

THE ROOF COMES FIRST · WHITEPAPER

From risk models to design requirements

Translating risk models into PV roof design requirements

CORE THESIS

For PV installed above combustible roof construction, the roof-PV design should include a consequence-limiting asset-protection baseline that interrupts the physical fire pathway into the building, alongside probability-reducing controls that act upstream of ignition. Baseline describes a design requirement, not the chronological order in which controls act during an incident.

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Prepared for asset owners, architects, roofing professionals, risk engineers, insurers and PV stakeholders.

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Author's perspective

I am investigating rooftop PV from the perspective of the complete commercial roof system rather than from individual product classifications. My starting point is the building: its structure, roof build-up, intended service life, fire behaviour, fixing strategy, insurability and economics. I call this a roof-first approach.

The papers in this series represent my own technical analysis. They are based on published research, existing fire tests, standards, approval documents and my interpretation of that evidence. They do not present new laboratory research or fire testing conducted specifically for these papers. Where I draw engineering conclusions from several sources, I distinguish those conclusions clearly from what has been demonstrated directly in testing.

My background is in architecture and building engineering and I have been directly involved in the development, preparation and supervision of fire-test programmes for commercial roof assemblies and rooftop PV systems. That experience inevitably influences the questions I ask, but the purpose of these papers is to test those questions against external evidence rather than to start with a preferred product.

I am affiliated with AllShield, which develops BarrierSheet and other roof fire-protection solutions. That commercial relationship is relevant and is therefore stated explicitly. The analysis does not assume that an AllShield product provides the effects discussed. The starting point is the physical or economic problem. Where an AllShield product is discussed, it is treated as one product-specific example and its performance should be read only within the boundaries of the cited tests, approvals and roof assemblies.

In this paper I use established fire-safety and risk-engineering frameworks to examine one specific question: once ignition prevention can no longer guarantee that a fire will not occur, what function should the roof itself perform? The objective is not to make the models point towards a particular product, but to test whether different analytical approaches lead to a consistent product-neutral design requirement.

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Executive summary

Commercial rooftop PV should be treated as part of the building-and-roof system rather than as an electrical installation sitting above an unrelated roof. Fire is one of the clearest examples of why this matters. FM research shows that the presence of PV can change flame geometry and increase both radiative and convective heat transfer to the roof. The same research states that quality products, better design, installation and maintenance can reduce ignition likelihood but cannot eliminate it. Robust fire testing of the combined roof-PV assembly therefore remains necessary. [1]

The 2026 ZAG Fire Safety Guideline reaches a closely related conclusion. It treats PV fire risk as a combination of probability and consequence and emphasises system-level assessment. For consequence limitation, ZAG identifies non-combustible insulation as its primary recommendation. Where other solutions are considered, it states that they should demonstrate similar robustness in tests of the complete roof segment and PV modules at a scale that includes several modules. [2]

In this whitepaper I apply five established fire-safety and risk-engineering frameworks to one specific scenario: PV installed above combustible roof construction. The models do not prescribe AllShield BarrierSheet or any other product. Instead, they are used to test whether different analytical methods support the same product-neutral design priority.

Five frameworks converge on the same asset-protection principle: do not leave an uninterrupted physical fire path from the PV fire into the building.

Framework	Risk function	PV roof implication
NFPA 550	Manage the impact	Ignition prevention is not the complete fire-safety strategy.
Bow-tie	Protect the consequence side	Place barriers after the Top Event as well as before it.
Event Tree	Interrupt the escalation	Create a safe stopping point before a roof fire becomes an internal building fire.
Fault Tree	Break the causal pathway	Remove or interrupt a necessary condition: the downward propagation path.
Defense in Depth	Establish the baseline	Combine preventive controls with passive protection that performs a different safety function.

The design conclusion I draw is deliberately risk-led rather than product-led. Where a fully non-combustible roof build-up is practical, it is the cleanest way to remove combustible fuel from the escalation pathway. Where existing lightweight roofs cannot reasonably be rebuilt in that way because of structural reserve, disruption or economics, an alternative consequence-limiting strategy should be demonstrated through robust whole-system testing. A tested non-combustible separation layer directly beneath the roof membrane is one such strategy.

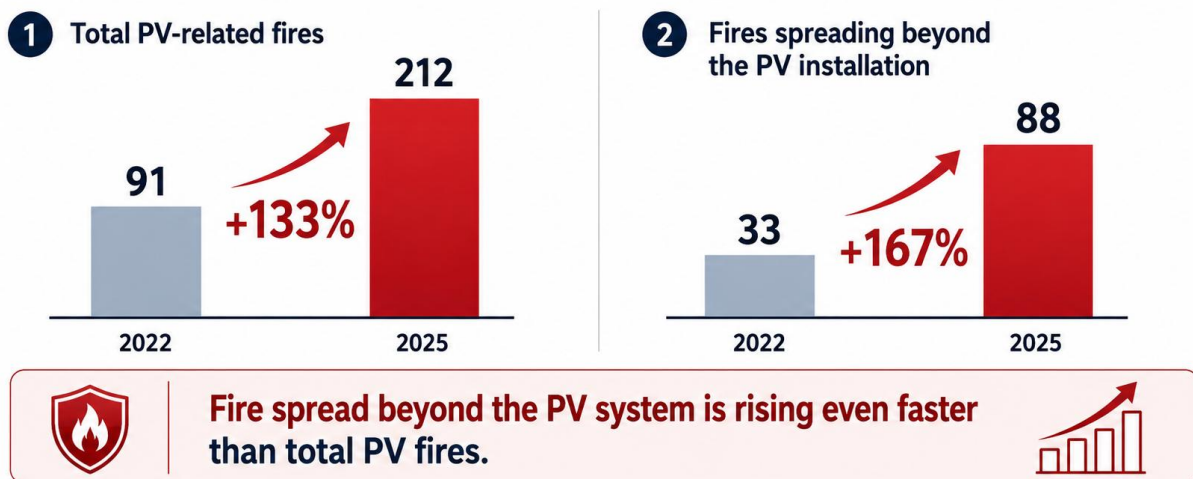
Rooftop PV is often approached primarily as an energy project. On commercial buildings, however, feasibility is frequently determined by the roof itself: structural capacity, roof build-up, remaining or intended service life, fire behaviour, fixing strategy and insurability. The order in which these questions are assessed matters. In this paper I focus on one of those gating questions, fire consequence, and use risk models to translate it into a design requirement before a product is selected.

