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MS5. BIPV systems performance proved

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PVSITES

"Building-integrated photovoltaic technologies and systems for large-scale market deployment"

Start date: January 2016. Duration: 4.5 Years

Summary

This document contains the evidences and information related to the accomplishment of Milestone 5 of PVSITES project, as defined in the Grant Agreement, Annex 1 (part A), corresponding to the validation of BIPV Modules, for c-Si (ONYX) and CIGS (FLISOM) versions, and PV inverters, for PV storage inverter (TECNALIA) and single-stage SiC PV inverter (CEA) by means of testing at laboratory scale. For PV modules, these tests included the modifications made on the modules (thus the delivery of updated versions of reports on validation testing for these products, D3.9 and D4.6 were the support for this milestone). Additionally, the results of the validation tests for inverters were reported in D5.4 and D5.5. The fulfillment of MS5 has been delayed because the delay in the development and testing of single-stage SiC inverter, which has been finally tested very recently in CEA testing labs.

Document Information

Title	BIPV systems performance proved
Lead Beneficiary	TECNALIA
Contributors	TECNALIA
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Document History

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Disclaimer

Contents

1 EXECUTIVE SUMMARY

1.1 Description of the milestone content and purpose

This document contains the information related to the fulfilment of Milestone 5 of PVSITES project, as defined in the Grant Agreement, Annex 1 (part A), corresponding to the reporting of laboratory tests for BIPV modules (CIGS and c-Si) and Inverters (PV storage inverters and SiC PV inverter), after modifications had been introduced in BIPV modules. The milestone was due for June 30th 2019 and has been completed with one year of delay according to the means of verification stated in the DoA "*Modifications made within the project to c-Si and CIGS BIPV modules, together with 10 kW PV storage inverter and single-stage SiC PV inverter validated by means of laboratory tests (D3.9, D4.6, D5.4 ad D5.5 issued)*". Reasons for the delay are the delay of the development and testing of SiC V inverter, which has been concluded in M54 at CEA laboratories.

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS5	BIPV systems performance proved	1 - TECNALIA	42	Modifications made within the project to c-Si and CIGS BIPV modules, together with the 10kW PV storage inverter and single-stage SiC PV inverter validated by means of laboratory tests. Test reports issued (D3.9, D4.6, D5.4, D5.5)

1.2 Reference material

- PVSITES Grant Agreement.
- D4.6 Results on performance validation testing of CIGS modules
- D3.6 Report on indoor validation tests, c-Si based BIPV elements (updated version).
- D5.4 Report on results of 10 kW PV storage inverter validation tests
- D5.5 Report on results of single-stage SiC PV inverter validation tests

2 BIPV MODULES VALIDATED AT LABORATORY

Two different BIPV module technologies have been developed and validated within PVSITES project: c-Si (ONYX, WP3) and CIGS (FLISOM, WP4)-

2.1 C-Si BIPV modules (ONYX)

D3.9, submitted in August 2019, describes the set of indoor tests performed to the different c-Si based BIPV products developed under the framework of WP3. Within WP3, several standards of interest were analysed and a set of associated tests were selected for each product. The testing work is focused on testing the new elements included in the developed products or the properties that could be different compared to the traditional product. This version of D3.9 includes the PV tests of X9 and X11 products and the description of the glass tests performed to the new PMMA adhesive batch that were not included in the first release. Final conclusions have been updated

The Table 1 describes the c-Si based products, the tests performed and the standard describing these tests.

Table 1. BIPV products based on c-Si and tests that have been performed

Product name	Test field	Standard and test	Comments
X5 - C-Si glazed products with hidden bus bars and L interconnections	Photovoltaic	IEC 61215: severe dielectric rigidity test, thermal cycling, damp heat	Fire tests of ETAG 034 have been performed using X5 glazing, thus the results can be used for X5 and X8 products
	Glass	ISO 12543-4: radiation, humidity, high temperature EN 12600: impact resistance EN 356: manual attack	
	Construction	EN 13823: Reaction to fire EN 11925-2: Reaction to fire - Single-flame source EN 410: Optical properties	
X6 - Glass-glass products with back contact c-Si cells	Photovoltaic	IEC 61215: severe dielectric rigidity test, thermal cycling, damp heat	-
	Glass	ISO 12543-4: radiation, humidity, high temperature	
	Construction	EN 410: Optical properties	
X8 - Framing system for c-Si large area glass	Photovoltaic	-	Fire tests of ETAG 034 have been performed using X5 glazing, thus the results can be used for X5 and X8 products
	Glass	-	
	Construction	CWCT TN67 (skylights): Impact due to maintenance ETAG 034 (ventilated façades): Wind resistance, impact, fire	

