Loss Prevention Standards – Asset Classes

# Roof Mounted Photovoltaic Solar Panel Systems - Planning for Installation

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Roof mounted solar arrays are present on many buildings and becoming more common. From planning to have them through to their end of life, these power generating devices present many additional hazards and exposures to a property. This document is one of a series, to provide guidance to identify and mitigate the risks associated with these arrays.

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# Roof Mounted Photovoltaic Solar Panel Systems – Planning for Installation

## Introduction

It is important to inform and discuss any proposals for the installation of PV solar panel systems with Insurers, Insurance Brokers, and any other interested authorities including the Fire and Rescue Service, long before any orders are placed, and the installation work begins.

✓ This includes singular panels if replacement is needed.

A design assessment must be completed for the suitability of the proposed panels and the nature of the roof they are to be mounted on e.g., slope, construction material. Consideration should also be given to:

- The maximum fuse rating of the array.
- How the panels are strung together i.e., in parallel or in series affects the current or voltage generation.

In addition to the General Considerations Loss Prevention Standard, this standard outlines Risk Management advice for those property risks that are planning to install a roof mounted solar array.

## Safe Access to Roof

The provision of solar panels on the roof means there should be a reliable, safe, and secure access to the roof. The roof and panels may need to be regularly accessed and especially when things fail or in an emergency. The roof access needs to consider specific clear access routes:

✓ For the original installation.
✓ For regular and periodic inspections, maintenance, and servicing.
✓ For cleaning.
✓ And in the worst-case scenario for emergency response and firefighting operations.

If there is no safe fixed roof access e.g., a sloped roof, then this needs to be formally risk assessed and a procedure to access the roof in planned routine tasks and in emergency conditions needs to be developed.

*Just because there is no 'safe access', it does not negate the need for regular inspection, maintenance, and servicing.*

There also needs to be safe clear access on the roof between the rows of PV panels.

Finally, the potential at any stage of the installation through to full operation, for potentially loose or broken PV equipment to fall from a roof, leading to property damage, injury or fatalities also needs to be considered.

## Lightning Protection

The building should be assessed for lightning protection and surge suppression needs. Any existing provision protection will need to be reassessed for the proposal.

## Panel Reflection

Solar panels do not normally create a significant reflection exposure. The external protective glass layer may cause a minor issue, but it is often produced with an anti-reflective coating.
The initial site feasibility assessment will determine the estimated power output at the roof's pitch, and if the panel angle is considered too low, then this might be adjusted to support optimum sunlight collection. For the most effective performance, the panels should normally be as perpendicular as possible to the sun, so reflection onto other objects or buildings should not normally occur. Also, given panels should be at this angle, then detrimental or 'polluting' reflection should be rare, unless it's reflecting into a nearby taller building. Building regulations and planning permissions are different depending on the city, especially where there are differences in building heights adjacent or nearby to each other, where reflection might become an issue. If there are any concerns, then the feasibility study should work with local regulators and planners to assure that all exposures are considered.

## Minimum Rating of Components & Standards

Moisture and water ingress can cause electrical faults which can damage components and/or lead to fires. In addition, due to unpredictable climate patterns and the increase and intensity in sudden downpour/inundation rain events, where a significant amount of rain falls in a short period of time, all panels and junction boxes should ideally be Ingress Protection (IP) 68 rated.

- The lowest acceptable combiner box rating is IP54.

PV panel quality and reliability can vary depending on the manufacture and design standard the panels conform to. It is important to ensure the manufactured panels and installation are certificated to a recognised standard such as a minimum IEC 61215 and IEC 61730.

- ✓ Ideally with an enhanced rating of Protection Class II, Fire Rating C.
- ✓ Internationally, local equivalent standards should be used.

International Electrotechnical Commission

- ✓ IEC 61215-1-1:2021 Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
- ✓ IEC 61730-1:2023 Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
- ✓ IEC 61730-2:2023 Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing

## Combustible Roofs & Engineered Timber Buildings

Regardless of the nature of the existing roof structure, the addition of solar panels means those elements of the roof that will have panels on, are then covered with a combustible object, that can and does burn. Therefore, a clear and full understanding of the existing roof structure and its components is needed prior to any installation, and the implications to this by covering it with a series of combustible panels and cables need to be fully understood.

- The combustibility of the entire building should be known and fully documented.
- The provision of such panels increases the fuel load of any building.

In the UK the MCS certification scheme *does not recommend solar panels be installed on a combustible roof*. While Aviva supports this view, in practice we know this is impractical. As a result, Aviva recommends the roof structure and proposal be fully risk assessed.

