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PVsites

Energy audit of PVSITES demonstration buildings and identification of BIPV possibilities

Project report

ACCIONA, TECNALIA, NOBATEK, FLISOM, CRICURSA,FD2, VILOGIA

March 2017

Summary

The report corresponds to the Subtasks 8.1.1 “Current performance assessment”, or “pre-auditory” and 8.1.2 “Pre-dimensioning of BIPV systems for every demo site” of the PVSITES project. In these sub-tasks, several BIPV implementing options are proposed and evaluated to facilitate the modelling and final designs of the demo-systems (subtasks 8.1.3 and 8.1.4). Previously, a constructive and energy analysis has been done for every demo-building to identify possibilities. Finally, the more suitable option has been identified and justified for each demo. Key issues, such as optimal location of the chosen BIPV systems, module dimensions, solar field layout, associated production expectations, etc., have been defined as part of a first evaluation. Final designs of BIPV systems will be decided, based on this previous study and newly emerging requirements, during the execution of the next sub-tasks.

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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

This report contains a summary of all the previous work carried out around the real opportunities for implementing BIPV systems in the available PVSITES demo-sites.

First of all, there is a brief explanation of the work procedure followed to achieve the objectives of the Subtasks 8.1.1 and 8.1.2.

Following, in a specific chapter per demo-site, a descriptive presentation of each demo-building has been included, with their main characteristics and possibilities to host the foreseen BIPV system. Finally, different BIPV implementing options have been defined and evaluated, and one of them has been chosen and justified as preferable. Sometimes, the selected option results from the conjunction of single options, to fulfil the project requirements related to the minimum power or occupied area expected for the demonstration systems.

Data collected and generated results are completed in Annex 1, which contains illustrative pictures, schemes, tables and graphics of every subject discussed.

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
D8.2	"D8.2. Result of modelling and BIPV strategies for every demo site" will preferentially use the chosen BIPV implementing options of each demo-site to check the modelling tools performance.
D8.3	"D8.3. Design pack for every demo site". Detailed designs of final demo-systems will be based on the previously recommended in D8.1 and defined as better options.
D8.8	"D8.8. Specific monitoring plan for every demo site" has been one of the main information source or the Subtask 8.1.1, because a previous auditory and some visits were carried out as part of the works.

2 PRE-AUDITORY & PRE-DIMENSIONING PROCEDURE

A pre-auditory of every demo-site has be done to establish an initial baseline for the pre-dimensioning of the demo BIPV systems. The following information has been collected from the demo owners or gathered from other tasks' results: building location, description and current use and occupation patterns; building envelope passive characteristics (walls, roofs, openings, doors, etc.); main energy consumption systems (heating, cooling, domestic hot water, ventilation, lighting, etc.), and consumption data (power, gas, etc.).

Several BIPV and storage location and implementation options have been analysed and pre-dimensioned for every demo building in this task. Architectural characteristics and requirements of the building have been considered in order to find the better placement of the PV solar fields and storage systems.

Although, in some cases, detailed plans of the buildings (particularly, of roofs and façades) and final designs of the BIPV elements are not available yet, a complete range of options has been generated to provide a basement for the advanced dimensioning of the demo-systems, that will be carried out in the next sub-task within WP8. In this regards, some geometrical measurements of the building envelopes and characteristics of the modules intended to be installed in the demo-sites have been approximated, based on the information provided by the demo-building owners and the module's manufacturers.

It is worth mentioning that module sizes, needed for the planning of the solar field layouts, have been chosen as a function of the manufacturing possibilities and criteria of the partners involved in the design and execution of the prototypes. Regarding the integrating mechanisms (anchoring, adhesion, etc.) of the module in the supporting structures or architectural elements, it has been supposed that the model's design chosen for each case will meet the required conditions to be installed with technical and operational guarantees.

Nevertheless, results obtained in the pre-dimensioning procedure must be understood just as suggested options for each demo-site. Final decisions about the definitive modules and integrated systems will be taken during the next subtasks, once the real possibilities of the buildings and the adaptation possibilities of the manufactures have been checked. These results will be shortly used as inputs by TECNALIA and CADCAMation, in order to progress in the design and definition of the final demo systems by means of the simulation software tools they are simultaneously developing in the WP7.

Regarding the submission of the work carried out in the sub-task T8.1, it has been considered convenient to create a set of file cards (included in Annex 1 attached to this document), gathering the more relevant information, collected or generated, about the pre-auditory and pre-dimensioning labours with the aim to facilitate the understanding of the specific problematics of each demo and to have a kick access to the info. The mentioned file cards include:

- Building location and description: brief description and pictures of the demo-building, particularly the areas considered suitable for implementing BIPV, and first evaluation of their possibilities.
- Building envelopes characterization: numerical data and descriptive details about the passive characteristics of the roof, façades and closings.
- Main energy consumption systems: list of main consumption equipment, especially dedicated to the heating, cooling and DHW systems.
- Energy consumption profiles: power and gas consumption data gathered during the pre-auditory procedure by means of the analysis of the existing energy bills and corresponding, in some cases, only to the areas of equipment selected for being energy supplied by the PV systems.

- Solar radiation resource: first estimation of the solar resource, in terms of monthly and yearly radiation on the solar collector plane, depending on the orientation and inclination of the solar fields suggested.
- BIPV and storage options: list of every option suggested, characterized by its orientation, inclination and available area, as well as some useful comments about the module and the integrating system foreseen.
- Pre-dimensioned options: main data defining each BIPV option, including total system power, recommended number and dimensions of modules and power production expectations; as well as, suggested distribution of modules in the solar field and location in the building environment.
- Options assessment: estimation of production related to the option in question, and rejection or acceptance of the option over the rest.

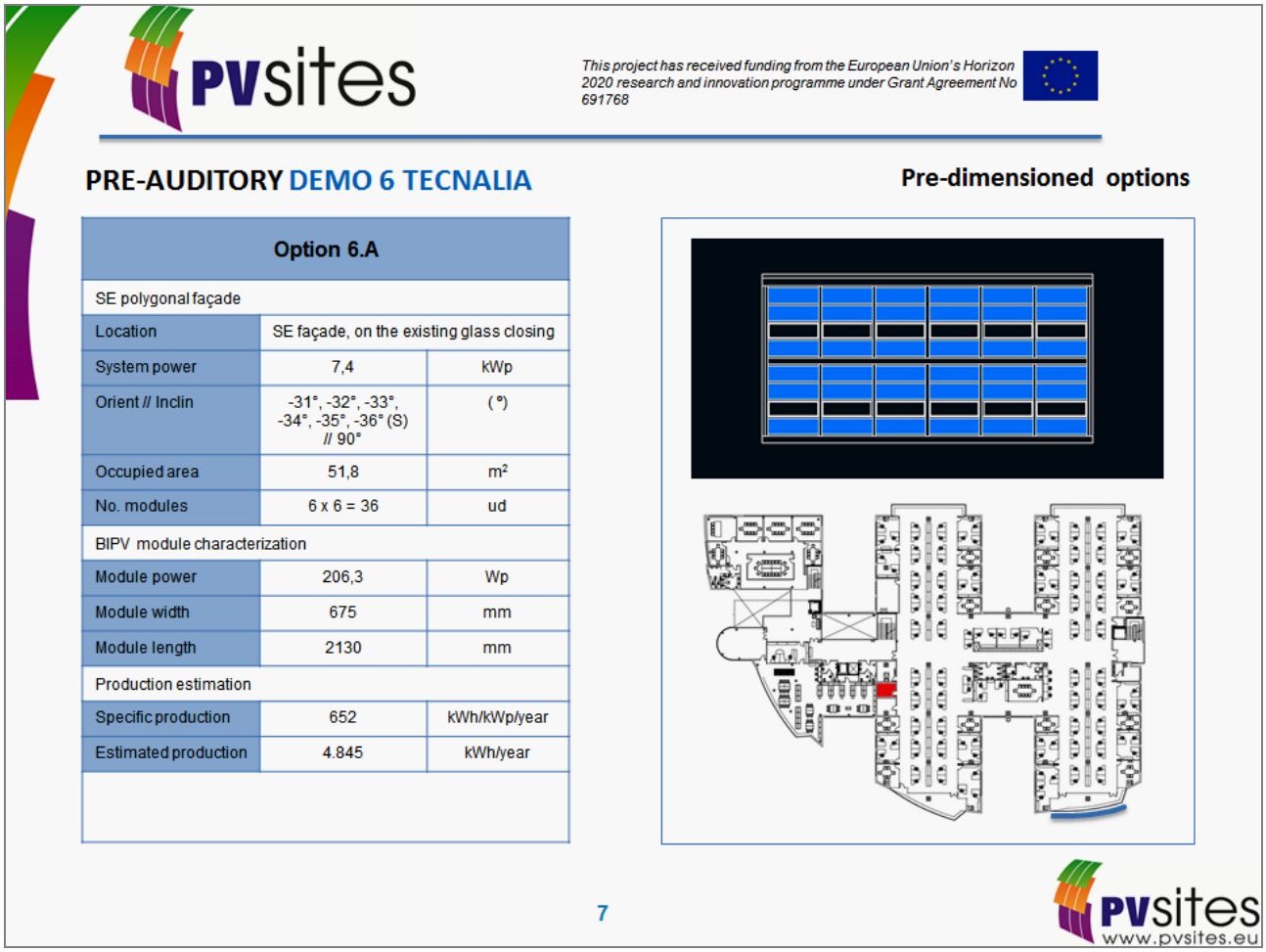

Figure 2.1: File card of the pre-dimensioned Option 6.A for the TECNALIA's demo-site.

3 SINGLE HOUSE - BELGIUM

The PVSITES Demo-Building 1, provided by the partner FORMAT D2 and located in the “Rue du Banc de Sable, 22 of Stambruges (Belgium)”, is simultaneously a residential and an office building for private and professional use (architectural studio).

- Geographical coordinates (sexagesimal): 50° 29' 58,7" N // 3° 42' 52,9" E.
- Geographical coordinates (°dec): 50,499652 // 3,714706.
- Elevation: 68 m.

Figure 3.1: Residential and professional building in Belgium provided by FORMAT D2.

The BIPV system proposed for this demo-site consists of a PV integrated roof composed of CIGS on steel modules by FLISOM (model X1), with a double functionality as a constructive roofing solution and a renewable energy generation system.

3.1 Building description, use and occupation patterns

The building has been built on the basis of the sustainable architecture and according with rural style in the area, using wood as construction material for its passive properties and as a fuel for heating the house. These characteristics make it very suitable for the implementation of a BIPV, because it improves the energy sustainability of the building and respects, at the same time, the aesthetical appearance of a rural house of the region where it is placed.

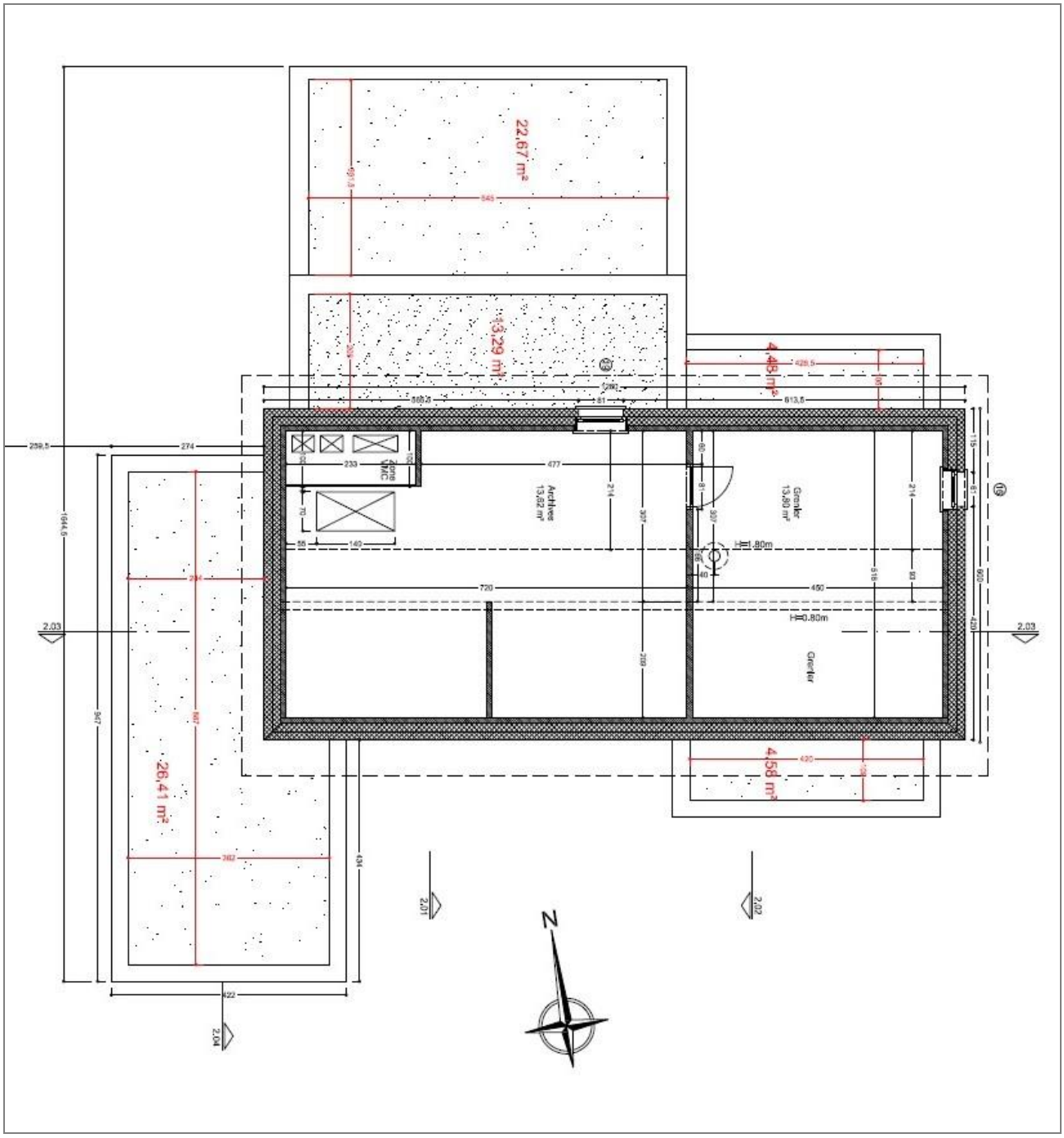

Figure 3.2: Floor plan of the Belgian Demo-building.

The house is composed by 3 floors with living and working places. There are a large sloped roof and 5 small and medium-size non-trafficable terraces at different levels; all of them, in principle, suitable for implementing BIPV systems. Different options will be proposed considering these available spaces. More architectural details are available in the file cards of Annex 1.

The occupation pattern is the typical of a residential building, with an extra consumption associated to the office during the working hours and periods. The BIPV system will allow covering part of the power demand reducing the electricity bill with a renewable energy source.

3.2 Passive behavior, energy systems and demand of the studied areas

As described above, the house has been built based on sustainable architecture principles. Roof, walls and closings have been selected with U values and insulations aimed to reduce the thermal losses and the use of wood as construction material has been a priority criterion.

The heating systems have been chosen according to the space and use to which they have been intended: wood-burning fireplace for the common spaces and bedrooms and direct electric radiators for the bathrooms, showers and offices. The electric double flux ventilation system allows recovering the residual heat during the air renewal in order to save heating energy. The DHW is provided by means of a conventional thermodynamic heat pump.

More details and numerical values, as well as power and wood consumptions data of the already built infrastructures throughout the year, are available in the file cards in Annex 1. Additionally, the average daily global irradiation onto a tilted surface for every possible solar field location has been estimated and evaluated, in order to estimate the energy production potential for each option considered.

Currently the Measurement and Verification Plan foreseen for the pilot site has been implemented, which will measure energy consumptions and collect indoor and outdoor environmental conditions before and after the BIPV system implementation.

3.3 Pre-dimensioning of BIPV and energy storage best options

Although the more recommendable option regarding the solar field location is clear for this demo-site, several alternatives have been considered:

- Option 1.A: SSW 30° sloped roof; orientation +14°, tilt 30° and 87.3 m^2 of available area.
- Option 1.B: North flat roof; orientation +14°, tilt 5° and 22.7 m^2 of available area.
- Option 1.C: West flat roof; orientation +14°, tilt 5° and 26.4 m^2 of available area.

The sloped roof is, obviously, the best location for a BIPV, because of its optimal orientation and inclination and considering the possibility of testing a PVSITES item aimed to perform, not only regarding energy production, but also complying with constructive and aesthetical functions in a real architectural environment. In this regard, it is worth noting that the solar field will be visible from the ground.

Nevertheless, as said before, every option has been considered in this development of the task: a set of 3 pre-dimensioned system options has been generated according to the specific characteristics of each location selected.

This procedure has required the assumption of some design criteria, mainly concerning the module size. The module selected for this demonstration is “Model X1, by FLISOM”, a PV roofing shingle on metal substrate unit. Depending of the available area and roof geometry a certain number of modules with specific widths and lengths has been proposed for each option. Once the solar source has been assessed, the specific location has been defined and the solar field has been configured, the production estimation has been calculated for each option. Details and schemes of the solar field layout, power system and expected energy production have been included in the file cards. The pre-dimensioned system of the chosen option has the following characteristics and will provide the estimated power production:

Option 1.A		
SSW sloped roof		
Location	SSW sloped roof	
System power	7,0	kWp
Orient // Inclin	+14° // 30°	(°)
Occupied area	12,2 x 6,5 = 79,6	m^2
No. modules	5 x 15 = 75	ud
BIPV module characterization		
Module power	92,9	Wp
Module width	435	mm
Module length	2440	mm
Production estimation		
Specific production	864	kWh/kWp/year
Estimated production	6.018	kWh/year

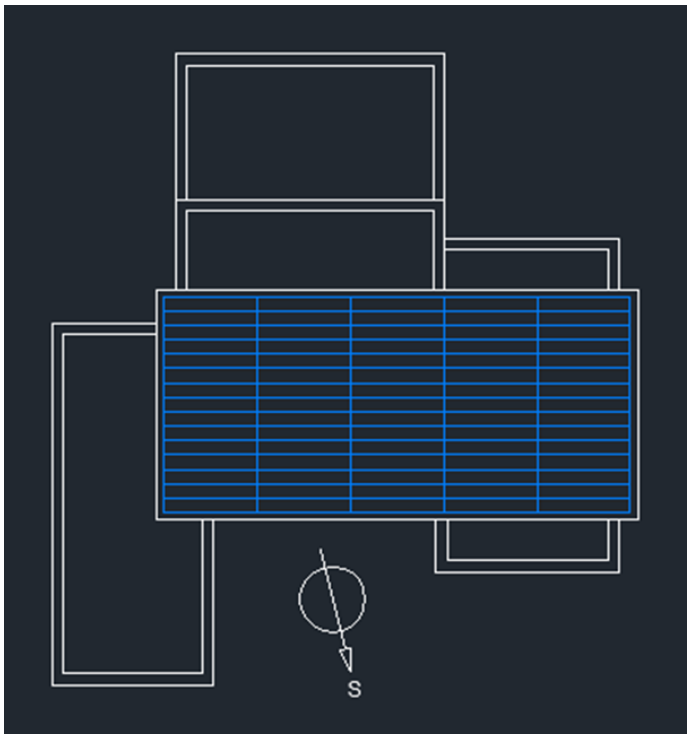

Figure 3.3: Proposed option for the BIPV demo-system.

Regarding the electricity storage system, a final location has not been decided yet, but it will be housed close to the inverter in order to reduce electrical losses and bring the equipment together.

4 EDUCATIONAL BUILDING - SWITZERLAND

PVSITES Demo-Site 2, provided by the partner FLISOM and located in the “Avenue de la Paix 12, 1202, Genève (Switzerland)”, is a set of buildings which houses the hotel school EHC (École Hôtelière de Genève). The complex includes not only the school facilities but also a hotel to host the students.

- Geographical coordinates (sexagesimal): 46°13'36.8"N // 6°08'17.4"E.
- Geographical coordinates (°dec): 46,226882 // 6,138152.
- Elevation: 431 m.

Figure 4.1: École Hôtelière de Genève provided by FLISOM.

The BIPV system proposed for this demo-site consists of 2 façades systems composed of CIGS on large area flexible membrane & bendable elements (models X2 & X4) by FLISOM, with a double functionality as constructive façade solution and renewable energy generation system.

4.1 Building description, use and occupation patterns

Regarding the buildings use, there are 3 ground-level buildings which house the administrative areas, a restaurant, a showroom, some classrooms and the hotel rooms. Additionally, there is an interconnected underground 4th building where a kitchen, a cafeteria and the technical zones are located.

The main building is a 20th century historical construction that cannot be intervened; thus, the 2 candidates to host the BIPV demo-systems are the recently constructed two-storey buildings (pavilion 1 & 2) placed in the sides of the parcel, which have suitable façades to install the solar fields. These façades are made in brick optic and will require a customized solution for integrating the PV modules.

The east façade of the pavilion 1 has 2 rows of windows in the ends of the building and a central curtain wall in the middle, from the top to the ground; 2 differentiated areas are available for PV. The west façade of the pavilion 2 has 2 centred vertical rows of windows, also from the top of the building to the ground; 3 differentiated areas are available for PV. Free areas in both cases will be used for implementing the demo-systems. Towards, the South both pavilions have a window front, which is not usable for a PV installation.

Flat roofs are made of gravel and host the cooling equipment, but it is considered as not suitable for a PV integrated system.

More information regarding the buildings is available in the file cards of Annex 1, but detailed architectural plans will be necessary to propose a completely defined integration plan.

Figure 4.2: East and West façades of the pavilions 1 and 2, respectively.

Since the facilities have a high range of uses and schedules, due to the diversity of activities carried out in the building complex, it is difficult to define a precise occupation pattern. Nevertheless, occupancy is intensive and continuous throughout the hours and the days of the year, foreseeing less usage level during the holiday periods.

4.2 Passive behavior, energy systems and demand of the studied areas

There is no detail about the thermal features of the walls, roofs and closings. Nevertheless indoor measurements will be taken before and after the BIPV system installation; thus, it will be possible to assess the changes in the passive behaviour of the buildings.

Regarding the consumption energy systems, the heating and the DHW of the building is provided by natural gas fired boilers. An electric heat recovery system is available for the non-used heat energy coming from the compressors and pumps of the heating systems. The cooling system consists of electrical heat pumps located on the building roofs. Electricity consumption data have been provided by the owner.

4.3 Pre-dimensioning of BIPV and energy storage best options

Some BIPV implementing options have been assessed, considering limitations and technical viability, in order to meet the project's objectives:

- Option 2.A: E façade pavilion 1; orientation -80°, tilt 90° and 45 m^2 of available area.
- Option 2.B: W façade pavilion 2; orientation +100°, tilt 90° and 97 m^2 of available area.
- Option 2.C: Roof pavilion 2; orientation +100°, tilt 5° and 85 m^2 of available area.
- Option 2.D: Options A+B; orientation -80° & +100°, tilt 90° and 142 m^2 of available area.

Although initially considered as an option, the foreseen BIPV roof system has been finally rejected because it would be an attached (not integrated) system, outside the purpose and scope of PVSITES project. Thus, only E and W façades of the Pavilion 1 and 2, respectively, are available for PV. It is necessary to use both surfaces in order to get an area able to produce an amount of energy relevant in comparison to building consumption. So, the chosen option is 2.D.

The BIPV system foreseen for this demo-site consists of two PV coverages made with CIGS large area flexible roofing membrane & bendable elements (models X2 & X4, by FLISOM):

Option 2.A		
E façade pavilion 1		
Location	E façade pavilion 1	
System power	3,9	kWp
Orient // Inclin	-80° // 90°	(°)
Occupied area	44,3	m^2
No. modules	2 x (2 x 14) = 56	ud
BIPV module characterization		
Module power	69,1	Wp
Module width	439	mm
Module length	1.800	mm
Production estimation		
Specific production	864	kWh/kWp/year
Estimated production	2.112	kWh/year

Option 2.B		
W façade pavilion 2		
Location	W façade pavilion 2	
System power	8,1	kWp
Orient // Inclin	+100° // 90°	(°)
Occupied area	92,1	m^2
No. modules	2x(3x13)+(3x7) = 99	ud
BIPV module characterization		
Module power	81,4	Wp
Module width	450	mm
Module length	2.067	mm
Production estimation		
Specific production	489	kWh/kWp/year
Estimated production	3.942	kWh/year

Figure 4.3: Definition of BIPV systems which take part of the chosen Option 2.D.

On the basis of the architectural plans provided by the owner and the maximum sizes of the modules defined by the manufacturer, number and most suitable dimensions of the BIPV units have been calculated. Because of the height of each building is different, dimensions and numbers of modules are also different. It is recommended to use the same model of modules for each façade.

