Technology Collaboration Programme
by iea

International Energy Agency
Photovoltaic Power Systems Programme

Task 15 Enabling Framework for the Development of BIPV

PVPS

FACT SHEET

Multi-Dimensional Evaluation of BIPV Installations

JULY 2024

Authors: Eder, G. C., Wilson, H. R., Frontini, F., Bonomo, P., Babin, M., Thorsteinsson, S., Adami, J., Maturi, L., Jing Yang, R., Weerasinghe, N., Martin-Chivelet, N., Boddaert, S., Frischknecht, R.

Task 15 Managers:
Helen Rose Wilson, Fraunhofer ISE, Germany
Francesco Frontini, SUPSI, Switzerland

International Energy Agency
Photovoltaic Power Systems Programme

Multi-Dimensional Evaluation of BIPV Installations

Building Integrated Photovoltaics (BIPV) represent a pivotal technology in sustainable building design, **integrating solar panels seamlessly into building structures**.

The multi-dimensional evaluation methodology for BIPV installations is designed to facilitate cross-sectional comparisons with the aim to increase the deployment of BIPV.

Development of the Multi-Dimensional Evaluation Tool

Establishing clear research objectives and defining variables and parameters across four main categories of performance indicators (PIs):

Energy Related PIs	Economic PIs	Environmental PIs	Visual PIs
BIPV array DC electricity yield	BIPV building element costs (entire BIPV system)	Cumulative demand for energy from non-renewable resources	Recognizability
Final system AC yield	Standard levelized cost of electricity	Climate change (GWP)	Colour (uniformity)
Area-specific AC final system yield	Extended levelized cost of electricity	Resource use, minerals and metals	Glare (risk)
Annual performance ratio	Material replacement value	Particulate matter	PV module in the BIPV system
Self-sufficiency index	Extended net present value / costs	Acidification	BIPV system in the building
	Extended discounted payback period	Water use	BIPV building in the urban environment

Development of a numerical rating system for each PI to enable a comparative quantitative and qualitative analysis of different BIPV installations according to several indicators per category. For the visual PIs, a semi-quantitative approach is used instead.

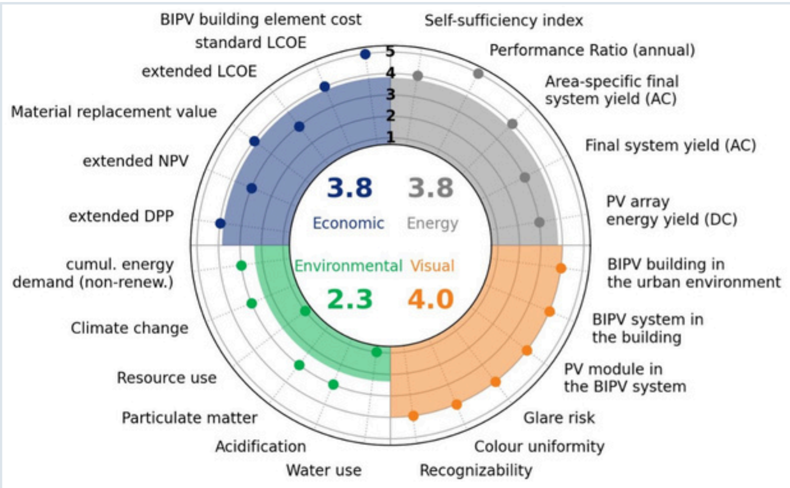
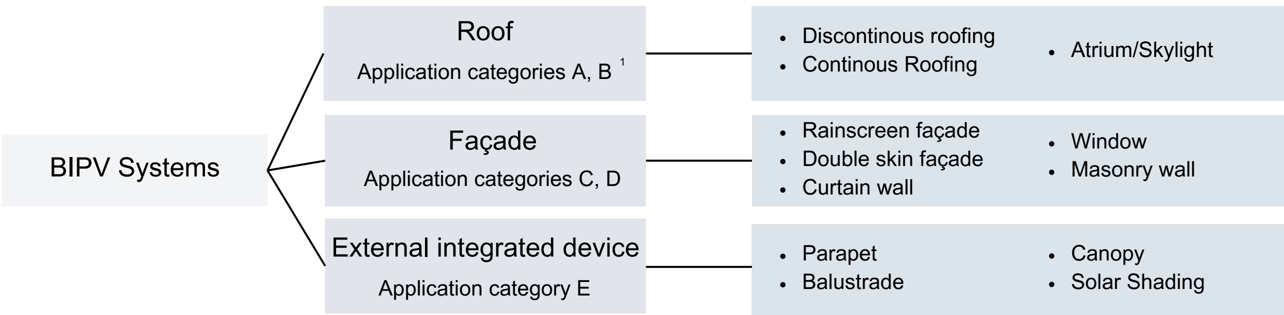


Fig. 1: Visualized performance appraisal results in the 4 categories indicating the numerical values of the evaluated PIs

*The aim of the comparative assessment of the multi-dimensional performance is to **learn from existing BIPV projects** and to **support architects, system developers and other stakeholders** involved in the planning of new BIPV projects.*

Development of a harmonized classification scheme for BIPV installation types. This scheme is an optimized approach that serves as a reference for the classification of BIPV building envelope technology.