- ✓ If the roof is of unknown construction, then one needs to assume it is combustible until confirmed otherwise.
- ✓ If support is needed to ascertain the nature of the roof, then contact your Property Insurer and Insurance Broker.
- ✓ Panels should be freestanding or mounted to a non-combustible surface/frame.

If the exposure is considered too great e.g., engineered/mass timber construction, timber frame, large Property Damage or Business Interruption values (e.g., over £15M combined Property Damage (PD) and Business Interruption (BI) value) etc., then the following should be applied at a minimum:

- ✓ All inspection, testing and maintenance is completed in accordance with the OEM/operator guidance.
- ✓ The performance of the panels and the associated infrastructure is monitored on a telemetry system or building management system connected to appropriate monitoring and response.
- ✓ At least a 1-hour fire resistance (insulation and integrity) rated barrier on the roof deck between the roof and the photovoltaic panels. This should extend at least 2m in all directions outside the perimeter of the solar array.
- ✓ Recorded visual inspections looking at housekeeping, wear, tear, impact damage, corrosion, contamination etc., are completed at least monthly.
- ✓ Thermographic surveys of the panels and infrastructure are completed at least every 6 months.

Any issues raised by any of the above should be recorded in a formal tracking system and the areas of concern monitored through to completion.

## Weight and Stability of Array & Weather Impact

Before any panels are planned to be installed on any roof, the planned weight of the array and its stability should be thoroughly investigated and fully assessed.

- ✓ Obtain professional advice on the roof/building structural stability and condition, to ensure the roof/building can support the additional weight of the PV panel array and still have an additional safety margin to withstand snow/ice loadings as originally designed.
- ✓ The structural report must also consider any other existing equipment already on the roof, or new equipment planned to be installed on the roof in the future.

PV panel arrays can significantly increase the weight loading on a roof, increasing the potential for a collapse or damage to the roof in normal or adverse conditions.

- Static and point loading.
- In normal winds, strong winds, and expected storm conditions wind the dynamic loading, potential impact of fatigue and the maximum expected wind uplift exposures.
    - In some territories, tornadoes, cyclones, hurricanes etc. should all be considered as a threat to the building integrity and damage with solar arrays.
    - Wind uplift calculations must be formally completed.
- Snow and ice loading in winter.
- Water pooling on flat roofs.
- Waste, detritus, dry leaves etc., accumulations which can block roof drainage.

Modern roof designs can be lightweight, with little tolerances for additional weight other than to satisfy local planning regulations, and older roof designs may have deteriorated with age or be in a poorer state of repair.

One also needs to consider the impact of hail on roof mounted solar. As a result, the panel selected should have a protective outer glass layer with a thickness consistent with the expected hail exposure in the area.
Note: PV protective glass types from best performing to least:

1. Tempered
2. Semi tempered
3. Heat strengthened

Thicknesses vary from 1.6 to 3.2mm with a strong correlation between glass thickness and impact protection.

Note: Bifacial panels have glass no thicker than 2mm to shed weight and reduce overheating, which makes them slightly weaker in resistance to impact damage.

Areas to consider:

- Panels are normally fixed to railings that are laid on the roof deck. This will be based on structural calculations and loading for the load bearing elements of the roof.
    - Fixing points for the railings should be on the load bearing elements of the roof infrastructure and not the roof deck itself.
- Ballast is not recommended to be used as a securing mechanism for panels and this should be avoided:
    - Additional loading on the roof.
    - Potential for movement over time and in wind/storm events.
        - Reducing securing mechanism for array.
        - Causing damage to the roof covering.
    - Increased water pooling and accumulation of waste and detritus.

Note: A reason ballast is sometimes used is because attaching or drilling anything through the roof may invalidate the roof warranty.

- Gaps between PV panels and the existing roof are exposed to increased lateral and uplifting forces created by higher wind speeds. Additional caution must be taken:
    - Where buildings are located on high ground or in exposed coastal areas, etc.
    - High rise buildings or in an area with other high-rise buildings where winds can be channelled.
    - Increased risk in high wind/storms.
- Solar panels can detach and cause further damage if subjected to sufficient wind uplift and/or due to improper installation.
- Use of wind deflectors where the exposure warrants it – this is included with the recognised design standards.

## Distribution of the Panels in the Array

The arrangement and distribution of the array is something that needs careful consideration. Aside from the weight static and dynamic loading, the spacing between the PV panels needs consideration in relation to:

- Size of each array.
- Safe roof access, movement, and ongoing inspection, testing, and maintenance.
    - Including existing roof mounted assets.
- Creation of fire breaks between arrays to prevent fire spread if they did catch fire.
- Expected emergency response and access.
    - This also needs to include appropriate signage to alert the emergency services of the presence of an array:
        - This impacts any firefighting strategy e.g., spray water in discrete short bursts to avoid electrocution.
        - Risk of premature collapse of the roof due to increased roof loading.

