THE ROOF COMES FIRST · WHITEPAPER

Rooftop PV on new commercial buildings

A decision framework for designing the roof and PV as one system from the start

CORE PRINCIPLE

Design the roof and PV as one system from the start.

ASSET → STRUCTURE → ROOF → MOUNTING → RISK → PV → EVIDENCE → APPROVAL → [INVESTMENT MILESTONE] → DELIVERY → LIFECYCLE

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Use and scope. This paper is a decision framework for project coordination. It is not a substitute for project-specific structural, fire, electrical, roofing, code, insurance, contractual or legal advice. Requirements vary by jurisdiction, insurer, manufacturer, building and assembly. The responsible professionals and approving parties remain responsible for project-specific decisions.

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Contents

Author's perspective....3
Executive summary....4
Introduction: PV is becoming part of the design brief....5
Design principle: control combustible involvement....8
1 Asset....9
2 Structure....11
3 Roof14
4 Mounting....17
5 Risk 19
6 PV 21
7 Evidence....24
8 Approval....27
Investment milestone....30
9 Delivery....31
10 Lifecycle....33
Conclusion: the roof comes first....35
The ten-gate decision framework....37
Appendix A : One-page decision framework....40
Appendix B : PV-ready roof checklist....41
References....43
About the author and transparency....44
Method and sources....45
About AllShield....47
REVISION HISTORY....48
THE SERIES....49

Author’s perspective

This series is a synthesis of published research, fire tests, standards, approvals and insurer guidance on fire safety and rooftop PV, written from an explicit roof-first perspective: I look at the complete commercial roof system and the building beneath it rather than at individual product classifications. Within that perspective I summarise what the evidence shows, add my own technical analysis and, where relevant, propose design principles. Those proposals are marked as mine and kept separate from what has been demonstrated.

My background is in architecture and building engineering. Over the past three years I have discussed this subject with engineers, risk specialists, insurers and test institutes, and I have been involved in setting up and supervising fire-test programmes for AllShield's own roof systems. That experience shapes the questions I ask; the papers test those questions against external evidence. How the sources were selected, and what remains open, is described at the end of each paper.

These papers are prepared by Olivier Langejan as lead author with support from a small team. His own professional focus is building and roof design; specialist findings are drawn from the cited evidence, with AI assistance disclosed separately in Method and sources.
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 apply that roof-first approach to new commercial buildings. New construction provides a particular opportunity because structural reserve, roof build-up, insulation, waterproofing, PV mounting and fire strategy can still be considered together before major design choices are fixed. My question is therefore not simply how to add PV safely to a new building, but how the roof should be designed when rooftop PV is already part of the brief. The decision sequence in this paper is my proposal; the evidence it draws on is inventoried.

Executive summary

Rooftop PV is moving from an optional addition to an increasingly normal part of the design brief for new commercial buildings. That changes the order in which decisions should be made. When PV is known from the beginning to be part of the building, it should not be treated as equipment added to a completed roof. The roof and the PV installation should be designed as one system.

The conventional sequence often runs the other way: the building is designed first, the roof second and the PV layout last. Each of those decisions can be technically correct on its own while the combined result consumes structural capacity, increases combustible involvement, restricts access or leaves interfaces that nobody owns. New construction offers a particular opportunity to avoid this, because structural reserve, roof build-up, insulation, waterproofing, mounting and fire strategy can still be resolved together.

This paper proposes a practical decision framework, not a prescribed or scientifically validated sequence. Its ten gates are: Asset, Structure, Roof, Mounting, Risk, PV, Evidence, Approval, Delivery and Lifecycle. After Gate 8, an unnumbered Investment milestone tests whether the accepted configuration still creates sufficient whole-life value before delivery begins. Each gate closes a design question before later decisions depend on it.

Three principles run through the framework:

- **The roof comes first.** The physical, structural, fire-safety and lifecycle boundaries of the roof should be established before the energy system is optimised.
- **Structural capacity is a budget, not merely a calculation.** Every kilogram added to the roof consumes capacity that may also be needed for PV, environmental actions, maintenance or future adaptation.
- **Prevent ignition, but design for what happens when prevention fails. Electrical and operational measures reduce the probability of fire; roof build-up and detailing can materially influence whether an incident remains local or develops into a larger property loss, alongside exposure, PV configuration, other safeguards and response.**

The objective is a new commercial roof that consumes as little structural capacity as reasonably necessary, minimises combustible content, limits the involvement of unavoidable combustible layers in a PV fire and provides a durable platform for the PV system throughout its intended life. That outcome is difficult to achieve when PV is added last. It becomes achievable when the sequence changes.

Introduction: PV is becoming part of the design brief

From optional technology to design requirement

Rooftop photovoltaics are moving from an optional addition to an increasingly normal part of the design brief for new commercial buildings. In Europe, this development is becoming regulatory. Article 10 of the revised Energy Performance of Buildings Directive requires Member States to ensure that all new buildings are designed to optimise their solar energy generation potential and requires suitable solar energy installations on new public and non-residential buildings with a useful floor area larger than 250 m² by 31 December 2026 where technically suitable and economically and functionally feasible. [1]

Similar developments can be seen outside the European Union. California's 2025 Energy Code requires solar photovoltaic systems on newly constructed non-residential buildings across a wide range of building types, including offices, retail buildings, schools and warehouses, subject to defined exceptions. [2] In Geneva, solar installations are required on suitable roof areas for new construction and certain roof renovations. The definition of a suitable roof area explicitly excludes surfaces where access, technical equipment, load-bearing capacity, waterproofing or structural integrity do not allow installation. [3]

These requirements differ between jurisdictions and do not amount to a universal global solar mandate. The direction, however, is increasingly clear: for many new commercial buildings, rooftop solar can no longer be treated simply as equipment that may or may not be added after the building has been designed.

Regional scope and evidence systems

This paper is international in intent, but the sources it uses belong to different legal, insurer and evidence systems. European regulation and external-fire classifications, UK guidance, FM property-loss-prevention requirements and North American code/listing routes answer different questions and should not be treated as interchangeable.

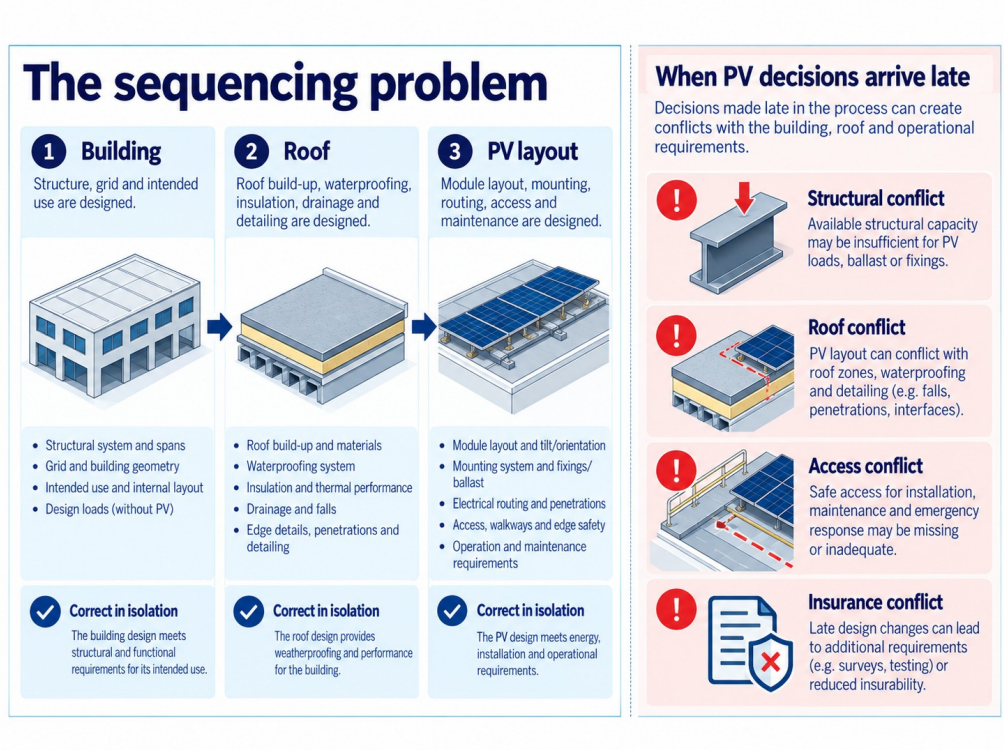
In North America, IBC-based codes use ASTM E108 or UL 790 for Class A, B and C roof fire classifications where required, while rooftop PV systems have separate listing and fire-classification provisions. These code and listing routes are not substitutes for FM Approval or for European external-fire classifications; the applicable jurisdiction determines which requirements govern the project. [13][14]

This paper is the new-construction companion to The roof comes first: rooftop PV on existing commercial buildings, which applies the same ten-gate decision sequence where the project begins with inherited roof conditions rather than a roof that can still be designed from the start.

The sequencing problem

That changes the design question. The conventional sequence is often still building first, roof second and PV later. Structural engineers design the building and roof structure, roofing specialists develop the roof build-up and the PV designer then attempts to optimise generation on the available surface. Fire safety, structural capacity, drainage, mounting loads, roof life, insurer requirements, maintenance access and warranty conditions may only become decisive once much of the design has already been fixed.

Each individual decision can therefore be technically correct while the resulting roof-PV system is not. The problem is not an absence of standards or guidance. Structural design, roofing, electrical safety, fire safety, PV installation and maintenance are all covered by established standards, guidance and industry practice. RC62 alone addresses commercial rooftop PV across planning, procurement, design, installation, operation and maintenance. [4] The missing link is often the sequence in which decisions across those disciplines are made.



The sequencing problem: decisions that arrive late can create structural, roof, access and insurance conflicts.

The roof and PV as one system

I propose a different starting point: the roof and the PV installation should be designed as one system from the beginning. The objective is not simply to maximise the number of panels that will fit on a roof. It is to create a roof that can support PV throughout its intended life without unnecessarily consuming structural capacity or introducing avoidable fire, water, maintenance, warranty or insurance problems.

That requires the roof to establish the boundaries within which the PV system is designed. Before the final PV layout is developed, the project should already understand what the building and its contents need to protect, how long the roof and PV system are expected to remain in service, how much structural capacity is available and how that capacity should be allocated.