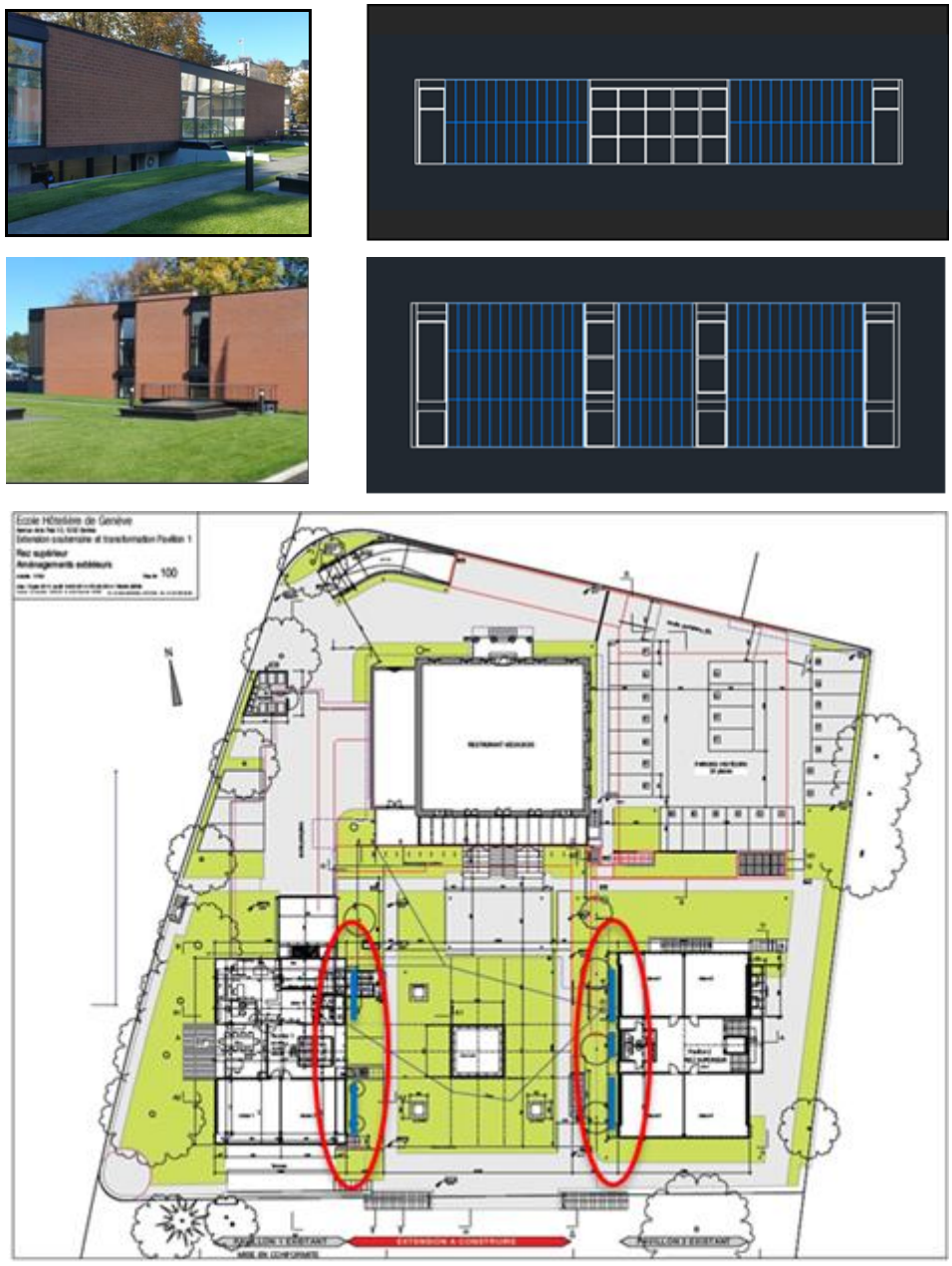

Figure 4.4: Solar fields (E & W façades) for the chosen Option 2.D.

Although the orientations of both systems (E & W) are not the more appropriated for PV systems from the power production point of view, there is an advantage associated to these configurations: daily production profile will match more exactly than a optimally faced systems to the daily consumption profile in any period of the year; in such a way that when the west-faced system does not receive any solar radiation during the morning, the east-faced system works at full capacity, covering part of the morning consumption. Reciprocally, during the afternoon, when the east-faced system is shadowed and does not generate any power the west-faced façade produces energy to meet the power demand. In the other hand, during the midday both systems work not at full capacity but jointly providing an important energy quantity.

The electricity storage systems have not yet a definitive location, but each demo-building will house the power and storage equipment of its BIPV system. Grid connection will be also possible in the same way, because each building has its own electricity delivery point located into basement of the principal building. In the other hand, there are also divisional distribution electricity boards into each level of the buildings.

5 CARPORT - SWITZERLAND

PVSITES Demo-Building 3, provided by the partner FLISOM and located in “Überlandstrasse 129, 8600, Dübendorf (Switzerland)”, is a public carport of 500 m^2 part of the EMPA facilities (Swiss Federal Laboratories for Materials Science and Technology).

- Geographical coordinates (sexagesimal): 47° 24' 08.9" N // 8° 36' 40.0" E.
- Geographical coordinates (°dec): 47,402487 // 8,611121.
- Elevation: 433 m.

Figure 5.1: Public carport in Switzerland, provided by FLISOM.

The BIPV system proposed for this demo-site consists on a PV integrated roof composed of CIGS on steel modules by FLISOM (model X1).

The typology, scope and conditions of the intervention are currently being discussed. The existing asbestos cladding is not appropriated to integrate the foreseen modules, and the complete replacement of the cladding by the new BIPV units has been proposed. Nevertheless, some disagreements with the property have appeared; thus, a final solution for the implementation of this demo-site is still on the table. This does not prevent, anyway, to elaborate some preliminary technical proposals in order to progress within the task.

5.1 Building description, use and occupation patterns

The demo-site consists of a carport with a double sloped cover with asbestos. The 2 rectangular canopies are 8º tilted to the central division. The carport is supported by 7 Y-shaped metal legs whose central post stand above the claddings throughout the middle opening. The arms of the structures are reinforced by 2 metal tie rods from the top of the posts to the ends of the arms. Both elements, posts and rods, might project shadows on a PV solar field located over the carport.

The use and occupation pattern coincides with the timetable of an office building.

5.2 Passive behavior, energy systems and demand of the studied areas

Obviously, the carport performs the function of protection against rain, hail, snow, frost and the direct rays of the sun. The complete replacement of the existing cladding by a new one including PV modules would not alter neither of these functions. On the contrary, the attachment of the modules to the asbestos cladding might put at risk the structural integrity of the cladding in itself and cause water filtrations through the anchoring points. Asbestos is, in the other hand, highly contaminant and its handling may be dangerous for installers.

In principal, there is no power demand directly associated to the carport performance, because it is not illuminated nor has any other permanent power load. Nevertheless, PV power production could be addressed to supply the electrical sockets located in the basis of the posts, and used for recharging electric vehicles and other applications.

5.3 Pre-dimensioning of BIPV and energy storage best options

Due to the fact that the 2 faces of the carports are almost horizontal it makes sense, from the power production point of view, to propose the installation of PV modules on both. Here below are shown both and the joint options:

- Option 3.A: SEE carport; orientation -61°, tilt 8° and 250 m^2 of available area.
- Option 3.B: WNW carport; orientation -61°, tilt 8° and 250 m^2 of available area.
- Option 3.C: Options A+B; orientation -61° & 119°, tilt 8° and 500 m^2 of available area.

The module used in this demonstration will be a CIGS roofing shingle on metal substrate (model X1, by FLISOM). In order to achieve the mechanical balance between the 2 sides of the carport, it is advisable to install the BIPV units in both sides; thus, the chosen option is 3.C. Maintaining the symmetry of the carport, the height will be equally distributed and the visual appearance more pleasant. Modules have been distributed throughout the surfaces avoiding the zones close to the central posts, in order to reduce the effect of possible shadows.

More details and production estimations of every option considered are included in Annex 1. Solar field and estimated results of the proposed option are shown below:

Option 3.C		
SEE & WNW carports		
Location	SEE & WNW carports	
System power	15,6	kWp
Orient // Inclin	-61° & +119° // 8°	(º)
Occupied area	178,6	m^2
No. modules	2 x (6 x 15) = 180	ud
BIPV module characterization		
Module power	86,8	Wp
Module width	400	mm
Module length	2480	mm
Production estimation		
Specific production	943	kWh/kWp/year
Estimated production	14.730	kWh/year

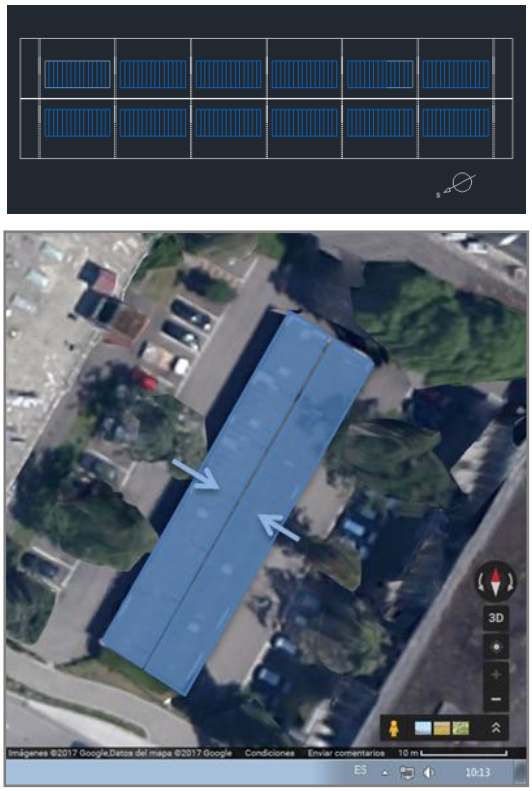

Figure 5.2: Proposed Option 3.C for the carport BIPV demo-system.

Regarding the electricity storage system, the more appropriated placement would be the base of the supporting posts, close to the electrical sockets.

6 INDUSTRIAL BUILDING - SPAIN

PVSITES Demo-Building 4, provided by the partner CRICURSA and located in “Polígon Industrial Coll de la Manya, Camí de Can Ferran, s/n, 08403, Granollers (Spain)”, is an industrial and an office building complex.

- Geographical coordinates (sexagesimal): 41° 35' 14.9" N // 2° 16' 01.7" E.
- Geographical coordinates (°dec): 41,587460 // 2,267135.
- Elevation: 153 m.

Figure 6.1: Industrial and office building complex in Spain, provided by CRICURSA.

The BIPV system proposed for this demo-site will consist of a PV integrated roof with CIGS on steel modules by FLISOM (model X4), with a double functionality as a constructive roofing solution and a renewable energy generation system.

6.1 Building description, use and occupation patterns

The building complex is composed by 4 industrial buildings, 1 office building and some auxiliary services areas dedicated to the manufacture of glass. There is a new building jointed to the factory recently constructed.

Façades and roofs initially available for the implementation of the PVSITES BIPV systems are different depending of the building in question: the office building has a large curtain wall occupying the whole façade and the industrial buildings are made of metal sheets. The roofs of the old buildings, in the other hand, are covered by asbestos modules. The more suitable surface for implementing the demo-system is the roof of the new building, where asbestos has not been used.

The new building consists of two pavilions with double-sloped roof. It is very well oriented (2°) for photovoltaics, being the south-faced surfaces the most suitable for the location of the system.

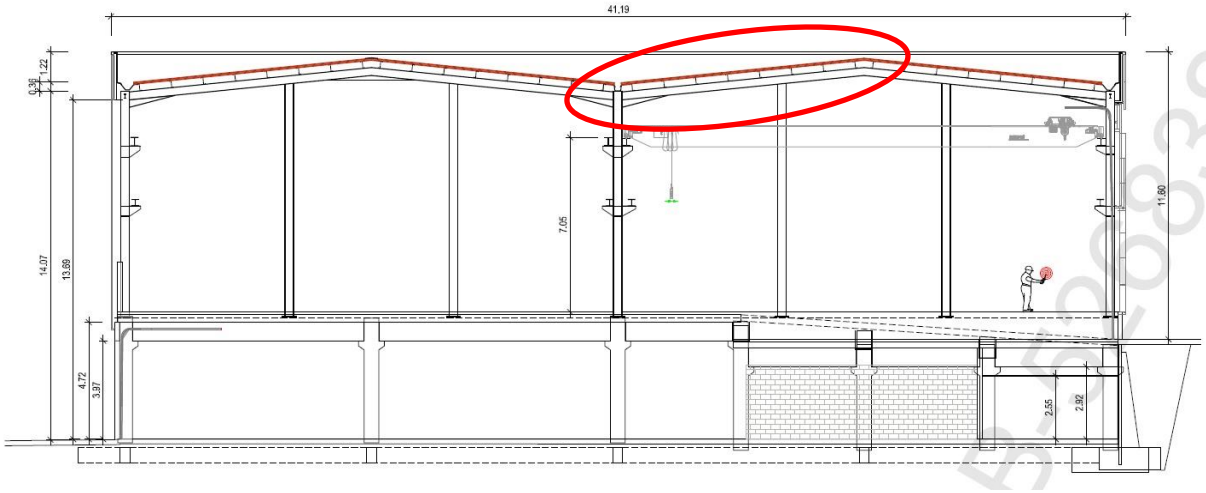

Figure 6.2: More suitable face for implementing the BIPV system.

Considering that there a roof parapet on the front and back façades which may project shadows, it is advisable to place the solar field in the south sloped-roof of the second pavilion, in order to avoid this adverse effect.

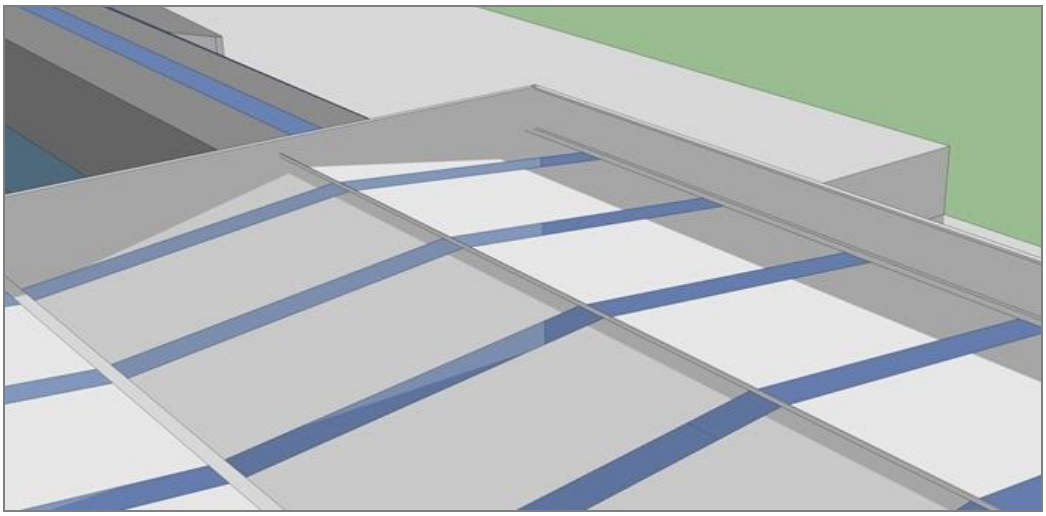

Figure 6.3: Roof parapet shadowing effect on a possible solar field layout.

The building has been planned as an addition to the manufacturing area; so, the activities developed in it will be associated to the manufacturing processes and the storage of raw materials and products. In this regards, occupation patterns will be the same of the existing factory zones, being occupied during 24 h a day. The office building, however, is used between 07:00 to 21:00 h from Monday to Thursday and between 07:00 to 15:00 on Friday. These schedules are the same throughout the year.

6.2 Passive behavior, energy systems and demand of the studied areas

Passive features of the new building are highly defined in the implementation project. The new building's roofs are made of polyurethane panel "AIS-3G of 50 mm". The PVSITES module will be specifically designed to adapt its shape and passive properties to those required for the demo-site in order to achieve an effective and aesthetic integration in conjunction with the original structures and materials of the roof.

Regarding the energy consumption systems, besides of those associated to the manufacturing processes, there are small and big capacity gas-boiler for heating and DHW, and electrical heating and cooling systems for the office areas.

The developed monitoring plan is already running in order to collect consumption and environmental data previously to the installation of the BIPV demo-system.

6.3 Pre-dimensioning of BIPV and energy storage best options

Two solar options for the solar field location have been initially considered. The first one has been finally rejected according with the objections explained in the previous point regarding the shadows projection:

- Option 4.A: South sloped roof of the new building's south pavilion; orientation +2°, tilt 6° and 529.7 m^2 of available area.
- Option 4.B: South sloped roof of the new building's north pavilion; orientation +2°, tilt 6° and 529.7 m^2 of available area.

The module selected for this demonstration is "Model X4, by FLISOM", a CIGS large area element for roofs and façades of industrial buildings laminated onto a metallic back sheet (model X4). The module design will allow the perfect mechanical integration in the roof, in the same way of a conventional metal sheet roofing item.

It is possible to install a 19.2 kWp PV system in the available area of the chosen roof. Distribution of modules may be changed if new environmental conditions or architectural requirements appear during the design of the integration project. More details and production estimations have been included in Annex 1.

Option 4.B		
South sloped roof of the new building's north pavilion		
Location	South sloped roof	
System power	19,2	kWp
Orient // Inclin	+2° // 6°	(°)
Occupied area	4,0 x 56,0 = 224	m^2
No. modules	2 x 140 = 280	ud
BIPV module characterization		
Module power	70,0	Wp
Module width	400	mm
Module length	2.000	mm
Production estimation		
Specific production	1.251	kWh/kWp/year
Estimated production	24.516	kWh/year

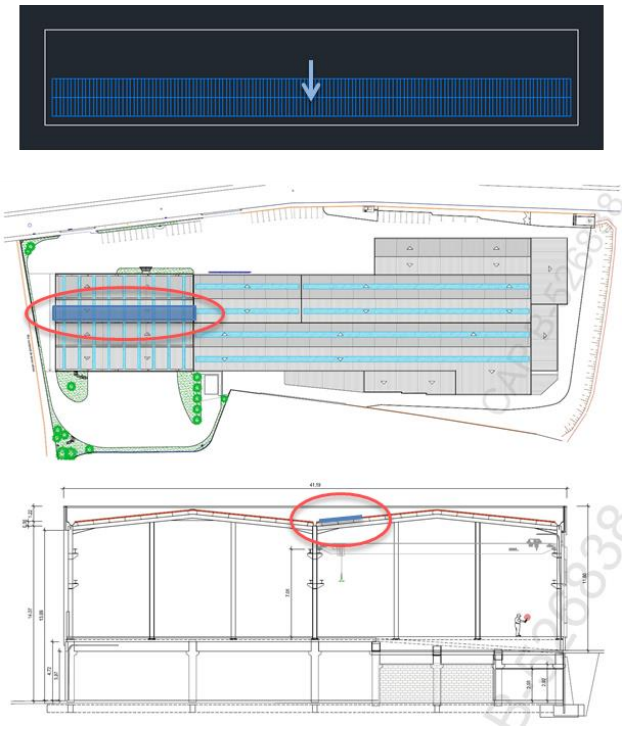

Figure 6.4: Proposed option for the BIPV demo-system.

Regarding the placement of the power and storage systems (inverters and batteries) there is not a final decision taken yet, although there are back yards next to the old and the new buildings, with available areas of 739 m^2 and 255 m^2, respectively, which could be used for this purpose.

7 APARTMENT BUILDING - FRANCE

PVSITES Demo-Building 5, provided by the partner VILOGIA and located in the “12-14, rue du Docteur Laennec, 59139, Wattignies (France)”, is a residential storey block.

- Geographical coordinates (sexagesimal): 41° 35' 14.9" N // 2° 16' 01.7" E.
- Geographical coordinates (°dec): 41,587460 // 2,267135.
- Elevation: 153 m.

Figure 7.1: Residential 8-storey building, provided by VILOGIA.

The BIPV system will consist of a BIPV ventilated façade made with glass-glass Si-crystalline modules with hidden bus bars and L-interconnections (model X5, by ONYX). It is expected that the passive effect of the system will improve the thermal performance of the building in the warm seasons.

7.1 Building description, use and occupation patterns

The building façades are made of masonry and brick cladding. The masonry façades are occupied, from the top to the ground, by vertical windows strings. South brick façade is clearer, with an only single window string. Roofs are constructed with reinforced concrete.

The building has a pending deep retrofitting, which will affect at least the south façade; thus, it is a propitious occasion to introduce a BIPV system which resolves the constructive requirements and improves the energy performance of the building. Orientation is optimal, furthermore, for the south façade (+16°), a total of 140 m^2 available, divided in 2 areas from the top of the building to the first floor.

Since there are some high trees in front of the south façade some shadows may be projected. Nevertheless, the property declares that it could be possible to remove or transplant them, as part of the retrofitting measures, in order to avoid the problem.

The occupation and use patterns are the typical of a residential block, with some common consumption that can be partially covered by the PV system.

Figure 7.2: South façade of the VILOGIA's demo-building.

7.2 Passive behavior, energy systems and demand of the studied areas

Composition of roof, walls and closings are well defined in Annex 1. Roofs are provided with foam glass insulation, a bituminous sealing and a gavel protection; brick walls includes polystyrene insulation and air chamber throughout the air can flow. Originally the openings were made of wood, but some of them were replaced by PVC double glazing units. All of them will be replaced in order to improve the thermal insulation during the retrofitting works.

Regarding the energy consumption, there is a district heating system which provides heat to the building. Cooling and ventilation systems work with electricity. Indoor lighting of transit areas and other common loads may be covered by the planned BIPV system.

In general terms, the BIPV system will be added to the set of measures and actions included in the retrofitting aimed to attend the construction aspects and improve the passive and active energy performance of the residential block.

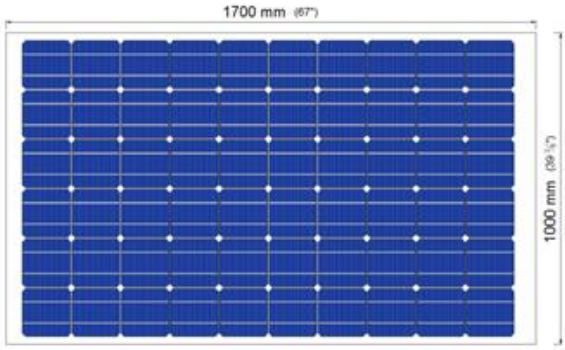

Figure 21: PV glass dimensions, X5 product

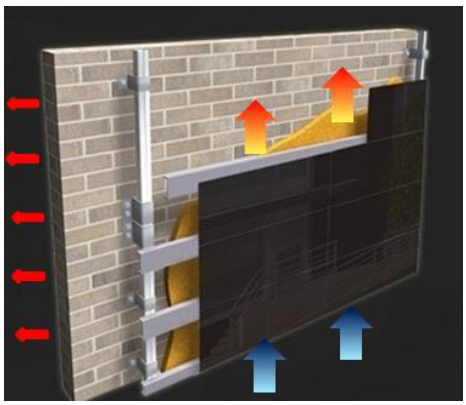

Figure 7.3: The BIPV system will perform with all the advantages of a ventilated façade.

7.3 Pre-dimensioning of BIPV and energy storage best options

Since the best area for implementing the BIPV system is clear, due to its optimal orientation and the available space with almost totally absence of windows, the only options considered have been located in the south façade:

- Option 5.A: East section of the SSE façade; orientation -16°, tilt 90° and 145 m^2 of available area.
- Option 5.B: West section of the SSE façade; orientation -16°, tilt 90° and 29 m^2 of available area.
- Option 5.C: Complete SSE façade (Options 5.A & 5.B); orientation -16°, tilt 90° and 174 m^2 of available area.

The ventilated façade modules intended to be installed in this demo-site are the fully opaque glass-glass BIPV units (model X5, by ONYX) with c-Si technology, hidden bus bars and black conductive ribbons over the welded cells which improve its aesthetical appearance.

The layout of the solar field has been conceived to take the advantage of all the available space, in such a way that power production will be maximum and the façade will present a continuous visual appearance and more effective thermal performance. Nevertheless, only from the first floor to the top of the building will be occupied by the system in order to maintain the PV modules inaccessible from the ground.

The pre-dimensioned system of the chosen option has the following characteristics and will provide the estimated power production:

Option 5.C		
SSE façade, from the first floor to the roof (complete façade)		
Location	SSE façade (complete façade)	
System power	26,6	kWp
Orient // Inclin	-16° // 90°	(°)
Occupied area	173,4	m^2
No. modules	(1 + 5) x 17 = 102	ud
BIPV module characterization		
Module power	261,0	Wp
Module width	1000	mm
Module length	1700	mm
Production estimation		
Specific production	509	kWh/kWp/year
Estimated production	13.561	kWh/year

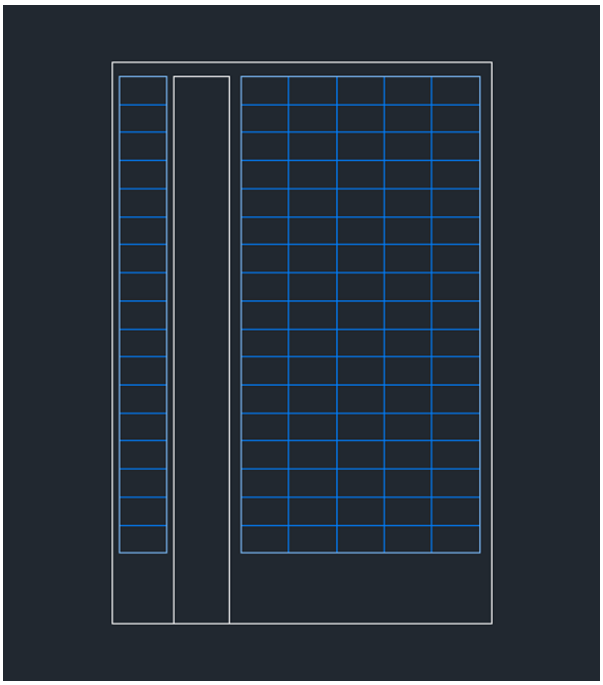

Figure 7.4: Proposed BIPV ventilated façade for the residential storey building.

