Fire Protection Association

RISCAuthority

Need to Know Guide RE3

Rooftop-mounted PV Solar Systems

RISK INSIGHT, STRATEGY AND CONTROL AUTHORITY

REDUCING INSURABLE RISK THROUGH RESEARCH, ADVICE AND BEST PRACTICE

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1 Introduction

Globally, PV (photovoltaic) solar is one of the fastest growing, most reliable, and most adaptable forms of electricity-generating technology available. The incidence of fires involving PV systems is very low. However, the addition to a building of a PV system which is not correctly designed, installed, or maintained could, like any electrical service, add to the overall risk of fire.

There are two principal types of PV system: rooftop and ground mount systems. Rooftop systems range in size from a few PV modules (1 kilowatt-peak (kWp)) on a single dwelling, up to several thousand PV modules (5 megawatts-peak (MWp)) on larger warehouse-type applications. Ground mount systems can range from a few kW up to several hundred MW and can cover huge expanses of land.

This concise guide supports RISCAuthority RC62: *Recommendations for fire safety with PV panel installations*, 2023, which covers a range of PV solar equipment and arrangements. The recommendations presented focus on commercial and industrial rooftop PV installations but have relevance to PV systems in general.

RC62 (2023) was developed as a Joint Code of Practice by RISCAuthority and the Microgeneration Certification Scheme (MCS), with the support of Solar Energy UK.

The main elements of a typical rooftop battery hybrid PV solar system are shown in Figure 1.

