LC-SC3-RES-9-2020 – Next generation of thin-film PV technologies (IA)

BOOSTER

Boost Of Organic Solar Technology for European Radiance

Starting date of the project: 01/09/2020
Duration: 48 months

= Deliverable: D1.3 =

Definition of the demonstrators

Due date of deliverable: 28/02/2021
Actual submission date: 26/02/2021

Responsible WP: Melanie Bertrand, ASPF
Responsible TL: Claudio Pesenti, Eni Spa
Revision: Final

Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952911.

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DOCUMENT CONTROL

Document version	Date	Change
V0.1	14/02/2021	Initial version for review by the partners
V0.2	23/02/2021	Review by work package leader
V1.0	26/02/2021	Review by project manager and project coordinator

VALIDATION

Reviewers		Validation date
Work Package Leader	Melanie BERTRAND	23/02/2021
Project Manager	Michael Ten Donkelaar	25/02/2021
Coordinator	Damien HAU	26/02/2021

DOCUMENT DATA

Keywords	Technical specifications, OPV demonstrators
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Delivery date	26/02/2021

DISTRIBUTION LIST

Date	Issue	Recipients
14/02/2021	V0.1	Project partners
23/02/2021	V0.2	Work Package leader
26/02/2021	V1.0	EC project officer, BOOSTER website

DISCLAIMER

Executive summary

The aim of this document is to define the technical specifications of the two OPV demonstrators that will be developed in the BOOSTER project: (1) ready-to-stick and (2) textile-integrated installations. Both products will be manufactured in the successive project tasks based on the following specifications.
Booster products are conceived in order to fit BAPV market requirements and to improve power production technical parameters.

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1. Content of deliverable

The goal of task 1.4 “Product requirements and design of demonstrators” is to define the specifications of the two demonstrators that will be developed in the BOOSTER project. These specifications will help and guide the project partners during the whole phase of development. The two demonstrators that will be developed in the project are:

- Ready-to-stick BAPV (Building Applied PhotoVoltaics) OPV (Organic PhotoVoltaics) installation at ENI (ENI SPA) site
- OPV demonstrator on textile (flexible outdoor architecture) at FAU (FRIEDRICH-ALEXANDER-UNIVERSITAET ERLANGEN NUERNBERG) research building.

Those realisations permit to show real products with OPV technology and how they can be installed and used in real conditions.
These 2 demonstrators will underline OPV technology benefits:

- Easy installation (ready to stick) and lower installation costs compared to Silicon technology
- Mechanical flexibility
- Design

ENI, FAU and ASPF will define the description and the technical specifications of the two BOOSTER demonstrators: 100 m² of ready-to-stick devices, representing a 15kW installation for the targeted 15% PCE efficiency of devices, and 25m² of textile demonstrator, representing a 3.75kW installation for the targeted 15% PCE efficiency of devices. The task activities will result in a list of requirements on the size, the performances, the aesthetic and the connections for the two demonstrators.

2. Results and discussion

ENI, FAU and ASPF finalized the definition of the description and the technical specifications of the two BOOSTER demonstrators. In particular, ENI defined the location and the installation features of the ready-to-stick demonstrator, whereas FAU defined the location and the installation features of the textile demonstrator; ASPF supported both teams in order to characterize the products in terms of technical feasibility (sizing, integration and connections).

2.1. Ready-to-stick OPV demonstrator

2.1.1. Installation features

With the aim of targeting building integration, as first step it was essential to identify targets of the BAPV market for a correct building integration. ENI reviewed the main building components prone to BAPV installations and associated substrate materials. In particular, for each main building component, a review of the key architectural/construction elements available on the market was conducted and for each key architectural/construction element a review of the possible materials was conducted.

