Industry best practice manual 2.0

Guidelines for the operation and maintenance of rooftop solar photovoltaic systems

Disclaimer

Please note that this document and the information contained in it do not, and are not intended to, constitute formal legal advice on any health, safety, or other requirements for operating and maintaining solar photovoltaic power generation systems as defined in law. The document is intended to provide an indication of key issues which Solar Energy UK considers important for solar system owners and operators to take into account for the safe operation and maintenance of their systems.

Whilst we endeavour to ensure that the information in this document is correct, no warranty, express or implied, is given as to its accuracy and we do not accept any liability for errors or omissions. Users of this document should contact their own independent legal adviser in respect of any legal matter arising from their own specific circumstances. We will aim to correct any errors or admissions as soon as reasonably possible after they are identified, and welcome suggestions for how this work could be improved.

Solar Energy UK would like to thank members of its Rooftop O&M Working Group and other organisations for contributing to this document, including the following. Please note that the contents of the report do not necessarily represent the views of any of these organisations:

Contact: enquiries@solar-trade.org

Foreword

Welcome to the second version of Solar Energy UK's Rooftop Operations & Maintenance (O&M) Best Practice Guidelines. This document, published December 2021, supersedes any previous versions.

The Guidelines have been produced by members of Solar Energy UK's Rooftop O&M Working Group. They discuss issues which are relevant to maintaining the condition and efficiency of roof-mounted solar power systems. O&M is the largest cost in the life of a solar PV installation, beyond the initial installation, and Solar Energy UK hopes the Guideline will support all involved in the solar industry to generate maximum value from their systems.

This version of the Guidelines has been updated to reflect the development of new aspects of O&M. It includes new or updated information on the use of drones and thermal imaging to monitor solar systems remotely, cybersecurity and how this relates to solar O&M, and emerging technologies such as floating solar.

Note that this is not a certification document, and the intention is not to try and compel solar rooftop O&M companies to abide by its contents. Rather, as professionals committed to improving standards in the UK solar industry, this is our view on best practice for safe working that can help ensure solar PV systems are appropriately monitored and maintained.

The Guidelines cover suggested training requirements and key issues relating to safe roof access and design, panel cleaning, and fault identification and monitoring. They also include suggested checklists for maintenance tasks, and provide information on warranty claims. The Guidelines comment throughout on health, safety, and training. This is of paramount importance, for the obvious reason that maintaining rooftop systems requires working at height.

Solar Energy UK would like to stress that due to the number of site-specific access, environment and installation factors, all rooftop O&M should be carried out based on detailed case-by-case planning, in consultation with solar industry O&M professionals. This is the best way to ensure that a rooftop PV system is operated safely, and as effectively as possible.

It should also be noted that as with the broader solar sector, O&M technology, training and challenges have evolved rapidly in the last few years, and will continue to do so. Solar Energy UK intends to update these Guidelines in future to reflect further changes as necessary.

Contributions to these Guidelines come from a wide range of Solar Energy UK members, who are experts in the UK O&M industry. Solar Energy UK would like to place on record its thanks for their engagement on this document.

Solar Energy UK welcomes feedback on this guidance.

Steve Williams
Managing Director, Clean Solar Solutions
Chair, Rooftop O&M Working Group

Chris Hewett
Chief Executive, Solar Energy UK

Contributors and co-authors to the first or second edition of this guide include:

Andrew Hancock & Jaime Arias, PSH Operations
Angus Rose and Adam Peat, Ineco Energy
Chris Roberts, MCS
David Harris, Bright Renewables
Elaine Teo & Grant Hilti, Heliospekt
Gina Matharu, Nerfsky
Helen Robinson & Kian Lissenburg, Armstrong Capital
Jason Kirrage, SolarEdge Technologies UK Ltd
Paul Dickens, CDM Expert
Philip Jones, Pearl Safety Solutions
Rachel Oakley, SmartWater
Robert Harley, Helios Solar Operations & Maintenance
Saffron Hooper-Kay, Wise Energy
Simon Godfrey, Ecovision Asset Management
Ypatios Moysiadis, Energybit

Thank you to the other individuals and organisations who provided additional advice and support to the development of this guide.

Published in the United Kingdom by

Solar Energy UK
Chapter House, 22 Chapter St, London, SW1P 4NP

Contents

Glossary

AMP: Annual Maintenance Plan

BS: British Standard

COSHH: Control of Substances Hazardous to Health

Client(s): A person or organisation that receives a service in return for payment.

H&S: Health and Safety

HCM: Hierarchy of Control Measures

HSE: Health and safety executive

MLPE: Module-level power electronics

O&M: Operations and maintenance

OEM: Original Equipment Manufacturer

PPE: Personal Protective Equipment

RAMS: Risk Assessment Methods Statement

SSOW: Safe System of Works

1. Overview

This document aims to provide clear, accessible guidelines for the safe maintenance, cleaning, and monitoring of domestic and commercial rooftop solar installations in the UK. The information in it is not intended to be an exhaustive list, and it must be stressed that all contractors and workers are responsible for ensuring they follow relevant legislation and codes of practice.

Regular maintenance, monitoring and cleaning may assist the effective life and power generation of a solar PV system, reducing the risk of damage and prolonging the life of major components.

This document provides advice on how to do this for roof-mounted solar systems. Solar Energy UK welcomes feedback and will incorporate this and further issues into the next version of these guidelines.

Health and safety is the most important consideration for all O&M activity, and so the guide begins with a discussion of safety topics. This includes core principles, the need for professional training, and how to plan for and carry out work at height.

The guide then considers key inspection and maintenance activities, and common faults these should help identify. Next, it discusses aspects of solar panel cleaning and site security. The final section provides information on warranty issues.

Note that the basis for all solar panel operations and maintenance should be consultation with professional solar companies for advice, and to consider the specific needs for each system on a site-by-site basis.

1.1. Who is this document for?

These guidelines are intended to inform the work of solar operations and maintenance (O&M) companies, and the clients who engage them. They provide an overview of issues which should be taken into account to ensure the safe cleaning and maintenance of rooftop solar systems in the UK. They outline key obligations for those planning to and working on roofs, and information needed to make informed decisions about how to do so safely.

All rooftop solar O&M should be carried out by professional solar O&M companies.

2. Health and Safety

2.1. Recommendations:

- Ensure that health and safety is a core consideration for every activity undertaken as part of solar operations and maintenance.
- Have a competent person carry out a full, site-specific safety assessment prior to any solar system operations or maintenance work.

Those contracted to undertake works on solar installations must be able to demonstrate effective health and Safety (H&S) management. It is recommended that all contractors meet an internationally recognised standard of H&S management. The UK recognises International Organization for Standardization certifications and there are other safety management schemes.

Site and task-specific H&S documentation must be written by a competent person who has received suitable training and instruction, and made available to all workers prior to attending and while on site. The HSE definition of a competent person is:

> *Someone who has sufficient training and experience or knowledge and other qualities that allow them to assist you properly. The level of competence required will depend on the complexity of the situation and the particular help you need.*

A Risk Assessment Methods Statement (RAMS) and other documentation specific to O & M and cleaning works should be delivered to all staff, and once understood, all persons are to sign and date to confirm they have read it. Workers should also be familiar with the roof and issues they are likely to face prior to arriving on site. This can be done via induction, site familiarisation and reviewing the RAMS, which should highlight site-specific risks and control measures.

Solar system maintenance, testing, inspection, and cleaning often involves accessing all areas of a site – and, most obviously, working at height – so each RAMS should pay particular attention to site-specific issues. To enable this and ensure the RAMS serves its purpose, it should be discussed and agreed with the solar system client or owner prior to work commencing. This will enable contractors to identify and control foreseeable risks. The RAMS shall include all relevant risks, relating to topics including:

- Airborne diseases
- Communication between staff
- Date and competent person’s name and signature
- Electrocution
- First aid and emergencies
- Lone working
- Manual handling
- Site access / egress
- Site name and address
- Slips, trips, and falls
- Tasks to be undertaken
- Third party protection
- Training
- Weather

It is a legal requirement for all employers to have Employers’ Liability Insurance. The value of public and product liability insurance required for contractors working on solar installations will be determined by contract.