X9 - C-Si semitransparent low concentration and Solar control BIPV system – skylight configuration	Photovoltaic	IEC 62108	Tests of X9 and X11 are focused in lenses (common PV glass is used). ISO 12543-4 and EN 11925-2 have been performed just once for both products. Mechanical tests have been performed with X11 lenses because they are weaker.
	Glass	ISO 12543-4: radiation, humidity, high temperature	
	Construction	-	
X11 - C-Si semitransparent low concentration and Solar control BIPV system – façade configuration	Photovoltaic	IEC 62108	
	Glass	ISO 12543-4: radiation, humidity, high temperature	
	Construction	EAD 220025-00-0401 (just for guidance): loading capacity, hard body impact, pull-out test EN 11925-2: reaction to fire	
X12 - Glazed modules treated for improved passive properties	Photovoltaic	-	-
	Glass	ISO 12543-4: radiation, humidity, high temperature	
	Construction	EN 410: Optical properties	

2.2 CIGS BIPV modules (FLISOM)

On the other hand, validation tests fro CIGS modules have been included un D4.6, submitted in June 2019. This deliverable sums up the tests result on CIGS prototypes manufactured for the project. Some tests are combined. For example, if two modules use the same back sheet and also all other materials are same (just the size is different), a test was done on one of the modules, and results are considered valid also for the other design. As shown in table 2, all the products were found to pass the performance testing of 1000h light-soaking and 1000h damp heat, exceeding the IEC standard. The “base products” eMetal and eFlex were also externally tested according to a full IEC cycle and passed the test.

Table 2 Overview, required test samples for verification of the specific designed solutions

Product	Corresponding Demo site	Ligth-soaking	Outdoor test	Lamination / peel test	Bending Lamination test	HiPot testing	Damp heat 85/85
P1 Roof-tile	D2 Belgium	Pass	Pass	Pass	done	Pass	Pass
P2 Carport Panel	Carport	Pass	Pass	Pass	n/a	Pass	Pass
P3 Metal panel	Cricursa Barcelona	Pass	Pass	Pass	done	Pass	Pass
P4 Facade	EHG	Pass	Pass	Pass	n/a	Pass	Pass
P5 eFlex	NEST Hilo	Pass	Pass	Pass	Pass	Pass	Pass
P6 Curved glass modules	None, only test bench	Fail	Fail	n/a	Pass	n/a	n/a

3 PV INVERTERS VALIDATED AT LABORATORY

Similarly to BIPV module technologies, 2 different approaches for PV inverters have been designed, manufactured and tested at laboratory scale: PV storage inverter, developed by TECNALIA (WP5) and single-stage SiC PV inverter, provided by CEA (WP5).

3.1 PV storage inverter (TECNALIA)

Validation tests for the PV storage inverter were detailed in D5.4, submitted to the EC in March 2018.

This document gathers the results of the characterization and functional validation tests carried out on a functional prototype of the 10kW PV storage inverter developed in PVSITES project by TECNALIA. These tests and the corresponding test benches are described in detail in the deliverable.

