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PVsites

**Roofing tiles and façade elements
prototypes with 10% - 14% efficiency**

Project report

FLISOM, BEAR

December 2017

Summary

D4.1 and D4.2 report the development of a metal based CIGS PV-module family for building integration. The technical development was completed by Flisom on time, by month 21 of project development.

Flisom has developed a basic eMetal family and 4 specific sub-families of products which will be demonstrated in 5 pilot-installations (two carports, a ventilated façade, a residential roof and an industrial roof) in WP8.

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Disclaimer

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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 Tecnia, 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:

Tecnia 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 document corresponds to the project deliverables D4.1 and 4.2, reporting on the development of a metal based PV module platform for building integrated applications. The deliverables titles originally contained in the project agreement are titled as follows:

- D4.1: Roofing tiles and façade elements with 10%-14% efficiency modules of 0.5x1 m² and 1x1 m² area (M21)
- D4.2: Large area roofing and façade elements of 0.5x2-3 m² or 1x2-3 m² using 10%-14% efficiency modules (M21)

Given that these BIPV products are based on the same technology and the main difference is the size, and most technical activities are common, it is proposed to merge the two deliverables in a single text. This deliverable contains the relevant information on product design, development and testing activities.

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
T1.3	D1.3 provided a clear route regarding the validation testing needs and performance levels for the products developed herein.
T2.1	Specifications at module and manufacturing level defined herein have been taken as a starting point for the development.
T4.3	Modelling at element and building level of these elements will be performed in task 4.3.
T4.4	Performance validation testing of the modules developed herein will take place in task 4.4.
WP8	The products developed within this task will be taken to demonstration level (TRL7) in WP8.

1.3 Reference material

The current deliverables are based on the deliverable D1.3 (Standardization needs), D4.5 (Samples for validation testing), and on work packages one and two.

1.4 Abbreviation list

DH	Damp heat test, if not defined differently 1000 h 80°C 80% humidity
HiPot	High potential test. If not defined differently 5kV for 1 minute
n/a	not applicable
eMetal	Basic metal sheet module which serves as platform and for testing
eRoof tile	Roof-tile, will be installed at demo site Format D2 in Belgium
eCarport	Carport Panel, will be integrated into carport
eMetal industrial	Metal panel, will be mounted on demo site Cricursa
eFacade	Façade element, will be mounted on demo site EHG
WP	Work Package

2 DEVELOPED PRODUCTS

The products produced by Flisom are based on CIGS eFilm in combination with building compatible aluminium and steel. In the framework of PVSITES project, Flisom has developed 4 metal based platforms for building integrated application of CIGS. All modules are glass free (unbreakable) and have a metal back sheet. The encapsulation material and front sheet are the same for all products, while material thickness, colour, bending, junction box and many other features can be varied, in order to offer the customer a maximum value. For PVSITES demo sites a specific number of variants have been designed. Table 2.1 provides an overview on these products.

Table 2.1 Overview of the developed product platforms

Product name	Size range [m]	Power range [W]	Main features	Backsheet material
eMetal basic	0.8 x 0.45 3.0 x 0.45	28 – 120	< 2 kg / m ² , semi flexible for curved application, glass free.	Steel or aluminium
eRoof tile	1.5 x 0.5	54 -62	Serves as roof skin, easy installation	Steel
eMetal industrial	1.5 x 0.5	54 - 62	Stiff, self-supporting, excellent ventilation, fits on metal roof without supporting structure.	Steel
eCarport	3.3 x 0.45 2.5 x 0.45	84 - 120	Perfect size for carports. Equipped with anti-condensation coating. Serves as roof.	Steel
eFacade	1.5 x 0.5	60	Easy hang in system. Stiff and low under construction need. Lightweight.	Aluminium

IEC certification of first 1m CIGS module based on metal backsheet was achieved in Q3 2016. Its efficiency is 10%, and it has several distinct market advantages (light weight: <3kg/m², ease of transport and robustness). The final design (see Figure 2.1) provides a great flexibility of application.

