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Photovoltaic Power Systems Programme

Task 15 Enabling Framework for the Development of BIPV -
Fire Safety of BIPV: International Mapping of Accredited and R&D Facilities in the Context of Codes and Standards

PVPS

Fire Safety of BIPV: International Mapping of Accredited and R&D Facilities in the Context of Codes and Standards

2023

Report IEA-PVPS T15-15: 2023

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What is IEA PVPS Task 15?

The objective of Task 15 of the IEA Photovoltaic Power Systems Programme is to create an enabling framework to accelerate the penetration of BIPV products in the global market of renewables, resulting in an equal playing field for BIPV products, BAPV products and regular building envelope components, respecting mandatory issues, aesthetic issues, reliability issues, and financial issues.

Subtask E of Task 15 is focused on pre-normative international research on BIPV characterisation methods and activity E.3 is dedicated to fire safety of BIPV modules and installations.

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COVER PHOTO: Reaction to fire test according to method SP Fire 105 on a BIPV façade system (Source: RISE Fire Research)
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IEA PVPS

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LIST OF ABBREVIATIONS

ABCB	Australian Building Codes Board
ABNT NBR	Associação Brasileira de Normas Técnicas – Norma Brasileira
AICA/VKG	Associazione degli istituti cantonali di assicurazione (AICA) - Vereinigung Kantonaler Gebäudeversicherungen (VKG) (Association of Cantonal Fire Insurance Institutions)
AENOR	The Spanish Association for Standardization and Certification (aenor.org)
ASTM	American Society for Testing and Materials International
BAPV	Building-Applied Photovoltaics
BIPV	Building-Integrated Photovoltaics
CAN/ ULC	Underwriters Laboratories of Canada
CEC	Canadian Electrical Code
CENELEC	European Electrotechnical Committee for Standardization (cencenelec.eu)
CIEMAT	Centre for Energy, Environmental and Technological Research (ciemat.es)
CPR	Construction Products Regulation (European)
CTE	Technical Building Code (CTE: Código Técnico de la Edificación)
DIBt	Deutsches Institut für Bautechnik (German Institute for Building Technology
DIN	Deutsche Industrienorm (German industrial standard)
EIB	The European Investment Bank (eib.org
FOTOPLAT	The Spanish Photovoltaic Technology Platform (fotoplat.es)
IBC	International Building Code
ICC	International Code Council
IEC	International Electrotechnical Commission (iec.ch)
IEA	International Energy Agency
IRC	International Residential Code
IREC	Catalonia Institute for Energy Research (irec.cat)
LVD	Low Voltage Directive (European)
MCI	Ministry of Science and Innovation (mci.gob.es)

MITECO	Ministry for the Ecological Transition and the Demographic Challenge (miteco.gob.es)
MFPA	(Gesellschaft für Materialforschung und Prüfungsanstalt für das Bauwesen) Centre for material research and testing
MPA	(Material Prüfanstalt) Material testing centre
MRAs	Mutual recognition agreements
MVV TB	Musterverwaltungsvorschrift Technische Baubestimmung (model administrative provision - technical building rules)
NANDO	New Approach Notified and Designated Organizations
NBCC	National Building Code of Canada
NFC	National Fire Code of Canada
NFPA	National Fire Protection Association
nZEB	Net Zero Energy Building
PNIEC	The Spanish Integrated National Energy and Climate Plan 2021-2030
PTEC	The Spanish Construction Technology Platform (plataformaptec.es)
PVPS-IEA	Photovoltaic Power Systems Program of the International Energy Agency
RFn	Reaction to fire
TABs	Technical Assessment Bodies
TIS	Technological Innovation System
TÜV	Technischer Überwachungsverein
UL	Underwriters Laboratories
UNE	The Spanish Association for Standardization (une.org)
UNEF	The Spanish Photovoltaic Association (unef.es)

EXECUTIVE SUMMARY

This report presents a non-exhaustive overview of more than twenty laboratories around the world where construction products and materials are being tested for fire safety. These laboratories are confirmed to have a common interest in the assessment of BIPV products and systems, even though not all of them may have any experience of it so far. Countries represented in this report are Australia, Austria, Brazil, Canada, China, France, Germany, Italy, Japan, Korea, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, The Netherlands, the United Kingdom and the United States.

The report furthermore aims to provide brief overviews of internationally applicable fire-safety standards, national building codes and regulations related to fire safety of BIPV modules and systems and to recommend the test methods which could be applied at some accredited and R&D facilities worldwide.

To achieve this, brief descriptions of fire-safety international standards are presented, together with their relationships with national and local building requirements and regulations for BIPV products, followed by a list of international standards and brief scope descriptions relevant to fire safety of BIPV. This is provided as background information but does not intend to be a detailed analysis of all international, European, and American standards as such.

The main content of this report presents fire-safety testing facilities, which are initially summarized in an overview map, including those facilities which are not further elaborated in the sub-sections. Examples of accredited laboratories and R&D facilities for BIPV/BAPV fire safety are presented per country, based on the answers that were received to questionnaires on experience made with accredited and R&D fire-safety test facilities for BIPV modules and systems. One version of the questionnaire on BIPV fire-safety test facilities, that was developed within Activity E.3 of the IEA-PVPS Task 15 and is applicable internationally, is included for documentation purposes. A total of fifteen responses was received to the questionnaire; these are summarized in an Annex for future reference.

Despite increasing deployment of BIPV modules and systems in the built environment, the challenges of harmonizing standards at the international level have not yet been overcome. The report concludes by briefly addressing the future development of new testing procedures and opportunities relevant to the fire-related safety of BIPV.

1. INTRODUCTION

The objective of this report is to provide an overview of laboratory resources available for the assessment and further development of fire properties of BIPV products and systems. The report also provides a brief overview of currently used international, European, and American testing and classification standards related to fire properties of PV and BIPV systems and how they relate to national building codes in several countries around the world. Thus, the report addresses an important part of what the term “fire safety” includes but it does not cover other parts. Considering the early stage of development of most of these applications, not only products and systems but also regulations, codes, test methods and standards need further development to reflect the fire-safety risks specific to PV systems in general and BIPV systems in particular. In this context, the laboratory resources listed herein and the large number of test standards that are being used in these laboratories also form an important base for development of new test methods or adaptation of existing ones. One important limitation in current testing of fire properties reviewed here is that it focuses on products and materials and more seldom assesses additional risks that arise from combining products into larger structures in buildings. These aspects have been identified and discussed in two review papers addressing fire-safety aspects of photovoltaics in buildings, including BIPV installations.[1,2]

2. FIRE SAFETY STANDARDS

Some of the laboratories listed in this report have provided extensive lists of standards for which they are accredited. The contents or scope of the standards must be determined by consulting the standards themselves. Table 1 to Table 3 provide a short, non-exhaustive overview of the most relevant standards, in the context of this report, developed in Europe, the US and internationally. National standards in most parts of the world are developed based on these standards even though there are many others developed in a national context. In almost all countries, the standards being used are a complex mix of national (most notably American), European and international standards. A few examples:

- In the US, the UL IEC 61730 was recently added to the list of UL/ ANSI standards, where IEC 61730 has been complemented with contents from UL standards.

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[1] R. Yang, Y. Zang, J. Yang, R. Wakefield, K. Nguyen, L. Shi, B. Trigunarsyah, F. Parolini, P. Bonomo, F. Frontini, D. Qi, Y. Ko, X. Deng. Fire safety requirements for building integrated photovoltaics (BIPV): A cross-country comparison. Renewable and Sustainable Energy Reviews 173 (2023) 113112 https://doi.org/10.1016/j.rser.2022.113112

[2] M. Aram, X. Zhang, D. Qi, Y. Ko. A state-of-the-art review of fire safety of photovoltaic systems in buildings. Journal of Cleaner Production 308 (2021) 127239 https://doi.org/10.1016/j.jclepro.2021.127239

- In Europe, as further described below, there is a harmonized system for classification of fire properties of materials and products based on the EN 13501 series of standards. However, test standards used to determine the classes can be either EN or ISO standards.
- In Australia, AS 5033 requires a fire resistance test as a basic test for BIPV fire safety. The proposed tests are derived from ANSI/UL 790. Additionally, BIPV applied in buildings should also satisfy the additional requirements in the National Construction Code (NCC) via Deemed-to-Satisfy Solution or Performance Solution.
- In China, all enterprises and testing institutions for photovoltaic modules implement the fire protection test method of the UL 790 standard.

One area where this absence of harmonization causes confusion is the classification of the fire properties of materials and products. Two classification systems, an international one (mainly based on IEC and UL standards) and a European one (“Euroclass” based on EN standards) use the same letter codes to rate classes. However, the meaning of e.g. Class A, B or C is significantly different in the two systems.

Table 1: International standards relevant for BIPV and/or fire safety.

Number: IEC 63092 **Name:** Photovoltaics in buildings Part 1: Building integrated photovoltaic modules Part 2: Building integrated photovoltaic systems **Scope (Short version):** IEC 63092 specifies BIPV module and system requirements. It applies to photovoltaic systems that are integrated into buildings with the photovoltaic modules used as building products. It focuses on the properties of these photovoltaic systems relevant to basic building requirements and the applicable electrotechnical requirements. **Comment:** As part of the building envelope, the fire safety of BIPV systems shall be considered with the aim of minimizing the risk of both fire propagation and fire penetration into the building. Until international standards are harmonized, national, regional, or local standards or codes may apply.
Number: IEC 61730 **Name:** Photovoltaic (PV) module safety qualification Part 1: Requirements for construction Part 2: Requirements for testing **Scope (Short version):** IEC 61730-1 specifies and describes the fundamental construction and testing requirements for photovoltaic (PV) modules to provide safe electrical and mechanical operation, including prevention of fire hazards. IEC 61730-2 is applied for safety qualification only in conjunction with IEC 61730-1. **Comment:** There are no mandatory requirements for fire tests, spread of flame and burning-brand tests for PV modules in this standard. The *informative* Annex B of Part 2 references e.g., EN 13501-5, CEN/TS 1187 and ANSI/ UL 1703. It contains some specific requirements for BIPV modules. Additional testing requirements outlined in relevant ISO standards, or the national or local codes which govern the topic of fire safety of BIPV modules or systems in their intended locations, should be considered.
Number: IEC 61215 **Name:** Terrestrial photovoltaic (PV) modules – Design qualification and type approval Part 1: Test requirements Part 2: Test procedures **Scope (Short version):** The objective of this test sequence is to determine the electrical characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure outdoors. **Comment:** Fundamentally, this is a mandatory standard for testing of PV modules. Additional testing of BIPV modules may be required (see IEC 63092 and EN 50583). It contains no tests directly related to fire safety but includes hot-spot endurance test and bypass diode testing.

Number: ISO/TS 18178

Name: Glass in building — Laminated solar photovoltaic glass for use in buildings

Scope (Short version): This document specifies requirements of appearance, durability and safety, test methods and designation for laminated solar photovoltaic (PV) glass for use in buildings. It is applicable to building-integrated photovoltaics (BIPV).

Comment: Contains no tests or requirements directly related to fire safety.

Table 2: European standards relevant for BIPV and/or fire safety.

Number: EN IEC 61730 **Name:** Photovoltaic (PV) module safety qualification Part 1: Requirements for construction Part 2: Requirements for testing **Scope (Short version):** See Table 1 **Comment:** The only difference between the international version of this standard and the European one is an introductory part in the latter explaining how it relates to European legislation.
Number: EN 50583 **Name:** *Photovoltaics in buildings –* *Part 1: BIPV modules* *Part 2: BIPV systems* **Scope (Short version):** Part 1 applies to photovoltaic modules used as construction products. It focuses on the properties of these photovoltaic modules relevant to basic building requirements as specified in the European Construction Product Regulation CPR 305/2011, and the applicable electro-technical requirements as stated in the Low Voltage Directive 2014/35/EU or CENELEC standards. Part 2 applies to photovoltaic systems that are integrated into buildings with the photovoltaic modules used as construction products. **Comment:** Depending on the application category, either of these standards apply for fire safety testing and classification of BIPV modules and systems as construction products: EN 13501-2 EN 13501-5 For modules, EN 13501-1 additionally applies, and the manufacturer shall declare the fire rating. Electro-technical requirements for BIPV modules (Part 1) refer to EN IEC 61215 and EN IEC 61730, where the latter is harmonized in accordance with the Low Voltage Directive LVD 2014/35/EU. For BIPV systems (Part 2), the EMC Directive 2014/30/EU additionally applies.
Number: EN 13501-1 **Name:** Fire classification of construction products and building elements Part 1: Classification using data from reaction to fire tests **Scope (Short version):** This document provides the reaction to fire classification procedures for all construction products. **Comment:** Applicable to all mounting categories for BIPV modules containing glass panes. Further requirements depend on application and country. One or more of the following standards are applied, depending on the targeted class: - Non-combustibility (EN ISO 1182) - Heat of combustion test (EN ISO 1716) - Single burning item test (EN 13823) - Ignitability test (EN ISO 11925-2)

Number: EN 13501-2 **Name:** Fire classification of construction products and building elements Part 2: Classification using data from fire resistance tests, excluding ventilation services **Scope (Short version):** This European Standard specifies the procedure for classification of construction products and building elements using data from fire resistance and smoke leakage tests which are within the direct field of application of the relevant test method. Classification based on extended application of test results is also included in the scope of this European Standard. **Comment:** Applies to BIPV modules and systems in some mounting categories. References more than 50 different test standards that, depending on function and application, can be applied. The standards cover load-bearing and non-load-bearing construction elements with or without a fire separating function.
Number: EN 13501-5 **Name:** *Fire classification of construction products and building elements* *Part 5: Classification using data from external fire exposure to roofs tests* **Scope (Short version):** This European Standard provides the fire performance classification procedures for roofs/roof coverings exposed to external fire based on the four test methods given in CEN/TS 1187:2012 and the relevant extended application rules. Products are considered in relation to their end use application. NOTE The distinction between roofs with a steep slope and facades, in terms of the test and classification standard to be applied, may be subject to national regulations. **Comment:** Applies to BIPV modules and systems in some of the mounting categories of EN 50583. In the Nordic countries, classification B_{ROOF}(t2) is applied. Other countries have different requirements, some examples are Germany which applies t1, UK t4 and France t3. The various test methods are described in more detail in the technical specification CEN/TS 1187.
Number: EN 14351-1 **Name:** *Windows and doors – Product standard, performance characteristics* *Part 1: Windows and external pedestrian door sets* **Scope (Short version):** This European Standard identifies material-independent performance characteristics, except resistance to fire and smoke control characteristics, that are applicable to windows (including roof windows).
Comment: Applies to BIPV systems in mounting category B. For determination of reaction to fire characteristics this standard refers to EN 13501-1 and Annex H for the selection, preparation, mounting and fixing and field of direct application of the roof windows. It also refers to EN 13501-5, here called “External fire performance”.

Number: EN 13823 **Name:** Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item **Scope (Short version):** This document specifies a method of test for determining the reaction to fire performance of construction products when exposed to thermal attack by a single burning item (SBI). **Comment:** The single burning item (SBI) test method is originally developed for testing of interior materials and products but is also used for externally applied construction products. Several European countries do not consider it to be appropriate for facade testing and therefore propose or require additional testing according to national standards. Recent research has proposed developing the method to make it more suitable for this purpose.
Number: EN 13830 **Name:** Curtain walling - Product standard **Scope (Short version):** This European Standard specifies requirements of curtain walling kit intended to be used as a building envelope to provide weather resistance, safety in use and energy economy and heat retention and provides test/assessments/calculation methods and compliance criteria of the related performances. **Comment:** When relevant, the reaction to fire test shall be carried out in accordance with the test method relevant for the class claimed by the manufacturer. Test results are classified according to EN 13501-1. The materials to be considered as belonging to Class A1 without test are listed in the EC Decision 96/603/EC (as amended). Fire resistance of curtain walls is tested according to EN 1364-3 or -4
Number: EN 1364 **Name:** Fire resistance tests for non-loadbearing elements – Part 1: Walls Part 3: Curtain walling – Full configuration (complete assembly) Part 4: Curtain walling – Part configuration **Scope (Short version):** The three standards are used to test non-loadbearing walls with and without glazing, The fire resistance of external non-loadbearing walls (except curtain walls) can be determined under internal or external exposure conditions according to Part 1. Curtain walls (external non-loadbearing walls suspended in front of the floor slab), are tested according to Part 3 or Part 4. **Comment:** The standard is intended to be read in conjunction with part 1 or parts 1 and 2 of EN 1363

Number: CEN/TS 1187 **Name:** Test methods for external fire exposure to roofs
Scope (Short version): This Technical Specification specifies four methods for determining the performance of roofs to external fire exposure. The four methods assess the performance of roofs under the following conditions: a) test 1 – with burning brands; b) test 2 – with burning brands and wind; c) test 3 – with burning brands, wind and supplementary radiant heat; d) test 4 – with two stages incorporating burning brands, wind and supplementary radiant heat. **Comment:** Classification according to EN 13501-5 is based on either of the tests 1 to 4. Out of the four tests, only one is used to show compliance to the requirements in any given European country. Since a harmonization so far could not be reached, different countries use different tests. A proposed test configuration for a BIPV roof based on test 1 is presented in EN IEC 61730 Annex B2.2.

Table 3: American standards relevant for BIPV and/or fire safety.

Number: UL 790 **Name:** Standard Test Methods for Fire Tests of Roof Coverings **Scope (Short version):** These requirements cover the measurement of the relative fire characteristics of roof coverings exposed to simulated fire sources originating from outside a building on which the coverings are installed. They are applicable to roof coverings intended for installation on either combustible or noncombustible roof decks (see 4) when the roof coverings are applied as intended. The following test methods are included: – Intermittent-Flame Exposure test; – Spread of Flame test; – Burning Brand test; – Flying Brand test; and – Rain test **Comment:** Among the countries represented in this report, the standard is applied as it is in the US, Japan, Korea and Singapore and formed the basis for Australian standards.
Number: UL 1703/61730 **Name:** Photovoltaic (PV) module safety qualification Part 1: Requirements for construction Part 2: Requirements for testing **Scope (Short version):** See Table 1: IEC 61730 **Comment:** The UL 61730 contains the IEC 61730 plus a US “National differences document” which, when it comes to fire safety, mainly refers to the UL 790 standard.

Harmonizing methods and standards on fire safety appears at present to be an impossible task at the global, or even the European level. In Europe, each country has authority over its own safety regulations. Nevertheless, relatively far-reaching harmonization has been achieved through the Euroclass system, see 2.1 and 3.5.

2.1 Relationship between European and international standards concerning fire safety and local building requirements

In brief, BIPV should comply with two different standardization and regulation schemes: one derived from building requirements, which are often regulated by local building codes and international ISO or EN standards, and the other derived from PV electrical requirements, which are often regulated by international IEC standards and local electrical regulations.

In terms of ensuring building safety, the final evaluation of the performance of BIPV modules needs to be based on the most stringent standards. In general, each country or region sets its own standards for the fire safety performance of the building envelope. In this context, PV power generation occurs in the building envelope, so the fire performance of BIPV modules must comply with the relevant building requirements.

Currently, there are few standards focusing on BIPV. Before 2020, three specific international standards existed for BIPV, ISO/TS 18178, IEC 62980 (subsequently withdrawn) and EN 50583. In 2020, IEC 63092 was published as the resultant international standard, based on the structure and content of EN 50583 and formally replacing IEC 62980, with appropriate updates in accordance with EN 50583 and ISO/TS 18178. For the electro-technical requirements, IEC 63092 refers to IEC 61215 and IEC 61730. For requirements related to construction products, IEC 63092-2 states, for many performance requirements, that one should refer to national, regional or local standards or codes, particularly in relation to fire safety.

As PV products, BIPV products must comply with the requirements and classification procedures relating to fire in the PV standards. The most important internationally used standards for PV testing are the American ANSL/UL 1703 and the IEC series of standards of the International Electrotechnical Commission, including IEC 61730 and IEC 61215. Additionally in the US, UL 790 describes test methods for fire safety of roof constructions. IEC 61215 mainly concerns durability and performance testing, while IEC 61730 concerns safety qualification, including relevant information (non-normative) on fire safety, see Table 1. All aspects that have an impact on safety (e.g. electrical and fire safety) are usually dealt with through national standards and codes. Thus, although Canada and US may use IEC standards as a basis for their standards (e.g. IEC 61730 as UL 61730 in the US and CSA C22.2 no. 61730 in Canada), or develop their own national standards (former UL 1703 in the US), certain sections like fire tests and electrical requirements in IEC standards are for the most part modified to comply with national codes and regulations through the addition of national deviations when a safety-related IEC standard is adopted in a given country.

As a building product, not only BIPV modules but also BIPV building elements/systems must comply with the relevant requirements of the local building codes. International standards for BIPV/PV (IEC 63092 and IEC 61730) state that the fire-safety requirements of BIPV should also comply with national/local building regulations. In Europe, IEC 61730 has been accepted with modifications as an EN standard, but European acceptance of IEC 63092 has been waived, as it references various ISO standards that are not the legally binding standards for building products in Europe. EN 50583 refers to EN standards for building products and fulfills the same role in Europe as IEC 63092 does outside of Europe.

In Europe, members of the European union and associated countries are obliged to follow European regulations and to implement them as part of their national regulations as soon as they enter into force. In the case of fire safety, the European Euroclass system of fire safety standards, defining test methods and classification systems is therefore part of all national building codes.

In addition to the fire classification scheme given by the EN 13501 series, the European countries have similar but not identical approaches to defining the requirements for the product when incorporated. Thus, the required fire-safety class normally depends on the building type, including the number of floors or building height and on the type of building usage. It can also be noted that the main standard in the Euroclass system, EN 13501-1, references several ISO standards. A fact that may be confusing is that the EN 50583 still has not been harmonized and therefore it is not a mandatory standard. However, since the Euroclass system is part of the national codes, it is to be followed when BIPV modules are used as construction products. A more extensive description of the European system for assessment and certification of construction products is presented in 3.5. Figure 1 illustrates how the French building code and related codes are governed by different ministries, depending on what type of building is addressed. This picture may differ significantly from one European country to another, as described in 3.5.