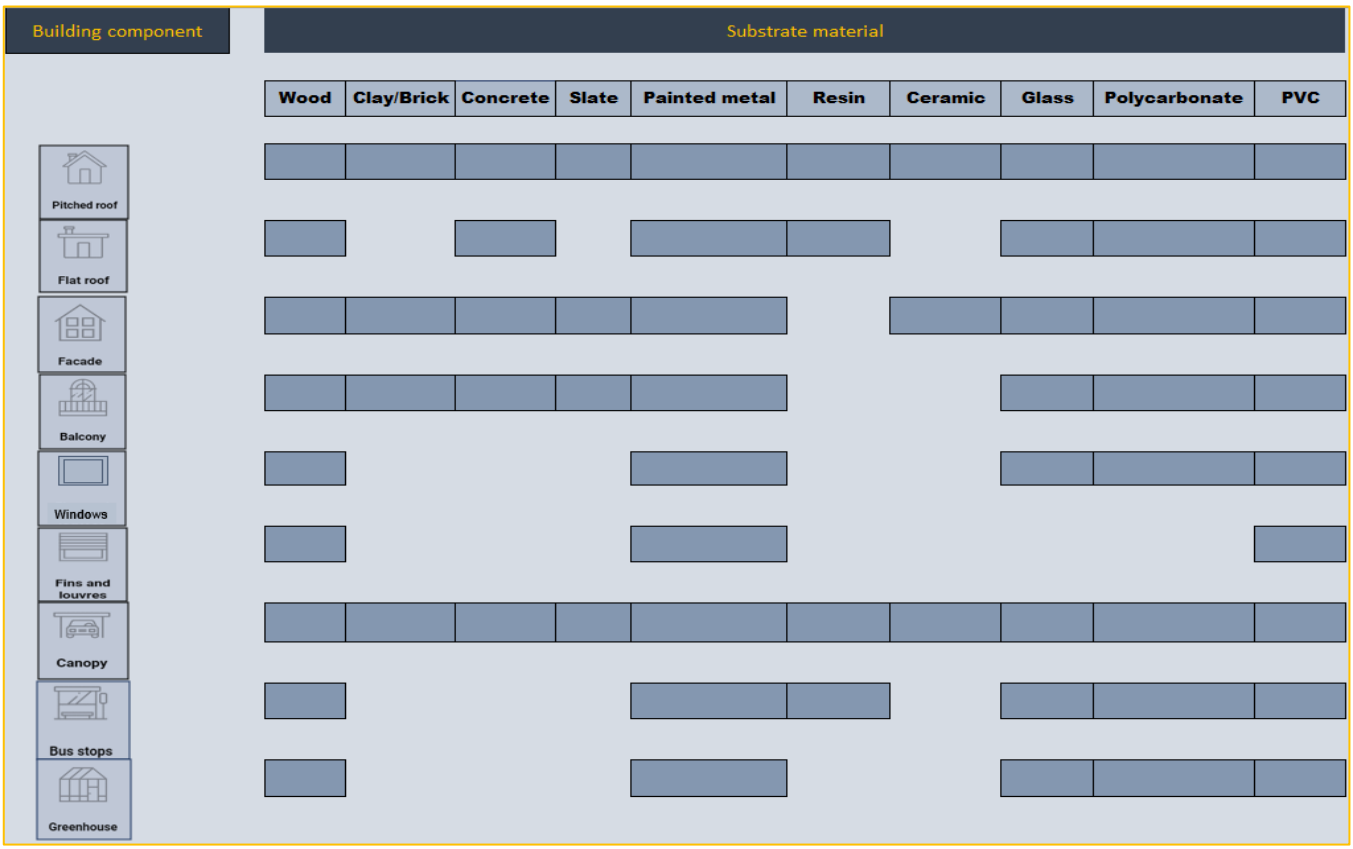


Figure 1 – Simplified version of a BAPV market matrix concerning components and materials.

The result of this research was a matrix reporting the BAPV market status, which simplified version was shared and commented with consortium partners (Fig. 1): the most used building components are roofs and canopies; the most used substrate material is painted galvanised metal (mainly aluminum and steel).
A canopy object of a total participation of restructure (Fig. 2) was identified at the Eni Renewable Energy and Environmental R&D Center in Novara (Italy). Current proposal is to rebuild this old structure replicating main features and size (azimuth south-south-east, inclination: ~10°, size: ~17*10 m, ground clearance: ~4 m) and intervening with modular panels made of pre-painted galvanised steel to create the flat top structure for the BAPV installation.

Figure 2 – Aerial view of the site with the old canopy to be rebuilt.

ENI identified specific pre-painted galvanised steel modules available on the market (called TTACK©) produced by Lattonedil Spa (Table 1): they are 104.6 cm wide and long as wished. The suggested modules are just an indication; in case these products won't be available, ENI will use similar modules with comparable size to build the canopy.
The desired final solution will be composed of roughly 16 steel modules 104.5 cm wide and 10 m long interconnected with each other, building a whole canopy surface of roughly 170 m^2.