National Fire Protection Association (NFPA) 5000 – Building Construction and Safety Code, section 38.12 refers to roof mounted solar.

## Existing Roof Exposures

The provision of PV panels needs to consider:

- ✓ Existing plant rooms and roof mounted equipment.
- ✓ Building extraction systems such as ventilation, dust, fume, or cooker hood outlets.
    - Also consider any ventilation air intake points.
- ✓ The discharge points from any emergency relief or venting systems (including explosion relief).
- ✓ Steam or heat sources including their exit points or relief valve discharges.
- ✓ Shade effects or potential shading from existing structures or equipment - including the potential of thermal stress, i.e., over-heating.
- ✓ Any emergency exit routes.
- ✓ Any exposures from adjoining or adjacent buildings.

Ensure the PV panels are located away from all areas that could impact their safe operation or the safety of the existing assets.

## Panel Clearance to Roof Deck

The spacing between the PV panels and the roof is really important. This can present issues with:

- Additional weight with items being trapped within the gap.
- An ignition source and fuel load in direct contact or array damage.

It is important to follow the OEM guidance and recommendations for the proposed installation.

Areas to consider and include in regular inspection and maintenance activities:

- Waste, detritus, and foliage etc., accumulations,
    - In autumn if there are deciduous trees in the area.
    - Vegetation growth in spring/summer months.
- There is the potential for increased growth of moss and lichen to roof areas below the panels.
- Bird and vermin nesting etc.
- They can become traps for snow and ice build-up, causing:
    - Additional weight accumulation and distribution issues.
    - Impacting array performance.
- Drifting snow can also become a problem where there was none before.

A useful reference for panel clearance is National Fire Protection Association (NFPA) 1 – Fire Code:
NFPA Accessways for Roof Mounted Photovoltaic Installations.

## DC Isolators, Location & Accessibility

DC isolators are required to be installed on the system, on the DC side of the Inverter. In the UK this is via a combination of:

- ✓ British Standard BS7671 – IET Wiring Regulations, and
- ✓ RC 62 document from RiscAuthority and Fire Protection Association RC 62 Recommendations for fire safety with PV panel installations.

While not common, in some cases the DC isolation switch has been located on the roof itself. This should not be the installed arrangement because of issues with:

- Access in an emergency by site response team or the Fire & Rescue services.
- Ongoing maintenance.
- Visibility for a Lock Out Tag Out (LOTO) isolation or other safety management systems e.g., Working at Height.

With an emergency event including the panels, having safety/isolation switches located on the roof could become inaccessible or involved in the event itself.

It should also be noted that the isolators themselves can be a fire exposure and there has been some debate about how close these should be to the inverter. The inverter has also been the source of fire. The most important guidance in this regard in the UK, is within the MCS certification scheme.

In addition, there are some arrangements where the isolators are mounted on the inverter itself. This again is not recommended. Such an arrangement creates a single point of failure.

- If the inverter catches fire, the ability to isolate the DC is also lost.

## Inverters

Inverters are often air cooled and require clear space and air movement for ventilation. In many cases Aviva has seen arrangements:

- Enclosed in small cupboards or rooms with limited to no air flow.
    - Also, whose construction is combustible.
- Located in areas with general storage/waste etc.

As a result, the inverter cannot cool down and this may present additional performance problems, cause premature failure and even a fire, while also being near a fuel source to exacerbate any fire that starts.

At a minimum the installation should follow OEM's installation guidelines both for air flow rates, and vertical and horizontal clearance. However, from a risk management perspective inverters should:

- Not be located on the roof itself or outside, exposed to the environment.
- Be enclosed in a secure fire-rated compartment (ideally at least 1 hour).
    - The area to be a clear sterile area, kept clear of combustibles, and clean.
    - Provided at a minimum with automatic fire detection and manual break glass alarms.
        - Consider appropriate safety interlocks to the automatic fire detection.
- Be mounted on non-combustible construction.
- Must have air movement around it.
    - The temperature profile must consider warmer months and air inflow and exhaust arrangements.
- Be readily accessible at all times and especially in an emergency event – on a safe ingress and egress route.
- Have appropriate ground and wall markings, and signage to help identify the equipment and any required separation distances to prevent any material proximity.
- If multiple inverters are required to be installed indoors, consider separating them into groups and the separation distance between them.