1. eMetal basic: this platform consists of flat CIGS modules laminated to metal sheets. The basic variant is IEC certified and can be varied in size, color etc. These modules serve for Flisom as proof of concept, but have also been sold to few costumers.
2. eRoof tile: A roof tile has been developed which allows to combine a solar module with all functions of a regular roof.
3. eMetal industrial: A special module for industrial roofs has been developed which allows optimal integration, low mounting efforts and a smart cooling of the roof and the panels for reduced air-conditioning need inside the building.
4. eCarport: 2 Modules for carport applications have been developed. They are bonded to construction compatible and stable steel and are compatible with standard carport formats.
5. eFacade: A metal panel for facades with premium aesthetics has been developed to be installed at demo site 2.

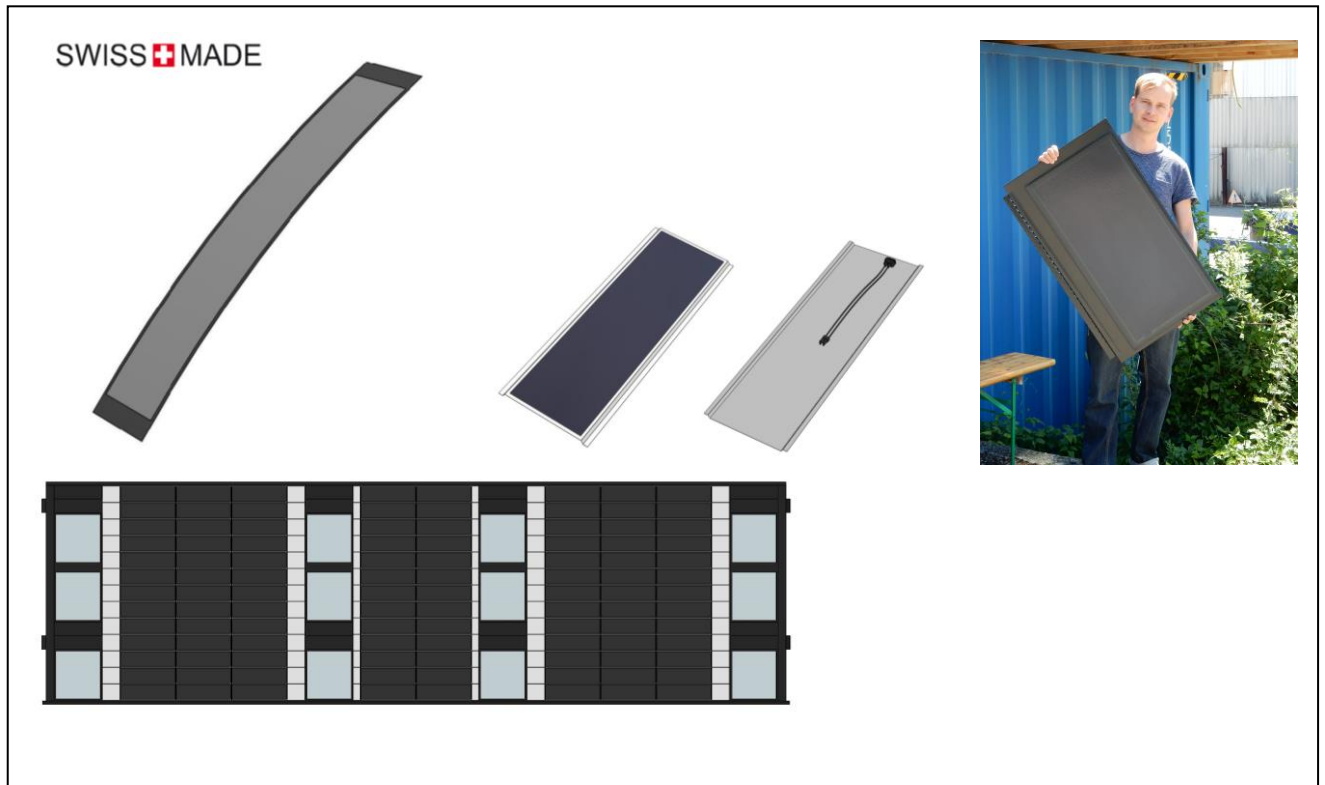


Figure 2.1 Visualizations of Flisom Products for PVSITES demo-sites. Clockwise: Panel for carports, Panel for industrial buildings residential roof tile advanced façade design