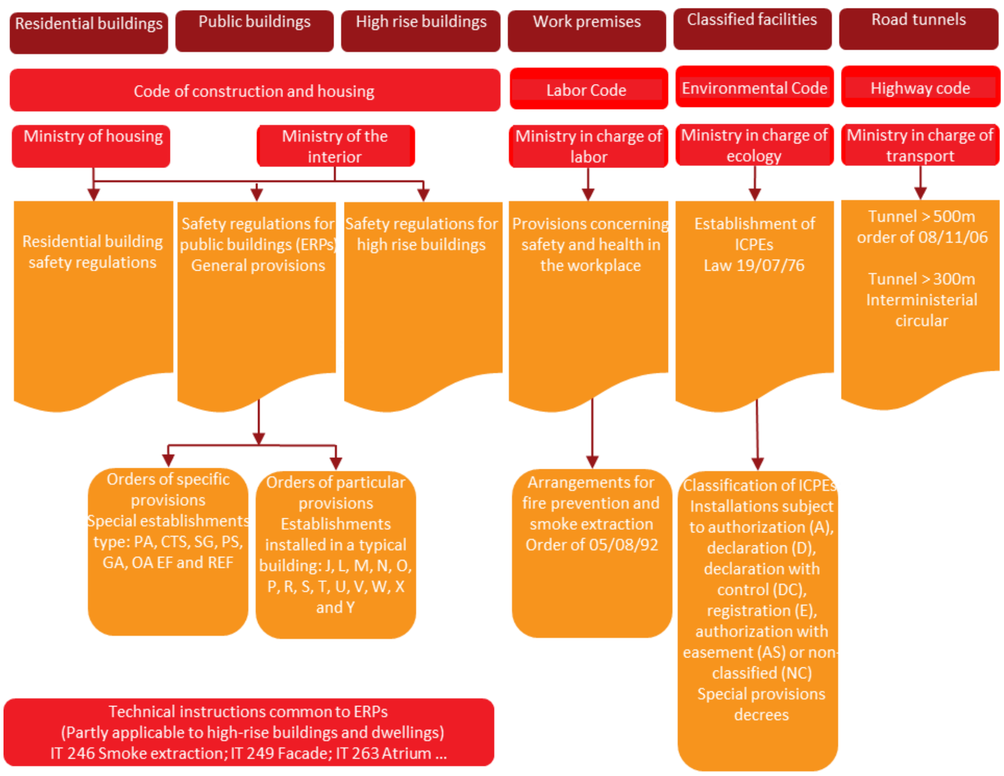

Figure 1: Schematic diagram of ministries responsible for different parts of the French building code.

3. EXAMPLES OF ACCREDITED LABORATORIES, R&D FACILITIES AND REGULATORY STATUS FOR FIRE SAFETY IN PARTICIPATING COUNTRIES

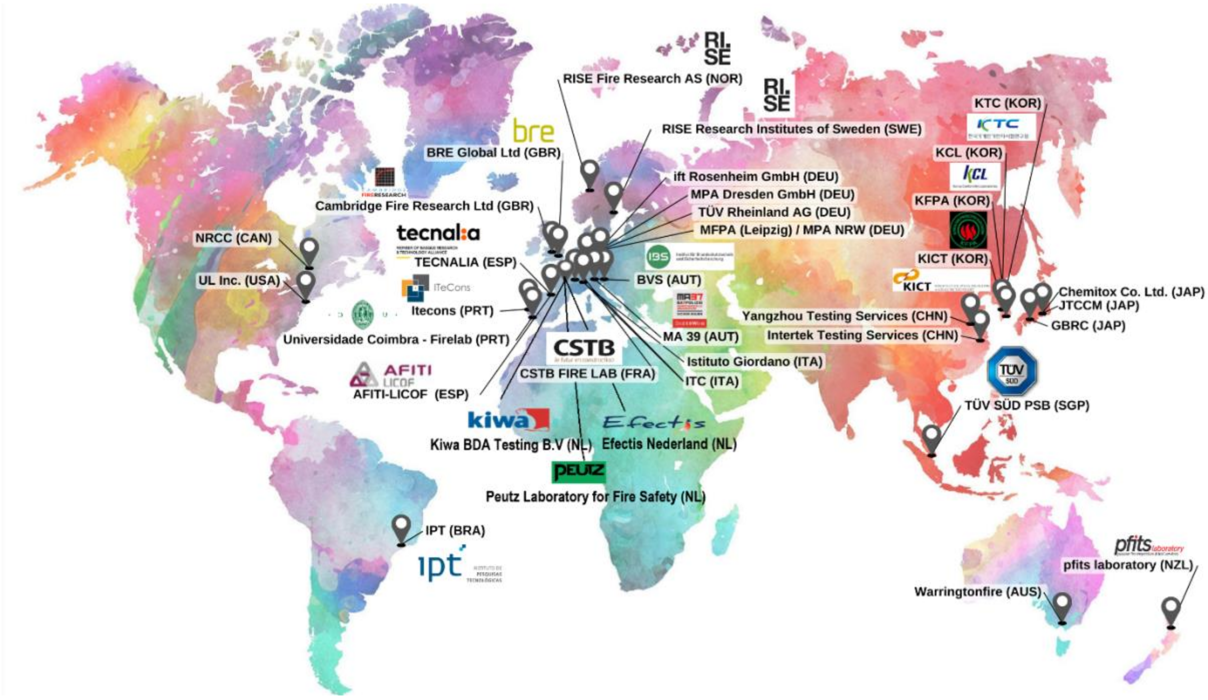

Figure 2: Accredited laboratories and R&D facilities represented in the report.

A non-exhaustive overview of more than twenty laboratories around the world, where construction products and materials including BIPV are tested for fire safety, is presented in Figure 2. These are the accredited laboratories and R&D facilities included in the main body of the report and further described in Annex A. Laboratories from three more countries, not included in this section, are also listed in the Annex.

3.1 Australia

Figure 3: Photo of the test facility from the outside.

Australian standards for electrical applications refer to the international standards of IEC. IEC 63092 and IEC 61730-2 state that the fire safety of BIPV/BAPV products should comply with the local regulations. BIPV/BAPV products in Australia should comply with the National Construction Code (NCC) released by the Australian Building Codes Board (ABCB).

There are two main Australian standards, AS/NZS 5033 and AS/NZS 3000, that take PV products into consideration. BIPV products should comply with the requirements for PV modules in Australian standards to mitigate the potential fire risk from the electrical components or circuit in the BIPV module. AS/NZS 5033 and AS/NZS 3000 are cross-referenced PV design and installation standards. AS/NZS 5033 recommends the methods to protect against overcurrent, overvoltage, and earth faults. For PV modules integrated into buildings, AS/NZS 5033 requires that BIPV should comply with the additional requirements in the National Construction Code (NCC). Consistent with IEC 63092, the requirements in AS/NZS 5033 relating to PV fire safety during the installation and operation phases also refer to international standards IEC 61215 and IEC 61730. In addition, AS/NZS 5033 requires that all equipment and wiring be selected and installed according to the provisions of AS/NZS 3000 and the requirements of this standard. AS/NZS 3000 establishes requirements for the design, construction, and verification of electrical installations, including the selection and installation of electrical equipment, including PV arrays.

As a building element, the building system with BIPV should comply with the relevant Performance Requirements of Section C in NCC based on the construction types. Deemed-to-Satisfy Solution and Performance Solution are two pathways to assess BIPV. According to the Performance Requirements, Parts 1, 3 and 4 of AS 1530 '*Methods for fire tests on building materials, components and structures*', which address '*Combustibility test for materials*', '*Simultaneous determination of ignitability, flame propagation, heat release and smoke release*', and '*Fire-resistance tests for elements of construction*' respectively, are related to the Australian standard which needs to be satisfied. Each building element should satisfy one or more parts of AS 1530. In addition, the NCC states the verification method used to judge the

Performance Solution. Section C's Verification 1, 2 and 3 (i.e. CV1, CV2, and CV 3) include the requirements and test methods in AS 5113.

Some test configurations are recommended when BIPV products are tested in terms of the above Australian standards. For AS 1530.1, a single burning items test is appropriate for BIPV products due to the requirement on the size of the specimen. In AS 1530.4, the location of the BIPV product should be considered inside or outside the furnace. A solar simulator should be used during the test procedure of AS 5113 and AS 1530.3, which could keep the BIPV/BAPV module electrically active. An example test lab is shown in the following table.

Table 4: Test facility information in Australia.

Test facility name: Warringtonfire Australia **Location:** 409-411 Hammond Road, Dandenong South 3175 Australia **Contact person:** Steven Halliday – steven.halliday@warringtonfire.com / Kai Loh – kai.loh@warringtonfire.com / Tanmay Bhat – tanmay.bhat@warringtonfire.com **For further details see A.1 Australia**

3.2 Brazil

Figure 4: LSFEx Vertical Furnace.

Local fire safety codes are the responsibility of state fire departments, 27 states and 27 codes. The most coherent adopt as a reference, in full, the Brazilian technical standards, for several themes of fire protection. The BIPV/BAPV requirements will be established next year in the Brazilian standard that will be prepared, which will follow international standards. Regarding civil construction issues, standards already exist and are established in Brazil. As BIPV/BAPV introduces new risks for starting and aggravating fires, whether on facades or roofs, the existing standards will have to be adjusted. The standard to be developed will also address issues related to access during fire-fighting, fire-fighting techniques and electrical protection.

Regarding photovoltaic systems, today, tests on products following these Brazilian standards are performed:
• ABNT NBR 16841:2020 – *“Fire behavior of roofs and coatings and coverage subjected to an external ignition source”.*
• The component (solar panel) must comply with ABNT NBR 16626:2017 for class II-A (internal part of the building) and II-B for the external part (according to ABNT NBR 9442 and ASTM E 662 standard);

• State legislation of the fire department through Technical Instructions IT-10: 2019.

INMETRO lists accredited IPT tests under ABNT NBR ISO/IEC 17025[3]. These tests comply with international standards, Brazilian legislation and regulations specific to the State of São Paulo. Product certification (ISO/IEC 17065) is centralized at Inmetro[4] that also registers the laboratories[5]. An example test lab is shown in the following table.

Table 5: Test facility information in Brazil.

Test facility name: LSFEx/IPT **Test facility location:** São Paulo, Brasil, Zip code 05508-901 **Contact person:** afberto@ipt..br **For further details see A.2 Brazil**

[3] http://www.inmetro.gov.br/laboratorios/rble/detalhe_laboratorio.asp ?nom_apelido=IPT%2FHE

[4] https://www.gov.br/inmetro/pt-br/assuntos/avaliacao-da-conformidade/selo-de-conformidade e https://www.gov.br/inmetro/pt-br/assuntos/acreditacao.

[5] http://www.inmetro.gov.br/laboratorios/rble/lista_laboratorios.asp?sigLab=&ordem=&tituloLab=&uf=&pais=&descr_escopo=fogo&classe_ensaio=&area_atividade=&ind_tipo_busca=&pagina=2

3.3 Canada

Figure 5: Photographs of fire-resistance testing facilities. Thermocouple trees installed in a test room built with massive timbers (top) and floor test furnace (bottom).

In Canada, BIPV/BAPV products should comply with the National Building Code of Canada (NBCC) for the installation and design as a component of the building. When developing code, the NBCC refers to the test and acceptance criteria which are obtained by the standard fire test methods of the American Society for Testing and Materials International (ASTM), Underwriters Laboratories (UL) and Underwriters Laboratories of Canada (CAN/ULC). Simultaneously, BIPV/BAPV products should also comply with the Canadian Electrical Code (CEC) as an electrical application and the National Fire Code of Canada (NFC) for fire protection.

The Canadian Electrical Code (CEC) defines the requirements for the PV system, e.g., PV circuit, PV wiring, junction box, and PV battery, which should be satisfied for BIPV/BAPV as a PV product. Moreover, the PV components can be the direct cause of fire so they should also follow the standards of the electrical requirements for fire safety. PV modules should comply with the test methods of UL 1699B standard *“PV DC Arc-Fault Circuit Protection”,* UL 4703 *“Standard for Photovoltaic Wire”,* UL 6703 *“Standard for Connectors for Use in PV Systems”*, and UL 3730 *“Standard for PV Junction Boxes”.* Those standards address the electrical risks of fire: reverse current overload, short circuit, and hot spot. Excluding the requirements of an individual component, the entire PV system installations must comply with CEC and the instructions from the manufacturer to avoid human-caused accidents related to PV panels, cables, inverters, connectors, junction boxes, and batteries.

As an integral part of the building, BIPV/BAPV should also ensure the installation safety of structural requirements called “dead load”, especially the support beams which can be weakened by fires. For example, BIPV should consider the collateral loads such as a glass

skylight and framing, based on the requirements of the NBCC. CAN/ULC S134 ‘*Standard Method of Fire Test of Exterior Wall Assemblies*’ also provides the requirements for a fire test of a BIPV façade on a vertical wall; CAN/ULC S107-03 '*Methods of Fire Tests of Roof Coverings*' provides the corresponding requirements for the roof-covering materials of BIPV ; CAN/ULC-S102 '*Surface Burning Characteristics of Building Materials and Assemblies Test*' provides the skylight and windows requirements for BIPV. BIPV/BAPV roofs also have a requirement on the access and pathway for the firefighter. In particular, requirements for ridge setbacks and pathway allowances at roof edges, hips and valleys are established by the local municipality, which is to allow fire departments access to the roof during a fire emergency for smoke ventilation. An example test lab is shown in the following table.

Table 6: Test facility information in Canada.

Test facility name: National Research Council Canada (NRCC) **Location:** Ottawa, Ontario, Canada **Contact person:** Yoon Ko – yoon.ko@nrc-cnrc.gc.ca **Check the link below for general information:** https://nrc.canada.ca/en/research-development/nrc-facilities/fire-safety-testing-facility **For further details see A.3 Canada**

3.4 China

Figure 6: Spread of flame test.

Relationship between local building/construction standards and international/national standards

The national standards relating to BIPV in China include *GB/T 51368 Technical Standard for Photovoltaic System on Building*, *GB/T37655 Acceptance Specification of Building Integrated Photovoltaic Power Systems*, *JGJ/T492 General Specification of Photovoltaic Components for Building*, *JGJ/T 365 Code for Electrical Design of Solar Photovoltaic Glass Curtain Wall*, etc.

The standards require that the fire rating of photovoltaic modules should not be lower than the fire rating of materials required for the building location. The requirements for fire protection and fire prevention are mainly based on the ratings according to standards such as IEC

61370, *GB 50016 "Code for Fire Protection Design of Buildings"*, *T/CSTM 00260 "Test Method for Fire Rating of Roof Crystal Silicon Photovoltaic and Profiled Steel Sheet Component"*, *GB 8624-2012 "Classification for Burning Behavior of Building Material"*, GB/T 9978.1 ~ GB/T 9978.9 series standards for fire-resistance testing of building construction elements, etc.

In IEC 61730, currently, all enterprises and testing institutions for photovoltaic modules implement the fire-protection test method of the UL 790 standard. *T/CSTM 00260 "Test Method for Fire Rating of Roof Crystal Silicon Photovoltaic and Profiled Steel Sheet Component"*, is consistent with GB 8624 standard, both using the fire-resistance rating test method of components in the UL 790 standard. *GB 8624 "Classification for Burning Behavior of Building Material"* mainly refers to *EN 13501-1 "Fire Classification of Construction Products and Building Elements – Part 1: Classification Using Data from Reaction to Fire Tests"*. The ratings are divided to be A, B1, B2 and B3, establishing the corresponding relationship with the European standard ratings, A1, A2, B, C, D, E and F, and adopting the same rating criteria as EN 13501-1:2007.

The series standards of GB/T 9978.1~GB/T 9978.9 are modified to adopt the ISO 834 series standards. GB 8624 mainly considers the combustible or inflammable or incombustible characteristics of materials (glass, metal, etc.) and the heat value that may be released after combustion. GB/T 9978 mainly considers the time when building components can maintain structural integrity or human safety after combustion.

Fire safety standards applicable to BIPV/BAPV products

The standards adopted in China for BIPV/BAPV products are mainly IEC 61215 and IEC 61730, *GB/T 29551 "Laminated Solar PV Glazing Materials in Building"*, *GB/T 29759 "Sealed Insulating Solar PV Glass Unit in Building"*, and *T/CSTM 00260 "Test Method for Fire Rating of Roof Crystal Silicon Photovoltaic and Profiled Steel Sheet Component"*. The fire-protection requirements in the IEC 61370 standard are implemented by Chinese enterprises and testing institutions according to UL 790. T/CSTM 00260 defines that the fire-rating test method of roof and profiled steel sheet components is consistent with the GB 8624 standard, and that the fire-rating test method of components is consistent with the UL 1703 standard. GB/T 29551 and GB/T 29759 consider that glass is a non-combustible material, and there are no provisions and requirements for fire protection.

Fire safety standards applicable to building materials relevant to BIPV/BAPV

The fire-safety standards for Chinese building products mainly include *GB 50016 "Code for Fire Protection Design of Buildings"*, *GB 8624 "Classification for Burning Behavior of Building Material"*, and GB/T 9978.1 ~ GB/T 9978.9 series standards for fire-resistance testing of building construction elements. According to GB/T 51,368 JG/T492, the fire-rating of photovoltaic modules shall not be lower than the fire-rating of materials required for the building

location, mainly including combustion rate and fire resistance limit. The incombustible body shall be used as the building material component, and the incombustible body can be used as the photovoltaic shading component. The fire resistance limit shall meet the fire-protection requirements of various types of buildings. The specific requirements are specified in the *GB 50016 "Code for Fire Protection Design of Buildings"*.

Modifications for BIPV/BAPV fire-safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

In China, China Building Material Test & Certification Group Co., Ltd. modified the existing fire-safety standard to create a new standard, T/CSTM 00260 *"Test Method for Fire Rating of Roof Crystal Silicon Photovoltaic and Profiled Steel Sheet Component",* which is only applicable to Si modules connected to the profiled steel sheet applied on roof.

More information on test facilities is available upon request. Examples of test labs are shown in the following table.

Table 7: Test facility information in China.

Test facility name: Beijing Building Materials Testing Academy Co., Ltd **Location:** Jinding North Road No. 69, Shijingshan District, Beijing, China **Contact person:** Mr. Liu – by1531949014@163.com **Check the link below for general information:** http://www.bmtbj.cn/enabout/enabout **Test facility name:** China Building Material Test & Certification Group Co., Ltd. **Location:** Guanzhuang Dongli 1#, Chaoyang Dist, Beijing, PR China **Contact person:** Ms. Zhang Kejia – kjzhang@ctc.ac.cn **Check the link below for general information:** http://web.ctc.ac.cn/en/ **Test facility name:** Intertek Testing Services Shenzhen Ltd. **Location:** Plant 5, No.6985 Daye Road, Fengxian District, Shanghai, China, Zip Code 201405 **Contact person:** Mr. Jeff – jeff.jf.deng@intertek.com **For further details on Intertek Testing Services Shenzhen Ltd. see A.4 China** **Test facility name:** Yangzhou Opto-Electrical Products Testing Institute **Location:** No.10 West Kaifa Road, Yangzhou, Jiangsu, P.R. China, Zip Code 225009 **Contact person:** Mr. Michal – michal2010yz@126.com

3.5 Europe

The first step to unify the regulatory framework in Europe for construction products was taken with the introduction of the Construction Product Directive 89/106/CEE - (CPD)[6]. The Directive 89/106 had as its objective the harmonization of the various European national regulatory systems, establishing the essential requirements for construction materials and components, and creating conditions for free circulation of products on the European market.

Subsequently, the Construction Products Regulation[7] (CPR 305/2011) was published to simplify the application of procedures to assess and verify the performance of construction products. Its status as a European Regulation means that the CPR is implemented as a law in all member states. The CPR "lays down conditions for the placing or making available on the market of construction products by establishing harmonized rules on how to express the performance of construction products in relation to their essential characteristics and on the use of CE marking on those products".

According to the CPR, a construction product is defined as "any product or kit, produced and placed on the market for incorporation in a permanent manner in construction works or parts thereof and the performance of which has an effect on the performance of the construction works with respect to the basic requirements for construction works". Thus, all PV modules that are to be incorporated into construction works must comply with the CPR.

A BIPV element is a building component used as part of the building envelope (roof covering element, facade cladding, glazed surfaces, etc.), solar shading devices (shading), architectural elements, or "accessories" (such as canopies, balustrades, parapets, etc.) and any other architectural element necessary for the proper functioning of the building. Therefore, the BIPV product is considered a construction product. In Europe, the EN 50583 standard on '*Photovoltaics in Buildings*' applies to photovoltaic modules used as construction products, referring to the CPR and stating that "photovoltaic modules are considered integrated into the building if the PV modules form a construction product that provides a function as defined in the European regulation on construction products CPR 305/2011". However, the EN 50583 standard is not harmonized, and it is not a mandatory standard, which means that it does not yet provide the basis for manufacturers to draw up the Declaration of Performance as defined in the Construction Products Regulation and affix the CE marking.

As mentioned in the CPR Annex I, entitled "Basic Requirements for Construction Works", "construction works as a whole and in their separate parts must be fit for their intended use" and the construction works must satisfy these basic requirements for construction works for an economically reasonable working life. "Safety in case of fire" is one of these seven basic requirements.

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[6] Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products.

[7] Regulation (EU) N° 305/2011 of the European Parliament and of the Council of March 9th 2011 Construction Products Regulation, CPR 305/2011.

In member states, if the product is covered by a harmonized standard referring to the CPR, reaction-to-fire tests shall be carried out following the guidance in EN 13501-1 *'Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests".* When the element constitutes part of the roof, the classification of the building element shall be carried out according to the results expressed in EN 13501-5 *'Fire classification of construction products and building elements - Part 5: Classification using data from external fire exposure to roofs tests'.*

It should be noted that there is not always a harmonized standard for a specific construction product. For façades, for example, the only harmonized standard is EN 13830: 2015 "*Curtain walling – Product standard",* which deals with curtain walls.

As there is no mandatory harmonized standard at the European Union level to follow in BIPV projects and thus no European consensus about the fire safety requirements apart from the classification scheme of EN 13501, national or local regulations shall apply. The above mentioned is valid for all EU member states and for states outside the European Union that have signed MRAs[8] such as Switzerland.

PV modules that are integrated into buildings or constructions are required to comply with the regulations defined in the CPR, as explained above. At the same time, PV modules, as electrical components, are required to comply with the regulations defined in the Low Voltage Directive (2014/35/EU).