Clients must exercise due diligence when selecting a contractor for their O & M work. It is recommended that clients request and scrutinise risk assessments, safe systems of work and method statements, training records, and insurance policies as part of this due diligence. Clients should use an experienced, reputable contractor which follows the minimum requirements set out in this document and use a company which adheres to all legal requirements. Should any contractor or worker deem a site or job unsafe they should cease activities pending further investigation.

Further information on these issues is included in the sections below.

3. Training

3.1. Recommendations:

- Carry out an annual audit of all staff training needs and develop individual plans to ensure relevant skills and knowledge are kept up to date.
- Ensure all training is carried out by an accredited organisation.

3.2. Overview

As the UK solar operations and maintenance (O&M) industry has developed, numerous issues have arisen relating to accessing and maintaining safe access to rooftop solar systems. This section of the Guidelines highlights the training available to help control access and other risks.

The training listed below is a sample of what could be required. All training should be carried out by accredited training providers, such as the Royal Society for the Prevention of Accidents, the Health and Safety Executive, the Construction Industry Training Board, or similar. Relevant training topics include:

- Asbestos training.
- Control of substances hazardous to health.
- Driving training for trailers and 4x4 vehicles.
- Electrical awareness.
- Emergency rescue at height.
- Fire awareness.
- Harness training.
- Job task-specific training.
- Ladders.
- Lone working.
- Manual handling.
- Personal Protective Equipment (PPE).
  Powerboat licences, for floating solar, and associated training relating to launching, docking, tying off, boarding and offboarding for staff and fuelling, as well as other issues.
- Prefabricated access suppliers’ and manufacturers’ association (PASMA) training, for scaffolding erection.

- Safety Health and Environmental Awareness Passport (such as the CCNSG, CSC or other schemes).
- Slips, trips and falls.
- Using water around electrical equipment.
- Working at height.
- Writing Risk Assessment Method Statements.

3.3. Essential steps

As with all aspects of O&M, any O&M contractor or staff member accessing any roof should be trained to do the work at hand. All work must also be risk assessed, with suitable controls applied.

Three key steps should be taken into consideration.

First, a site-specific risk assessment should be undertaken by a trained and competent person, in conjunction with the HSE's five steps to risk assessment document, and using the working at height hierarchy outlined below. A risk assessment and method statement (RAMS) should be the cornerstone document for any working at height. All O&M staff should have a good knowledge of what a RAMS is, and how it applies to them and to the task at hand. A RAMS should be written for each task that will be completed on a rooftop solar array. Because roofs are often unique in design and layout, the RAMS for solar O&M work should be site-specific.

A Hierarchy of Control Measures (HCM) should be followed to avoid and manage risk when working at height – on a roof or elsewhere. This HCM is:

- Avoid working at height, if possible.
- Use an existing safe place of work.
- Provide work equipment to prevent falls.
- Mitigate the distance and consequences of a fall.
- Instruction and training and/or other means.
- The RAMS and HCM should shape your organisational training.

Second, you should decide what your training needs are. It is important that your staff have the appropriate skills and knowledge to be able to work at height, such as on a solar roof, safely. To do this, you need to:

- Identify the type of person capable of doing the work for a particular project.
- Identify the skills and knowledge needed for people to do their job in a safe and healthy way. Compare these against people's current skills and knowledge and identify the gaps.
- Identify and implement product-specific training necessary for equipment including solar modules, power optimisers and inverters.
- Review your experience of injuries, near misses, or cases of ill health, including where these may relate to work at height.
- Look at your risk assessments to see where information and/or training have been identified as factors in controlling risks.

- Consider awareness training needs for everyone, including directors, managers, and supervisors, including:

    - How you manage health and safety.
    - Who is responsible for specific tasks.
    - The cost to the business if things go wrong.
    - How to identify hazards and evaluate risks.
    - The hazards encountered and measures for controlling them.

Third, you should decide what your training priorities are. Your training priorities should be under constant review:

- As part of standard organisational procedures.
- To ensure that the site-specific risks of new clients are taken into consideration.
- To ensure new and existing staff skills are kept up to date.
- To ensure that requirements for new equipment and technology are covered.

You could consider accredited e-learning for training staff, where this is appropriate. E-learning can support workforce-wide learning at a reasonable cost and is time effective. Staff do not have to travel to a destination for e-learning. It can be carried out at their place of work or their own home.

To help decide what your training priorities should be, things to consider include:

- Whether the law requires you to carry out specific training (e.g. first-aid training).
- Where a lack of information and / or training might result in harm.
- How many staff will benefit.
- New recruits or those new to the working environment.
- People changing jobs, working practices, or taking on new responsibilities.
- People using new equipment.
- Employees' views, or those of their representatives.
- That you must provide training during working hours, and not at the expense of your employees.

Further information on training is available from the HSE.

3.4. Legislation

The Health & Safety at Work Act 1974 requires any employer to provide whatever information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of their employees.

This is expanded on in the Management of Health and Safety at Work Regulations 1999, which apply a specific duty to undertake risk assessments, and notes the importance of appropriate and continual training relating to relevant risks associated.

Maintenance is considered as construction work, and so the Construction (Design and Management) Regulations 2015 also apply. The Safety Representatives and Safety Committees Regulations 1977 and the Health and Safety (Consultation with Employees) Regulations 1996 require you to consult your employees, or their representatives, on health and safety issues. Representatives appointed under either of these sets of regulations are entitled to time off with pay for training in their duties.

Other regulations include specific health and safety training requirements, for example relating to asbestos, driving, and first aid. It is the responsibility of each company to decide what their employees' training needs are.

Working on rooftop solar systems involves working above ground. The Work at Height Regulations 2005 (WAHR) replaced the working at height parts of the Construction (Health, Safety & Welfare) Regulations 1996.

The WAHR have no minimum height requirement for work at height. They include all work activities where there is a need to control a risk of falling a distance liable to cause personal injury. This is regardless of the work equipment being used, the duration the person is at a height, or the height at which the work is performed. It includes access to and egress from a place of work. For rooftop O&M, this may include:

- Working on a scaffold or from a mobile elevated work platform (MEWP)
- Working on the back of a lorry, e.g. sheeting a load
- Arboriculture and forestry work performed in trees that are overhanging or near to solar arrays
- Using cradles or ropes to gain access to parts of a building
- Painting, pasting or installing signage at height
- Using a ladder/step ladder for access or for carrying out other maintenance tasks such as changing a pyranometer

More information on working at height is available from the HSE.

4. Roof access

4.1. Recommendations:

- Ensure that provision for safe roof access is discussed in advance of arrival at site with all relevant parties.
- Ensure that anyone who will be accessing a roof is fully trained by an accredited provider and has access to the necessary equipment, which meets all relevant standards.

4.2. Overview

Rooftop solar O&M has numerous issues not associated with ground mounted O&M work. Most obviously, workers are operating above ground, and so there is a risk of injury from falls and other access. A key issue is therefore how workers access and operate on rooftop solar systems. This section provides an introduction to issues surrounding roof access that present risks to O&M contractors.

Each O&M company should have a process in place for the event of a member of their staff arriving at site to find that any access is not fit for purpose, and what protocol is to be followed. O&M workers should not feel obliged to use a particular form of roof access simply because it is there, or because the client is in front of them.

A key document to consult on roof safety issues if the Health and Safety Executive's Health and safety in roof work.

4.3. Planning to work at height

The core task for safety on a roof is to ascertain from the building owner, or someone with the skills, knowledge and experience to determine it, what the condition of the roof is before accessing it. The building owner or those in charge of the maintenance of the building have a responsibility under the Construction (Design and Management) Regulations 2015 to check and ensure the roof is safe to access.

