

EUROPE SHOULD DEFINE THE FIRE-SAFETY OUTCOME FOR ROOFTOP PV BEFORE CHOOSING THE TECHNICAL ROUTE

A position paper on required fire behaviour, EPBD implementation
and fire safety requirements for PV roof assemblies



Lidl Warehouse Solar Panels on fire, Alwalton Hill, Peterborough\$ Friday 23 February 2024. Picture by Terry Harris

Key Insights

- The revised Energy Performance of Buildings Directive will accelerate rooftop PV deployment on European buildings. Article 10 requires Member States to ensure deployment of suitable solar energy installations on defined categories of new and existing buildings where technically, economically and functionally feasible.
- PV panels change roof fire conditions. A review for the UK Building Safety Regulator found that rooftop PV can alter fire dynamics, introduce added risks for roof constructions and affect firefighting operations.
- PV changes the fire, not only the ignition risk. An overlying panel deflects heat and flame back onto the roof surface (fire-induced reradiation), so the completed PV-roof assembly — not the panel or the roof alone — determines how a fire develops.
- Regulators should define the required fire behaviour of PV roof assemblies now. Performance objectives, acceptance criteria and test methods should follow from that definition — not precede it.
- The first step is regulatory clarification, not new standards. Defining the target now reduces the risk that roofs are built to incomplete fire-safety assumptions. This clarification should be manageable and can build on current BRoof(t1–t4) safety levels, adjusted for PV-specific fire exposure. Clear fire-behaviour criteria would support robust, evidence-based and technology-neutral fire-safety requirements.
- The work should be linked to EPBD implementation, national fire-safety guidance, construction product regulation and European roof-fire standardisation processes.

Note on terminology: required fire behaviour

In this paper, **required fire behaviour** means the behaviour that the completed PV roof assembly is expected to achieve under credible PV-related fire exposure. It does not refer to an existing classification or pass/fail test. The target should be stated before technical requirements, test methods or material and assembly requirements are selected.

Rooftop PV is changing the fire conditions on European buildings

Europe is entering a major expansion of rooftop photovoltaic systems. Under the revised EPBD, all new buildings must be designed to optimise their solar energy generation potential. Member States must also ensure deployment of suitable solar energy installations on several categories of buildings, subject to national criteria for suitability, feasibility, structural capacity and economic potential.^{i, ii}

The Commission's implementation timeline starts with new public and non-residential buildings above 250 m² by 31 December 2026. It then extends to existing public buildings, existing non-residential buildings undergoing relevant works, new residential buildings and new roofed car parks.ⁱⁱⁱ

This is a necessary part of the energy transition. It is also a major change in the fire environment of European roofs.

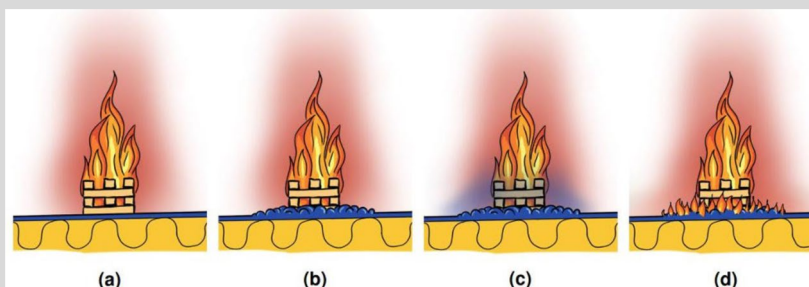
PV panels do not simply add weight or equipment to the roof. They create new ignition sources and

change the way fire can develop. Relevant ignition sources include DC arc faults, connector and junction-box failures, inverter and isolator faults and other electrical failures. Experimental work on flat roof constructions with multiple PV panels has shown that PV installations can affect fire behaviour on the roof surface.^{iv} Once a fire starts, PV modules can create a semi-enclosed space between the panel and the roof surface. This can trap heat, redirect flames and increase thermal exposure to the roof system.^v Fire-induced reradiation beneath PV arrays can increase heat feedback to the roof surface.^{vi, vii}

On a conventional flat roof, flame spread beyond the ignition source is limited (Figure 1). With an overlying PV panel, flame and heat are deflected back toward the roof surface, driving membrane heating, pyrolysis-gas release and self-sustained spread beneath the panel (Figure 2, next page).