This is the reason why there are two classification schemes for fire properties of materials and products:

The classification according to the UL 790 (which is referenced in the PV standard IEC 61730 but is irrelevant in Europe for construction products) and the classification scheme acc. to EN 13501.

8 International Agreements (Mutual Recognition Agreements - MRA)

3.5.1 Austria

Relationship between local building/construction code and international/national standards

The building regulations in Austria are regulated by the "OIB-Richtlinien". The "OIB-Richtlinien" refer to Austrian standards (ÖNORM) and European Standards (EN).

Fire safety standards applying to PV products relevant to BIPV/BAPV

The fundamental EN standards applying to PV modules, EN IEC 61730-1 and -2, include sections addressing fire safety. However, these sections do NOT provide information that can be used to evaluate fire safety according to the established safety concepts and conformity proofs of the construction industry.

Fire safety standards applying to building products

Depending on the position where the BIPV/BAPV product is to be installed (façade or roof), it must meet a minimum requirement in its reaction to fire classification (according to EN 13501-1) as required by the "OIB-Richtlinien".

In Austria, two institutions exist that are equipped to perform fire tests on BIPV elements for either facades, roofs or any other building application. These test facilities are listed in the table below. Tests on fire resistance and fire behavior of building products can be carried out in specifically designed fire test halls. In addition, a large test stand for facades is available. The experts carry out assessments of structural fire protection in buildings and help with fire protection-related questions about construction (see the list below).

Reaction to fire

- non-combustibility test
- bomb calorimeter test
- SBI test
- small burner test
- inspection of roofing
- classifications according to EN 13501-1 and 13501-5
- flammability tests according to national standards

Fire resistance

- load-bearing walls up to 3 by 3 meters and non-load-bearing walls up to 5 by 5 meters
- load-bearing and non-load-bearing ceilings up to 6 by 4 meters
- fire barriers
- smoke barriers
- glazing
- foreclosures
- fire dampers
- classifications according to EN 13501-2 and 13501-3

- extended areas of application
- monitoring and inspection
- facade systems
- special tests

Appraisal and advice

- fire protection evaluation in the existing building
- construction supervision and supervision
- advice on topics of structural fire protection

Table 8: Test facility information in Austria.

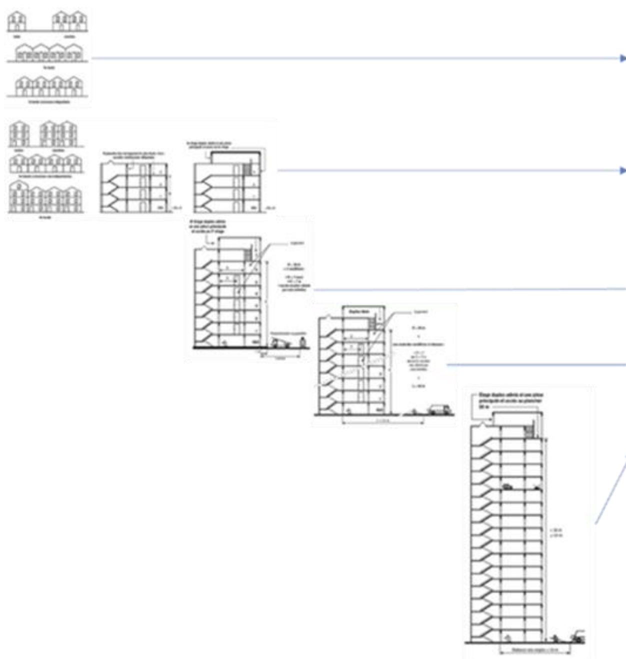
Test facility name: MA 39 - Testing, Inspection and Certification Body of the City of Vienna **Location:** Rinnböckstraße 15, 1110 Wien, Austria **Contact person:** DI Dieter Werner – dieter.werner@wien.gv.at **Check the link below for general information:** https://www.wien.gv.at/forschung/laboratorien/vfa/bauphysik/brandverhalten.html **Test facility name:** IBS – Institut für Brandschutztechnik und Sicherheitsforschung Gesellschaft G.m.b.H **Test facility location:** Austria, 4020 Linz, Petzoldstraße 45 **Contact persons:** Roland BECK; r.beck@ibs-austria.at and Dr. Arthur Eisenbeiss – a.eisenbeiss@bvs-ooe.at **For further details** see A.5.1 Austria

3.5.2 France

Figure 7: Facade tests with full-scale mockup of any system, including BIPV installations.

Relationship between local building/construction code and international/national standards

In France, the generic requirements for structural works and the use of construction products depend on the usage of the buildings and their corresponding classification, see Figure 8. Four main families from the French Building Code are identified with several sub-families according to building height (number of floors).



1ère famille		Individuelle	Habitations isolées en bande à structures non indépendantes en bande à structures indépendantes	Niveaux maximum ≤ R + 1 R + 0 R + 1
2ème famille		Individuelle	Habitations isolées jumelées en bande à structures non indépendantes en bande à structures indépendantes	> R + 1 R + 1 > R + 1
2ème famille		Collective	Habitations collectives	≤ R + 3 (III)
3ème famille	A	Collective	3 conditions : R + 7 maxi D < 7 M (I) accès escalier atteint par voie échelle	≤ R + 3 (III) R + 7
3ème famille	B	Collective	Hauteur < 28 m, une seule des conditions ci-dessus non satisfaite Accès aux escaliers à moins de 50 mètres d'une voie ouverte à la circulation	H ≤ 28 m (II)
4ème famille		Collective	Accès aux escaliers protégés à moins de 50 mètres d'une voie ouverte à la circulation	H > 28 m (II) H ≤ 50 m

Figure 8: French building classification for fire requirements.

Among many decrees and orders relating to intended building use (individual dwellings, collective building, office building, public building, etc.), five main decrees are driving current fire policy in France for any building components, and are also applicable to BIPV elements:

- Order of 4 November 1975 regulating the use of certain materials and products in establishments open to the public.
- Order of November 21, 2002 relating to the reaction to fire of construction and development products.
- Order of August 13, 2003 modifying the order of November 21, 2002 relating to the reaction to fire of construction and development products.
- Order of September 18, 2006 modifying the order of November 21, 2002 as amended relating to the reaction to fire of construction and fittings products.
- Order of October 25, 2013 modifying the order of November 21, 2002 relating to the reaction to fire of construction and fittings products to take into account the European classification of linear pipe insulation products.

Eurocodes and Euro classes are also included in the assessment of all PV elements integrated into the building. Reference is made both to European standards (EN) and French standards (NF), see

Figure 9. Additional information about fire classification of materials can be found on the website of the French Building Federation[9]. All official decrees are available on the Building Code website[10].

[9]https://www.ffbatiment.fr/techniques-batiment/reglementation-construction/reglementation-produits-de-construction-marquage-ce/dossier/le-classement-au-feu-des-materiaux

[10]https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000006074096/LEGISCTA000006143513/

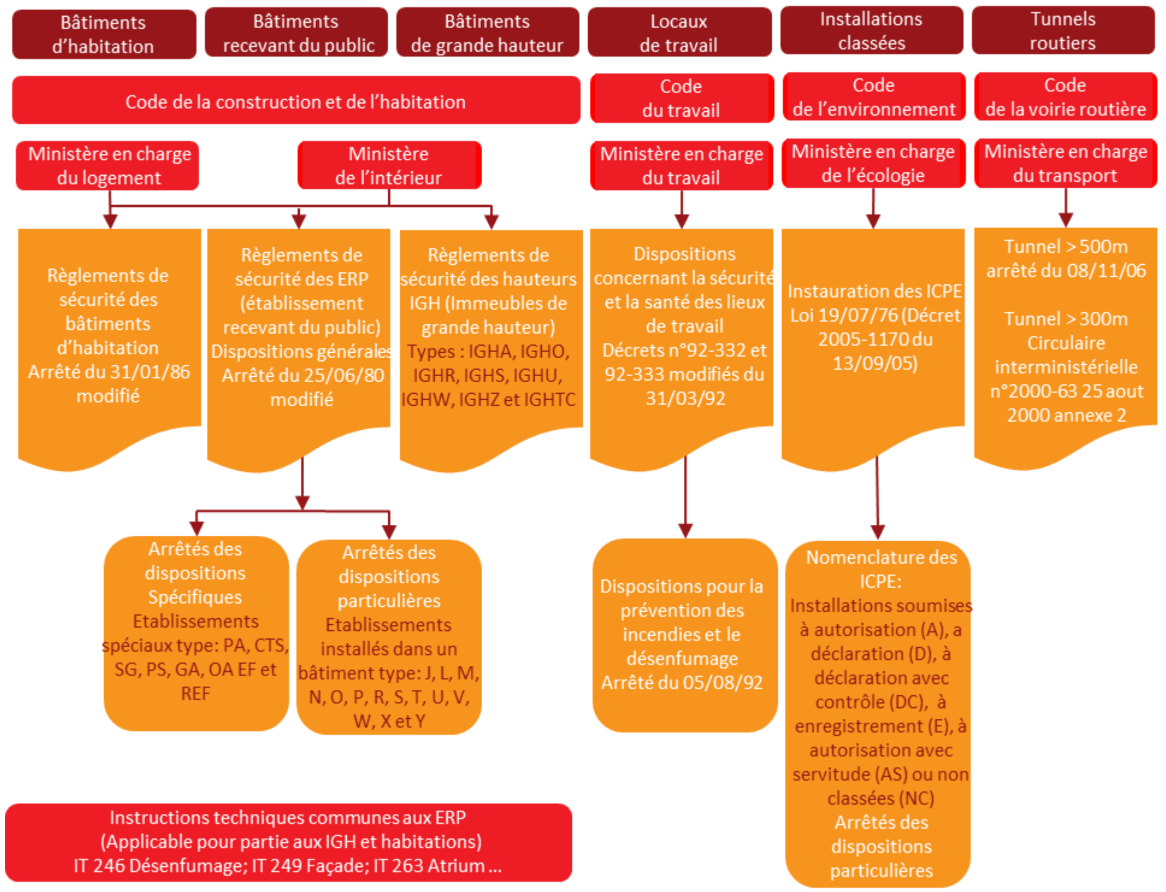


Figure 9 Overview of French orders and decrees dealing with fire requirements.

Fire safety standards applying to PV products

In addition to the French fire standards for building components, the fundamental EN standards applying to PV modules, NF EN IEC 61730-1 and NF EN IEC 61730-2, include sections addressing fire safety, without specific recommendations or mandatory rules for building-related applications. The fire safety assessment considers both building and PV requirements.

Fire safety standards applying to building products relevant to BIPV/BAPV

Relevant standards are dependent on the location where the BIPV or BAPV product will be installed. It must meet a minimum requirement in its tests on reaction to fire as classified in EN 13501-1 and comply also with NF EN 13501-6 for electric cables. The second essential requirement in the CPR (305/2011/EU), as detailed in the Interpretative Document Number 2: Safety in case of fire (OJ C62 Vol. 37), could also be applied. Details of the different requirements can be found on demand to the CSTB Fire Lab. For example, the laboratory assesses the reaction of BIPV components to fire by carrying out tests for building products exposed to thermal attack by a single burning item according to NF EN 13823:2000.

Figure 10 Fire resistance bench test requirements applied to BIPV components (SBI).

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

CSTB is currently involved in the EU BIPVBoost project to support development of new standard procedures, to support BIPV development and to increase test capabilities to assess active building products such as BIPV solutions. With the support of CERTISOLIS, a PV certified laboratory and a subsidiary of CSTB, CSTB is working on the development of new testing procedures related to NF EN 61215, NF EN 61730, 61853 and 62915 through activity in standardization committees at national and international levels.

Furthermore, CSTB is very active in the PC92 national committee to authorise and contribute to standards development for fire aspects and promote new test procedures for PV and specifically PV in buildings.

A large part of ongoing work is supported by the equipment and facilities available at the CSTB Fire Lab and new ones are currently under development. An example test lab is shown in the following table.

Table 9: Test facility information in France

Test facility name: Centre Scientifique et Technique du Bâtiment (CSTB Fire Lab) **Location:** 84 avenue Jean Jaures 77420 CHAMPS sur MARNE, FRANCE **Contact persons:** Valérie GOURVES (Head of Fire Laboratory) – valerie.gourves@cstb.fr, Simon BODDAERT (Head of PV Innovation)– simon.boddaert@cstb.fr **For further details see A.5.2 France**

3.5.3 Germany

Figure 11: ift Rosenheim GmbH facility.

Relationship between local building/construction code and international/national standards

"In Germany, the generic requirements for structural works and the use of construction products are laid down in the Building Codes of the federal states. Where necessary, these generic requirements can be specified by Technical Building Rules".[11]

Each German federal state implements its own Administrative Provisions – Technical Building Rules (VV TB) based on a single common model (MVV TB) that is prepared by Deutsches Institut für Bautechnik DIBt (German Institute for Building Technology).

Within the MVV TB, reference is made both to European standards (EN) and German standards (DIN).

Fire-safety standards applying to PV products

The fundamental EN standards applying to PV modules, DIN EN IEC 61730-1 and -2, include sections addressing fire safety. However, these do NOT provide information that can be used to evaluate fire safety according to the established safety concepts and conformity proofs of the construction industry.

Fire-safety standards applying to building products relevant to BIPV/BAPV

Depending on the position where the BIPV/BAPV product is to be installed, it must meet a minimum requirement on its reaction to fire tests as classified in EN 13501-1. Details of the different requirements can be found in the brochure *"Technische Baubestimmungen für PV-Module als Bauprodukte und zur Verwendung in Bauarten: Bauordnungsrechtliche Vorgaben zu Produkt- und Anwendungsregeln"* (Technical Building Requirements on PV Modules as Construction Products and for Usage in Construction Works: Building Code Specifications for Product and Application Rules), which is available from the Allianz BIPV, www.allianz-bipv.org

[11] https://www.dibt.de/en/we-offer/technical-building-rules

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

At the time when information was requested, ift Rosenheim GmbH was open to testing BIPV/BAPV products but had not conducted such tests. Accordingly, it has not made any relevant modifications.

Table 10: Test facility information in Germany.

Test facility name: ift Rosenheim GmbH **Location:** Rosenheim, Germany **Contact person:** Ms. Anyke Aguirre Cano – aguirrecano@ift-rosenheim.de **Check the link below for general information:** https://www.ift-rosenheim.de/akkreditierung-prueflabor **For further details see A.5.3 Germany**
Test facility name: MPA Dresden GmbH **Location:** Fuchsmühlenweg 6 F, 09599 Freiberg, Germany **Email:** info@mpa-dresden.de **Check the link below for general information:** https://www.mpa-dresden.de
Test facility name: MFPA Leipzig **Location:** Hans-Weigel-Straße 2B, 04319 Leipzig, Germany
Test facility name: MPA NRW **Location:** Marsbruchstraße 186, 44287 Dortmund, Germany
Test facility name: TÜV Rheinland AG **Location:** Am Grauen Stein, 51105 Köln, Germany

3.5.4 Italy

Figure 12: SBI test facility (UNI EN 13823).

Depending on its characteristics, a photovoltaic system installation in an existing or new building may increase the fire risk.

A building subject to fire prevention controls should comply with the procedures provided in DPR 151/2011 and the fire risk assessment in accordance with the criteria of Annex I of DM 10 March 1998, classifying this level into one of the following categories:

(a) high risk;

b) medium risk;

c) low risk.

The Decree of September 3, 2021 / Minicode decree ‘*Activities at low risk of fire*’ that contains the general criteria for the design, implementation, and operation of fire safety for workplaces replaced the DM 10 March, 1998 from October 29, 2022.

Considering BIPV products, Italy, as a member of the European Union, must follow the requirements seen in general for Europe. BIPV modules are construction products, both according to the CPR and according to EN 50583 and IEC 63092. In the Italian market, therefore, BIPV products must be regulated by the CPR (305/2011) and by the relevant harmonized standards. In the absence of harmonized standards, BIPV modules must follow the requirements of EN 50583 (not a harmonized standard with respect to the CPR).

By contrast, conventional PV modules, not being considered products for construction, must follow national standards. However, these standards are not specific to PV modules but have been applied for different products such as wall panels and similar materials.

The main provisions in force in Italy, to date, are the following:

- Ministero dell'Interno - Dipartimento dei Vigili del fuoco, del Soccorso pubblico e della Difesa civile - Area DCPST Prevenzione incendi, Nota prot. n. 1324 del 07 febbraio 2012 - Oggetto: *"Guida per l'installazione degli impianti fotovoltaici - Edizione Anno 2012*";

- Ministero dell'Interno - Dipartimento dei Vigili del fuoco, del Soccorso pubblico e della Difesa civile - DCPST, Nota prot. n. 6334 del 4 maggio 2012 - Oggetto: "Chiarimenti alla nota prot. DCPREV 1324 del 7/2/2012 *'Guida per l'installazione degli impianti fotovoltaici - Edizione 2012'*".

Both provisions are based on fire risk analysis and provide fire classification criteria in accordance with UNI 9177 "*Classification of reaction to fire of combustible products*" (Photovoltaic module) and UNI EN 13501-5:2016 "*Fire classification of construction products and building elements - Part 5: Classification using data from external fire exposure to roof tests*" (roofs).

These criteria for reaction to fire, however, are based on separate test results considering the module and the roof individually and not on actual assemblies consisting of the PV module and the roof portion. To overcome this division, recently the IEC TR 82-89:2021 "*Fire hazard in photovoltaic systems - Fire behavior of photovoltaic modules installed on building roofs: test protocols and classification criteria*" was published, which is specific to BAPV on building roofs and focuses on fire protocols and fire behavior evaluation criteria for photovoltaic roof installations. Examples of test labs are shown in the following table.

Table 11: Test facility information in Italy.

Test facility name: Istituto Giordano **Location:** Strada Erbosa uno, 70/84 - 47043, Gatteo (FC), Italy, 47043 **Contact person:** g.traina@giordano.it **For further details see A.5.4 Italy** **Test facility name:** ITC **Location:** Viale Lombardia, 49, San Giuliano Milanese (MI), Italy, 20098 **Contact person:** direttore@itc.cnr.it

3.5.5 Norway

Figure 13: Test apparatus for reaction to fire test of external fire exposure to roofs (CEN TS 1187). Photo credit: RISE Fire Research.

The national regulation in Norway is performance-based and the overall requirements are generally as listed below from the regulation on technical requirements for construction works[12].

Section 11-9 The fire properties of products and materials

(1) Construction works shall be designed and constructed to ensure that the probability of fires occurring, developing and spreading is minimal. The use of the construction work and the time necessary for escape and rescue shall be considered.

(2) Products and materials shall not have properties that make an unacceptable contribution to the development of a fire. Consideration shall be given to the possibility of ignition, speed of heat transfer, smoke production, development of burning drops and time to flashover.

[12] https://dibk.no/globalassets/byggeregler/regulation-on-technical-requirements-for-construction-works--technical-regulations.pdf

Section 11-10 Technical installations

(1) Technical installations shall be designed and installed to ensure an installation does not substantially increase the risk of a fire occurring or fire and smoke spreading.

In addition to this regulation, there is a guideline that is not mandatory, but describes pre-approved performance that is defined to comply with the performance requirements in the regulation. If these pre-approved guidelines are not followed, compliance needs to be documented through other analysis.

The pre-approved solutions are based on the Eurocodes as defined in EN 13501-XX. For external cladding surfaces of buildings, the classification D-s3,d0 can be used on buildings in fire class 1, and B-s3,d0 should be used in fire class 2 and 3. For roofing surfaces, the class B_{ROOF}(t2) based on the test method CEN/TS 1187 and EN 13501-5 applies. These requirements would apply to roof-mounted and façade-mounted BIPV, as they would be defined as an integral part of the building even though neither BAPV nor BIPV is mentioned in the regulation or guidelines.

For electrical installations, the electrotechnical standard NEK 400 defines pre-approved solutions. This standard was revised in 2018 with detailed requirements for PV installations that mainly cover electrical safety, but also some fire-related requirements like distance from the edge of the roof and doors or windows that are used as escape routes.

Table 12: Test facility information in Norway.

Test facility name: RISE Fire Research AS, Norway **Location:** Tillerbruvegen 202, Trondheim **Contact person:** Robert Olofsson – robert.olofsson@risefr.no **Check the link below for general information:** https://risefr.no/,https://www.akkreditert.no/en/akkrediterte-organisasjoner/akkrediteringsomfang/?AkkId=67 **For further details see A.5.5 Norway**

3.5.6 Spain

Figure 14: SBI (single burning item) testing of an external cladding system.

Relationship between local building/construction code and international/national standards in detail

The Spanish Building Code, known as Código Técnico de la Edificación or CTE, has the following requirements regarding Reaction to Fire of materials and systems installed on building envelopes:

“Construction systems” covering more than 10% of the façade surface, should have at least the following Reaction to Fire classification according to EN 13501-1:

- D-s3, d0 up to 10 m height
- C-s3, d0 up to 18 m height
- B-s3, d0 from 18 m on

“Insulation material systems” within ventilated cavities in façades, should have at least the following Reaction to Fire classification according to EN 13501-1:

- D-s3, d0 up to 10 m height
- B-s3, d0 up to 28 m height
- A2-s3, d0 from 28 m on

Vertical fire propagation within ventilated cavities in façades should be limited by placing a fire barrier in every fire compartmentation slab (E30 classification for Fire Resistance is considered as a valid measure for that purpose).

In façades with a height up to 18 m that are accessible to people from the ground level, the above classifications should be improved to B-s3, d0 class at least up to the first 3,5 m of façade.

To avoid fire propagation at the external roof level, materials, products or systems covering more than 10% of the roof surface should have a B_{ROOF} (t1) classification for Reaction to Fire according to EN 13501-5.

Fire safety standards applying to building products relevant to BIPV/BAPV

EN 13501-1 Reaction to fire classification for materials, products and systems (facades).

EN IEC 61730 Photovoltaic (PV) module safety qualification

EN ISO 1182 Non-combustibility test method.

EN ISO 1716 Gross heat of combustion (PCS value) test method.

EN 13823 Single burning item (SBI) test method.

EN ISO 11925-2 Flammability test method.

EN 13501-5 External fire performance classification for materials, products and systems (roofs).

CEN/TS 1187 External fire performance test method.

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

There is neither a specific national standard nor specific test procedures or classification criteria for fire safety performance of BIPV/BAPV products, other than the ones included in Appendix A.5.7. TECNALIA operates one of the fire safety test facilities in Spain.