Regarding electricity storage systems, they may be located in the same separated, no accessible for tenants, space that has been constructed in the cellar to store the inverter and monitoring equipment.

8 OFFICE BUILDING - SPAIN

PVSITES Demo-Building 6, provided by the partner TECNALIA and located in “Paseo Mikeletegi 2, San Sebastian (Spain)”, is one of the TECNALIA’s facilities, an office building with engineering and chemical laboratories.

- Geographical coordinates (sexagesimal): 43° 17' 10.9" N // 1° 59' 05.6" W.
- Geographical coordinates (°dec): 43,286363 // -1,984883.
- Elevation: 132 m.

Figure 8.1: TECNALIA offices and labs in San Sebastian.

The BIPV system foreseen for the TECNALIA’s demos-site consists of a PV double-skin over the existing curtain walls with c-Si back contact laminated glass modules, by ONYX.

8.1 Building description, use and occupation patterns

The Demo-site 6 is a large building with a complex floor section, an irregular polygon with several flat and curve façades oriented in different directions and with different constructive characteristics. The main material used as façade cladding is white ceramic brick and some sections are covered by metal sheets. Office areas, from the first floor to the roof, are closed by large curtain walls with customized structures depending of the façade geometry and uses.

The most suitable zones for BIPV are the 3 south-faced façades. All of them present a polygonal curtain wall cladding, adapted to the curved section of the façades and covering the first and second floors of the building. They are composed of an aluminium structure closed with double-glazing units. Some of these units (throughout the second horizontal row, referred to the floor ground) are openable windows; therefore, these rows will not be occupied for photovoltaics. In this regards, there would be two constructive solutions for these areas: maintaining them empty, allowing the direct entrance of outdoor air, or occupied for double-glazing units without PV. Final decision will be taken by the building's owner.

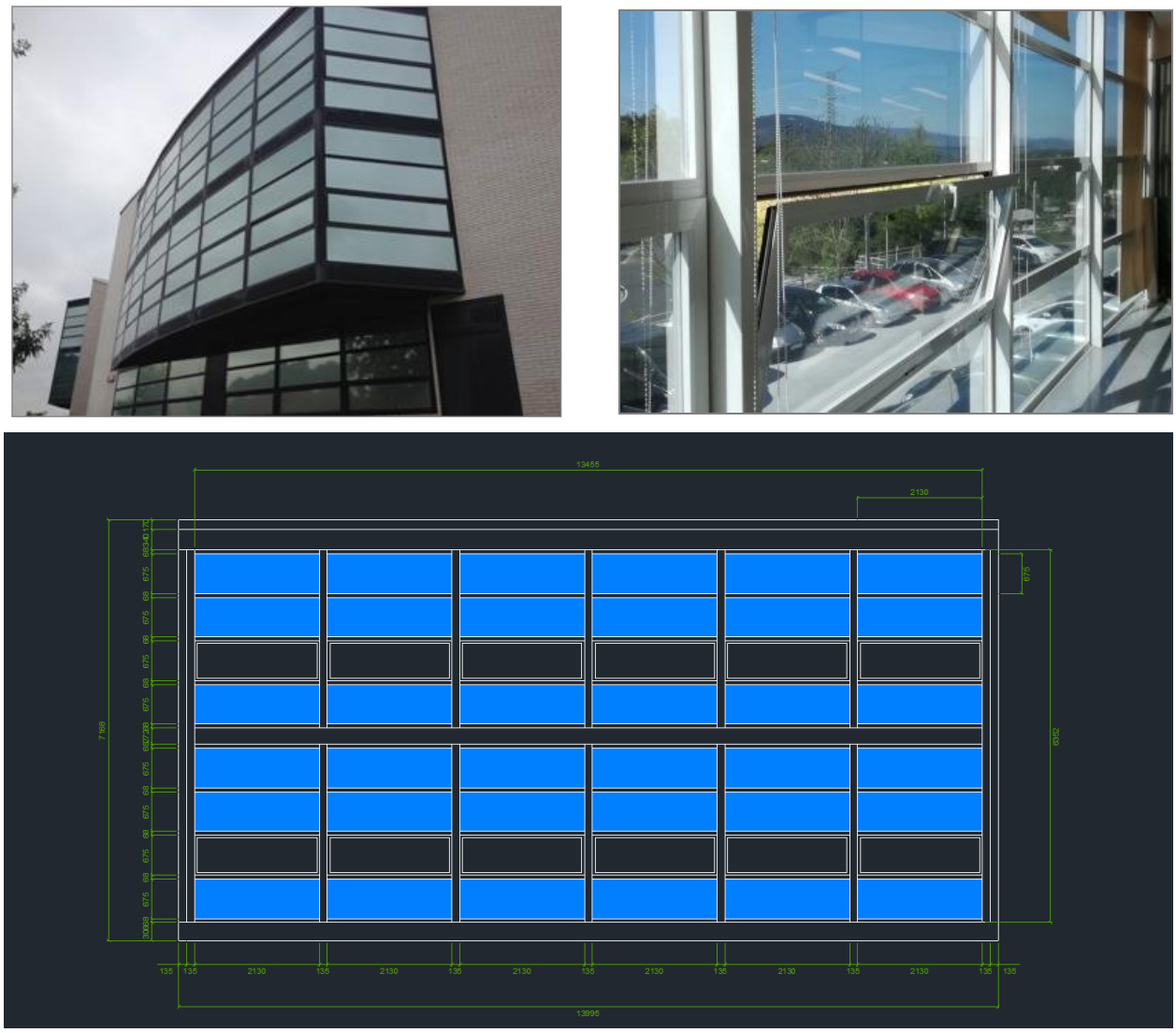

Figure 8.2: SE curtain wall, openable windows and planned layout of the PV solar field.

The occupation pattern corresponds to an office building, used between 08:00 to 17:00. These schedules are the same throughout the year. Some works carried out in the laboratories may require consumptions out of this time periods.

8.2 Passive behavior, energy systems and demand of the studied areas

Thermal features of the aluminum frames of the curtain wall structures and the double-glazing elements have been defined and included in Annex 1. One of the objectives of the new BIPV system proposed for the chosen locations is to improve the indoor conditions of rooms closed by the curtain walls. Currently, these rooms are not well conditioned, being too hot in warm seasons and too cold in winter. Shadowing by the solar cells will significantly reduce the temperature in summer; the second skin over the existing cladding will improve reduce the cold during the winter seasons.

Regarding the energy consumption equipment, there are 2 gas boilers for heating and DHW, 2 gas boilers and 2 electrical chillers for cooling, additionally supported by the cold water distribution network.

The lighting system is turned on all day long (from 8:00 until 17:00). The electricity consumption for lighting and plugs represent only 30% of the whole electricity consumptions. The machines have the most important share of electricity consumptions.

8.3 Pre-dimensioning of BIPV and energy storage best options

As said before, the BIPV will consist on a second skin over the existing curtain wall, performing as double-glazing ventilated façade. There are 3 curtain walls candidates to host the BIPV systems. The last option 6.D is a conjunction of the Options 6.A & 6.B:

- Option 6.A: SSE polygonal façade; orientations -31°, -32°, -33°, -34°, -35°, -36°, tilt 90° and 85,5 m2 of available area.
- Option 6.B: S polygonal façade; orientations -1°, 0°, +1°, +2°, +3°, +4°, tilt 90° and 85,5 m2 of available area.
- Option 6.C: SW polygonal façade; orientations +32°, +33°, +34°, +35°, +36°, +37°, tilt 90° and 85,5 m2 of available area.

Option 6.D: SSE & S polygonal façades. Due to the fact that the floor section of the selected façades is polygonal, it is advisable that each PV modules vertical row, with different orientation, is separately connected by means of a distributed power conditioning system. This measure would allow achieving the maximum production for every row, by means of the individualized maximum power point tracking.

In order to occupy the required PV area, Option 6.D has been chosen for implementing the BIPV demo-system.

Nevertheless, as said before, every option has been considered at this stage of the task: a set of 4 pre-dimensioned system options have been generated according to the specific characteristics of each location selected. The pre-dimensioned system of the chosen option has the following characteristics and will provide the estimated power production:

Option 6.D		
SW polygonal façade		
Location	SW façade, on the existing glass closing	
System power	14,9	kWp
Orient // Inclin	+32°, +33°, +34°, +35°, +36°, +37° (S) // 90°	(º)
Occupied area	103,5	m^2
No. modules	12 x 6 = 72	ud
BIPV module characterization		
Module power	206,3	Wp
Module width	675	mm
Module length	2130	mm
Production estimation		
Specific production	655	kWh/kWp/year
Estimated production	9.728	kWh/year

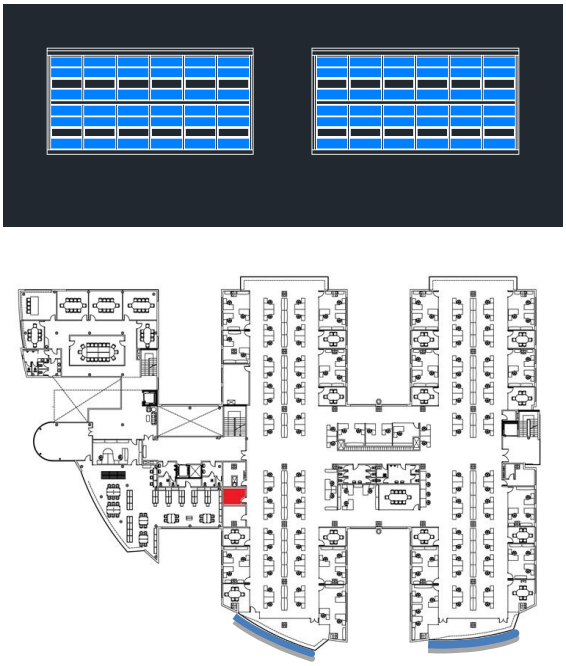

Figure 8.3: Proposed option for the BIPV demo-system.

Regarding the electricity storage system, a final location has not yet been decided, but it will be housed close to the inverter in order to reduce electrical losses and bring the equipment together.

9 REFERENCES

Different tools, sources and references used in this deliverable are listed below:

[1] “PVSyst PV” modelling tool.

[2] “Meteonorm” radiation and meteorology data base.

[3] Googlemaps: https://www.google.es/maps.

[4] Plans, data and descriptions sent by the demo owners and the module manufacturer partners.

[5] Measurement and Verification Plans for the Pilot-sites, from the work carried out in the T8.4.

[6] Reports and pictures made from the visits of some partners to the demo-sites.

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PVSITES Report:

Energy audit of PVSITES demonstration buildings and identification of BIPV possibilities

Annex 1: Pre-auditory of demo buildings and Pre-dimensioning of system options

DEMO 1 FORMAT D2 - Residential house – Belgium

DEMO 2 FLISOM - École Hôtelière de Genève - Switzerland

DEMO 3 FLISOM - Carport - Switzerland

DEMO 4 CRICURSA - Industrial building - Spain

DEMO 5 VILOGIA - Storey block - France

DEMO 6 TECNALIA - Office building - Spain

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PRE-AUDITORY

DEMO 1 FORMAT D2 - Residential house - Belgium

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PRE-AUDITORY DEMO 1 FORMAT D2

Building location and description

Location	Stambruges (Belgium)	**Description**
Typology	Residential & office	Detached passive wooden house, located in a rural area, for residential and professional uses (architect's office). Currently in construction.
Area	280 m² (219 m² heated floor)	
Floors	3	

South façade

Main façade with large door in the ground floor and windows in the first floor. Boundary wall limiting the parcel. Scarce space available for BIPV, and possible shadows of the wall on the façade.
Orientation: +14° (SSW).

West façade

Entrance : windows in the first floors. Boundary wall limiting the parcel. Some space available for BIPV in the first and second floors, and possible shadows of the wall on the façade.
Orientation: +104° (NNW).

East façade

Windows in the first floors. Boundary wall limiting the parcel. Some space available for BIPV in the first and second floors, and possible shadows of the wall on the façade.
Orientation: -76° (ESE).

Roofs

Single 30° sloped roof with tiles. Available area of 107 m² for implementing BIPV systems. Small shadows caused by a chimney. Optimum orientation and inclination with maximum production guarantied.
Orientation: +14° (NNW).
Inclination: 30°.

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PRE-AUDITORY DEMO 1 FORMAT D2

Building envelop characterization

	Description
Roofs	Single 30° sloped roof with tiles (107 m2) and flat roofs (92 m2).
Walls	Structural wood panels (CLT 10cm) + insulation and finition.
Closings	PVC windows and doors. Triple glazing.

Roofs

Slope roof:
tiles + lathing.
CLT wood 5 layers (10 cm).
PU insulation (22 cm).
U roof = 0.092 W/m^{2}K.

Flat roof:
CLT wood 5 layers (10 cm).
PU insulation (24 cm) + EPDM.
U flat roof = 0.098 W/m^{2}K.

Façades

First Floor (39cm):
U wall = 0.091 W/m^{2}K.
Wood siding (2.2 cm) + lathing (3.8 cm) + rain barrier.
PU insulation (22 cm).
CLT wood 5 layers (1 0cm) + plasterboard (1 cm).

Second floor (41 cm):
U wall = 0.097 W/m^{2}K.
Silicone plastered (1 cm).
Expanded graphite polystyrene (30 cm).
CLT wood 5 layers (10 cm) + plasterboard (1 cm).

Closings

PVC windows and doors. Triple glazing.
Ug = 0.5 W/m^{2}K – g = 0.53.
Uf = 0.89 W/m^{2}K.
Uw average = 0.72 W/m2K.

Other elements

-

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PRE-AUDITORY DEMO 1 FORMAT D2

Main energy consumption systems

Equipment	Description	Intended use	Energy source
Direct electric radiator	Bathroom = 700 W Shower = 350 W Office = 1250 W	Heating of bathrooms and office	Electricity
Thermodynamic heat pump	Air/water (300 l) + extra electric resistance. COP of 3.5	DHW	Electricity
Wood-burning fireplace	4.8 kW. Efficiency = 83 % (fed with outside air)	Heating of the house	Wood (logs)
Double flux ventilation	Paul Novus 450. Efficiency = 89 % (heating recovering)	Air renewal with energy recovery	Electricity
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

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PRE-AUDITORY DEMO 1 FORMAT D2

Energy consumption profiles

Electricity	
Period	Consumption (kWh/period)
Jan	590.75
Feb	601.47
Mar	606.00
Apr	542.24
May	535.83
Jun	534.09
Jul	499.69
Aug	495.61
Sep	483.87
Oct	603.17
Nov	602.74
Dec	725.89
Year	**6821.50**

Natural gas	
Period	Consumption (kWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

Renewable energy and other sources	
Period	Consumption (kWh/period)
Jan	664.00
Feb	664.00
Mar	398.40
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	112.88
Nov	556.10
Dec	765.26
Year	**3160.64**

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PRE-AUDITORY DEMO 1 FORMAT D2

Solar radiation resource

Option 1.A [sloped roof, +14° (SSW), 30º] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	27,6	2,5
Feb	45,5	3,0
Mar	78,2	5,7
Apr	108,8	8,6
May	140,2	12,8
Jun	139,2	15,4
Jul	140,7	17,4
Aug	129,1	17,1
Sep	95,8	14,2
Oct	70,1	10,4
Nov	34,3	5,9
Dec	24,6	3,6
Year	**1034,1**	**9,7**

Option 1.B [North flat roof, +14° (SSW), 0º] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	21,5	2,5
Feb	38,8	3,0
Mar	69,1	5,7
Apr	104,6	8,6
May	141,3	12,8
Jun	142,4	15,4
Jul	143,4	17,4
Aug	126,0	17,1
Sep	87,2	14,2
Oct	57,0	10,4
Nov	26,4	5,9
Dec	17,3	3,6
Year	**975,0**	**9,7**

Option 1.C [West flat roof, +14° (SSW), 0º] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	21,5	2,5
Feb	38,8	3,0
Mar	69,1	5,7
Apr	104,6	8,6
May	141,3	12,8
Jun	142,4	15,4
Jul	143,4	17,4
Aug	126,0	17,1
Sep	87,2	14,2
Oct	57,0	10,4
Nov	26,4	5,9
Dec	17,3	3,6
Year	**975,0**	**9,7**

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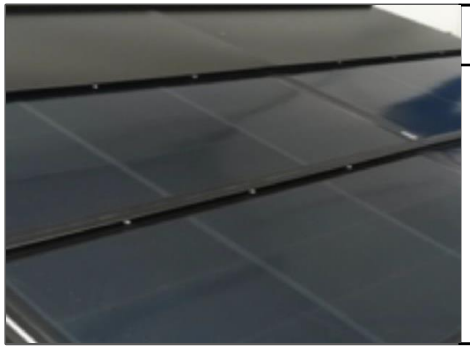
PRE-DIMESIONING DEMO 1 FORMAT D2

BIPV and storage possibilities

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 1.A	SSW sloped roof	+14°	30°	87,3 m^2	Power	10 kWp
Option 1.B	North flat roof	+14°	5º	22,7 m^2	Area	106 m^2
Option 1.C	West flat roof	+14°	5º	26,4 m^2	Grid interface	DC coupled PV storage system



PV module (FLISOM)

CIGS roofing shingle on metal substrate (model X1): PV module with Flisom's CIGS monolithically interconnected cell technology, laminated onto a metallic roof tile. Supplied standard connectors.
Max length: 3.0 m.
Max width: 0.4 – 2.0 m.

Mounting system

PV shingles are mounted to the roof using conventional roofing technology. The geometrical design of the shingles make easy the installation and simulate the visual aspect of a slate gabled roof.

Evaluation of existing BIPV and storage implementation possibilities

On the basis of the options valuated below, the SSW sloped roof of the house is clearly the best option for implementing the CIGS roofing shingle by FLISOM. Orientation and inclination are optimal and available area is the highest of all options, thus the production is maximum. In the other hand, the developed products has been specifically designed for sloped roofs, with a geometry allowing the tiles overlapping. Due to the fact that the building is currently being constructed, the roof structure will be conformed according with the geometrical and mechanical characteristics of the product in order to facilitate the installation.
Flat roofs are also an alternative, but inclination is not optimal and it would not be fully exploited the possibilities associated to the geometrical product design. Additionally, the available area for PV is lower some shadows from the sloped roof, located in a higher floor, would affect the production during those periods where the solar elevation is lower.

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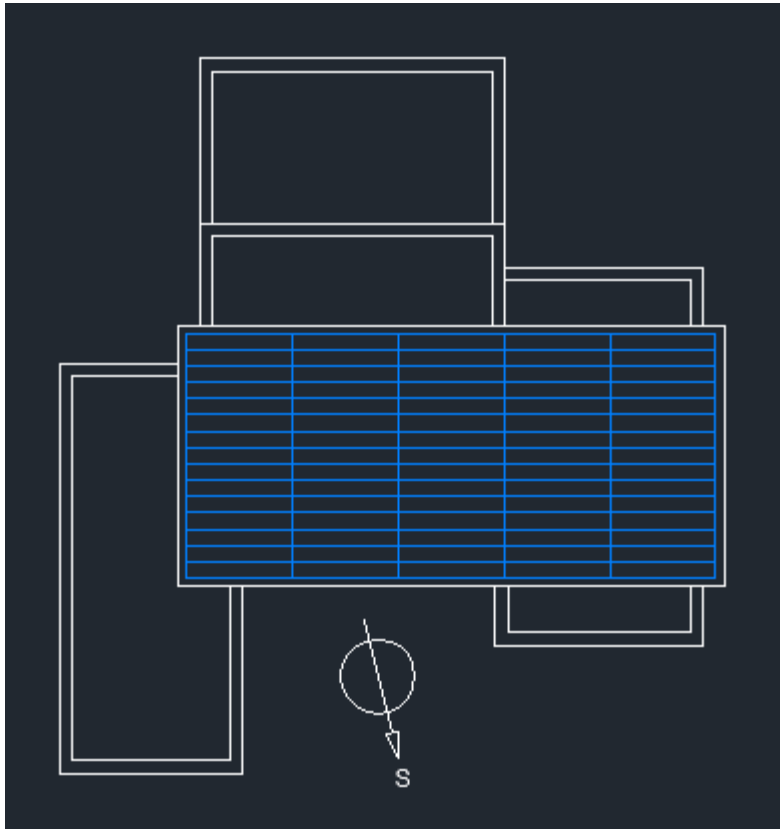
PRE-DIMESIONING DEMO 1 FORMAT D2

Option 1.A		
SSW sloped roof		
Location	SSW sloped roof	
System power	7,0	kWp
Orient // Inclin	+14° // 30°	(º)
Occupied area	12,2 x 6,5 = 79,6	m^2
No. modules	5 x 15 = 75	ud
BIPV module characterization		
Module power	92,9	Wp
Module width	435	mm
Module length	2440	mm
Production estimation		
Specific production	864	kWh/kWp/year
Estimated production	6.018	kWh/year

Pre-dimensioned options



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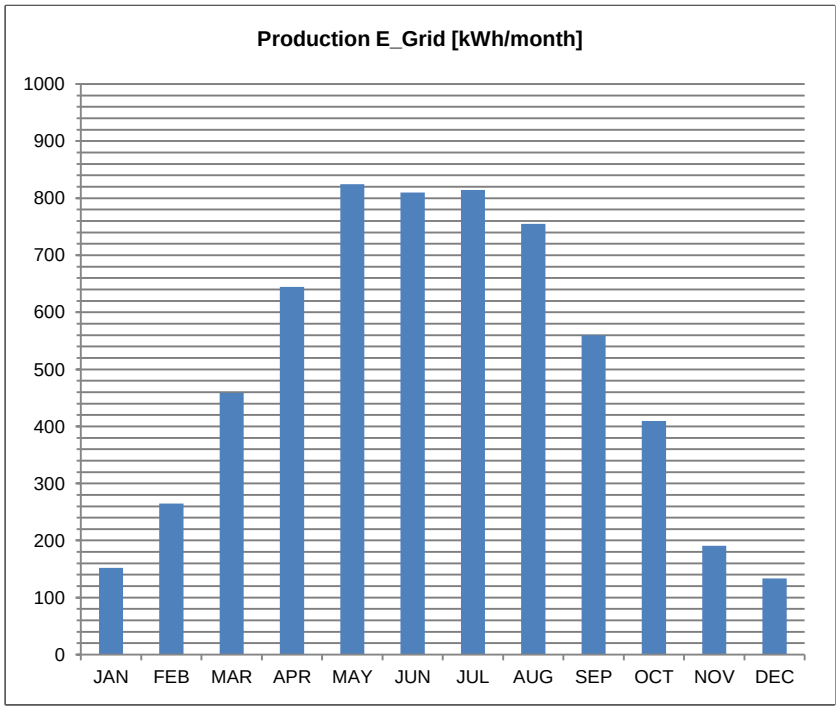
PRE-DIMESIONING DEMO 1 FORMAT D2

Options assessment

Production estimation (data)

Option 1A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	27,6	2,5	152
FEB	45,5	3,0	265
MAR	78,2	5,7	459
APR	108,8	8,6	645
MAY	140,2	12,8	825
JUN	139,2	15,4	810
JUL	140,7	17,4	814
AUG	129,1	17,1	755
SEP	95,8	14,2	560
OCT	70,1	10,4	410
NOV	34,3	5,9	191
DEC	24,6	3,6	134
YEAR	**1034,1**	**9,7**	**6018**

Production estimation (graph)



Option 1.A	SSW sloped roof	Proposed

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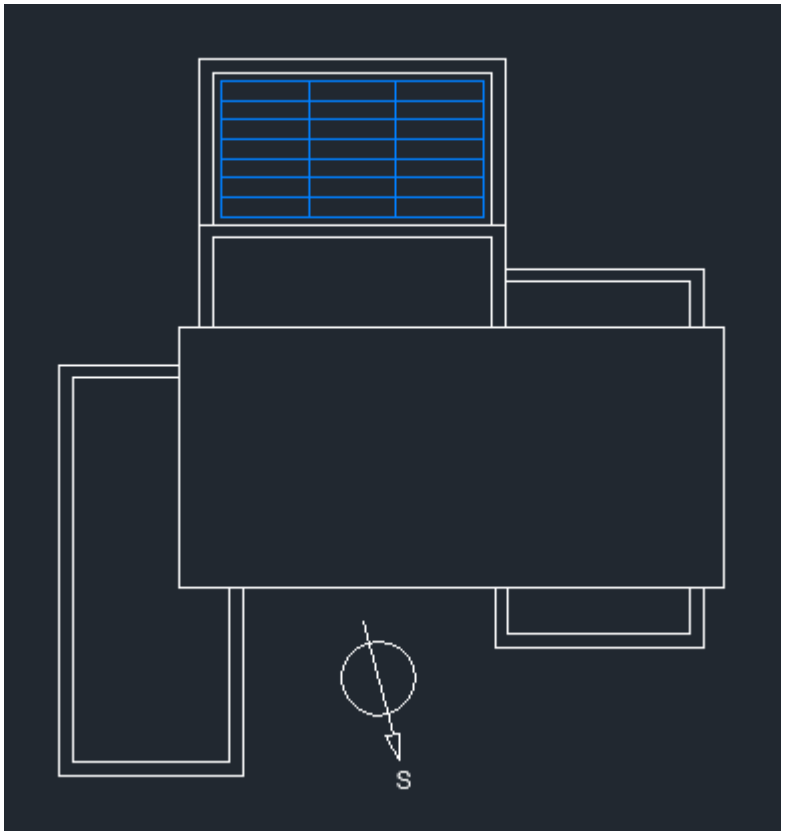
PRE-DIMESIONING DEMO 1 FORMAT D2