2.1 eMetal basic and CIGS platform

This platform consists of flat CIGS modules laminated to metal sheets. The basic variant is IEC certified and can be varied in size, color etc. These modules serve Flisom as proof of concept.



Figure 2.2 CIGS module on metal back sheet (Flisom). The so called eMetal platform ranges from 0.8 m – 3 m long products with 28 W -120 W.

Using a black aluminium backsheet, the same type of module becomes a fully black, aesthetically pleasing building element for BIPV (for use in residential applications or others where aesthetics are important). An example of a Flisom 10 kW façade installation is shown in Figure 2.3. The installation was mounted in July 2017 and is the first Façade installation with the black module type. The modules are laminated on to black elox. aluminum, giving them a homogenous black appearance.



Figure 2.3 Façade BAPV installation with Flisom eMetal modules, laminated on black aluminum

Work continues on improving module efficiency. The average production efficiency is (end 2017) above 11% and Flisom targets to continuously improve this value. On cell level Flisom has successfully achieved more than 16% efficiency with roll-to-roll CIGS from production deposition machine. The lab record of the R&D partner Empa keeps on rising and is above 20.4%. Flisom's R&D efforts to translate the more than 20% cell results from the lab into average production efficiency. The eMetal basic is not considered a building integrated product, but it is the prototype, proof of concept, testing module and basis of all metal back sheet products.

2.2 eRoof tile

The eRoof-tile combines all functions of a regular metal roof with the functionality of PV. It is fabricated in 2 steps. The tile is manufactured by the supplier (Wittenauer) and sent to Flisom. Then the CIGS foil is laminated onto the bent tile and junction box is applied. Through the use of black busbar tape, black edge seal and black painted steel, the roof tile gets a homogeneous black appearance.

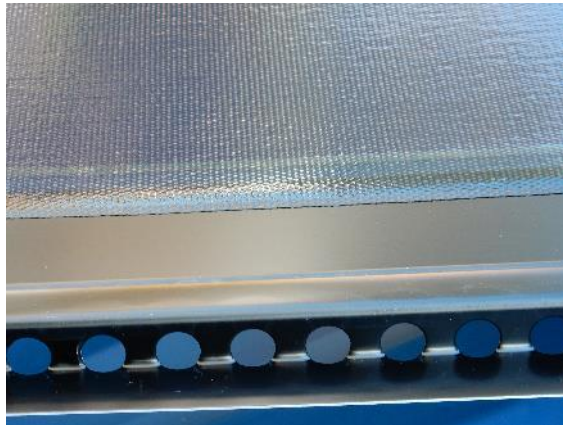


Figure 2.4 Prototype number 4, first full functional prototype of eRoof tile

2.3 eMetal industrial

On industrial buildings, functionality is important. Further easy installation and possibly low weight are points to look at. An optimal ventilation shall be achieved in order to maximise energy production and decrease the energy use for cooling and heating in the building. A typical industrial roof made from standard roof panels is shown in Figure 2.5. The roof belongs to Cricursa and is part of the demo site portfolio of PVSITES project.



Figure 2.5 Industrial roof at Cricursa.

For industrial buildings Flisom has developed a dedicated platform. The eMetal Industrial is formed on a bent metal sheet and has an additional support glued on. The module is stiff enough to be mounted without additional under construction, but not heavier than needed. It is glass free and the colour is adjusted to the underlying roof. A drawing is shown in Figure 2.6.