Table 13: Test facility information in Spain.

Test facility name: Fire Safety Lab TECNALIA **Location:** Area Anardi No.5, E-20730 Azpeitia-Gipuzkoa, SPAIN **Contact person:** Xabier OLANO– xabier.olano@tecnalia.com **For further details see A.5.7 Spain**

3.5.7 Sweden

Figure 15: Vertical furnace for fire-resistance testing.

Relationship between local building/ construction code and international/ national standards in detail

The Swedish PV market is still small but growing rapidly with > 50% annual growth over the past five years. Fire safety of PV installations is a current topic for discussion, but it still has not really affected research, method development or legislation. The Swedish National Board of Housing, Building and Planning (Boverket), responsible for the Swedish building code, addresses the topic of PV and fire safety in a dedicated text from 2020.[13] Briefly, this text tells us that the same legislation applies to PV panels, regardless of whether they are building-integrated (BIPV) or building-applied (BAPV). However, since BAPV is not part of the climate screen, it is not covered by the building code meaning that there are no detailed requirements applicable to BAPV.

Classification of construction products according to EN 13501-1, 2 and 5, i.e. the Euroclass system, is part of the Swedish building code, where part 5 refers to class B_{ROOF} t2 for roof coverings. An in-depth analysis of the test method CEN/TS 1187:2012 related to this classification, as well as some tests on PV modules according to this standard, has made it clear that it is not fully applicable to PV on roofs in general and even more so, not applicable to

[13] https://www.boverket.se/sv/PBL-kunskapsbanken/regler-om-byggande/boverkets-byggregler/brandskydd/solpaneler/

BIPV roof installations. A proposed test set-up for a BIPV roof is described in EN IEC 61730-2 but such a set-up cannot be achieved in a B_{ROOF} t2 test rig.

Fire safety standards applying to building products relevant to BIPV/BAPV

European standards EN 13501-1, -2 and -5 are all used to classify construction products in Sweden and therefore they can also be considered as relevant for classification of BIPV products, even though there is room for improvement to make them even more relevant. As mentioned above they cannot be considered relevant for BAPV products or systems since these are not covered by the building code. Depending on the type of product and application, various standards referenced in these three standards are applied, e.g. EN 13501-2 tells us that EN 1364-3 is the standard to apply for curtain walls. Thus, even if there exist several “sub-standards” that are relevant to BIPV, the knowledge and experience related to BIPV among fire consultants in general is still low and therefore the standards are rarely applied.

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

As already mentioned, there is a need for further development of codes, standards and testing procedures, taking into account additional risks related to the electricity generation by building products. Since the Swedish code is leaning firmly on the European Euroclass system and Sweden is a relatively small market, future developments will probably be initiated on the European and not on the national level.

For facades in class BR1, generally applying to buildings having three floors or more, the code requires either non-combustible materials (Class A2-s2,d0) or that they are tested and approved according to the Swedish “SP Fire 105” method, a full-scale facade fire test.

The Swedish Civil Contingencies Agency (MSB), an insurance company and the business organization Svensk Solenergi have issued some smaller guides on the topic of PV and fire safety. Furthermore, such guidelines have been developed by several regional rescue services but since they are not harmonized, this causes many challenges to the PV businesses that meet different requirements in different regions of Sweden.

There are no Swedish fire safety standards applying to PV products that are relevant to BIPV/BAPV. The above-mentioned facade test “SP Fire 105” is generally applied to construction products and materials in facades and is relevant to BIPV/BAPV. From 2020 to 2023, RISE is leading a European project aiming at a European standard for fire safety of facades[14]. In this context, RISE has approached Solar Power Europe as well as their Swedish counterpart to encourage their involvement in this work but so far no action has been taken. The project ends in 2023 but the time frame for a new standard to enter into force is probably several years beyond that.

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[14] https://www.ri.se/en/what-we-do/projects/finalization-of-the-European-approach-to-assess-the-fire-performance-of-facades

RISE has an internationally recognized test facility dedicated to fire safety in a wide range of applications and a staff of 200 engineers and researchers connected to it.

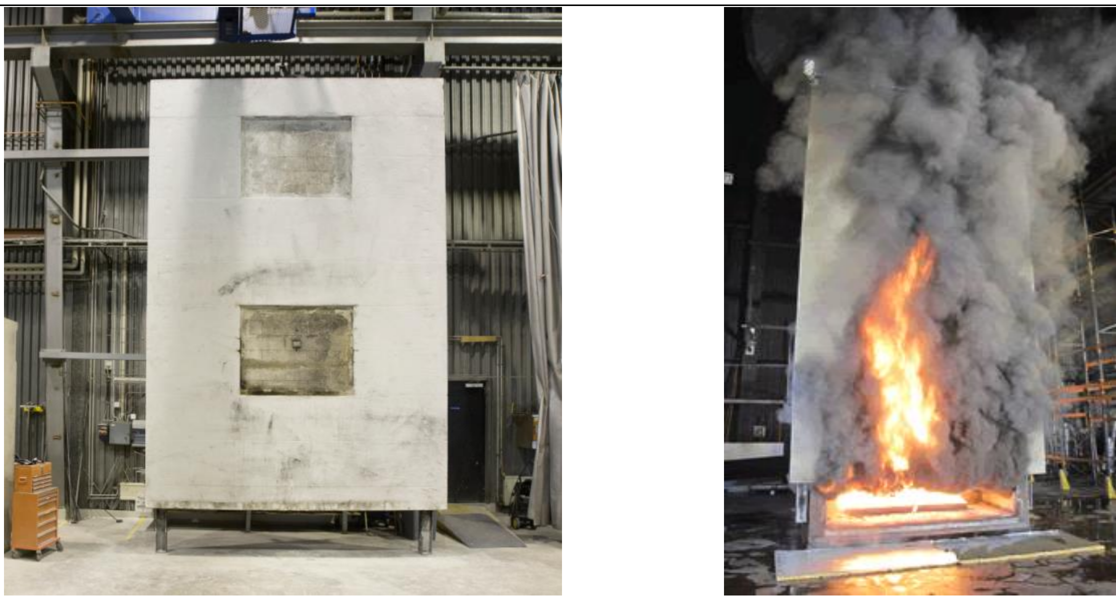

Figure 16: Test rig at RISE for full-scale testing of facades e.g. according to method SP Fire 105.

Figure 17: Horizontal furnace for fire-resistance testing (left) and small-scale testing facilities (right).

Table 14: Test facility information in Sweden.

Test facility name: RISE Research Institutes of Sweden **Location:** Borås, Sweden **Contact person:** Anders Lönnermark – anders.lonnermark@ri.se **Web:** https://www.ri.se/en/what-we-do/fire-safety **For further details see A.5.8 Sweden**

3.5.8 Switzerland

The Swiss confederation is not a member of the EU, but it has signed mutual recognition agreements (MRAs)[15] with the European Community. The agreement on mutual recognition in relation to conformity assessment entered into force on 1 June 2002 and applies to the most important product sectors, including construction products, for which the CPR[16] (EU regulation 305/2011) has been adopted.

On 14 April 2015, the new chapter on construction products, based on the revised Swiss regulatory acts concerning construction products and the European Construction Products Regulation, entered into force. Fire safety is one of the seven basic requirements specified in CPR 305/2011 for construction works and products, which has been adopted by Swiss regulations.

At the Swiss level, the fire protection regulations are issued by the Association of Cantonal Fire Insurance Institutions (VKG/AICA)[17]. They include the fire standard and the directives together with explanatory notes on fire protection, as well as thematic support publications and references to specific sectors of use.

Criteria for fire-protection requirements in buildings and systems are mainly determined by the following factors:

- Intended use (hospitals, hotels, shops, places with a large concentration of people, etc.)

- Geometry of the building:

  a) buildings of reduced height: up to 11 m overall height

  b) buildings of average height, up to 30 m overall height

  c) tall buildings, more than 30 m in total height

  d) small buildings

  e) annex buildings

- Number of floors

- Building materials and parts of the construction with fire protection requirements

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[15] International Agreements (Mutual Recognition Agreements - MRA)

[16] Regulation (EU) N° 305/2011 of the European Parliament and of the Council of March 9th 2011 Construction Products Regulation, CPR 305/2011

[17] https://www.vkg.ch/de - https://www.vkg.ch/it

At the Swiss level, the construction materials can be classified according to the AICA or according to the EN 13501 series standard.

In fact, the fire protection standard 1-15, chapter 2 "parts of the building", article 27 "Examination and classification" states: "The parts of the construction are classified according to regulated tests, or other procedures recognized by AICA".

For this reason, when they are assigned to different fire-reaction groups, it is possible to use them without limitation in both schemes, that of AICA and that of EN 13501.

According to AICA, construction materials are divided into the following groups based on their reaction to fire:

- RF1 (no reaction to fire)
- RF2 (minimum reaction to fire)
- RF3 (reaction to fire allowed)
- RF4 (reaction to fire not allowed)

Hence, according to the Swiss fire directive n. 13-15 "*Building materials and construction parts - Classification*", the classification of building materials can be carried out according to the relevant European standards considering:

- Fire reaction (building materials are subdivided into classes A1, A2, B, C, D, and E);

- Smoke formation (building materials are defined with an additional classification s1, s2, or s3);

- Dripping / falling fragments of incandescent material (building materials are defined with an additional classification d0, d1, or d2);

- Corrosivity (electric cables are classified into categories B1ca, B2ca, Cca, and Dca. An additional classification a1, a2, or a3 is envisaged to define the presence of corrosive combustion gases).

Thus, construction materials can be classified according to the SN EN 13501-1: 2009 standard or according to AICA. In the Swiss fire directive n. 13-15 *"Building materials and construction parts - Classification*" attribution tables to fire classification are reported in order to pass from AICA classification to EN classification.

The requirements seen above are all valid for construction works and building products but, in the case of BIPV, fire safety has to involve the fire safety requirements of both PV and building products.

In Switzerland, the non-mandatory European standard EN 50583 series and the international IEC 61730 series have been adopted.

The EN 50583 states that “photovoltaic modules are considered to be building-integrated if the PV modules form a construction product providing a function as defined in the European Construction Product Regulation CPR 305/2011".

The IEC 61730:2016 defines the fire resistance requirements of PV modules, introducing a new approach that considers the building aspect. It states: "PV modules as building products – i.e. serving as roof covering materials, elements for building integration or that are mounted on buildings – are subject to specific safety requirements originating from national building codes... ...Fire test requirements are to be included as national differences in this standard".

Furthermore, at the Swiss level, a fire safety memorandum on solar systems (2001-15, VKF) has been recently updated (01.01.2022) and it considers the following topics:

- Fire protection (requirements, materials, and risks)
- Firefighters (preparation and risks)
- Protection against natural hazards
- Insurance

In the document, the PV plants are divided in two categories:

1 Building-integrated systems.

2 Systems applied to the building.

This document references the fire standard, the directives, explanatory notes, and the national standard concerning low voltage installations SN 411000 (NIBT)[18] but no PV standard is mentioned.

Regarding the fire test laboratories, no fire testing laboratories within Switzerland have been identified by the authors.

However, it is noted that Technical Assessment Bodies (TABs)[19] are members of the European Organisation for Technical Assessment (EOTA) and in Switzerland are recognized according to MRAs. It is possible to find all Swiss notified bodies on the NANDO[20] list.

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[18] NIN 2020 NIBT , Classeur A4 (F) Norme installations à basse tension (NIBT)", édition 2020, classeur A4

[19] https://www.eota.eu/tabs

[20] https://ec.europa.eu/growth/tools-databases/nando/

3.5.9 The Netherlands

Relationship between local building/construction code and international/national standards

In the Netherlands, constructions need to comply with the Building Decree 2012 (Bouwvesluit 2012). This Decree does not contain dedicated tools to determine the fire safety risk of PV installations, neither for BAPV nor BIPV.

For this reason, in 2019 the Dutch standardisation institute NEN started the working group "Fire safety of PV panels in and on the building cladding". They are working on the development of an assessment and testing method for PV panels. This method was implemented on 1 May 2021 in the form of a new standard: NEN 7250 "Solar energy systems - Integration into roofs and facades – Buildings aspects". An update was published in December 2021. Previous versions of NEN 7250 also form the basis of TR 16999, which was prepared by CEN/TC128/WG3. NEN 7250 addresses relevant assessment aspects which come directly from the Building Decree, e.g. wind load, wind resistance, water resistance, fly fire resistance.

The Building Decree 2012 will be updated and will be combined with the Decree *"Energy performance of buildings"* into the Decree buildings *"Living Environment",* which is expected to be implemented in January 2024. It is not clear whether the NEN 7250 will be part of that or that it will remain a separate document.

Fire safety standards applying to PV products

The Building Decree gives requirements for the fire resistance of the rooftop and refers to the NEN 6063:2019 *"Test method for external fire exposure to roofs"*. However, there are no legal requirements for the fire safety class (Euroclass) of rooftop materials and insulating materials, and thus PV systems. Sometime FM Approvals are advised or are compulsory. There is no relation between FM Approvals and Euroclass classification and there is no relation between FM Approvals and the national requirements from NEN 6063.

PV installations are electrical installations and must comply with the legal (safety) requirements for electrical installations. Based on the Building Decree 2012, the electrical installation must meet the requirements in NEN 1010 "Low-voltage installations" as far as they relate to safety. In 2015, NEN 1010 was expanded with requirements for PV installations (part 712). NEN 1010 explicitly mentions the prevention of fire resulting from short circuit and overheating in the installations. DC connectors that connect strings together must comply with NEN-IEC 628529, in such a way that they are properly matched. Connectors from different manufacturers may not be compatible with each other and therefore may not be used together.[21] It is therefore only permitted to use a plug and a socket from different

[21] TNO report "Brandincidenten met fotovoltaïsche (PV) systemen in Nederland. Een inventarisatie", 2019.

manufacturers if both manufacturers confirm the compatibility. In addition, there is a legally required CE marking on components of PV systems.

Fire safety standards applying to building products relevant to BIPV/BAPV

There are no statutory quality systems for PV installations in the Benelux countries. In the Netherlands, the *Zonnekeur* exists as a voluntary quality scheme. The regulation addresses installation companies and obliges them to supply products that meet the aforementioned standards and sets requirements for professional competence.

InstallQ is developing a new quality scheme for installers of PV systems in collaboration with Techniek Nederland, Holland Solar and the Alliance of Insurance Companies.

SCIOS recently introduced an inspection scheme for solar power installations (scope 12). The inspection scheme provides for a retrospective inspection, whereas the InstallQ scheme focuses on the process from design to connection. The impression is that the quality of the installations has improved over the past period as a result. The above-mentioned standards also apply for BIPV and BAPV.

These quality systems are not compulsory, although insurance companies tend to ask for them before offering insurance.

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

The Dutch Knowledge Institute TNO is working with several partners (NEN and IFV) on the development of a database that will help to determine the risk of fire related to PV systems. The database will contain information on the type of system (BAPV or BIPV), the possible cause of the fire and whether the PV system was the main cause. The results will form the basis for new test standards and protocols that will be developed by the NEN committee.

Furthermore, a consortium is working on the development of PV panels that are intrinsically safer. This concerns aspects related to inflammable materials as well as improved interconnection schemes for high-power PV panels.

Additionally, several branch organizations have taken up their responsibility in performing fire tests on roofing materials in combination with PV systems. Some of these have resulted in a series of recommendations[22]:

- Control cabinet on a non-flammable surface;
- Fire-resistant cable ducts;
- Metal support structures;

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[22] Efectis, website: efectis.com/nl, Branden Op Industriële Platte Daken Met Zonnepanelen: Dit Leren We Ervan | Efectis

- Comply with test methods and standards;
- Ballast under PV panels;
- Safe distance between PV panels and roof/wall penetrations and skylights;
- Barrier with perforated roofing sheet.

Additionally, with the increasing power rating of PV panels, it might be necessary to revisit the current IEC test procedures to determine whether they are still valid for those innovative panels and their integration into buildings.

Table 15: Test facility information in The Netherlands.

Test facility name: Kiwa BDA Testing B.V **Location:** Gorinchem, the Netherlands **Contact person:** Albert Hameete - albert.hameete@kiwa.com **Check the link below for general information:** https://www.kiwa.com/nl/nl/markten/bouw-en-infrastructuur/bouw/services/testen/ **Accreditations:** ISO/IEC 17025 **Activities:** Testing **Experience:** Reaction to Fire, Fire Resistance
Test facility name: Efectis Nederland **Location:** Bleiswijk, the Netherlands **Contact person:** Harm Verster – harm.verster@efectis.com **Check the link below for general information:** http://www.efectis.nl/ **Accreditations:** ISO/IEC 17025 **Activities:** Testing, certification **Experience:** Reaction to Fire, Fire Resistance, Fire Detection, Fire Suppression, Smoke Control, Active Fire Protection
Test facility name: Peutz Laboratory for Fire Safety **Location:** Haps, the Netherlands **Contact person:** Harm Leenders - h.leenders@peutz.nl **Check the link below for general information:** http://www.peutz.nl/ **Accreditations:** ISO/IEC 17025 **Activities:** Testing **Experience:** Reaction to Fire, Fire Resistance, Fire Detection, Fire Suppression, Smoke Control

3.6 Japan

Figure 17: Large wall furnace for façade and window.

In Japan, there are two types of fire safety standards for façades such as building exterior walls and windows, both of which are to comply with domestic laws (Building Standards Law of Japan). The purpose of tests on reaction to fire is to suppress the spread of fire due to an internal or external fire, and the purpose of tests of resistance to fire is to maintain the prevention of fire spread from indoors and outdoors for a certain period of time. In addition to the Building Standards Law, related domestic laws include the Fire Service Law and association standards which are Japan's own standards.

Fire safety of BIPV/BAPV modules (intended for module manufacturers)

IEC 61730-2 MST23 (UL 790) and MST24 are applicable. MST23 has a spread-of-flame test and a burning brand test as shown in Figure 18 and Figure 19. This test applies to Categories A and C in EN 50583 and IEC 63092-1.

It may be possible to apply the spread-of-flame test also to a facade installed on a vertical surface. However, the fire-prevention test for a facade including windows that are subject to the risk of fire spread according to the Building Standards Act is more severe than the IEC test.

In addition, there are differences in the type and amount of burning brand and roof angle between the Building Standards Law and IEC 61730-2 in the ignitability test (Figure 20). Therefore, the standards to be handled are different for each technical aspect. The module should comply with IEC 61730-2, and the building should comply with the Building Standards Act.

On the other hand, MST24 (ignitability test) applies to flexible type PV modules that do not use laminated glass.

Examples subject to MST24 include PV venetian blinds, PV roller shades, and various flexible modules (Figure 21)[9] [10].

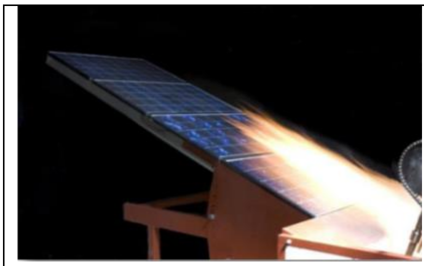

Figure 18: Spread-of-flame test[23].

Figure 19: Burning brand test.

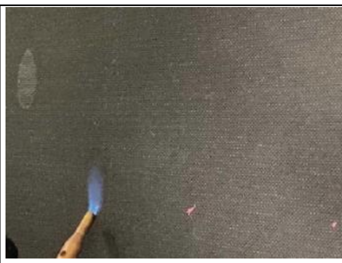

Figure 20: Ignitability test[24].

Figure 21: Examples of flexible PV modules[25] that are subject to different tests than for laminated glass-glass modules.

Fire safety of façades (intended for architects, general contractors, façade contractors)

If a fire occurs in a fire-resistant or semi-fire-resistant building, inside or around the building, fire should not reach through façade openings to non-heated surfaces within a specified period, see Figure 22. (Building standards Law Article 2, Item 9-2 / Ordinance Article 109-2).

BIPV and BAPV modules need to be treated in the same way as glass and other facade materials, as one element of the façade. It is necessary to maintain flame prevention to avoid overheating from fire in an adjacent building and indoors.

In addition, it is necessary to satisfy multiple requirements to prevent the fire from spreading upwards or spreading beyond the fire compartment.

Figure 23 and Figure 24 show examples of tests conducted in accordance with the Building Standards Act and JIS, furthermore with consideration given to BIPV-specific requirements. In the test, a wall furnace was used, and a full-size curtain wall sample incorporating an actual BIPV module was prepared and heated according to the ISO 834 standard heating curve.

Research on the fire safety of BIPV has been carried out mainly by H. Ishii and as a METI (Ministry of Economy, Trade and Industry) project in 2017. To make the BIPV circuit similar to

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[23] Chemitox Co., ltd.,https://www.chemitox.co.jp/business/hyouka/mojyuru/kasaishiken

[24] LIXIL Corporation, https://newsroom.lixil.com/ja/2022071902

[25] FWAVE Co.,Ltd., https://www.fwave.co.jp/en

actual conditions, the test was conducted in a closed-circuit state, and it was clarified that performance equivalent to that of a normal glass curtain wall was obtained[12].

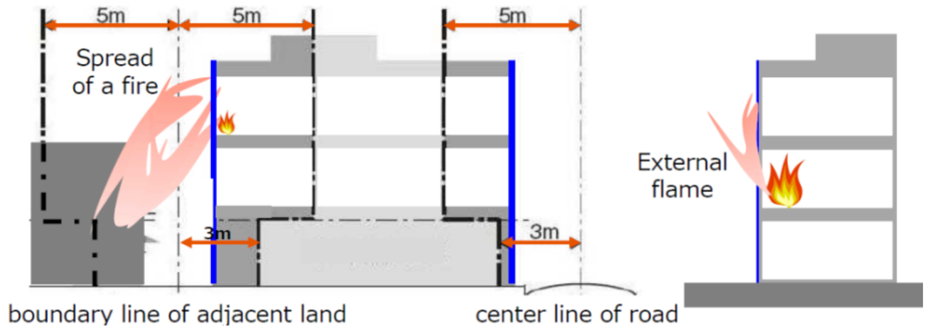

Figure 22: Fire safety requirements for facades.[26]

Figure 23: Actual test sample.