It should also be clear how much combustible material can be removed from the roof build-up, how any necessary combustible layers will be protected from PV fire exposure and how rainwater, snow and wind will interact with the completed roof-PV system. The project should know how the PV system will be attached without creating unnecessary ballast or compromising waterproofing, which areas of the roof must remain available for drainage, rooflights including dome and continuous rooflights, smoke vents, technical installations, maintenance and emergency access, which performance claims require evidence at complete assembly level and which manufacturers, insurers and other stakeholders must accept the proposed system before construction begins.

One decision affects another

These decisions are interdependent. Optimising one in isolation can make another worse. A fire-safety measure may add weight. A ballast strategy may solve wind uplift but increase structural load and contribute to ponding. Increasing the space beneath PV modules may change fire behaviour while also changing wind and snow effects. Increasing panel density may increase electricity generation while reducing access to drains, rooflights, continuous rooflights or firefighting routes.

A good roof-PV design therefore does not maximise one performance characteristic. It manages the complete system.

Design principle: control combustible involvement

Start with the roof build-up

Fire safety is one of the clearest examples of why the roof and PV system cannot be designed separately. A useful starting point is to control combustible involvement: avoid unnecessary combustible material where practical and, where combustible components remain for structural, thermal, economic or other project reasons, design the assembly so their involvement in a PV-related fire is limited.

Different evidenced routes can achieve that objective. Non-combustible roof components may be appropriate in one project; another may retain combustible components behind a protective layer or use a different evidenced roof-PV strategy. The route should be selected against the complete structural, waterproofing, wind, fire, approval and lifecycle requirements rather than a material hierarchy.

1 Asset

Define what the building must protect

Start with consequence, not panel count

The first design question should not be how many panels can fit on the roof. It should be: what does this building need to protect? The answer changes the significance of every decision that follows.

A speculative warehouse, a pharmaceutical facility, a refrigerated distribution centre, a data centre and an office building can have roofs of comparable dimensions. Their consequences of fire, water ingress or extended loss of roof functionality can be entirely different. The asset may contain high-value stock, support a production process that cannot easily be relocated or depend on continuous temperature control. A building may be replaceable while the interruption to the business operating inside it creates the greater loss.

This does not mean that every building needs the highest possible level of protection. It means that the required performance of the roof-PV system should be informed by the consequences of failure rather than being determined only by minimum compliance.

The asset defines the design brief

RC62 reflects this broader property-risk perspective. It is designed around protection of people, property, business and the environment and recognises that insurability and risk requirements differ depending on the location, type and ownership of the PV installation. Business interruption is also part of that risk perspective. [4]

For a new commercial building, these questions can be resolved before they become constraints. At concept stage, the project should establish the building's use and what activities and assets will be located below the roof. It should determine the consequence of downtime if part or all of the building cannot operate following a roof fire or major water ingress.

The required design life should also be defined and compared with the expected service life of both the roof and PV system. Future expansion of the PV system, additional rooftop equipment or a foreseeable change in building use should be considered at the same stage. Property-protection and insurer expectations that exceed regulatory minimums should be identified early. The project should also establish whether the building, roof and PV installation will remain under one owner or whether responsibility may later be divided between landlord, tenant, PV operator and other parties.

Identify who pays and who carries the consequence

New commercial property is not always designed, owned and operated by the same party. A developer may fund construction and sell the completed asset; an investor or owner may inherit insurance, maintenance and replacement obligations; a tenant or operator may carry operational disruption and energy costs.

Gate 1 should therefore make the incentive split visible. The project should identify who pays the initial CAPEX, who carries recurring OPEX and insurance exposure, who depends on the building remaining financeable and marketable and who will own the consequences of a roof-PV decision after handover.

A lower construction cost is not automatically higher asset value if it creates technical, maintenance or insurance conditions that a future owner, lender or insurer regards as restrictive. The objective is not to

predict a valuation outcome but to make the transfer of cost and risk explicit before design choices are frozen.

Design for the life of the asset

These are not administrative questions to be answered after the technical design. They determine the design brief. A building that requires high operational continuity may justify a different roof assembly or passive fire strategy from a building where short-term interruption has limited consequence. A roof expected to remain under PV for decades may justify greater attention to durability, access and replaceability. A property intended to remain highly marketable may benefit from a roof design that does not depend on unusually restrictive assumptions to remain insurable.

The purpose of this first step is not to put a monetary value on every possible failure. It is to make the consequence visible before technical choices begin so that the project can decide what the roof must achieve.

2 Structure

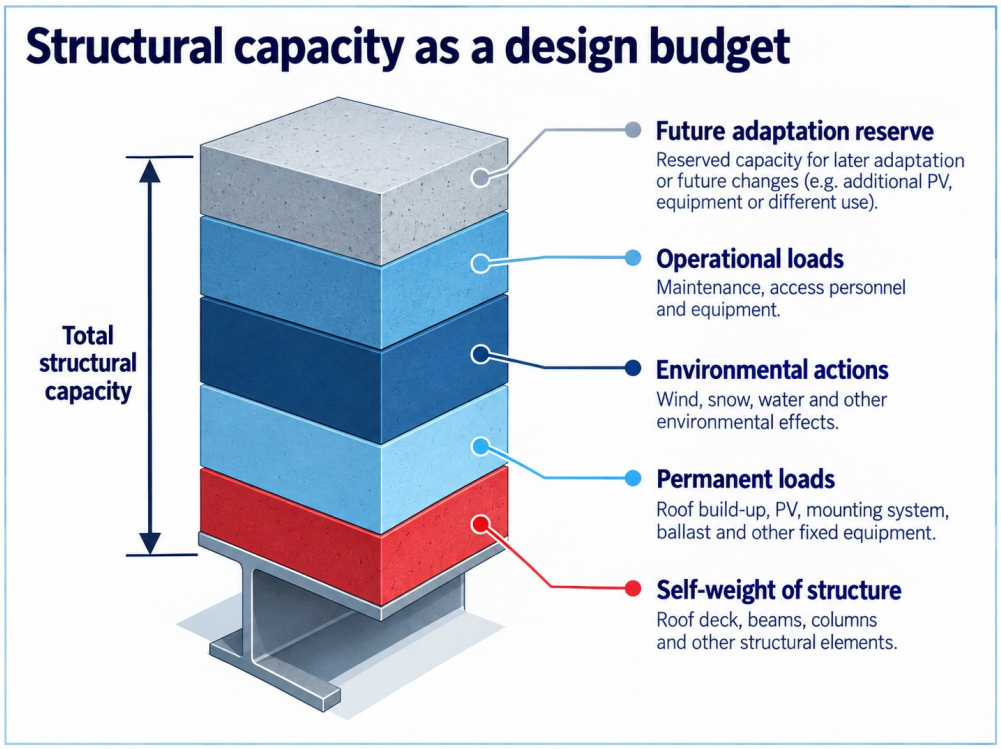
Define the weight and load budget

From structural check to structural budget

Once the required performance and design life are understood, the next question is structural. Traditional PV feasibility studies often ask whether the roof can carry the PV system. For a new building, that question is too late and too narrow. The better question is: how should the available structural capacity be allocated across the roof-PV system?

Structural capacity is a finite design budget. Part of that budget is consumed by the roof itself. Part may be required for fire protection. Part is required by PV modules, mounting systems, cables and other equipment. A ballasted mounting system may consume substantially more. The structure must then still accommodate relevant variable and environmental actions including maintenance loads, snow and possible water accumulation. Reserve capacity may also have value over the life of the building.

The objective should therefore not be to make every roof as light as technically possible. Nor should weight be considered only at the end of design. The objective is to achieve the required structural, fire, waterproofing and durability performance while consuming as little structural capacity as reasonably necessary.



Structural capacity is a finite design budget shared by permanent, environmental and operational demands.

Weight creates secondary effects

This matters particularly for large commercial roofs. PV arrays, especially ballasted systems, can add significant roof loading and the consequences can extend beyond the additional dead load itself. Structural deflection can affect drainage and promote rainwater pooling and the additional retained water then creates further load. Snow and ice can also accumulate differently around and beneath PV arrays and drifting snow may occur where the original roof geometry would not have produced the same pattern. [4]

These interactions make simple weight-per-square-metre comparisons inadequate.

Permanent loads

The permanent load budget includes the structural roof deck, vapour-control layers, insulation, protective or coverboard layers, waterproofing, PV mounting components, PV modules, cabling and permanent plant. Where ballast is proposed, its contribution should be visible from the beginning rather than appearing as a late solution to a wind-uplift problem.

This allows competing design choices to be compared while there is still freedom to change the roof structure, roof build-up or mounting principle.

Environmental actions

Wind, snow and water are not independent of the PV geometry. Panel orientation, tilt, spacing, height above the roof, edge zones and array configuration can change the forces acting on both the PV system and the roof. Snow can accumulate or drift around raised obstructions. Rainwater behaviour can change where structural deflection or rooftop equipment interferes with the intended drainage strategy.

This creates an important design rule: a change made to improve one performance characteristic must be checked for the effects it creates elsewhere in the system. A geometry selected to influence fire behaviour may change wind or snow loading. A heavier fire-protection strategy consumes structural capacity that may otherwise be available for PV or future use. Additional ballast intended to control uplift can affect deflection and drainage.

Operational loads

A roof with PV remains a working roof. Inspection, cleaning, membrane maintenance, replacement of equipment and access to drains and technical installations all create operational requirements. Those activities should be designed into the structural and roof concept rather than treated as exceptional events after completion.

The structure and roof layout should therefore accommodate not only the permanent PV installation but also the people and equipment required to maintain it safely throughout its life.

Preserve future capacity

Not every kilogram of available capacity needs to be consumed on day one. New equipment, replacement systems, technological changes or changes in building use may place new demands on the roof during its service life. Keeping reasonable structural reserve can therefore have economic and operational value.

This is particularly relevant where the expected life of the building exceeds that of individual rooftop systems.

Allocate before you optimise

This leads to the second principle I propose: structural capacity should not merely be checked. It should be allocated. For new construction, this is an opportunity. A project does not have to accept whatever residual structural capacity happens to remain after the building and roof have already been designed.