The validation plan carried out aims to (1) Analyze the capability of the PV storage inverter to operate as expected, verifying the fulfillment of a list of requirements gathered from several standards to ensure a safe operation with the appropriate power quality and (2) Characterize the overall efficiency of the PV storage inverter as key performance indicator. For this purpose, its power conversion and maximum power point tracking (MPPT) efficiencies were measured according to EN50530, but also designing and implementing new procedures for measurement of MPPT efficiency under heterogeneous working conditions, as occurred in Building Integrated Photovoltaic (BIPV) systems

As main conclusion of this report, the 10kW PV storage inverter provides a really good performance during all the considered tests, with fully accomplishment of the minimum requirements established by the corresponding standards

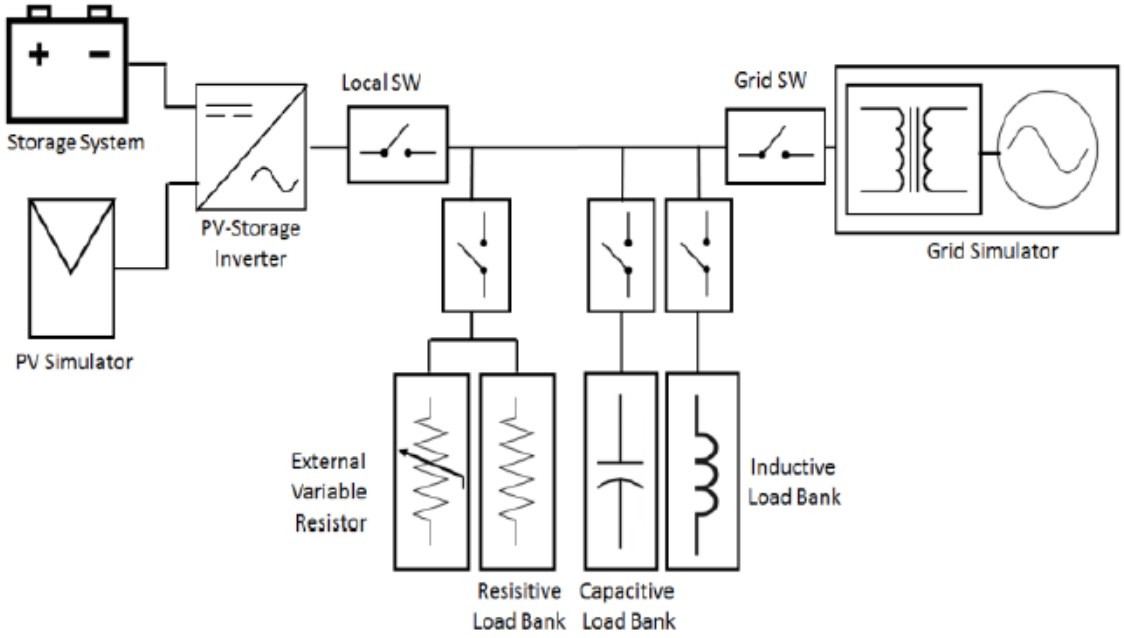

Figure 2.1 Test platform scheme, implemented at TECNALIA's labs

3.2 Single-stage SiC PV inverter (CEA)

Validation tests for the SiC PV inverter were detailed in D5.5, submitted to the EC in August 2020 with a great delay due to difficulties in the prototyping phase suffered by CEA. In fact, these validation tests were carried out at CEA testing facilities instead of TECNALAI's labs, as foreseen, in order to accelerate the testing procedure and arrive in time, just before the end of the project.

This document, D5.5, gathers the results of the characterization and functional validation tests carried out on a functional prototype of the single-stage SiC inverter developed in PVSITES project by CEA. These tests and the corresponding test benches are described in detail in the deliverable.

Table 3 Validation tests for CEA solar inverters

1- Normal Operating Range
a. Voltage & Frequency Operating Range. (EN50438)
b. Under-frequency response (EN50438)
c. Over-Frequency response (EN50438)
2- Interface Protection
a. Under / Over Voltage Test (EN50438)
b. Under / Over Frequency Test (EN50438)
c. Main Loss Detection (Islanding) (IEC 62116)
d. Automatic Reconnection (EN50438
3- Safety Protections
a. Residual current detection (IEC 62109:2)
b. PV array insulation resistance detection (IEC 62109:1)
4- Power Quality
a. Harmonic & Flicker (61000-3-2, 61000-3-3)
b. DC Current Injection (EN50438)
5- Low Voltage Ride Through (IEC 62910)
6- Reactive Power Delivery (EN50438)
7- MPPT Tests (EN50530)
8- Power Conversion Efficiency (EN50530)