1. Why the design question matters

The installed base of commercial rooftop PV is growing while incident data shows that the fire risk is not theoretical. In August 2026 QBE European Operations reported 212 UK solar-panel-related fires in 2025 compared with 91 in 2022. More importantly for asset protection, fires reported as spreading beyond the solar installation increased from 33 to 88 over the same period. QBE recommends avoiding combustible roofs or ensuring appropriate separation and fire-resistant barriers. [3]

QBE: PV fires are rising fast.

UK fire service data, 2022 vs 2025.



 Source: QBE European Operations, FOI-based UK fire service data, published 2026.

This fire question should not be isolated from the broader roof decision. Whether the project concerns an existing roof or a new roof that can still be designed from the start, structural capacity, roof build-up, service life, fixing strategy and insurability can all govern whether rooftop PV is feasible. Fire consequence is therefore one gating condition within a wider roof-first assessment, not a standalone product question.

Figure 1. Recent QBE data illustrates the distinction between incident frequency and escalation beyond the PV installation.

From a building-design perspective, the distinction is straightforward. Preventive measures act mainly on the likelihood of ignition. Consequence-limiting measures act on what happens after ignition. Both matter but they perform different safety functions.

RISK EQUATION

Risk is commonly conceptualised as the combination of likelihood and consequence. Reducing likelihood is valuable but a severe consequence can justify direct consequence-limiting measures even when the initiating event is uncommon.

This matters particularly for warehouses, factories and distribution centres where a fire entering the building can create losses far beyond the PV installation and the building itself: structural damage, inventory loss, production interruption, supply-chain disruption and long recovery times.

2. What current fire research says about roof-PV systems

A central premise of my analysis is that the PV array and the roof below it should not be assessed as independent fire-safety questions. FM research describes how PV panels can alter the flame from a more vertical or wind-tilted shape into a flame constrained closer to the roof surface. This can increase radiative and convective heat transfer to the roof. Heated PV panels can also radiate energy back towards the roof and combustible panel components can add fuel. [1]

FM also makes the prevention limitation explicit: better products, design, installation and maintenance reduce ignition likelihood but do not eliminate it. Its research therefore treats robust fire testing of the combined roof construction and PV assembly as necessary to address large-loss potential. FM 4478 was developed to evaluate the roof and PV module assembly under a wind-driven fire exposure rather than testing the two as unrelated components. [1]

ZAG takes the same system view in its 2026 Fire Safety Guideline for Building Applied Photovoltaic Systems on Flat Roofs. The guideline states that PV can increase both the probability and the consequences of roof fire and that the real risk emerges from the interaction of components. It recommends system-level fire-safety assessment rather than relying only on individual product classifications. [2]

INDEPENDENT RESEARCH CONCLUSION

For consequence limitation, ZAG identifies non-combustible insulation as the primary recommendation. If other solutions are considered, ZAG says they should demonstrate similar robustness in experiments on the complete roof segment and PV system at a scale that includes several modules. [2]

This gives the risk discussion an important hierarchy. For new construction, using non-combustible insulation and minimising combustible content in the roof build-up is the most direct consequence-limiting route where it is structurally, technically and economically practical. Existing lightweight industrial roofs create a different problem. Structural load can be as decisive as fire performance: full replacement of combustible insulation with a substantially heavier non-combustible insulation build-up can consume limited roof reserve, compete with the load allowance required for PV or trigger costly structural strengthening. A lightweight consequence-limiting assembly may therefore be the more realistic engineering route, provided its performance is demonstrated at system level. In those cases the correct question is not whether a thin barrier is “the same as” non-combustible insulation. The question is whether an alternative assembly can demonstrate the required consequence-limiting function under representative system-level fire exposure.

Structural capacity is a finite design budget. Every kilogram allocated to the roof build-up, fire-protection strategy or mounting system reduces the capacity available for PV or may trigger structural reinforcement. Structural feasibility should therefore be established before the technical route is optimised.

Illustrative load comparison. Published flat-roof system data from ArcelorMittal show a U-value of 0.18 W/m²K for both a 120 mm PIR roof build-up and a 200 mm mineral-stone-wool roof build-up, with the mineral wool stated at 120 kg/m³. [18] That corresponds to approximately 24 kg/m² of mineral wool. A representative flat-roof PIR board with the same declared thermal conductivity of 0.022 W/mK has a density of approximately 30 kg/m³, or about 3.6 kg/m² at 120 mm. [19] Adding the 3.0 kg/m² BarrierSheet example used later in this paper [17] gives an illustrative insulation-plus-barrier mass of about 6.6 kg/m²,

roughly 17 kg/m² below the mineral-wool example. This comparison is assembled from published system and product data; it is not a representative market value or a generic weight-saving claim. Mineral-wool density, insulation thickness, thermal target and the complete roof build-up vary materially between projects. The example shows the scale that a roof-system weight difference can reach and why structural reserve should be assessed before a fire-protection strategy is selected.