Option 1.B		
North flat roof		
Location	North flat roof	
System power	1,7	kWp
Orient // Inclin	+14° // 5°	(º)
Occupied area	6,1 x 3,1 = 18,9	m^2
No. modules	3 x 7 = 21	ud
BIPV module characterization		
Module power	78,9	Wp
Module width	447	mm
Module length	2017	mm
Production estimation		
Specific production	806	kWh/kWp/year
Estimated production	1.336	kWh/year

Pre-dimensioned options



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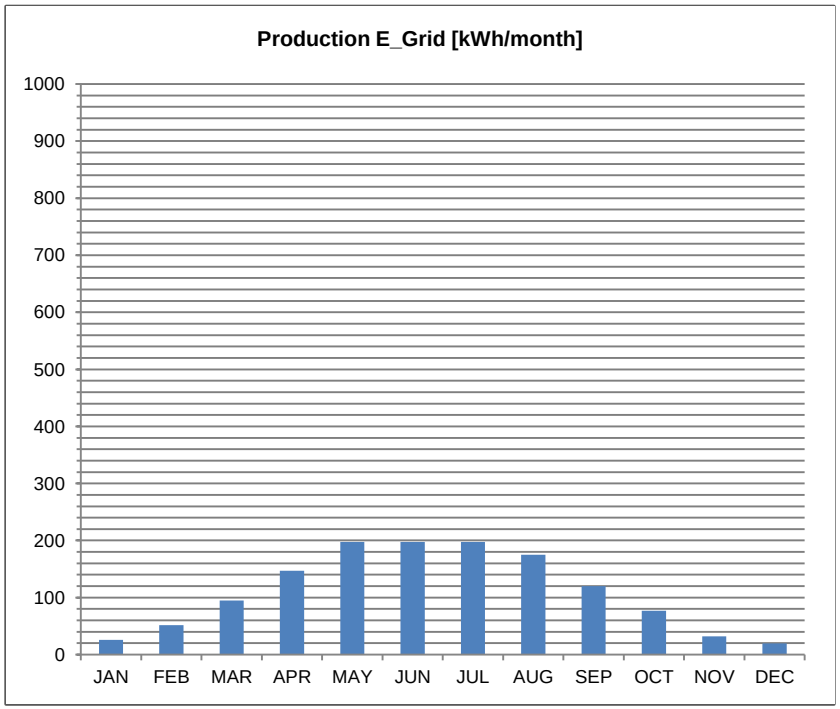
PRE-DIMESIONING DEMO 1 FORMAT D2

Options assessment

Production estimation (data)

Option 1B	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	21,5	2,5	26
FEB	38,8	3,0	52
MAR	69,1	5,7	95
APR	104,6	8,6	147
MAY	141,3	12,8	198
JUN	142,4	15,4	197
JUL	143,4	17,4	198
AUG	126,0	17,1	175
SEP	87,2	14,2	120
OCT	57,0	10,4	77
NOV	26,4	5,9	32
DEC	17,3	3,6	20
YEAR	**975,0**	**9,7**	**1336**

Production estimation (graph)



Option 1.B	North flat roof	Rejected

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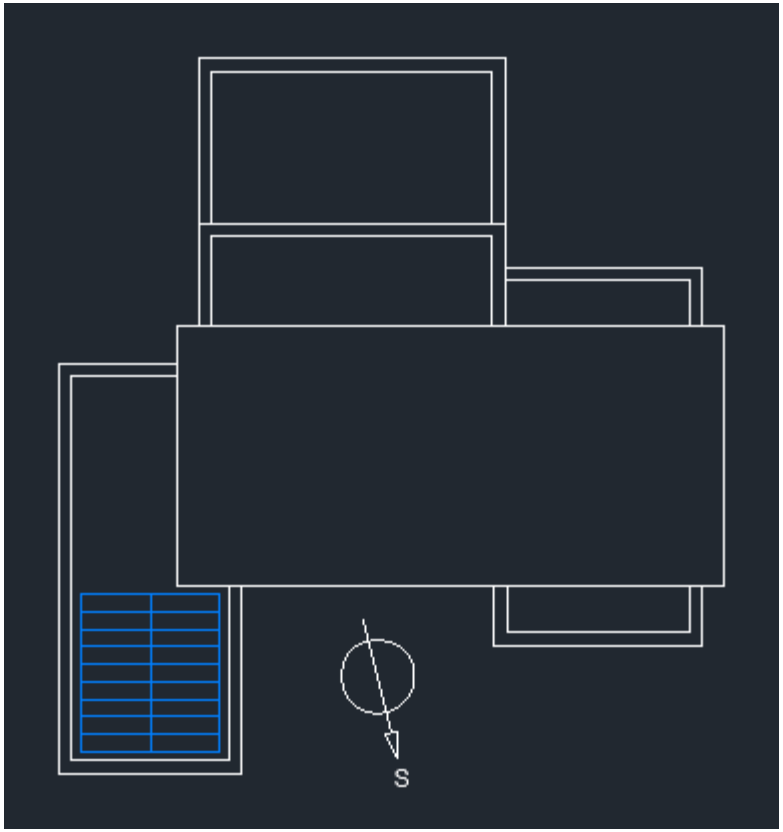
PRE-DIMESIONING DEMO 1 FORMAT D2

Option 1.C		
West flat roof		
Location	West flat roof	
System power	1,0	kWp
Orient // Inclin	+14° // 5°	(º)
Occupied area	3,2 x 3,7 = 11,6	m^2
No. modules	2 x 9 = 18	ud
BIPV module characterization		
Module power	56,5	Wp
Module width	406	mm
Module length	1590	mm
Production estimation		
Specific production	806	kWh/kWp/year
Estimated production	820	kWh/year

Pre-dimensioned options



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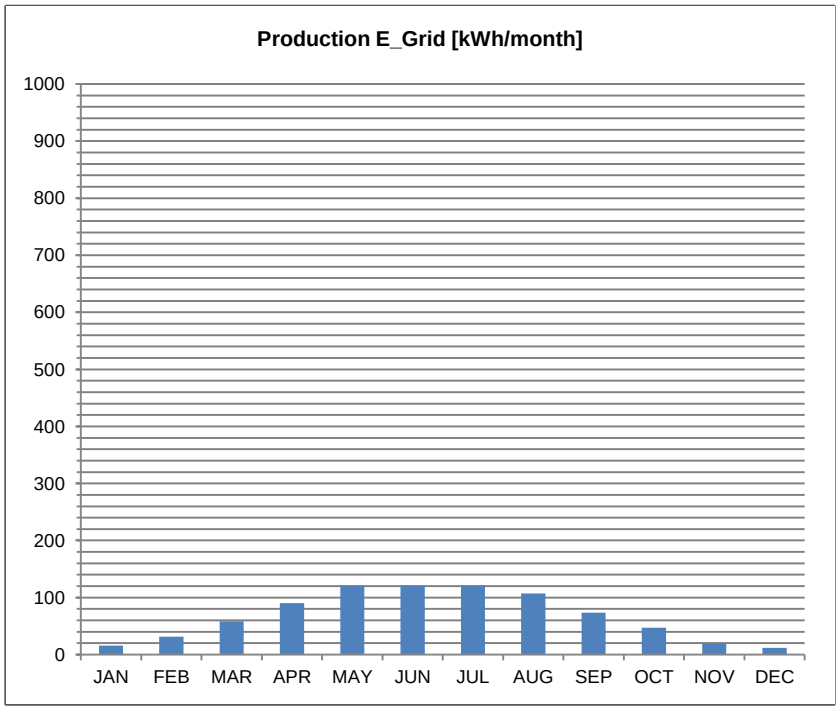
PRE-DIMESIONING DEMO 1 FORMAT D2

Options assessment

Production estimation (data)

Option 1C	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	21,5	2,5	16
FEB	38,8	3,0	32
MAR	69,1	5,7	58
APR	104,6	8,6	90
MAY	141,3	12,8	121
JUN	142,4	15,4	121
JUL	143,4	17,4	121
AUG	126,0	17,1	107
SEP	87,2	14,2	74
OCT	57,0	10,4	47
NOV	26,4	5,9	20
DEC	17,3	3,6	12
YEAR	**975,0**	**9,7**	**820**

Production estimation (graph)



Option 1.C	West flat roof	Rejected

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PRE-AUDITORY

DEMO 2 FLISOM - École Hôtelière de Genève - Switzerland

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

PRE-AUDITORY DEMO 2 FLISOM

Building location and description

Location	Genève (Switzerland)	**Description**
Typology	Educational building	The hotel school *École Hôtelière de Genève (EHG)* of Geneva is a block of 3 land-based buildings. The main one is an old building constructed in 20th century. They are interconnected underground by a 4th building which hosts a technical installations, a kitchen and a cafeteria.
Area	130 m2	
Floors	2	

South façade

The principal building hosts the school restaurant, the offices and a showroom. Its façade is not available for BIPV. South façades of the pavilions 1 and 2 are not either, because they have completely occupied by glass closings .
Orientation: -10° (SSW).

East façade of the pavilion 1

The pavilion 1 is currently being finished. It will host rooms for education purposes. It has a brick façade with a medium-size area available for BIPV, although the orientation is not the most appropriated.
Orientation: -80° (E).
Area: 2x(3,6mx6,15m)=44,3 m^2

West façade of the pavilion 2

The pavilion 2, built some years ago, hosts classrooms. It has a brick façade with a large area available for BIPV, although the orientation is not the most appropriated.
Orientation: +100° (W).
Area: 2x(6,2mx5,9m) +1x(6,2mx3,2m)=94.8m^2

Roofs of the pavilion 2

The west side of Pavilion 2 roof offers an ideal space for an innovative flat-roof PV-system, as there is no shading during most of the day.
Inclination: 0°.
Area: 80 m2.

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PRE-AUDITORY DEMO 2 FLISOM

Building envelop characterization

	Description
Roofs	Gravel roof.
Walls	Brick façade.
Closings	Large windows over 2 floors.

Roofs

The building has a flat gravel roof with some cooling devices on top. The roof is not considered for a BIPV installation.

Façades

The outside of the building façade is made in brick optic. There is no detailed info regarding u-values. The transition from the PV façade to the window frame requires detailed customization.

Closings

East façade has 2 window sections. The windows go over 2 floors and have a black frame design.

West façade has 3 window sections. The windows go over 2 floors and have a black frame design.

Other elements

-

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PRE-AUDITORY DEMO 2 FLISOM

Main energy consumption systems

Equipment	Description	Intended use	Energy source
Heat pumps	Located on the top of building's roofs. The cooling energy is emitted into classrooms by radiant panels located closely to ceiling.	Cooling of classrooms at both pavilions	Electricity
2 gas-fired boilers.	Installed into the basement of the principal building.	Heating of the buildings.	Natural gas
1 gas-fired boiler	-	DHW	Natural gas
Heat recovery system	Non-used waste heat energy recovery system coming from compressors and pumps of heating system.	Supporting for DHW	Electricity

Observations: the buildings are supplied by the EDF grid through one electricity delivery point located into basement of the principal building. Each building is supplied by this general electricity distribution board; there are also divisional distribution electricity boards into each level of buildings.

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PRE-AUDITORY DEMO 2 FLISOM

Energy consumption profiles

Electricity	
Period	Consumption (MWh/period)
Jan	32,3
Feb	31,4
Mar	30,2
Apr	25,9
May	28,0
Jun	35,9
Jul	25,9
Aug	27,2
Sep	30,7
Oct	28,7
Nov	31,5
Dec	26,8
Year	**35,5**

Natural gas	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

Renewable energy and other sources	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

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

PRE-AUDITORY DEMO 2 FLISOM

Solar radiation resource

Option A [E façade pavilion 1, 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	19,3	0,9
Feb	26,3	1,5
Mar	48,7	5,5
Apr	58,9	8,9
May	76,8	12,9
Jun	85,9	16,7
Jul	93,3	20,1
Aug	85,5	19,1
Sep	62,2	15,6
Oct	39,4	11,1
Nov	20,2	5,0
Dec	15,5	2,6
Year	**632,0**	**10,0**

Option B [W façade pavilion 2, 90º] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	20,2	0,9
Feb	26,3	1,5
Mar	55,0	5,5
Apr	64,5	8,9
May	84,3	12,9
Jun	95,8	16,7
Jul	100,8	20,1
Aug	91,9	19,1
Sep	65,5	15,6
Oct	44,1	11,1
Nov	22,3	5,0
Dec	19,5	2,6
Year	**690,3**	**10,0**

Option C [Roof pavilion 2, 0º] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	31,0	0,9
Feb	44,0	1,5
Mar	92,5	5,5
Apr	117,4	8,9
May	146,0	12,9
Jun	175,4	16,7
Jul	189,2	20,1
Aug	159,7	19,1
Sep	115,0	15,6
Oct	70,5	11,1
Nov	33,0	5,0
Dec	25,1	2,6
Year	**1198,8**	**10,0**

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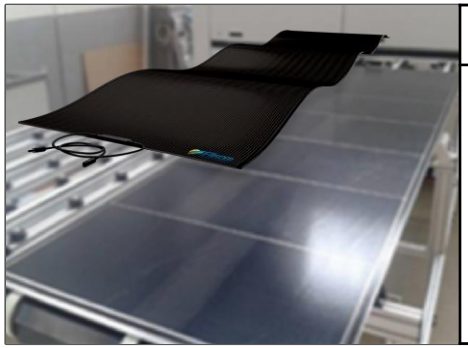
PRE-DIMESIONING DEMO 2 FLISOM

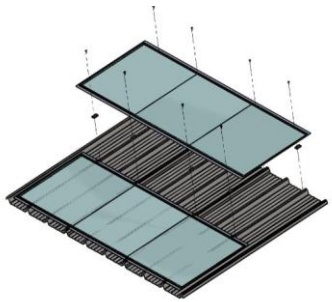
BIPV and storage possibilities

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 2.A	E façade pavilion 1	-80°	90°	45	Power	100 m^2 (façade) + 100 m^2 (roof)
Option 2.B	W façade pavilion 2	+100°	90°	97	Area	10 kWp + 10 kWp
Option 2.C	Roof pavilion 2	-80°	5°	85	Grid interface	AC coupled PV storage system
Option 2.D	Options A+B	-	-	142		



PV module (FLISOM)

X2 & X4. CIGS large area flexible roofing membrane & bendable elements: lightweight BIPV modules for roof and façade applications.
Max length: 3.0 m.
Max width: 0.4 – 2.0 m.



Mounting system

Several building integration possibilities, depending of the arquitecture requirements: adhesive bonding, tapes of Velcro, mechanical fixation, back rails, overlapping metal back sheet, etc. assembled to the roof or façade supporting structure.

Evaluation of existing BIPV and storage implementation possibilities

Since the area covered by PV foreseen in the project is high, it will be necessary to use at least 2 available locations although they do not fully offer the optimal operational conditions. Thus, the 2 façades will be chosen for demonstration. Nevertheless, the different orientation of the E and W façades, although not optimal, will have an extra advantage: one façade will have sun from morning to noon, the other façade will have sun starting around noon to the evening. As there are no trees or other obstacles shadowing the facades this arrangement may lead to an almost straight generation profile over the course of a day. However this needs to be confirmed by modelling during the next sub-tasks. In both cases the same type of façade system has to be used to keep installation cost under control. The only challenge there is to make a nice transition from the PV façade to the window frame. Although initially considered as an option, the foreseen BIPV roof system has been finally rejected because it would be an attached (not integrated) system.

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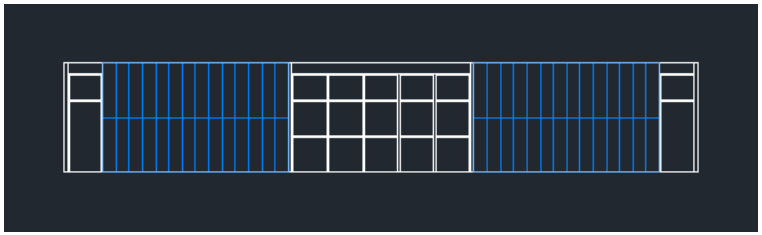
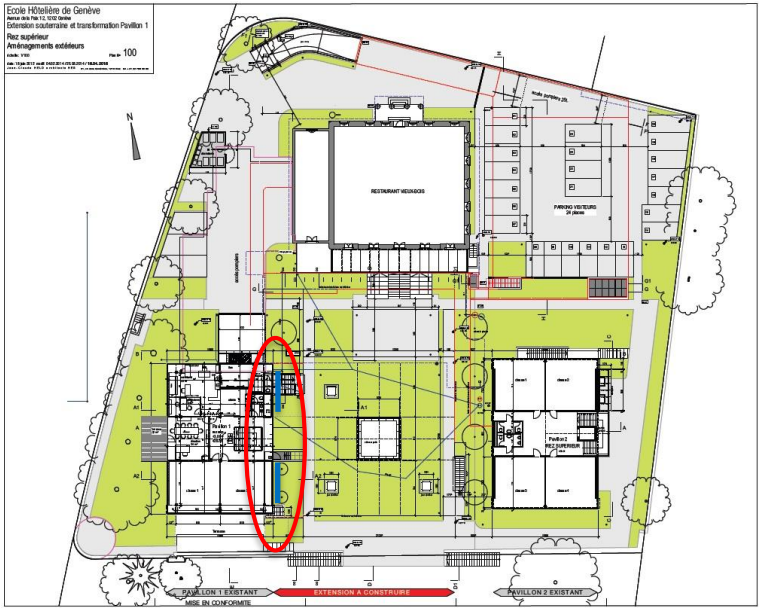
PRE-DIMESIONING DEMO 2 FLISOM

Option 2.A		
E façade pavilion 1		
Location	E façade pavilion 1	
System power	3,9	kWp
Orient // Inclin	-80° // 90°	(º)
Occupied area	44,3	m^2
No. modules	2 x (2 x 14) = 56	ud
BIPV module characterization		
Module power	69,1	Wp
Module width	439	mm
Module length	1.800	mm
Production estimation		
Specific production	864	kWh/kWp/year
Estimated production	2.112	kWh/year

Pre-dimensioned options





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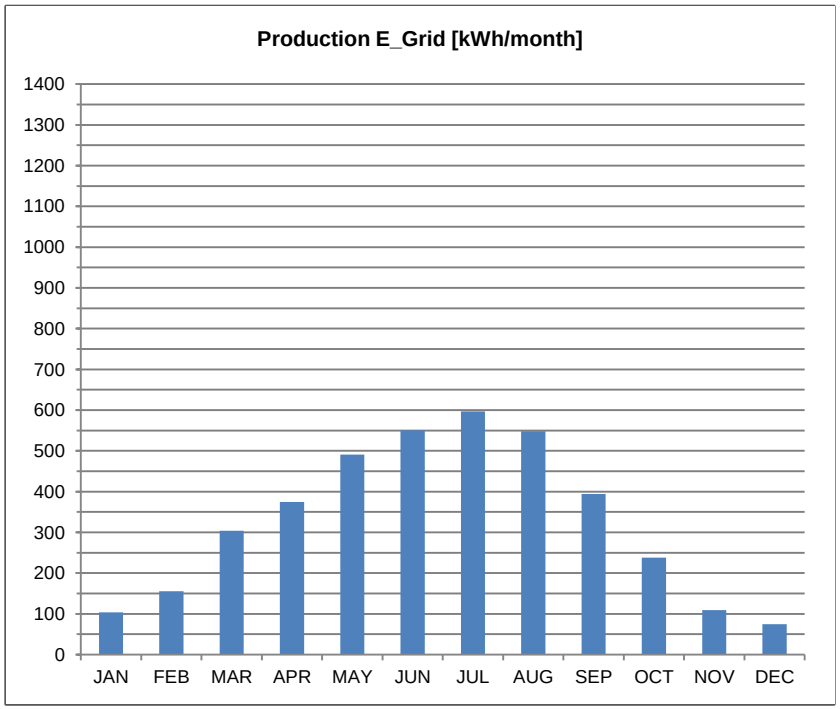
PRE-DIMESIONING DEMO 2 FLISOM

Options assessment

Production estimation (data)

Option 2B	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	19,3	0,9	104
FEB	26,3	1,5	156
MAR	48,7	5,5	304
APR	58,9	8,9	375
MAY	76,8	12,9	491
JUN	85,9	16,7	551
JUL	93,3	20,1	597
AUG	85,5	19,1	548
SEP	62,2	15,6	394
OCT	39,4	11,1	238
NOV	20,2	5,0	110
DEC	15,5	2,6	75
YEAR	**632,0**	**10,0**	**3942**

Production estimation (graph)



Option 2.A	E façade pavilion 1	Rejected

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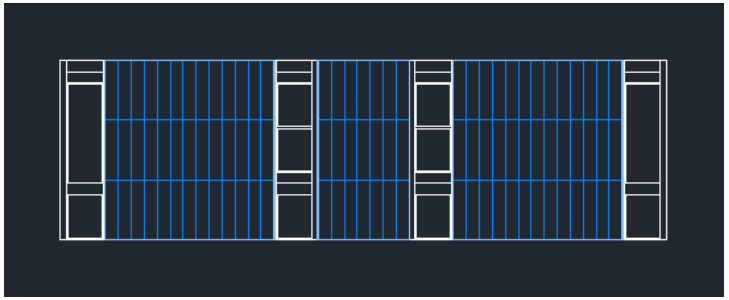
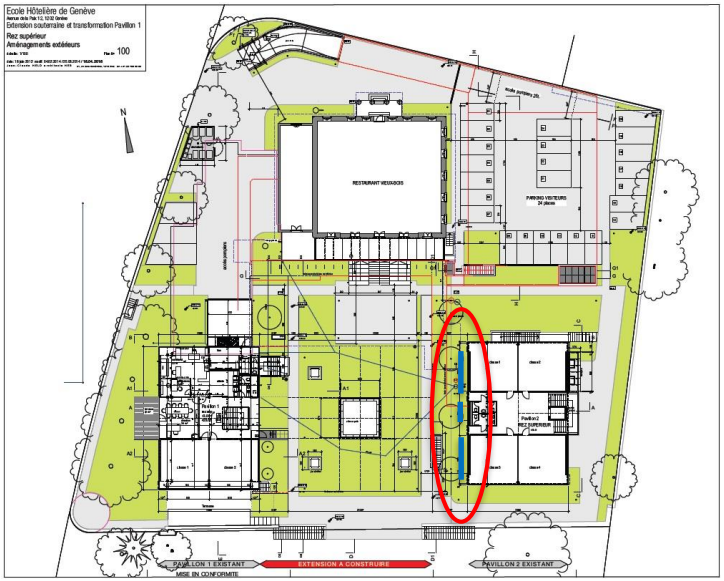
PRE-DIMESIONING DEMO 2 FLISOM

Option 2.B		
W façade pavilion 2		
Location	W façade pavilion 2	
System power	8,1	kWp
Orient // Inclin	+100° // 90°	(º)
Occupied area	92,1	m^2
No. modules	2x(3x13)+(3x7) = 99	ud
BIPV module characterization		
Module power	81,4	Wp
Module width	450	mm
Module length	2.067	mm
Production estimation		
Specific production	489	kWh/kWp/year
Estimated production	3.942	kWh/year

Pre-dimensioned options





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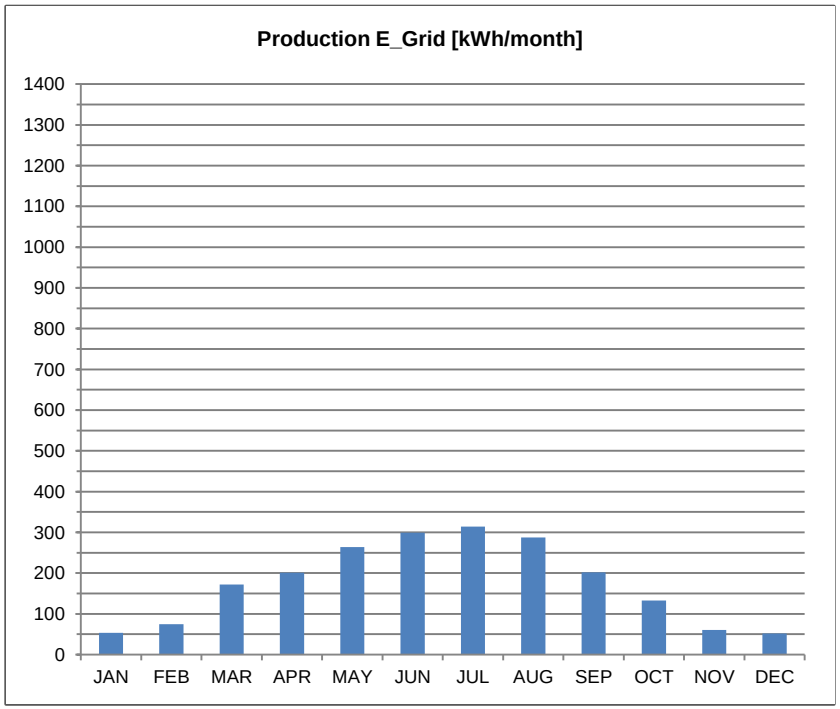
PRE-DIMESIONING DEMO 2 FLISOM