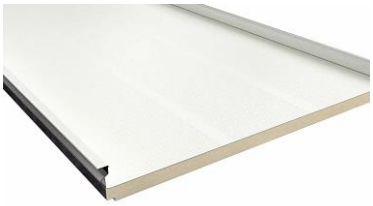
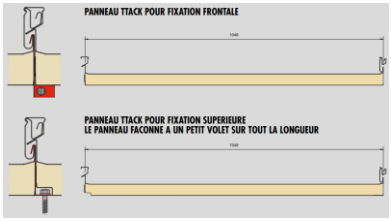
Structure	Material	Reference	Width of one steel pannel	Canopy Lenght	Canopy width	Inclination	Azimuth	Ground clearance
Canopy	Steel	TTACK (LATTONEDIL) 	1048mm 	10m	17m	10°	SSE	4m

Table 1 – Summary of the canopy modular realization with geometrical data.

2.1.2. Product features

Ready-to-stick OPV modules are meant explicitly for BAPV market thanks to:

- adhesion to several materials
- flexibility to adhere to curved surfaces
- lightness and low bulk volume.

Booster ready-to-stick modules will preserve architecture and aspect ratio of current OPV BAPV industrial products, which are compatible with both roll-to-roll production process and application to several building geometries.
A rectangular BOOSTER ready-to-stick product will be realized with the following main sizes (Fig. 3):

- module length: 3200 mm
- active length: 3000 mm
- module width: 372 mm
- active width: 279 mm.

Width tolerance will be +/- 1 mm per edge.

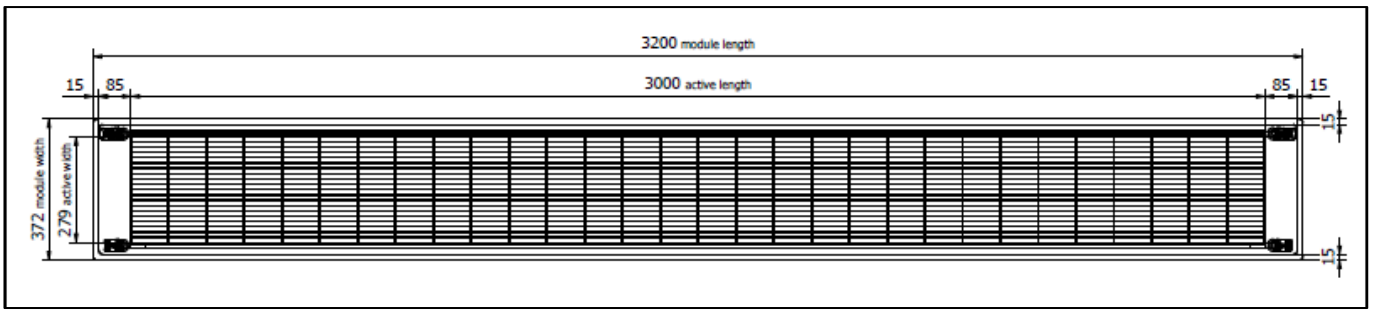


Figure 3 – Schematic top view of the characteristics and sizes of the BOOSTER ready to stick module.

Connections will be done with JB twin boxes from STAUBLI so with ASPF standard laser opening.
Product flexibility will be achieved thanks to a maximum declared bending radius of roughly 10 cm (larger bending radius if achievable). Shipment of the product should be prepared coherently, with the product kept flat or through rolling up the product with at least the declared bending radius specification.
Concerning surface requirements, the ready-to-stick module will need high surface energy since the THB film will be stoked on ETFE.
Temperature during the utilization of the demonstrator will be 85°C maximum.