As part of this, the client should provide a range of important information before work comments, including on:

- Site rules and an induction.
- Fire and emergency procedures.
- Signing-in and signing-out procedures, and any permit-to-work procedure (for example, Working at Height or Roof Access Permits).
- Segregation and emergency evacuation arrangements.
- Specific site hazards that the surveyor needs to be aware of. This might include:
- Fragile roof materials
- Live electric
- Asbestos-containing materials
- Vehicle movements
- Process hazards, such as fumes and extraction.
- Welfare facilities including first aid procedures.

4.4. Emergency evacuation

Being able to get off a roof in an emergency is extremely important. Arrangements for roof evacuation should be discussed and factored into a Working at Height rescue plan, to form part of the Risk Assessment Methods Statement (RAMS).

4.5. Segregation arrangements

Arrangements should be discussed and made in advance of rooftop solar system maintenance and cleaning to ensure that workers are segregated from the building's users, as well as members of the public, where relevant. This is to prevent accidents and incidents. Segregation arrangements may also be needed to protect rooftop workers from activities being carried out within the building itself – for example, manufacturing processes.

4.6. Fall prevention

As part of Working at Height planning, fall prevention arrangements should be reviewed and organised as necessary. These can include edge protection, such as railings installed around the edge of a roof, and the use of personal fall arrest systems, such as harnesses.

4.7. The Working at Height Hierarchy

The Working at Height Hierarchy is a key tool to support control decisions. It should be used to inform the design of a site-specific RAMS, based on detailed site information. This can be obtained by way of a site survey prior to a quotation being provided to the client, or by the client providing photographs of the risks on their site, along with existing roof access arrangements, if present.

Open communication with the facility owner is very important. O&M staff must understand all risks before they arrive on site, and ensure they have suitable PPE with them.

The following are all requirements in law that you need to consider when planning and undertaking work at height. You must:

- Take account of weather conditions that could compromise worker safety, and other potential hazards such as power lines or other cables.
- Check that the place (eg a roof) where work at height is to be undertaken is safe. Each place where people will work at height needs to be checked, each time, before use.
- Stop materials or objects from falling or, if it is not reasonably practicable to prevent objects falling, take suitable and sufficient measures to make sure no one can be injured, eg use exclusion zones to keep people away, or mesh on scaffolding to stop materials such as solar panels falling off.
- Store materials and objects safely so they will not cause injury if they are disturbed or collapse.
- Plan for emergencies and rescue, eg agree a set procedure for evacuation. Think about foreseeable situations and make sure employees know the emergency procedures. You should not rely solely on the emergency services for rescue in your plan.

4.8. Condition of equipment

Work equipment, for example scaffolding, needs to be assembled, installed and kept in good condition, according to the manufacturer's instructions and in keeping with industry guidelines.

Where the safety of the work equipment depends on how it has been installed or assembled, an employer should ensure it is not used until it has been inspected in that position by a competent person. In the solar industry, MEWPs, scaffolding and mansafe systems are all examples of such equipment. No roofs should be accessed or worked on without knowledge by the O&M contractor that this equipment has been tested by a competent person.

Mansafe and other safety system equipment should be checked regularly. No uncertified or out of date equipment should be used.

According to the HSE, a competent person is:

Someone who has sufficient training and experience or knowledge and other qualities that allow them to assist you properly. The level of competence required will depend on the complexity of the situation and the particular help you need.

Any equipment exposed to conditions that may cause it to deteriorate, and which may therefore result in a dangerous situation, should be inspected at intervals appropriate to the environment and use. An inspection should be carried out every time something happens that may affect the safety or stability of the equipment, such as adverse weather or accidental damage.

Employers are required to keep a record of any inspection for types of work equipment including:

- Guard rails, toe-boards, barriers or similar collective means of protection.
- Working platforms (any platform used as a place of work or as a means of getting to and from work, eg a gangway) that are fixed (eg a scaffold around a building) or mobile (eg an MEWP or scaffold tower).
- Ladders.

Any working platform used for construction work and from which a person could fall must be inspected:

- After assembly in any position
- After any event liable to have affected its stability
- At intervals not exceeding seven days

Where it is a mobile platform, a new inspection and report is not required every time it is moved to a new location on the same site. You must also ensure that before you use any equipment, such as a MEWP, which has come from another business or rental company, it is accompanied by an indication (clear to everyone involved) of when the last thorough examination has been carried out.

4.9. What must employees do?

Employees have general legal duties to take reasonable care of themselves and others who may be affected by their actions, and to co-operate with their employer to enable their health and safety duties and requirements to be complied with. For an employee, or those working under someone else's control, the law says they must:

- Report any safety hazard they identify to their employer.
- Use the equipment and safety devices supplied or given to them properly, in accordance with any training and instructions (unless they think that would be unsafe, in which case they should seek further instructions before continuing).

You must consult your employees (either directly or via safety representatives), in good time, on health and safety matters. Issues you must consult employees on include:

- Risks arising from their work.
- Proposals to manage and / or control these risks.
- The best ways of providing information and training.

Employers can ask employees and their representatives what they think the hazards are, as they may notice things that are not obvious and may have some good, practical ideas on how to control the risks. As noted previously, the HSE provides information on how to consult employees.

4.10. Ladders

Internal or external vertical access ladders are often fitted to buildings to provide roof access. Ladder types include:

- Standard Vertical Access Ladder.
- Standard ladder with cage.
- Standard ladder with walk-through.
- Standard ladder with cage and walk-through – this is one of the most common types of ladder.
- Standard ladder with walk-through and parapet stepover platform.
- Standard ladder with cage and retractable lower section.

Note that the focus on ladders in this document is not a presumption in favour of their use. Access via a mobile elevated work platform, scaffolding, or an internal staircase is preferable, where available. The guidance here is extensive in order to ensure that where ladders must be used, they are used safety.

Not all ladders will be appropriate for use. For example, those with a cage may be too tight for a worker to climb with a backpack, while all ladder access, vertical or sloped, requires three points of contact by the operative at any one time: one hand and two feet, or two hands and one foot. This means that no materials or tools can be carried by hand.

As such, in some cases vertical fixed ladders have been fitted to buildings specifically for solar O&M work, but they cannot be used.

To avoid this, it is advisable that vertical ladders are not fitted to buildings during the design phase of any solar array. Instead, where possible a fixed staircase should be installed.

Research into the fall arrest protection of vertical ladders is available from HSE. This shows that sloped access staircases provide workers with safer roof access.

4.10.1. Ladders and the law

Ladders and stepladders can be a sensible and practical option for low-risk, short-duration tasks, although they should not automatically be your first choice. Make sure you and your staff use the right type of ladder, and you know how to use it safely. The law calls for a sensible, proportionate approach to managing risk and thought should be given in regard to deciding if a ladder is the right type of equipment for a particular task.

4.10.2. When is a ladder suitable?

The law says that ladders can be used for work at height when:

- A risk assessment has shown that using equipment offering a higher level of fall protection is not justified, because of the low risk and short duration of use.
- There are existing workplace features which cannot be altered.

Note that duration is not the deciding factor in establishing whether use of a ladder is acceptable or not – you should have first considered the risk. As a guide, if your task would require staying up a leaning ladder or stepladder for more than 30 minutes at a time, it is recommended that you consider alternative equipment. You should only use ladders in situations where they can be used safely: where the ladder will be level and stable, and, where it is reasonably practicable to do so, the ladder can be secured.

4.10.3. Who can use a ladder at work?

To use a ladder you need to be competent. This means you have had instruction and understand how to use the equipment safely. Appropriate training will help. If you are being trained, you should work under the supervision of somebody who can perform the task competently. Training can often take place on the job.

The law should be followed when assessing risk relating to ladders being used as part of O&M, and best practice would see employees using ladders have some form of formal ladder training.