Options assessment

Production estimation (data)

Option 2A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	20,2	0,9	53
FEB	26,3	1,5	75
MAR	55,0	5,5	172
APR	64,5	8,9	201
MAY	84,3	12,9	264
JUN	95,8	16,7	299
JUL	100,8	20,1	314
AUG	91,9	19,1	287
SEP	65,5	15,6	202
OCT	44,1	11,1	132
NOV	22,3	5,0	60
DEC	19,5	2,6	52
YEAR	**690,3**	**10,0**	**2112**

Production estimation (graph)



Option 2.B	W façade pavilion 2	Rejected

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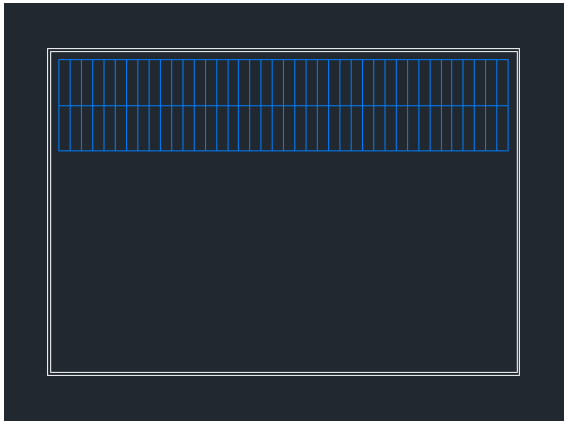
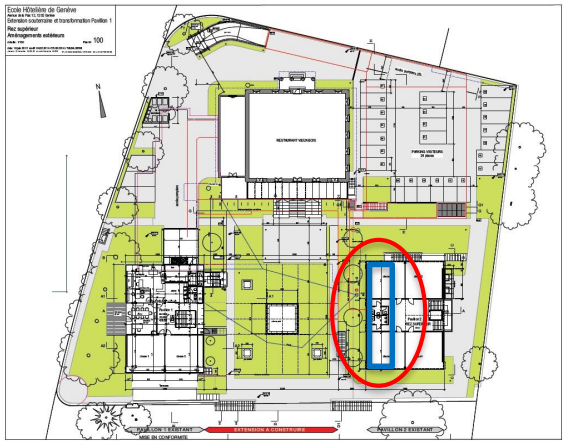
PRE-DIMESIONING DEMO 2 FLISOM

Option 2.C		
Roof pavilion 2		
Location	Roof pavilion 2	
System power	7,2	kWp
Orient // Inclin	-80° // 5°	(º)
Occupied area	82,7	m^2
No. modules	2 x 40 = 80	ud
BIPV module characterization		
Module power	90,4	Wp
Module width	500	mm
Module length	2067	mm
Production estimation		
Specific production	992	kWh/kWp/year
Estimated production	7.178	kWh/year

Pre-dimensioned options





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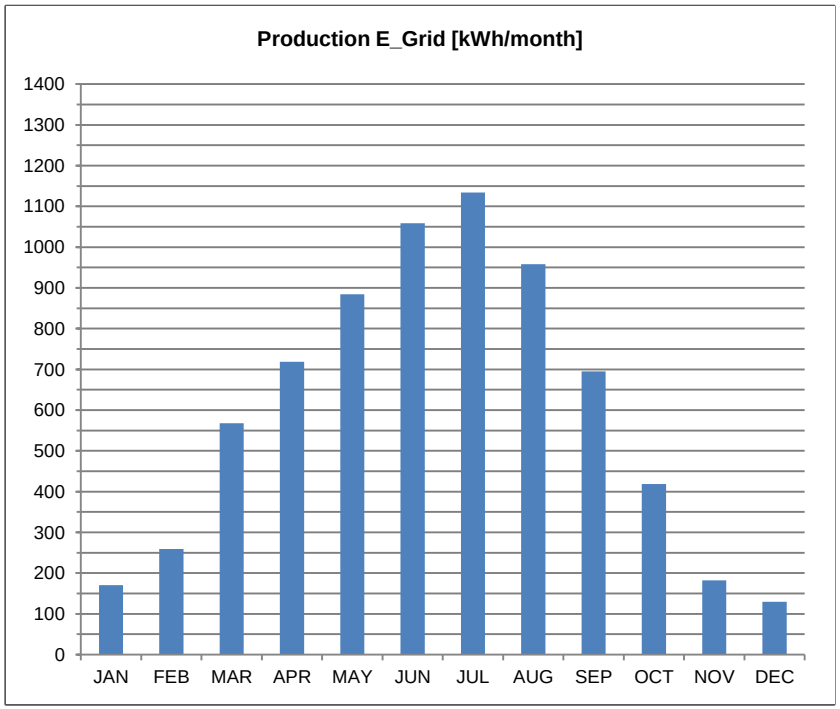
PRE-DIMESIONING DEMO 2 FLISOM

Options assessment

Production estimation (data)

Option 2C	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	31,0	0,9	171
FEB	44,0	1,5	260
MAR	92,5	5,5	568
APR	117,4	8,9	719
MAY	146,0	12,9	884
JUN	175,4	16,7	1058
JUL	189,2	20,1	1134
AUG	159,7	19,1	958
SEP	115,0	15,6	695
OCT	70,5	11,1	419
NOV	33,0	5,0	182
DEC	25,1	2,6	130
YEAR	**1198,8**	**10,0**	**7178**

Production estimation (graph)



Option 2.C	Roof pavilion 2	Rejected

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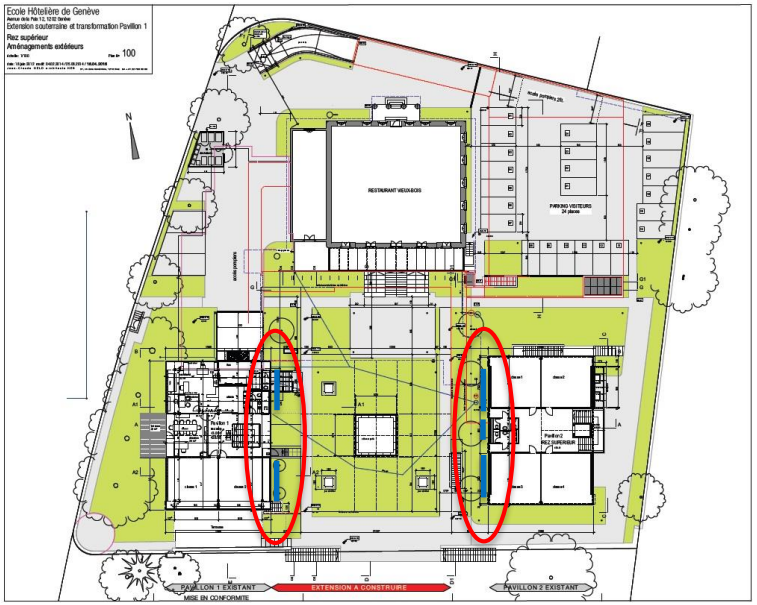
PRE-DIMESIONING DEMO 2 FLISOM

Option 2.D		
E façade pavilion 1 + W façade pavilion 2		
Location	Several	
System power	11,9	kWp
Orient // Inclin	Several	(º)
Occupied area	136,3	m^2
No. modules	155	ud
BIPV module characterization		
Module power	Several	Wp
Module width	Several	mm
Module length	Several	mm
Production estimation		
Specific production	507	kWh/kWp/year
Estimated production	6.054	kWh/year

Pre-dimensioned options



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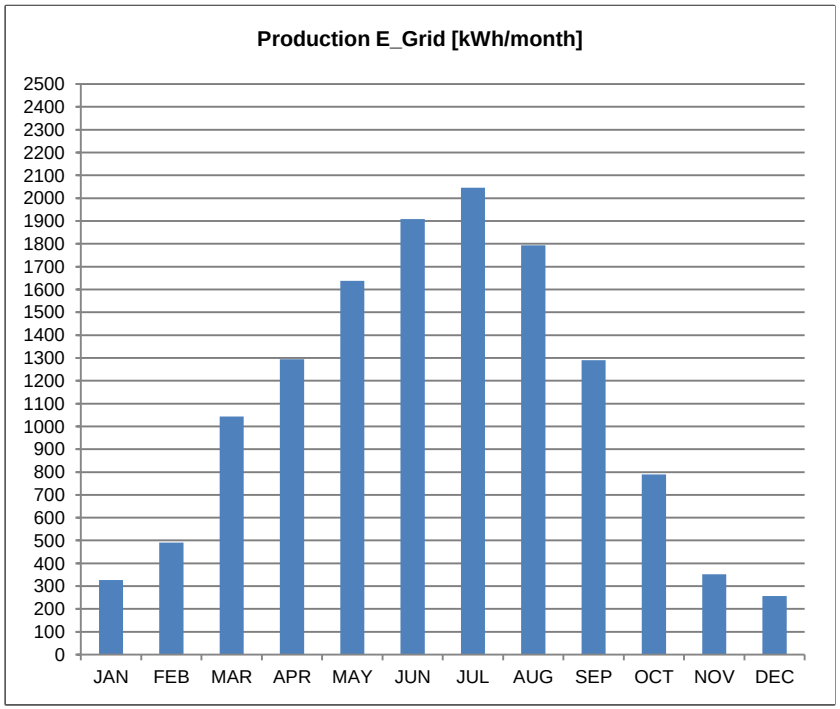
PRE-DIMESIONING DEMO 2 FLISOM

Options assessment

Production estimation (data)

Option 2D	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	-	-	157
FEB	-	-	231
MAR	-	-	476
APR	-	-	576
MAY	-	-	754
JUN	-	-	850
JUL	-	-	911
AUG	-	-	835
SEP	-	-	596
OCT	-	-	371
NOV	-	-	170
DEC	-	-	126
YEAR	-	-	6054

Production estimation (graph)



Option 2.D	E façade pavilion 1 & W façades pavilion 2	Proposed

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

PRE-AUDITORY

DEMO 3 FLISOM - Carport - Switzerland

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

PRE-AUDITORY DEMO 3 FLISOM

Building location and description

Location	Dübendorf (Switzerland).	**Description**
Typology	Public carport.	Carport of double-slope flat cladding of asbestos, for partial/total substitution or overlapping. Located at EMPA facilities, closed to Flisom building.
Area	500 m^2.	
Floors	0	

Roof SEE

Available area for BIPV (totally or partially replacement of existing asbestos claddings) or BAPV (coverage off existing claddings). No shadows exist.
Orientation: -61° (SEE).
Inclination: 8°.
Area: 250 m^2.

Roof WNW

Available area for BIPV (totally or partially replacement of existing asbestos claddings) or BAPV (coverage off existing claddings). No shadows exist.
Orientation: +119° (WNW).
Inclination: 8°.
Area: 250 m^2.

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PRE-AUDITORY DEMO 3 FLISOM

Building envelop characterization

	Description
Roofs	Asbestos sheets.
Walls	-
Closings	-

Roofs
This carport is located at EMPA facilities, closed to Flisom building. The current cladding is made of asbestos and it shows two inclined planes, one oriented to South-East and the other to North-West. The planned BIPV generator occupies less than a half of any of these inclined planes.

Façades
-

Closings
-

Other elements
-

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PRE-AUDITORY DEMO 3 FLISOM

Main energy consumption systems

Equipment	Description	Intended use	Energy source
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

Observations: there is no lighting, nor either any other electrical load in the carport. However, electrical supply is accessible in one side of the base.

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

PRE-AUDITORY DEMO 3 FLISOM

Energy consumption profiles

Electricity	
Period	Consumption (kWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

Natural gas	
Period	Consumption (kWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

Renewable energy and other sources	
Period	Consumption (kWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

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PRE-AUDITORY DEMO 3 FLISOM

Solar radiation resource

Option A [Carport, -61º (SEE), 8º] Average daily GlobInc Irradiation		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	29,7	-0,1
Feb	46,5	0,4
Mar	86,1	4,7
Apr	114,4	8,1
May	144,8	12,5
Jun	154,2	15,4
Jul	167,7	18,5
Aug	144,5	17,5
Sep	101,7	14,4
Oct	62,9	10,1
Nov	33,2	4,1
Dec	23,8	1,9
Year	**1109,5**	**9,0**

Option B [Carport, +119° (WNW), 8°] Average daily GlobInc Irradiation		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	25,8	-0,1
Feb	42,2	0,4
Mar	79,6	4,7
Apr	110,1	8,1
May	139,7	12,5
Jun	151,2	15,4
Jul	163,4	18,5
Aug	136,6	17,5
Sep	94,9	14,4
Oct	58,6	10,1
Nov	31,7	4,1
Dec	21,0	1,9
Year	**1054,8**	**9,0**

Option C [SEE & WNW carports , 8°] Average daily GlobInc Irradiation		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	Several values	-0,1
Feb	Several values	0,4
Mar	Several values	4,7
Apr	Several values	8,1
May	Several values	12,5
Jun	Several values	15,4
Jul	Several values	18,5
Aug	Several values	17,5
Sep	Several values	14,4
Oct	Several values	10,1
Nov	Several values	4,1
Dec	Several values	1,9
Year	**Several values**	**9,0**

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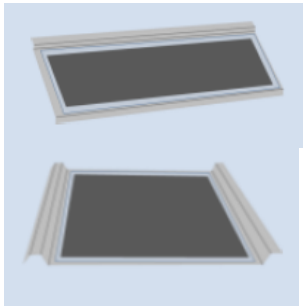
PRE-AUDITORY DEMO 3 FLISOM

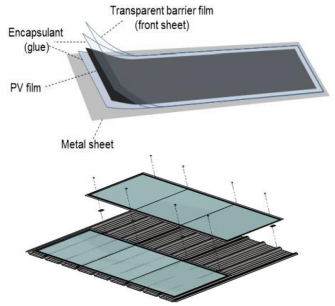
BIPV and storage possibilities

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 3.A	SEE carport	-61°	8°	250 m^2	Power	15 kWp
Option 3.B	WNW carport	+119°	8°	250 m^2	Area	150 m^2
Option 3.C	SEE & WNW carports	-61° & +119°	8°	500 m^2	Grid interface	AC coupled PV storage system



PV module (FLISOM)

CIGS roofing shingle on metal substrate (model X1): PV module with Flisom's CIGS monolithically interconnected cell technology, laminated onto a metal sheet and with supplied standard connectors.
Max length: 3.0 m.
Max width: 0.4 – 2.0 m.



Mounting system

CIGS modules on steel sheet, standing seam design, can be used for industrial buildings and urban furniture, as carports, where could be directly attached or substitute the roof or façade construction units.

Evaluation of existing BIPV and storage implementation possibilities

The nature of the demo-site significantly reduce the implementation possibilities of an integrated PV system, compared to building cases, because of only the cars canopy surface is available. In this regards, 3 possible areas could be occupied: SEE (option A), WNW (option B) faces, or both (option C). PV area required to meet the project's objectives are 150 m^2; this means that the demo-system should occupy less than half of the complete area (500 m^2). Although the better inclined face is SEE, from the energy point of view, the option is C is the preferential one based on constructive criteria, because the weight of the modules (although low) would be equally distributed between both faces and it would have a better visual impact from above. In the other hand, the BIPV CIGS on metal sheet units by FLISOM would partially replace the existing asbestos claddings. Implementing a BAPV system, covering off the existing claddings, would also be an feasible option, if preferred. It would be possible to include storage systems (batteries) housed in the base of the supporting posts, close to the existing electrical outlets for outdoor-lighting or charging electric cars.

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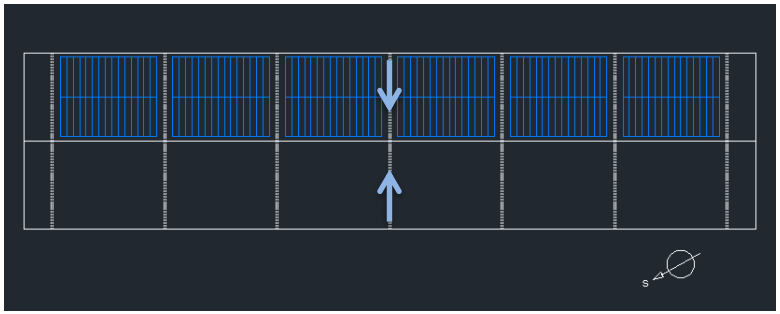
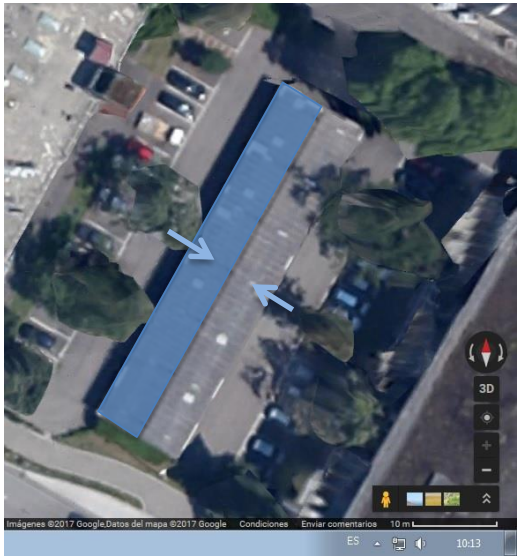
PRE-DIMENSIONING DEMO 3 FLISOM

Option 3.A		
SEE carport		
Location	SEE carport	
System power	15,6	kWp
Orient // Inclin	-61° // 8°	(º)
Occupied area	178,6	m^2
No. modules	2 x (6 x 15) = 180	ud
BIPV module characterization		
Module power	86,8	Wp
Module width	400	mm
Module length	2480	mm
Production estimation		
Specific production	968	kWh/kWp/year
Estimated production	15.129	kWh/year

Pre-dimensioned options





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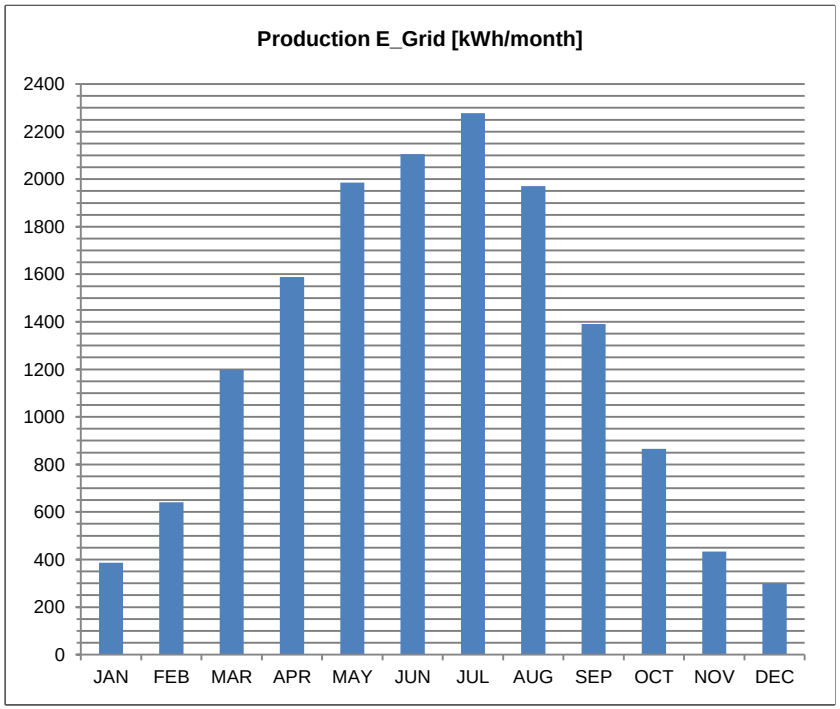
PRE-DIMENSIONING DEMO 3 FLISOM

Options assessment

Production estimation (data)

Option 3A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	29,7	-0,1	387
FEB	46,5	0,4	641
MAR	86,1	4,7	1198
APR	114,4	8,1	1588
MAY	144,8	12,5	1985
JUN	154,2	15,4	2106
JUL	167,7	18,5	2278
AUG	144,5	17,5	1970
SEP	101,7	14,4	1390
OCT	62,9	10,1	866
NOV	33,2	4,1	434
DEC	23,8	1,9	298
YEAR	**1109,5**	**9,0**	**15129**

Production estimation (graph)



Option 3.A	SEE carport	Rejected

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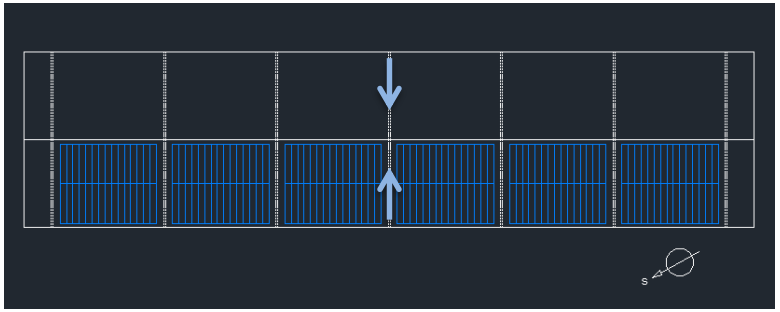
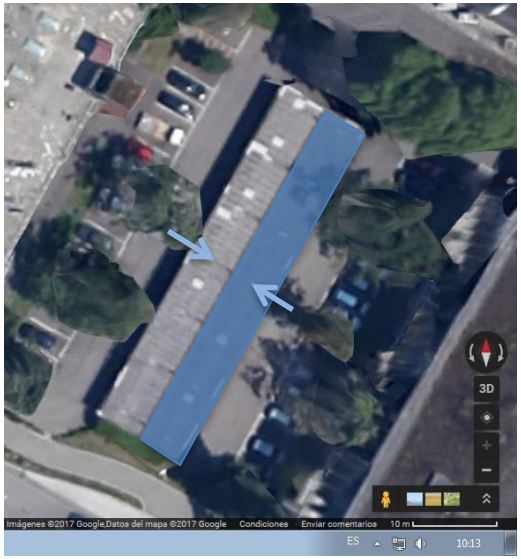
PRE-DIMENSIONING DEMO 3 FLISOM

Option 3.B		
WNW carport		
Location	WNW carport	
System power	15,6	kWp
Orient // Inclin	+119° // 8°	(º)
Occupied area	178,6	m^2
No. modules	2 x (6 x 15) = 180	ud
BIPV module characterization		
Module power	86,8	Wp
Module width	400	mm
Module length	2480	mm
Production estimation		
Specific production	917	kWh/kWp/year
Estimated production	14.331	kWh/year

Pre-dimensioned options





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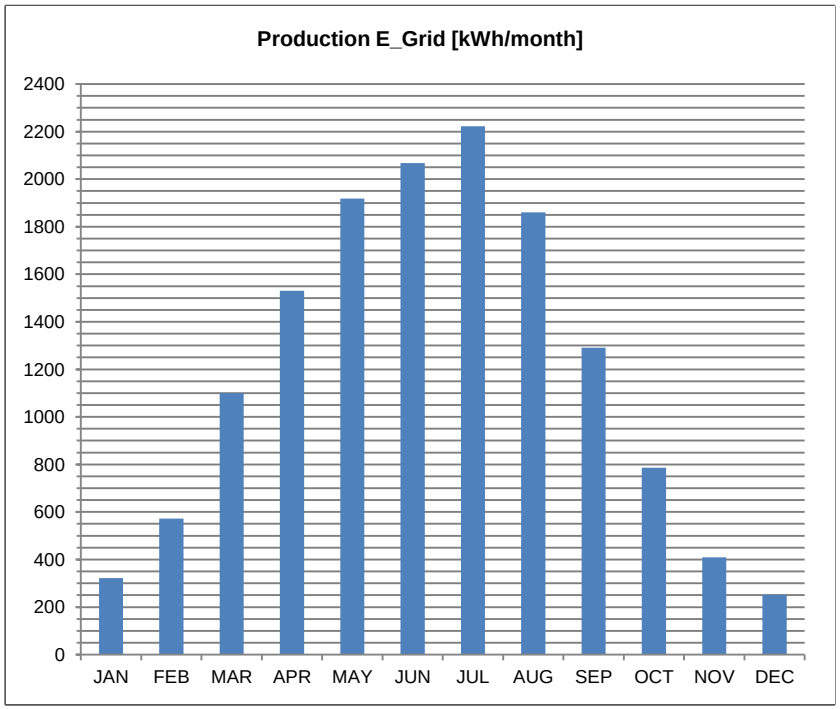
PRE-DIMENSIONING DEMO 3 FLISOM

Options assessment

Production estimation (data)

Option 3B	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	25,8	-0,1	322
FEB	42,2	0,4	572
MAR	79,6	4,7	1100
APR	110,1	8,1	1530
MAY	139,7	12,5	1918
JUN	151,2	15,4	2068
JUL	163,4	18,5	2222
AUG	136,6	17,5	1860
SEP	94,9	14,4	1291
OCT	58,6	10,1	786
NOV	31,7	4,1	409
DEC	21,0	1,9	252
YEAR	**1054,8**	**9,0**	**14331**