The UK Building Safety Regulator review reports experimental findings of heat fluxes up to 50 kW/m² beneath PV arrays, compared with 12.5 kW/m² in standard roof test methods such as BS EN 13501-5. It also reports that flame spread may accelerate by a factor of 38 when gap height falls below critical limits.^{viii}

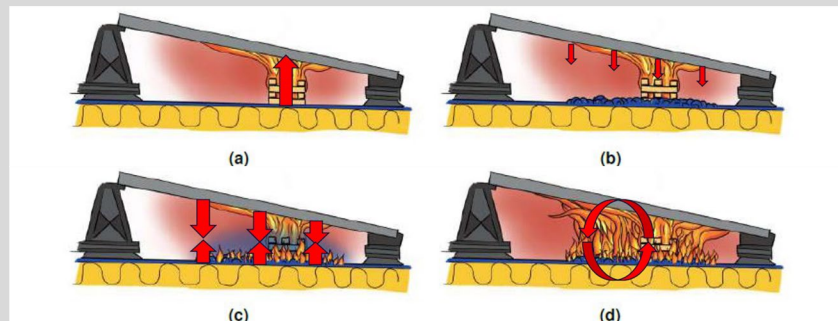
Figure 1: Fire development on a conventional flat roof (a–d)



- a) Radiative heat transfer from ignited wood crib.
- b) Heat of nearby roofing membrane.
- c) Release of combustible pyrolysis gases.
- d) Heat of nearby roofing membrane.

Figure Adapted From:
Kristensen, J. S. (2022). Fire
risk of photovoltaic
installations on flat roof
constructions. The University
of Edinburgh

Figure 2: Fire development on a flat roof with an overlying PV panel (a–d) ; the roofing membrane and insulation are identical to Figure 1.



- a) Radiative heat transfer from deflected flame.
- b) Heat of nearby roofing membrane.
- c) Release of combustible pyrolysis gases and initial ignition.
- d) High heat release rate, heating nearby materials and self-sustained flame spread

Figure Adapted From:
Kristensen, J. S. (2022). Fire
risk of photovoltaic
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Arrows added.

CFPA Europe has summarised the same concern in European fire-safety communication. It reports Jens Steemann Kristensen's point that PV panels mounted on flat roofs create a cavity between the roof and the back of the panel, allowing fire to spread if ignition occurs. It also records his concern that current test methods do not account for how building-applied photovoltaics affect the fire dynamics of large roof structures.^{ix}

Existing roof classifications remain relevant within their intended scope. The question is whether supplementary criteria are needed for PV-specific fire exposure. That question should be answered before deciding which material or assembly requirements to prescribe. The relevant question is not which material to require, but what fire behaviour a PV roof assembly must demonstrate to be considered safe. Material and assembly requirements should follow from the defined fire-behaviour target, not be selected before it.

The UK review also identifies possible technical responses, including non-combustible roof coverings, fire-resistant construction, PV layout measures and new test methods.^x Any of these

routes may prove necessary. The policy point is different: requirements should follow from clear fire-behaviour criteria for the completed PV roof assembly, so that materials, layout, protective layers, electrical installation quality and fire-service access are all assessed against the same safety objective.

Case in point: Lidl distribution centre, Peterborough, February 2024:

A recent case illustrates the stakes. In February 2024, a fire involving rooftop solar panels broke out on the 45,000 m² roof of Lidl's £70m distribution centre in Peterborough, England. It was attributed to an electrical fault in the PV installation; more than 50 firefighters attended and the site was evacuated before the fire was brought under control, and operations resumed the same evening (see case photo on front page).^{xi} The incident shows the practical stakes: large rooftop-PV installations are already in service at scale, the PV system itself can be the origin of the fire, and the outcome depends on how the

completed roof assembly behaves and on fire-service access.

Existing roof classifications were not designed to answer the PV-specific systems question

Current roof classification systems can determine whether a roof assembly meets a given standard test. They do not define the fire behaviour that a completed PV roof assembly must achieve under PV-specific fire exposure.^{xii} The ZAG/FRISSBE BAPV Fire Safety Guideline also treats PV roof fire safety as a system issue and identifies the lack of a complete system test standard as an unresolved challenge.^{xiii}

That creates a **performance-definition gap** in the way PV roof assemblies are assessed.

Builders, developers, fire engineers, insurers, authorities and manufacturers need a clear target. Without it, they cannot know what level of fire safety they are designing towards. They can comply with a classification, but the classification does not itself answer whether the roof assembly will behave safely under a credible PV fire scenario.

The missing question is simple:

What fire behaviour must the roof assembly achieve for this PV installation to be considered fire-safe?

That question comes before decisions about test methods, classifications or material requirements. At minimum, the required fire behaviour must be defined across several dimensions: how far fire may penetrate the build-up, how far it may spread beneath the panels, how much smoke it produces, how long it may keep burning, and whether the

fire service can still intervene effectively. Three of these are set out first.