## Cables

All cables associated with an array will need to be protected against ultraviolet (UV) exposure and deterioration. They should also be protected from mechanical damage and impact and be located so they cannot be stepped on. Cables should be installed in conduit and/or cable trays and suitably secured to the building structure. High Voltage (HV) and electric shock hazard signage must be clearly displayed.

Where power cables pass through into the building they need to enter through a non–combustible sleeve fitted to the full thickness of the wall/roof and provided with non-combustible packing around the cable within the sleeve. This is to prevent:

- ✓ Damage or wear to the cable.
- ✓ Heat radiation from the cables affecting the building fabric.

If cables pass through any fire compartment walls, these penetrations should be fire stopped with a material having a fire resistance rating (insulation and integrity) consistent with the existing wall.

Note: Aviva does not recommend the use of expandable, aerosol 'pink foam' materials as a fire stopping material. Please see Aviva's Loss Prevention Standard Fire Compartmentation Loss Prevention Standard.

Care must be taken to avoid running or routing cables over any sharp edges or around any tight angles. Cables should be protected against sharp or abrasive objects or edges by corrugated plastic sleeves or grommets. As an example, a hole cut in an insulated metal wall panel for the cable to pass from outside the building to inside, without any protection for the edge of the cut metal panel. This sharp edge then cuts into the cable insulation layer causing performance issues for the installation and potential life safety exposures.

Finally, for commercial installations, all cables should be clearly labelled to know which array/strings they are connected to, either at the inverter end or panel end.

## Array Monitoring

The ongoing performance of the array (including fault conditions) should be recorded on a telemetry system or building management system connected to appropriate monitoring and response. The decision to monitor should be based on discussions with your Property Insurer and Broker, and will be influenced by enhanced risk factors such as:

- Combustible building construction; combustible roof; timber frame or engineered timber building.
    - If the building or roof is combustible, then Aviva recommends monitoring for the array, regardless of its size.
- Height of the building and accessibility to the roof.
- Values and business impact exposed.
- Size of the array e.g., 1MW or over.
- Actual expected response to an emergency situation, including resources available for the Fire & Rescue Services.

Having the appropriate monitoring with an aligned cause and effects logic, to safely shut down or isolate the array or sections of the array, coupled with a commensurate response will hopefully prevent any event escalating to a fire.

## Fire Detection & Fire Suppression

The questions to ask oneself, is if there is a fire on the roof involving the solar panels…

- How will I know?
- How will my employees know?
- Are we evacuating the building within the correct timeframes?
- How am I preventing a small fire on the roof developing into a larger fire that threatens my entire property and business activity therein?
- Has it been included in an updated fire risk assessment for the building?
- How are the Fire & Rescue Services going to safely access the area and finally extinguish the fire?
    - What resources do they have for the height of the building?
    - Are they aware of the solar arrays on the roof?
    - Where do they get their fire water from and how much do they have?
    - What happens in a fire on the roof on a windy day?
        - At elevated heights, the wind speeds are naturally greater than at ground level.

A very good example of this was an incident that occurred to an Aviva customer where a fire started on the flat roof of the multi-storey building due to their solar panels. The building was occupied at the time and the occupants were totally unaware the fire had started and was growing. The only reason the fire was spotted was because the local police force was in the area for another incident, and they spotted the fire. By the time the fire was eventually extinguished the loss exceeded £1M, with significant fire damage to the roof and fire water damage within the building across multiple levels.

There is no standard to apply for this and there is no 'best practice', so it is up to each project to work closely with Insurers and Insurance Brokers to understand the risk and mitigate this in a way that is consistent with the exposures.

Also, it is worth understanding that existing fire detection and fire suppression within any building (e.g., automatic sprinklers) will not detect or suppress a fire on the roof.

The key to developing a strategy for this is understanding the approach to fire detection vs fire suppression.

- ✓ If we provide solely detection, then what will our response be and how will the fire eventually be extinguished – to minimise Property Damage & Business Interruption exposures.

### Fire Detection

Automatic fire detection can be provided to detect fires involving the PV panels and control equipment. Examples include but are not limited to:

- ✓ Multi-band infrared heat detectors.
- ✓ Integrated Infra-Red (IR) and/or smoke CCTV camera systems.
- ✓ Addressable linear heat detection.

In relation to any detection provided, questions to ask include:

- ✓ Coverage and spacing?
- ✓ Where are these monitored and what is the level of response? 24 hours per day, 365 days per year?
- ✓ Upon 'fire detection' what interlocks are provided to safely shut down and isolate the solar array?

Ordinary (non IR) CCTV can be used in some cases, with the caveat that these need to be constantly monitored, 24 hours per day, every day of the year. In reality, one needs to understand the reliability of this type of arrangement across the life cycle of the building and the provision of the correct equipment and a monitoring service that will actually actively and reliably monitor the cameras.