4.10.4. Ladder condition

Where a vertical ladder is suitable for the O&M contractor to safely complete their task, they should follow the requirements of relevant regulations and standards. These include the Workplace (Health, Safety and Welfare) Regulation Approved Code of Practice and Guidance and British Standard 4211. Key ladder considerations to check include that:

- The ladder is of sound construction, properly maintained, and securely fixed.
- The assembly is sufficiently rigid and stable to ensure safety of the user under normal conditions.
- Handrails extend at least 1100mm above landing.
- Stiles should extend to the height of guarding.
- The ladder should not exceed 6m without an intermediate landing
- Hoops should be fixed if the ladder exceeds 2.5m.
- Fall protection, preferably passive such as cages, should be provided if there is a risk of falling more than 2m.
- Handrails should open out to between 600mm and 700mm above the landing.
- The top rung should be level with the platform.

Communication with the facility user and the RAMS is very important when deciding if a ladder is safe for use. It may be that a ladder has been damaged since its last use, rust has started to appear, or there are other problems with its condition.

Employers need to make sure that any ladder or stepladder is suitable for the task and in a safe condition before use. As a guide, only use ladders or stepladders that:

- Have no visible defects. The ladder should have a pre-use check by each user prior to use.
- Have an up-to-date record of the detailed visual inspections carried out regularly by a competent person. These should be done in accordance with the manufacturer's instructions. Ladders that are part of a scaffold system still have to be inspected every seven days as part of the scaffold inspection requirements
- Are suitable for the intended use – in other words, that they are strong and robust enough for the job. HSE recommends British Standard Class 1 'Industrial' or BS EN 131 ladders for use at work
- Have been maintained and stored in accordance with the manufacturer's instructions

4.11. Mobile elevating work platforms

The use of a Mobile Elevating Work Platform (MEWP) entails specific training, inspection and maintenance requirements. This section includes information from the HSE. Information is also available from the International Powered Access Federation.

4.11.1. Training and competence

According to HSE, MEWP operators should have attended a recognised operator training course and hold a certificate, card, or ‘licence’, listing the categories of MEWP the bearer is trained to operate.

The expiry date of the training licence or card should be checked.

In addition to formal training for the type of MEWP, operators should have familiarisation training on the controls and operation of the specific make and model of MEWP they are using.

4.11.2. Inspection, maintenance, and examination

A programme of daily visual checks, regular inspections and servicing schedules should be established in accordance with the manufacturer’s instructions and the risks associated with each MEWP.

Operators should be encouraged to report defects or problems. Reported problems should be put right quickly and the MEWP taken out of service if the item is safety critical.

The MEWP must be thoroughly examined at least every six months by a competent person or in accordance with an examination scheme drawn up by such a competent person.

4.12. Scaffolding

Scaffolding is another form of roof access commonly used in solar O&M activities. There are two types of scaffolding: fixed (traditional-style), and mobile.

Mobile scaffolding should only be used as a working platform, not for access/egress to a roof. Fixed scaffolding should never be altered, except by a suitably qualified person.

A scaffold should be assembled to a recognised standard configuration, such as the NASC Technical Guidance TG20 for tube and fitting scaffolds. The scaffold should be designed by bespoke calculation, by a competent person, to ensure it will have adequate strength, rigidity and stability while it is erected, used and dismantled.

Information should be shared prior to attending a site, and scaffolding should form part of that conversation. Included should be a hand over certificate and checking of ‘scaf tags’ and other relevant factors. Further information on the use of scaffolding is available from the HSE.

4.13. Hatches

An alternative way to access a roof is through a hatch in the building below. Roof hatches are fitted at ceiling level, and often serve a dual, fire protection purpose as a smoke vent.

As with ladders, roof hatches can present safety risks to workers accessing roofs. The main issue is often the position of the roof hatch in relation to the roof edge. Roof hatches should not be located in dangerous positions – for example, near to the roof edge, where any person accessing the roof may be exposed to the risk of falling.

Incorporating roof edge protection makes for safer and easier access to rooftop solar systems.

4.14. Fragile roofs and roof hazards

Roofs have different design and strength characteristics, which can contribute to accidents and injuries. Falls through fragile surfaces, such as fibre-cement roofs and skylights, can cause fatal injuries. This topic is therefore very relevant to rooftop solar O&M. Everyone involved in this type of work, including clients, designers and contractors, should treat falls through fragile surfaces and roof hazards as a priority.

4.15. Skylights and rooflights

Workers undertaking roof work and building maintenance can fall through fragile surfaces or skylights, and particular care should be paid to identifying and avoiding the risk of this happening. It should be assumed that all skylights are fragile until proven otherwise. Fixed and temporary covers can both be effective in preventing falls through skylights.

4.16. Fragile surfaces

Fragile surfaces and materials will not safely support the weight of a person and the materials they may be carrying.

All roofs, once fixed, should be treated as fragile until a competent person has confirmed that they are non-fragile. This demonstrates the importance of gaining information from clients or owners on the solar installation in question before work begins.

The following aspects of a roof, in particular, may be fragile:

- Fibre-cement sheets – non-reinforced sheets, irrespective of profile type
- Rooflights – particularly those in the roof plane that can be difficult to see in certain light conditions, or when hidden by paint
- Liner panels – on built-up sheeted roofs
- Metal sheets – where corroded
- Glass – including wired glass
- Chipboard – or similar material where rotted

- Others – including wood wool slabs, slates and tiles

4.16.1. Fragile surface precautions

Effective precautions are required for all work on or near fragile surfaces, no matter how short the duration, or whether the work concerns construction, maintenance, repair, cleaning or demolition. The HSE publishes a free guide which provides full details of the dangers presented by fragile surfaces and the precautions available. This guidance should be consulted by all involved in such work.

The hierarchy of steps to be taken to deal with the danger is:

- Avoidance: Plan and organise work to keep people away from fragile surfaces as far as possible. For example, this includes working from below the surface on a mobile or other suitable platform
- Control: Work on or near fragile surfaces requires a combination of stagings, guard rails, fall restraint, fall arrest and safety nets slung beneath and close to the roof
- Communication: Warning notices must be fixed on the approach to any fragile surface. Those carrying out the work must be trained, competent and instructed in use of the precautions required
- Co-operation: On business premises, contractors should work closely with the client and agree arrangements for managing the work

4.16.2. Roof type and condition

Roof conditions can vary depending on pitch, orientation, local environmental factors, such as work completed on site, and weather on the day of work. Below are three common rooftops:

- A domestic pitch tiled roof.
- A commercial flat roof.
- A commercial sheeted roof.

Slips, trips and falls are possible on all types of roofs, and this should be taken into account in planning. Roof materials also vary, and provide differing levels of stability and underfoot grip. North-facing slopes of roofs often provide more of a risk due to their receiving less sunlight. This makes them more prone to algal and lichen growth, both of which can be slippery underfoot. This can also be the case on flat roofs at zero degrees, due to the lack of water run-off.

5. Monitoring

5.1. Recommendations:

- Consider how best your solar system can be monitored to prevent faults and optimise performance
- Consider what connectivity requirements may be required as part of system design.
- Consider the most appropriate monitoring solution or provider at design stage.

5.2. What is monitoring

Monitoring is the process of constantly checking the power and other performance characteristics of a solar PV system, such as the electricity generated, temperature of key components. This can help identify faults and optimise system performance, by providing an indication of when a system needs investigation by trained and authorised engineers.

Monitoring can be performed based on information received at different levels of a solar installation: for example, the meter, inverter, or strings. Monitoring systems can be installed at installation stage or retrofitted later on. The monitoring requirements and equipment needed for a solar system should be discussed in consultation with a professional solar company as part of the design of a project, or as part of the establishment of an O&M contact with a professional O&M provider.

5.3. Why is monitoring important?

Monitoring is important for three key reasons:

- Safety: a faulty solar system is a potential hazard to people working within a building, or those working to maintain the system. Early monitoring can indicate and provide analysis of any faults that arise which may pose a safety concern.
- Fault alarms: for all system sizes these are usually to identify a system not generating, not communicating, or underperforming.
- Revenue: loss of power production due to faults, soiling and downtime can be more expensive than proper monitoring. Monitoring can help build up a historic database of system performance information, which can enable the identification of component issues, the optimisation of revenue, and the presence of excessive dirt, lichen and other substances, and hence help inform cleaning requirements.
- Insurance: in the case of an insurance claim, owners may be asked to demonstrate that they were diligent in their operation and maintenance of a solar system, including monitoring the system for faults and other issues.

