

Scuola universitaria professionale della Svizzera italiana  
Dipartimento ambiente costruzioni e design  
Istituto sostenibilità applicata all'ambiente costruito

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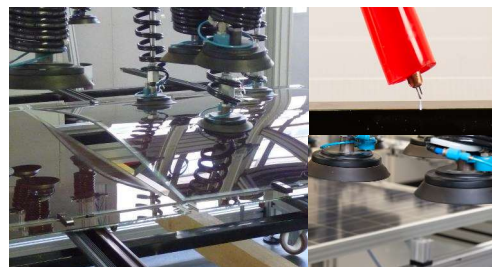
## SUPSI

# Multifunctional BIPV evaluation

National and international standardization experiences

Prof. Dr. Francesco Frontini

*Head of Building System sector  
Swiss BIPV competence centre  
SUPSI-ISAAC*



2 luglio 2021

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## BIPV: Technology, dynamics of innovation

- Multifunctional facades and roofs  
(PV is ...building skin)
- Opaque and transparent products  
(mimicry, evident or invisible)
- Standard towards customized  
(mass-production and tailor-made design)
- Flexibility and automation  
(Automatic, self-configurable production)
- Integrated process management  
(data-driven chain from design to O&M)



(source: Faceactive-Batineg)



Coloured modules (photo: P. Bonomo)



Lightweight system (source: Solar Retrofit SA)



(source: Compaz)



(source: AG Technovation center, Gosselies, Belgium)



(source: Kamaleon Solar)

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Kindergarten Einigen, HMS Architekten, Module: 3S-solar Plus



Baübüro In situ AG, Basel, Module: Kromatix



02/07/2021 Mario Campi e Associati, Lugano, Module: Sunage SA



René Schmid Architekten, Module: Kioto Solar



Source: Solarchitecture.ch

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What else is needed for market transfer?

- **BIPV > Quality of a multifunctional system**  
Safety (mechanical, fire), durability, etc.
- **BIPV> Standards compliance**  
Qualification as an active building product  
(CPR 305/2011-CE Marking, building codes ...)

Performance of a BIPV system may significantly differ from a traditional construction system or PV module.

**PV+BUILDING is not BIPV: the sum in not enough!**

The real obstacle to the market is very practical: the uncertainty due to the lack of reference rules, norms and performance assessment approaches

Technology


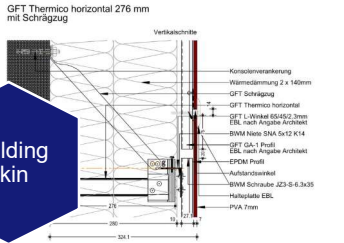
Building skin

Customization

Costs

Quality

Performance



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Reference:  
E. Saretta, P. Bonomo, F. Frontini, *Active BIPV Glass Facades: Current Trends of Innovation*, Glass Performance Days, Tampere, Finland, 2017

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## BIPVBOOST: Towards a new approach for BIPV performance assessment

### Reference methodology/workflow:

**Starting point:** PV and building standards actually in force/defined

### Methodology:

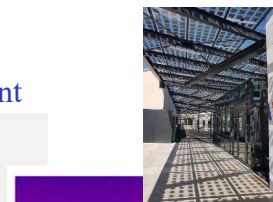
- Analysis of relevant technical requirements in cross-comparison of building and PV standards
- Determination of missing, redundant or incomplete requirements for BIPV
- Decision on the need of add/improve a BIPV requirement for LS/PBA
- *Feedback* from industries and arch./engineers
- Execute test campaigns for validation

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### Key-requirements

- **Energy economy (EE)**
- **Electrical safety in non-conventional scenarios**
- **Mechanical safety and performance**
- **Fire reaction of BIPV components/systems**



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## Ongoing developments. BIPV Energy Economy

### Determination of thermal transmittance (U value)

- Laminated/Insulated PV glass
- Assess the impact of the different BIPV features (cells, JB, cabling) and provide new calculation criteria

### Determination of solar gain (g value)

- Laminated/Insulated PV glass
- Assess the impact of the different BIPV features (cells position, ratio, etc.) and provide new calculation criteria

### Energy economy (EE): Energy Performance of Buildings (EPB)

- Assess the impact of PV glazing as “dynamic transparent element” (electric/thermal/optical) in calculation of EPB and proposal of new calculation criteria

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source: AGC Glass Europe  
Second skin in SunEwat Vision Square

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Ongoing developments. BIPV Electrical performance and safety in non-conventional scenarios

Thermal behaviour in non-conventional scenarios due to shading effects (Serviceability Limit State-SLS)


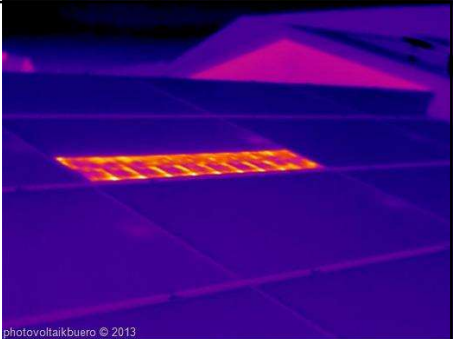
- assess the reference operating temperature of BIPV with regard to reference mounting/shading scenarios for outdoor service life