Production estimation (graph)



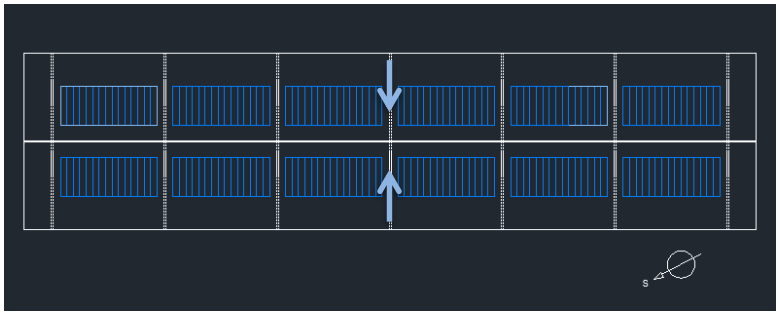
Option 3.B	WNW carport	Rejected

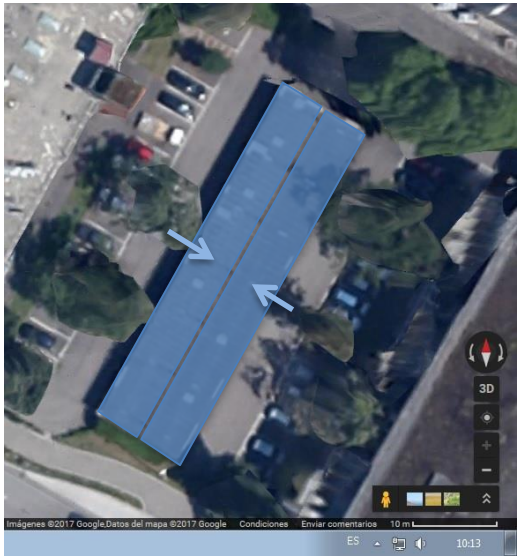
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 691768

PRE-DIMENSIONING DEMO 3 FLISOM

Option 3.C		
SEE & WNW carports		
Location	SEE & WNW carports	
System power	15,6	kWp
Orient // Inclin	-61° & +119° // 8°	(º)
Occupied area	178,6	m^2
No. modules	2 x (6 x 15) = 180	ud
BIPV module characterization		
Module power	86,8	Wp
Module width	400	mm
Module length	2480	mm
Production estimation		
Specific production	943	kWh/kWp/year
Estimated production	14.730	kWh/year

Pre-dimensioned options





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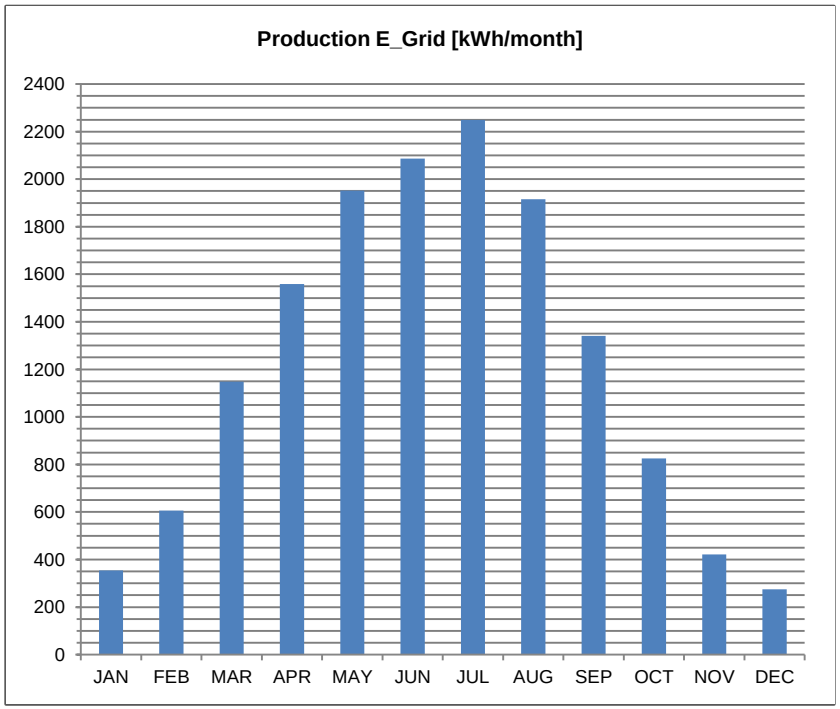
PRE-DIMENSIONING DEMO 3 FLISOM

Options assessment

Production estimation (data)

Option 3C	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	-	-0,1	355
FEB	-	0,4	606
MAR	-	4,7	1149
APR	-	8,1	1559
MAY	-	12,5	1952
JUN	-	15,4	2087
JUL	-	18,5	2250
AUG	-	17,5	1915
SEP	-	14,4	1340
OCT	-	10,1	826
NOV	-	4,1	422
DEC	-	1,9	275
YEAR	**-**	**9,0**	**14730**

Production estimation (graph)



Option 3.C	SEE & WNW carports	Proposed

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PRE-AUDITORY

DEMO 4 CRICURSA - Industrial building - Spain

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

PRE-AUDITORY DEMO 4 CRICURSA

Building location and description

Location	Granollers (Spain)	**Description**
Typology	Industrial building	Set of 4 industrial buildings, 1 office and some auxiliary services zones dedicated to the manufacturing of glass. One of the industrial buildings has recently been constructed.
Area	13.635 m^2 (built area)	
Floors	2	

Façades (offices)

The building office's façades are already covered by a glass curtain wall, thus they are not available for a BIPV integration.

Roofs (old factory buildings)

The old industrial buildings are covered by asbestos tiles. An effective BIPV implementation would be difficult.
Orientation: +2° (S).
Inclination: 6°.

Façades (factory)

The façades of the industrial buildings are made of metal sheet. A BIPV would be possible. Available orientations are: +2° (S), -88° (E) and +92° (W). Some elements might project shadows.

Roofs (new factory building)

The new industrial building (blue in the picture) is roofed by metal sheet. An effective BIPV implementation, in the south slope, would be possible. The available area is 529,7 m^2 .
Orientation: +2° (S).
Inclination: 6°.

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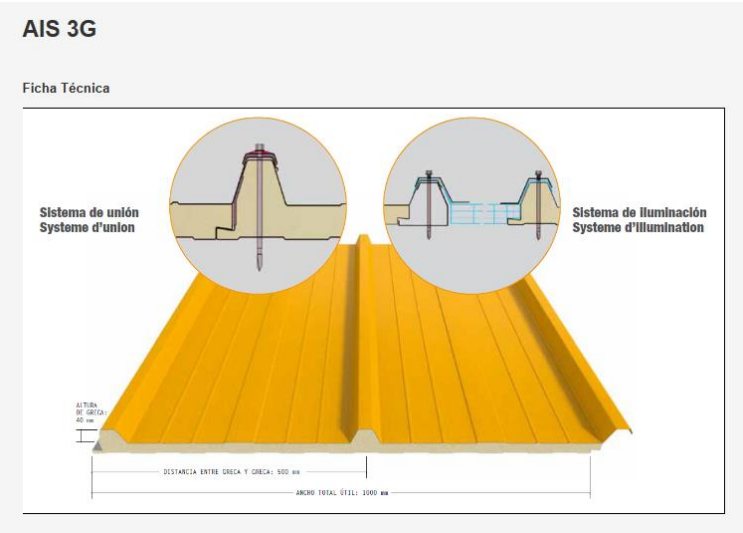
PRE-AUDITORY DEMO 4 CRICURSA

Building envelop characterization

	Description
Roofs	Asbestos cladding in the industrial buildings.
Walls	Metal sheet in the industrial buildings.
Closings	Curtain walls in the office buildings and skylights in the industrial building.

Roofs

The new building's roofs are made of polyurethane panel "AIS-3G of 500 mm", and the skylights of "Arcoplus 1000 Plano" with a U-value of 2,68W/m^{2}K.



Closings

There is no opening in the new building. In the factory building there are skylights and air extractors in the roof. There are 2 curtain walls in the office building: north curtain wall (U=2,70 W/m^{2}K), west curtain wall (U=2,70 W/m^{2}K).

Façades

The façades of the new building, in principal the best option for the BIPB implementation, are made of:

North façade: 25 mm Glass and sandwich panel "Etna Advance".
West façade: 25 mm Glass and sandwich panel "Etna Advance".
East façade: nothing, it is open to the factory.
South façade: sandwich panel "Panel Olimpia".

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PRE-AUDITORY DEMO 4 CRICURSA

Main energy consumption systems

Equipment	Description	Intended use	Energy source
Heating and cooling system	Heating and cooling system	Heating and cooling of the offices placed in the first floor.	electricity
Boiler 1	Small capacity gas-boiler Roca.	Ventilation units (AHU) of clean rooms. Heating and DHW for changing rooms.	Natural gas.
Boiler 2	Big capacity gas-boiler Roca CPA-BT (or BTH).	Heating of factory buildings, DHW and hot water for special machineries.	Natural gas.

Demand cover, set-points and use schedule data:

- The load intended to cover by the BIPV system, and according to NOBATEK and R2M, are the heating and cooling system as well as other electrical loads (computers, different plugs, and so on). These load represent the total consumption of this offices floor. Since, currently there is no energy consumption data in the offices, NOBATEK have installed meters to collect them.
- Related to the main energy consumption in the production building, there are hundred of machines in the factory with a huge amount of electrical and gas consumption. This loads will not be covered by the BIPV system, because the power production of the PV modules is not representative in comparison with the high consumption of these machines.
- Set-point of the offices temperature limited between 21ºC-26 ºC. In winter it used to manually set 24 or 25 ºC.
- Use schedule: Monday to Thursday from 07:00 to 19:00, Friday from 07:00 to 15:00.

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PRE-AUDITORY DEMO 4 CRICURSA

Energy consumption profiles

Electricity	
Period	Consumption (kWh/period)
Jan	290.921
Feb	305.102
Mar	311.513
Apr	352.757
May	311.960
Jun	355.565
Jul	352.632
Aug	351.674
Sep	319.426
Oct	323.960
Nov	365.411
Dec	360.113
Year	**4.001.034**

Natural gas	
Period	Consumption (kWh/period)
Jan	1.060
Feb	787
Mar	797
Apr	715
May	767
Jun	711
Jul	854
Aug	699
Sep	790
Oct	908
Nov	810
Dec	860
Year	**9.758**

Renewable energy and other sources	
Period	Consumption (kWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

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PRE-AUDITORY DEMO 4 CRICURSA

Solar radiation resource

Option A [Old roofs, +2° (S), 13°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	59,1	9,7
Feb	74,7	9,9
Mar	124,0	11,3
Apr	146,1	12,9
May	169,8	16,2
Jun	188,8	20,1
Jul	201,7	23,7
Aug	179,2	23,5
Sep	139,8	21,3
Oct	100,6	17,0
Nov	64,3	12,7
Dec	54,6	10,8
Year	**1502,8**	**15,8**

Option B [New roof, +2° (S), 13°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	59,1	9,7
Feb	74,7	9,9
Mar	124,0	11,3
Apr	146,1	12,9
May	169,8	16,2
Jun	188,8	20,1
Jul	201,7	23,7
Aug	179,2	23,5
Sep	139,8	21,3
Oct	100,6	17,0
Nov	64,3	12,7
Dec	54,6	10,8
Year	**1502,8**	**15,8**

Option C [Factory façades, +2° (S), 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	-	-
Feb	-	-
Mar	-	-
Apr	-	-
May	-	-
Jun	-	-
Jul	-	-
Aug	-	-
Sep	-	-
Oct	-	-
Nov	-	-
Dec	-	-
Year	**-**	**-**

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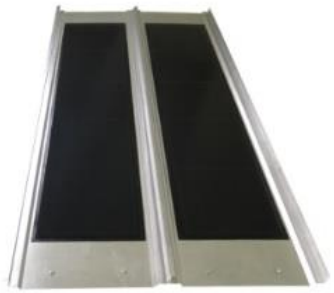
PRE-DIMESIONING DEMO 4 CRICURSA

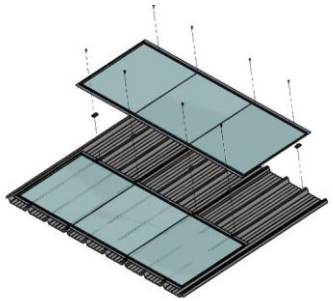
BIPV and storage possibilities

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 1.A	S sloped roof of the new building's north pavilion	+2°	6°	529,7 m^2	Power	20 kWp
Option 1.B	S sloped roof of the new building's south pavilion	+2°	6°	529,7 m^2	Area	200 m^2
Option 1.C	-	-	-	-	Grid interface	DC coupled PV storage system



PV module (FLISOM)

CIGS large area element for roofs and façades of industrial buildings (model X4), made with CIGS monolithically interconnected cell technology laminated onto a metallic back sheet.
Max length: 3.0 m.
Max width: 0.4 – 2.0 m.



Mounting system

The geometrical design of the metal substrate make easy the installation of modules in the roofs. They are very suitable for industrial building applications, where could be directly attached or substitute the roof or façade construction units.

Evaluation of existing BIPV and storage implementation possibilities

Both options proposed are similar from the energy point of view, based on the production estimation results showed below, because the configuration, orientation and inclination of the systems are the same. Nevertheless, the most advisable option is A (south pavilion); since, as it is accessible from the façade, it would be easier to install than option B, which it is located in the middle of the roof. Thus, option A is the chosen one.

Regarding the placement of the power and storage systems (inverters and batteries) there is jet not a final decision taken, although there are back yards next to the old and the new buildings, with available areas of 739 m^2 and 255 m^2, respectively, which could be used for this purpose.

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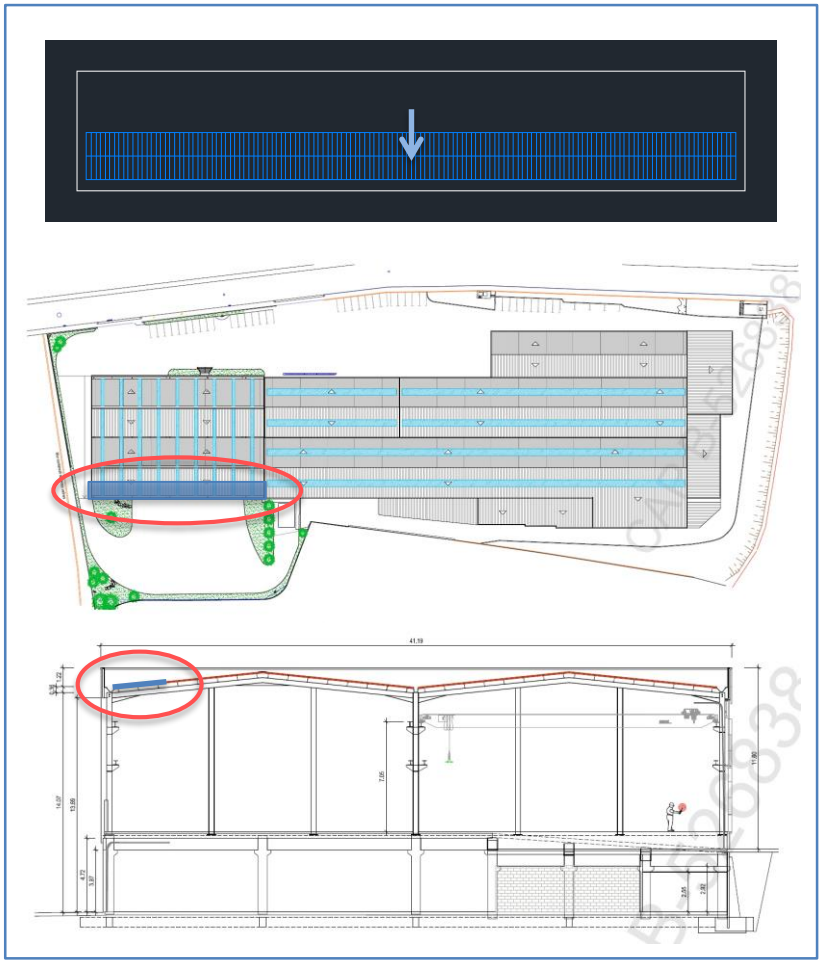
PRE-DIMESIONING DEMO 4 CRICURSA

Option 4.A		
S sloped roof of the new building's south pavilion		
Location	South sloped roof	
System power	19,2	kWp
Orient // Inclin	+2° // 6°	(º)
Occupied area	4,0 x 56,0 = 224	m^2
No. modules	2 x 140 = 280	ud
BIPV module characterization		
Module power	70,0	Wp
Module width	400	mm
Module length	2.000	mm
Production estimation		
Specific production	1.251	kWh/kWp/year
Estimated production	24.516	kWh/year

Pre-dimensioned options



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

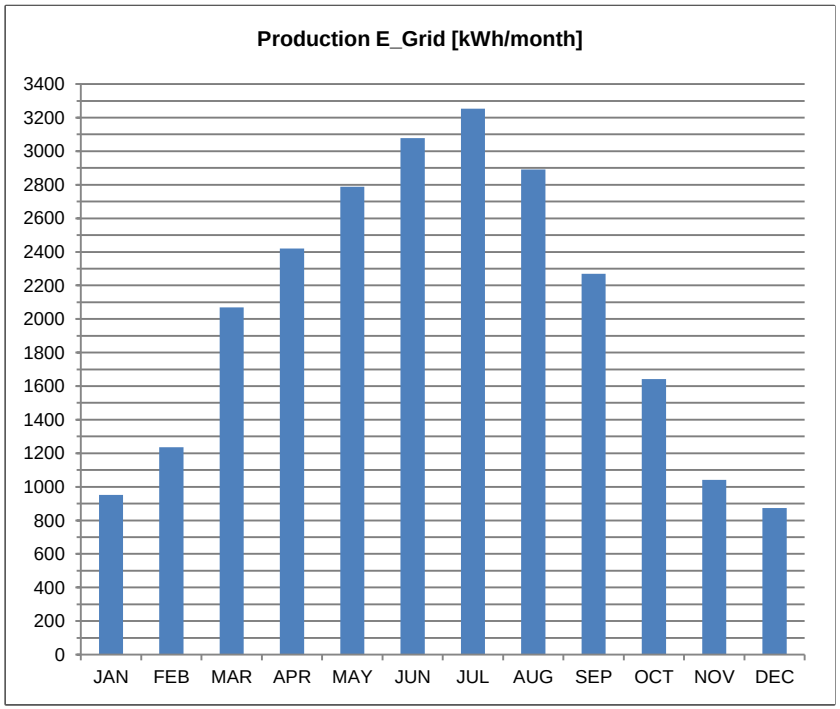
PRE-DIMESIONING DEMO 4 CRICURSA

Options assessment

Production estimation (data)

Option 4A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	59,1	9,7	952
FEB	74,7	9,9	1235
MAR	124,0	11,3	2069
APR	146,1	12,9	2420
MAY	169,8	16,2	2788
JUN	188,8	20,1	3078
JUL	201,7	23,7	3254
AUG	179,2	23,5	2892
SEP	139,8	21,3	2270
OCT	100,6	17,0	1643
NOV	64,3	12,7	1042
DEC	54,6	10,8	873
YEAR	**1502,8**	**15,8**	**24516**

Production estimation (graph)



Option 4.A	South sloped roof of the new building's north pavilion	Rejected

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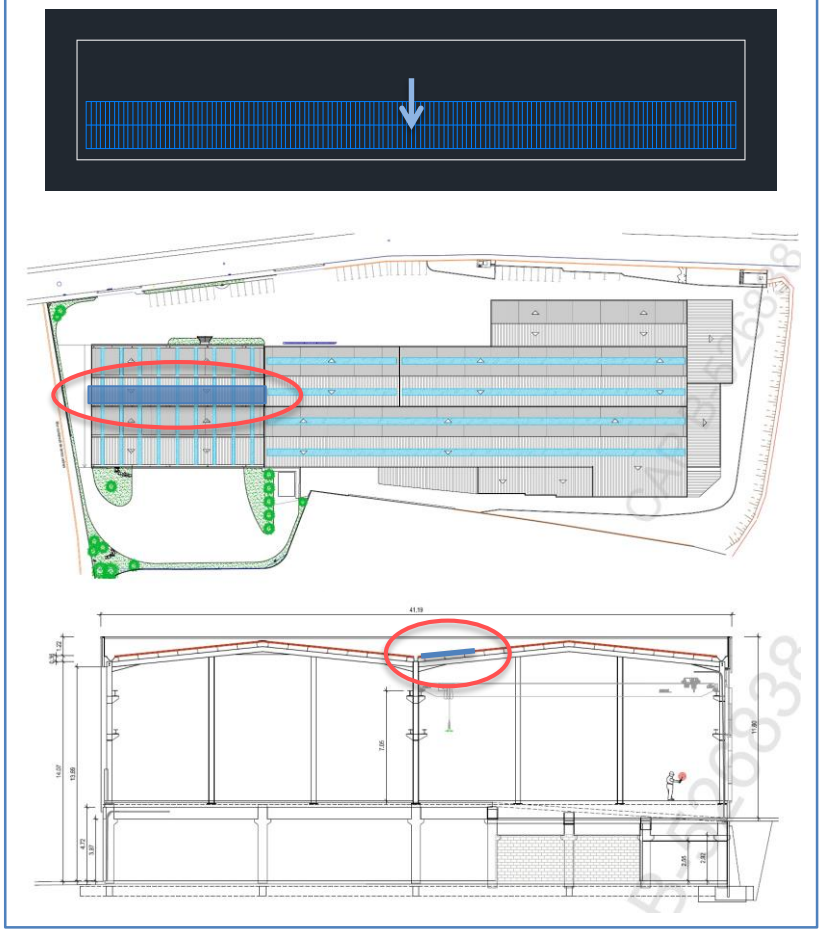
PRE-DIMESIONING DEMO 4 CRICURSA

Pre-dimensioned options

Option 4.B		
South sloped roof of the new building's north pavilion		
Location	South sloped roof	
System power	19,2	kWp
Orient // Inclin	+2° // 6°	(º)
Occupied area	4,0 x 56,0 = 224	m^2
No. modules	2 x 140 = 280	ud
BIPV module characterization		
Module power	70,0	Wp
Module width	400	mm
Module length	2.000	mm
Production estimation		
Specific production	1.251	kWh/kWp/year
Estimated production	24.516	kWh/year



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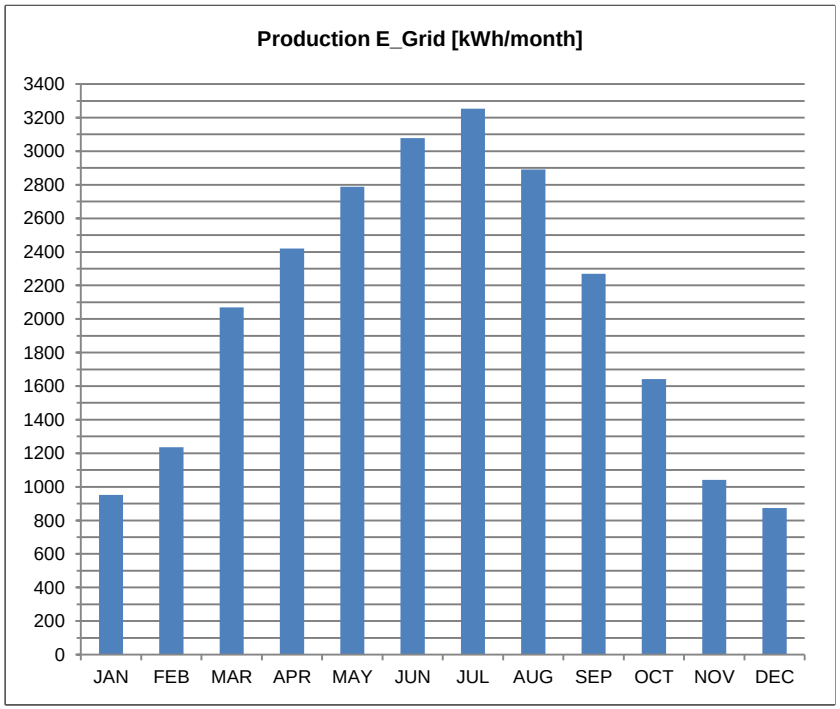
PRE-DIMESIONING DEMO 4 CRICURSA

Options assessment

Production estimation (data)

Option 4A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	59,1	9,7	952
FEB	74,7	9,9	1235
MAR	124,0	11,3	2069
APR	146,1	12,9	2420
MAY	169,8	16,2	2788
JUN	188,8	20,1	3078
JUL	201,7	23,7	3254
AUG	179,2	23,5	2892
SEP	139,8	21,3	2270
OCT	100,6	17,0	1643
NOV	64,3	12,7	1042
DEC	54,6	10,8	873
YEAR	**1502,8**	**15,8**	**24516**

Production estimation (graph)



Option 4.B	South sloped roof of the new building's south pavilion	Proposed

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PRE-AUDITORY

DEMO 5 VILOGIA - Storey block - France

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

PRE-AUDITORY DEMO 5 VILOGIA

Building location and description

Location	Wattignies (France).	**Description**
Typology	Residential storey building	Residential 8 storey building, constructed in 1975, with 48 social dwellings of different typologies. VILOGIA is the owner of the building and it undertake a retrofitting in 2018 or 2019, thus a BIPV system, such as a PV ventilated façade, could be included in the project.
Area	3639 m² (built area).	
Floors	8	

South façade

The double wall south façade is entirely covered with brick cladding and a vertical string of windows. An area of 140 m² is available for BIPV, from the first floor slab to the roof (to be verified while presenting legal permissions). The trees will be cut for retrofitting works; thus, no shadow will exist if the BIPV system is installed here.
Orientation: -16° (SSE).
Inclination: 90°.