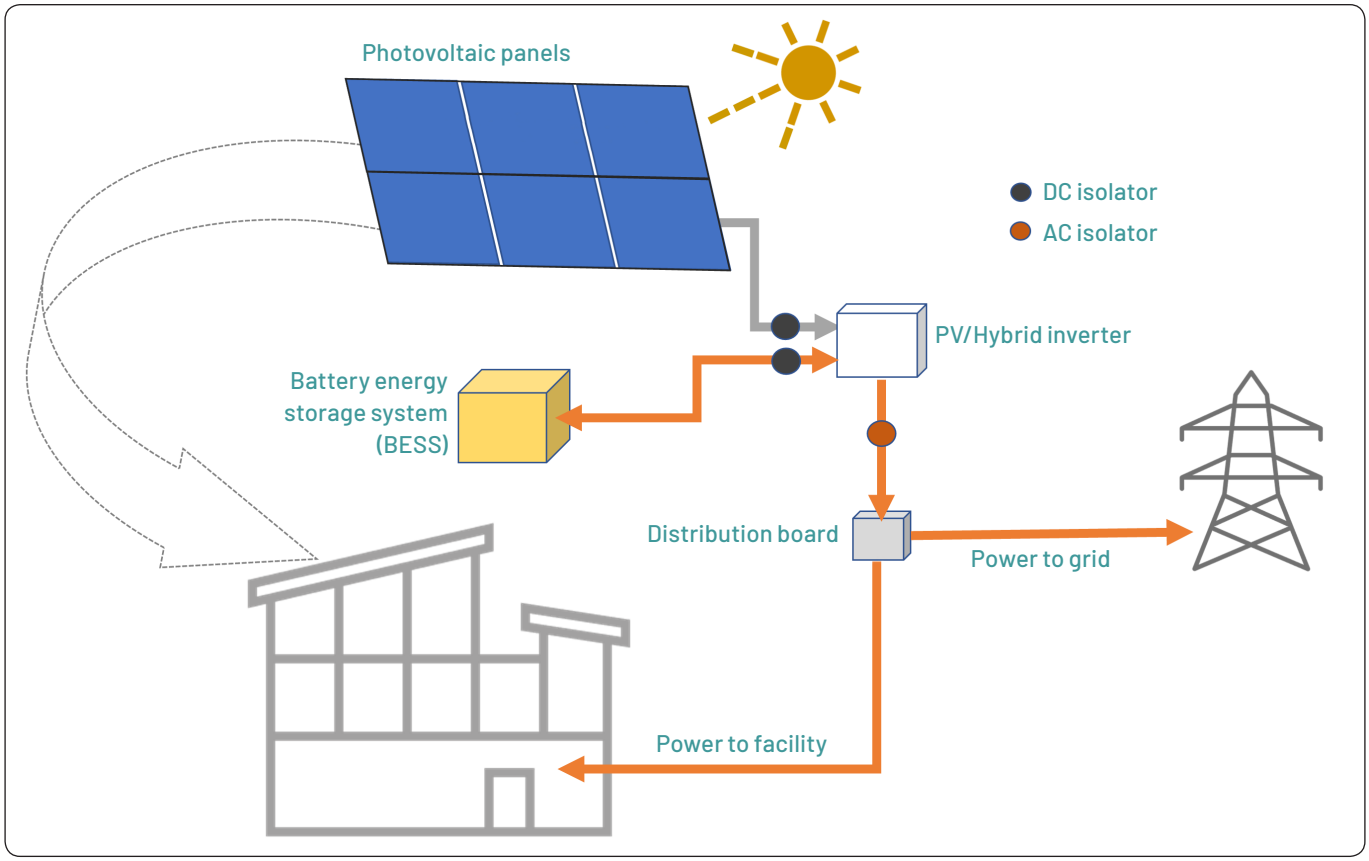


Figure 1: The main elements of a typical solar installation

PV modules are typically made of a thin layer of semi-conducting material between a sheet of glass and a polymer resin/glass backing, fitted in an aluminium frame. They are then clamped to a metal frame, typically made of aluminium. That frame is, in turn, attached to the roof either with mechanical fixings, or secured with ballast. Ballast avoids issues around roof weather-tightness, especially for retrofit systems, but can be problematic if the roof structure deflects under the weight.

Battery energy storage systems (BESS) provide a constant energy supply from variable sources of energy such as solar power. Fire safety advice for these systems can be found in RISCAuthority *Need to Know Guide RE1: Battery Energy Storage Systems (BESS) – Commercial Lithium-ion Battery Installations*.

2 Hazards

Visual inspection of roof mounted solar panels by a technician

PV installations are essentially 'solid state' systems, with a low frequency of failure and are consequently less vulnerable to wear than rotating machine generators as they have no moving parts. However, they may comprise hundreds or thousands of electronic sub-components which, despite having a high individual reliability and low failure rate, in combination present a significant potential for system faults which could result in fires.

Good design, equipment-selection, installation, operation, and maintenance are essential to minimising the incidence of component and system failures.

Circumstances that have led to fire losses include:

- Moisture and water ingress into PV system components, such as DC and AC isolators, and combiner boxes, leading to short-circuits and consequent failure.
- A build-up of dirt and in particular bird-droppings on PV panels, causing partial shading, leading to hot spots developing into faults.
- Failure of poor quality or incompatible components that were part of the initial installation, or subsequently fitted as spare parts.

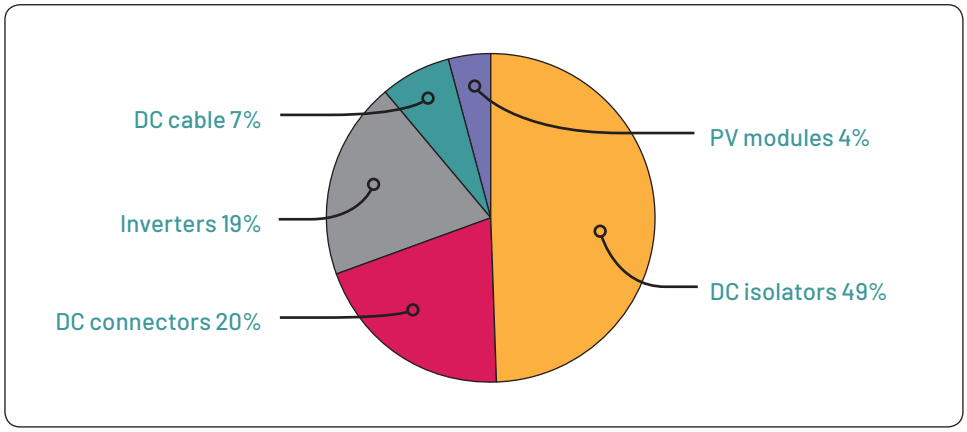


Figure 2: A study by BRE (2017), based on investigation of 46 incidents, identified the PV system components most likely to develop faults leading to fire incidents.