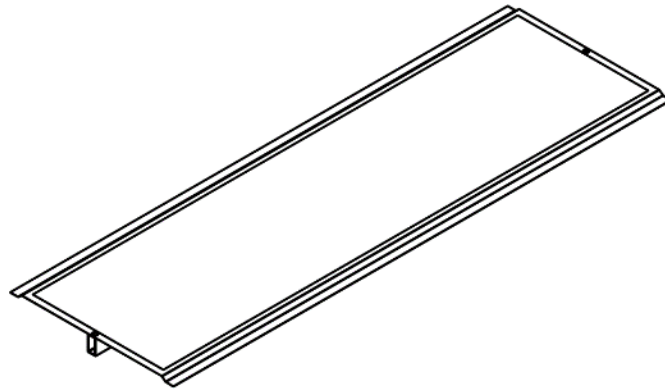


Figure 2.6 Drawing of the product eMetal industrial.

2.4 eCarport

Carports are optimally suited to be used for PV electricity production. They are often exposed to sunlight, as they should provide cover for the car. Further, in case of electric cars parking below, the energy might be locally used. The roof is free from chimneys or other obstacles which are often present on residential roofs.

Flisom has developed a module which serves as roof of the carport while also generating solar electricity. The corresponding carport design is shown in Figure 2.7. The corresponding panel is made from mild steel coated with PVDF. The demo carport will be black, while other colors are also possible.

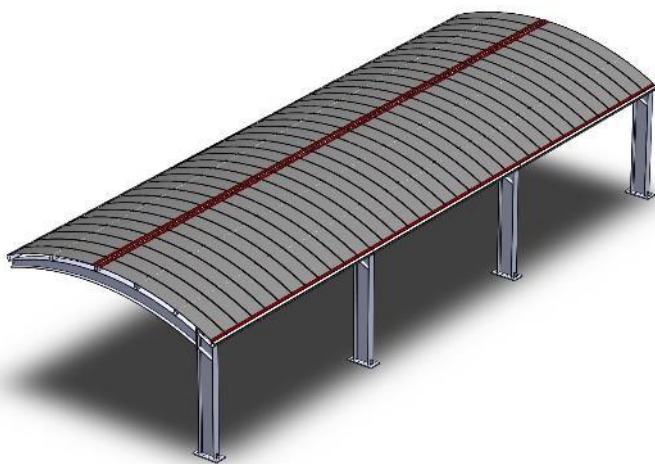


Figure 2.7 Carport concept with solar-roof and the corresponding panel design.

2.5 eFacade

The product eMetal basic has already been used for 2 façade installations, one of them is shown in Figure 2.3. The mounting of these panels is however rather complicated and is not compatible with façade building standards. Therefore, Flisom developed a panel which can be easily mounted. Further the panel is bent borders to provide stiffness and avoid complicated under-construction.

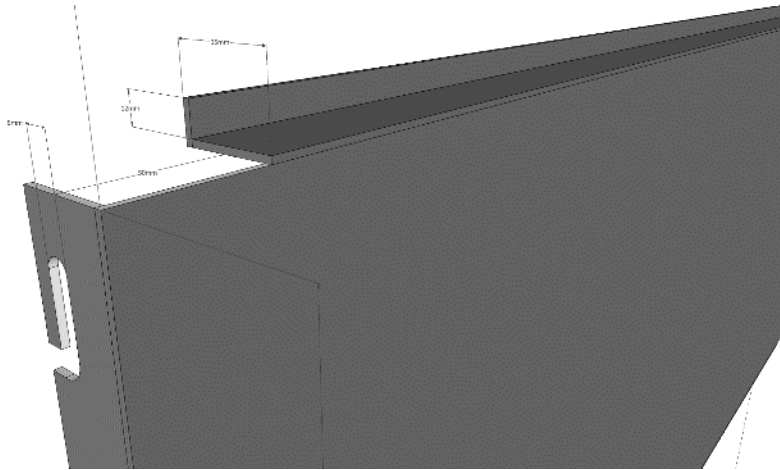


Figure 2.8 Detail drawing, showing the façade panel hang in system for easy installation

The product is manufactures similar to the roof-tile by laminating on the already pre-manufactured, façade element.

