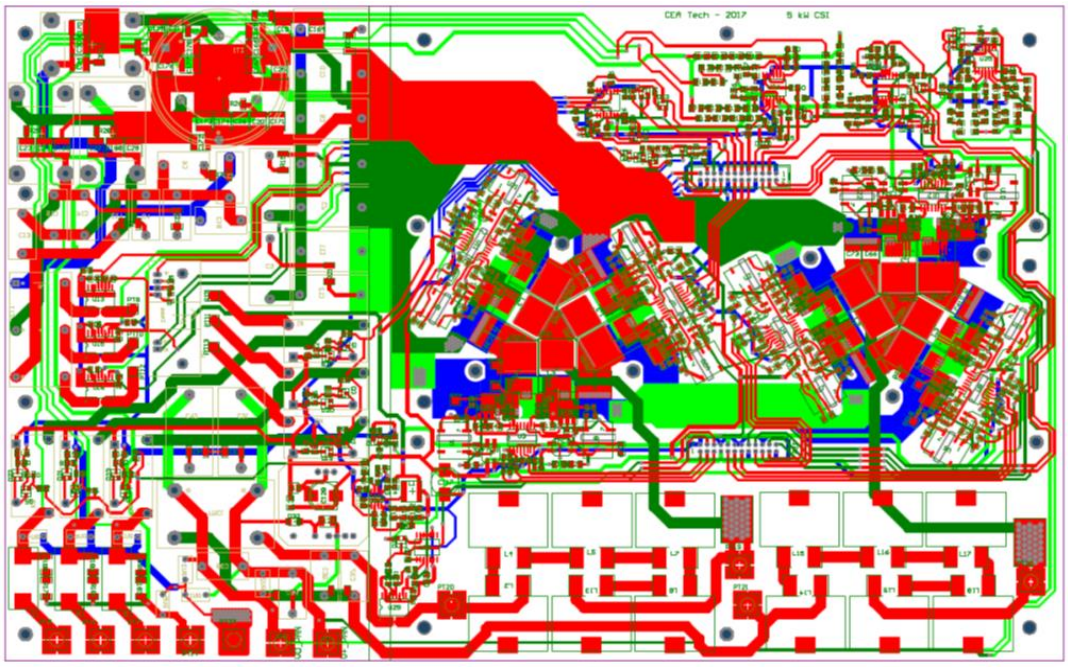
PICTURES
REALISTIC DRAWING

Observations: View of the 5kW three-phase PV current-source inverter packaged in a metallic box with front door.