When fires do occur in PV panels that support spreading combustion, these may spread between inadequately separated PV panel arrays, or via cabling that is not properly sealed within fire resisting cable ducts.

Where PV installations are secured using ballast weights, careful consideration of the roof structure and strength is required. Excess loading may lead to deflection of the roof and consequently to pooling of rainwater. The combined weight of ballast and rainwater could exceed the roof's design capacity, which in the worst case, can lead to a collapse. The basis of roof structural design should also account for potential loadings from snow and ice build-up.

Wind and storms can lead to damage to PV systems that have not been designed to resist peak wind speeds or other severe weather exposures. Suitable design references include BS EN 1990:2002+A1 Eurocode: *Basis of structural design* and BRE DG 489 *Wind loads on roof-mounted photovoltaic and solar thermal systems*.

Theft of equipment from rooftop systems, though achievable, is made difficult due to the height of the equipment and the fact that most buildings with this type of system are occupied; unlike ground mounted solar systems that are often located in unmanned, remote sites, making these sites more vulnerable to theft. RISCAuthority S33: *Solar farm security* is largely focussed on ground mounted systems but remains a useful general reference for PV installation theft-security.

Fire and Rescue Service personnel should be aware that, even in absence of direct sunlight, PV panels produce a DC voltage from daylight and other light sources, including any floodlights used to illuminate a fire incident, even if the AC side of the circuit is isolated from the mains electrical supply. This continuing production of DC voltage may have to be addressed in the risk assessment undertaken before firefighting commences. In many existing installations, a DC disconnector for the DC cables on the roof is not provided. To help ensure the safety of firefighting personnel and facilitate fire fighting it is good practice, and may be mandatory, to install suitably located DC disconnection switches, aka fire service switches, to remotely isolate the DC side of the PV system.

Source: Avon & Somerset Constabulary drone footage

Solar panel fire on roof of Bristol science museum, April 2022

3 Essential risk control recommendations for PV solar installations

These recommendations focus largely on commercial and industrial rooftop PV systems, but generally apply in principle to other types of conventional PV solar installations. Full risk control specification details for roof mounted PV solar systems are provided in RC62: *Recommendations for fire safety with PV panel installations*, 2023.

1. Carry out a suitable fire risk assessment.
2. Undertake a full consultation with the building owner and insurer.
3. Ensure there is a structural engineer's report to approve the PV installation for the building, taking into account the age of the building, the method of PV system mounting, and the avoidance of leaking roof penetrations and weather-related roof loads. Particular attention is required for ballast-based PV panel mounting systems, to avoid increased water-pooling on the roof due to flexing of the roof structure. It is also essential, for all roof mounted systems that loadings from snow and ice build-up are fully assessed.

4. Ensure roofing materials are non-combustible* OR if installation on a combustible or partly-combustible roof is unavoidable, then apply a fire resistant covering.

   * Class A1/A2 s1, d0 to BS EN 13501-1

5. Aim to select PV panels made from materials with low propensity for spreading fire or producing burning droplets, following ignition.

6. System design and installation to be undertaken in accordance with the IET PV Code of Practice, MCS requirements, and industry good practice guidelines, using installers, engineers, and technicians holding relevant qualifications and certifications (ref. 1, 2, 3).

7. Where mandatory for compliance with BS EN 7671, OR to meet 'good practice' requirements specified by the client or insurer, provide a DC disconnection switch (aka fire service switch) to remotely isolate the DC side of the PV system. Locate the fire service switch in a prominent position that is readily accessible to firefighters (ref. 4).

   (*Section 5.5.6 of RC62 outlines when a fire service switch is mandatory.*)

8. Where a DC disconnection switch (fire service switch) is installed, implement switch-testing as part of planned maintenance.

9. Implement suitable operating procedures, and planned and preventive maintenance arrangements, for PV panels and associated power distribution equipment and cables; to include annual inspection of commercial systems by a competent person (ref. 5).

   Infrared (IR) thermography is an effective method to determine PV system health, and good practice to include in preventive maintenance arrangements.