Electrical insulation and durability of insulating materials in non-c.s. (SLS)

- determine the BIPV module electrical safety/durability while exposed to extreme environmental conditions, relevant for its mounting application category, shading and temperature range

Suitability of protection devices (bypass diodes) and reverse current overload test in non-c.s. (SLS)

- Assess the suitability and relative long-term reliability of bypass diodes under the impact of combined thermal stress



photovoltaikbuero © 2013

Visit also Poster n. 10: E. Ozkalay et al, Operating Temperature of Modules in Open-Rack and BIPV Mounting Configurations

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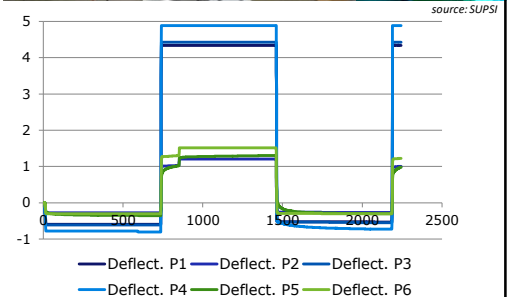

Ongoing developments. BIPV Mechanical performance

Combined mechanical&thermal stress for performance assessment in SLS

- mechanical load at different environmental scenarios
- define/assess the “BIPV” threshold performance for construction and electrical parts (e.g. mechanical rigidity and deflection) as suitable in operative conditions

Combined mechanical&thermal stress for performance assessment in Safeguard Limit State (SfLS) Ultimate Limit State (ULS)

- mechanical load at different environmental scenarios
- define/assess the “BIPV” integrity/safety thresholds for construction and electrical parts (e.g. mechanical rigidity and deflection) as suitable in ultimate/safeguard conditions
- assess the construction and electrical in the product ULS



source: SUPSI

P. Bonomo, F. Parolini, F. Frontini, Safety of laminated BIPV glasses: progresses towards product qualification, Engineered Transparency Conference 2020, under publication

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### Ongoing developments. BIPV Fire Safety


**Fire reaction of BIPV components/systems**

Test procedure with active elements (with/without electrical load) focused on a specific fire safety test (e.g. SBI), and product category (e.g. façade system)

- Investigate current missing gaps for describing BIPV fire behavior due to BIPV critical parts.
- Identification of BIPV specific features (e.g. high operating temperature, cabling, electric part interaction) that influence fire safety.
- The purpose of this work is to suggest new procedures, adapted to BIPV components under fire reaction standard test

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source: SUPSI

source: CSTB

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### IEA PVPS Task 15: *Enabling Framework for the Acceleration of BIPV*

The second phase of Task 15 is divided into 5 subtasks:


- A: Technological Innovation System (TIS) Analysis for BIPV
- B: Cross-sectional analysis: learning from existing BIPV installations
- C: BIPV Guidelines
- D: Digitalization for BIPV
- E: Pre-normative international research on BIPV characterisation methods**

**WEB-site of the Task:**  
<https://iea-pvps.org/research-tasks/enabling-framework-for-the-development-of-bipv/>

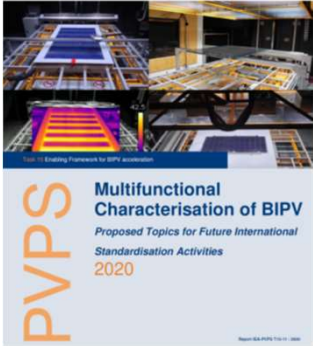
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Technology Collaboration Programme



International Energy Agency  
Photovoltaic Power Systems Programme



PVPS

**Multifunctional Characterisation of BIPV**  
Proposed Topics for Future International Standardisation Activities  
2020

Multifunctional Characterisation of BIPV Proposed Topics for Future International Standardisation Activities

Editors: Helen Rose Wilson (Fraunhofer ISE, Germany),  
Francesco Frontini (SUPSI, Switzerland)

### *ST-E: Pre-normative international research on BIPV characterisation methods*

Sub Task E is focused on four main challenges:

- E.1: Determination of SHGC/g value, taking generated and extracted electricity into account
  - Round robin test organized among different institution
- E.3: Fire safety of BIPV modules and installations
  - Collection of best practices
- E.4: Safety and Reliability of BIPV (new testing procedures and accelerated aging)
  - Combined test for solar facades
- E.5: Standardised procedures to quantify the annual electricity yield of installed BIPV systems

**WEB-site of the Task:**

<https://iea-pvps.org/research-tasks/enabling-framework-for-the-development-of-bipv/>

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### *IEC 63092-1/2 Photovoltaic in buildings (Requirements for building-integrated photovoltaic)*