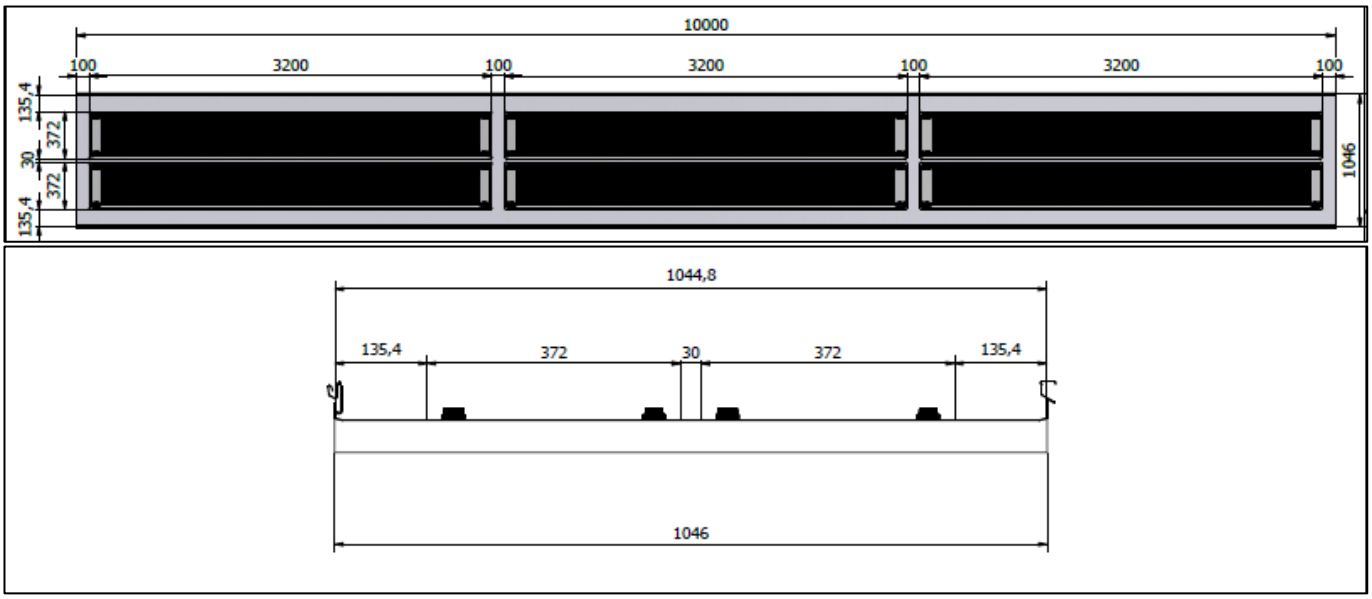


Figure 4 – Top – Schematic top view of one canopy steel module and six Booster ready to stick products attached to it with sizes. Bottom – Sketch of the above schematics viewed in section.

Application of ready-to-stick modules to the canopy will be conducted thanks to an adhesive backsheet: six products will be pasted to each canopy steel module (Fig. 4). A total amount of at least 84 Booster ready-to-stick modules will be installed at the Eni Renewable Energy and Environmental R&D Center in Novara (Italy) in order to reach the desired demonstrator surface of 100 m^2.
All modules should be installed on the canopy, with the exception of a 10-15% of modules that could be tested on different auxiliary structures with different materials and geometries (curved PVC shelter, flat vertical polycarbonate sheet, etc.) in case of need.
On the canopy, the ready-to-stick modules will be connected in series; strings will be connected in parallel to the inverter using MC-4 solar connections and 4 mm^2 solar cables.
The demonstrator will be integrated with monitoring devices, thus continuous real-time monitoring on site will be performed in environmental conditions: instantaneous power, energy produced by the system, I-V curve measurements to evaluate demonstrator performance and eventual anomalies.

2.1.3. Specifications summary

a. Dimensional specifications

Feature	Target	Tolerance	Comment
Active primary module length (mm)	3000	5	
Total primary module length (mm)	3200	5	
Active primary module width (mm)	279	1 per edge	
Total primary module width (mm)	372	1 per edge	
Number of cells for primary modules	20		
Number of primary modules	84	+10%	10% margin
Number of primary modules connected for one strip of modules	3 to 9		Depending on installation voltage limitation
Demonstrator surface (m^2)	>100		

b. Product integration specifications

Feature	Target	Tolerance	Comment
Frontsheet encapsulant	Fluoropolymer Film		
Frontsheet encapsulant transparency	>92% 400 – 800nm		
Frontsheet encapsulant UV cut	>380nm		
Frontsheet encapsulant dielectric strength	>200 kV/mm		
Backsheet encapsulant	Permanent adhesive		
Connectics	Staubli Twin box		

c. Performance specifications

Feature	Min	Max	Comment
1. Aesthetics			
Colour	No spec		
Reflexion	No spec		
Total thickness	<2mm	<1,5mm	
Total weight	<700g/m²	<500g/m²	
2. Performances			
PCE for primary modules		15%	
Max voltage for one strip	To be determined		
Installation power		15kW	
Bending radius	>10cm	/	
Lifetime		35 years	
Temperature stability	85°C max in use	120°C	Resistance to be tested: 85°C 1000h
3. Manipulation			
Storage and shipment	Flat	>10cm radius	

