Loss Prevention Standards

Photovoltaic Solar Panel Systems on Buildings

Introduction

Although the majority of electricity within the UK is currently generated by burning fossil fuels such as natural gas and coal, renewable energy technologies such as photovoltaic (PV) solar panel systems are increasingly being used to create what many would say is an environmentally friendly source of energy/power. In some countries, government incentives are available and planning laws now often include environmental considerations such as the installation of rainwater harvesting and PV solar panel systems. As a consequence of this there are an increasing number of companies supplying and installing PV systems, and whilst such installations may benefit the environment, they do present additional hazards when installed on building rooftops.

PV solar panels can vary in size and weight and come with various types of fixings, and associated equipment such as electrical cables, connectors, junction boxes, isolation switches, inverters, etc. PV solar panel systems are often seen fixed onto roofs or purposely built into the roofs of residential homes, and increasingly are roof-mounted on industrial and commercial buildings. These installations can provide cost effective electrical power to the buildings concerned.

PV solar farms are large-scale operations which involve considerable numbers of PV panels laid out over acres of rural/farm land. These sites generate power on an industrial level exporting it when required to the national grid/network.

PV solar panel systems operate by collecting solar radiated energy and converting it into electrical power. The solar panels contain large numbers of PV cells made of semiconductor materials that convert the energy into direct current (DC). The DC runs along a number of electrical cables, connectors and junction boxes to a DC isolation switch and then to an inverter. The power inverter converts the DC into alternating current (AC) that runs via an AC isolator to the main electrical supply switchgear. In some cases the DC power can be stored in batteries ‘off line’ and used as a standby supply.

A number of countries have developed their own national standards and/or guidance documents including in some cases product certification schemes. These standards and documents are often completed in conjunction with the PV solar panel industry, covering manufacturing, design standards, installation, servicing and maintenance, etc. In the UK the Microgeneration Certification Scheme (MCS) is a nationally recognised quality assurance scheme which covers products and installation of microgeneration technologies, including PV.

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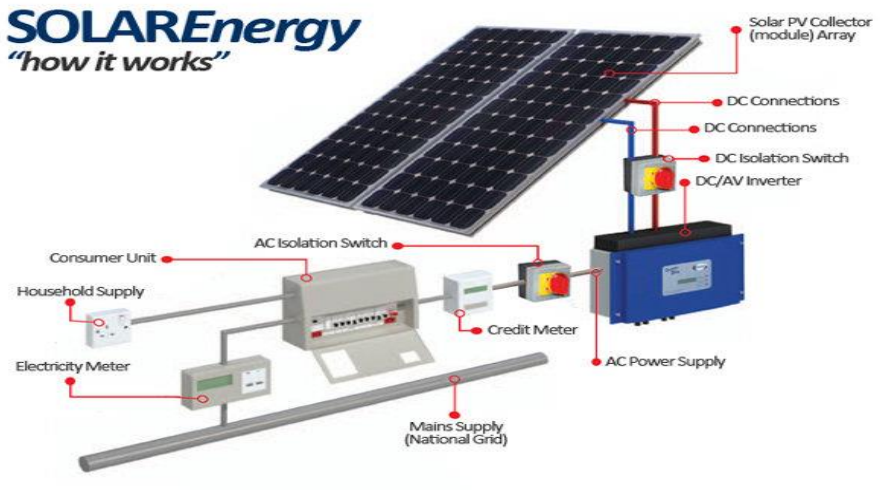

Figure 1 - Basic photovoltaic system

Potential Hazards

There have been a number of reported fires involving PV solar panels, mainly in Germany and North America where the majority of these panels have been installed. A number of fires have been caused as a result of poor PV panel installation, using incorrectly specified equipment, faulty equipment, panel faults or electrical system failures. It is important to understand the risks associated with the installation and use of PV solar panel systems within buildings. Potential hazards which need to be considered include:

- Building fire load. PV panels and associated equipment will contribute to and increase the fire load.
    - They are normally sited outside of any existing protected space and/or can inadvertently be installed on top of combustible construction.
- Roof construction. PV panels should not be installed directly on top of combustible roofs.
    - The roof/coverings should be fire-resistive and/or non-combustible.
    - Potential fire spread – fires involving combustible roofs will spread quickly, above any protection within the building. Adjoining or nearby buildings can also be at risk.
    - PV panel arrays may affect the site's Estimated Maximum Loss (EML) for insurance purposes.
    - **Note.** An external fire close to or on top of a building that has automatic sprinklers protecting the inside of the building may possibly spread to the interior of the building; or spread on the roof covering until a point where the roof fails and so compromising the installed sprinkler protection.
- Extensive PV panel roof arrays may restrict fire fighters from:
    - Venting a fire from within a building.
    - Tackling a fire within a building.
- Increased roof loading. PV panel arrays can significantly increase the weight loading on a roof, increasing the potential for a collapse of the roof during a fire. Modern roof designs are often 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 poor state of repair.