3 TESTS PERFORMED

Flisom has installed 90 eMetal basic modules on its own façade in May 2017. The façade installation is delivering consistent high energy yield. The energy yield and a picture of the installation is shown in Figure 3.1.

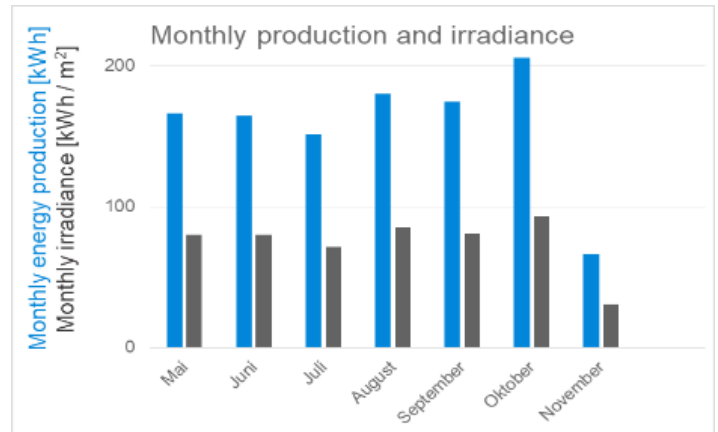


Figure 3.1 Flisom eMetal basic test installation at Flisom location Niederhasli

Flisom has also completed other installations using the eMetal platform. A roof installation in Zürich was made beside a conventional C-Si installation which allows to compare the energy yield. The energy yield kWh / kWp installed in the year 2017 (Aug – Nov) is shown in Figure 3.2.

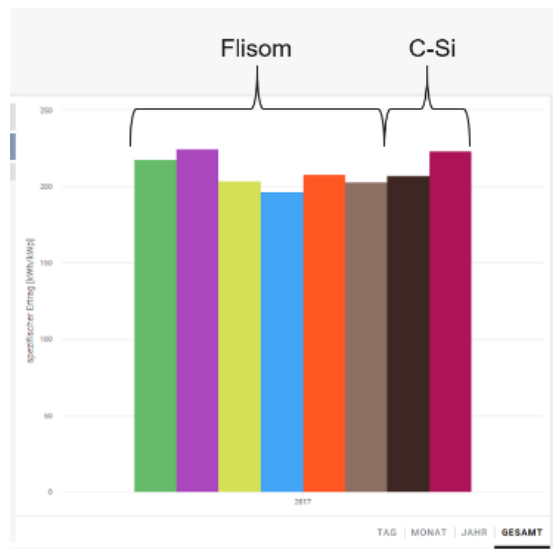


Figure 3.2 Specific energy yield of Flisom installations compared to C-Si standard module installation. Each bar represents one inverter. The total power of the Flisom installation is 23 kW.

Flisom has performed peel test in order to make sure, that the adhesion of the materials is sufficient to achieve non-delamination for 25 years. Peel tests were performed after lamination directly, 2 weeks waiting period, 2-month waiting and also 1000 h-2000 h damp heat exposure. An example for such peel test results is shown in Figure 3.3.