The roof build-up, fire strategy, mounting method and PV system can be developed together so that structural capacity is used deliberately. If mounting is considered only after the PV layout has been completed, ballast may become the easiest solution. If fire protection is added only after the roof build-up

has been selected, additional dead load may appear late. If ponding is considered only after structural deflection has been calculated, drainage may have to be redesigned.

By treating weight as a budget from the start, the project can compare those consequences before they become redesign problems. The result is not simply a roof strong enough to carry PV. It is a roof that uses its structural capacity intelligently.

3 Roof

Control combustible involvement and protect the assembly

Start with the complete roof build-up

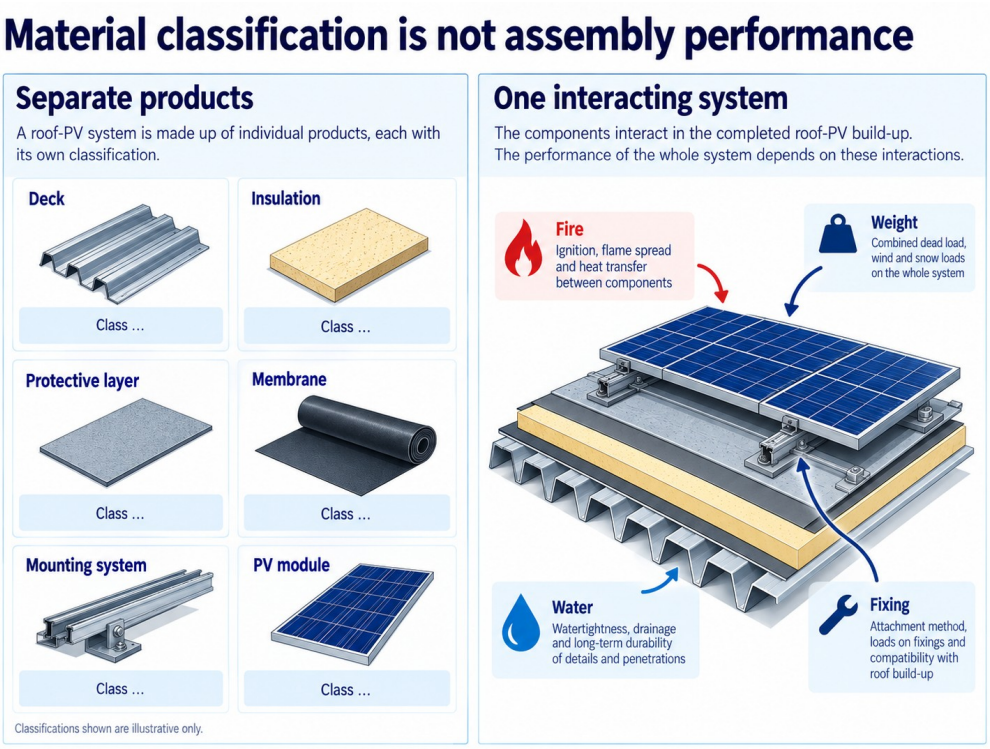
A new commercial roof intended for PV should be developed as a complete assembly. Combustibility is one variable alongside structural capacity, thermal performance, waterproofing, durability, cost and the known future presence of PV. Where combustible materials remain, the design should address whether and how they can become involved in the relevant fire scenario.

This leaves more than one legitimate design route: reduce combustible content, separate retained combustible components from the relevant exposure, or use another evidenced roof-PV strategy. The routes should be compared against the same project requirements rather than presented as a universal hierarchy.

Material classification is not assembly performance

Individual material classifications remain important, but they do not by themselves predict the behaviour of the complete roof beneath a PV array. Panel geometry, heat feedback, airflow, insulation, waterproofing, joints and other components interact, so assembly-level evidence is required where system performance is material to the project.

The same principle works in both directions: the classification of one component cannot substitute for evidence about the assembly, and the presence of a combustible insulation product does not by itself describe the behaviour of an assembly in which that material is effectively separated from the exposure. [5,10,12]



A roof-PV system should be designed as one interacting system rather than as a collection of separate products.

Embodied carbon belongs in the roof decision

If embodied carbon is a project objective, compare complete functionally equivalent roof systems using project-appropriate EPD/LCA evidence. Low mass, non-combustibility, thermal performance and low embodied carbon are different design objectives and should not be used as proxies for one another.

Design the build-up as one continuous system

The deck, vapour-control layer, insulation, protective or coverboard layer, waterproofing and critical interfaces should be developed as one coordinated roof system before the mounting principle and PV layout are finalised. Each layer influences the others. Insulation thickness affects dead load, detailing and roof height, a protective layer can affect fastening, joints and penetrations and the waterproofing membrane must remain compatible with the layers beneath it and with the eventual mounting system. The comparison should also consider handling, detailability, installation sequencing, membrane workflow and tolerance for normal structural movement.

Drainage depends on falls, structural deflection and the equipment subsequently placed on the roof. When these decisions are made independently, the final roof often becomes a stack of individually rational products rather than a deliberately engineered assembly. For new construction there is no need to accept that sequence. The build-up can be designed from the beginning around structural capacity, fire behaviour, waterproofing, thermal performance, durability and the known future presence of PV.

Protection depends on continuity

Where a protective layer forms part of the fire strategy, continuity at joints, penetrations, upstands, rooflights, smoke vents, parapets, drains and plant supports matters as much as the open roof area. These interfaces should be designed before they become construction-site improvisations.

Drainage and design life remain part of the roof strategy

Fire performance is not the only reason to resolve the roof before PV. Falls, outlets, emergency drainage and the roof's tolerance for ponding are part of the primary roof design and can all be influenced by the PV system placed above it. Ballast trays, rails, cable routes and rooftop equipment can interrupt intended drainage paths while additional dead load can create deflection and local low points. Maintenance access can also become difficult where panel fields extend too close to outlets, rooflights, continuous rooflights or other areas that require periodic inspection.

The design life of the roof belongs in the same discussion. A PV installation intended to operate for decades should not be placed over a new waterproofing system that is expected to require disruptive replacement substantially earlier without that consequence being recognised during design. Removing or temporarily dismantling PV to replace the roof underneath it can create significant cost, operational disruption and new technical risks. The objective is not necessarily to claim identical lifespans for every component but to plan interventions deliberately and understand which parts are expected to require replacement, how they can be accessed and whether those interventions can occur without dismantling large parts of the system.

Use assembly-level evidence where performance matters

Where fire performance is material to the project, the design should move from product assumptions to assembly-level evidence. FM Approvals Standards 4470 and 4478 illustrate this principle clearly. Approvals apply to defined roof and PV assemblies with specified combinations of waterproofing,

insulation, coverboards, fastening systems and PV components. The approval of the individual components is not interchangeable with approval of any arbitrary combination of those components. [9]

The same logic appears in experimental programmes where the complete deck, insulation, protective layers, membrane, mounting system and PV array are exposed together. This does not mean that every project requires a new fire test. It means that the designer should understand what has actually been demonstrated, the limits of that evidence and how closely the proposed roof resembles the tested or approved configuration.

Lightweight non-combustible protection as one design route

Where combustible components remain and additional dead load is constrained, a low-mass non-combustible protective layer can be one relevant route. Its suitability still depends on the complete roof-PV assembly, continuity, constructability, structural budget and evidence applicable to the intended configuration.

Three routes should be kept distinct. An inherently less combustible build-up, for example with non-combustible insulation, removes fuel from the roof construction. An added separation layer leaves combustible material in place but interrupts the downward pathway to it. A complete roof-PV system with formal evidence, such as an FM Approved RoofNav assembly, documents a defined combination as a whole. These routes answer different questions and are not interchangeable. For a new building, the practical decision is therefore which reference build-up the project will be designed around, before the PV layout and insurance conditions are fixed.

> **Is the complete roof build-up defined, including its fire strategy, protection continuity, drainage, design life and critical interfaces such as rooflights, smoke vents and penetrations?**

4 Mounting

Choose attachment before layout

Mounting is part of the roof design

Once the roof build-up has been resolved, the next decision is how the PV system will be physically connected to it. This should happen before the final PV layout is optimised because the mounting principle affects additional dead load, wind resistance, point loading, waterproofing, fire protection, maintenance, warranty conditions and future replacement. These are not consequences that can be efficiently resolved after panel positions have already been fixed.

Choosing mounting after layout effectively treats one of the main structural interfaces between roof and PV as a secondary PV decision. In reality it is part of the roof-PV system itself and should therefore be selected with reference to the decisions already made about structure, roof build-up and fire strategy.

Compare attachment strategies as system choices

Commercial rooftop PV systems generally use combinations of three broad approaches: ballast, mechanical attachment and membrane-integrated or bonded attachment. A ballasted system avoids direct penetrations through the waterproofing but consumes structural capacity through additional dead load. The amount and distribution of ballast depend on factors including wind conditions, roof zones, array geometry and mounting-system design.

Mechanical attachment can substantially reduce ballast but transfers forces into the structure through discrete fastening points. Penetrations must be detailed and sealed correctly and they must remain compatible with the waterproofing and fire-protection strategy. Membrane-integrated or bonded systems can reduce both ballast and structural penetrations but depend heavily on compatibility between the mounting solution, waterproofing membrane and underlying roof assembly. No approach is universally preferable. The correct choice depends on the structural budget, roof build-up, fire protection, wind, water and design life already established.

Total weight is only part of the structural question

A mounting system should not be assessed only by its average weight per square metre because load distribution matters just as much as total mass. A roof can have sufficient capacity for the total additional load while still being unsuitable for concentrated loads at particular support or fixing locations. Ballast blocks, rails and mechanical anchors can create very different load paths through the roof build-up and deck.

The same applies to deflection. A change in load distribution can affect roof falls and drainage even when the total added weight remains within the overall structural capacity. The mounting strategy therefore needs to be considered together with the structural design rather than treated as a product-specific calculation carried out after the main building structure has already been fixed.

Wind resistance depends on geometry

Wind uplift is also a system property. Panel height above the roof, inclination, orientation, row spacing, roof height and position relative to edges and corners all affect the aerodynamic forces acting on the array. A mounting strategy demonstrated for one geometry cannot automatically be assumed to perform identically after the PV layout is changed.