1. Vertical fire development

How far may fire penetrate or affect the roof assembly before the result becomes unacceptable?

This includes damage to protective layers, retraction, smouldering, sustained combustion and involvement of the insulation layer.

2. Horizontal fire spread

How far may fire spread beyond the PV module or array section?

Should the fire stay within the first module, spread only to nearby modules or remain within a defined roof area?

3. Fire duration

How long may sustained burning continue?

Should the assembly self-extinguish once the affected PV modules have burned out, or is longer duration burning acceptable provided that life safety, property protection and fire-service objectives are still met? How much smoke the fire produces belongs to the same question: smoke can reach and contaminate neighbouring buildings without direct flame contact, hinder firefighting on the roof, and, together with firefighting water and later rain, cause damage and interruption well beyond the area actually burnt. The absence of vertical burn-through is therefore not by itself a full measure of the consequence.

These are system questions. Ideally government authorities give a preliminary indication of these answers.

The BRoof(t1–t4) levels are used here as an illustrative reference for the roof-safety expectations Europe already accepts, not as a direct acceptance criterion for a PV roof assembly. Based on current European BRoof(t1–t4)^{xiv}

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classification, illustrative criteria for vertical fire development and fire duration could be:

- Fire must not penetrate the roof deck into the interior, and internal fire spread should remain within the limits set by the applicable BRoof classification.
- The assembly should self-extinguish, with burning stopping within about 5 minutes after the external heat and flame sources are removed (consistent with BRoof(t4)).

Those criteria are aligned with current requirements. However, as illustrated above, horizontal fire spread beneath a PV panel may exceed the current BRoof limits — a maximum damaged length of up to roughly 0.8 m, depending on the BRoof test. Because the PV panel deflects heat and flame in a way the no-PV BRoof test does not contemplate, a realistic PV criterion will permit somewhat greater spread than BRoof allows, while still requiring bounded containment.

On that basis, a PV-specific criterion could be:

- Horizontal fire spread should be contained within the initial PV panel and the immediately neighbouring panels. This is offered as an illustrative starting point for discussion, not a final regulatory acceptance limit prescribed by NEPSA.

Without a European route, the market falls back on private approval standards.

In the absence of clear European regulatory direction, designers, building owners, insurers and manufacturers still need a way to judge whether a PV roof assembly is acceptable. Where public regulation does not yet define that, market actors look to the assessment routes that already exist. One such route is FM Approvals' examination standard for roof-mounted rigid photovoltaic module systems (FM 4478).^{xv} It is relevant here

because it assesses the PV system as part of a finished roof assembly, the modules are examined on an FM-approved roof-cover assembly (FM 4470)^{xvi}, rather than assessing a material in isolation. Its fire section applies a modified ASTM E108 Class A spread-of-flame test with a stated acceptance criterion: no fire damage to the roof cover or to the PV panel within 152 mm of the last PV module (Figure 3). That is a system-level fire-behaviour target for the completed assembly, precisely the kind of outcome definition this paper argues Europe should set. FM 4478 is referenced here as an example that system-level acceptance criteria are possible, not as a European method to adopt without technical and regulatory adaptation.

FM approval is not, however, a European regulatory pathway. It is an insurer-led, project-specific route developed primarily for property protection. It can provide useful evidence about system performance, but it is not designed to serve as the general European basis for demonstrating that a PV roof assembly is fire-safe.

The policy problem is therefore not only that European standards work is incomplete. It is that, without interim European fire-behaviour expectations, the market is left to choose between ordinary roof classifications that were not developed around PV-specific fire exposure and private approval routes that are not built for general European use. European authorities should use the direction of system-level testing — including FM-type approaches where relevant — to help define interim criteria, which can then guide national guidance, project approvals, insurance assessments and future European standardisation.

Set interim fire-behaviour expectations now

NEPSA recommends that European regulators, standards bodies and fire authorities define interim fire-behaviour expectations now, to guide project-level decisions while harmonised test methods are developed.

This supports implementation; it does not delay it. PV roofs are already being installed at scale, so interim guidance, project approvals and insurance assessments should point toward the same safety outcome.

The seven questions below specify the challenge in practical terms. They can be used as a starting point for national guidance, European standards work and stakeholders' consultation. They do not prescribe the answer. They define the information

insulation, protective layers and the underlying structure?

2. Horizontal fire spread under PV panels

Which criteria should apply to horizontal fire spread beneath PV panels, including spread from panel to panel, spread within an array and the role of sectioning, fire breaks or separation distances, and whether fire could cross fire-safety boundaries or compartment lines within the roof construction?