FM Property Loss Prevention Data Sheet 1-15 applies the same assembly logic. Its fire objective is to limit fire spread and prevent roof-PV fires from entering the building. For new roofs it directs designers towards FM Approved roof-PV assemblies (FM 4478). For existing roofs receiving PV it recognises retrofit strategies that must be evaluated as complete systems. [4]

DESIGN FRAMING

Do not begin by asking which product should be added. Begin by defining the asset-protection function: the roof-PV system should not provide an easy downward fire pathway from the PV incident into combustible construction and the building below.

3. Analytical question and design hierarchy

The five frameworks in this paper are intentionally different. NFPA 550 is a fire-safety concepts structure. Bow-tie is barrier-oriented. Event Tree is forward and sequential. Fault Tree is backward and deductive. Defense in Depth is an architecture philosophy. Their value is precisely that they do not share the same analytical lens.

The common test question is therefore narrow and product-neutral: if PV is installed above combustible roof construction, what must the roof-PV design achieve to limit escalation if ignition still occurs?

Design consequence limitation into the roof-PV system as a baseline requirement while continuing to reduce ignition probability.

This baseline is a design requirement, not a reversal of incident chronology and not a claim that prevention is secondary. Electrical design, component quality, installation, inspection, maintenance, monitoring and shutdown remain necessary. The proposition is simply that the building should not depend entirely on every preventive layer succeeding for its survival.

The following five sections apply that same question to each framework.

4. NFPA 550 | Manage the impact

NFPA 550, Guide to the Fire Safety Concepts Tree, provides a structured way to organise fire-safety concepts. At the highest level the tree separates the objective into two broad strategies: prevent fire ignition and manage fire impact. [5]

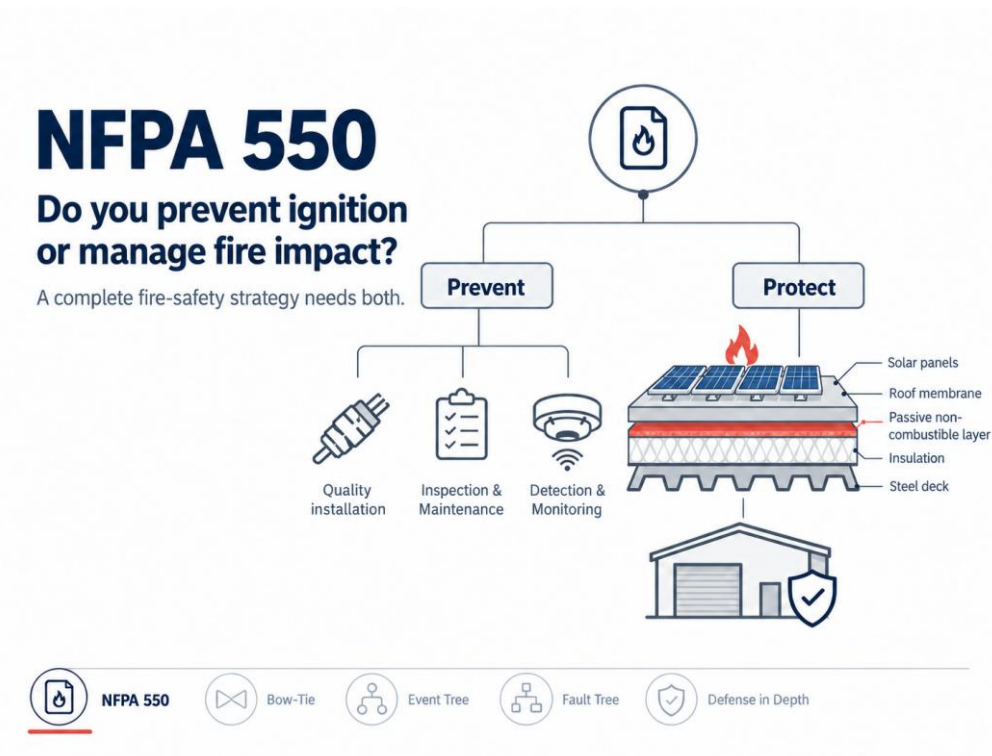


Figure 2. Simplified application of the NFPA 550 logic to a PV roof.

Applied to rooftop PV, connector quality, electrical design, installation, inspection, monitoring and shutdown predominantly sit on the ignition-prevention side. A passive roof measure that continues to perform after a physical fire has already started belongs on the impact-management side.

The important point is not that NFPA 550 specifically prescribes a coverboard. It does not. The inference is that an asset-protection strategy which contains only ignition-prevention measures leaves the impact-management branch underdeveloped.

DESIGN IMPLICATION

If ignition cannot be reduced to zero, fire-impact management must be designed into the roof-PV strategy. For combustible roof construction, that means securing physical separation between the fire exposure and the combustible layers below.