This creates another sequencing problem. If the PV designer optimises array geometry first and mounting is selected afterwards, wind resistance may need to be achieved with additional ballast, additional fixings or reductions in usable panel area. Selecting the attachment principle earlier allows the PV layout to develop within known structural and aerodynamic boundaries.

Mounting must respect waterproofing and fire protection

The attachment strategy has to be compatible with the waterproofing system. Mechanical penetration requires durable detailing around each fixing, membrane-integrated systems require verified material compatibility and ballasted systems still place supports, protection layers and concentrated loads on the membrane surface. None of these approaches is neutral to the roof.

The waterproofing manufacturer should therefore be involved before the attachment strategy is finalised. Warranty conditions, approved accessories and installation requirements should be understood at design stage rather than discovered once the mounting system has already been procured. The same applies to fire protection. Where the roof uses a non-combustible protective layer to separate combustible materials from a PV fire, mechanical fixings, penetrations and support details must not create uncontrolled routes through that protection.

Consider future access and replacement

The mounting strategy also determines how easily parts of the roof and PV system can later be accessed, repaired, replaced or modified. Modules fail, cables require replacement, waterproofing needs inspection, drains need cleaning and rooftop plant can change. Rooflights, continuous rooflights and smoke-control equipment may also require replacement or maintenance during the life of the PV installation.

The initial mounting choice can either make those interventions manageable or turn them into expensive dismantling exercises. This connects mounting directly back to the asset and design-life decisions made at the start of the process.

Layout can now become an optimisation exercise

Only once the mounting principle is compatible with the structural budget, roof build-up, waterproofing, fire strategy and manufacturer requirements does the PV layout have a stable foundation. At that point layout can genuinely be optimised for generation, access and maintainability without that optimisation silently undermining decisions made earlier.

The objective of this sequence is not to restrict the PV designer unnecessarily. It is to give the PV designer reliable boundaries within which optimisation will remain valid.

> **Is the mounting principle compatible with the structural budget, roof build-up, waterproofing, fire strategy, wind design and warranty requirements?**

5 Risk

Prevent ignition and limit consequences

Fire risk has two variables

Once the roof build-up and mounting strategy have been established, the fire-risk question can be addressed more completely. Risk is influenced by both the probability of an event and the consequences if that event occurs. Much of PV safety correctly focuses on reducing the probability of ignition through product quality, electrical design, connector compatibility, installation workmanship, commissioning, monitoring, inspection and maintenance.

A wide range of measures can help reduce ignition probability or identify developing faults before they escalate. These include component and connector quality control, electrical protection and isolation, system monitoring, fault detection, thermal inspection, commissioning, periodic testing and preventive maintenance. Their applicability and effectiveness vary by system and technology and they should be selected as part of the electrical and operational safety strategy. My purpose here is not to rank those measures. It is to recognise that even a well-designed combination of preventive measures leaves a residual possibility of ignition that the building design still needs to address. [5]

Evidence from operational PV systems reinforces that point. In an international audit programme covering more than 600 commercial rooftop PV systems, major safety concerns were identified in 97% of the systems inspected. The issues included grounding defects, damaged modules, mismatched connectors, poor terminations and hotspots. Not every defect represents an ignition event but several can increase the probability of one. [6]

The relevant lesson is therefore not that 97% of all PV systems are unsafe. The audited systems are not a statistical representation of every commercial installation. The conclusion I consider more defensible is that even mature technologies installed within established standards continue to exhibit defects capable of increasing ignition risk. Good design and maintenance reduce that probability but they do not justify designing the building as though ignition cannot occur.

Consequence limitation is the second line of defence

Once ignition is considered possible, the next question is what happens after it occurs. The incident may remain local to a component or module or the waterproofing and underlying roof layers may become involved. The geometry beneath the panels can increase heat feedback and flame spread and a local incident can potentially move across larger continuous PV fields, towards combustible roof details or towards interruptions in the roof such as rooflights, continuous rooflights and smoke vents.

These are questions of consequence rather than ignition and the roof becomes one of the principal passive systems available to influence those consequences. Unlike monitoring, isolation devices or human intervention, passive roof protection does not need to detect the event or receive power before it begins to perform its function. That independence gives it a different role from electrical prevention measures.

A robust fire strategy therefore contains two complementary layers. Ignition prevention addresses electrical design, equipment quality, connectors, installation, inspection, commissioning, monitoring and maintenance. Consequence limitation addresses roof combustibility, non-combustible protection, assembly behaviour, PV geometry, field segmentation, roof openings, access and the ability of an incident to propagate into a larger property loss.

The second layer should not be used to excuse poor electrical design and the first should not be used to justify ignoring the roof beneath the panels. Ignition probability can be reduced but not assumed to be zero, so the roof must also be designed to limit escalation when prevention fails.

Geometry changes fire behaviour

PV modules do not merely add components to a roof. They also alter the geometry of the fire environment. Experimental research has shown that the cavity between module and roof can influence flame orientation, heat feedback and flame-spread behaviour. In specific experimental configurations, relatively small changes in gap height produced very large differences in flame-spread rate and research by Kristensen reported increases of up to approximately 38 times the reference condition in particular tests. [7,8]

Those values should not be converted into universal installation dimensions because the critical gaps observed were specific to the tested panel geometry, roof surface, inclination and fire scenario. The design lesson is therefore not that there is one correct minimum gap but that PV geometry itself is a fire variable. Any geometric change made for fire reasons must also be checked against its effects on wind, snow and structural performance.

Avoid transferring risk elsewhere

This leads to a broader rule that applies throughout the roof-PV system. Every mitigation measure should be checked for the risks it creates elsewhere. Raising modules may alter fire behaviour but can also change wind and snow loading. Additional ballast can resist uplift while consuming structural capacity and affecting drainage. More electrical protection can reduce some failure modes while introducing additional components, connectors or maintenance requirements.

Risk reduction should therefore not be assessed within one discipline only. A measure is successful only when the overall system risk is reduced rather than transferred from one part of the design to another.

Passive protection increases robustness

In my analysis, passive protection is particularly valuable because it can remain effective when other systems fail. An electrical protection strategy may depend on correct installation, intact sensors, power, software, communication or human intervention. A non-combustible layer or appropriately designed roof assembly has a different failure logic. It can still be compromised by joints, penetrations, damage or poor installation but it does not depend on active detection or response before it begins to function.

Combining preventive electrical measures with independent passive consequence limitation therefore reduces reliance on any single safety mechanism. This is the practical value of applying risk-model thinking without turning the whitepaper into a theoretical discussion of individual risk models.

> **If ignition occurs despite preventive measures, how does the roof-PV design limit the consequences and which independent protective layers remain effective?**

6 PV

Define the safe usable roof area

The full roof is not the PV area

Once the asset requirements, structural budget, roof build-up, mounting principle and fire strategy are understood, the project can finally answer the question that is often asked first: where should the PV modules go? The answer should not automatically be every location where a module physically fits because the gross roof area and the safe usable PV area are different quantities.

Part of the roof has other functions that must remain available throughout the life of the building. The PV designer should therefore optimise within the safe usable area defined by the roof rather than forcing drainage, maintenance, rooflights, continuous rooflights, technical installations and emergency access around a maximum-energy layout.

Protect drainage and building services first

Drains, gutters, emergency overflows and the routes by which water reaches them need permanent access and sufficient clear space to remain inspectable and maintainable. A PV layout that makes drainage inaccessible creates a roof-maintenance problem even if it does not physically block an outlet on day one. Leaves, debris and maintenance activities are normal parts of roof operation and the drainage strategy should therefore define exclusion and access zones before the final module field is drawn.

Rooflights including dome and continuous rooflights, smoke-control equipment, HVAC units, penetrations and other rooftop plant also need functional space around them. The required clearance is not always determined by one universal dimension because it can depend on the fire strategy, equipment manufacturer requirements, maintenance access, daylighting function, smoke-control performance and local regulation.

Rooflights and continuous rooflights should therefore be treated as primary roof functions rather than obstacles to be worked around after the PV layout has been optimised. Their daylighting, ventilation or smoke-control function, inspection requirements and eventual replacement need to remain possible throughout the life of the building. The PV layout must not compromise those functions or make their maintenance dependent on dismantling substantial parts of the PV array.

Provide real maintenance and emergency access

RC62 requires safe and unobstructed access for servicing, maintenance, cleaning and firefighting but does not prescribe one universal walkway width for every commercial roof. [4] Access should therefore be designed around the actual roof, equipment and maintenance strategy rather than by copying a generic dimension from another project.

The resulting routes must allow people to reach critical equipment, drains, rooflights, continuous rooflights, smoke vents and other serviceable roof elements without stepping over cables, climbing across modules or dismantling the array. They should also remain useful after years of minor modifications and replacements. Fire-service access should be treated in the same way. The objective is not to design the entire roof around a theoretical firefighting scenario but to avoid creating a panel field so dense that emergency access becomes practically impossible.

Think in fields rather than one continuous array

Very high panel density may maximise installed capacity but can make inspection, maintenance and emergency intervention more difficult. Dividing the installation into logical fields can preserve access to parts of the roof and create clearer separation between PV zones, building services, roof openings and critical roof details.

This is particularly relevant where long continuous rooflights divide an industrial roof into natural zones. Rather than treating the continuous rooflight as an inconvenience around which panels should be packed as tightly as possible, the roof layout can use these existing architectural elements as part of a deliberate zoning strategy. That does not mean that every continuous rooflight automatically becomes a fire break. Its construction, materials and surrounding detailing still need to be understood as part of the complete roof and fire strategy.

Field separation should therefore not be reduced to one universal fire-break dimension. Appropriate separation depends on the roof configuration, fire strategy, compartmentation, applicable guidance and insurer requirements. The important principle is that layout should support the risk strategy rather than undermine it.

Cable routing belongs in the layout

DC and AC cable routes are another example of infrastructure that should be designed rather than added after panel positions are fixed. Cables need protection from mechanical damage, water and inappropriate contact with the roof surface. Connectors should remain inspectable and cable routes should avoid creating obstacles across maintenance paths or drainage zones.