3. Temperature exposure and material requirements

Which temperature exposure should be used as the design basis, and which material or assembly requirements should apply when fire beneath PV panels can create very high temperatures in the cavity between the panel and the roof surface?

4. Smouldering, re-ignition and concealed fire spread

Which criteria should apply to smouldering fire, re-ignition and hidden fire spread after the primary fire exposure?

5. Fire-service intervention

Which criteria should apply to the fire service's ability to

intervene effectively, including access, extinguishment, cooling, safe working conditions and the risk of consequential damage from firefighting water?

6. Consequential damage and business interruption

Which criteria should apply to consequential damage and operational loss from roof fires, and

Figure 3: FM 4478 fire acceptance criterion (§4.1, "Combustibility from Above the Roof Deck").

4.1 Combustibility from Above the Roof Deck

Testing for combustibility from above the roof deck and/or rigid photovoltaic module shall be in accordance with a modified version of the ASTM E108 Class A Spread of Flame Test. The modifications are as follows:

The samples shall have rigid PV on top of the roof covers. The length of the test deck for the Spread of Flame test shall be 8 ft (2.4 m) minimum to a maximum of 16 ft (4.9 m). The samples shall be long enough to accommodate 2 panels if the combined length of 2 panels is greater than 13 ft (4.0 m) or long enough to accommodate 3 panels if the combined length of 2 panels is less than 13 ft (4.0 m). If the combined length of 2 panels is less than 13 ft (4.0 m) and the combined length of 3 panels is longer than 16 ft (4.9 m) then the test shall be run with 2 panels. The test deck sample shall be minimum 3 ft – 4 in. (1 m) wide up to a maximum of 6 ft – 8 in. (2 m) wide. The samples shall be wide enough to accommodate 2 panels in a tent shape arrangement or 1 panel if the slopes are south facing.

4.1.1 Conditions of Acceptance for Combustibility from Above the Roof Deck/Photovoltaic Module

4.1.1.1 There shall be no fire damage to the roof cover nor to the PV panel within 6 in (152 mm) of the end of the last PV module.

Source: FM Approvals, FM 4478, p. 11

needed before technical requirements can be judged as necessary, sufficient and proportionate.

Seven criteria questions for PV roof fire safety

1. Vertical fire impact and burn-through

Which criteria should apply to vertical fire impact, burn-through or fire development within the roof build-up, including acceptable damage to

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should those criteria differ according to building use?

7. Equal performance criteria across roof build-ups

How can the same fire-behaviour criteria be applied to all roof build-ups, so that each assembly is assessed on documented system performance rather than assumptions about individual material categories?

This includes assemblies with different insulation classes, protective-layer strategies, membranes and PV layout configurations.

Technology-neutrality should not lower the burden of proof. It should ensure that all roof build-ups are assessed against the same criteria and evidence requirements. Substitution or product variation may be acceptable where it falls within a defined field of application, an EXAP report or other documented extended-application logic (EN 15725), and where the documentation demonstrates that the required fire behaviour and classification are maintained. On that basis, worst-case or class-based assessment can reduce repeated testing.

Answering these questions would give builders, roof designers, insurers, authorities and manufacturers a common basis for judging whether a roof assembly delivers the required fire behaviour.

This may be done through a dedicated working group (below).

First practical step: convene a PV roof fire-safety working group

National authorities implementing the EPBD solar requirements should convene a PV roof fire-safety

working group linked to the implementation process.

The group should include fire authorities, building regulators, fire engineers, insurers, PV installers, electrical safety actors, test institutes, roof-system manufacturers and construction product manufacturers.

The group should have four tasks:

1. Agree the interim fire-behaviour expectations — what the completed PV roof assembly must be able to demonstrate — using the seven questions above as the starting point.
2. Translate those expectations into criteria that can guide national guidance, project approvals and insurance assessments.
3. Identify what documentation can be used for project-level decisions until harmonised test methods are available.
4. Identify where European standardisation is needed.

This would give the authorities and market actors a practical decision route now, while allowing standards and test methods to mature.

Electrical safety and roof-assembly fire behaviour should be treated as complementary. PV fire scenarios can originate in electrical components or installation quality.^{xvii}, ^{xviii} Electrical safety reduces the likelihood of ignition. Roof-assembly criteria reduce the consequences if ignition occurs.

The immediate objective is not to finalise a new European test method, nor to prescribe a particular roof construction. It is to define what counts as fire-safe for the completed PV roof assembly — the behaviour it must demonstrate under credible fire exposure — so that any design can then be assessed against that target. A prescriptive rule can improve consistency, but on its own it does not guarantee safety in every

configuration; a defined behaviour target is what lets a design be accepted or rejected on the evidence.

