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MS6. Demonstration activities completed and assessed

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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 information related to the fulfilment of Milestone MS6 of PVSITES project, as defined in the Grant Agreement, Annex 1 (part A), corresponding to the reporting and analysis of the global results of the PVSITES project's demonstration activities, as well as to the assessing of the next steps to be taken for possible market uptake and replication. The milestone was due in 30th June, 2020.

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1 EXECUTIVE SUMMARY

1.1 Description of the milestone content and purpose

The main objective of MS6 is the global assessment of the demonstration results, after the monitoring period of the real demo-systems implemented. The Life Cycle Assessment (LCA) of products and installations must be also understood as part of this milestone, as well as the lessons learnt throughout the development, installation, commissioning and operation of demo-systems. All these studies constitute a complete analysis of the final results of the project and provide very useful information for the future assessing of the market replication possibilities of PVSITES products and solutions.

1.2 Reference material

- "PVSITES Grant Agreement"
- Deliverable "D8.5. Prototypes for demo-sites - Second batch"
- Deliverable "D8.6. Results of installation and commissioning for every demo site"
- Deliverable "D8.7. Common monitoring guidelines"
- Deliverable "D8.8. Specific monitoring plan for every demo site"
- Deliverable "D8.9. Report on the baseline assessment of the demo sites"
- Deliverable "D8.10. Installation and execution of monitoring of BIPV systems"
- Deliverables "D8.11, D8.12 & D8.13. Impact of BIPV systems on the building performance and PV assessment from monitoring activities"
- Deliverable "D8.14. Life Cycle Assessment at product level"
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- Deliverable "D8.16. Report on general architectural, photovoltaic, operational, economic and environmental assessment of the demo sites"
- Deliverable "D8.17. Guidelines and recommendations for replicability of PVSITES approach".
- Deliverable "D8.18. Lessons learnt in PVSITES BIPV installation process: acceptance and use of BIPV elements"

1.3 Abbreviation list

BAPV: Building Attached Photovoltaics.

BEMS: Building Energy Management System

BIPV: Building Integrated Photovoltaics

CIGS: Copper indium gallium selenide

C-Si: crystalline silicon

EHG: Ecole Hotelière de Genève

EKZ: Elektrizitätswerke des Kantons Zürich

EMPA: Swiss federal laboratories for materials science and technology

LCA: Life Cycle Assessment

PV: Photovoltaics

2 ANALYSIS OF RESULTS

Sections included in this chapter take part of the analysis of results obtained during the demonstration activities, and the starting point of the guidelines and recommendations elaborated for a possible market replication of PVSITES products and solutions.

Deliverable “D8.16. Report on general architectural, photovoltaic, operational, economic and environmental assessment of the demo sites” gathers all these conclusions, including also the assessment of the architectural, comfort, economic, standardization and regulations aspects.

2.1 MONITORING OF INSTALLATIONS

The demo-systems monitoring task required, in all cases, the undertaking of previous works that can be summarized as follows: definition of a measurement & verification plan for each pilot (described in " D8.8. Specific monitoring plan for every demo site”), on the basis of a common agreement about the monitoring strategy (defined in " D8.7. Common monitoring guidelines”); installation of the monitoring infrastructure and collection of the first data (described in D8.10. Installation and execution of monitoring of BIPV systems”); assessment of the baseline status used as a reference, in terms of energy consumption and indoor environmental conditions, to be compared with the situation after BIPV systems installation on site (described in "D8.9. Report on the baseline assessment of the demo”).

Once implemented, every demo-systems were monitored throughout the longest period possible from their commissioning to the end of the project. Due to the fact that multiple circumstances occurred during the first months of functioning (residual breakers tripping, faulty electricity meters, inverters malfunctioning, problems with sharing of IT infrastructure between monitoring systems and EMS, data collecting disruption due to the commissioning works of BIPV systems and the monitoring devices, etc.), the monitoring period has been shorter than planned in most of the cases.

The monitoring results were analysed and showed in the series of deliverables: “D8.11, D8.12 & D8.13. Impact of BIPV systems on the building performance and PV assessment from monitoring activities”. This work basically consisted on the comparison of the building behaviour after the BIPV installation, through the measurements collected, with the previously assessed baseline situation. In this way, it was possible to analyse the impact the BIPV and BAPV installations in the active and passive energy performance of the buildings, as well as the new indoor environmental conditions.

A brief conclusion, specific for every demo-system, has been included below:

- **Demo 1. Solar roof in a Single family house, Belgium (FORMAD2):**
  There is still an important gap between the expected and the real PV production values. Despite this gap, the BIPV system largely covers the electricity needs of the house for the summer months whereas it covers less than 30% of the electricity demand for winter and autumn months.
- **Demo 2. Ventilated facades in the Catering school of Genève, Switzerland (FLISOM):**
  The two BAPV facades installed in EHG can be considered as almost optimal because the difference between expected and real production is less than 10%.
- **Demo 3. Solar carports at EKZ and EMPA facilities, Switzerland (FLISOM):**
  The installation of EMPA Carport can be considered as almost optimal, with a difference between expected and real production less than 10%. EKZ carport presented a performance below the EMPA carport’s one, but it allowed FLISOM to suppress some issues and to improve the fabrication process of the CIGS modules.
- **Demo 4. Solar industrial roof of a glass factory, Spain (CRICURSA):**
  CRICURSA's BIPV demo-system has not been fully operative since its installation, due to leakage current problem that required intense efforts to be solved. However, despite of many technical interventions on the pilot site to solve it, the gap is still significant and the energy production shows low values far below the expected one.