Cable routing also needs coordination around rooflights, continuous rooflights, smoke vents and other openings. Routes that appear efficient on a PV drawing can interfere with the inspection, opening or replacement of roof components once the system is built. Electrical design therefore influences physical layout and reinforces the same sequencing principle seen throughout the paper: the final module arrangement is the result of multiple resolved constraints, not the starting point from which those constraints are negotiated backwards.

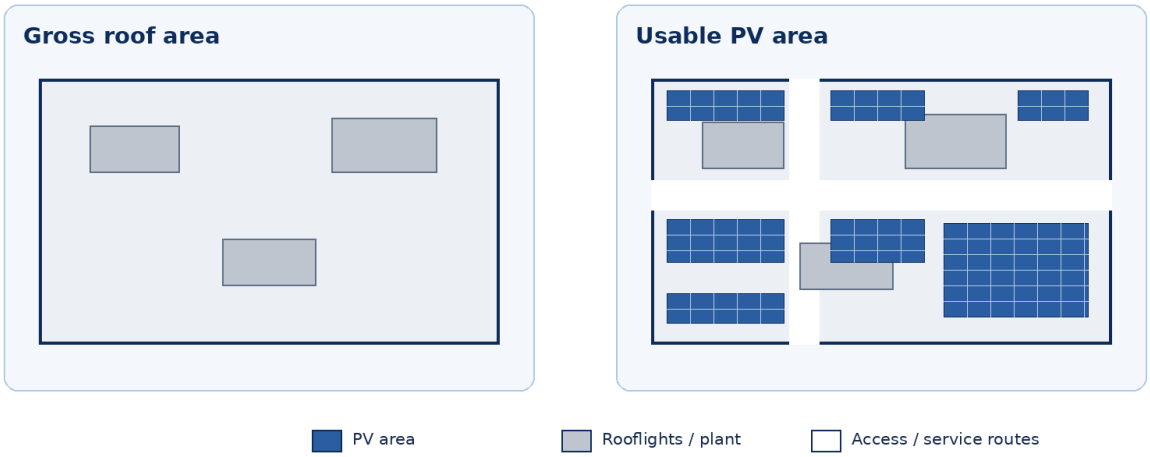
Optimise generation inside the safe envelope

None of this means that energy yield is unimportant. The purpose of rooftop PV is to produce electricity and efficient use of valuable roof area matters. Optimisation should, however, occur within an envelope defined by structural capacity, roof performance, fire strategy, mounting, access, roof openings and building operation.

The more useful design question is therefore not how many panels can fit on the roof but what maximum useful PV capacity can be installed without compromising the roof's other required functions. That creates a fundamentally different design brief and one that is much more consistent with treating roof and PV as one system.

From gross roof area to usable PV area

Define roof functions and constraints before optimising the PV layout.



Gross area is a geometric input. Usable PV area is the output after roof functions and constraints are protected.

Gross roof area is not the same as usable PV area. The layout should work around roof functions, access and technical constraints.

Has the safe usable roof area been defined after accounting for drainage, rooflights, smoke vents, building services, maintenance, fire strategy, emergency access, cable routing and all earlier structural and roof constraints?

7 Evidence

Prove the complete assembly

Evidence must match the design question

Once the roof-PV system has been designed, the next question is not whether individual products have certificates. It is whether the evidence available actually supports the performance being claimed for the proposed configuration.

This distinction is important because different forms of evidence answer different questions. A reaction-to-fire classification may describe one material. A wind-uplift test may address a mounting system under defined conditions. A roof classification may apply to a particular build-up without PV. None of these automatically demonstrates how the complete roof, mounting system and PV array will behave together under the conditions relevant to the project.

Classification terminology also needs to be kept scheme-specific. A Class A roof classification and an FM Approved Class 1A roof designation are not interchangeable labels; each belongs to its own test and approval context and should be cited only within that context.

The evidence strategy should therefore start with the required performance and work backwards. For each critical claim, the project should identify what has been tested or approved, which components were included, how they were assembled, which loads or fire scenarios were applied and which limitations define the field of application.

Approved components do not automatically create an approved system

This principle is particularly clear in FM Approvals. FM 4470 and FM 4478 do not simply provide a collection of independently approved products that can be combined freely. Approval is linked to defined assemblies and those assemblies are listed in RoofNav with specified roof covers, insulation, coverboards, fastening systems, PV modules and mounting arrangements. [9]

For new construction this is also an opportunity. A project can often be designed directly around a complete FM Approved RoofNav assembly. At FM-insured locations it still goes through plan review, but the assembly itself does not need to be re-engineered or re-tested. Substituting one component, however, does not make the new combination FM Approved.

A project that substitutes one of those elements cannot automatically assume that the approval remains unchanged. The replacement product may itself be FM Approved, but that does not establish that the new combination has the same approved performance as the listed assembly.

This is the difference between asking whether every component is approved and asking whether this complete configuration is supported by the relevant approval.

Understand what the test actually demonstrated

Assembly-level evidence also needs to be read carefully. A successful test does not prove every possible characteristic of every variation of the system. It demonstrates defined performance under defined test conditions.

The project team should therefore understand the scope behind the headline result. Which roof build-up was tested? What deck and insulation were used? Which membrane and attachment method were included? Was PV part of the test configuration? What slope, fixing arrangement or panel geometry

applied? Were some performance requirements demonstrated through earlier testing rather than repeated in the current programme?

These details are not technical fine print. They define the boundary between evidence and assumption. A test report is most useful when it is used to identify that boundary clearly rather than being reduced to a logo or a single pass/fail statement.

Evidence has a field of application

No practical project will match every test specimen in every detail. The task is therefore not to demand an identical test for every building but to understand how far the available evidence can reasonably be applied.

Some differences may have no meaningful effect on the performance being considered. Others can change the system fundamentally. Changing insulation type, waterproofing, fastening, coverboard continuity, mounting geometry or PV securement can affect fire, wind or structural behaviour depending on the claim being made.

Not every deviation requires a new fire or wind test. Where a technically justified engineering assessment, written manufacturer acceptance, certification-body judgement or other competent evaluation demonstrates that the variation remains within an acceptable field of application, the existing evidence can remain useful. What matters is that the deviation is recognised and assessed rather than silently assumed to be equivalent. [9]

The closer the proposed configuration is to the proven assembly, the smaller the number of unsupported assumptions. Where significant deviations are necessary, those deviations should be assessed explicitly rather than disappearing into the specification unnoticed. Every material deviation from the evidence base should therefore have an identified technical justification and an owner responsible for accepting it.

Evidence should survive procurement

A design can be well supported during specification and still lose that support during procurement. Product substitutions are common when contractors seek alternatives because of price, availability or programme pressure. A membrane may change, a fixing may be replaced, insulation may come from another supplier or a mounting component may be substituted for a nominally equivalent product.

From a procurement perspective these changes may appear minor. From an assembly-performance perspective they may not be. The evidence basis should therefore be visible in the procurement documents. Where a particular combination is required to support a fire, wind, waterproofing or warranty claim, the specification should make clear which elements are fixed and which may be substituted subject to technical review.

Value engineering should not become evidence engineering by accident.

Environmental evidence has boundaries too

Where environmental claims influence the decision, they should be traceable to project-appropriate EPD/LCA evidence and a comparable functional basis.

Application example : reading product evidence within its boundaries

AllShield BarrierSheet is used here only as an example of how product evidence should be read.

FM Approval Report PR472014 identifies BarrierSheet within a defined RoofNav roof-PV assembly with specified roof covering, securement, FM Approved insulation, PV modules, PV mounting and a steel deck. [9] The approval supports that defined configuration and its conditions; it does not establish generic approval for arbitrary roof-PV combinations or substitutions. The programme uses previous test data and waivers, including the FM 4478 external-fire requirement; PR472014 does not document a new fire test with PV (PR472014, §3.2, Table 1).

Separate ZAG, Efectis and Kiwa-BDA programmes provide additional evidence for their own tested configurations. Efectis classification report R000983 covers the stated PVC build-up with BarrierSheet above and below PIR, within its defined field of application [C1], while the FM listing covers a single-layer assembly with a TPO roof cover on a new steel deck; evidence for one reference build-up does not transfer to the other. ZAG concluded that direct flame penetration into deeper layers was prevented in its tested configurations, while heat damage below the sheet and localised burn-through in two runs were also recorded. Kiwa-BDA tested an earlier 1.2 mm product. These results should be read within their own specimen, thickness and test boundaries rather than combined into a broader universal claim. [9][10][11][12] The classification is specific to that construction and its permitted variations; the number of layers remains as tested. For the national role of methods t1–t4, see What does a fire test actually prove?, Chapter 8.

The principle is the same for any product: identify what was actually demonstrated, the configuration to which it applies and any deviation that requires additional technical acceptance.

Evidence should be traceable

The project should retain the documents that support critical design decisions rather than relying on web links, marketing summaries or the recollection of individual consultants. Test reports, classifications, RoofNav listings, manufacturer approvals, calculations, drawings and written technical acceptances should form part of the project record.

This becomes increasingly important as the building moves from design to construction and later into operation. Years after completion, the original designer may no longer be involved and individual products may have changed. The evidence package should allow a future owner, insurer, contractor or engineer to understand why the system was designed as it was and what assumptions must be preserved when changes are made.

The objective is not more paperwork for its own sake. It is to ensure that the design intent remains verifiable.

Can the project identify the evidence supporting each critical system claim, the configurations to which it applies and the deviations that require additional technical acceptance?

8 Approval

Close the interfaces before construction

Technical design does not equal accepted design

A technically coherent roof-PV system can still fail as a project if the parties responsible for individual parts of the system have not accepted the interfaces between them. The membrane manufacturer may accept the roof build-up but not the selected mounting detail. The mounting supplier may have calculated wind resistance on assumptions that differ from the structural engineer's final design. A fire engineer may rely on a protective layer whose continuity is later altered by penetrations. An insurer may apply property-protection requirements that go beyond statutory compliance.

These issues are much easier to resolve on drawings than on a completed roof. Approval should therefore be treated as a design phase rather than as an administrative check at the end of procurement.