West façade

The facades consist of a double wall formed by vertical stripes of brick masonry. Space is scarce for implementing BIPV.
Orientation: +74° (WSW).
Inclination: 90°.

East façade

On the building entrance the masonry is painted on floors levels and tiled at the ground floor level. Windows are located in vertical strings. Space is scarce for implementing BIPV.
Orientation: -106° (ENE).
Inclination: 90°.

Roof

Flat terrace made of reinforced concrete. Possible location of a BIPV roof system.
Inclination: 0°.

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PRE-AUDITORY DEMO 5 VILOGIA

Building envelop characterization

	Description
Roofs	Concrete slab. Absence of vapor barrier. 150mm insulation FOAM GLASS. Bituminous sealing, Heavy gravel protection.
Walls	The walls have three different compositions: 1. Plaster brick + polystyrene insulation 20mm + air blade + brick cladding (E&W); 2. Plaster brick + polystyrene insulation 20mm + air blade + painted coating (E&W); 3. concrete sail + air blade + brick cladding (N&S).
Closings	Originally openings were made of wood but some of them were replaced by PVC double glazing ones, they have different origins and have been installed in a various ways. All of them will be replaced during retrofitting works.

Roofs

Façades

Closings

Other elements

The improvements foreseen for the next retrofitting could include the following actions, in addition to the BIPV ventilated façade:

Shell and core:
- Insulating cellar and roof with fibrastyrene CF1h with existent insulation.
- Siding (15cm) on all the outside walls.
- New PVC windows with double glazing and low emissivity glass (4-16-4).
- Insulating landing door.

Common parts:
- Replacing the tower heater, insulation included.

Inside of dwellings:
- Installation of controlled, low pressure and humidity sensitive mechanical ventilation.
- Installation of heating with thermostatic head.

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PRE-AUDITORY DEMO 5 VILOGIA

Main energy consumption systems

Equipment	Description	Intended use	Energy source
Mechanical ventilation	-	Ventilation of kitchens.	Electricity.
District heating system	The district heating distribution system do not allow the separated measurement of the consumption.	Heating.	Indeterminate.

Foreseen demand covered by PV: only common spaces of the building will be covered with BIPV System (lightening and MV). Elevators will stay under common electrical installations to avoid risks.

Usage and occupation patterns of the building: because of the current legal situation in France , the more interesting scenario for this BIPV system is to use self-consumption and sell the surplus energy to the grid. The building Fauvette has 3 entrances (12-13-14 rue Laennec). There are 4 general electric meters: 3 for the elevator and 1 for common space (lighting). Common space consumption (only for lighting):
2016 (only 10months): 7573 kWh
2015 : 10 276kWh
2014 : 10 622 kWh
2013: 15 194 kWh
VMC= +/- 9000kWh/year (three phase)

Observations: the building is electrically supplied by the EDF grid through one electricity delivery point.

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PRE-AUDITORY DEMO 5 VILOGIA

Energy consumption profiles

Electricity	
Period	Consumption (MWh/period)
Jan	1,35
Feb	0,96
Mar	0,96
Apr	0,36
May	0,36
Jun	0,60
Jul	0,60
Aug	0,80
Sep	0,80
Oct	0,75
Nov	1,25
Dec	1,25
Year	**10,05**

Natural gas	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

District heating	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	**-**

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PRE-AUDITORY DEMO 5 VILOGIA

Solar radiation resource

Option A [Façade, -16° (SSE), 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	23,1	0,0
Feb	59,2	0,5
Mar	62,3	3,3
Apr	77,3	5,6
May	82,1	10,2
Jun	71,9	12,7
Jul	84,9	15,1
Aug	81,7	15,7
Sep	75,6	12,0
Oct	57,1	8,4
Nov	39,8	3,7
Dec	23,0	1,2
Year	**738,1**	**7,4**

Option B [Façade, -106° (ENE), 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	23,1	0,0
Feb	59,2	0,5
Mar	62,3	3,3
Apr	77,3	5,6
May	82,1	10,2
Jun	71,9	12,7
Jul	84,9	15,1
Aug	81,7	15,7
Sep	75,6	12,0
Oct	57,1	8,4
Nov	39,8	3,7
Dec	23,0	1,2
Year	**738,1**	**7,4**

Option C [Roof, 0°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	23,1	0,0
Feb	59,2	0,5
Mar	62,3	3,3
Apr	77,3	5,6
May	82,1	10,2
Jun	71,9	12,7
Jul	84,9	15,1
Aug	81,7	15,7
Sep	75,6	12,0
Oct	57,1	8,4
Nov	39,8	3,7
Dec	23,0	1,2
Year	**738,1**	**7,4**

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PRE-DIMESIONING DEMO 5 VILOGIA

BIPV and storage possibilities

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 5.A	SSE façade (east section)	-16°	90°	187 m²	Power	20kW
Option 5.B	SSE façade (west section)	-16°	90°	44 m²	Area	150 m²
Option 5.C	SSE façade (complete façade)	-16°	90°	231 m²	Grid interface	DC coupled PV storage system

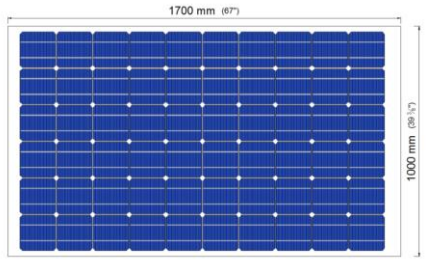
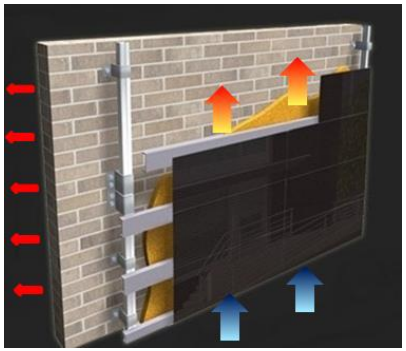


Figure 21: PV glass dimensions, X5 product

PV module (ONYX)

Fully opaque glass-glass BIPV unit with hidden bus bars for ventilated façades (model X5), using black conductive ribbons over the welded cells, different fully plastic sheets compatible with the lamination process to hide the L-interconnections and black frit patterned rear glazing.
Length: 1700 mm.
Width: 1000mm.
Thickness: 6+6 = 12 mm.



Mounting system

Integration by a conventional mounting system for ventilated façades, with mechanical anchorages, aluminium/steel profiles, shapes/staples/clips, adhesives, etc., according with the new standard "EN50583. Photovoltaics in buildings", considering the mounting system categories defined in EN 5058-2.

Evaluation of existing BIPV and storage implementation possibilities

Façade: from first floor slab to the roof, over the brick cladding area (to be checked according to law).
Storage, inverter and monitoring system: a separated, no accessible for tenants, space was constructed in the cellar to store the inverter and monitoring equipment.

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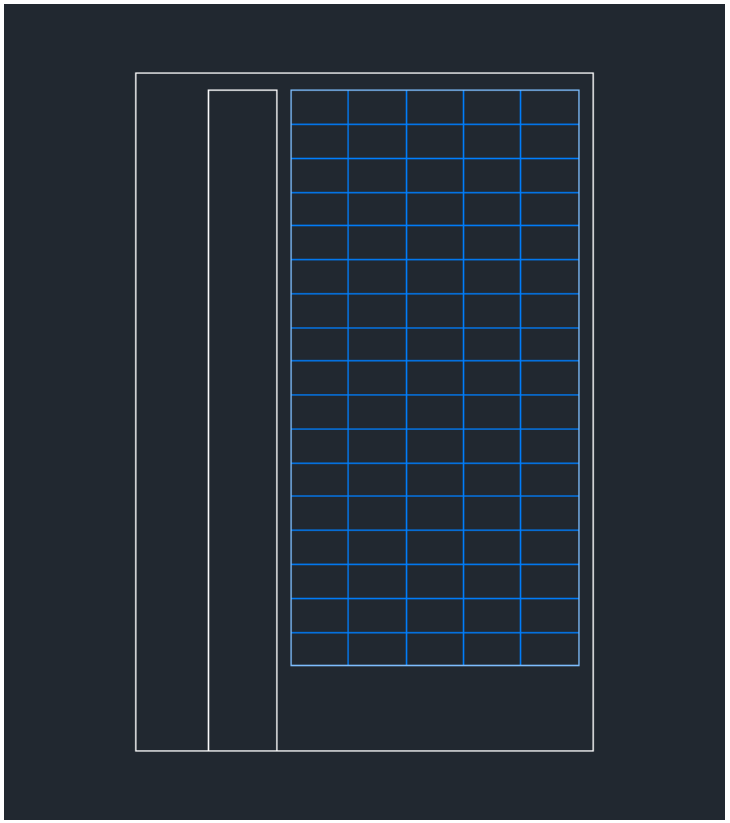
PRE-DIMESIONING DEMO 5 VILOGIA

Option 5.A		
SSE façade, from the first floor to the roof (east section)		
Location	SSE façade (east section)	
System power	22,2	kWp
Orient // Inclin	-16° // 90°	(º)
Occupied area	144,5	m^2
No. modules	5 x 17 = 85	ud
BIPV module characterization		
Module power	261,0	Wp
Module width	1000	mm
Module length	1700	mm
Production estimation		
Specific production	509	kWh/kWp/year
Estimated production	11.301	kWh/year

Pre-dimensioned options



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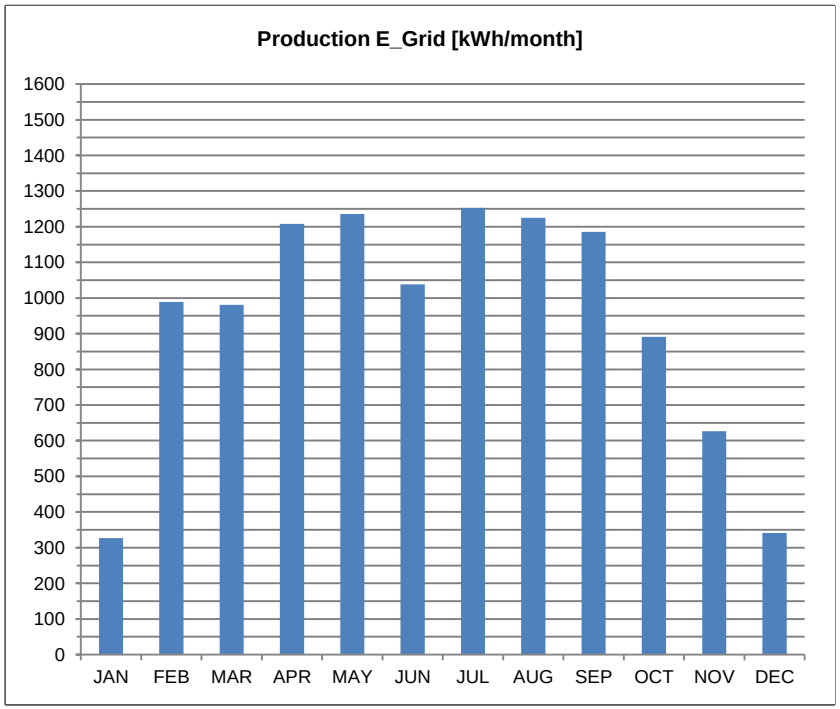
PRE-DIMESIONING DEMO 5 VILOGIA

Options assessment

Production estimation (data)

Option 5A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	23,1	0,0	327
FEB	59,2	0,5	989
MAR	62,3	3,3	981
APR	77,3	5,6	1208
MAY	82,1	10,2	1236
JUN	71,9	12,7	1038
JUL	84,9	15,1	1253
AUG	81,7	15,7	1225
SEP	75,6	12,0	1185
OCT	57,1	8,4	891
NOV	39,8	3,7	627
DEC	23,0	1,2	341
YEAR	**738,1**	**7,4**	**11301**

Production estimation (graph)



Option 5.A	SSE façade, from the first floor to the roof (east section)	Rejected

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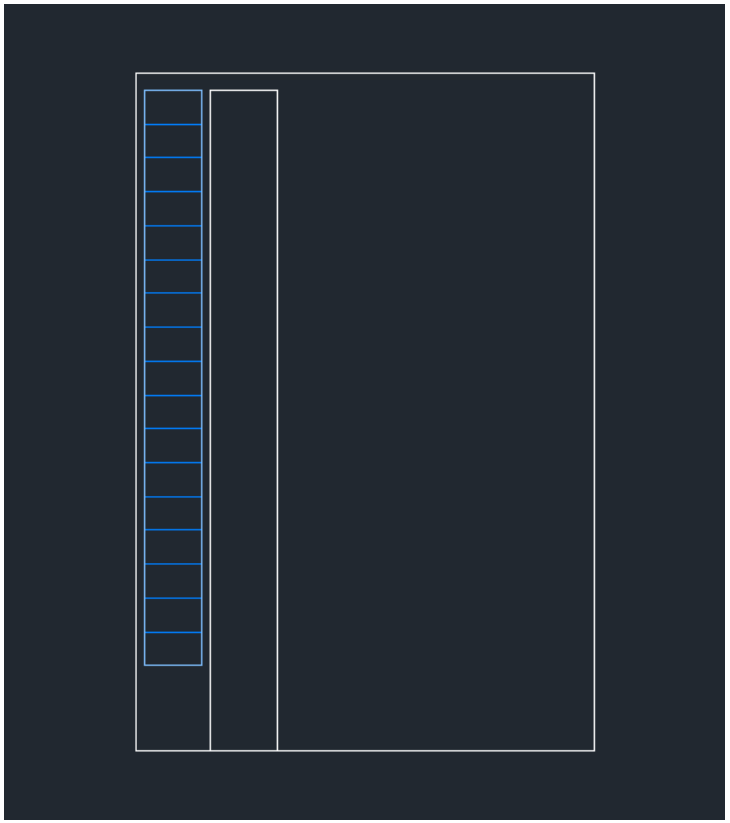
PRE-DIMESIONING DEMO 5 VILOGIA

Option 5.B		
SSE façade, from the first floor to the roof (west section)		
Location	SSE façade (west section)	
System power	4,4	kWp
Orient // Inclin	-16° // 90°	(º)
Occupied area	28,9	m^2
No. modules	1 x 17 = 17	ud
BIPV module characterization		
Module power	261,0	Wp
Module width	1000	mm
Module length	1700	mm
Production estimation		
Specific production	509	kWh/kWp/year
Estimated production	2.260	kWh/year

Pre-dimensioned options



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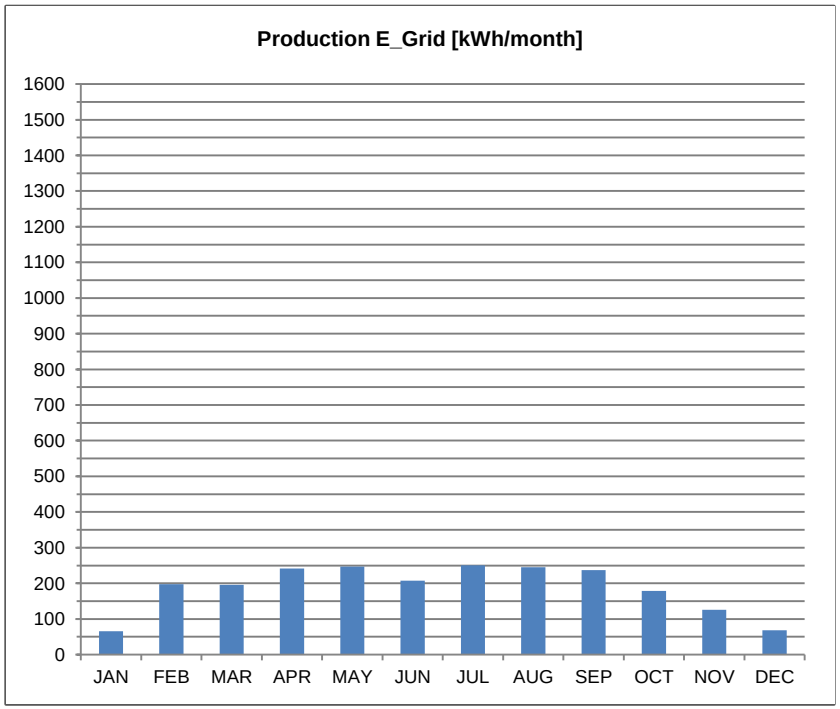
PRE-DIMESIONING DEMO 5 VILOGIA

Options assessment

Production estimation (data)

Option 5B	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	23,1	0,0	65
FEB	59,2	0,5	198
MAR	62,3	3,3	196
APR	77,3	5,6	242
MAY	82,1	10,2	247
JUN	71,9	12,7	208
JUL	84,9	15,1	251
AUG	81,7	15,7	245
SEP	75,6	12,0	237
OCT	57,1	8,4	178
NOV	39,8	3,7	125
DEC	23,0	1,2	68
YEAR	**738,1**	**7,4**	**2260**

Production estimation (graph)



Option 5.B	SSE façade, from the first floor to the roof (west section)	Rejected

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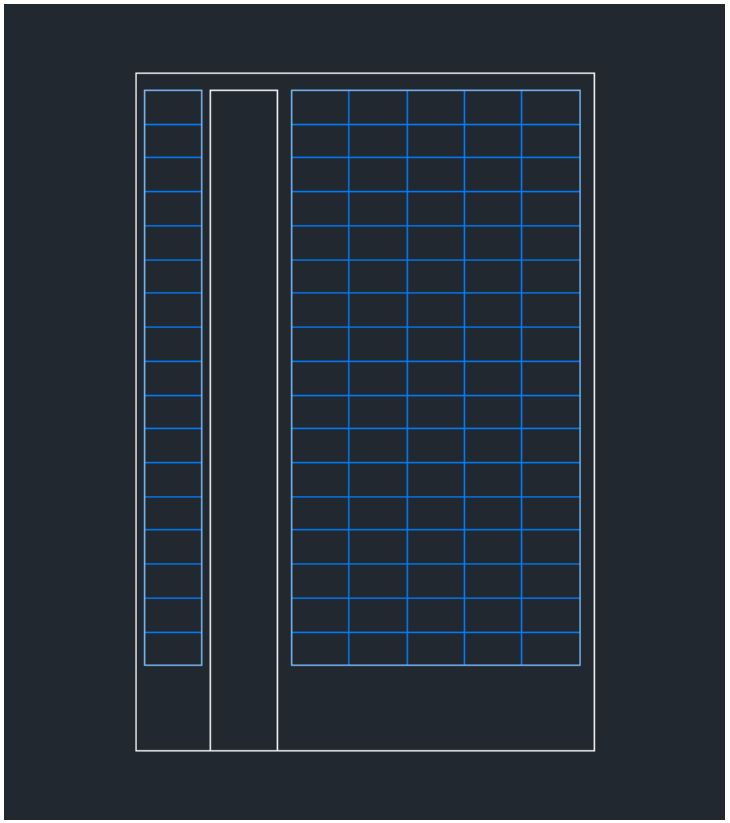
PRE-DIMESIONING DEMO 5 VILOGIA

Option 5.C		
SSE façade, from the first floor to the roof (complete façade)		
Location	SSE façade (complete façade)	
System power	26,6	kWp
Orient // Inclin	-16° // 90°	(º)
Occupied area	173,4	m^2
No. modules	(1 + 5) x 17 = 102	ud
BIPV module characterization		
Module power	261,0	Wp
Module width	1000	mm
Module length	1700	mm
Production estimation		
Specific production	509	kWh/kWp/year
Estimated production	13.561	kWh/year

Pre-dimensioned options



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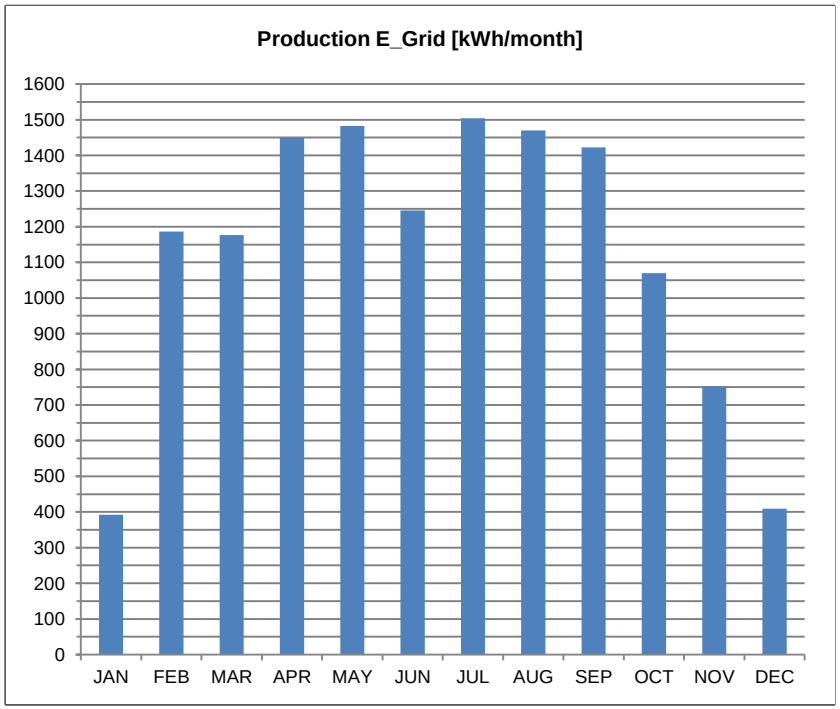
PRE-DIMESIONING DEMO 5 VILOGIA

Options assessment

Production estimation (data)

Option 4C	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	23,1	0,0	392
FEB	59,2	0,5	1186
MAR	62,3	3,3	1177
APR	77,3	5,6	1449
MAY	82,1	10,2	1483
JUN	71,9	12,7	1246
JUL	84,9	15,1	1504
AUG	81,7	15,7	1470
SEP	75,6	12,0	1422
OCT	57,1	8,4	1070
NOV	39,8	3,7	752
DEC	23,0	1,2	409
YEAR	**738,1**	**7,4**	**13561**

Production estimation (graph)



Option 5.C	SSE façade, from the first floor to the roof (complete façade)	Proposed

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PRE-AUDITORY

DEMO 6 TECNALIA - Office building - Spain

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

PRE-AUDITORY DEMO 6 TECNALIA

Building location and description

Location	San Sebastian (Spain)	**Description**
Typology	Office building	TECNALIA office building with laboratories. The most suitable zone for BIPV are the offices zone located in the 2nd and 3rd floors.
Area	-	
Floors	4	

SE façade

Polygonal section façade with a glass closing and a room separated from the offices by an intermediate glass wall. Aprox. dimensions of windows: 75x220 cm, available for BIPV.
Orientation: -31°(…) -36º (SSE)
Inclination: 90°
Area: 79 m^2

S façade

Polygonal section façade with a glass closing. Dimensions of windows: aprox. 75x220cm, available for BIPV.
Orientation: -1° (…) +4° (S)
Inclination: 90°
Area: 79 m^2

SW façade

Polygonal section façade with a glass closing. Dimensions of windows: aprox. 75x220cm, available for BIPV.
Orientation: +32 (…) +37° (SW)
Inclination: 90°
Area: 79 m^2

WSW façade

Flat façade compound by two different parts: left section of ceramic brick and right section of metal sheet; both with windows and glass closings irregularly distributed. Clearly not suitable for BIPV due to the lack of homogeneity and the unfavorable orientation.

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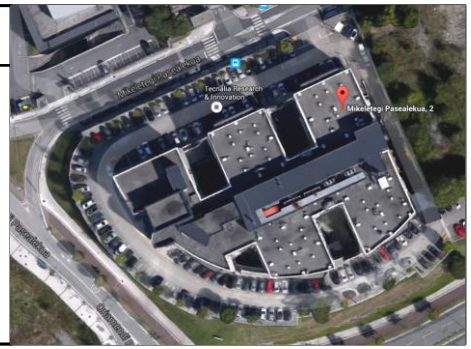
PRE-AUDITORY DEMO 6 TECNALIA

Building envelop characterization

	Description
Roofs	Asphalt fabric.
Walls	Ceramic brick and metal sheet.
Closings	Double-glazing curtain walls.

Roofs

Roofs of asphalt fabric.



Façades

Frame width 35 mm.
U value frame 3 W/m^{2}K.

Closings

Glazing, 4/10/4, U value 2.935 W/m^{2}K.
Dimensions glazing 2150 x 600 mm.

Other elements

-

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PRE-AUDITORY DEMO 6 TECNALIA

Main energy consumption systems

Equipment	Description	Intended use	Energy source
2 gas boilers	-	Building heating and DHW	Natural gas
2 gas chillers	-	Building cooling	Natural gas
2 electrical chillers	-	Building cooling	Electricity
Cold water distribution network.	-	Contribution to cooling air conditioning system and some machines located in the ground floor.	Cold water

Observations: It should be highlighted that the lighting system is turned on all day long (from 8:00 until 17:00). The electricity consumption for lighting and plugs represent only 30% of the whole electricity consumptions. The machines have the most important share of electricity consumptions.