5. Bow-tie | Protect the consequence side

Bow-tie analysis places a Top Event in the centre, threats and preventive barriers to the left and consequences and mitigating barriers to the right. The Energy Institute and CCPS use the method to make barrier placement and escalation pathways visible. [6]

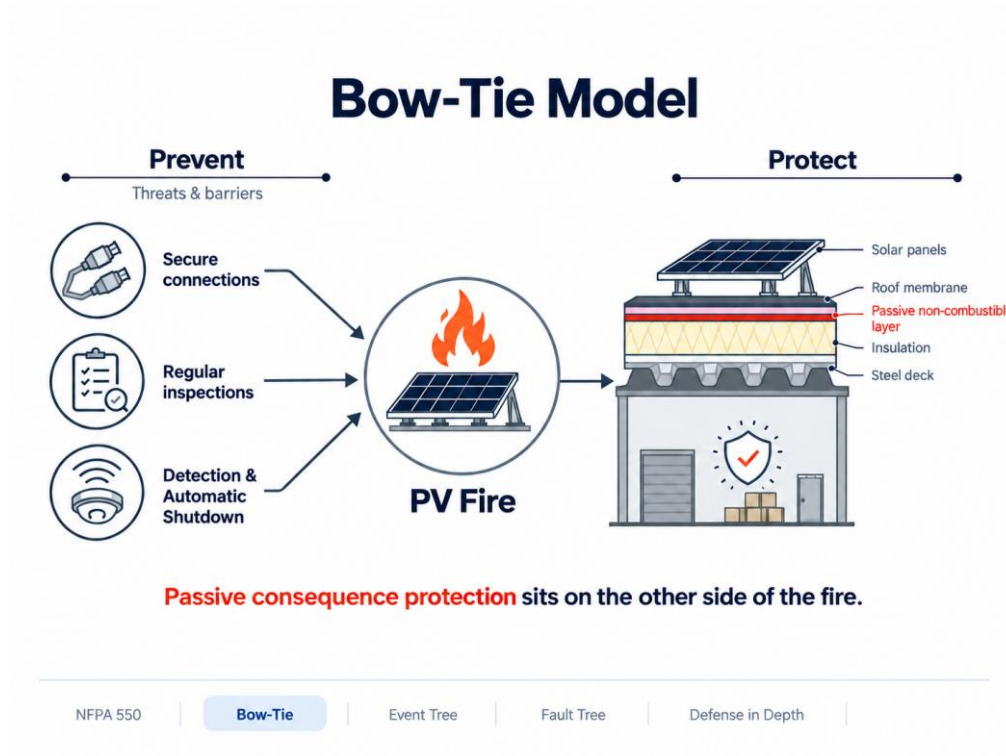


Figure 3. A PV fire as the Top Event: preventive barriers on the left and consequence-limiting protection on the right.

For PV fire risk, most familiar controls sit before the Top Event: component quality, workmanship, inspections, monitoring, arc detection and shutdown. Once a physical PV fire exists, these measures have either already performed or failed to prevent the Top Event. The engineering objective then changes from preventing ignition to limiting escalation.

CCPS distinguishes between barriers that prevent a threat from developing into the Top Event and barriers that mitigate consequences after the Top Event has occurred. [7] A non-combustible physical layer below the membrane is therefore not a competitor to good electrical engineering. It occupies a different position in the risk pathway.

DESIGN IMPLICATION

If all controls sit before the Top Event, the consequence pathway remains open. A robust roof-PV strategy needs a mitigating barrier between the fire and the asset as well as preventive barriers before the fire.

6. Event Tree | Interrupt the escalation

Event Tree Analysis starts with an initiating event and follows possible sequences forward. IEC 62502 describes ETA as a method for modelling the consequences of an initiating event as later functions succeed or fail. [8]

Event Tree

Where can you interrupt escalation before catastrophic loss?

Same initiating fire.
Different end state.

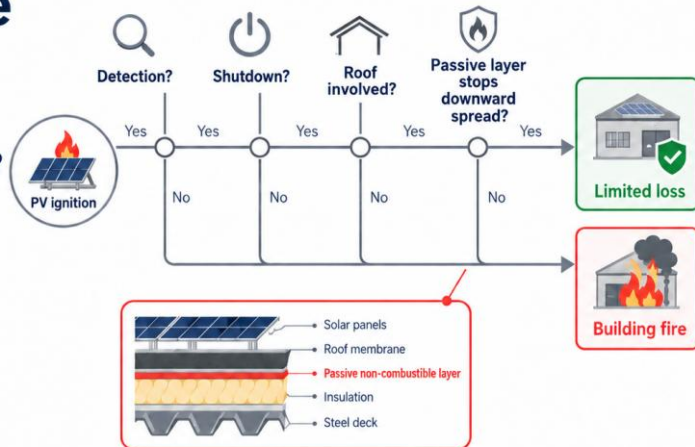


Figure 4. Event-tree logic applied to the escalation from PV ignition to building fire.

A PV fire does not destroy a building in one step. An ignition may be detected, electrical energy may be isolated, the physical fire may or may not involve the roof and the roof assembly may or may not permit further downward propagation. Each branch changes the final state.

This is why shutdown should not be confused with extinguishment. Electrical isolation can work correctly while material that has already ignited continues to burn and expose the roof to heat and flame.

Event Tree thinking also changes how a late barrier is valued. Its importance is not reduced because earlier failures have already occurred. If that barrier separates a local roof incident from internal building fire, it has high consequence leverage.