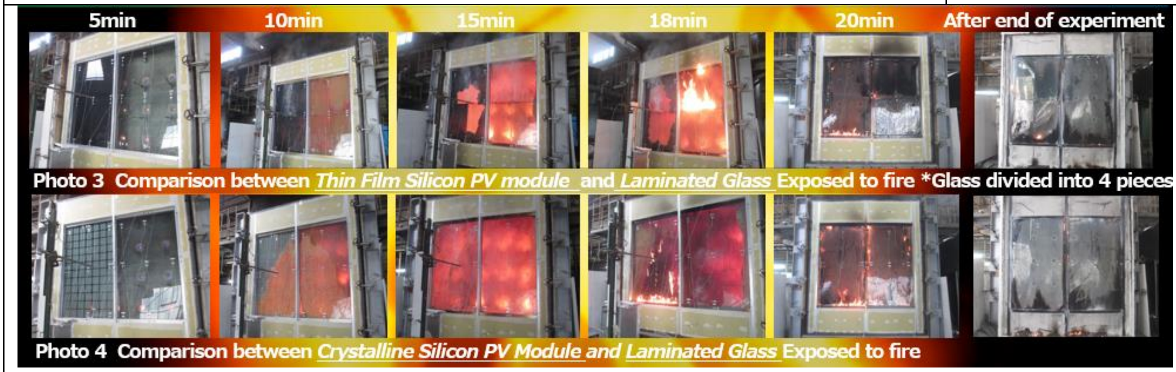

Figure 24: Test steps and test results.

Regulations on firefighting (intended for architects, general contractors, façade contractors)

For the facade and roof where BIPV/BAPV modules are installed, requirements are specified to facilitate fire-extinguishing activities if a fire occurs. The Fire Service Law Enforcement Ordinance stipulates installation standards that do not interfere with the fire extinguishing activities of the fire department in the event of a fire as the “Guidance Standards for Fire Safety Measures Related to Photovoltaic Power Generation Facilities” (Figure 25)[27]. To ensure safety during firefighting activities, PV modules should not be installed around emergency openings, outer stairs and entrances that firefighters use in firefighting activities, in order to reduce the electric shock risk (Figure 25).

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[26] Hisashi.Ishii, Experimental Study on BIPV Module during Power Generation Exposed to Fire, EU PVSEC 2018 Brussels Belgium, Sep 2018 (Projects supported by METI)

[27] Tokyo Fire Department, Guidance standards for fire prevention and safety measures for photovoltaic power generation facilities, Jul. 2014

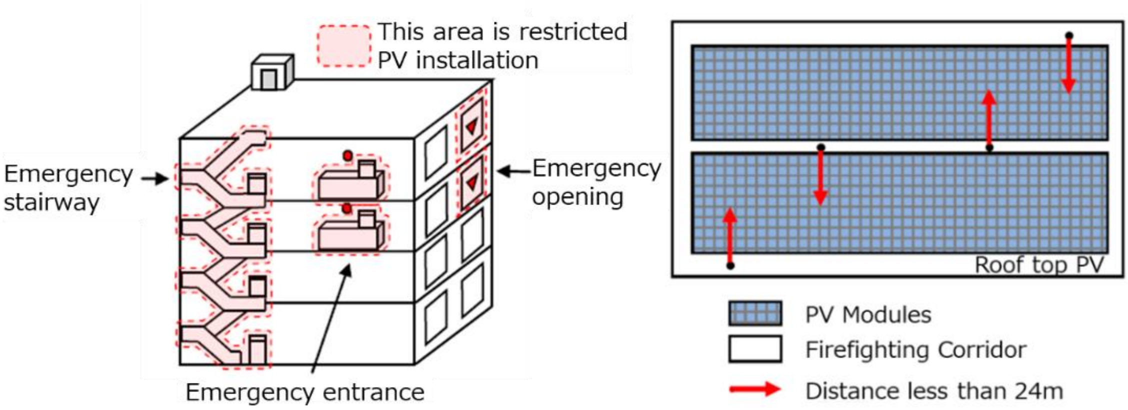

Figure 25: Restrictions for facade and roof top PV installation areas.

Note: Emergency openings are stipulated in Article 126-6 of the Enforcement Ordinance of the Building Standards Law and are provided to ensure that fire-extinguishing activities can be carried out smoothly and evacuation is possible in the event of a fire.

Examples of test facilities in Japan are shown in the following table.

Table 16: Test facility information in Japan.

Test facility name: JTCCM Japan Testing Center for Construction Materials **Location:** 5-21-20 Inari Soka city Saitama Prefecture 340-0003 Japan **Contact person: Shinji** Hagiharai – hagihara@jtccm.or.jp **Test facility name:** Chemitox co.,ltd. (IEC 61730 MST23, MST24 and others) **Location:** 18349 Egusa, Sutama-cho, Hokuto City, Yamanashi Prefecture 408-0103 Japan **Contact person:** Mitsuya Mochizuki – m-mochizuki@chemitox.co.jp **For further details see A.6 Japan** **Test facility name:** GBRC General Building Research Corporation of Japan **Location:** 5-8-1 Fujishirodai, Suita, Osaka 565-0873 Japan **Contact person:** contact to the person in GBRC via hisashi.ishii@lixil.com

3.7 Republic of Korea

Relationship between local building/construction code and international/national standards in detail

In Korea, requirements for structural works, MEP (mechanical, electrical, and plumbing), fire safety, and building materials are defined in the National Building Codes. The National Building Regulations and Codes of Korea defines building codes for all regions nationwide. Original national building/ construction codes (Korean standard - KS), and modified standards (E.g., KS ISO, KS IEC …) that are directly based on international standards are both used. Most local standards refer to international standards.

Fire-safety standards applying to PV products

The fire-safety standards for PV products, i.e., IEC 61730-1 and -2 are applied in Korea.

For the BIPV system, KS C 8577 standard '*Building-integrated photovoltaics (BIPV) modules — The requirement of performance evaluation*' refers to Appendix A in IEC 61730-2 for PV modules. The minimum requirement of PV/BIPV fire safety performance is C class for roofs. Also, PV products attached to and integrated into roofs should be tested for both burning brand and spread of flame. Furthermore, PV products integrated into roofs need to get additional tests according to ANSI/UL 790.

Fire-safety standards applying to building products relevant to BIPV/BAPV

There are several fire-safety standards applying to building products, such as KS F 2269 *"Methods for fire tests of roof coverings"* based on ASTM E 108 *"Standard test methods for fire tests of roof coverings*", KS F 8414 *"Standard test method for fire performance of external cladding systems of buildings",* and others. Relevant standards for specific building products are dependent on the location where the BIPV or BAPV will be installed. The installations must meet a minimum requirement on fire tests as classified in KS F 2257-1 "*Methods of fire resistance test for elements of building construction - general requirements*".

Modifications for BIPV/BAPV fire safety standards and testing procedures, equipment, PV components, and dimensions of specimens (new developments)

In accordance with recognition of quality and management standards for building materials, composite wall finishing systems (made of more than 2 materials) have to pass an additional mock-up fire safety test, and also current fire tests (KS F 2257-1, 4-9), (KS F 8414).

KETEP (Korea Institute of Energy Technology Evaluation and Planning) recently (2022) commissioned a research project about the establishment of a BIPV/BAPV testing facility specifically to test fire safety of BIPV/BAPV systems. KNU (Kongju National University) is involved in the project. Also, standard testing models, general requirements for fire performance of BIPV/BAPV, etc. are being developed for mock-up fire-safety tests.

With the stricter fire-safety regulations, combustible materials are not permitted for use in BIPV/BAPV systems. Possibly, glass-glass PV modules with tempered glass or fire-retardant materials could be a general model for newly approved BIPV/BAPV modules.

Table 17: Test facility information in Republic of Korea.

Test facility name: Korea Testing Certification Institute **Location:** Republic of Korea, Gunpo (City), 15809 (Zip code) **Contact person:** Hyeon-Dong Choi, choihd@ktc.re.kr **Test facility name:** Korea Conformity Laboratories **Location:** Republic of Korea, Cheongju (City), 28115 (Zip code) **Contact person:** Kyu-Jin Kim, kjkim@kcl.re.kr **Test facility name:** Korea Conformity Laboratories **Location:** Republic of Korea, Samcheok (City), 25913 (Zip code) **Contact person:** Hak-Byeong Chae, chb1087@kcl.re.kr **Test facility name:** Korea Fire Protection Association **Location:** Republic of Korea, Yeoju (City), 12661 (Zip code) **Contact person:** Kye-Won Park, kwpark@kfpa.or.kr **Test facility name:** Korea Institute of Construction Technology **Location:** Republic of Korea, Hwaseong (City), 18544 (Zip code) **Contact person:** Seung-un Chae, seungun.chae@kict.re.kr **For further details see A.8 Republic of Korea**

3.8 Singapore

Figure 26: Furnace for fire-resistance testing.

Relationship between local building/construction code and international/national standards in detail

In Singapore, requirements for structural works, MEP (mechanical, electrical, and plumbing), fire safety, and building materials are defined in the respective National Building Codes. The respective Codes include requirements from the Building Construction Authority (BCA), the Singapore Civil Defence Force (SCDF) and multiple other government agencies. Within these Codes, reference is made both to international standards and Singapore standards (SS).

Fire-safety standards applying to PV products

The fire-safety standards for PV products, i.e., IEC 61730-1 and -2, are applied in Singapore. For roof-mounted PV installations and wall-mounted PV installations, they shall comply with Fire Code 2018 Clause 10.2.1 and Fire Code 2018 Clause 10.2.2 respectively.

The fire performance of roof-mounted PV shall meet a minimum of Class C for both spread of flame and burning brand tests, in accordance with IEC 61730-2. The fire performance of wall-mounted PV shall meet a minimum requirement of Class A for both spread of flame and burning brand for Module Safety Tests (MST)23, in accordance with IEC 61730-2.

In addition, wall-mounted PV shall meet a minimum requirement of Class B with a Fire Growth Rate (FIGRA) <= 70 W/s for its reaction to fire as classified in EN 13501-1.

Full details of the requirements can be found in the Fire Code 2018: https://www.scdf.gov.sg/firecode2018/firecode2018.

Table 18: Test facility and certifier information in Singapore.

Test facility name: TUV SUD PSB Tuas Firelab **Location:** 10 Tuas Avenue 10, Singapore 639134 **Contact person:** info.sg@tuvsud.com **Website:** www.tuvsud.com **For further details on the test laboratory, see** A.9 **Singapore** **Certification bodies:** **Company:** UV SUD PSB Pte Ltd, **Website:** www.tuvsud.com **Company:** Setsco Services Pte Ltd, **Website:** www.setsco.com **Company:** Singapore Test Services Pte Ltd, **Website:** www.singaporetestservices.com

3.9 United States

USA Regulations – In the U.S., regulations governing the installation of BIPV are based on model installation codes that are developed by organizations such as the International Code Council (ICC) and the National Fire Protection Association (NFPA). These codes are developed using a consensus process and are typically updated every three years. The model codes are then adopted in states and jurisdictions across the country and become legally enforceable regulations. The most current codes that cover the installation of BIPV and BAPV are as follows:

- 2014, 2017, 2020, and 2023 editions of the National Electrical Code (NFPA 70)
- 2015, 2018, and 2021 editions of the International Residential Code (IRC) and International Building Code (IBC), for roofing
- 2024 IRC and IBC, for exterior wall coverings and fenestration

These codes are available for free viewing and can be purchased from the ICC (www.iccsafe.org) and NFPA (www.nfpa.org).

Product Safety Standards – Underwriters Laboratories, the non-profit affiliate of UL, developed the following product safety standards for BIPV/BAPV-related products. These standards are used to test and certify products, which in the U.S. are referred to as listed and labelled. Among other things, these standards include construction, testing and marking requirements for these products. Copies of all UL standards can be purchased or viewed online for no charge (using the 'Digital View' functionality) at https://shopulstandards.com/.

- UL 7103 *"Outline of Investigation for Building-Integrated Photovoltaic Roof Coverings"*
- UL 1703 "*Flat-Plate Photovoltaic Modules and Panels"*
- UL 2703 "*Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels"*
- UL 61730-1 *"Photovoltaic (PV) Module Safety Qualification - Part 1: Requirements for Construction"*
- UL 61730-2 *"Photovoltaic (PV) Module Safety Qualification - Part 2: Requirements for Testing"*

Related Fire-Safety Standards – The IBC (Chapter 15) and IRC (Chapter 9) require roofing products to comply with UL 790 (ASTM E108), "*Test Methods for Fire Tests of Roof Coverings".* This basic fire test method is incorporated into the above list of PV product standards, which are also referenced in the IBC and IRC.

Code Considerations - The IBC requires building products used for cladding of the building envelope to comply with the NFPA 285, *"Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible*

Components". This requirement is as specified in the IBC (Chapter 14), along with many other requirements for fenestration and exterior wall coverings.

The installation codes in some areas also require BIPV and BAPV products to demonstrate compliance with these standards through third party certification – called listing and labelling. Accordingly, when these products are installed in accordance with their listing (certification), compliance with the building code and the fire test standards is provided.

Accredited testing laboratory and certification body – UL holds numerous accreditations as a product certification body (ISO/IEC 17065) and as a testing laboratory (ISO/IEC 17025) related to testing and certifying building products, including BIPV and BAPV. These accreditations held by UL are from accreditation bodies which are participating members of the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF). Additional information about UL's accreditations can be provided upon request.

International regulations – UL is currently working with Dubai regulators in the UAE to help them develop electrical, structural and fire regulations and training on proper, safe BIPV and BAPV installations. The regulations being considered for adoption in the UAE include reference to the UL product safety standards described above.

An example of a test facility is shown in the following table.

Table 19: Test facility information in USA.

Test facility name: Underwriters Laboratories Inc **Location:** 2500 Dundee Rd, Northbrook, IL 60062, United States **Contact person:** Scott Jezwinski – Scott.Jezwinski@ul.com **For further details see** A.10 United States

4. DEVELOPMENT OF NEW TESTING PROCEDURES

Based on the requirements of codes for buildings and construction works, and for electrical equipment and installations, there are several challenges[28] that need to be addressed with new or further developed standards and guidelines. In general, PV should be treated like any other construction component when applied onto, or integrated into, a building. A major difference, however, is that BIPV/BAPV elements need to be considered as potentially self-igniting construction components. When developing new standards and codes relating to fire safety, two different approaches could be followed in addressing BIPV and BAPV: Either by distinguishing between the two different installation types and preparing two sets of regulations, or by assuming that in principle, the risks, testing and mitigation methods are similar for BIPV and BAPV and should thus be handled by the same set of regulations. Further investigations should reveal which approach is more practicable.

Smoke from a PV installation on a building has been reported to potentially contain dangerous substances[24] whereas another study concludes that these emissions do not differ significantly from those released in any fire involving construction and electronic products [29]. Thus the need for new standards or guides addressing this should be further discussed but is not deemed to be an urgent matter.

BIPV/BAPV needs new test methods for fire safety which consider the actual burning behavior of PV in operation; new firefighter guides are needed for firefighter safety to avoid hazards of chemical fumes and the risk of electric shock.

The ongoing European work with facade fire safety test methods[30] should take PV into account so that both BIPV and BAPV on facades can be tested on a full scale and compared with other types of facade cladding. For roofs, there is now an initiative in CEN/TC 127/ WG 5 to define a test method that takes account of BAPV on roofs, but there is currently no initiative to include BIPV.

Classification of construction products according to EN 13501-1, -2 and -5, i.e. the Euroclass system, is part of the building code in all EU countries, where part 5 refers to class B_{ROOF} tx for roof coverings. An in-depth analysis of the test method for classification B_{ROOF} t2 according to CEN/TS 1187:2012, as well as some tests on PV modules according to this standard, has made it clear that it is not fully applicable to PV on roofs in general and furthermore is not applicable to BIPV roof installations. A proposed test set-up for a BIPV roof is described in

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[28] Ko, Y., Aram, M., Zhang, X. and Qi, D. Fire Safety of Building Integrated Photovoltaic Systems: Critical Review for Codes and Standards, Indoor and Built Environment. Indoor and Built Environment, 32 (2022) pp. 25 - 43 https://doi.org/10.1177/1420326X211073130

[29] NW van Veen et al. Harmful substances in fires involving solar panels. RIVM rapport 2022-0103.

[30] https://www.ri.se/en/what-we-do/projects/european-approach-to-assess-the-fire-performance-of-facades

Annex B of EN IEC 61730-2 but such a set-up cannot be achieved in a B_{ROOF} t2 test rig. The method thus needs to be modified so that it can handle larger test objects. Moreover, it would be desirable if the four different tests for classifications t1, t2, t3 and t4 could be harmonized into one single test.

5. DISCUSSION AND FUTURE OPPORTUNITIES

Faced with the difficulty of harmonization at the international level, an intermediate step toward addressing BIPV/BAPV components/systems correctly is to gather all relevant standards from building code (IBC) and International Fire Code (US) – Eurocodes (EU) – BCA (AUT) – ICC (CN) – JBC (JP)) that deal with fire safety, and electrical standards addressing photovoltaics (IEC – ISO -UL – ASTM). According to recent BIPV definitions (EN 50583 – IEC 63092), those components must support various building functionalities and must be assessed accordingly.

The identification, design and trial of test solutions that are the most representative of real operating conditions pave the way for future normative work. The combination of normative requirements in the field of construction with normative requirements in the electrotechnical sector will make it possible to assess the photovoltaic components under the most realistic implementation and operating conditions. Similarly, the additional functions provided by the BIPV components must be correctly assessed regarding the components they are meant to replace.

The validation of these new procedures will support the development of BIPV components by proposing relevant and recognized evaluation solutions, to define the specific performance of BIPV components in relation to conventional construction components and to confirm that no additional risks have been introduced compared to traditional solutions.

It is essential to prove that BIPV components can meet the requirements of the construction sector, even when their active function (electricity generation) is considered. This is a pre-requisite, when BIPV components are to replace conventional building components and to simultaneously generate electricity, allowing the energy performance requirements of the building to be met.

Indeed, incorporation of BIPV must be based on proof of performance, durability and risk management. By proving that BIPV components are durable and equivalent to passive components, a solid basis will be provided for manufacturers, architects, builders and developers to promote this application.

This report, identifying many of the relevant codes and standards, laboratories, research teams and equipment capable of supporting the development of this work with respect to fire safety, is a contribution to this effort.

ANNEX A

A.0 Original Survey Form 1

Fire safety of BIPV: International mapping of accredited and R&D facilities for fire safety testing of BIPV.

For any questions, feel free to reach out to Veronika Shabunko at veronika.shabunko@nus.edu.sg

Please provide high resolution images of facilities and test laboratories, in addition to the ones indicated in the tables below

Test facility technical drawings (cad or HD pdf) **Test facility HD photo** (minimum 300 dpi) **READ ME:** **How to name the files:** IEA-PVPS-T15-STE-E3 Country of Lab # Surname # revyymmdd, e.g. IEA-PVPS-T15-STE_Singapore_1_rev200101.jpg, etc.

BIPV test facility technical information

General information on test facility

Test facility name (if applicable):

Test facility location (please indicate details of country, city/zip):

Contact person (email, mail address):

Fire safety test standards for which your facility is accredited (if applicable):

Test facility description (Please delete all parts that are not relevant to your facility):

Specimen information (in m):

If you have more than one rig, please use column B, and C.

Specimen information	**Type Rig A**	**Type Rig B**	**Type Rig C**
1. **Bench Scale**			
• Complies to standard(s) (please specify)			
• Max and min length of sample			
• Max and min thickness of sample			
• Any modifications (inclination, fixed, movable)			
• Testing with PV module frame/without PV module frame			
• Testing single sample or combined façade element			
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)			
• Fire curve (yes/no)			
• System size (MW)			
• Fire reaction (yes/no)			
• Fire resistance (yes/no)			
• Approximate price per test			

• Please provide images of the facilities, including captions			
2. Unique set up, e.g. R&D purposes (non-standard)			
• Max and min length of sample			
• Max and min thickness of sample			
• Max and min height of sample			
• Max and min weight of sample			
• Any modifications (inclination, fixed, movable)			
• Testing with PV module frame/without PV module frame			
• Testing single sample or combined façade element			
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)			
• Fire curve (yes/no)			
• System size (MW)			
• Fire reaction (yes/no)			
• Fire resistance (yes/no)			
• Approximate price per test			
• Please provide images of the facilities, including captions			
3. **Standard set up/ Furnace**			
• Complies to standard(s) (please specify)			
• Max and min length of sample			
• Max and min thickness of sample			
• Max and min height of sample			

• Max and min weight of sample			
• Any modifications (inclination, fixed, movable)			
• Testing with PV module frame/without PV module frame			
• Testing single sample or combined façade element			
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)			
• Fire curve (yes/no)			
• System size (MW)			
• Fire reaction (yes/no)			
• Fire resistance (yes/no)			
• Approximate price per test			
• Please provide images of the facilities, including captions			
4. **Full façade set up**			
• Complies to standard(s) (please specify)			
• Max and min length of sample			
• Max and min thickness of sample			
• Max and min height of sample			
• Max and min weight of sample			
• Any modifications (inclination, fixed, movable)			
• Testing with PV module frame/without PV module frame			
• Testing single sample or combined façade element			

• Analytical facilities (smoke, toxicity, online, offline, attached/separated)			
• Fire curve (yes/no)			
• System size (MW)			
• Fire reaction (yes/no)			
• Fire resistance (yes/no)			
• Approximate price per test			
• Number of floors/ storeys			
• Please provide images of the facilities, including captions			
5. **Hood system**			
• Complies to standard(s) (please specify)			
• Max and min length of sample			
• Max and min thickness of sample			
• Max and min height of sample			
• Max and min weight of sample			
• Any modifications (inclination, fixed, movable)			
• Testing with frame/without frame			
• Testing single sample or combined façade element			
• Analytical facilities (smoke, toxicity, online, offline)			
• Fire curve			
• System size (MW)			
• Fire reaction (small samples)			
• Fire resistance			
• Approximate price per test			

• Please provide images of the facilities, including captions			
6. **Analytical tools available, e.g. simulation tools, modeling, etc.**			
Please include the specifics of the procedure:			

Test capability and experience in accordance with e.g. IEC, UL, etc. standards

- For BIPV product (please specify standard IEC, UL, etc.)
- For conventional building products (cladding, fenestrations, roofing, curtain wall)
- For façade assemblies (please specify standard IEC, UL, etc.)
- Any additional details, i.e. test on preventive measures?