Different parties approve different things

There is no single approval that resolves every aspect of a commercial roof with PV. Building control or the relevant authority addresses regulatory compliance within its remit. Manufacturers determine whether the proposed use is compatible with their products and warranties. Structural engineers accept load paths and structural performance. Fire engineers assess the fire strategy. Insurers or risk engineers may impose separate requirements for property protection and insurability.

These forms of acceptance should not be confused with one another. Regulatory compliance does not automatically guarantee insurer acceptance and insurer acceptance does not replace regulatory compliance. Both paths need to be addressed deliberately. [4]

A manufacturer's product warranty does not demonstrate the fire performance of the complete roof-PV system and an FM Approved assembly only carries its defined meaning when it is used within the conditions of that approval. The project therefore needs to know which party is responsible for each decision and what form of evidence that party requires.

Close manufacturer interfaces early

The most common unresolved interfaces sit between products supplied by different manufacturers. Waterproofing, insulation, protective layers, fasteners and PV mounting may all come from different companies, each with its own technical requirements and warranty conditions.

These interfaces should be closed before construction. The membrane manufacturer should confirm that the proposed substrate, coverboard, attachment and mounting strategy are compatible with the waterproofing system. The mounting supplier should work from the same roof geometry, structural assumptions and membrane specification used by the rest of the design team. Where a protective layer forms part of the fire strategy, its manufacturer and installer should understand how penetrations, joints and interfaces are to be treated.

Written confirmation is preferable to assumptions based on previous projects or general product literature.

Bring the insurer into the design process

Insurer involvement should also occur before the design is frozen. RC62 makes clear that individual insurers may have requirements that differ from the guidance and from one another. [4] A system that

meets statutory requirements may therefore still encounter additional conditions before property cover is offered on acceptable terms.

For a new commercial building, discovering those requirements after the roof has been built is avoidable. Insurer or risk-engineering input can influence roof combustibility, fire separation, array segmentation, access, electrical protection or evidence requirements while those decisions are still relatively inexpensive to change.

Insurability should not become the sole design objective. The primary objective remains protection of the asset, its function and business continuity. But insurer acceptance is an important project gate because it tests whether the proposed risk strategy is acceptable to a party that may ultimately carry part of the financial consequence of failure.

Someone must own the complete system

The fragmentation of responsibilities is itself a design risk. A structural engineer can correctly calculate the roof, a roofing contractor can correctly install the membrane and a PV contractor can correctly install the electrical system while nobody is explicitly responsible for confirming that the complete roof-PV system still matches the intended design.

The project should therefore define responsibility across the interfaces, not only within each discipline. A simple responsibility matrix can identify who specifies, calculates, approves, supplies, installs and verifies each critical element. It should also identify who has authority to accept deviations.

This is particularly important where one decision affects several disciplines, such as a change in mounting geometry that alters ballast, wind loading, drainage, fire behaviour and maintenance access simultaneously. Someone must be able to say whether the complete system remains acceptable after that change.

Freeze the critical interfaces before construction

Not every detail needs to be immovable before work starts. Construction always requires normal coordination and controlled adjustment. The critical system interfaces, however, should no longer be unresolved.

The project should have an agreed roof build-up, mounting principle, PV geometry, drainage strategy, fire-protection concept and evidence basis. Manufacturer compatibility and warranty conditions should be understood. Insurer requirements should be known where relevant and the parties responsible for inspection and commissioning should already be identified.

Any subsequent change to those critical elements should follow a defined change-control process rather than being treated as an ordinary site substitution. The objective is simple: the system that reaches the construction site should be the system that was actually assessed.

Approval creates the basis for delivery

Closing these interfaces also creates a clear reference against which construction can later be inspected. Without an approved design baseline, it is difficult to distinguish an acceptable site adjustment from a deviation that undermines performance.

That is why approval comes before delivery in the decision sequence. The next stage is not to continue designing through installation. It is to verify that the approved system is actually built.

From evidence to project acceptance

Claims, evidence, scope and acceptance are different questions.

1

Claim

What performance is being claimed?

Define the system-level statement that matters to the project.

2

Evidence

What was actually demonstrated?

Identify tests, classifications, listings or approvals and the configuration evaluated.

3

Scope

Does it apply to this configuration?

Compare membrane, insulation, deck, mounting, PV, geometry and other relevant conditions.

4

Acceptance

Who must accept the project-specific use?

Close code, manufacturer, insurer, warranty and professional interfaces before construction.

Evidence informs acceptance; it does not replace professional judgement or project-specific review.

Evidence informs assessment and acceptance; it does not replace professional judgement or project-specific review.

> **Have the critical roof-PV interfaces been accepted by the responsible parties, with manufacturer, insurer and change-control requirements resolved before construction?**

Investment milestone

Confirm the whole-life project and asset case before delivery

By Gate 8, the project should know what roof-PV system it intends to build, what structural and fire strategy it relies on, what evidence supports it and what acceptance conditions have been imposed by manufacturers, authorities, insurers and other responsible parties.

That is the point at which the project case should be rebuilt using the real design rather than the assumptions used at concept stage. Relevant inputs can include roof and structural CAPEX, PV and mounting CAPEX, energy yield, testing and approval costs, insurance conditions, maintenance, replacement cycles, whole-life carbon where relevant to the brief, operational disruption, adaptability and future roof access.

For developer-led projects, the milestone should also test the transfer of value and risk. The party paying construction CAPEX may not be the party carrying future OPEX, insurance, maintenance or replacement costs. The final design should therefore be reviewed not only for initial cost but also for insurability, marketability, financing constraints and whole-life value to the future owner or operator.

This does not imply that every more robust design creates a higher sale value or that every insurer will price risk in the same way. It means that material design conditions that can affect future acceptance or operating cost should be visible before construction is committed.

> **Now that the complete roof-PV configuration and acceptance conditions are known, does the final design still create sufficient whole-life value for the project and the future asset?**

9 Delivery

Build what was designed

Performance depends on what is actually built

By the time construction starts, the principal roof-PV decisions should already be fixed. Delivery is the process of verifying that the installed system remains consistent with the accepted structural, roof, mounting, PV, evidence and interface decisions.

Inspect before critical details disappear

Inspection should use hold points before critical roof-PV details become concealed or inaccessible. RC62 makes the same point for PV systems: once modules are positioned, full inspection becomes more difficult. [4]

Control substitutions during procurement and construction

Substitutions require formal review where assembly-level evidence, warranty or compatibility depends on the specified combination. A replacement may be suitable in isolation while changing the basis of the complete system.

Protect the interfaces during installation

Roofers, mounting installers, electricians and mechanical contractors share the same roof. Traffic, fixings, penetrations, cable routes or later plant can damage waterproofing, interrupt protective layers or obstruct drainage and access, so the interfaces require active coordination.

Interface responsibility and warranty continuity

Interface responsibility should be agreed before work starts. The project should define who records the pre-installation roof condition, who is responsible for membrane or protective-layer damage caused during PV works, which repairs require approval by the roof-system provider and what evidence is required to preserve or reinstate warranty coverage.

Without that allocation, later defects can become disputes between roofing, PV and other contractors rather than managed building defects. The construction documents should therefore make damage attribution, repair authority and close-out responsibility visible before the trades arrive on the roof.

Commission the system against the design

Commissioning should confirm not only electrical performance but also that module fields, access routes, mounting geometry, drainage clearances, cable routes and critical roof openings match the accepted design. Material deviations should be assessed rather than merely recorded.

Record the hidden system

The handover record should preserve the final roof build-up, mounting principle, relevant evidence and approvals, critical details, accepted deviations, commissioning results and useful photographic records of concealed interfaces.

Handover transfers the design intent

Handover transfers responsibility for preserving the system to the owner and future operators. They should understand which interfaces are critical, which areas must remain accessible and which later changes require technical review.

Has the installed roof-PV system been inspected at the appropriate stages, have critical deviations been technically accepted and does the as-built record accurately describe what was actually constructed and handed over?

10 Lifecycle

Preserve the design intent

Completion is the beginning of the operational phase

A roof-PV system will change over its service life. Modules, electrical components, roofing and rooftop plant may be repaired, replaced or extended, and changes in use can introduce new requirements. Lifecycle management therefore has to preserve the assumptions on which the accepted system was based.

Inspection keeps the system visible

Periodic inspection should cover both PV and roof condition: waterproofing, drainage, ponding, mounting supports, penetrations, protective details, cable routes, rooflights, smoke vents and access zones. The purpose is to identify changes that may invalidate the original assumptions. [4]

Maintenance must include both roof and PV

Roof and PV maintenance are often procured separately but physically share the same system. The maintenance plan should define how access, temporary module removal and work around drains, rooflights, membranes and protective layers are coordinated.

Lifecycle responsibility must remain explicit

Roof and PV maintenance contracts should define responsibility for access, temporary module removal, membrane damage, penetrations, reinstatement, warranty-sensitive repairs and defect close-out. Pre-maintenance condition records can provide a practical baseline for damage attribution where different contractors access the roof.

Control change throughout the building life

Material changes should be checked against the original structural, waterproofing, fire, electrical and evidence requirements before implementation. The building need not be frozen, but change should be managed rather than accumulated.

Use the original evidence as the reference point

The evidence package should remain with the asset so future owners and contractors can compare proposed changes with the original accepted configuration.

Reassess when the system materially changes

Routine work does not require reopening the full design, but review becomes important when geometry, ballast, penetrations, cable routes, critical roof layers, smoke-control systems, rooftop plant, building use or PV extent changes materially.

Coordinate replacement cycles

Roof and PV components have different replacement cycles. Those cycles should be planned so that roof renewal, PV replacement and temporary removal can be coordinated rather than discovered as separate emergency projects.

Preserve rather than assume resilience

A robust roof-PV system is preserved through inspection, maintenance, controlled modification and retention of the information needed to understand its design.

Does the roof-PV system still operate within the structural, waterproofing, fire and electrical assumptions of the approved design, with material changes assessed before implementation?

Conclusion: the roof comes first

Rooftop PV is increasingly becoming part of the design brief for new commercial buildings. That changes the order in which decisions should be made. If PV is known from the beginning to be part of the building, it should no longer be treated as equipment that is added to a completed roof. The roof and PV installation should be designed as one system.