2.2. Textile OPV demonstrator

2.2.1. Installation features

At the FAU institute facilities in Erlangen (Germany) the façades belonging to the Lounge building (Fig. 5) were evaluated and chosen as the best option for the Booster textile installation.
Façades are one of the fundamental building components for the BAPV market since they provide a flat surface for the installation of photovoltaic products otherwise untapped for power generation. Moreover, glass is one of the most utilized materials for building integration or application of photovoltaic devices (Fig. 1).

Figure 5 – Left - Aerial view of the site. Right – Lounge facades dedicated to the textile demonstrator installation.

The chosen building surfaces are glass façades with an aluminium load-bearing structure extended on two floors (ground floor and first floor) and have north-east and south-east azimuth orientation.
South-east ground floor façade and first floor façade are 19 m^2 extended each (total south-east façade is 38 m^2), whereas north-east ground floor façade and first floor façade are 11 m^2 extended each (total north-east façade is 22 m^2). Thus, the total surface preliminarily available for textile demonstrator installation is 60 m^2.
A student contest was launched at the Technical University of Nürnberg in cooperation with FAU in 2018 in order to gather possible creative solutions concerning the aesthetics and general technical aspects of the Booster textile demonstrator. The competition winner conceived an installation with several rectangular textile products next to each other: they reveal high aspect ratio and should be fixed with differential spacing from the façade to facilitate the light filtering inside the building (Fig. 6).
This concept was the start point for the definition of the technical specifications of the Booster textile demonstrator to be installed at FAU facilities.