5.4. Monitoring system components and issues

Solar PV monitoring involves three main sets of parts and issues:

- Hardware: the physical components of a system.
- Software and data management.

- Connectivity and cybersecurity.

Key data a monitoring system can collect include:

- Irradiance (light), via a pyranometer.
- The temperature of the system and its components.
- Local meteorological conditions, such as the ambient temperature, rainfall, irradiation, and windspeed.
- Power generated, consumed, and exported on site.
- Alarm / fault data, to generate and manage specific system alerts. This might be, for example, an underperformance trigger – when a system is not producing as much power as expected.

A monitoring system will enable this information to raise reactive faults as per contract and system definitions. The information can be translated into a performance report for the solar system. This can then be analysed by a monitoring specialist, who will be able to analyse the report – for example, by comparing the actual power yield from a system against what might be expected for it – to identify other problems. For example, they may be able to infer soiling from the performance data, because this limits irradiance and hence reduces the energy yield. There should be a clear journey for owners to receive and act on this information, managed through the monitoring platform including:

- Fault alarm
- Client / solar professional fault triage, via a desktop or other process.
- Engineering visit and development of associated reports
- Remedial action as necessary

The overall management approach can be reactive – responding to problems as they arise – preventive – taking action to forestall problems developing – or a combination of both. This should be discussed and agreed with the O&M provider.

5.5. Installation

As with all aspects of a solar array, monitoring systems should be installed and operated according to product and manufacturer specifications, by trained professionals. All relevant documentation and manuals should be provided and kept for the life of the system.

5.6. Aerial inspection

One form of data collection for monitoring purposes is thermographic imaging via aerial inspection. Typically conducted by drones, thermographic inspection is the use thermal imaging cameras to produce a visual picture of where there may be problems with the solar equipment, such as fault panels.

5.6.1. The aerial inspection process

Drone-enabled aerial inspections are typically a three-part process, involving the capture of thermal imagery data, the processing and analysis of that data, and the delivery of a report with the findings from that data. The process works as follows:

- First, a drone is flown over the PV asset being inspected, typically with a pre-programmed flight path. Doing so allows for precise and repeatable flights to be performed, increases the accuracy of results, and ensures the same parameters are used during each subsequent aerial inspection.
- During these flights, the drone will fly capture high resolution video or images, usually including information used to geolocate anomalies.
- After the flight and data capture has been completed, the data is then processed and analysed for anomalies (such as panel soiling, cracking, or hot spots).

The last step in the process is the delivery of the findings of the inspection, in either a report or through a software platform.

5.6.2. Health and safety

Drone-enabled inspections can avoid the health and safety risks involved in manual inspections, such as those related to working at height, tripping, accidental damage to components, and exposure to the weather.

5.6.3. Recommendations for Drone-Enabled Inspections

Drone-enabled inspections as part of rooftop O&M can be used on a variety of systems. As the size of installation increases, the time and cost savings of drone vs manual inspections may become more attractive. For smaller PV arrays, such as residential installations which can be relatively quickly and easily inspected manually, drone-enabled inspections may not be so relevant, for the time being. However, there is emerging interest in using drone service providers to inspect a larger group of residential solar systems at once.

Drone-enabled inspections can be performed either in-house or through the use of a third-party service provider. Factors to keep in mind when deciding on whether to perform these inspections in-house or to use a third party include the following:

- **Pilots:** Drones should only be operated by pilots who are licensed and registered to operate a drone commercially in accordance with Civil Aviation Authority and any local regulations. The pilots should also be insured and up to date on the technology in use, appropriate industry guidelines (such as IEC TS 62446-3:2017), and changes in rules, regulations, and requirements. The drone pilot will need to perform thorough pre-flight planning from a regulatory, logistical, and safety perspective, as well as recording all necessary risk assessments, and flight log data (including time, date, weather conditions, and equipment inspection information).

- **Equipment:** Drone equipment can be costly and require advanced knowledge of proper operation, upkeep, and repair. Drones require dedicated personnel to ensure up to date knowledge of their technology, rules, and regulations.

- **Data processing and analysis**. Data processing and analysis can be performed manually or using specialised software. When choosing a software or service provider it is important to think about things like ease of use, the features available, and the deliverables that they offer.

- **Size and spread of asset portfolio**. With larger portfolios of multiple rooftop assets, particularly those spread out geographically or internationally, it can be difficult to keep up a regular drone-enabled inspection practice in-house. The person in charge of any in-house programme will also have to ensure the inspection methodologies, standards, and reporting are consistent across regions.

  Specialised drone service providers will typically take all of these into account in their service delivery, with access to networks deploying licensed, certified and insured pilots with the proper equipment, who are familiar with the software, flight planning and execution requirements.

- **Services required.** Third-party drone service provides should be able to provide a flexible set of inspection services that can be tailored to meet client requirements relating to the frequency, scope and type of inspection and reports needed. Drone service providers typically also offer a wide suite of services over and above thermographic inspections. These span the entire solar PV lifecycle, from planning, engineering and procurement through construction and commissioning to the 30+ years of operation each PV asset is expected to deliver. Examples of such services include rooftop modelling, shading analysis, construction progress monitoring, and capturing visuals for marketing materials.

5.6.4. Monitoring connectivity and security

- Connectivity

  Residential and commercial/industrial solar systems work on a remote access basis. The inverters and data loggers are designed to send and receive the data collected through monitoring systems, aerial inspection or any other method, which is collected in the monitoring system and accessed via an online platform to which owners and operators have access. It is therefore essential for monitoring that a solar system is connected to a reliable internet network, with sufficient bandwidth for the system to send and receive data. Alternatively, connection to the monitoring platform can be via the mobile data network. The most appropriate approach will depend on system size, the type of components providing data (from total generation meter to inverters), and infrastructure: for example, whether there is an internet connection or any mobile reception to facilitate communication, and cost considerations.

- Cybersecurity and renewable energy assets

  As a solar PV system is effectively a micro power plant, its data may have commercial or other sensitivities, and relevant cybersecurity measures should be applied.

  Cybersecurity refers to technologies, processes and controls that are designed to protect systems, networks, devices and data from attacks and unauthorised access. With respect to renewable energy assets such as solar systems, each control with physical or digital access presents a potential intrusion point. Access must be controlled and data integrity maintained at each accessible point. Many renewable systems use advanced controls, digital sensors, and network architectures near generation sources. These should be adequately secured. Examples of components and systems that require consideration include:

  - Alarm systems (intruder detection and environmental)
  - CCTV
  - Communications
  - Field sensors
  - Weather and environmental data sensors
  - Inverter control and monitoring systems
  - Networking architecture and routers
  - Supervisory control and data acquisition
  - Substation control system

5.6.5. State of the industry

Cybersecurity has not been a major consideration during the design phase for many renewable energy assets operating in the UK to date. The inclusion of off-the-shelf communication systems has been an industry norm, and key components have not been selected with regard for cyber security concerns.

There is also a lack of clear policies and regulations to follow, while buyers and their technical advisors have in some cases not properly scrutinised the cybersecurity aspects of transactions.

As a result, asset owners in the UK may not know where their generation data is stored, how secure their connections are, and who may have access to their systems and information. There are commercial and other risks associated with this. For example, every digital access point is a potential site of intrusion, which could lead from issues including the infiltration of ransomware and viruses, to more serious cases including loss of access to monitoring and performance data, and the leaking of sensitive personal and business information. This can impact the ability of generators to fulfil time sensitive contracts, where live management of plants is required. This can also cause grid and other system balancing issues, if generators do not know how much power they are producing.

Leaving a solar system unprotected, with the right behavioural and technical protection measures, will expose the system owner to cyberthreats.