The proposed regulatory sequence

NEPSA recommends the following sequence:

1. Define the intended fire-safety outcome.
2. Define the required fire behaviour of the completed PV roof assembly.
3. Answer the seven criteria questions set out above.
4. Use the resulting criteria as a common target for design, approval, insurance and interim guidance.
5. Select or develop test methods that measure the relevant behaviour.
6. Evaluate material and assembly requirements against those criteria.

Steps 1 to 4 provide the immediate safety target. They are needed now because PV roofs are already being planned and installed at scale.

Steps 5 and 6 provide the longer-term standards route. They ensure that future standardised test methods and technical requirements are developed against the right fire-safety target.

This sequence defines what success looks like before technical solutions are selected. It then allows different solutions to be assessed against the same safety objective.

What does it cost?

The proposal is not, in itself, a new construction requirement. It is a request for regulatory clarity. The direct cost is the work needed to define fire-behaviour criteria, align standards and decide what evidence is needed to show compliance. That work will require time from regulators, standards bodies, fire engineers, insurers, PV

experts, electrical safety actors and construction product manufacturers.

Some roofs may become more expensive if they need to meet a clearer and more demanding fire-behaviour target. That cannot be ruled out.

The risk is that later correction may prove more costly than defining the target before large-scale deployment. That cost could arise through redesign, retrofitting, insurance restrictions or avoidable loss events.

Without clear fire-behaviour criteria, Europe may also adopt requirements that are more costly without demonstrating proportionate safety benefits. It may leave building owners, insurers and authorities without a clear basis for deciding whether a PV roof assembly is safe enough.

Clear criteria would also reduce uncertainty for public authorities procuring or approving PV installations on schools, hospitals, municipal buildings and other public assets.

There is also a cost to doing nothing. In the absence of a European route, larger market actors are likely to fall back on the demanding private approval schemes that already exist — most visibly FM Approvals' system-level route (FM 4478). Such approval is resource-intensive and project-specific: full FM approval has been indicated at a reported minimum of around €50,000 per system design.¹ Larger companies can absorb costs at this level; smaller manufacturers and installers often cannot. Without interim European fire-behaviour expectations, the practical effect could be a two-tier market, in which the only recognised way to demonstrate system-level fire performance is one that smaller firms struggle to access. Clear, outcome-based criteria that any firm can design and document against would keep the route to demonstrating fire safety open across the market.^{xix}

Clear, outcome-based fire-behaviour criteria will raise both fire safety and regulatory quality

Defining the required fire behaviour before specifying technical requirements would:

- make the fire-safety objective explicit;
- allow regulators to evaluate different technical solutions on a consistent, comparable basis;
- support technology-neutral performance requirements;
- give fire engineers and insurers a clearer and unambiguous performance target;
- reduce inappropriate reliance on material-level proxies when system-level assessment is needed;
- direct standards bodies toward test methods that measure relevant, assembly-level behaviour.

Prioritising how the completed PV roof assembly performs in a credible fire scenario keeps focus on the outcome that determines risk in practice.

The risk is not merely theoretical: the UK Building Safety Regulator review concluded that rooftop PV systems form semi-enclosed cavities that trap heat and channel flames toward the roof surface, and existing classification tests and guidance in England do not fully capture these altered fire dynamics, prompting calls for new test methods that reflect those modified fire conditions.^{xx}

At building and portfolio scale, even relatively infrequent events can become relevant when the number of exposed roofs rises sharply. Ong et al. estimate an annual frequency of approximately 28.9 fires per GW of installed PV capacity. Ong et al. also note that in almost half of the fires they

analysed the initial ignition source was unknown or unrelated to the PV system — which underlines why the fire behaviour of the completed roof assembly, not the ignition source alone, is what a fire-safety criterion must address.^{xxi} Recent large-scale testing by DBI has examined flame spread on roof build-ups with PV systems. This work should inform the standards phase once the required fire behaviour has been defined.^{xxii}

About Position Papers

NEPSA Position Papers set out the association's position on key regulatory or classification developments affecting expanded polystyrene (EPS) and its applications. Each paper presents structured evidence, policy context, and procedural detail to support informed dialogue with EU institutions and stakeholders. They aim to clarify how specific proposals relate to market practice, regulatory frameworks, and environmental goals.

About NEPSA

Nordic EPS Alliance represents Nordic EPS associations and companies. *NEPSA* promotes the sustainable use and circular integration of EPS in packaging, construction, and other applications.

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^{xix} Reported minimum based on an offer indicated by FM Approvals to EUMEPS prior to 2025. Pricing varies with the scope and design assessed; the figure is indicative, not a quotation.

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