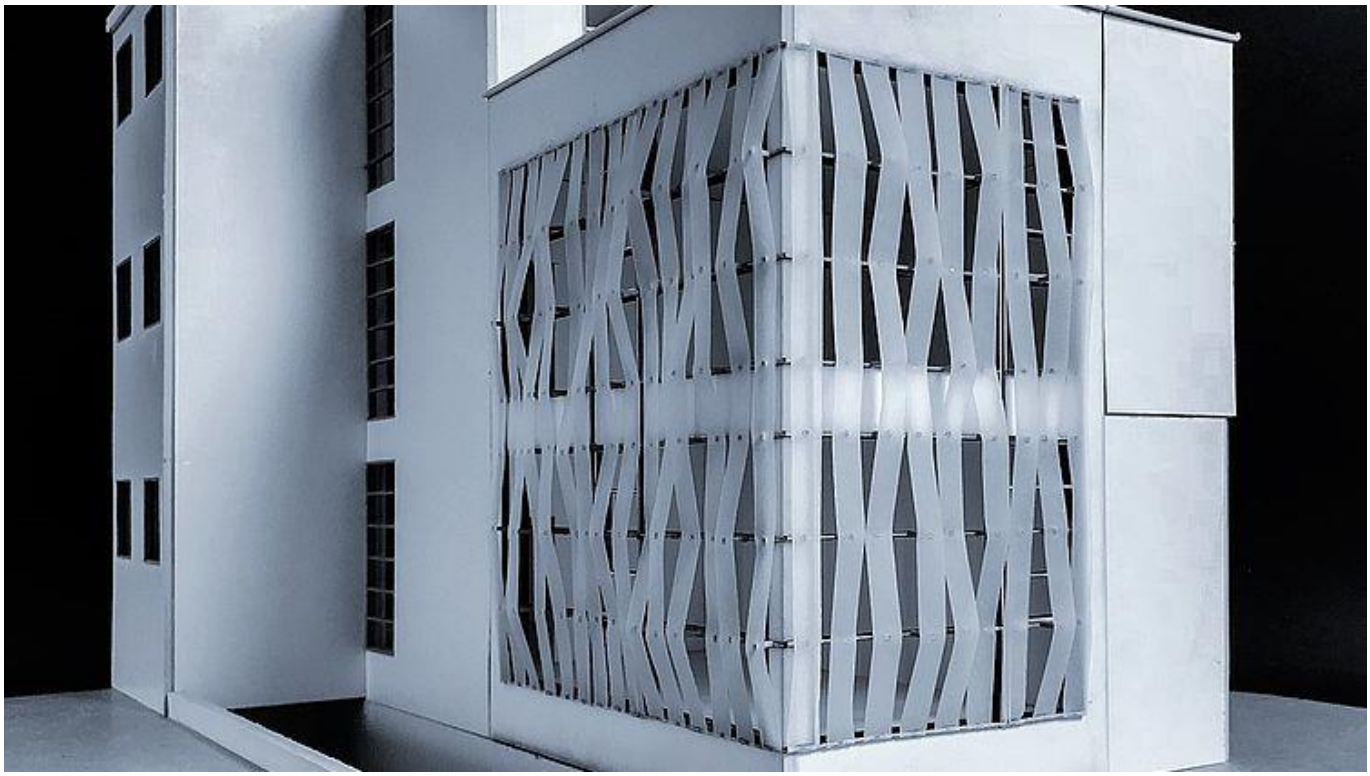


Figure 6 – Rendering of the textile OPV concept that provided the basis for the definition of the technical specifications of the Booster demonstrator.

2.2.2. Product features

Textile OPV modules are versatile products meant for several applications (BAPV market, outdoor applications, etc) thanks to:

- textile (sensu lato) support
- flexibility
- lightness and low bulk volume.

Booster textile modules will be composed of an active area enclosed in transparent ETFE material due to the need for avoiding massive light shading through the glass façades inside the building. In this sense, the Booster textile demonstrator will not resemble a network of interlacing fibers, but will match the idea of a product encapsulated into a flexible and rollable material anyway.

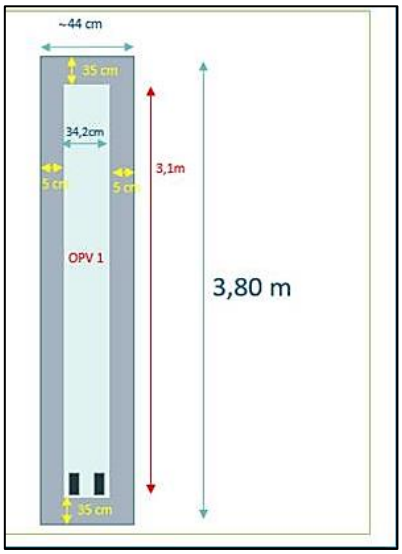


Figure 7 – Schematic top view of the characteristics and sizes of the Booster textile module.

A rectangular Booster textile product will be realized with the following main sizes (Fig. 7):

- module length: 3800 mm
- active length: 3100 mm
- module width: 440 mm
- active width: 342 mm.

Width tolerance will be +/- 1 mm per edge.

Connections will be fixed with JB twin boxes from STAUBLI so with ASPF standard laser opening.
Product flexibility will be achieved thanks to a maximum declared bending radius of 10 cm (smaller bending radius if achievable). Shipment of the product should be prepared coherently, through rolling up the product with at least the declared bending radius specification.
Concerning surface requirements, the ready-to-stick module will need high surface energy since the THB film will be stoked on ETFE.
Temperature during the utilization of the demonstrator will be 85°C maximum.