Cybersecurity assessment goals and mitigation measures

To prevent and mitigate against these risks, asset owners and operators should develop a cyber security strategy. This should include assessing and considering:

- The potential losses which might result from a cyberattack, compared with the cost of implementing relevant security measures.
- Implementing inexpensive and easy-to-implement measures as a minimum, such as:
    - Updating passwords on a regular basis, as with all password-protection systems.
    - Using professional hardware with embedded firewall and other security systems
    - Not connecting multiple devices to the same network, if possible. Instead, a dedicated Virtual Private Network for the solar PV system could be considered. Wireless connections should be avoided if possible.
    - Ensuring network traffic checks are part of annual inspections.
    - Checking and restricting physical access. A simple sensible password management system should be in place. When there is a change of an employee, on either owner or service provider side, passwords should be reset.
    - Upgrading to hardware.
    - Ensuring software and firmware is kept updated, with relevant anti-virus firewalls and software installed

Solar system owners and operators should also consider developing a dedicated cybersecurity policy. This could include:

- Carrying out site and portfolio-level risk identification, prevention and mitigation assessment as part of the standard suite of inspections and assessments.
- Ensuring staff are professionally trained. This is particularly important because many cybersecurity risk is tied to human behaviour.
- Updating all cybersecurity planning is reviewed on an annual basis, to reflect that fact that digital technology evolves rapidly.

6. Maintenance checklists

6.1. Recommendations:

- Identify product and system-specific inspection tasks and frequency
- Ensure provisions are made for a competent person to carry these out, as necessary

As with other installed technology and appliances (for example, domestic and commercial boilers), all solar PV systems need professional inspection and maintenance to identify and resolve technical and other problems before and as they arise. Planned professional maintenance is important for:

- The mechanical and electricity safety and security of a system.
- Performance and longevity.
- Ensuring the system meets its owner's expectations.

This section provides a checklist of activities for rooftop solar inspection and maintenance activities. It includes suggestions for the tasks which can be carried out by an owner-occupier, and those which should only be carried out by a competent person.

Note that the suggested frequencies provided for non-domestic systems are recommendations for systems over 50KW in size. The Microgeneration Certification Scheme (MCS) has recently published an updated version of its Solar PV Standard, and Solar Energy UK recommends consulting this document for systems of less than 50KW in size, to which MCS applies.

All three-phase electrical systems should be professionally inspected on at least an annual basis. For systems over 100KW, a six-monthly check is advisable, and for systems over 500KW, quarterly checks are advisable.

6.2. Inspection checklist and frequency – occupier

This information in this section and the testing intervals proposed are based on the 18th edition of the British Standard 7671 IET Wiring regulations. Product and manufacturer guidelines should also be consulted, and building-specific issues considered in the development of a maintenance schedule.

Inspection task	Domestic	School and hospitals	Commercial, industrial, agricultural / other
Check that the system inverter(s) are producing, either through a monitoring platform, or the inspection of production	Weekly / daily if remote	Weekly / daily if remote	Weekly / daily if remote

on the generation meter, or of the inverter(s).	monitoring available	monitoring available	monitoring available
Check for signs of wear and tear, heat damage, discolouration and unusual smells, and conduct a visual inspection of inverter internal components for discolouration, corrosion, wear and damage.	Annual	Six-monthly	Annual
Check that there is no loose equipment or materials on the roof	Annual	Six-monthly	Annual
Check emergency shutdown procedure is displayed and visible.	Annual	Six-monthly	Annual
Check for visible damage to any part of the roof, condition of gutters or presence of moss/birds' nests (from ground level)	Annual	Six-monthly	Annual
Check the roof internally for any visible signs of damage/deterioration.	Annual	Six-monthly	Annual
Are any panels visibly broken/cracked?	Annual	Six-monthly	Annual
Check for panels that have moved/shifted out of alignment.	Annual	Six-monthly	Annual

6.3. Inspection checklist and frequency – competent person

The inspection intervals proposed below are based on the IET monitoring schedule. Product and manufacturer guidelines should also be consulted, and building-specific issues considered in the development of a maintenance schedule.

Inspection task	**Domestic**	**Schools, hospitals and commercial, public sector (depending upon classification)**	**Public sector (depending upon classification), industrial and agricultural / other**
Meter			
Are the correct labels in place?	5 – 10 years	Annual	Annual
Health and safety items			
Visual and document check to ensure that no alteration or addition to the installation will	Prior to installation of additions / alterations	Prior to installation of additions / alterations	Prior to installation of additions / alterations

compromise safety and the warranty.			
Is appropriate safety signage provided (dual supply label, system diagram, fire and rescue label).	5 - 10 years	Annual	Annual
Is appropriate safety signage provided on the junction boxes/isolators indicating electrical shock and are the junction boxes/inverters lockable?	5 - 10 years	Annual	Annual
Is a PV warning sign in place?	5 - 10 years	Annual	Annual
Are DC warning signs fitted on DC cables?	5 - 10 years	Annual	Annual
Is there any equipment or materials left on the roof following any works, solar or otherwise?	5 - 10 years	Annual	Annual
Are all access and egress points clean and unobstructed?	5 - 10 years	Annual	Annual
Are AC and DC cables correctly separated?	5 - 10 years	Annual	Annual
Is there sufficient ventilation around the inverters?	5 - 10 years	Annual	Annual
Roof condition (as relevant to the solar system)			
Check the roof internally for any visible signs of damage/deterioration.	5 - 10 years	Annual	Annual
Solar panels			
Check integrity of panels, replace as needed.	5 - 10 years	Annual	Annual
Mounting system - roofs			
Check mounting system secured / identify any slippage (for example, via a visual inspection of the array, and a pull-test on a sample of panels).	5 - 10 years	Annual	Annual

Check framing system for distortion.	5 - 10 years	Annual	Annual
Confirm the correct clamps remain in the correct position as per the manufacturer's design.	5 - 10 years	Annual	Annual
Check for exposed sharp edges to identify potential cable damage.	5 - 10 years	Annual	Annual
Check torque setting of a sample of clamp fixings as per manufacturer's design, if possible.	5 - 10 years	Annual	Annual
Is there any visible corrosion on any part of the mount or framing?	5 - 10 years	Annual	Annual
DC and AC cabling			
Check DC cables are secured adequately, have clear routes, and are free from stress and sharp edges, discolouring or damage.	5 - 10 years	Annual	Annual
Check AC cables are secured adequately, have clear routes, and are free from stress and sharp edges, discolouring or damage.	5 - 10 years	Annual	Annual
Confirm the isolation switch(es) work and are able to lock off.	5 - 10 years	Annual	Annual
Check and verify DC connectors are watertight, correctly torqued and secured, with the correct roof spacing, if possible.	5 - 10 years	Annual	Annual
Check junction boxes are correctly sealed (cable glands tightened and no water/dirt/dust ingress possible or visible) and clean where required (as applicable).	5 - 10 years	Annual	Annual
Are all internal junction box systems held firmly in place?	5 - 10 years	Annual	Annual

Are all earth cables (if applicable) fitted, secure and free from stress?	5 - 10 years	Annual	Annual
Check AC cable(s) from PV have not been compromised/modified, as relevant.	5 - 10 years	Annual	Annual
Inverters – as per manufacturer guidelines, if available			
Check integrity and functionality of inverters, record any warning or error messages. Note that assuming the inverter can be accessed safely, this could be carried out by the occupier.	As frequently as possible (consult product guidelines)	As frequently as possible (consult product guidelines)	As frequently as possible (consult product guidelines)
Visual inspection of inverter internal components (for discolouration, corrosion, wear, damage, etc).	5 - 10 years	Annual	Annual
Check functionality of ventilation system.	5 - 10 years	Annual	Annual
Clean/replace fans as necessary.	5 - 10 years	Annual	Annual
Are the covers and door locks as they should be? Check the humidity inside the cabinet.	5 - 10 years	Annual	Annual
Check and clean the heat exchangers, if applicable.	5 - 10 years	Annual	Annual
Can labelling be clearly read?	5 - 10 years	Annual	Annual
Clean/replace filters as necessary.	5 - 10 years	Annual	Annual
Check inverter is securely mounted on a fire rated board (if applicable).	5 - 10 years	Annual	Annual
Check functionality of any internal sensors, where applicable.	5 - 10 years	Annual	Annual
Check cables entering inverter are secured adequately and free from stress and sharp edges.	5 - 10 years	Annual	Annual