In my view, the central design challenge is not simply to maximise generation or to prove that individual products comply with relevant standards. It is to create a roof that can support the PV system throughout its intended life while protecting the building, using structural capacity intelligently, managing water, limiting combustible involvement, maintaining access and remaining maintainable, acceptable to relevant project-risk requirements and transferable as an asset.

That requires decisions to be made in the right sequence. First, the project must understand what the building needs to protect and what the consequences of failure would be. Structural capacity can then be treated as a budget to be allocated rather than as a final pass-or-fail check. The roof build-up should minimise combustible content and limit the involvement of unavoidable combustible layers in a PV-related fire. Mounting should be selected in relation to that roof and its structural budget before the final PV layout is optimised.

Ignition prevention remains essential but it cannot reasonably be assumed to eliminate ignition entirely. Monitoring, inspection, fault detection, electrical protection and maintenance can all reduce the probability of an incident. In the proposed framework, the roof should also provide consequence limitation when prevention fails. Only after those boundaries are understood should the safe usable PV area be defined.

The design process does not end there. Critical performance claims need evidence that is relevant to the complete assembly rather than only to its individual components. Manufacturers, engineers, insurers and other responsible parties need to close the interfaces before construction. The Investment milestone then tests whether the accepted configuration still creates sufficient whole-life value before Delivery begins. Delivery has to preserve the approved design and lifecycle management has to preserve its assumptions as the building changes over time.

Three principles

The roof comes first. The physical, structural, fire-safety and lifecycle boundaries of the roof should be established before the energy system is optimised.

Structural capacity is a budget, not merely a calculation. Every kilogram added to the roof consumes capacity that may also be needed for PV, environmental actions, maintenance or future adaptation.

Prevent ignition, but design for what happens when prevention fails. Electrical and operational safety measures reduce the probability of fire. Roof build-up and detailing can materially influence escalation alongside the fire exposure, PV configuration, other safeguards and response.

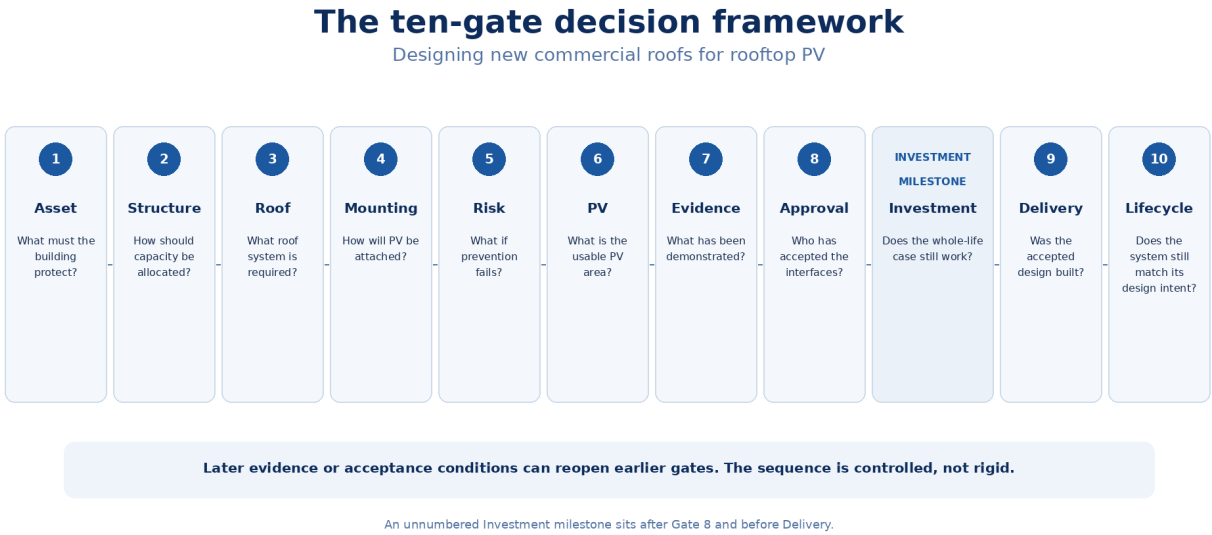
A well-designed PV-ready roof is therefore not simply a roof that can carry solar panels. It is a durable, structurally efficient and fire-robust platform designed from the beginning to work with the PV system above it.

I would summarise the objective in one design principle: a new commercial roof intended for PV should consume as little structural capacity as reasonably necessary, minimise combustible content, limit the involvement of unavoidable combustible layers in a PV fire and provide a durable platform for the PV system throughout its intended life.

That outcome is difficult to achieve when the building is designed first, the roof second and PV last. It becomes achievable when the sequence changes. The roof comes first.

The ten-gate decision framework

The framework below is intended as a practical sequence for project teams designing new commercial buildings where rooftop PV forms part of the brief. The ten numbered gates remain unchanged; an unnumbered Investment milestone sits after Gate 8, once the design and acceptance conditions are known and before Delivery is committed.



> **After Gate 8: Investment milestone : confirm the final whole-life project and asset case before Delivery.**

1. Asset: define what the building must protect

Establish the use of the building, the value and sensitivity of the activities below the roof, the consequences of downtime, the required design life and any insurer or property-protection expectations.

Decision: What performance does this asset actually require?

2. Structure: define the weight and load budget

Allocate structural capacity across the roof build-up, fire protection, PV modules, mounting system, ballast where applicable, environmental actions, maintenance and future reserve.

Decision: How much structural capacity can each part of the roof-PV system consume?

3. Roof: control combustible involvement and protect the assembly

Define the complete roof build-up, including deck, insulation, protective layers, waterproofing, drainage and critical interfaces. Minimise combustible content where practicable and protect necessary combustible materials from meaningful involvement in a PV-related fire.

Decision: Does the roof provide the required waterproofing, durability and passive fire strategy before PV is added?

4. Mounting: choose attachment before layout

Select the mounting principle in relation to the structural budget, wind conditions, waterproofing, fire strategy and warranty requirements.

Decision: How can PV be attached without undermining the roof decisions already made?

5. Risk: prevent ignition and limit consequences

Combine electrical and operational prevention measures with independent passive consequence limitation.

Decision: If prevention fails, what stops a local incident becoming a major property loss?

6. PV: define the safe usable roof area

Determine the part of the roof genuinely available for PV after accounting for drainage, rooflights, smoke vents, rooftop plant, maintenance, emergency access, cable routes and earlier constraints.

Decision: What is the maximum useful PV area that does not compromise the roof's other functions?

7. Evidence: prove the complete assembly

Identify the evidence supporting critical system claims and understand its field of application.

Decision: What has actually been demonstrated and how closely does the proposed system match that evidence?

8. Approval: close the interfaces before construction

Obtain the necessary technical and commercial acceptance from manufacturers, engineers, insurers and other responsible parties.

Decision: Has every critical interface been accepted by the party responsible for it?

Investment milestone

Rebuild the project and asset case using the accepted roof-PV configuration, including CAPEX, energy yield, insurance, maintenance, replacement cycles, whole-life carbon where relevant, adaptability and transfer to the future owner/operator.

Decision: Does the accepted configuration still create sufficient whole-life value to proceed to construction?

9. Delivery: build what was designed

Inspect critical work before it becomes concealed, control substitutions, commission the completed system and retain an accurate as-built record.

Decision: Is the system that was designed and approved the system that was actually built?

10. Lifecycle: preserve the design intent

Maintain the roof and PV system as an integrated asset, retain its technical documentation and assess material changes against the original design assumptions.

Decision: Does the roof-PV system still operate within the boundaries on which its original design was based?

From sequence to system

The ten steps are deliberately sequential but they should not be interpreted as ten isolated disciplines. Decisions made later in the process may require an earlier assumption to be revisited. What matters is that those interactions are recognised and controlled rather than discovered after construction.

The framework therefore does not attempt to replace structural standards, roofing guidance, electrical codes, fire engineering or insurer requirements. Its purpose is to connect them.

For new commercial buildings, the opportunity exists to make those connections before physical constraints and contractual boundaries make them expensive to change. That is the advantage of designing the roof for PV from day one.

For projects involving an existing commercial roof, the companion paper The roof comes first: rooftop PV on existing commercial buildings uses the same ten gates but begins with a baseline assessment of the inherited roof and its constraints.

Appendix A : One-page decision framework

Gate	Core question	Primary owner	Decision outcome
1 Asset	What must the building protect and over what horizon?	Asset owner	Define required performance
2 Structure	How should structural capacity be allocated?	Structural engineer	Set load and reserve budget
3 Roof	What roof build-up and passive strategy are required?	Roof / design team	Fix roof build-up and interfaces
4 Mounting	How can PV be attached without undermining the roof?	PV + structural + roofing	Select attachment principle
5 Risk	If prevention fails, what limits consequences?	Relevant risk specialists	Define prevention + consequence controls
6 PV	What roof area is genuinely usable for PV?	PV designer	Fix coordinated layout
7 Evidence	What has actually been demonstrated?	Technical / evidence parties	Confirm evidence and deviations
8 Approval	Have critical interfaces been accepted?	Project lead + approvers	Close approvals and conditions
Investment	Does the accepted configuration still create sufficient whole-life value?	Project / investment lead	Proceed / redesign / re-scope / defer
9 Delivery	Was the accepted system actually built?	Contractors + QA	Verify installed configuration
10 Lifecycle	Can design intent be preserved through operation and change?	Owner + O&M	Maintain, inspect and reassess

Appendix B : PV-ready roof checklist

Before the final roof-PV design is treated as frozen, the project team should be able to answer the following questions. The checklist is a coordination aid, not a substitute for project-specific engineering, code compliance or insurer review.

Local requirements may determine part of the roof build-up before the PV arrangement is selected. Hamburg's published Solargründach guidance, for example, describes green-roof duties from 1 January 2027 for qualifying new buildings and major roof alterations. The applicable local rules, exceptions and implementation provisions must be checked for the actual project. [15]

□ Have aggregate, ballast, vegetation or other overburden been included in the complete roof build-up, structural loads, drainage, fire scenario and maintenance strategy?