Please specify:

Facility to do fire safety testing of electrically active PV (R&D facilities):

Please specify:

Test environmental conditions:

- **Exhaust gas treatment**
- **Disposal of test specimen**

Please specify:

Test results:

- work used for industry
- work required by building code/ country regulations
- work used for R&D

Please specify:

Associated mounting structure/solution:

Please provide example/image:

Other important technical information that we might have missed, e.g. tests which are unique to your test facility

A.1 Australia

Test facility name: Warringtonfire Australia

Contact person: Steven Halliday – steven.halliday@warringtonfire.com / Kai Loh – kai.loh@warringtonfire.com / Tanmay Bhat – tanmay.bhat@warringtonfire.com

Specimen information	**Type Rig A**	**Type Rig B**
1. Bench Scale		
• Complies to standard(s)	ISO 5660-1	AS 1530.1
• Max and min length of sample	100 mm × 100 mm ±1 mm	cylindrical specimen with a diameter of 45 mm
• Max and min thickness of sample	Max: 50 mm	max height of 50 mm
• Any modifications (inclination, fixed, movable)	Vertical or horizontal orientation	-
• Testing single sample or combined façade element	single sample	single sample
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Heat release, smoke release and mass loss	-
• Fire curve (yes/no)	no	no
• System size (MW)	up to 100 kW/m^2	up to 750 °C
• Fire reaction (yes/no)	yes	yes
• Fire resistance (yes/no)	no	no
• Approximate price per test	$2,350	$3,900


Photo of the ISO 5660-1 test rig

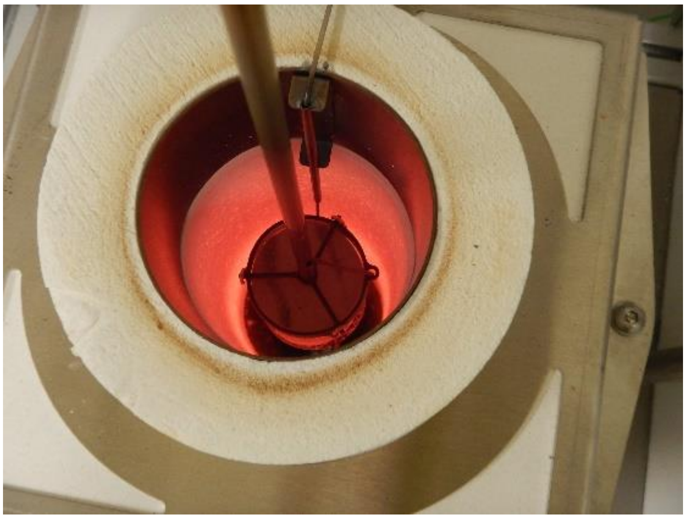


Photo of the AS 1530.1 test rig

2. Unique set up, e.g. R&D purposes (non-standard)		
• Max and min length of sample	We can build custom assemblies and test with direct flame exposure or radiant exposure or both with temperature, heat flux, air velocity	
3. Standard set up/ Furnace		
• Complies to standard(s)	Full scale - Fire resistance test standards eg: AS 1530.4, BS 476, EN 1363-1, UL, ASTM	Pilot scale - Fire resistance test standards eg: AS 1530.4, BS 476, EN 1363-1, UL, ASTM
• Max and min length of sample	Max: 3 m	Max: 1.6m
• Max and min thickness of sample	Max: 0.4 m	Max: 0.4 m
• Max and min height of sample	Max: 4 m	Max: 1.6m
• Max and min weight of sample	Max: 10 tonnes including test frame	5T
• Any modifications (inclination, fixed, movable)	Vertical and horizontal, oversize specimens if required	Vertical and horizontal
• Testing with PV module frame/without PV module frame	Possible	Possible
• Testing single sample or combined façade element	Combined	Combined
• Fire curve (yes/no)	Yes	Yes
• System size (MW)	20,000,000 BTU	
• Fire reaction (yes/no)	No	No
• Fire resistance (yes/no)	Yes	Yes
• Approximate price per test	Available on inquiry	Available on inquiry
4. Full façade set up		
• Complies to standard(s)	BS 8414-2, AS 5113	ISO 9705

• Max and min length of sample		32 m^2 (sample needs to cover 3 walls and the ceiling)
• Max and min thickness of sample	Up to nominally 400mm	per application
• Max and min height of sample	8m high standard, 10m high and 18m high on special request	per application
• Max and min weight of sample	20-30T max (crane limited)	per application
• Any modifications (inclination, fixed, movable)	Possible, very customizable	Variation of room sizes and configurations, ISO13784 testing as well
• Testing with PV module frame/without PV module frame	Possible	Possible
• Testing single sample or combined façade element	Combined	Combined
• Analytical facilities		HRR, Smoke release, CO and CO_2 production
• Fire curve (yes/no)	No	no
• System size (MW)	3 MW	300 kW
• Fire reaction (yes/no)	Yes	yes
• Fire resistance (yes/no)	No	no
• Approximate price per test	Available on inquiry	$16,750
• Number of floors/ storeys	3 storeys (Up to 5)	-

Photo of façade test rig.

Photo of the ISO 9705 test rig.

5. Hood system		
• Complies to standard(s)	ISO 9705	
• Max and min length of sample	As per section 4	
• Max and min thickness of sample		
• Max and min height of sample		
• Max and min weight of sample		
• Any modifications (inclination, fixed, movable)		
• Testing with frame/without frame		
• Testing single sample or combined façade element		
• Analytical facilities		
• Fire curve		
• System size (MW)		
• Fire reaction (small samples)		
• Fire resistance		
• Approximate price per test		
• Please provide images of the facilities, including captions		

6. Analytical tools available, e.g. simulation tools, modeling, etc.

Our fire safety engineering branch operates a suite of smoke, egress, thermal and structural simulation software.

Facility to do fire safety testing of electrically active PV (R&D facilities): Presently no, but we can do

Test environmental conditions: Bag filter used for exhaust scrubbing of equipment

Test results:

- work used for industry
- work required by building code/ country regulations
- work used for R&D

All the above

Other important technical information that we might have missed, e.g. tests which are unique to your test facility: This facility developed the AS1530.8.1 and AS1530.8.2 bushfire standards.

A.2 Brazil

Test facility name: LSFEx/ IPT

Test facility location: São Paulo, Brasil, Zip code 05508-901

Contact person: afberto@ipt..br

Specimen information	Type Rig A	Type Rig B	Type Rig C
1. Bench Scale			
• Complies to standard(s)	ASTM E662	UL 94	ISO 11925-2
• Max and min length of sample	According to the test method	According to the test method	According to the test method
• Max and min thickness of sample	According to the test method	According to the test method	According to the test method
• Any modifications (inclination, fixed, movable)	no	no	no
• Testing with PV module frame/without PV module frame	no	no	no
• Testing single sample or combined façade element	no	no	no
• Analytical facilities	yes	no	no
• Fire curve (yes/no)	-	-	-
• System size (MW)	-	-	-
• Fire reaction (yes/no)	yes	yes	yes
• Fire resistance (yes/no)	no	no	no
• Approximate price per test			
• Please provide images of the facilities, including captions	http://www.ipt.br/LSFEx	http://www.ipt.br/LSFEx	http://www.ipt.br/LSFEx

2. Unique set up, e.g. R&D purposes (non-standard): N.a.			
3. Standard set up/ Furnace			
• Complies to standard(s) (please specify)	ASTM E162	EN 13823	ISO 5658-2
• Max and min length of sample	According to the test method	According to the test method	According to the test method
• Max and min thickness of sample	According to the test method	According to the test method	According to the test method
• Max and min height of sample	According to the test method	According to the test method	According to the test method
• Max and min weight of sample	According to the test method	According to the test method	According to the test method
• Any modifications (inclination, fixed, movable)	no	no	no
• Testing with PV module frame/without PV module frame	no	no	no
• Testing single sample or combined façade element	Single sample only	Single sample only	Single sample only
• Analytical facilities (smoke, toxicity, online, offline, attached/ separated)	no	no	no
• Fire curve (yes/no)	no	no	no
• System size (MW)			
• Fire reaction (yes/no)	yes	yes	yes
• Fire resistance (yes/no)	no	no	no
• Approximate price per test			
• Please provide images of the	http://www.ipt.br/LSFEx	http://www.ipt.br/LSFEx	http://www.ipt.br/LSFEx

facilities, including captions			

4. **Full façade set up: N.a.**

5. **Hood system: N.a.**

6. **Analytical tools available, e.g. simulation tools, modeling, etc.: N.a.**

Test capability and experience in accordance with e.g. IEC, UL, etc. standards: See above

Facility to do fire safety testing of electrically active PV (R&D facilities): None

Test environmental conditions: N.a.

Test results:

- work used for industry
- work required by building code/ country regulations
- work used for R&D

All situations apply

Associated mounting structure/solution: N.a.

Other important technical information that we might have missed, e.g. tests which are unique to your test facility: N.a.

A.3 Canada

Test facility name: National Research Council Canada (NRCC)
Contact person: Yoon Ko – yoon.ko@nrc-cnrc.gc.ca
Check the link below for general information:
https://nrc.canada.ca/en/research-development/nrc-facilities/fire-safety-testing-facility

Specimen information	Type Rig A	Type Rig B	Type Rig C
1. Bench Scale			
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW) • Fire reaction (small samples) • Fire resistance	Cone Calorimeter -sample sizes as per ASTM E 1354 ISO 5660-1 NFPA 271 Horizontal and vertical orientations Smoke measurement as per the standards Sample reaction to various levels of heat fluxes	FTIR could be connected to the cone calorimeter testing setup Data could be used for toxicity analysis	STA (Simultaneous thermogravimetric analyzers processing both DSC and TGA) MCC (Micor combustion calorimeter) to get combustion behavior
2. Unique (non-standard)			
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element	Intermediate scale wall and floor furnace 1.5 m by 2.0 m wall/floor samples With frame Smoke and FTIR measurement possible		

• Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW) • Fire reaction (small samples) • Fire resistance	using the ASTM E119, CAN/ULC-S101, ISO 834, UL 1709 and ASTM 1529 standards	
3. Standard/ Furnace		
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW) • Fire reaction (small samples) • Fire resistance	Full scale Wall furnace 3 m x 3 m with a load of up to 2000 kN With frame using the ASTM E119, CAN/ULC-S101, ISO 834, UL 1709 and ASTM 1529 standards	Full scale floor furnace 3.9 m x 4.8 m specimens with loads up to 2000 kN With frame using the ASTM E119, CAN/ULC-S101, ISO 834, UL 1709, and ASTM 1529 standards
4. Full façade set up		
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW)	Please contact for inquiries on facade fire tests as per ULC S134	

• Fire reaction (small samples) • Fire resistance • Number of stories		
5. Hood system		
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW) • Fire reaction (small samples) • Fire resistance	Sample can be placed under a hood approx. 3 m x 1 m Contact for any inquires on ad-hoc tests using a hood system Smoke and FTIR measurement possible Contact for any inquires on the MW size and other hood details	
6. Analytical tools available, e.g. simulation tools, modeling, etc.: N.a.		
Test capability and experience in accordance with (IEC, UL, etc.) • For BIPV product (IEC, UL, etc.) Experiences in PV system mechanical tests (e.g., wind uplift of BAPV on roof) • For conventional product (cladding, fenestrations, roofing, curtain wall) • For facade assembly Experiences in testing fenestration and various facade systems (e.g, UL S134) • Any additional details, i.e. test on preventative measures? Experiences in testing fire suppression systems, fire detection systems and firefighting tactics		
Facility to do fire safety testing of electrically active PV (R&D facilities): Arrangement possible, please contact for inquiries, (yoon.ko@nrc-cnrc.gc.ca)		
Test environmental conditions • **Exhaust gas treatment –** may need to get approvals for testing based on anticipated gas emission		

• **Disposal of test specimen** – all disposal required to follow the local environmental regulations
Test results: to support the development of national building codes of Canada or support industry • work used for industry • work required by building code/ country regulations (pls specify) • work used for R&D
Equipment/sensors used for testing: Measurement capabilities – smoke temperature/ velocity, heat release rates (HRR), heat flux, thermal imaging (IR cameras), FTIR toxic gas measurements, smoke densities and so on.
Associated mounting structure/solution (please provide example): N.a.
Other important technical information that we might have missed, e.g. tests which are unique to your test facility For more information, go to https://nrc.canada.ca/en/research-development/nrc-facilities/fire-safety-testing-facility

A.4 China

Test facility name: Intertek Testing Services Shenzhen Ltd

Contact person: Mr. Jeff – jeff.jf.deng@intertek.com

Specimen information:

Accredited standard: IEC 61730-2 & UL 790
Test Report bears ILAC-MRA & IAS logo
Lead Time: 25 working days after sample arrived at Shanghai Lab
Sample Requirement(UL 790):
2 pcs 1m wide by 1.3m long , 2pcs 1m wide by 3.9m long
Approximate Test Price: $ 6000 (Singapore Dollar)

Accredited standard: IEC 61730-2
Test Report bears ILAC-MRA & CNAS logo
Lead time: 5 to 8 days after sample arrived at Yangzhou Lab
Sample Requirement(61730-2):
3 pcs 1m wide by 3.9m long
Approximate Test Price: $ 2000-$2400 (Singapore Dollar)

Specimen information	**Type Rig A**
1. Bench Scale	
• Complies to standard(s) (please specify)	Refer to above
• Max and min length of sample	
• Max and min thickness of sample	Available on inquiry
• Any modifications (inclination, fixed, movable)	
• Testing with PV module frame/without PV module frame	
• Testing single sample or combined façade element	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	
• Fire curve (yes/no)	
• System size (MW)	
• Fire reaction (yes/no)	
• Fire resistance (yes/no)	
• Approximate price per test	Refer to above
• Please provide images of the facilities, including captions	Available on inquiry
2. Unique set up, e.g. R&D purposes (non-standard)	

• Max and min length of sample	Refer to above
• Max and min thickness of sample	Available on inquiry
• Max and min height of sample	
• Max and min weight of sample	
• Any modifications (inclination, fixed, movable)	
• Testing with PV module frame/without PV module frame	
• Testing single sample or combined façade element	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	
• Fire curve (yes/no)	
• System size (MW)	
• Fire reaction (yes/no)	
• Fire resistance (yes/no)	
• Approximate price per test	Refer to above
• Please provide images of the facilities, including captions	Available on inquiry
3. Standard set up/ Furnace	
• Complies to standard(s) (please specify)	Refer to above
• Max and min length of sample	
• Max and min thickness of sample	Available on inquiry
• Max and min height of sample	
• Max and min weight of sample	
• Any modifications (inclination, fixed, movable)	
• Testing with PV module frame/without PV module frame	
• Testing single sample or combined façade element	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	
• Fire curve (yes/no)	
• System size (MW)	
• Fire reaction (yes/no)	
• Fire resistance (yes/no)	
• Approximate price per test	Refer to above
• Please provide images of the facilities, including captions	Available on inquiry
4. Full façade set up	
• Complies to standard(s) (please specify)	Refer to above
• Max and min length of sample	
• Max and min thickness of sample	

• Max and min height of sample	Available on inquiry
• Max and min weight of sample	
• Any modifications (inclination, fixed, movable)	
• Testing with PV module frame/without PV module frame	
• Testing single sample or combined façade element	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	
• Fire curve (yes/no)	
• System size (MW)	
• Fire reaction (yes/no)	
• Fire resistance (yes/no)	
• Approximate price per test	Refer to above
• Number of floors/ storeys	Available on inquiry
• Please provide images of the facilities, including captions	
5. Hood system	
• Complies to standard(s) (please specify)	Refer to above
• Max and min length of sample	
• Max and min thickness of sample	Available on inquiry
• Max and min height of sample	
• Max and min weight of sample	
• Any modifications (inclination, fixed, movable)	
• Testing with frame/without frame	
• Testing single sample or combined façade element	
• Analytical facilities (smoke, toxicity, online, offline)	
• Fire curve	
• System size (MW)	
• Fire reaction (small samples)	
• Fire resistance	
• Approximate price per test	Refer to above
• Please provide images of the facilities, including captions	Available on inquiry
Test capability and experience in accordance with e.g. IEC, UL, etc. standards For BIPV: IEC 61730-2 & UL 790	

A.5 Europe

A.5.1 Austria

BIPV test facility technical information

General information on test facility

Test facility name: IBS – Institut für Brandschutztechnik und Sicherheitsforschung Gesellschaft m.b.H

Test facility location: Austria, 4020 Linz, Petzoldstraße 45

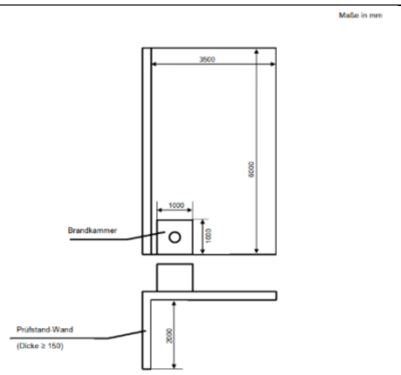
Contact persons: Roland BECK; r.beck@ibs-austria.at and Dr. Arthur Eisenbeiss – a.eisenbeiss@bvs-ooe.at

Fire safety test standards for which your facility is accredited:

https:// www.ibs-austria.at/en/about-us/certificates-and-verifications/

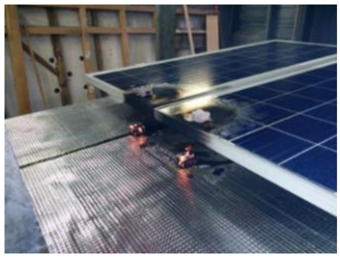
Test facility description

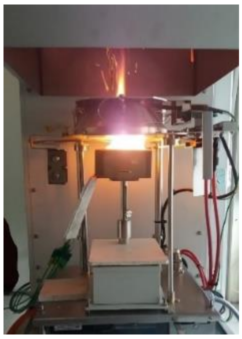
Specimen information	Type Rig A	Type Rig B	Type Rig C
1. Bench Scale			
• Complies to standard(s)	EN 13823	ONR CEN/TS 1187	
• System size (MW)	0,5 x 1,0 x 1,5 m L-shaped	800 x 1800	
• Fire reaction (yes/no)	y	y	
• Fire resistance (yes/no)	n	n	
• Approximate price per test	~ 2500 €	~ 3000	
			
2. Unique set up, e.g. R&D purposes (non-standard): N.a.			

3. Standard set up/ Furnace: N.a.			
4. Full façade set up			
• Complies to standard(s)	ÖNORM B 3800-5		
• System size (MW)	5,5 x 6 m, L-shaped		
• Fire reaction (yes/no)	-		
• Fire resistance (yes/no)	-		
• Approximate price per test	~ 6000€		
• Number of floors/ storeys	2		
			
5. Hood system: N.a.			
6. Analytical tools available, e.g. simulation tools, modeling, etc.: N.a.			
Test capability and experience in accordance with e.g. IEC, UL, etc. standards: Façade according to ÖNORM B 3800-5 (Austrian standard) Reaction to fire according to EN 13823 (SBI), EN 1716 (Bomb calorimeter), EN 11925-2 (small flame test) and CEN/TS 1187 (external fire exposure to roofs)			
Facility to do fire safety testing of electrically active PV (R&D facilities): N.a.			
Test environmental conditions: After burning system with flue gas scrubbing			

A.5.2 France

Test facility name: Centre Scientifique et Technique du Bâtiment (CSTB FIRE LAB) **Contact persons:** Valérie GOURVES (Head of Fire Laboratory) – valerie.gourves@cstb.fr, Simon BODDAERT (Head of PV Innovation)– simon.boddaert@cstb.fr			
Specimen information **From small scale (100x100mm) up to 9m large scale samples**	**Type Rig A**	**Type Rig B**	**Type Rig C**
1. Bench Scale			
• Complies to standard(s)	Flammability test EN ISO 11925-2	SBI test EN 13823	External fire performance CEN TS 1187 (B_{ROOF} t3 and t1, t2)
• Max and min length of sample	250 x 90mm	L shaped sample 0,5x1,5m + 1x1,5m	2,5 x 3m
• Max and min thickness of sample	60mm máx	200 mm máx	No restriction
• Any modifications (inclination, fixed, movable)	Fixed, inclination	fixed	Movable, inclination Up to 30°
• Testing with PV module frame/without PV module frame	Without frame	With frame	With frame
• Testing single sample or combined façade element	6 samples minimum	3 samples	2 samples per each inclination
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Off-line, attached	Off-line, attached	n/a
• Fire curve (yes/no)	no	no	no
• Fire reaction (yes/no)	Yes	Yes	yes
• Fire resistance (yes/no)	no	no	no
• Approximate price per test	< 1500€		

	 Flammability test EN ISO 11925-2	 SBI test EN 13823	  External fire performance CEN TS 1187 (B_{ROOF} t3 and t1, t2)
2. Unique set up, e.g. R&D purposes (non-standard)			
Description	Experimental cubic furnace	Cone calorimeter	
• Max and min length of sample	1.4x1.4x1.4m3	100mmx100mm	
• Max and min thickness of sample	Up to 0.5 m	50 mm	
• Any modifications (inclination, fixed, movable)	movable	fixed	
• Testing with PV module frame/without PV module frame	With frame	without	
• Testing single sample or combined façade element	Complete PV system	single	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	-	Attached FTIR	
• Fire curve (yes/no)	no	no	
• System size (MW)	1	100 kW/m2	
• Fire reaction (yes/no)	Yes (fire spread)	yes	

• Fire resistance (yes/no)	no	no	
• Approximate price per test	Range between 1000-8000€		
	 Experimental cubic furnace	 Cone calorimeter	
3. Standard set up/ Furnace			
• Complies to standard(s)	Vertical furnace 3x3m	Horizontal furnace 4x3m	Modular Vertical and horizontal furnace Vertical 3 x9 m Horizontal: 4x7 m
• Max and min length of sample	Max 3 m	Max 4 m	Max 4m
• Max and min thickness of sample	Max 0, 5m	Max 1m	Max 1m
• Max and min height of sample	Max 3m	-	Max 9m
• Any modifications (inclination, fixed, movable)	fixed	Fixed	Fixed
• Testing with PV module frame/without PV module frame	with	with	with
• Testing single sample or combined façade element	combined	combined	combined
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Attached offline	Attached offline	
• Fire curve (yes/no)	yes	yes	yes
• System size (MW)	1,5	6	13

• Fire reaction (yes/no)	no	no	no
• Fire resistance (yes/no)	yes	yes	yes
• Approximate price per test	Range between 6000-30000€		
	 Vertical furnace 3x3m	 Horizontal furnace 4x3m	 Modular Vertical and horizontal furnace Vertical 3 x9 m Horizontal: 4x7 m
4. Full façade set up			
• Complies to standard(s) (please specify)	Midscale façade test	LEPIR II	
• Max and min length of sample	2.5m width	5 m width	
• Max and min thickness of sample	No restriction	No restriction	
• Max and min height of sample	Up to 5 m	Up to 8 m	
• Any modifications (inclination, fixed, movable)	Movable test frame	fixed	
• Testing with PV module frame/without PV module frame	With frame	With frame	

• Testing single sample or combined façade element	combined	combined
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	smoke	Not available yet
• Fire curve (yes/no)	no	no
• System size (MW)	Up to 2	Up to 4
• Fire reaction (yes/no)	yes	yes
• Fire resistance (yes/no)	no	no
• Approximate price per test	Range between 9000-27000€	
• Number of floors/ storeys	1	3
	 Midscale façade test	 LEPIR II
5. Hood 4x3 m		
• National Directive published in Official journal (JORF-19700929_226)	No specific standard, this test is performed according to specific requirements from LEPR and intermediate size tests	
• Max and min length of sample	Up to 3 m	

• Max and min thickness of sample	Up to 1m
• Max and min height of sample	Up to 5 m
• Any modifications (inclination, fixed, movable)	movable
• Testing with frame/without frame	with
• Testing single sample or combined façade element	combined
• Analytical facilities (smoke, toxicity, online, offline)	Smoke , toxicity
• Fire curve	no
• System size (MW)	3
• Fire reaction (small samples)	Yes
• Fire resistance	no
• Approximate price per test	10000 €
	

6. Analytical tools available, e.g. simulation tools, modeling, etc.

Our fire safety engineering team operates a suite of smoke, egress, thermal and structural simulation software.