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- Gaps between the PV panels and the roof can become traps for snow and ice build-up causing additional issues with accumulation and weight distribution.
    - Drifting snow can also become a problem where there was none before.
- Gaps between the PV panels and the roof can trap waste debris, foliage, etc., especially in autumn, with the increased growth of moss and lichen to roof areas below the panels.
    - This can present an ignition source and fuel load in direct contact.
- Increased risk of damage to existing roof during the installation of PV panels, resulting in possible water ingress into the building and expensive repairs.
- Increased risk of storm damage. Gaps between PV panels and the existing roof are exposed to increased lateral and uplifting forces created by high wind speeds. Additional caution must be taken where buildings are located on high ground or in exposed coastal areas etc.
- Restricted roof access. Poor design with no specific clear access routes may restrict safe access to the roof for servicing, maintenance, cleaning and fire fighting operations.
- Live electrical cables. DC is present from the PV panel to the inverter increasing the risk of electrical shock/injury or death.
- Damage to the PV panel, live electrical cables, connectors and/or junction boxes and inverters can lead to fires. Potentially loose or broken PV equipment could fall from the roof, leading to injury or fatalities.

Operational and Management Controls

- It is important to inform and discuss any proposals for the installation of PV solar panel systems with your insurers and all other interested authorities including the Fire and Rescue Service, long before any orders are placed and installation work begins.
- 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 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 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 Underwriters Laboratories (UL), Factory Mutual (FM) or German VdS and TUV-SUD, and have the correct safety devices fitted.
- Installation work must be carefully supervised, inspected and commissioned with completion test and certification issued along with operating manuals, prior to handover.
- Equipment must be correctly specified and compatible for a PV solar panel system.
- Electrical cables, connectors and/or junction boxes need to be fire-resistant or enclosed in a fire-resistant material, conduit or fire-rated compartment.
- Cables need to be protected against ultraviolet (UV) exposure/deterioration and installed in conduit and/or cable trays, suitably secured to the building structure. High Voltage (HV) hazard signage must be clearly displayed.
- Ensure PV panels are located away from dust/fume outlets and not positioned near to sources of steam or heat.

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- Shade affects the performance of a PV system, including the potential of thermal stress, i.e. over heating. System design and placement should take into consideration potential shading.
- 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, to prevent damage to the cable and preventing any chaffing to the cable or heat radiation from the cables affecting the building fabric.
- PV panel inverters need to be enclosed in a secure fire-rated compartment, at least 1 hour, kept clear of combustibles and provided with fire detection.
- PV panel power isolation switches need to be located in readily accessible and clearly signed areas to allow safe access by Fire and Rescue Services etc. Consider remotely operated controls to operate isolation switches that can be operated well away from the area of fire.
- PV solar panel systems will need regular inspections, cleaning, servicing and maintenance to check for damage and to ensure the panels operate to their full capacity. Ensure all servicing and maintenance is completed in accordance with the manufacturer's instructions and by competent, qualified engineers.
- Safe clear access to the roof and between rows of PV panels must be maintained to permit servicing, maintenance, cleaning and fire-fighting operations.
- Automatic fire detection can be provided to detect fires involving the PV panels and control equipment, e.g. multi-band infrared heat detectors, or integrated IR/smoke CCTV camera systems, or addressable linear heat detection.
- Automatic/manually operated fire suppression systems can be designed to protect the areas covered by PV panels, with safety interlocks to automatically shut down the PV system on activation of the fire detection/fire suppression system.
- Ensure the premises' fire and health and safety risk assessments are reviewed and updated to take into consideration the PV solar panel system.
- Business Continuity Plan(s) will need to be reviewed and revised where necessary.

Checklist

A generic Photovoltaic Solar Panel Systems on Buildings Checklist is presented in Appendix 1 which can be tailored to your own organisation.