Check integrity of fuses and surge protectors, replace as needed.	5 - 10 years	Annual	Annual
Check all seals and glands are undamaged and secure to avoid water ingress as per IP65 rating.	5 - 10 years	Annual	Annual
Check DC isolator functional/operational. Note that this may not be required for all PV inverters.	5 - 10 years	Annual	Annual
Check AC isolator functional/operational.	5 - 10 years	Annual	Annual
Distribution labels			
Site specific schematics clearly displayed onsite.	5 - 10 years	Annual	Annual
Safe isolation procedure displayed on distribution boards.	5 - 10 years	Annual	Annual
Dual supply labels visible at the point(s) of connection.	5 - 10 years	Annual	Annual

Other inspection tasks which could affect performance and reliability include the following. Note that some of these may require specialist equipment or access:

- Checking for visible damage to the roof, the condition of gutters, and the presence of moss and bird nests.
- Checking panels for shading by nearby objects and trees.
- Thermal imaging of internal components and connections. This may be of greater value on sites with a large installed capacity.
- DC string testing to verify measurements of current, voltage and resistance, as per BS7671 (alternatively conduct series resistance testing).
- Checking all enclosure penetrations (entry points to the roof) are firmly tied, weather-proofed and fire-rated.

7. Fault identification

7.1. Recommendations:

- Develop a fault identification plan to monitor your system and its performance. This should be specific to the site and its equipment.
- Ensure that relevant work is only carried out by a competent person.

Fault identification is a crucial part of maintenance for domestic, commercial and industrial PV systems. The accuracy and timing with which faults are detected and addressed affects the performance of a solar system. Fault identification can help prevent failures and ensure compliance with H&S regulations.

Approaches to fault identification include remote monitoring and preventative maintenance, corrective action in response to an identified problem, and predictive maintenance to estimate when components may fail in the future. Commercial and industrial PV projects usually require assistance from third parties or PV specialists such as O&M providers, whereas domestic system users tend to rely on the advice from their PV system suppliers.

Fault terminology and coding can vary across the industry, according to each manufacturer and the equipment installed, although fault definitions to identify generation and underperformance are usual. One of the most common faults identified is linked to DC cable failures between the PV array and the inverters. These faults are sometimes referred to as a 'Riso fault', an 'insulation resistance fault', an 'isolation fault', or an 'error code 447'. The following table aims to categorise and describe the main type of faults and issues that can occur on a rooftop system, providing an overview of causes, indicators and corrective actions usually involved. Note that in order to carry out an assessment of faults, specialist electrical knowledge and training may be required.

Fault	Causes (including but not limited to)	Indicators	How to identify	How to resolve
RISO / Insulation Resistant faults	Water ingress/moisture-corrosion on MC4s and other connections -causing electrical resistance, poor installation of connectors, or damage to strings (due to sharp edges, rodents). Other potential causes include the use of incorrect connectors and cables, cables lying in water, cables not supported or mechanically protected deteriorating due to abrasion, the incorrect installation of string boxes, shorting due to gaps between the frame and glass, the incorrect installation of DC isolators and cables, and bird droppings, vandalism, extreme weather, and transport and installation damage.	Strings with no current, late starts, inverters underperforming, data from inverters and real-time monitoring systems.	Daily monitoring, subject to weather conditions, easier to identify faulty strings on site while raining, insulation resistant test	Replacing strings, readjusting/ replacing MC4s. For some products this may include turning off inverters to reduce the voltage below 50 volts per string. Carry out insulation resistance test on strings, using a high ohm insulation resistance meter set to 500 volts. Use the half split method to locate the isolation faults.

Broken modules / Micro cracks	Bird droppings, stones, vandalism /during transport and installation, extreme weather-expanding and contracting the cells	Snail trails, visible cracks, drop on performance or module efficiency, data from inverter sand real-time monitoring systems.	During panel cleaning and site inspections, through thermal surveys, electro-luminescence, I-V tests, compare monthly performance of the plan with same month on the previous year (over 1% difference)	Prevention-certified installers and reputable manufacturers. Replacing broken modules
Overheating of system component, arcing	Bad equipment configuration and setup, lack of ventilation, inverter fans or cooling system not working correctly, incorrect connectors used, damage to cable insulation, damage to modules	Data from inverters and monitoring that enables real-time reporting of underperformance	Inverters tripping due to MCBs overheating, marks on MCBs, thermal imaging to check temperature, visual inspection of components for discolouration, changes in connector shape, and cable suppleness	Installing new fans, shelter inverters, redesign, installation of arc detection
Hot spots and faulty diodes	Soiling, lichen, damaged module, shading	Using a product with MLPE, and monitoring that enables real-time reporting of faulty diodes	Thermal survey	Cleaning as required

Communication loss	Bad signal, adverse weather, faulty datalogger/ router /antennae	Using a product with monitoring that allows real-time reporting of loss of communication	Via monitoring platform	Reset datalogger remotely, reset/replace devices on site
Loose clamps / framework	Clamps not tightened properly. Bad installation	Loosen modules / blown off by the wind	Array inspections	Torque checks
Soiling and component damage due to wildlife	Animals (principally birds) nesting beneath or around panels	System yield not as expected and fire risk created	Visual inspection in response to monitoring or other fault identification data	Specialist removal of nests, and potential installation of bird deterrents to prevent re-occurrence

8. Cleaning

8.1. Recommendations:

- In coordination with a professional solar PV O&M provider, identify an appropriate cleaning schedule and regime for each solar system, on a site-by-site basis.
- Ensure that health and safety factors such as roof access, biohazards and adverse weather are incorporated into all cleaning planning and activity.

8.2. Overview

Solar PV systems generate electricity when light strikes the panels which form the system. This means their efficiency decreases when the panels are soiled, which can happen because of the weather or commercial or animal activity.

The inspection and cleaning of solar systems is therefore a crucial activity to maintain solar system performance. This can be undertaken as part of regular (preventative) maintenance, or in response to specific events (corrective or extraordinary maintenance). This section provides a description of these types of cleaning, and notes specific issues, such as water quality, which need to be taken into account.

8.2.1. Types of cleaning

8.2.2. Preventative maintenance

Preventative cleaning maintenance activities are the core element of maintenance services for a PV system. Regular panel cleaning and maintenance should include:

- Visual inspection of panels and their condition.
- Reporting damaged or broken panels and any other issues.
- The physical cleaning of the panels themselves.

Products with module-level power electronics and monitoring systems help enable real time reporting of underperformance. Where these have been used this should inform assessments of when cleaning should take place, using historical performance and other data.

Regular cleaning maintains equipment and reduces the probability of failure or degradation of the modules. An O&M contract should include panel cleaning in its scope of services. Provision should be made for extraordinary maintenance events also (see below).

As systems get larger, they warrant a greater level of attention. The frequency of scheduled maintenance for a solar array should be discussed with a professional solar PV O&M provider.

8.2.3. Corrective maintenance

There are times when panel cleaning is needed as a corrective measure. These are around activities that are expected and can be predicted. Most frequently this is seen in the agricultural sector where harvest time means that excessive dust is kicked up, which can settle on the solar panels. The movement of animals in and out of their living quarters can also create dust. To return production quickly, a panel clean may be required.