10. Use only OEM appropriate spare parts for maintaining and repairing PV systems.

11. Install mains-powered automatic smoke detection, linked to the existing building fire detection system, in all areas inside the building in which electrical control equipment for PV installations is located.

12. Consider installation of water sprinkler protection in buildings on which roof-mounted PV systems are installed. Sprinkler protection is highly beneficial for the protection of property and should be considered for areas inside buildings where equipment associated with PV systems is installed, as well as for adjacent areas that are exposed by, or expose these areas to, fire.

13. Ensure that sections of PV panels mounted either side of a compartment wall (within the building on which the panels are mounted) are arranged with adequate fire separation, including (ref. 6):

    a. Avoidance of cables passing over the compartment/fire wall.

       If this cannot be avoided, install cables in fire-resistant cable ducts and shafts.

    b. Provision of a minimum distance of 2.5m between the PV modules on each side of the compartment/fire walls.

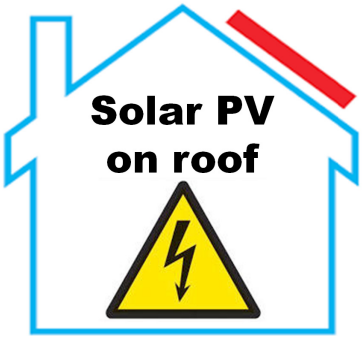
       i. A reduced distance is permitted if the potential for fire spread across the compartment boundary is considered low, based on a suitable risk assessment.

       ii. For PV installations where the potential for a fire to spread across a compartment boundary is considered low, provide a minimum 1.2m separation between the PV modules on each side of the compartment/fire wall.

14. Suitably support cable runs to avoid sagging, flapping, or lying in areas where there may be a risk of pooling water, with cable connectors orientated to minimise the chance of water ingress. Also check cable routes for sharp edges and other aspects that may damage cables over time.

15. Ensure that the location of inverters is given careful consideration, with particular attention to providing adequate levels of ventilation as inverters can produce significant heat during normal operation.

16. Provide specific clear routes to facilitate safe access to the roof for servicing, maintenance, cleaning, and firefighting operations.
17. Prepare an emergency plan, including actions to be taken in the event of PV system fires, also ensuring:
    a. there is adequate access for firefighters, including good site access for fire service vehicles
    b. fire information grab packs are provided for the fire and rescue service at a prominent location.
18. Implement systems to avoid accumulation of windblown litter and leaves, around or beneath PV panels. Also, implement appropriate mitigation measures to control the potential impact of rodents, nesting birds, and other animals that can cause harm and alter the fire safety properties of a PV system.



19. Provide adequate protection measures for prevention of theft and vandalism (ref. 7).
20. Ensure that adequacy of lightning protection has been considered (ref. 8, 9).
21. Implement scheduled cleaning regimes for PV systems, the frequency of which should be based on a risk assessment. A major issue for PV modules is bird droppings, which will adhere to the modules irrespective of angle. Cleaning to be undertaken by suitably trained personnel, who follow a detailed risk assessment method statement (RAMS) for this work.
22. Provide adequate ground-level signage where PV systems on a building are not obvious from ground level, clearly visible for the fire and rescue service on arrival.

4 References

1. IET Code of Practice for Grid-connected Solar Photovoltaic Systems (referred to within this guide as the IET PV Code of Practice)
2. MCS001-1 The MCS Contractor Standard – Part 1: Requirements for MCS Contractors, Issue 4.1, 2020
3. MCS001-2 The MCS Contractors Standard – Part 2: The Certification Process, Issue 4.2, 2020
4. BS EN 7671:2018+A2:2022 *Requirements for Electrical Installations. The IET Wiring Regulations*, 2022, BSI
5. Solar Energy UK, *Industry best practice manual 2.0: Guidelines for the operation and maintenance of rooftop solar photovoltaic systems*
6. CFPA-E Guideline No 37:2018 F *Photovoltaic systems: Recommendations on loss prevention*, 2018, The Confederation of Fire Protection Associations Europe
7. RISCAuthority S33 *Solar farm security*
8. RISCAuthority RC35 *Protection of buildings against lightning strike*
9. DTI *Photovoltaics in Buildings: Guide to the installation of PV systems* (2nd edition)

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