While not part of standard solar panel design and not very well established, (at the time of publishing) there are automatic temperature actuated DC isolators. These normally actuate above 85C and are seen as a positive enhancement to existing solar panel design.

## Fire Suppression & Extinguishment

Whilst not common, automatic and manually operated fire suppression systems can be designed to protect the areas covered by PV panels, with safety interlocks upon its activation. Depending on the arrangement, a reliable and dedicated fire water supply should be provided.

- An appropriate Internationally recognised design and installation standard should be used, by approved/listed organisations only using approved/listed equipment.

Systems to consider:

- ✓ Dry risers with connection points on the ground floor and the roof level.
  - An open pipe that the Fire & Rescue Services can connect a hose at both ends to quickly get water to the roof.
  - Arranged with more than one riser located in different areas of the roof, so the Fire & Rescue Services can safely access a water supply on any side of the building, depending on the nature of the fire.
- ✓ Wet risers connected to an appropriate water source with connection points at the roof level.
  - A closed water filled pipe connected to a reliable and suitable water supply that the Fire & Rescue Services can connect a hose at the roof level.
  - Arranged with more than one riser located in different areas of the roof, so the Fire & Rescue Services can safely access a water supply on any side of the building, depending on the nature of the fire.
  - This will need to be protected against freezing in colder months.
- ✓ Manually and/or automatically actuated deluge or water spray systems.
  - Zoned based on the maximum array area to be involved in any one fire area.
    - Spacing or parapet walls between panel arrays to prevent fire spread between adjacent arrays.
  - An exposure design density of 10mm/min may be appropriate. The agreed design should be discussed with your Property Insurer.
  - Actuated by IR automatic fire detectors, linear detection, or pilot line closed head quick response sprinklers (arranged not to compromise the solar array performance).
  - Connected to a reliable and suitable fire water supply.
- ✓ Manually and/or automatically actuated normally oscillating monitor nozzles. Designed and arranged:
  - Each area of the solar array can be reached by at least 2 operating devices.
  - With at least 950 litres per minute flow from each device.
  - Connected to a reliable and suitable fire water supply.

Note: An external fire close to or on the roof of a building that has automatic sprinklers protecting its interior, may cause the interior protection to actuate. However, this protection will not suppress the fire at its seat and the fire will probably eventually overtax it. In the worst-case scenario, if the protection is overtaxed, compromised or the roof collapses at all, the existing protection will be totally impaired. Having internal protection within a building, does not stop a fire on the roof causing the total loss of that building.

## Malicious Damage, Vandalism & Security

Some residential, commercial, and industrial buildings can be subject to vandalism and malicious damage e.g., missiles being thrown, street art/graffiti, urban runners, even protestors etc. Regardless of whether this is an existing exposure or not, the provision of such an installation on a roof needs to be considered in relation to the local area and the security history of the building.
As part of this assessment consider:

- What are the access arrangements to the roof?
- Is there any external access including stairway or ladder?
    - Or is there solely internal access?
- Is the existing security arrangements and provision appropriate now?

Note: Street art/graffiti will contaminate the surface of the panel and impact its performance.

# Specialist Partner Solutions

Aviva Risk Management Solutions can offer access to a wide range of risk management products and services at preferential rates via our network of Specialist Partners, including:

- Electrical inspections and thermographic imaging: Bureau Veritas
- Fire stopping and passive protection: Checkmate Fire
- Thermographic imaging and PAT testing: PASS
- Automatic fire detection and portable extinguishers: SECOM
- Security marking: Selectamark

For more information please visit:

Aviva Risk Management Solutions – Specialist Partners

# Sources and Useful Links

- Guide to the Installation of Photovoltaic Systems: Published by the Microgeneration Certification Scheme (MCS) https://mcscertified.com/

## Additional Information

Relevant Loss Prevention Standards include:

- Contamination Following a Fire
- Control and Management of Combustible Waste Materials
- Electrical Installations – Inspection and Testing
- Emergency Response Teams
- External and Internal Third Party Exposures – Property Protection
- External Wall Insulation Systems
- Fire Compartmentation
- Fire Safety Inspections
- Heat and Smoke Venting Systems
- Housekeeping – Fire Prevention
- Managing Change – Property
- Managing Contractors
- Smoke Contamination
- Smoking and the Workplace
- Thermographic Surveys

To find out more, please visit Aviva Risk Management Solutions or speak to one of our advisors.

## Email us at riskadvice@aviva.com or call 0345 366 6666.*

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# LOSS PREVENTION STANDARDS