Topic	Questions to close
Asset	Building use and criticality defined? Consequences of downtime understood? Design life, ownership and insurer expectations identified? Who pays CAPEX, who carries OPEX/insurance exposure and who will own or operate the asset after handover? Whole-life carbon objectives defined where relevant?
Structure	Permanent, environmental and operational load budget defined? Ballast visible? Reserve capacity preserved where appropriate? Weight kept separate from carbon assumptions?
Roof	Complete build-up defined? Combustible involvement addressed? Protection continuity, drainage, rooflights, smoke vents, penetrations and design life coordinated? Functionally comparable build-ups assessed for embodied carbon where required?
Mounting	Attachment strategy selected before final layout? Load path, wind, waterproofing, fire interfaces and warranty conditions resolved?
Risk	Ignition-prevention measures defined? Consequence limitation independent where required? Mitigation checked for effects on structure, wind, snow and drainage?
PV	Safe usable area defined after access, drainage, roof openings, plant, cable routes and emergency needs?
Evidence	Critical claims linked to tests, classifications, listings or approvals? Field of application and deviations explicit? Environmental claims traceable to appropriate EPD/LCA evidence where used?
Approval	Manufacturers, engineers, insurer/risk engineer and relevant authorities consulted as required? Critical interfaces accepted in writing?
Investment	Accepted configuration re-costed? Insurance and maintenance implications included? Split incentives visible? Whole-life carbon, replacement cycles, marketability and future owner/operator implications considered where relevant?

Topic	Questions to close
Delivery	Inspection hold points defined? Substitutions controlled? As-built configuration, photos, commissioning and accepted deviations recorded? Pre-installation roof condition recorded? Responsibility for membrane/protective-layer damage and warranty-sensitive repair allocated?
Lifecycle	Roof and PV maintenance coordinated? Documentation retained with the asset? Triggers for reassessment after material change defined? Interface responsibility, defect attribution and replacement-cycle impacts defined? Whole-life carbon tracked where relevant?

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[13] International Code Council. International Building Code, Section 1505, Fire Classification (edition as adopted by the relevant jurisdiction). Class A, B and C roof assemblies/coverings are tested in accordance with ASTM E108 or UL 790 where required by the code.

[14] UL Solutions. UL 790, Standard Test Methods for Fire Tests of Roof Coverings; see also UL guidance on Class A, B and C roof ratings and ASTM E108/UL 790 roof-covering classifications.

[15] Freie und Hansestadt Hamburg. FAQ zum Solargründach; §16 HmbKliSchG. Official guidance accessed 1 November 2026. https://www.hamburg.de/politik-und-verwaltung/behoerden/bukea/themen/energie/erneuerbare-energien/photovoltaik/pv-pflicht-in-hamburg/faq-zum-solargruendach-989244

About the author and transparency

Olivier Langejan is Chief Commercial Officer of AllShield. His architectural and building engineering background informs the series' focus on commercial roof and PV decisions. Authorship, contributions and specialist evidence boundaries are described in Method and sources.

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Method and sources

This is a targeted inventory and synthesis of identified knowledge, updated through the checks documented for 1 November 2026. It does not claim exhaustive coverage of the latest literature. Source findings, author analysis and practical design proposals remain distinct. The author endorses the conclusions within these evidence boundaries.

Authorship and contributions

Olivier Langejan is the lead author, supported by a small team. His professional focus is building and roof design. The papers synthesise the cited research, standards and test evidence; specialist fire-science and electrical findings are attributed to those sources rather than presented as expertise personally established across every discipline. The author endorses the synthesis and its stated limits. AI assistance is described separately below.

Key source boundaries

Approval Report PR472014 (11 December 2025), §§1.3, 3.2 and 9, identifies the applicable standards and evaluated assemblies and refers to RoofNav for the listing. The programme uses previous test data and waivers, including the 4478 external-fire requirement based on 4470 evidence. It does not document a new fire test with PV. Approval of a listed assembly and project-specific engineering acceptance are distinct decisions.
ZAG Report 448/25-560-1-EN, summary p. 3 and conclusion p. 46, reports prevention of direct flame penetration into deeper structural layers in the tested configurations during the documented test periods. Heat transfer, local gaps or burn-through and damage to underlying insulation were also recorded. These observations do not mean that all underlying layers remained undamaged. The programme has no unprotected reference from which a quantified reduction in risk can be calculated.

Scope and selection

This paper synthesises the coordinated design of commercial roofs and building-applied PV before construction. Sources address early design decisions, roof functions, structural capacity, fire, evidence and interfaces. The proposed decision sequence is the author's synthesis. Detailed product selection and exhaustive treatment of electrical installation are outside its scope.

Sources and dates

The evidence base is the research, standards, approval documents, technical guidance and incident material identified in the references. This is a targeted narrative synthesis, not a systematic review. English-language sources and relevant Dutch or German material are included where cited. The original search dates and a complete search log are not available in the retained publication record, so no reconstructed search period or exhaustive publication cut-off is asserted. Sources retain their individual publication dates. The present editorial and targeted source checks were completed on 1 November 2026.

Publication range

Publication dates and editions are identified for the individual references. This targeted synthesis does not claim exhaustive chronological coverage or a reconstructed complete search period.

Verification

This revision checked the requested wording against the source papers and carried out targeted primary-source checks for the additions and source corrections identified in its revision history. It is not a new claim-by-claim audit of the entire paper. References identify primary documents where available; secondary accounts and access limitations are identified where material. Author interpretations and design proposals do not acquire test or approval status.

Known gaps

The decision framework does not supply assembly-specific fire performance, a universal structural reserve or automatic insurer acceptance.

Relationships and commissioning

AllShield commissioned the product-specific ZAG programme 448/25-560-1-EN and other AllShield test programmes cited in this paper. The May 2024 ZAG/FRISSBE guideline is a separate publication; its acknowledgements identify support from ROCKWOOL and the EU-funded FRISSBE project. Sharing an institute or a co-author does not make these different programmes one evidence source. Commissioning and funding are stated where known; unknown funding is not treated as evidence of independence.

Reading evidence

The series distinguishes claim status (DEMONSTRATED, PHYSICALLY SUPPORTED, CONTRADICTED or UNKNOWN) from the route to the intended roof (as tested, formally covered or engineering extrapolated). A cited test demonstrates its observed outcome for the specimen and exposure. Guidance is a recommendation and a proposed framework is author analysis; neither demonstrates a product outcome. A project acceptance decision does not extend the formal scope of evidence.

AI-assisted research and writing

Artificial intelligence was used to help identify and locate technical literature, compare findings across sources, analyse evidence boundaries, organise the argument and assist with drafting and editing. AI-generated summaries were not treated as technical evidence. The selection of sources, interpretation of the evidence, conclusions and final wording remain the responsibility of the author.

Updates

New research, test results, incidents and regulation may lead to new versions. Editorial corrections and technical additions are identified separately in the revision history. Missing sources and evidence that challenges a conclusion are welcome.

About AllShield

AllShield develops passive fire-protection solutions for commercial and industrial roof assemblies, including BarrierSheet. The author is its Chief Commercial Officer.

REVISION HISTORY

Version	Date	Changes
6.5	21 October 2026	Distinguished an inherently less combustible build-up, an added separation layer and a complete formally evidenced roof-PV system, with the reference build-up as an early design decision. Added that new construction can be designed around a complete FM Approved RoofNav assembly. Specified the two documented reference build-ups and the ZAG observations, including localised burn-through. Corrected the author description. Revision history and series overview introduced with this version.
6.51	1 November 2026	Editorial corrections: reframed as a roof-first knowledge synthesis; shortened the author perspective, added method and source limitations, labelled author interpretations and corrected the requested wording and transparency statements. Technical additions and source checks: Checked Hamburg's official Solargründach guidance and added its local-design implication. Expanded the roof checklist to cover vegetation and other overburden.
6.52	1 November 2026	Executive summary and conclusion: ten gates identified as a proposed practical framework; roof influence on escalation qualified. Source clarification: Efectis R000982/R000983 and the two-layer PVC/PIR build-up; PR472014 §3.2 and ZAG pp. 3, 46 added in Method and sources.
6.53	1 November 2026	Gate 7 product example: added FM §3.2 limitation and Efectis R000983 classification scope; conclusion identifies passive-protection statement as the proposed framework. Added A1 reference, authorship and corrected running version stamp.

THE SERIES

The roof comes first is a synthesis of knowledge on fire safety and rooftop PV from a roof-first perspective, by Olivier Langejan. Each paper stands on its own; together they follow one line of thought.

At the time of this version, the series consisted of:

Paper	For	In one line
Rooftop PV on existing commercial buildings	Asset owners, developers, project teams	A decision framework for resolving roof constraints before the PV investment is committed.
Rooftop PV on new commercial buildings (this paper)	Developers, architects, project teams	Designing the roof and PV as one system from the start.
The economics of the rooftop PV decision	Asset owners, CFOs, risk managers	Probability, consequence and lifecycle cost from the asset owner's perspective, including Business Interruption.
From risk models to design requirements	Risk engineers, insurers, designers	An application of five established risk frameworks to consequence-limiting design for roofs with PV.
Beyond flame spread	Risk engineers, insurers, fire engineers	How far a rooftop PV fire can travel into the roof before it becomes a building loss, and what a separation layer changes.
What does a fire test actually prove?	Insurers, risk engineers, specifiers	What a fire test result does and does not demonstrate about a real roof with PV.
DC arcs as a heat source	Insurers, risk engineers, PV designers	How DC arc faults start, persist and end in rooftop PV.
DC arcs at the roof-PV interface	Insurers, risk engineers, PV and roof designers	What determines roof exposure to a sustained DC arc and what current evidence shows about measures to limit it.
How much does PV clearance actually solve?	Insurers, risk engineers, PV designers, asset owners	What module-to-roof clearance does and does not demonstrate about the roof beneath it.
What if the PV panel could not burn?	Asset owners, risk engineers, insurers, PV designers	What a lower-combustibility PV module does and does not change for the roof beneath it.
What does an inspection actually prove?	Insurers, risk engineers, asset owners, inspectors	What inspection can establish, what it cannot and what still protects the roof when a fault is missed.

All papers and their latest versions: allshield.com/en/olivier-langejan

Comments, corrections, missing sources, evidence that contradicts a conclusion and field experience are welcome at ol@allshield.com. Relevant input is used in future versions. To be notified of new papers and versions, send a short email to the same address.

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