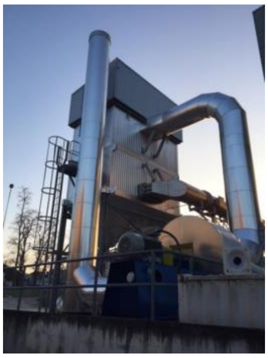
Test capability and experience in accordance with e.g. IEC, UL, etc. standards

- For BIPV product: In progress to implement EN 50583-1 and EN 50583-2
- For conventional building products (cladding, fenestrations, roofing, curtain wall): all European standard

- For façade assemblies: national std, LEPIR II

Test environmental conditions:

Exhaust gas treatment: Bag filter used for exhaust scrubbing of equipment.



Disposal of test specimen:
Separated disposal and waste treatment depending on the tested materials.

Test results:

- work used for BIPV industry 10%
- work required by building codes or regulations 60%
- work used for R&D 30%

Other important technical information that we might have missed, e.g. tests which are unique to your test facility:

Other relevant tests: Non combustibility tests to EN ISO 1182

Gross heat OF combustion (PCS value) to EN 1716

A.5.3 Germany

Test facility name: ift Rosenheim GmbH
Contact person: Ms. Anyke Aguirre Cano – aguirrecano@ift-rosenheim.de
Check the link below for general information: https://www.ift-rosenheim.de/akkreditierung-prueflabor

Specimen information	**Type Rig A** vertical furnace max. 5 x 5 m	**Type Rig B** vertical furnace max. 8 x 5 m	**Type Rig C** Column furnace 3 x 3 x 3 m	**Type Rig D** Small Scale furnace vertical 1,5 x 1,5 / horizontal 1,5 x 2 m	**Type Rig E** combi furnace vertical 4 x 2,5 / horizontal 4 x 5 m
1. Bench Scale					
• Complies to standard(s)	according to accreditation				
• Max and min length of sample	according to furnace size				
• Testing with PV module frame/without PV module frame	no experience with PV modules				
• Testing single sample or combined façade element	combined façade element	combined façade element	not possible	too small	combined façade element
• Fire curve (yes/no)	standard curve (EN 1363-1 / ISO 834-1) / HC-curve / UL-curve				
• Fire reaction (yes/no)	yes (according to accreditation, please contact moarcas@ift-rosenheim.de)				
• Fire resistance (yes/no)	yes				
• Approximate price per test	depending on size, test standard and test duration				

Test facility name: Currenta GmbH & Co. OHG (listed in TÜV Rheinland OSHA Accreditation)

Fire safety test standards for which your facility is accredited:

IEC 61730, UL 61730, EN 1187-1, EN 13823, EN 13501-1

Test facility description

Specimen information	**Type Rig A**	**Type Rig B**	**Type Rig C**
1. Bench Scale			
• Complies to standard(s) (please specify)	All mentioned		
• Max and min length of sample	Max. 4 m		
• Max and min thickness of sample	diverse		
• Any modifications (inclination, fixed, movable)	Expandable test stand for larger test specimens, inclination adjustable, movable		
• Testing with PV module frame/without PV module frame	With and without		
• Testing single sample or combined façade element	Single and combined		

• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Not applicable		
• Fire curve (yes/no)	yes		
• System size (MW)	2 MW		
• Fire reaction (yes/no)	yes		
• Fire resistance (yes/no)	yes		
• Approximate price per test	Available on enquiry		
• Please provide images of the facilities, including captions	Not applicable		
2. Unique set up, e.g. R&D purposes (non-standard) n.a.			
3. Standard set up/ Furnace n.a.			
4. Full façade set up n.a.			
5. Hood system n.a.			
6. Analytical tools available, e.g. simulation tools, modeling, etc.: n.a.			

Test capability and experience in accordance with e.g. IEC, UL, etc. standards:

IEC 61730, UL 61730, EN 1187-1, EN 13823, EN 13501-1

Test environnemental conditions:

- Exhaust gas treatment:
  - Thermal exhaust gas treatment
  - Venturi quench, column scrubber and electrostatic precipitator
  - Disposal of test specimen: TÜV

Test results:

- work used for industry: TÜV
- work used for R&D

A.5.4 Italy

Test facility name: Istituto Giordano **Contact person:** g.traina@giordano.it			
Specimen information: **Reaction to fire Max 1500 x 1000 mm, Fire Resistance 3 m x 3 m)**	**Reaction to Fire**	**Fire resistance**	**Type Rig C**
1. Bench Scale			
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (kW) • Fire reaction (small samples) • Fire resistance	1500 mm 200 mm / / Yes Yes Both Smoke density / 30 kW /	3000 mm any 3000 mm / Yes Yes Both / (Fire resistance) EN 1373-1, EN 1373-2	
2. Unique (non-standard) (TEST FOR BIPV_outdoor)			
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (kW) • Fire reaction (small samples) • Fire resistance	2000 mm 10-50 mm 1000 mm 80 kg / Any Combined Electrical parameter and visual observation 10-50 FIRE REACTION		

3. Standard/ Furnace		
• Max and min length • Max and min thickness • Max and min height • Max and min weight • Any modifications (inclination, fixed, movable) • Testing with frame/without frame • Testing single sample or combined façade element • Analytical facilities (smoke, toxicity, online, offline) • Fire curve • System size (MW) • Fire reaction (small samples) • Fire resistance		3000mm any 3000 mm / Yes Yes Both / (Fire resistance) EN 1373-1, EN 1373-2

Test capability and experience in accordance with (IEC, UL, etc.)

- For BIPV products (IEC, UL, etc.) – UNI and EN standard
- For conventional products (cladding, fenestrations, roofing, curtain wall) - YES
- For façade assembly

Test environmental conditions (10-30°C)

- Exhaust gas treatment (bag filter + CaO-active carbon treatment)
- Disposal of test specimen (according to Italian legislation)

Equipment/sensors used for testing:

- I.e. heat fluxmeters, propane gas fluxmeters, thermocouples, Oxygen and CO2 analyzer, balances, multimeters, anemometers.

SBI test “original”.

SBI test “variant” for PV roofs.

PV façade with Rapid Shutdown System – outdoor scoping test.

A.5.5 Norway

Test facility name: RISE Fire Research AS, Norway **Contact person:** Robert Olofsson – robert.olofsson@risefr.no **Check the link below for general information:** https://risefr.no/,https://www.akkreditert.no/en/akkrediterte-organisasjoner/akkrediteringsomfang/?AkkId=67			
Specimen information	**Type Rig A**	**Type Rig B**	**Type Rig C**
1. Bench Scale			
• Complies to standard(s) (please specify)	Yes, available on inquiry		
2. Unique set up, e.g. R&D purposes (non-standard)			
• Max and min length of sample	Yes, available on inquiry		
3. Standard set up/ Furnace			
• Complies to standard(s) (please specify)	EN 1363 / ISO 843 / IMO FTP Code part 3: Vertical furnace	EN 1363 / ISO 843 / IMO FTP Code part 3: horizontal furnace	EN 1363 / ISO 843 / IMO FTP Code part 3: small scale furnace (vertical and horizontal)
• Max and min length of sample	3000	3000	1500
• Max and min height of sample	3000	4000	1500
• Max and min weight of sample	8000 kg	8000 kg	5000 kg
• Any modifications (inclination, fixed, movable)		Inclination available	
• Testing with PV module frame/without PV module frame	yes	yes	yes
• Testing single sample or combined façade element	yes	yes	yes
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	All	All	All
• Fire curve (yes/no)	yes	yes	yes
• Fire resistance (yes/no)	yes	yes	yes
• Approximate price per test	100 000 NOK	100 000 NOK	100 000 NOK
• Please provide images of the facilities, including captions			
4. Full façade set up			

• Complies to standard(s)	Yes, SP/EU setup, available on inquiry
5. Hood system	
• Complies to standard(s) (please specify)	Yes, available on inquiry
• System size (MW)	Up to 1MW standardized
6. Analytical tools available, e.g. simulation tools, modeling, etc.	
Please include the specifics of the procedure: Yes, available on inquiry	
Test capability and experience in accordance with e.g. IEC, UL, etc. standards: Test capability and experience in standardized and ad-hoc testing, from small to full scale. Large flexibility in test facilities, with numerous reaction to fire test apparatus, fire resistance testing (see above), and one of the largest fire test halls in Europe. Can adapt test apparatus to needs.	

A.5.6 Portugal

Test facility name: Itecons
Test facility location: Rua Pedro Hispano, Pólo II da Universidade de Coimbra 3030-289 Coimbra, Portugal
Contact person: Mafalda Cardoso, qualidade@itecons.uc.pt; tadeu@itecons.uc.pt; mafalda.cardoso@itecons.uc.pt; ph. +351 239 798 949, +351 239 798 939; **Website**: www.itecons.uc.pt
Fire safety test standards for which your facility is accredited: Accreditation for ISO/IEC 17025, Testing for Reaction to Fire

Test facility name: Universidade Coimbra - Firelab
Test facility location: Department of Civil Engineering, University of Coimbra Rua Luís Reis Santos - Pólo II, 3030-788 Coimbra, Portugal
Contact person: firelab@uc.pt, ph. +351 239 797 298 Website: www.firelab.dec.uc.pt/site/
Fire safety test standards for which your facility is accredited: No accreditation, Testing on Reaction to Fire, Resistance to Fire

A.5.7 Spain

Test facility name: Fire Safety Lab TECNALIA **Contact person:** Xabier OLANO– xabier.olano@tecnalia.com			
Specimen information **from small scale (100x100mm) up to 9 m large scale samples**	**Type Rig A**	**Type Rig B**	**Type Rig C**
1. Bench Scale			
• Complies to standard(s)	Flammability test EN ISO 11925-2	SBI test EN 13823	External fire performance CEN TS 1187 (B_{ROOF} t1)
• Max and min length of sample	250 x 90mm	L shaped sample 0,5x1,5m + 1x1,5m	0,8 x 1,8m
• Max and min thickness of sample	60mm Max	200 mm Max	No restriction
• Any modifications (inclination, fixed, movable)	Fixed, inclination	Fixed corner	Movable, inclination
• Testing with PV module frame/without PV module frame	Without frame	With frame	With frame
• Testing single sample or combined façade element	6 samples minimum	3 corner samples	4 samples per each inclination
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Off-line, attached	Off-line, attached	Not available yet
• Fire curve (yes/no)	no	no	no
• System size (MW)		0,03	Burning brands 600gr
• Fire reaction (yes/no)	Yes	Yes	yes
• Fire resistance (yes/no)	no	no	no
• Approximate price per test	Range between 1500-4000€		
• Please provide images of the facilities, including captions	Provided upon request	Provided upon request	Provided upon request

2. Unique set up, e.g. R&D purposes (non-standard)			
Description	Intermediate scale fire spread test bench	Experimental cubic furnace	Cone calorimeter
• Max and min length of sample	Up to 2,2m	1,5x1,5x1,5m3	100mmx100mm
• Max and min thickness of sample	Up to 1m	1,5m	50mm
• Max and min height of sample	Up to 4m	1,5m	-
• Max and min weight of sample	1000kg	Up to 500kg	Few kg
• Any modifications (inclination, fixed, movable)	movable	fixed	fixed
• Testing with PV module frame/without PV module frame	With frame	With frame	without
• Testing single sample or combined façade element	Complete PV system	Complete PV system	single
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Not available yet	Not available yet	Attached FTIR
• Fire curve (yes/no)	no	Yes (ISO +RWS)	no
• System size (MW)	0,1-0,3	0,8	100 kW/m2
• Fire reaction (yes/no)	Yes (fire spread)	no	yes
• Fire resistance (yes/no)	no	yes	no
• Approximate price per test	Range between 2500-8000€		
• Please provide images of the facilities, including captions	Provided upon request	Provided upon request	Provided upon request
3. Standard set up/ Furnace			
• Complies to standard(s)	LE_024 scope Vertical furnace 3x3m	LE_024 scope Horizontal furnace 4x3m	
• Max and min length of sample	Máx 3m	Máx 4m	

• Max and min thickness of sample	Máx 0,5m	Max 1m	
• Max and min height of sample	Max 3m	Max 3m	
• Max and min weight of sample	4000kg	6000kg	
• Any modifications (inclination, fixed, movable)	fixed	Fixed	
• Testing with PV module frame/without PV module frame	with	with	
• Testing single sample or combined façade element	combined	combined	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	n/a	n/a	
• Fire curve (yes/no)	yes	yes	
• System size (MW)	1,6	6	
• Fire reaction (yes/no)	no	no	
• Fire resistance (yes/no)	yes	yes	
• Approximate price per test	Range between 7000-15000€		
• Please provide images of the facilities, including captions	Provided upon request	Provided upon request	
4. Full façade set up			
• Complies to standard(s)	NFPA 285	BS 8414	
• Max and min length of sample	4,1m width	L shaped sample 2,6x10m + 1,5x10m	
• Max and min thickness of sample	No restriction	No restriction	
• Max and min height of sample	Up to 5,3m	Up to 10m	
• Max and min weight of sample	?	?	
• Any modifications (inclination, fixed, movable)	Movable test frame	fixed	
• Testing with PV module frame/without PV module frame	With frame	With frame	

• Testing single sample or combined façade element	?	?	
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	Not available yet	Not available yet	
• Fire curve (yes/no)	no	no	
• System size (MW)	Up to 1,2	Up to 3,5	
• Fire reaction (yes/no)	yes	yes	
• Fire resistance (yes/no)	no	no	
• Approximate price per test	Range between 15000-25000€		
• Number of floors/ storeys	2	4	
• Please provide images of the facilities, including captions	Provided upon request	Provided upon request	
5. Calorimetric Hood			
• Complies to standard(s) (please specify)	Not designed to specific standard		
• Max and min length of sample	3,5m max.		
• Max and min thickness of sample	1m max.		
• Max and min height of sample	3,5m max.		
• Max and min weight of sample	1,5 ton		
• Any modifications (inclination, fixed, movable)	fixed		
• Testing with frame/without frame	With frame		
• Testing single sample or combined façade element	combined		
• Analytical facilities (smoke, toxicity, online, offline)	yes		
• Fire curve			
• System size (MW)	3MW		
• Fire reaction (small samples)	yes		
• Fire resistance	no		

• Approximate price per test	12000-2000 €		
• Please provide images of the facilities, including captions	Provided upon request		

6. Analytical tools available, e.g. simulation tools, modeling, etc.

-Analysis of applicable building regulations and standards.

-3D design and modelling of the BIPV systems.

-Definition of relevant parameters for materials & products (geometry, thermal conductivity, density, reaction to fire classification, etc.)

-Compilation of initial sort of data based on experimental campaigns (temperature distribution, heat flux, deformation, HRR, etc.)

-Create the fire development model in CFD software (FDS) together with the fire scenarios (fuel loads, compartment ventilation, etc.)

-Thermo mechanical analysis of the structural analysis in FEM software (ANSYS). Heat transfer analysis followed by Structural response analysis.

-Detailed analysis of junctions, supports and other singular constructive details of the systems.

-Assessment of simulation results and compliance with the relevant fire performance criteria (integrity, insulation, radiation, falling debris, fire spread, etc.)

Test capability and experience in accordance with e.g. IEC, UL, etc. standards: BIPV products according to EN 50583 part 1 (bipv modules) and part 2 (bipv systems). Laminated glass and laminated safety glass to ISO 12543. Curtain walls to EN 13830. Windows and doors to EN 14351 parts 1 and 2.

For more info, check our current scope of accreditation.

Facility to do fire safety testing of electrically active PV (R&D facilities): Not available yet, to be developed in 2021.

Test environmental conditions: No gas treatment, but limited number of tests per year

and regular inspections from an independent environmental measurements and control company. Separated disposal and waste treatment depending on the tested materials.
Test results: work used for BIPV industry 20% work required by building codes or regulations 40% work used for R&D 40%
Associated mounting structure/solution: Provided upon request
Other important technical information that we might have missed, e.g. tests which are unique to your test facility: Other relevant tests: Lateral flame spread to ISO 5658-2 Gas effluents analysis (NBS chamber) to ISO 5659-2 Flammability of plastic materials to UL 94 Non combustibility tests to EN ISO 1182 Gross heat OF combustion (PCS value) to EN 1716

TECNALIA´s accreditation scope (4/LE024 issued by ENAC) can be consulted in the following link: [ANEXO TÉCNICO (enac.es)]

Reaction to fire test labs

TECNALIA is accredited to perform all the necessary tests for classification according to EN 13501-1 for construction products. In addition, we can also perform B_{ROOF}(t1) test method for classification according to EN 13501-5.

Fire resistance test labs

TECNALIA is accredited to perform resistance to fire tests for many products and constructive systems, in particular doors, partitions, ceilings, facades, curtain walls, roofs, structural protection, floor slabs, service installations, penetration seals, etc.

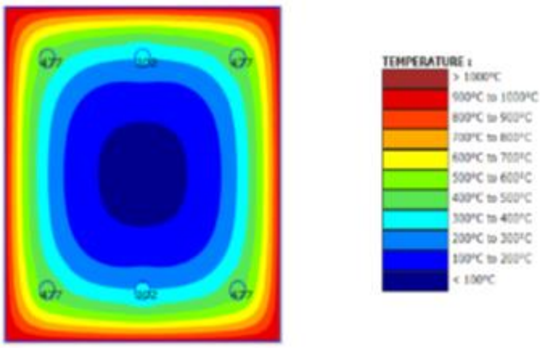
Fire spread on facades labs

TECNALIA has also facilities to perform large scale tests for fire propagation in facades according to the requirements for the UK and US markets.

R&D labs

As part of the materials and products development process, TECNALIA can also offer bench scale tests (cone calorimeter, lateral fire spread, NBS chamber, etc.) and fire performance modelling and simulation services.

In addition, we have a Calorimetric Hood (up to 3MW) to obtain fire properties of innovative products and systems.



Test facility name: Gaiker

Test facility location: Parque Tecnologico de Bizkaia Edificio 202
E- 48170 Zamudio -Bizkaia (Spain)

Phone: +34.94.600.23.23

Contact: Luis Madariaga

E-mail: madariaga@gaiker.es

Website: www.gaiker.es

Accreditation: ISO/IEC 17025

Activities: Testing

Experience: Reaction to fire

Test facility name: Certiberia Europe Solutions S.L.

Test facility location: Avenida Quitapesares, 46. E- 28670 Villaviciosa de Odón -Madrid (Spain)

Phone: +34 916 133 014

Contact: certiberia

E-mail: certiberia@certiberia.com

Website: https://certiberia.com/

Accreditation: ISO/IEC 17025, ISO/IEC 17065

Activities: Testing, Certification

Experience: Fire Resistance

Test facility name: Applus+Laboratories (LGAI Technological Center S.A)

Test facility location: Campus UAB, Ronda de la Font del Carme, s/n
E – 08193 Bellaterra - Barcelona (Spain)

Phone: + 34 93 567 20 00

Contact: Jordi Mirabent

E-mail: jordi.mirabent@applus.com

Website: www.appluslaboratories.com

Accreditation: ISO/IEC 17025, ISO/IEC 17065

Activities: Testing, Certification

Experience: Reaction to Fire, Fire Resistance, Fire Detection, Smoke Control

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Test facility name: AITEX, textile research institute

Test facility location: Plaza Emilio Sala, 1 E03801 Alcoi (Spain)

Phone: +34 96 554 22 00

Contact: Celia Dolçà Camáñez

E-mail: cdolza@aitex.es

Website: www.aitex.es

Accreditation: ISO/IEC 17025

Activities: Testing

Experience: Reaction to fire

Test facility name: Aidimme. Instituto tecnológico metalmecánico, mueble, madera, embalaje y afines

Test facility location: Parque Tecnológico, C/ Benjamín Franklin, 13

E-46980 Paterna (Valencia)

Phone: +34 961 366 070

E-mail: mjsoler@aidimme.es

Website: https://www.aidimme.es/

Accreditation: ISO/IEC 17025

Activities: Testing

Experience: Reaction to fire

Test facility name: AFITI-LICOF, Centro de ensayos e investigación del fuego

Test facility location: Camino del Estrechillo, 8 E – 28500 Arganda del Rey (Madrid) Spain

Contact: Tomás de la Rosa

Phone: + 34 902 112 942

E-mail: trosa@afiti.com

Website: www.afiti.com

Accreditation: ISO/IEC 17025

Activities: Testing

Experience: Reaction to Fire, Fire Resistance, Fire Suppression, Active Fire Protection

A.5.8 Sweden

Test facility name: RISE Research Institutes of Sweden
Contact person: Anders Lönnermark – anders.lonnermark@ri.se
Web: https://www.ri.se/en/what-we-do/fire-safety

As mentioned in the main section of this report, we have chosen not to describe the size and flexibility of our staff and equipment resource in detail since it is huge and our clients' requirements are in principle always met once we get that far. Regarding test specimen sizes there are in principle no limitations.