DESIGN IMPLICATION

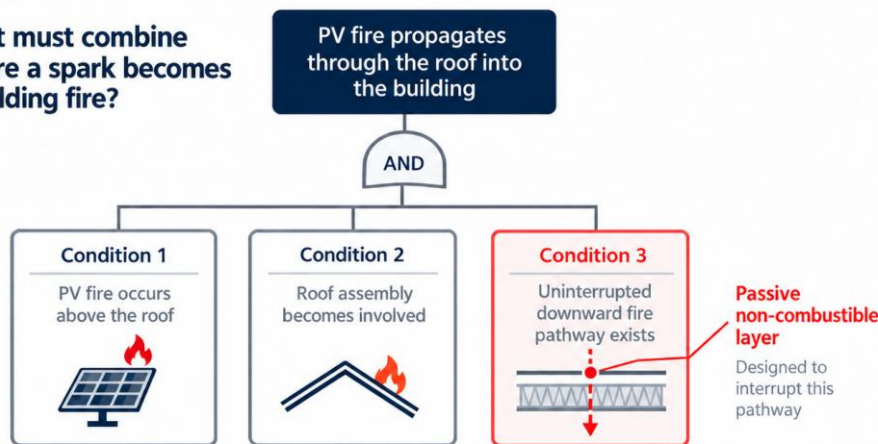
The decisive design task is to create a safe termination point before the sequence reaches internal building fire. A passive non-combustible layer can provide that stopping point in the downward propagation path.

7. Fault Tree | Break the causal pathway

Fault Tree Analysis works in the opposite direction. IEC 61025 defines FTA as a deductive method for identifying and analysing the events and conditions that can cause a defined undesired state. [9]

Fault Tree Analysis

What must combine before a spark becomes a building fire?



Break one condition, and this pathway to building fire is broken.

NFPA 550

Bow-Tie

Event Tree

Fault Tree

Defense in Depth

Figure 5. Simplified Fault Tree: one specific path to fire propagation into the building.

Define the Top Event precisely: a PV fire propagates through the roof into the building. A simplified causal pathway requires three conditions to remain available: a PV fire occurs above the roof, the fire exposure involves the roof assembly and an uninterrupted downward propagation pathway remains into combustible construction.

Fault Tree logic is useful because it shows that preventing the initiating fire is not the only way to prevent that specific Top Event. If one necessary condition in an AND-dependent pathway is interrupted, that route to the Top Event is broken.

A complete Fault Tree must also account for other branches such as penetrations, rooflights, edges, expansion joints and equipment details. A passive layer does not make every possible fire pathway impossible. It addresses a defined causal pathway.

DESIGN IMPLICATION

Engineer the uninterrupted downward fire path out of the roof assembly. A non-combustible separation layer is one way to make that necessary condition unavailable in the intended roof zone.

8. Defense in Depth | Establish the baseline

Defense in Depth is not primarily an incident-analysis diagram. It is a protection architecture. Nuclear safety guidance from the NRC and IAEA uses multiple levels of protection so that safety does not depend entirely on a single safeguard. Diversity is important because layers with different functions and dependencies are less vulnerable to the same failure mechanisms. [10][11]

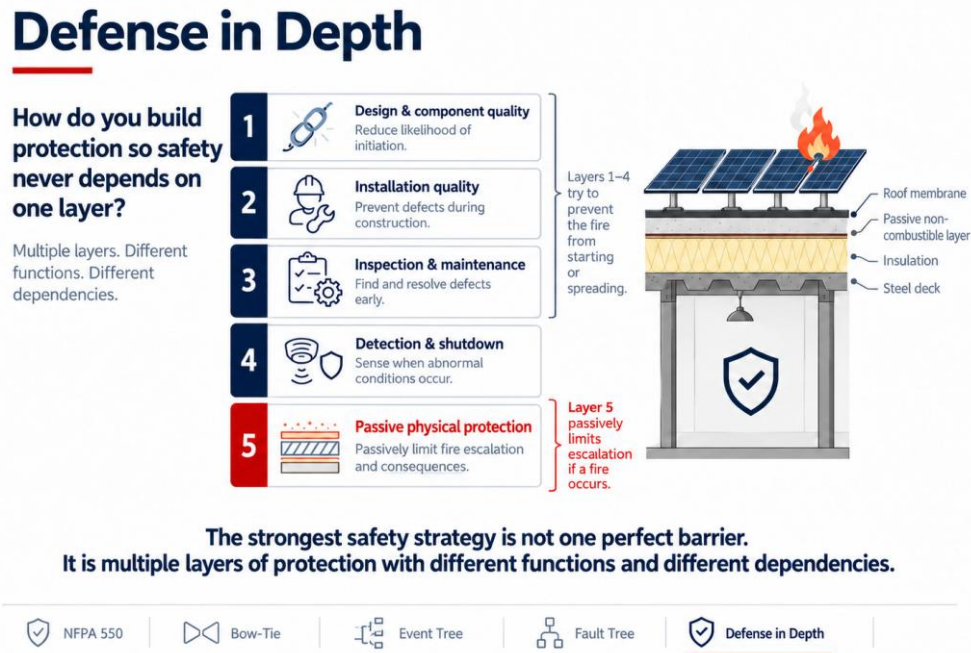


Figure 6. A five-layer PV roof protection architecture derived from Defense in Depth principles.

Applied to a commercial PV roof, the architecture can be expressed as five functional layers: design and component quality, installation quality, inspection and maintenance, detection and shutdown and passive physical protection. This is my application of the Defense in Depth principle, not a formal five-level classification from NRC or IAEA.

The first four layers are themselves different safeguards and should not be treated as though they all fail identically. They can nevertheless share operational dependencies on competent human action, timely detection or active electrical and digital systems.

Passive physical protection has its own design and installation dependencies but its function at the moment of fire exposure does not require power, software, communication or a response to be initiated.

DESIGN IMPLICATION

Treat passive consequence protection as one baseline layer within a protection architecture that also includes probability-reducing controls. The objective is not one perfect barrier but several layers with different functions and different dependencies.

9. Five frameworks, one design conclusion

The frameworks differ significantly in purpose, method and terminology. None of them can be used as a substitute for another and none of them individually proves the performance of a particular product. Yet when they are applied to the same narrowly defined scenario, a consistent design priority emerges.