- **Demo 5. Solar ventilated facade of a multi-store apartments building, France (VILOGIA):** BIPV system is operating from June 2020. Problems with the grid connection, due to an external protection, did not allow the commissioning on time. Therefore, no result was drawn, only the evolution of the modules temperature and the PV production estimate are available.
- **Demo 6. Solar ventilated facade of an office building, Spain (TECNALIA):** Almost optimal performance, with a difference between expected and real production less than 10%. For most of the pilot sites the energy passive impact of the BIPV integration is not noticeable. TECNALIA's pilot is an exception in this regard, because of the semi-transparency of the BIPV modules: a significant impact on the luminosity and the indoor temperature of the room located behind the facade are observed.

Overall, the BIPV installations worked well, but with a performance slightly below the expectations; nevertheless, some levers can still be activated for some of them to reach the full expected performances.

2.2 LIFE CICLE ASSESSMEMT OF PRODUCTS AND INSTALLATIONS

A complete Life Cycle Assessment (LCA) of products and installations were carried out as part of the tasks addressed to totally assess the final performance and impact of the PVSITES products and solutions developed in the project.

The scope of the LCA studies included the assessment of the energy and material flows, as well as the transport, during the production phase of the BIPV modules: mining works, transport and manufacturing, in a cradle-to-gate LCA approach (results were reported in deliverable “D8.14. Life Cycle Assessment at product level”). At system level, all the materials needed to integrate the BIPV modules in the building: mounting structures, solar inverters, battery blocks, cables, transport, etc., were considered (results were reported in deliverable “D8.15. Life Cycle Assessment at installation level”). The complex requirements of some demo-buildings caused an intense debate about how to carry out the most effective integration, so this LCA study suffered some delays.

The input data to carry out the LCA studies were provided by the PVSITES industrial partners and taken from external sources. The environmental impacts were assessed, for each impact category, according to commonly used LCA methods and tools.

Overall, the results show that the metal substrate have a major influence in the environmental performance of the CIGS modules. Regarding the c-Si modules, it is concluded that the production materials of this technology have an important environmental impact. The remaining processes produce extremely low environmental impacts, except for the framing structure in the human toxicity and cancer effects category. At system level, the main contributor is the production of PV panel, followed by inverters or batteries, depending on the impact category. The mounting structures and the transport process do not considerably affect the environmental performance of any demo-site.

Comparing both PV technologies, if the annual electricity production is considered, the LCA studies show that the CIGS technology has lower environmental impacts than the c-Si technology, mainly due to the raw materials and processes used for their manufacturing. These results are similar to the ones obtained from reliable bibliographical sources.

Although the obtained environmental impacts are within the expectations for BIPV technologies, there are improvement possibilities, regarding the product design and manufacturing and integration processes, which might be adopted to reduce the environmental performance in the categories assessed.

2.3 LESSONS LEARNT

One of the main points to be considered for the final results assessment of PVSITES technologies, has been the collection of the lessons learnt throughout the development and demonstration phases. This matter is the object of deliverable “D8.18. Lessons learnt in PVSITES BIPV installation process: acceptance and use of BIPV elements”. Although this document was initially focused on the lessons learnt related to the installation, permitting and commissioning processes, some useful comments about the design process have also been included.

Most relevant learnings, resulting from this study, concern to the subjects listed below:

- Module and system design, to meet the specifications and requirements from the different parties: building owner, national and local authorities, electricity companies, financial agents, etc.
- Planning and execution of building project, needed to properly coordinate and carry out the installation by the professionals involved: project manager, building company, energy services company, PV installer, etc.
- Permitting process, which include local architectural regulations, construction permissions and grid connection conditions, can be complex and produce unforeseen delays.
- Commissioning process, which might entail unexpected technical problems.

3 MARKET REPLICATION

On the basis of the conclusions drawn throughout the demonstration activities, a set of guidelines and recommendations, specific for each PVSITES solutions, has been generated in order to make easy a possible market replication.

This information, together with the complete and detailed "PVSITES Catalogue" developed in “Task 9.8. Implementation of the BIPV product portfolio”, will provide a solid foundation for a possible market replication of PVSITES products; market replication that, in fact, has already happened in some cases by means of the commercialization of some on the BIPV modules developed by FLISOM and ONYX.

Deliverable “D8.17. Guidelines and recommendations for replicability of PVSITES approach” has been conceived as a case studies portfolio, where the products included in the "PVSITES Catalogue" has been chosen to implement real BIPV system. These case studies correspond to the PVSITES demonstration systems, which results have been wide and deeply assessed during the last tasks of WP8.