- CDV (Enquire Stage) for IEC 63092-1 and -2 was approved by national committees.
- PT 63092 has prepared responses to IEC 63092-1 and is now working on responses to comments to Part 2. Then the responses will have to be integrated into the CDs for IEC 63092-1 and -2
- It applies to photovoltaic modules used as construction products (Part 1), and to their corresponding systems to integrate them into the building (Part 2).
- It focuses on the properties relevant to basic building requirements, and on the applicable electro-technical requirements (PV modules).
- It is inspired by the European EN 50583.
- It references international standards, technical reports and guidelines.
- New Proposed IEC 63092-3, Photovoltaics in buildings – Part 3: Evaluation methodology of SHGC for building integrated photovoltaic modules

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### SIA 2062: Gebäudeintegrierte Photovoltaik (title to be confirmed)

**For Engineers, Architectes, Planners and building owners**

- Energy and economic relevance (*Energetische und ökonomische relevanz*)
- Properties of the products (*Eigenschaften der produkte*)
- Architecture, layout, design (*Architektur, gestaltung, design*)
- Constructive implementation (*Konstruktive umsetzung*)
- Technical system (*Systemtechnik*)
- Project procedure and responsibilities (*Projektablauf und verantwortlichkeiten*)
- Commissioning, acceptance and documentation (*Inbetriebsetzung, abnahme und dokumentation*)
- Operation (*Betrieb*)

For further information:

Präsident SIA2062: Herr Pius Hüsser, Nova Energie GmbH



**sia**  
schweizerischer ingenieur- und architektenverein  
société suisse des ingénieurs et des architectes  
società svizzera degli ingegneri e degli architetti  
swiss society of engineers and architects

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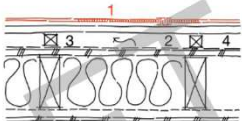
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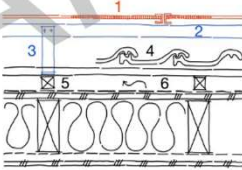
### SIA 2062: Gebäudeintegrierte Photovoltaik (title to be confirmed)

**Different categories of product/system, different solution possible, different recommendation**

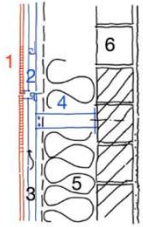
Kategorie	1	2	3	4	5
A: Flachdach (Kap. 4.2)	giebelartig (ost-west-aufgeständert)	shedartig (süd-aufgeständert)	dachrandparallel	stark geneigt oder vertikal	hoch aufgestellt (begrünte Dächer)
B: geneigte Dachfläche (Kap. 4.3)	vollständig integriert	teilflächig integriert	aufgesetzt	Spezialformat	
C: Fassade (Kap. 4.4)	hinterlüftet	Brüstungsbländer integriert	Lichtdurchlässige Fläche integriert	nicht hinterlüftet: Kompaktfassade	abgesetzt
D: Anbauten am Gebäude (Kap. 4.5)	Brüstung, Geländer freistehend	Vordach	Wintergarten, Pergola	fixe Verschattungselemente	bewegliche Verschattungselemente



1 gerahmtes PV-Modul / 2 Ziegellattung  
3 Konterlattung Hinterlüftung / 4 Unterdach



1 gerahmtes PV-Modul / 2 Unterkonstruktion  
3 Befestigungshaken / 4 Ziegeleindeckung auf Ziegellattung / 5 Konterlattung zur Hinterlüftung / 6 Unterdach



Photovoltaikmodul (Bekleidung) z.B. ohne Rahmen  
1/2 Aufhängungssystem der Bekleidung / 3 Hinterlüftungsebene / 4 Unterkonstruktion / 5 Wärmedämmung / 6 Tragwerk, Massivbauweise

Categorisation of PV systems

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Source: prSIA 2062 Bauwesen

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### Conclusions

- The construction of **multifunctional BIPV products**, involves the use of several materials that must coexist
- These elements, assembled together, mutually induce and **influence changes** both in **energy** and in the **construction performance**
- At the state of art of BIPV quality assessment is based on the application of the test **methodologies provided separately by the PV or the building regulations**.

### BI (building) + PV (photovoltaics) ≠ BIPV

- A **harmonized technical/normative approach** for BIPV is welcome (IEC, EN, SIA are working on that)
- Next activities will be aimed at progressing on the research and development of **new qualification procedures for BIPV** performance assessment towards an integrated approach.

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### Platform for «sun as a building material»: [www.solarchitecture.ch](http://www.solarchitecture.ch)

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ETH zürich

SWISSOLAR

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Visit our poster n. 22

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Thanks to all partners and contributors

Prof. Francesco Frontini

[francesco.frontini@supsi.ch](mailto:francesco.frontini@supsi.ch)

[www.supsi.ch/isaac](http://www.supsi.ch/isaac)

[www.solarchitecture.ch](http://www.solarchitecture.ch)



SOLARCHITECTURE

sun as a building material

Mit Unterstützung von

energieschweiz



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra







3S Solar Plus

Kromatix

KIOTO  
SOLAR

SYNAGE  
SOLAR BUILDING SKIN

SEEN

ewz

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