Framework	What the model exposes	Resulting design priority
NFPA 550	Impact management must exist after ignition.	Secure physical separation.
Bow-tie	A consequence-side barrier is needed after the PV fire.	Place a mitigating barrier between fire and asset.
Event Tree	Escalation needs a safe stopping point.	Interrupt downward propagation before internal fire.
Fault Tree	The Top Event depends on an available propagation path.	Remove or interrupt that necessary condition.
Defense in Depth	Safety should not depend only on preventive and active controls.	Use passive physical protection as a baseline layer.

Design consequence limitation into the roof-PV system as an asset-protection baseline while continuing to reduce ignition probability.

This is an analytical design hierarchy for property protection. It does not mean that preventive measures are optional. It means that the roof-PV design should not depend entirely on ignition never occurring.

10. From individual models to the incident chain

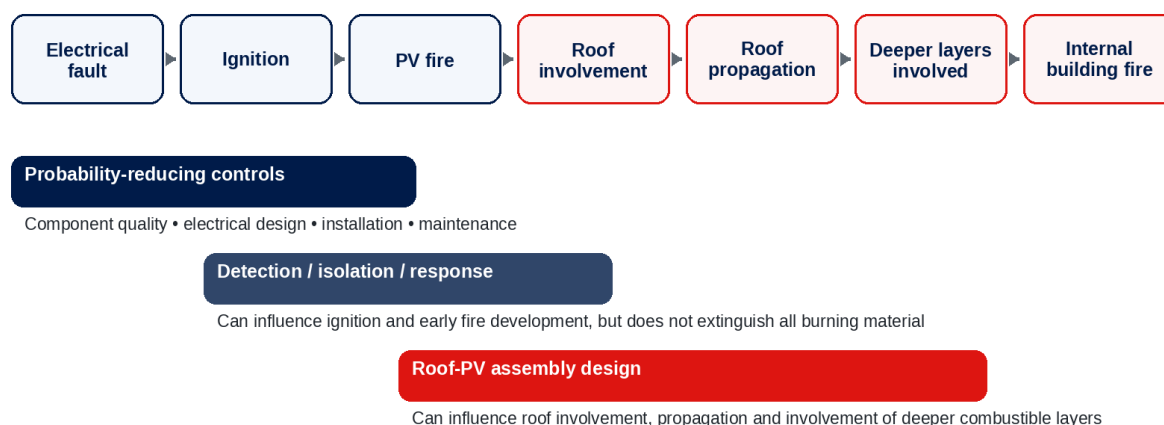
The five frameworks also reveal a practical distinction that matters when controls are selected: a measure can only influence an incident while the relevant escalation step is still available to it.

Connector quality, electrical design, installation and maintenance act primarily before ignition. Once a physical PV fire exists, those measures can no longer determine whether the roof becomes involved. The relevant controls then shift towards the behaviour of the roof-PV assembly itself.

A simplified escalation sequence is: electrical fault → ignition → PV fire → roof involvement → propagation through the roof build-up → involvement of deeper layers → internal building fire.

From incident chain to design leverage

Different safeguards retain influence at different stages of escalation.



A safeguard cannot manage a downstream consequence after the incident has passed its point of influence.

Figure 7. Incident-chain view: safeguards act at different points of influence as an incident escalates.

Viewed as a chain of connected Bow-ties, the consequence state from one stage can become the starting condition for the next. A line of defence therefore has a particular point of influence in that chain.

Different safeguards act at different positions in this sequence. Some have a relatively narrow window of influence. Others can affect several downstream escalation steps by limiting roof involvement, reducing the opportunity for combustible layers to become involved and interrupting propagation towards deeper parts of the roof assembly.

A roof build-up based on non-combustible insulation can reduce the combustible fuel available in the relevant pathway. Other fire-limiting assemblies can retain combustible materials behind a tested protective layer. The engineering question is not whether those strategies are materially identical, but whether the intended roof-PV assembly demonstrates the required consequence-limiting function.

This does not mean that one passive measure controls every fire pathway. Penetrations, rooflights, edges, upstands and other details can create separate escalation routes. The effectiveness of a control therefore has to be assessed against the particular stage and pathway it is intended to influence.

A downstream consequence cannot be managed solely by an upstream control once the incident has already passed that control's point of influence.

11. From risk logic to fire-test evidence

Risk models can define the safety function but they cannot prove that a material or assembly performs that function. That requires evidence. The strongest bridge from theory to specification is therefore to define the required consequence-limiting function and then verify the proposed solution at the complete-system level.

Evidence source	What it contributes	Important boundary
FM research on rooftop PV fire mitigation	PV changes fire dynamics. Prevention can reduce but not eliminate ignition. Roof-PV assembly fire testing remains necessary.	Research principle, not a product approval.
ZAG 2026 PV fire-safety guideline	Risk must address probability and consequence. Non-combustible insulation is the primary recommendation. Alternatives should demonstrate similar robustness in whole-system multi-module tests.	Guideline principle. It does not prescribe BarrierSheet.
ZAG 2025 BarrierSheet fire programme	Across the tested scenarios the barrier prevented direct flame penetration to deeper structural layers while thermal damage and pyrolysis still affected deeper materials.	Specific tested assemblies. Joints, thickness, anchoring and material layering influenced results.
Kiwa BDA 2024 CLC/TR 50670 programme	In two realistic PV tests an earlier BarrierSheet build-up reduced measured fire spread underneath the barrier relative to spread above it by approximately 40% and 30%.	Earlier 1.2 mm BarrierSheet specimen and specific roof/PV configurations.
FM Approvals PR472014	Current 2.5 mm BarrierSheet is Approved under FM 4470 and FM 4478 in listed assemblies including RoofNav 568563-0-0.	Approval applies to the listed assembly and conditions, not arbitrary substitutions.
Efectis 2025 CEN/TS 1187 Test 1	The tested roof assembly recorded no fire penetration, no burning or glowing particles penetrating the roof and no through openings in the four specimens.	Specific double-BarrierSheet assembly. Formal EN 13501-5 classification is assessed separately.