Additional Information

Guide to the Installation of Photovoltaic Systems: Published by the Microgeneration Certification Scheme (MCS)
Roof Mounted Solar Photovoltaic Panels 1-15: FM Global Data Sheets

Further risk management information can be obtained from Aviva Risk Management Solutions

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Appendix 1 – Photovoltaic Solar Panel Systems on Buildings Checklist

Location	
Date	
Completed by (name and signature)	

	Photovoltaic Solar Panel Systems on Buildings	Y/N	Comments
1.	Has a risk assessment been completed to identify potential fire, security, housekeeping and safety hazards associated with the installation, or proposed installation, of a PV solar panel system?		
2.	Has a structural engineering report been commissioned to assess the building(s) and roof(s): • Condition? • Design? • Combustibility? • Suitability for proposed additional loads, including weather-related loads? With any recommendations completed before any orders or installation work has started?		
3.	Have your insurers and any other interested authorities such as the local planning authority and fire service been informed and approved the proposals?		
4.	Is the roof suitable for PV panel installation and is it: • Constructed with fire-resistive or non-combustible materials? • Stable and in good condition?		
5.	Are the PV panels securely fixed (bolted) to a fire-resistive or non-combustible surface?		
6.	Has the possibility of fire spread been considered, particularly if the roof or sections are constructed of combustible materials, and what corrective actions have been implemented?		
7.	Is the roof able to withstand high winds with the additional weight loadings?		
8.	Are the designer, supplier and installer well established companies with a good history of workmanship, and are they appropriately accredited and certified?		

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	Photovoltaic Solar Panel Systems on Buildings Contd.	Y/N	Comments
9.	Has the installing company completed full specific risk assessments and method statements, and have these been checked and accepted by the health and safety adviser?		
10.	Are the PV panels manufactured installed and serviced to a recognised national standard, e.g. Underwriters Laboratories (UL), Factory Mutual (FM) or German VdS or TUV-SUD?		
11.	Is the PV system protected against lightning, and electrical earth bonded and installed to the national electrical regulations/guidance?		
12.	Are there any arc sensors and safety interlocks fitted to automatically shut down the PV system should any PV panels develop a fault?		
13.	Is there residual current DC monitoring on +/- supply circuits or electronic DC current sensing relay in ground circuits in series with ground fault fuses?		
14.	Are there any safety interlocks to: • Trip the DC supply to the inverter? • Initiate an onsite building alarm and remote alarm monitoring? • Automatically shut down the DC & AC power from the PV panel? • Detect a fault/malfunction of the PV panels and/or associated equipment?		
15.	Are all electrical cables, connectors and/or junction boxes fire-resistant or enclosed in a fire-resistant material, conduit or fire-rated compartment?		

16.	Are cable runs carefully thought through and formally plotted on drawings?
	• Is there any possibility of fire spread on the cables?
	  ○ From inside the building onto the roof?
	  ○ From the roof to inside the building?		

17.	Are cables protected against UV exposure/deterioration and installed in conduit and/or cable trays, suitably secured to the building structure?		

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	Photovoltaic Solar Panel Systems on Buildings Contd.	Y/N	Comments
18.	Is electrical HV hazard signage clearly displayed at least every 3 metres along the route of the cabling?		
19.	Is the PV power inverter installed on a non-combustible material such as a block or brick wall?		
20.	Is the PV power inverter installed in a dedicated fire-rated compartment and provided with automatic fire detection?		
21.	Is the PV inverter room kept clear of all combustibles and secured against unauthorised entry?		
22.	Are the DC and AC power isolation switches located in a safe location and clearly signed to allow safe access by fire fighters, etc.?		
23.	Can the power from the PV panels be safely isolated and with relative ease?		
24.	Is there a remote DC disconnect for each combiner/junction box as close as possible to the output side of the box prior to the inverter?		
25.	Can the AC supply be safety isolated in an emergency?		
26.	Is there safe clear access provided to the roof and between rows of PV panels to permit servicing, maintenance, cleaning (including snow/ice clearance) and fire fighting operations?		
27.	Are the PV panels and associated equipment regularly inspected for signs of damage?		
28.	Are the roof, PV panels and associated equipment regularly cleaned, serviced and maintained by specialist contractors?		
29.	Are infrared thermal inspections completed of the PV system as part of the routine inspections and maintenance?		
30.	Is automatic fire detection provided to detect a fire involving the PV panel array?		
31.	Are automatic fire suppression systems provided to protect the areas of PV panels, e.g. automatic deluge, water/foam monitors?		

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	Photovoltaic Solar Panel Systems on Buildings Contd.	Y/N	Comments
32.	Are there any safety interlocks to automatically shut down the PV system on activation of the fire detection or fire suppression systems?		
33.	Do fire alarms signal to a constantly attended location that is acceptable to insurers and other interested authorities?		
34.	Is there a prompt response required to any alarm that includes a full investigation and inspection of the reported fault, and planned actions for isolation in the event of fire as part of the site emergency procedures?		
35.	Have all Emergency Plans and Business Continuity Plans been updated?		
36.	Does the proposed emergency response actually detail how a fire on the roof involving the PV panels will be tackled to protect the property and the business, including the actual expectation and resource required for the public fire brigade?		
37.	Additional comments:		

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