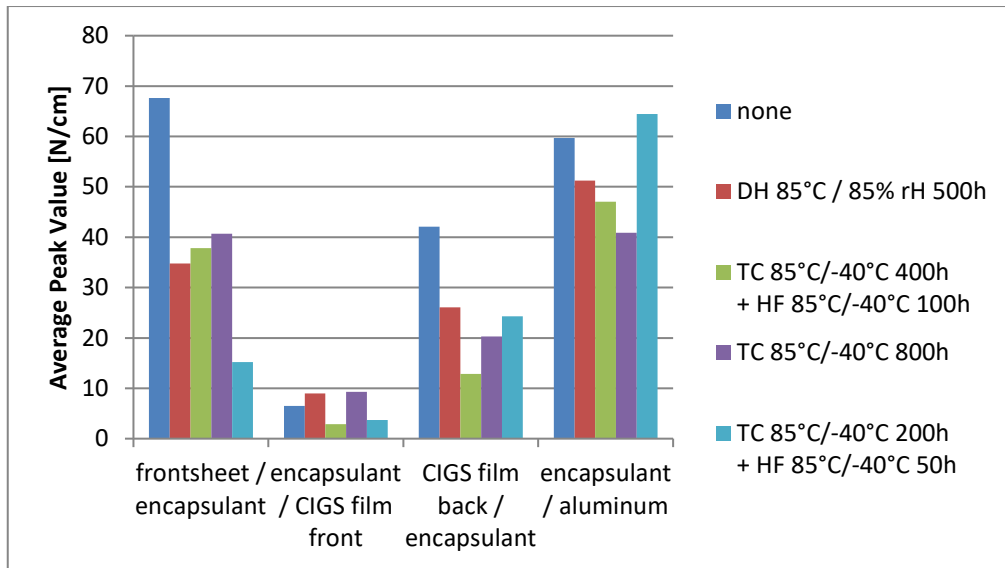


Figure 3.3 Example of peel test results for different pairings and for different conditions.

Flisom has also done in house damp heat test which are continuously ongoing. To comply with the DH of 2000 h at 85°C and 85% humidity is challenging without using glass. Flisom did successfully identify suitable materials and did test complete solar modules.

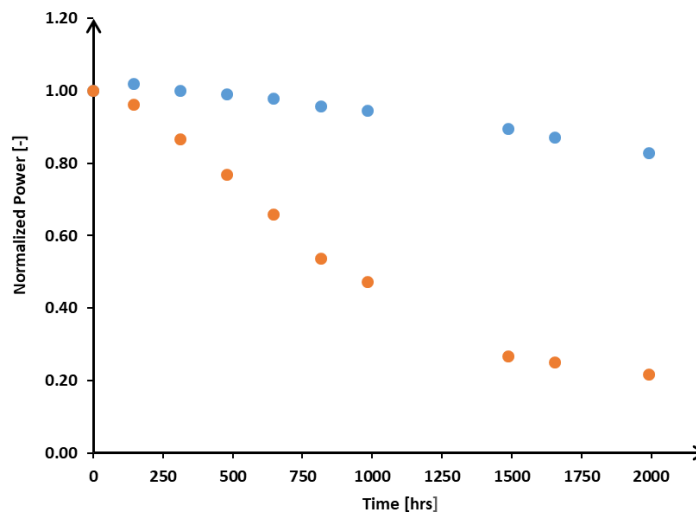


Figure 3.4 Example of DH test for 2000 with two different flexible front sheets.

While the aluminum back sheet did not cause any difficulty, neither in adhesion, nor in damp heat, many painted steel substrates failed in both tests. Flisom did test 12 different coatings, out of which 2 passed all testing. The “winner coating” is now being used for PVSITES products.

Further tests performed are, high potential leakage current test, potential induced degradation test, mechanical testing, hail test, fire test. More details will be provided in deliverable D4.5 “Samples for validation testing, CIGS elements”.

4 SUMMARY

Flisom has developed a metal back-sheet based product platform which consists of a basic flat module and 4 product families, based on this concept. Flisom has performed internal testing to qualify the product and ensure long term durability. Flisom has also successfully achieved IEC certification for the eMetal module. The eMetal basic is in the meantime already installed in several locations with a cumulative power of ~40 kW. The installations prove now consistent high energy yield for more than 6 months already. Flisom did additional to IEC certification harsher internal tests, doubling the IEC requirements. Flisom is ready now to produce and install the 4 building integrated variants.