The ZAG 2025 programme is particularly useful because it also demonstrates why “no flame penetration” is not the same as “no thermal effect”. The report records subsurface thermal damage, decomposition and local gaps or burn-through areas while still concluding that direct flame penetration into deeper structural layers was prevented in the tested scenarios. [13] That is an important engineering distinction and a reason to treat detailing and full-system behaviour as part of the risk control.

Kiwa’s 2024 tests provide a second useful perspective. They used a realistic PV array above a PVC membrane, BarrierSheet and PIR. The report states that measured fire spread above the fire barrier compared with damage in the thermal insulation beneath it was reduced by approximately 40% in one test and 30% in the other. Temperatures near the barrier reached 575 °C and 837 °C while the highest measured temperature underneath the insulation was 63 °C and 71 °C respectively. [14] These results are specific to the tested arrangements and should not be extrapolated to every roof.

EVIDENCE PRINCIPLE

The models define what the barrier must do. The fire tests determine whether a specific roof-PV assembly actually does it.

12. From analysis to a product-neutral design requirement

The combined risk analysis and fire-safety guidance support a product-neutral specification principle rather than a brand statement:

PROPOSED RISK-BASED SPECIFICATION PRINCIPLE

For PV installed above combustible roof construction, provide an evidenced consequence-limiting roof-PV strategy that prevents or interrupts downward fire propagation into combustible layers and is validated for the intended roof-PV assembly.

This wording deliberately focuses on function. It also avoids claiming that one material class or one individual product is universally sufficient. The complete assembly, interfaces, attachment, penetrations, roof details and PV configuration remain relevant.

For new construction, a roof build-up based on non-combustible insulation is the clearest route where practical and is the primary recommendation in the ZAG 2026 guideline. [2] For existing lightweight roofs, however, structural reserve can be the governing constraint. Replacing an existing lightweight roof with a much heavier non-combustible insulation build-up may require strengthening of the steel deck or primary structure or may compete directly with the load allowance needed for PV.

As the illustrative comparison in Section 2 shows, roof-system weight differences can be large enough to matter where structural reserve is limited, but no generic kg/m² saving should be inferred from that example. In that situation a lightweight, tested non-combustible separation strategy can be considered, provided that its robustness is demonstrated in representative whole-system fire testing and the complete roof-PV assembly is structurally verified.

This distinction matters. The engineering objective is not to declare the underlying combustible insulation “non-combustible”. The objective is to prevent a roof-level PV fire from having an easy propagation route into that combustible material and ultimately into the building.

RC62, the UK insurer-supported Joint Code of Practice for PV installations, is also framed around both prevention and mitigation and calls for additional fire-protection measures where roofing conditions require them. [12] This reinforces the broader industry principle that electrical prevention and building fire protection are complementary risk controls.

The design requirement does not determine one material solution. Depending on the building, roof and applicable evidence, consequence limitation may be achieved through a fully non-combustible roof build-up, an evidenced protective layer over retained combustible materials, an approved retrofit coating or recover strategy, or another system-level approach supported by applicable guidance and evidence. These routes are not interchangeable; each has different implications for structural load, wind, waterproofing, constructability, approval and lifecycle. [4]

13. BarrierSheet as one evidenced implementation

BarrierSheet is examined here as one evidenced implementation because AllShield has access to the underlying FM Approval and independent test programmes needed to examine its evidence boundaries in detail. It is not presented as the only route to consequence limitation.

FM Approvals report PR472014 describes the current product as a 2.5 mm formulated cementitious coverboard measuring 1000 x 2000 mm. The report lists two distinct standards. FM 4470 addresses single-ply roof assemblies, including relevant TPO/PVC systems, polymer-modified bitumen sheet, built-up roof (BUR) and liquid-applied roof assemblies for use in Class 1 and non-combustible roof deck construction. FM 4478 is the Examination Standard for Roof-Mounted Rigid Photovoltaic Modules. The evaluated BarrierSheet assemblies meet the applicable requirements of both standards when installed as specified. [15]

One listed example is RoofNav assembly 568563-0-0. In that assembly the 2.5 mm BarrierSheet is added to the top insulation layer and used with specified FM Approved PV modules, Sika SolaRoof mounting, Sarnafil TS roof cover, FM Approved insulation and a steel deck. The Approval also includes specific wind, hail and slope conditions. [15]

The current BarrierSheet Product Data Sheet lists a nominal mass of approximately 3.0 kg/m² ±10% at a nominal thickness of 2.5 mm. [17] That low added dead load is relevant to retrofit feasibility on lightweight industrial roofs, but it does not remove the need for project-specific structural, wind-uplift and complete roof-system engineering.

Its risk function should be described narrowly. BarrierSheet does not prevent a defective connector, does not replace inspection and does not extinguish a PV fire. Its intended role is to create a passive physical separation layer directly beneath the roof membrane so that a fire above the roof has a more difficult path into combustible construction below.