[1] The application categories A, B, C, D and E are those used by the BIPV standards, EN 50583 and IEC 63092

Application of the Multi-Dimensional Evaluation Tool

Selecting diverse BIPV installations representing different building typologies (e.g., facades, roofs, external devices). Each installation serves as a case study for comparative analysis. The evaluation can be performed for

- planned projects and is then based on data from data sheets, tabulated environmental data, simulations and renderings;
- existing BIPV installations and is then based on measured performance data, real costs, known environmental data and an on-site assessment of the visual and optical performance.

Applying the multi-dimensional methodology to quantify and rate each installation's performance across defined PIs. This involves data collection, analysis, and interpretation using standardized evaluation methods. The results are presented in a structured format, allowing for detailed comparison and assessment.

Case Studies

1 Apartment Building Retrofit with Colored BIPV Modules (Switzerland)


Foto: © Vividén + Partner AG

- Retrofit of an apartment building integrating colored photovoltaic modules on facades (leading to a performance loss of around 35 %).
- The complex building design results in severe shading conditions.
- 18 different sizes of modules were used, with only four types being dummies (non-active panels). Approximately 98% of the glazed façade is theoretically active.
- A significant share of power optimizers (more than 7%) had to be replaced within the first few years, leading to electricity generation losses and increased resource use and energy demand.

2 Office Building with Integrated BIPV Facades and Roofs (Uppsala, Sweden)


Foto: © Nils Lindstrand/ Nordiske Medier

- LEED Platinum certified office building with BIPV on facades and roofs, necessitating the implementation of highly effective energy systems and innovative solutions.
- Built with a full timber frame and designed for high energy-relevant performance to minimize climate impact from both building materials and energy use.
- PV panels are integrated into both the roof and the façade (frosted or satinated to blend with the rest of the façade without hiding the cells.

3 Terrace Houses with Standardized BIPV Roofs (Delft, the Netherlands)


Foto: Exasun © Jan-Jaap van Os;
https://exasun.com/

- Exasun uses prefabricated, standardized products to replace traditional roof tiles.
- The X-Roof system seamlessly integrates with dormer windows, skylights, and roof irregularities.
- The entire roof consists of PV panels for maximum energy yield.

4 Retrofit of Apartment Building with BIPV Window Balustrades (Northern Italy)


Foto: © Eurac Research

- BIPV Parapets: Installed as part of the retrofit using a versatile click-&-Go substructure developed in the EnergyMatching R&D project (Horizon 2020).
- BIPV Window Balustrades: Developed within a "Solar Window Block" system, which is prefabricated and multi-functional. It includes a BIPV system integrated with a battery to power a ventilator within the window.
- The sizing and placement of the BIPV system was optimized, aimed to enhance the matching between hourly electricity production and consumption, thereby maximizing the overall efficiency of the system.

Challenges and Considerations

The evaluation tool faces several challenges:

- **Data Availability:** Limited availability and authorization for data usage can hinder comprehensive evaluations.
- **Standardization Issues:** The lack of standardized definitions for determining each PI can lead to significant problems when comparing the performance of different BIPV applications, e.g. when calculating economic benefits, where different studies have used different cost and benefit elements.
- **Environmental Data Variability:** Different methods of data generation for environmental data can complicate the calculation of environmental PIs.
- **Subjective Aesthetic Assessment:** Visual performance assessments are inherently subjective, requiring a semi-quantitative approach to standardize ratings.

Outlook

The tool was initially designed for a **cross-sectional comparison** of different BIPV installations. However, the method can be used for other types of evaluations:

- **Assessing competing options for a specific project in the planning phase:** External boundary conditions are fixed (location, construction, operation time), economic conditions (interest rate, capital provision) can be consistent across BIPV variants, pre-defined evaluation methods for performance indicators (PIs) can consistently be used.
- **Seperate evaluation of of each performance indicator:** This can be useful for potential BIPV customers who can prioritize relevant indicators for their case.
- **Analysing pioneering installations (like Case Study 1)**: This helps determine achievements, identify improvement areas, and contribute to market development.
- **A longitudinal analysis** of a BIPV installation over its lifetime is planned in Phase 3 of Task 15.

Ongoing research will explore long-term performance impacts and evolutionary trends of BIPV installations, supporting sustainable PV integration in building structures.

This methodology represents a significant advancement in evaluating BIPV systems, fostering effective and sustainable integration of photovoltaics in various architectural contexts.

IEA PVPS Task 15

Task 15 aims to establish a framework to accelerate the global adoption of BIPV products in renewable energy and construction sectors, ensuring fair competition with BAPV and traditional building components. It integrates BIPV into both electric and construction technologies, emphasizing value-added contributions to building aesthetics, energy performance, and multifunctionality. The task covers new and existing buildings, various PV technologies, diverse applications, and scales ranging from residential homes to large-scale BIPV installations in commercial and utility buildings.

This Fact Sheet is based on an article from IEA PVPS Task 15 experts, which has been published in *Energy and Buildings.* Please find a detailed description of the method in the paper:

Wilson, H. R., Frontini, F., Bonomo, P., Eder, G. C., Babin, M., Thorsteinsson, S., Adami, J., Maturi, L., Yang, R. J., Weerasinghe, N., Martin-Chivelet, N., Boddaert, S., & Frischknecht, R. (2024). Multi-dimensional evaluation of BIPV installations: Development of a tool to assess the performance as building component and electricity generator. Energy and Buildings, 312.