Accreditation of the test facility and relevant test methods can be found under the following link: https://swedacsearchfiles.blob.core.windows.net/omfattning/A002626-075%20Scope%20Testing%20laboratory%20Bor%C3%A5s%20220630.pdf

A.5.9 United Kingdom

Test facility name: BRE Global Ltd
Test facility location: Bucknalls Lane, Garston WD25 9XX Watford Herts (UK)
Contact person: Philip Howard, philip.howard@bre.co.uk, ph. +44 (0)1923 664000 **Website:** www.bre.co.uk
Fire safety test standards for which your facility is accredited: Accreditation for ISO/IEC 17025, ISO/IEC 17020, Testing for Reaction to Fire, and Fire Resistance

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Test facility name: Cambridge Fire Research Ltd

Test facility location: Brewery Road, Pampisford, Cambridge, CB22 3HG, UK

Contact person: Emma Wilson, emmawilson@cambridge-fire.co.uk, ph. +44 (0)1223 834752
Website: www.cambridge-fire.co.uk
Fire safety test standards for which your facility is accredited: Accreditation for ISO/IEC 17025, Testing for Fire Resistance

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Test facility name: Warringtonfire testing and Certification Ltd

Test facility location: Holmesfield Road Warrington Cheshire WA1 2DS UK

Phone: + 44 (0)1925 655116

Contact: Wiktor Drazkiewicz

E-mail: Wiktor.Drazkiewicz@Warringtonfire.com

Website: www.warringtonfire.com

Accreditation: ISO/IEC 17025, ISO/IEC 17020, ISO/IEC 17065

Activities: Testing, Inspection, Certification

Experience: Reaction to Fire, Fire Resistance, Fire Suppression

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Test facility name: The Fire Protection Association Ltd
Test facility location: London Road Moreton-in-Marsh GL56 0RH United Kingdom
Contact person: John Briggs Tel: +44 (0) 1608 812506 Phone: +44 (0) 7535 457123
E-Mail: jbriggs@thefpa.co.uk
Website: www.thefpa.co.uk
Fire safety test standards for which your facility is accredited: ISO/IEC 17025
Activities: Testing **Experience:** Reaction to Fire

Test facility name: FM Approvals Ltd
Test facility location: Voyager Place Maidenhead Berkshire SL6 2PJ UK
Contact person: Richard Zammitt
E-mail: richard.zammitt@fmapprovals.com
Website: www.fmapprovals.com
Accreditation: ISO/IEC 17065
Activities: Certification
Experience: Reaction to Fire, Fire Resistance, Fire Detection, Fire Suppression, Smoke Control, Active Fire Protection

Test facility name: EFECTIS UK/Ireland Ltd

Address: Shore Road Jordanstown BT37 0QB

Contact: Talal Fateh

Phone: +44 (0)2890368766

E-Mail: talal@efectis.com

Website: http://efectis.com

Accreditation: ISO/IEC 17025

Activities: Testing

Experience: Reaction to Fire, Fire Resistance

A.6 Japan

Test facility name: JTCCM Japan Testing Center for Construction Materials **Contact person: Shinji** Hagiharai – hagihara@jtccm.or.jp			
Specimen information	**Large wall furnace Façade and window**	**Medium wall furnace Façade and window**	**Horizontal furnace Atrium, roof**
1. Bench Scale			
• Complies to standard(s) (please specify)	ISO 834, MLIT notification 1360, 1369 MLIT Building Guidance Division Notice No.619		
• Max and min length of sample	3500mm/none	3050mm/none	2960mm (saitama) 3000mm (yamaguchi)
• Max and min height of sample	3400mm/none	3380mm/none	3010mm (saitama) 4000mm (yamaguchi)
• Max and min thickness (depth) of sample	100-200mm	100-200mm	1560mm (saitama) 2000mm (yamaguchi)
• Any modifications (inclination, fixed, movable)	To be discussed	To be discussed	To be discussed
• Testing with PV module frame/without PV module frame	both accept	both accept	both accept
• Testing single sample or combined façade element	Combined façade element	Combined façade element	Combined façade element
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	May be separated	May be separated	May be separated
• Fire curve (yes/no)	Yes, ISO 834	Yes, ISO 834	Yes, ISO 834
• Fire reaction (yes/no)	Yes	Yes	Yes
• Fire resistance (yes/no)	Yes	Yes	Yes
• Please provide images of the facilities, including captions			
2. Unique set up, e.g. R&D purposes (non-standard)			

• Consider electric condition	Connect to load device under Closed circuit To be discussed	Connect to load device under Closed circuit To be discussed	Connect to load device under Closed circuit To be discussed
There are many test furnace regarding fire safety. e.g. External fire exposure to roofs, Cone calorimeter, Toxicity test equipment, Noncombustible test furnace (ISO 1182), Model box test equipment, Flame test equipment (JIS A 1322, JIS Z 2150), Ignition test equipment (ISO 5657, JIS A 9523), and so on     			

Please see EUPVSEC 2018 Poster https://www.eupvsec-proceedings.com/proceedings?paper=46029 https://www.jtccm.or.jp/english/tabid/554/Default.aspx

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Test facility name: GBRC General Building Research Corporation of Japan

Specimen information (in m):

Specimen information	Large wall furnace Façade and window	Medium wall furnace Façade and window	Horizontal furnace Atrium, roof
1. Bench Scale			
• Complies to standards (please specify)	ISO 834, MLIT notification 1360, 1369 MLIT Building Guidance Division Notice No.619		
• Max and min length of sample	3500mm/none	3000mm/none	3000*10000mm
• Max and min height of sample	3400mm/none	3000mm/none	Depth:1560mm
• Max and min thickness of sample	100-200mm	100-200mm	
• Any modifications (inclination, fixed, movable)	To be discussed	To be discussed	To be discussed
• Testing with PV module frame/without PV module frame	both	both	both
• Testing single sample or combined façade element	Combined façade element	Combined façade element	Combined façade element

• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	May be separated	May be separated	May be separated
• Fire curve (yes/no)	Yes, ISO 834	Yes, ISO 834	Yes, ISO 834
• Fire reaction (yes/no)	Yes	Yes	Yes
• Fire resistance (yes/no)	Yes	Yes	Yes
• Please provide images of the facilities, including captions			
There are many test furnaces regarding fire safety. e.g. External fire exposure to roofs, Cone calorimeter, Toxicity test equipment, Noncombustible test furnace (ISO 1182), Model box test equipment, Flame test equipment (JIS A 1322, JIS Z 2150), Ignition test equipment (ISO 5657, JIS A 9523), and so on.     			
https://www.gbrc.or.jp/english/			

Test facility name: Chemitox

Specimen information (in m):

Specimen information	**Spread of flame test Atrium, roof**	**Burning brand test Atrium, roof**	**Ignition test**
1. **Bench Scale**			
• Complies to standard(s)	IEC 61730-2 MST23, JIS C 61730-2, JIS C 8993, ANSI/UL 1703,UL 790 Spread of flame test, Burning brand test, Building standard law (Building code) No.22, no.63		
• Max and min length of sample	3000*5000-8000mm	3000*5000-8000mm	
• Max and min height of sample	-	-	-
• Max and min thickness of sample	-	-	-

• Any modifications (inclination, fixed, movable)	To be discussed	To be discussed	-
• Testing with PV module frame / without PV module frame	both	both	-
• Testing single sample or combined façade element	Combined roof element	Combined roof element	-
• Analytical facilities (smoke, toxicity, online, offline, attached/separated)	May be separated	May be separated	-
• Fire curve (yes/no)	-	-	-
• Fire reaction	yes	yes	-
• Fire resistance	yes	yes	-
• Please provide images of the facilities, including captions			 
https://www.chemitox.co.jp/			

A.7 New Zealand

Test facility name: Passive Fire Inspection & Test Services trading as Fire TS Lab

Test facility location: 1/113 Pavilion Drive, Mangere, Auckland, New Zealand, 2022
PO Box 14147, Panmure, Auckland, 1741, New Zealand

Contact person: Mr Andrew Bain, Mr Alexey Kokorin, ph. +64 (0) 2041820543

Website: www.firelab.co.nz

Fire safety test standards for which your facility is accredited:

AS1530.4:2014 (Excluding Section 11 Fire dampers and air transfer grille assemblies in ducts)
BS 476 Fire tests on building materials and structures

- Part 20 Method for determination of the fire resistance of elements of construction (general principles)
- Part 21 Method for determination of the fire resistance of loadbearing elements of construction
- Part 22 Method for determination of the fire resistance of non-loadbearing elements of construction
- Part 23 Method for determination of the contribution of components to the fire resistance of a structure

EN 1363-1 Fire resistance tests – General requirements

EN 1363-2 Fire resistance tests – Alternative and additional procedures:

- Section 4 Hydrocarbon curve
- Section 5 External fire exposure curve
- Section 6 Slow heating curve
- Section 8 Measurement of radiation

EN 1364-1 Fire resistance tests for non-loadbearing elements – Walls
EN 1364-2 Fire resistance tests for non-loadbearing elements – Ceilings
EN 1364-3 Fire resistance tests for non-loadbearing elements. Curtain walling. Full configuration (complete assembly)
EN 1364-4 Fire resistance tests for non-loadbearing elements. Curtain walling. Part configuration
EN 1365-1 Fire resistance tests for loadbearing elements – Walls
EN 1365-2 Fire resistance tests for loadbearing elements – Floors and roofs
EN 1366-3 Fire resistance tests for service installations – Penetration seals
EN 1366-4 Fire resistance tests for service installations – Linear joint seals

EN 1634-1 Fire resistance test for door and shutter assemblies and openable windows
ISO 834-1 Fire-resistance tests – Elements of building construction – General Requirements

Additional standards in conjunction with AS1530.4 test method:

AS 1735.11 Lifts, escalators and moving walks - Part 11: Fire-rated landing doors
AS 1905.1 Components for the protection of openings in fire-resistant walls Part 1: Fire-resistant doorsets
AS 1905.2 Components for the protection of openings in fire-resistant walls - Part 2: Fire-resistant roller shutters
AS 4072.1 Components for the protection of openings in fire-resistant separating elements Part 1: Service penetrations and control joints
NZS 4520 Fire-resistant doorsets

EFNARC - Specification and Guidelines for Testing of Passive Fire Protection for Concrete Tunnels Linings

Efectis-R0695:2020 Fire testing procedure for concrete tunnel linings and other tunnel components

- Applicant is responsible for sample preparation; the laboratory will make measurements and perform testing in accordance with this method and any referenced test methods that is included in the laboratory's scope of accreditation.
- Tensile and compression testing is excluded.
- Section 7 – Test protocol for mobile furnace tests is excluded

Determination of the fire resistance of products listed in the current Schedule to the Certificate of Accreditation using the alternative heating conditions specified in:

- RABT-ZTV (Car) curve
- RABT-ZTV (Train) curve
- RWS - Rijkswaterstatt curve
- HCM - Modified Hydrocarbon curve
- HC - Hydrocarbon curve

A.8 Republic of Korea

Test facility name: Korea Testing Certification Institute
Test facility location: Republic of Korea, Gunpo (City), 15809 (Zip code)
Contact person (Head of fire Laboratory): Hyeon-Dong, Choi, choihd@ktc.re.kr
Fire safety test standards for which your facility is accredited: IEC 61730-1, IEC 61730-2, UL 1703, UL 790, ASTM E108
Test facility description: Fire spread test system for photovoltaic module

Test facility name: Korea Conformity Laboratories

Test facility location: Republic of Korea, Cheongju (City), 28115 (Zip code)
Contact person (Head of fire Laboratory): Kyu-Jin, Kim, kjkim@kcl.re.kr
Fire safety test standards for which your facility is accredited: KS C IEC 61730-2, KS C IEC 60695
Test facility description: Hotwire coil ignition tester for PV/BIPV module
Specimen information (in m): 0.125 m x 0.013 m

Test facility name: Korea Conformity Laboratories

Test facility location: Republic of Korea, Samcheok (City), 25913 (Zip code)
Contact person (Head of fire Laboratory): Hak-Byeong, Chae, chb1087@kcl.re.kr
Contact person: Head of PV Innovation:
Fire safety test standards for which your facility is accredited: KS F 8414, KS F ISO 13784-1
Test facility description: Small-size, medium-sized and large-sized sample could be tested for fire safety of building envelope
Specimen information (in m): 2.6 m x 8.0 m for large size

Test facility name: Korea Fire Protection Association

Test facility location: Republic of Korea, Yeoju (City), 12661 (Zip code)
Contact person (Head of fire Laboratory): Kye-Won, Park, kwpark@kfpa.or.kr
Fire safety test standards for which your facility is accredited: KS F ISO 1182, KS F ISO 5660-1, KS F 2271 KS F 2257-1,4,5,6,7,8,9 ASTM E 119 ISO 834-1,4,5,6,7,8,9 FS 01
Test facility description: Testing insulation and integrity of specimen exposed to fire (using furnace) and fire spread to other parts
Specimen information (in m): 3 m x 3 m (vertical structure), 3 m x 4 m (horizontal structure)

Test facility name: Korea Institute of Construction Technology

Test facility location: Republic of Korea, Hwaseong (City), 18544 (Zip code)
Fire safety test standards for which your facility is accredited: ISO 9705, KS F ISO 9705
Test facility description: Vertical heating furnace
Specimen information (in m): 3 m x 3m

A.9 Singapore

Test facility name: TUV SUD PSB Tuas Firelab

General information on test facility

Test facility name: TUV SUD PSB Tuas Firelab

Contact person: info.sg@tuvsud.com

Test facility location: 10 Tuas Avenue 10, Singapore 639134

Fire safety test standards for which your facility is accredited: IEC 61730-2: 2012: Clause 10.8 Annex A

Test facility description:

Test apparatus and set-up in accordance with UL 790

Specimen information (in m):

Specimen information	Type Rig A	Type Rig B	Type Rig C
1. **Bench Scale** Spread of flame test: 1.8mx1m (Class A), 2.4mx1m (Class B), 3.9mx1m (Class C) Burning brand test: 1.3m (minimum) x 1m			
2. Unique set up, e.g. R&D purposes (non-standard)			
3. **Standard set up/ Furnace**			
• Complies to standard(s)	UL 790, ASTM E108, IEC 61730-2		
• Max and min length of sample	Min. 1.3m Max. 3.9m		
• Max and min thickness of sample	No requirement		
• Max and min height of sample	No requirement		
• Max and min weight of sample	No requirement		
• Any modifications (inclination, fixed, movable)	NIL		

• Testing with PV module frame/without PV module frame	With frame		
• Testing single sample or combined façade element	Single sample		
• Fire reaction (yes/no)	Yes		
• Fire resistance (yes/no)	No		
• Approximate price per test	S$6800 (spread of flame + burning brand)		
Please include the specifics of the procedure: NIL (visual observation of test)			
Test capability and experience in accordance with e.g. IEC, UL, etc. standards For BAPV product, IEC 61730-2, UL 1703 & UL 790.			
Facility to do fire safety testing of electrically active PV (R&D facilities):N.A.			
Test environmental conditions: Exhaust scrubber is used to treat the exhaust gas. Specimen are disposed safely.			
Test results: • work used for industry • work required by building code/ country regulations • work used for R&D			
A minimum fire resistance rating Class C shall be provided for any roof-mounted PV module according to Fire Code.			

A.10 United States

Test facility name: Underwriters Laboratories Inc

Contact person: Jezwinski, Scott– Scott.Jezwinski@ul.co

Specimen information:

1. Bench Scale / Small Scale Fire Testing			
All Use Cases	PV components -electric wires, converter, etc	PV module type	Building assemblies
	UL 1699B UL 4703 UL 6703 UL 3730 UL 1741	UL 1703 UL 61730-2	UL 2703
2. Roofing Applications Fire Testing			
Roofing - BIPV	UL 790 (ASTM E108) UL 7103 • Spread of Flame • Intermittent Flame • Burning Brand		
Roofing - BAPV – Rack Mounted	UL 1703 / UL 2703 / UL 61703-2 • Spread of Flame on Top of Module • Burning Brand on Top of Module • Spread of Flame Between PV and Rood • Burning Brand Between PV and Roof		
3. Exterior Wall - Facades			

Exterior Wall – Cladding or Facade	US, UAE, India – NFPA 285* Canada – CAN/ULC S134** UK – BS 8414, Part 1** Europe – ISO 13785, Part 2** Sweden – SP Fire 105 France – LEPIR II Australia – AS 5113** Japan – JSA JIS A1310** *UL has a multi-story test apparatus for conduct of NFPA 285 tests in Northbrook, Il. **UL would conduct tests at one of its partner laboratories
4. Fire Resistance	
When BIPV is used as part of a Fire Resistance Roof or Wall Assembly	US – UL 263 (ASTM E119) Canada – CAN/ULC S101 ISO 864 BS 476 EN 1363-1
5. **Full Scale Testing – Hood Calorimeter**	
General when BIPV is used on a structure	3 calorimetry hoods with the maximum hood capacity of 10 MW. UL Northbrook has a movable ceiling from 5 to 48 ft (1.5 to 14.63 m).

Test capability and experience in accordance with (IEC, UL, etc.):

- **For BIPV product (IEC, UL, etc.)?**
  Capabilities and experience in testing BIPV roofing products to UL 1703.

Capabilities in testing BAPV to UL 1703 and UL 61730-2. Created and participating in the currently active UL 61730 Task Group 2, a cross-functional group of industry experts who are collaborating in the development of proposed improvements to the fire classification process applied in UL 61730-2 and UL 2703.

- **Any additional details, i.e. test on preventative measures?**
  To support changes to the 1703 fire test protocol based on data, UL collaborated with University of New Mexico and Solar ABC's to conduct a series of R&D projects funded by the US Department of Energy. Reports can be found at: http://solarabcs.org/current-issues/fire_class_rating.html. This research established the safety science foundation for PV fire testing in the UL standards noted above.

  To address first responders' concerns regarding PV installations, UL conducted a research project funded by the US Department of Homeland Security through the Assistance to Fire Fighters grant program. The report and fire service training can be found at:

  https://ulfirefightersafety.org/research-projects/firefighter-safety-and-photovoltaic-systems.html.

  A second research project on first responder interactions with PV was conducted with Sandia National Laboratory to study firefighter body impedance, personal protective equipment, and fire suppression methods as they relate to PV systems and PV rapid shutdown/hazard control technologies.

Facility to do fire safety testing of electrically active PV (R&D facilities):

Yes; UL has conducted testing of electrically active PV as part of the research noted above. However we note the need for additional safety measures in this case and would need to review the technical justification for conducting such testing with elevated safety concerns.

Test environmental conditions

- **Exhaust gas treatment:** Yes
- **Disposal of test specimen;** Yes

Test results:

- work used for industry: UL experience in developing and conducting fire tests on PV modules and systems is leveraged to continually improve fire safety standards, such as the work of the UL 61730 Task Group 2 that is working on improvements to the fire testing and classification methodology in UL 61730-2 and UL 2703.

- work required by building code/ country regulations (pls specify): Certifications to UL 1699B (PV Arc-Fault Protection), UL 1703 and UL 61730-2 (PV modules), 2703 (mounting systems), 4703 (PV cable), , and UL 1741 (inverters/converters, combiners etc.)are required by U.S. regulators based on the requirements of Article 690 of the National Electrical Code (NEC), which serves as the basis for the local codes enforced throughout the US. There requirements are also mandated by the International Fire Code (IFC) by reference to the NEC. The International Building Code (IBC) requires that rooftop PV systems shall be listed and comply with a fire classification in accordance with UL 1703 and UL 2703; that rooftop PV modules, BIPV and PV shingles shall be listed to UL 1703; that inverters be listed to UL 1741. Compliance with UL 790 or ASTM E108 is referenced in codes including the IBC and the IFC, and the IBC requires fire resistance rating of building elements, components or assemblies to be based on UL 263 or ASTM E119. UL 1703, UL 1741 and UL 4703 are identified as appropriate for use under the US Occupational Safety and Health Administration (OSHA) Nationally Recognized Testing Laboratory (NRTL) program for workplace safety.

Other important technical information that we might have missed, e.g. tests which are unique to your test facility

UL has been active in leading advancement of fire and energy safety through conducting research, establishing testing methodologies and administering certification programs for building materials and PV systems. UL's work on roofing materials dates back well over a century, and our work in PV safety for decades.

We have established an active network of global partners in fire research testing, including laboratories, academic institutions and custom built structures.

Our parent company, Underwriters Laboratories Inc., operates the Firefighter Safety Research Institute (https://ulfirefightersafety.org/), dedicated to increasing firefighter knowledge to reduce injuries and deaths in the fire service and in the communities they serve. Their fire research work has included efforts for the U.S. Department of Homeland Security specialized construction of single family homes to investigate fire behavior and firefighter tactics, and to compare fire safety aspects of traditional constructions with new styles of construction.

Additional relevant information for exterior wall use of BIPV / BAPV.

- One of our customers placed UL's tremendous work with IIT in India on YouTube. This work was selected / awarded sponsorship as part of the William Henry Merrill Society. Pravin and our Regulatory specialist from India were very involved. https://www.youtube.com/watch?v=aRvkwBW8rKE
- You already have the video that UL produced in conjunction with the International Association of Firefighters – including again here for those on the e-mail. NFPA 285: Testing Combustible Facades (IAFF & UL Video) YouTube Video
- Article recently appeared in UL's The Code Authority newsletter: Catastrophic Exterior Wall Fires in Highrise Buildings UL Article
- UL LinkedIn Live Event – Perspective on Exterior Wall Fires: LinkedIn Live - Exterior Wall Fires - Moderated Discussion (during Q&A a specific question was asked about how PVs would be tested if used as exterior cladding)

Link to the UL Fire Safety Research Institute work on Firefighter & PV Safety:

https://ulfirefightersafety.org/research-projects/firefighter-safety-and-photovoltaic-systems.html

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