WHY THE IMPLEMENTATION IS DIFFERENT

Most PV controls try to reduce the probability of the Top Event. BarrierSheet is intended to reduce the probability that the Top Event develops into the loss event. Its function at the moment of fire exposure does not depend on detection, power, software, communication or human intervention.

The independent fire-test programmes also indicate why the product should be treated as an assembly component rather than as a universal standalone solution. ZAG recorded thermal damage below the barrier despite preventing direct flame penetration in the tested scenarios. [13] Kiwa observed different behaviour depending on test intensity. [14] Efectis (The Netherlands) tested a different double-layer build-up. [16] FM Approval is tied to listed assemblies and conditions. [15] These are not weaknesses in the evidence. They are exactly what system-level fire engineering should reveal.

14. Boundaries, limitations and engineering discipline

A risk-based specification should avoid turning a useful design principle into an absolute claim. A non-combustible coverboard is not a substitute for complete roof detailing, electrical safety or project-specific engineering.

- Roof penetrations, rooflights, drains, expansion joints, parapets, edges and equipment openings can create alternative fire pathways and require specific treatment.
- Wind uplift, hail, structural capacity, drainage, seismic exposure and other natural hazards remain part of the complete roof-PV risk assessment.
- Passive protection depends on correct specification, compatible system selection, workmanship and continuity at details.
- Electrical design, connector quality, installation, inspection, maintenance, monitoring, detection and shutdown remain valuable probability-reducing controls.
- No individual product should be represented as making every possible PV fire scenario impossible.
- Approval, classification or test results apply only within their stated field of application and must not be extrapolated to untested assemblies without engineering justification.

FM's own framework reflects this multi-hazard discipline by addressing fire, wind, hail, electrical design, commissioning, operation and maintenance as parts of the roof-PV risk picture. [4]

WHAT THE FIVE MODELS DO NOT PROVE

They do not prove that one product is sufficient, that all combustible insulation becomes safe in every configuration or that prevention can be omitted. They define why a consequence-side physical barrier is a rational asset-protection requirement and why its performance must be verified in the complete system.

15. Conclusion

The question I started from is simple: if PV is installed above combustible roof construction, what must the roof-PV design achieve to limit escalation if ignition still occurs?

Current fire research and guidance now make the context clearer. FM shows that PV changes the roof fire exposure and that good design, installation and maintenance reduce but do not eliminate ignition likelihood. ZAG's 2026 guideline states that PV risk must address both probability and consequence and recommends non-combustible insulation as the primary consequence-limiting route, with alternative solutions required to demonstrate similar robustness through whole-system multi-module testing. [1][2]

Five established risk frameworks were then applied to the same design problem. None of them prescribes BarrierSheet or any other specific product. Their value is more fundamental: each exposes a reason why a roof-PV design based only on ignition prevention is incomplete for property protection.

The recurring engineering requirement is to interrupt the physical fire pathway into the building.

NFPA 550 explains why fire-impact management matters. Bow-tie shows why barriers belong on the consequence side of the Top Event. Event Tree shows where escalation can be stopped. Fault Tree identifies a downward propagation pathway as a condition that can be engineered out. Defense in Depth explains why passive physical protection adds value when it has a different function and different runtime dependencies from the preventive layers.

For new roofs, the most direct route is to use non-combustible insulation and minimise combustible content in the roof build-up where practical. For existing combustible roofs, an alternative separation strategy can be justified only by representative system-level evidence. AllShield BarrierSheet is one engineered implementation of that approach and its current FM Approval and the ZAG, Kiwa and Efectis test evidence should be read within the boundaries of the specific assemblies evaluated. [13][14][15][16]

That fire hierarchy sits within a broader roof-first decision sequence. Before rooftop PV is treated as an energy project, the roof should be assessed for structural capacity, roof build-up, service life, fire behaviour, fixing strategy and insurability. What I aim to add with this analysis is a definition of how the fire-consequence question fits into that sequence: before selecting a product, establish the asset-protection function the roof-PV design must perform.

FINAL RISK STATEMENT

Design consequence limitation into the roof-PV system as a baseline requirement while continuing to reduce the probability of ignition.

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Scope note. In this whitepaper I apply risk-engineering methods from a building-engineering and roof-design perspective. It does not replace project-specific code review, insurer requirements, FM engineering review, product approvals, RoofNav conditions or professional fire-engineering judgement. Test results and approvals apply only within their stated fields of application.

About the author

Olivier Langejan has an architectural and building engineering background. His work focuses on how commercial roofs should be assessed and designed when rooftop PV forms part of the brief. He combines that background with experience in commercial construction and entrepreneurship.

His approach combines building design with hands-on technical research. Olivier has been directly involved in developing, setting up and supervising fire-test programmes for commercial roof assemblies and rooftop PV systems at FM Approvals, ZAG, Efectis and SwRI. Further testing and validation of AllShield systems has involved organisations including Kiwa-BDA and SGS-Intron.

Olivier also presents internationally to asset owners, engineers, risk professionals and insurers on commercial roofs, rooftop PV, residual fire risk and consequence-limiting design, including expert sessions involving specialists from organisations such as FM and Allianz.

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About AllShield

AllShield develops passive fire-protection solutions for commercial and industrial roof assemblies, with particular expertise in roofs supporting photovoltaic systems. Its work focuses on the interaction between roof construction, structural capacity, fire behaviour and rooftop PV rather than on individual products in isolation.

AllShield BarrierSheet is a lightweight cementitious coverboard intended for incorporation into defined roof assemblies. Its performance has been evaluated through independent testing and approval programmes including FM Approvals and ZAG. Product-specific performance claims apply only within the scope and boundaries of the relevant tested or approved assemblies.