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PRE-AUDITORY DEMO 6 TECNALIA

Energy consumption profiles

Electricity	
Period	Consumption (MWh/period)
Jan	175
Feb	185
Mar	200
Apr	200
May	210
Jun	210
Jul	220
Aug	190
Sep	220
Oct	210
Nov	200
Dec	185
Year	**2.400**

Natural gas	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	-

Renewable energy and other sources	
Period	Consumption (MWh/period)
Jan	-
Feb	-
Mar	-
Apr	-
May	-
Jun	-
Jul	-
Aug	-
Sep	-
Oct	-
Nov	-
Dec	-
Year	-

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PRE-AUDITORY DEMO 6 TECNALIA

Solar radiation resource

Option A [SSE Façade, 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	Several values	9,7
Feb	Several values	10,3
Mar	Several values	10,8
Apr	Several values	11,9
May	Several values	14,3
Jun	Several values	17,0
Jul	Several values	19,3
Aug	Several values	19,6
Sep	Several values	18,6
Oct	Several values	16,1
Nov	Several values	12,5
Dec	Several values	10,5
Year	**Several values**	**14,2**

Option B [S Façade, 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	Several values	9,7
Feb	Several values	10,3
Mar	Several values	10,8
Apr	Several values	11,9
May	Several values	14,3
Jun	Several values	17,0
Jul	Several values	19,3
Aug	Several values	19,6
Sep	Several values	18,6
Oct	Several values	16,1
Nov	Several values	12,5
Dec	Several values	10,5
Year	**Several values**	**14,2**

Option B [SW Façade, 90°] Average daily GlobInc Irradiation and temp.		
Month/ Year	GlobInc [kWh/m2]	T Amb [°C]
Jan	Several values	9,7
Feb	Several values	10,3
Mar	Several values	10,8
Apr	Several values	11,9
May	Several values	14,3
Jun	Several values	17,0
Jul	Several values	19,3
Aug	Several values	19,6
Sep	Several values	18,6
Oct	Several values	16,1
Nov	Several values	12,5
Dec	Several values	10,5
Year	**Several values**	**14,2**

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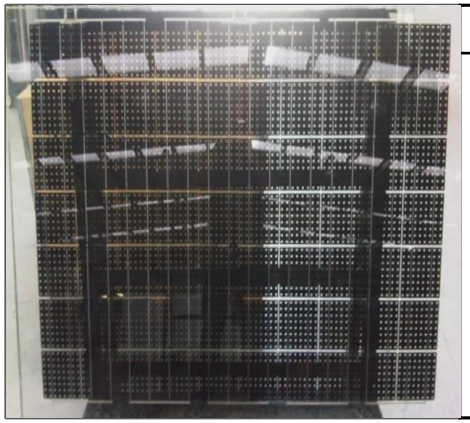
PRE-DIMESIONING DEMO 6 TECNALIA

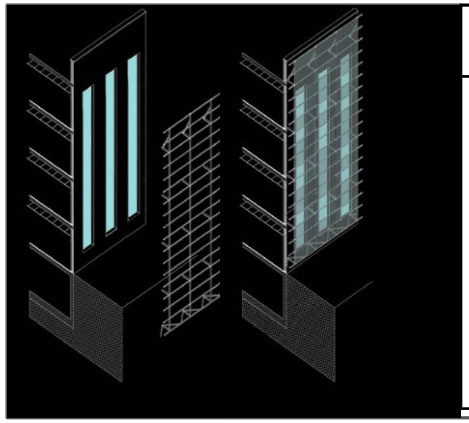
BIPV and storage options

	PV field				Power, area, grid interface and storage foreseen	
	Location	Orient	Tilt	Availab A		
Option 6.A	SSE polygonal façade	-31°(…) -36º (SSE)	90°	85,5 m^2	Power	20 Wp
Option 6.B	S polygonal façade	-1° (…) +4° (S)	90°	85,5 m^2	Area	150 m^2
Option 6.C	SW polygonal façade	+32 (…) +37° (SW)	90°	85,5 m^2	Grid interface	AC coupled PV storage system
Option 6.D	SSE & S polygonal façades	(SSE & S)	90°	170,1 m^2		



PV module (ONYX)

Ventilated façade unit with glass-glass back contact c-Si cells (model X6), which avoid visible front bus-bars offering efficiencies higher than 22%. The cell density make possible to obtain certain solar light transmission degree, as it is required for a curtain wall.
Length: 1700 mm.
Width: 1000mm.
Thickness:13.80 mm.



Mounting system

Metal supporting structure for ventilated façades, superposed on the existing curtain wall.

Evaluation of existing BIPV and storage implementation possibilities

Possible location of the storage system in the building:

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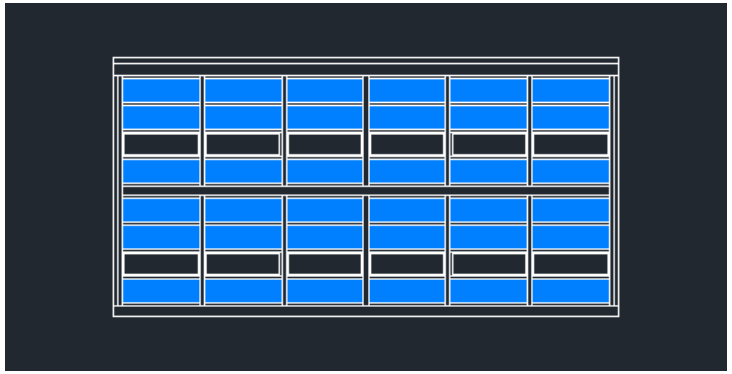
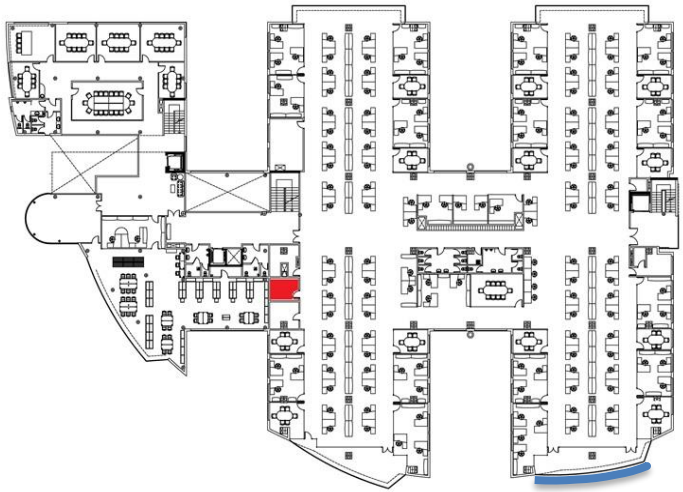
PRE-DIMESIONING DEMO 6 TECNALIA

Option 6.A		
SE polygonal façade		
Location	SE façade, on the existing glass closing	
System power	7,4	kWp
Orient // Inclin	-31°, -32°, -33°, -34°, -35°, -36° (S) // 90°	(º)
Occupied area	51,8	m^2
No. modules	6 x 6 = 36	ud
BIPV module characterization		
Module power	206,3	Wp
Module width	675	mm
Module length	2130	mm
Production estimation		
Specific production	652	kWh/kWp/year
Estimated production	4.845	kWh/year

Pre-dimensioned options





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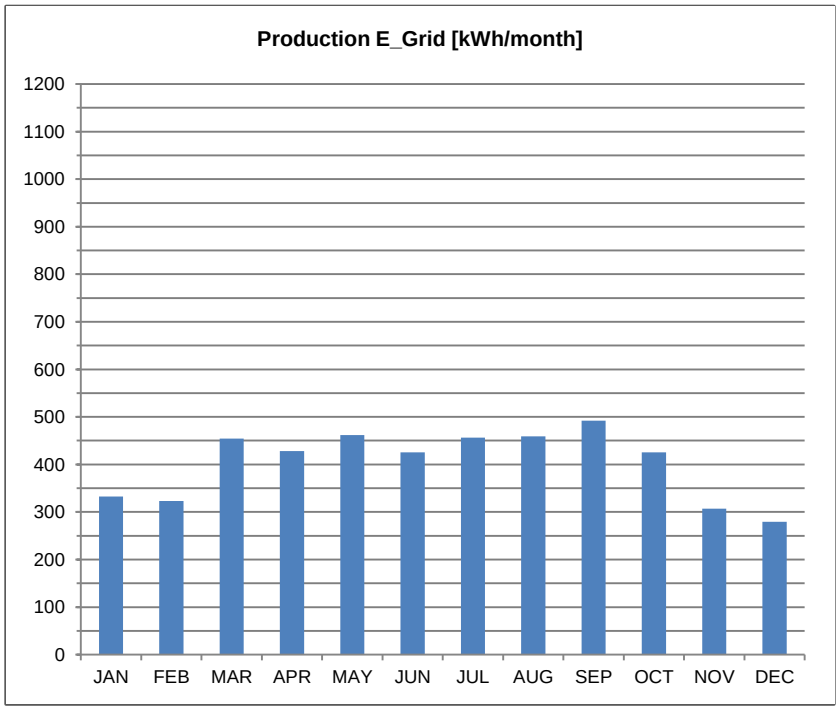
PRE-DIMESIONING DEMO 6 TECNALIA

Options assessment

Production estimation (data)

Option 6A	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	Several values	9,7	332
FEB	Several values	10,3	323
MAR	Several values	10,8	454
APR	Several values	11,9	428
MAY	Several values	14,3	462
JUN	Several values	17,0	425
JUL	Several values	19,3	456
AUG	Several values	19,6	459
SEP	Several values	18,6	492
OCT	Several values	16,1	426
NOV	Several values	12,5	307
DEC	Several values	10,5	279
YEAR	**Several values**	**14,2**	**4845**

Production estimation (graph)



Option 6.A	SE polygonal façade	Rejected

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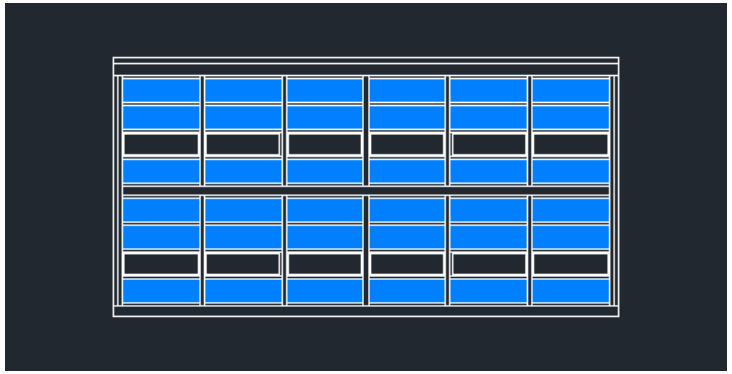
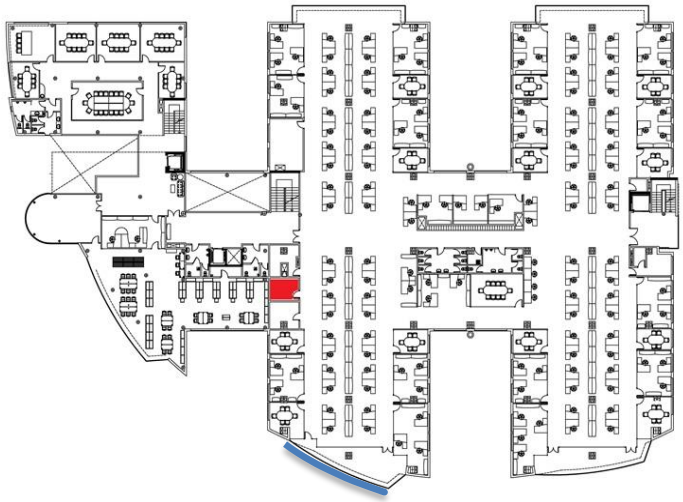
PRE-DIMESIONING DEMO 6 TECNALIA

Option 6.B		
S polygonal façade		
Location	S façade, on the existing glass closing	
System power	7,4	kWp
Orient // Inclin	-1°, 0°, +1°, +2°, +3°, +4° (S) // 90°	(º)
Occupied area	51,8	m^2
No. modules	6 x 6 = 36	ud
BIPV module characterization		
Module power	206,3	Wp
Module width	675	mm
Module length	2130	mm
Production estimation		
Specific production	657	kWh/kWp/year
Estimated production	4.883	kWh/year

Pre-dimensioned options





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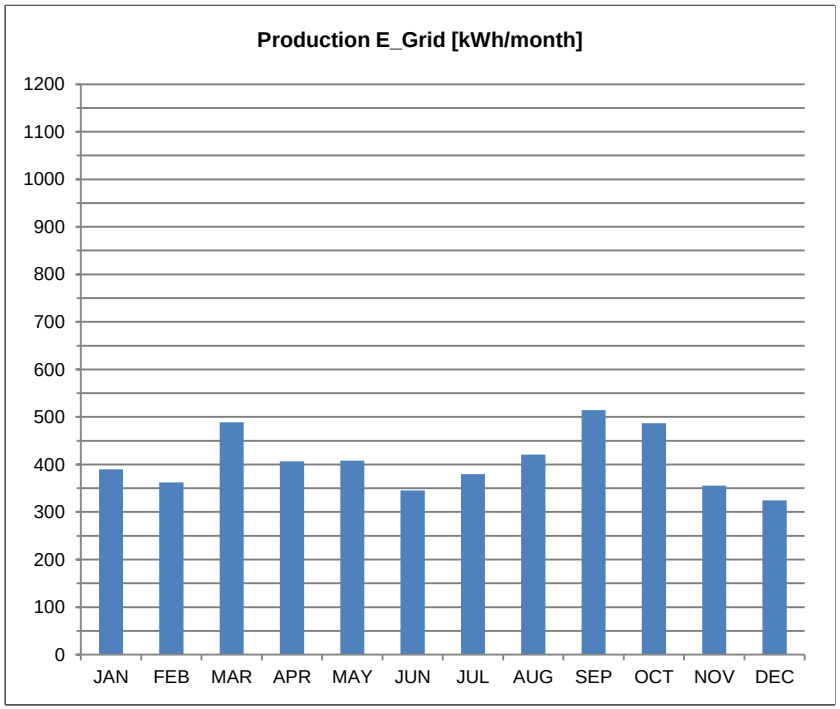
PRE-DIMESIONING DEMO 6 TECNALIA

Options assessment

Production estimation (data)

Option 6B	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	Several values	9,7	390
FEB	Several values	10,3	362
MAR	Several values	10,8	489
APR	Several values	11,9	407
MAY	Several values	14,3	408
JUN	Several values	17,0	346
JUL	Several values	19,3	380
AUG	Several values	19,6	421
SEP	Several values	18,6	514
OCT	Several values	16,1	486
NOV	Several values	12,5	356
DEC	Several values	10,5	325
YEAR	**Several values**	**14,2**	**4883**

Production estimation (graph)



Option 6.B	S polygonal façade	Rejected

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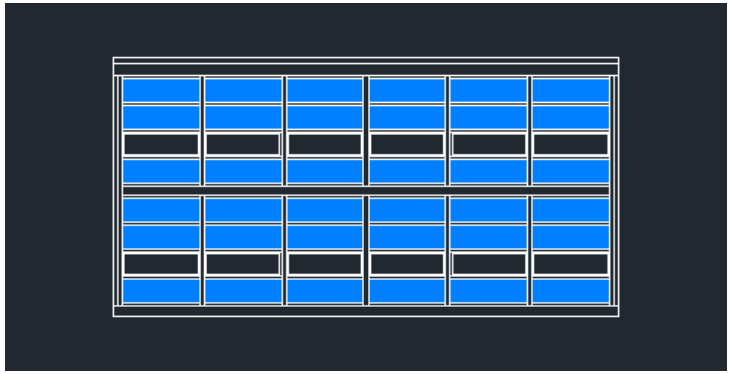
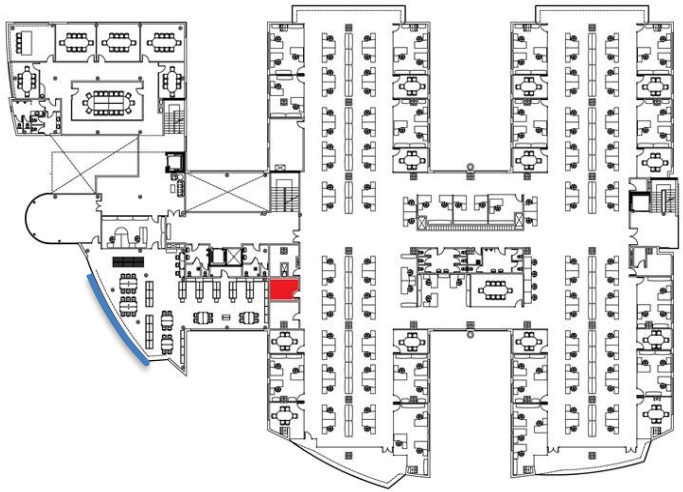
PRE-DIMESIONING DEMO 6 TECNALIA

Option 6.C		
SW polygonal façade		
Location	SW façade, on the existing glass closing	
System power	7,4	kWp
Orient // Inclin	+32°, +33°, +34°, +35°, +36°, +37° (S) // 90°	(º)
Occupied area	51,8	m^2
No. modules	6 x 6 = 36	ud
BIPV module characterization		
Module power	206,3	Wp
Module width	675	mm
Module length	2130	mm
Production estimation		
Specific production	641	kWh/kWp/year
Estimated production	4.760	kWh/year

Pre-dimensioned options





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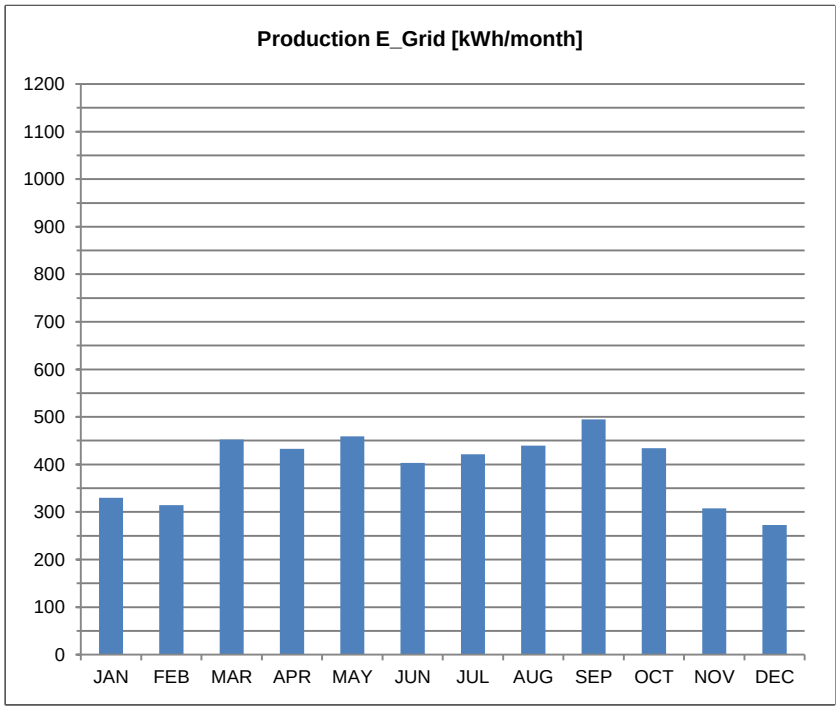
PRE-DIMESIONING DEMO 6 TECNALIA

Options assessment

Production estimation (data)

Option 6C	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	Several values	9,7	330
FEB	Several values	10,3	315
MAR	Several values	10,8	452
APR	Several values	11,9	433
MAY	Several values	14,3	459
JUN	Several values	17,0	403
JUL	Several values	19,3	421
AUG	Several values	19,6	439
SEP	Several values	18,6	494
OCT	Several values	16,1	434
NOV	Several values	12,5	307
DEC	Several values	10,5	273
YEAR	**Several values**	**14,2**	**4760**

Production estimation (graph)



Option 6.C	SW polygonal façade	Rejected

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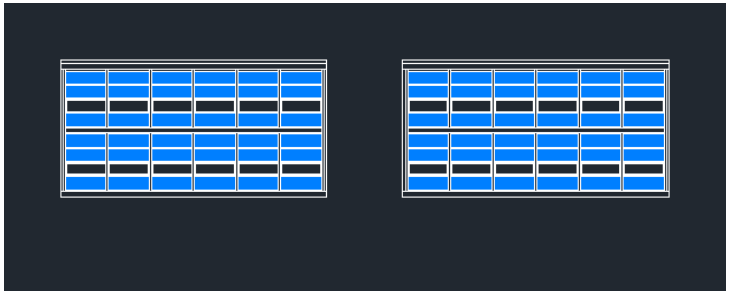
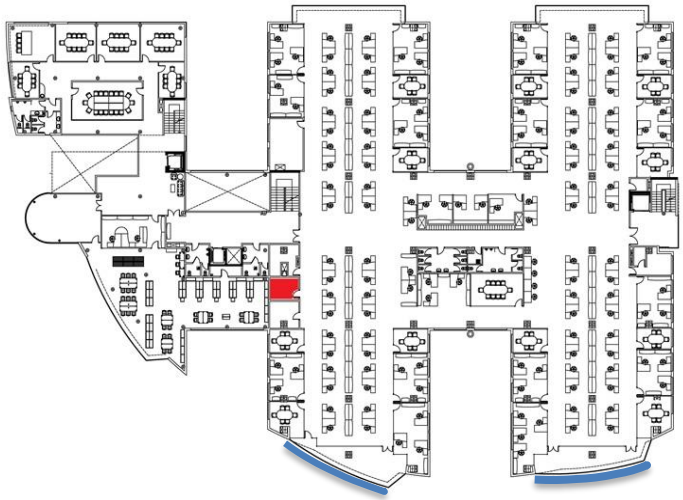
PRE-DIMESIONING DEMO 6 TECNALIA

Option 6.D		
SW polygonal façade		
Location	SW façade, on the existing glass closing	
System power	14,9	kWp
Orient // Inclin	+32°, +33°, +34°, +35°, +36°, +37° (S) // 90°	(º)
Occupied area	103,5	m^2
No. modules	12 x 6 = 72	ud
BIPV module characterization		
Module power	206,3	Wp
Module width	675	mm
Module length	2130	mm
Production estimation		
Specific production	655	kWh/kWp/year

Pre-dimensioned options





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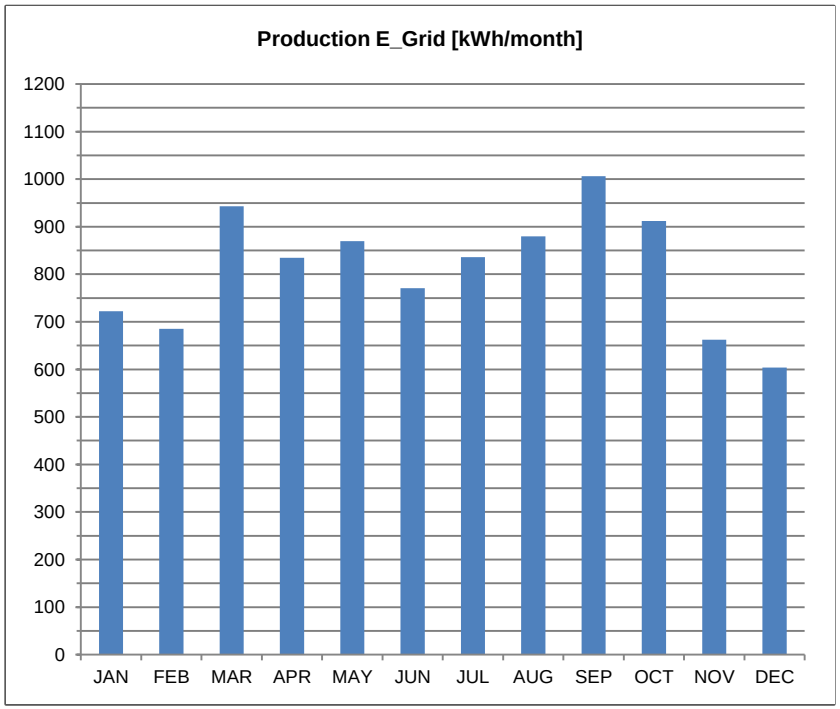
PRE-DIMESIONING DEMO 6 TECNALIA

Options assessment

Production estimation (data)

Option 6D	Production		
	GlobInc [kWh/m2]	T Amb [°C]	E_Grid [kWh]
JAN	Several values	9,7	722
FEB	Several values	10,3	685
MAR	Several values	10,8	943
APR	Several values	11,9	835
MAY	Several values	14,3	870
JUN	Several values	17,0	771
JUL	Several values	19,3	836
AUG	Several values	19,6	880
SEP	Several values	18,6	1007
OCT	Several values	16,1	912
NOV	Several values	12,5	663
DEC	Several values	10,5	604
YEAR	**Several values**	**14,2**	**9728**

Production estimation (graph)



Option 6.D	SW polygonal façade	Proposed