SCHEMATICS AND LAYOUT

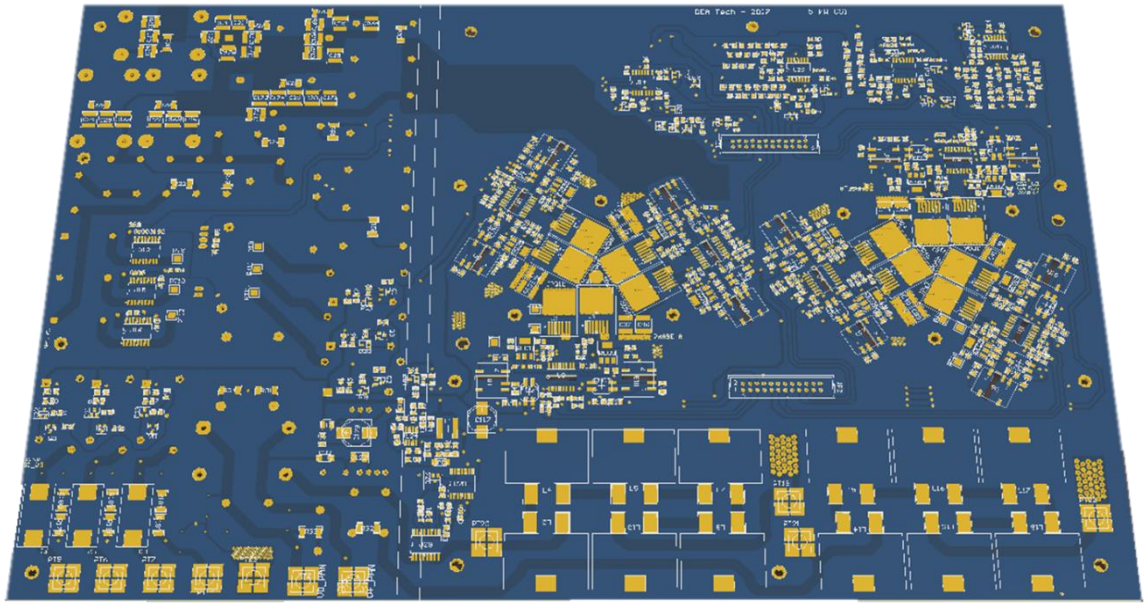
General schematics



Board layout



Board 3D rendered solid image



DETAILED DESCRIPTION	
Functionality description	5 kW, three-phase, photovoltaic inverter
Technology description	Current-source topology (CSI) based on silicon carbide (SiC) semiconductors
Number of PV inputs	1
Number of MPP trackers	1
Battery regulator	no
Nominal AC Power	5 (kW)
Maximum PV power	5 (kW)
Dimensions	410x160x290 (mm)
Weight	N/A (kg)
Enclosure	Metallic box with front door
Protection degree	IP65
HMI	Front LCD screen and push buttons
Communication	Ethernet connexion
CAPEX	N/A€
OPEX	N/A€/year

Lifetime	N/A

17.2 Installation – X14

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Installation of PV inverters
Partner	CEA
Author	Anthony BIER

PRODUCT CODE	
Denomination	5 kW SiC based PV CSI

INSTALLATION AND MAINTENANCE MEASUREMENTS	
Dimensions	410x160x290 (mm)
Weight	N/A (kg)
Enclosure	Metallic box with front door
Protection degree (IEC 60529)	IP65
Refrigeration	Natural air-cooling heatsink
Operating temperature	80 ºC
General protections	Metallic box with preventing electric shocks
Safety procedure	Before any intervention on the inverter : 1) AC-side electrical separation 2) PV cable disconnection
AC connectors	Screw terminal blocks
Communication connectors	RJ45 connector
HMI	Front LCD screen

17.3 Electrical Performance – X14

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Electrical performance of inverters
Partner	CEA
Author	Anthony BIER

PRODUCT CODE	
Denomination	5 kW SiC based PV CSI

DESIGN/DATASHEET VALUES	
Maximum Efficiency	98% (expected)
Overall efficiency (50530)	97.5% (expected)
Input voltage Range	140V – 500V
MPPT voltage Range	280V - 400V (at full rated power)
Max DC Input Power	5 kW
Min DC Input Power	0 W
Max Input Current	18 A
Maximum Output Power	5 kVA
Power factor (PF)	>0.90
Nominal Output Voltage	230 V_{RMS}
Max Output Current	10 A_{RMS}
Frequency	50 Hz
Reactive power control	no
Stand-by consumption	15 W (expected)
Night consumption	0 W
Residual Current Detector (RCD)	y
Low Voltage Ride through (LVRT)	y
Anti-islanding protection	Detection based on active method

PV array insulation resistance detection	y
CE conformity	y

17.4 Monitoring and control – X14

TECHNICAL TEMPLATE REFERENCE	
Technical subject	Monitoring and control of inverters
Partner	CEA
Author	Anthony BIER

PRODUCT CODE	
Denomination	5 kW SiC based PV CSI
DESIGN/DATASHEET VALUES	
Communication protocol	Ethernet
OUTPUT MONITORING DATA	
Parameter 1	Phase A voltage
Parameter 2	Phase B voltage
Parameter 3	Phase C voltage
Parameter 4	Phase A current
Parameter 5	Phase B current
Parameter 6	Phase C current
Parameter 7	PV voltage
Parameter 8	PV current
Parameter 9	AC active power
Parameter 10	AC reactive power
Parameter 11	DC power
Parameter 12	Grid frequency
Parameter 13	Heatsink temperature
Parameter 14	Internal ambient temperature
Parameter 15	Operation mode
Parameter 15	Error code