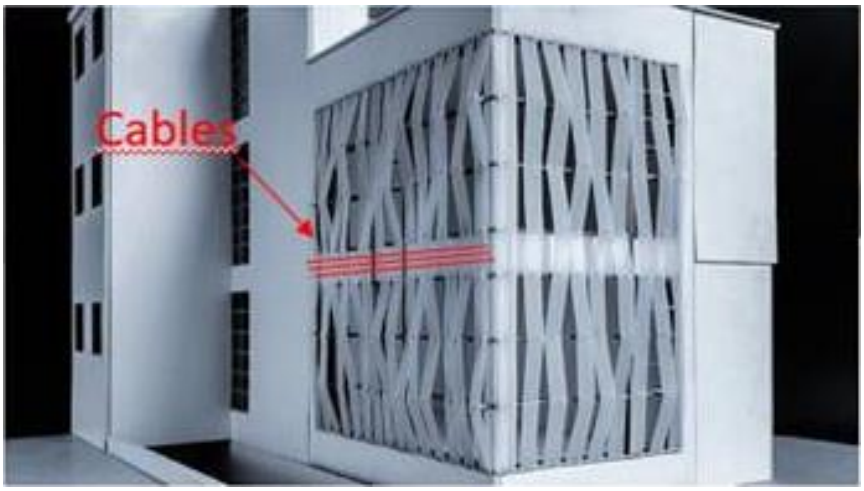


Figure 8 – Schematics of the position of cables of the Booster textile demonstrator.

60 Modules will be provided by ASPF and placed onto the SE and NE façade as shown in Fig. 6.
The modules will be mounted by attaching bottom and top of the modules stripes to the façade by terminal strips. This type of mounting requires the bending radius of the module stripes to be 10 cm or less, at least in those parts which go into the terminal strips. For the parts of the modules which are outside the terminal strips, larger bending radii are acceptable. The wavy appearance of the modules shown in Fig. 6 is achieved by horizontal metal bars which bend the modules towards or away from the façade in an alternating fashion. This also allows the modules to move slightly in the wind, which gives the façade a light and lively character.
The modules will be contacted at the top (for modules in front of the ground floor) and at the bottom (for modules in front of the 1st floor) with STAUBLI JB twin boxes. The solar cables (4 mm^2) will be guided in front of the concrete between the two floors (Fig. 8) to the inverter. Junction boxes and cables will be concealed with covers, which also protect the electrical circuitry against weathering. The demonstrator will be provided with monitoring equipment, thus continuous real-time monitoring will be possible under environmental conditions.

2.2.3. Specifications summary

a. Dimensional specifications

Feature	Target	Tolerance	Comment
Active primary module length (mm)	3100	5	
Total primary module length (mm)	3800	5	
Active primary module width (mm)	342	1 per edge	
Total primary module width (mm)	440	1 per edge	
Number of cells for primary modules	20		
Number of primary modules	30+10%	60+10%	Depending on building coverage – 10% margin
Module surface	30m²+10%	60m²+10%	Depending on building coverage – 10% margin
Number of primary modules connected for one strip of modules	To be determined		

b. Product integration specifications

Feature	Target	Tolerance	Comment
Frontsheet and backsheet encapsulant	ETFE Fluoropolymer Film		
Frontsheet encapsulant transparency	>92% 400 – 800nm		
Frontsheet encapsulant UV cut	>380nm		
Frontsheet encapsulant dielectric strength	>200 kV/mm		
Connectics	Staubli Twin box		

c. Performance specifications

Feature	Min	Max	Comment
1. Aesthetics			
Colour	No spec	Semi-transparent	
Reflexion	No spec		
Total thickness	<2mm	<1,5mm	
Total weight	<1000g/m²	<500g/m²	
2. Performances			
PCE for primary modules		15%	
Max voltage for one strip	To be determined		
Installation power		9kW	
Bending radius	>5cm	<10cm	
Lifetime		35 years	
Temperature stability	85°C max in use	120°C	Resistance to be tested: 85°C 1000h
3. Manipulation			
Storage and shipment	Flat	>10cm radius	

3. Conclusions

Booster ready-to-stick and textile demonstrators were conceived beginning with the evaluation of the BAPV market: building components, features and materials were studied in order to find the most promising product applications.
Painted metal and glass are among the most utilized materials for building components, in particular for roofs/canopies and façades respectively.
Ready-to-stick modules will be installed by ENI on a pre-painted steel canopy at the Eni Renewable Energy and Environmental R&D Center in Novara (Italy): 100 m² of ready-to-stick devices, representing a 15kW installation for the targeted 15% PCE efficiency of devices.
Textile modules will be installed by FAU on glass façades at the FAU institute facilities in Erlangen (Germany): 25m² of textile demonstrator, representing a 3.75kW installation for the targeted 15% PCE efficiency of devices.

4. Degree of progress

The task goal was completely fulfilled. Both ready-to-stick and textile demonstrators were defined: technical specifications of single modules and installation of the demonstrators.

5. Dissemination level

The deliverable D1.3 is public and will be available on the project website for download.