8.2.4. Extraordinary maintenance

Not all events which impact on roof mounted solar installations can be expected or predicted, and cleaning may also need to be undertaken in response to these. Such events might include:

- Lime spreading by farmers. This activity can kick up huge plumes of lime dust which can blow in the wind. This can land on solar panels on nearby roofs and cover the panels in a thick white dust. Lime can be very corrosive to people and some types of metal. If it is discovered that a nearby farm has been spreading lime and this has settled on the solar panels, cleaning should be performed to prevent damage to the framework of the solar panels.
- Bird nesting and strikes, which occur when a large population of birds gather on a roof and deposit droppings across a whole roof. Migratory birds often do this overnight, and the effect can damage the performance of a solar array, causing a drop in output. A clean will then be needed to remove the bird droppings and restore performance.
- Lichen growth is evidence that the solar panels are not being cleaned often enough. It is very difficult to remove from solar panels and can require chemical intervention, which requires specialist knowledge and training on hazardous substance control. Lichen removal should only be completed by a company with expert knowledge on how to do this.

8.3. Cleaning frequency

The frequency with which a solar panel system should be cleaned depends on many factors. These include manufacturer requirements, the specific local soiling issues, and the environment – for example, birdlife in the area – as well as the actual installation itself. Solar arrays in size, design, panel angle and roof type and access, among other differences.

It is therefore important that cleaning is considered on a site-by-site basis, on with the individual needs of the site and its level of cleanliness considered in the context of the cost of cleaning and any impact on financial performance. Systems with module-level power electronics, which allow real time reporting of performance, will help enable detailed assessments of when cleaning should take place.

8.4. Water use and equipment

Care should be taken when cleaning solar systems not to damage any panels or other components. Only equipment specifically designed for panel cleaning should be used to clean panels, and all machinery used on site must be fit for purpose. As with other equipment, workers operating cleaning tools must be properly trained and equipped.

8.5. Water quality

Water quality can be graded in different ways. Water with the lowest possible level of mineral content is best for solar panel cleaning. This is because mineral deposits can leave streaks and spots on solar panels. Mineral content in water is measured in parts per million (PPM) and measured using a total dissolved solids (TDS) meter. Asset managers, O&M contractors and end users can use a TDS meter to assess the level of mineral content in different sources of water.

8.6. Water temperature

The temperature of the water used to clean a solar system is an important consideration and mentioned in many installation and maintenance manuals. As with all rooftop maintenance and cleaning, the product-specific manuals should be consulted as part of the work planning process.

Manufacturers frequently recommend that cleaning take place in the early morning, late afternoon, or with a water temperature within a specific range of the panel temperature. The solar system’s product warranties and installation guides should be consulted for guidance on the water temperature to be used when cleaning solar panels. Failure to do so may result in thermal shock where cold water is sprayed on to hot glass, or vice versa. Particular care should be taken when dealing with very cold water and very hot glass, which is the most common cleaning scenario where thermal shock may present a risk.

8.7. Environmental management

All contractors should take care to minimise any negative affects their operations have on their surroundings and comply with legal requirements relating to the environment. Contractors should monitor and review their operations with a view to reducing environmental impacts in the long term. This is particularly the case when chemical cleaning is needed to remove heavy soiling.

There are many chemicals available that purport to be suitable for solar panel cleaning. However, many of these have not been tested for this purpose, and do not have the approval from solar panel manufacturers for use on their panels. If these are used, damage to the modules may occur and the warranty could be invalidated.

Considerations should be made by contractors relating to spillage of chemicals and fire control. Care must be taken to ensure chemicals do not enter water courses and where petrol/diesel is used, spill kits and fire extinguishers should be on hand.

8.8. Weather

Weather conditions should be monitored throughout cleaning operations. Panels should not be cleaned during storms or high winds. Doing so may increase the risk of electrocution and fire, and of panels becoming dislodged and injuring workers. As such, and as with all cleaning and maintenance, the planning for any cleaning and maintenance work should involve consulting manufacturer product specifications and guidelines.

8.9. Biohazards

There are two main hazards associated with panel cleaning on roofs. These are stagnant water in guttering, and the potential inhalation of fungus spores in bird droppings, which can become disturbed during cleaning and maintenance.

8.9.1. Stagnant water

Stagnant water is often seen on roofs when the guttering on the buildings are blocked. It can represent several risks to health, mainly caused by microorganisms in the water, with diarrhoea and vomiting the most common symptoms that can arise. The most common waterborne diseases that O&M personnel be exposed to include:

- Campylobacteriosis – through hand to mouth contact with water contaminated with faeces.
- Legionnaires' disease – Legionella is a very common organism that reproduces in high numbers in warm water.
- Leptospirosis – through contact with water contaminated by animal faeces.
- Cryptococcus – a yeast-like fungus found in pigeon droppings.
- Psittacosis – a respiratory infection caught from exposure to pigeon faeces.
- Salmonellosis – presents as food poisoning and is traced back to disease bacteria found in the droppings of pigeons, sparrows, and starlings.

8.9.2. Respiratory risks

While cleaning or working on solar panels, bird and animal faeces can disturbed and made airborne. Exposure to airborne gull faeces and other organic matter such as feathers, carcasses and nesting material may pose a health threat to people who come into contact with or inhale them. This includes histoplasmosis, which is a respiratory illness caused by inhalation of fungus that grows in dried bird droppings. Some solar sites are now installing bird scaring systems to help prevent problems associated with birds.

8.9.3. Mitigation

Care should be taken when working on or cleaning solar panels to prevent the risk of disease. As part of the site-specific risk assessment, mitigation measures should be considered and implemented to protect employees, including issuing appropriate PPE, as necessary.

9. Floating solar

9.1. Recommendations:

- Ensure that the challenges of operating and maintaining floating solar arrays are factored into the development and implementation of O&M.
- Ensure that specific health and safety risks which relate to working on water are identified and that appropriate measures are taken to prevent and mitigate them.

9.2. Overview

Solar arrays which float on water are beginning to become more widespread around the UK. Many installation and O&M principles hold true with floating solar, as with ground and roof mounted installations. However, there are also some unique challenges that if not recognised at the design phase can be either difficult or costly to rectify. The O&M budget for maintaining a floating solar array will likely need to be higher than either a roof or ground mounted system and this should be anticipated, calculated, and justified to the client at design phase. Points to consider include:

- **System design**. The design of the solar array should not be based purely on budget. A tight install budget may lead to higher O&M costs. Care and thought should be taken in the system design to ensure safe access and workplace conditions for future contractors. This will include access and egress points, emergency situations, cleaning, electrical servicing and maintenance issues.
- **Array access.** Access to and around the array needs to be carefully considered as part of floating O&M. Access to the array may be difficult, require a boat of a suitable type, and the array itself may lack a walkway and present other obstacles.
- **Cleaning.** Floating solar arrays can effectively create bird sanctuaries, which are ideal nesting sites for local and migrating bird populations. The guidance presented elsewhere in this document relating to fouling is therefore particularly relevant, and may result in increased costs for floating solar systems. This should be explained to clients.
- **Monitoring and maintenance.** As with other solar systems, visual and other inspections should take place at an interval appropriate to the project and recommended by a professional solar O&M company. Floating solar arrays will require additional checks relating to the buoyancy, mounting, anchorage and other equipment required for this type of system, some of which may need to be carried out by divers.
- **Health, safety, training and qualifications.** Floating solar contractors may require additional skills, training, knowledge and equipment relating to the fact that the O&M work is taking place on water, which is potentially very dangerous. For example, first aid training should cover water-related injuries and the risk of drowning.

10. Security

10.1. Recommendations:

- Carry out a review of site security and anti-theft measures and consider if they offer an adequate level of protection.
- Report any instances of solar crime to Solar Energy UK, who are producing a database to support anti-theft activity

10.2. Overview

Solar power systems and associated equipment are an attractive target for thieves. With theft on the increase, enhanced security is something to be considered.

Determined thieves will consider multiple ways to attack a target, but will also always look for the easiest option. Anything you can do to make your system more secure and less attractive to thieves is a worthwhile investment.

While panels are located at roof level, there is often other equipment located at ground level, such as inverters and DC cabling that thieves find attractive.

Thieves are becoming more sophisticated and bolder in their approach to stealing solar equipment. For example, they may move CCTV cameras on site so that they point away from installed equipment.

In some cases, roofs are accessible from ground level via unlocked and accessible ladders, and it is possible that thieves can spend some time at roof level removing panels and cabling, passing these to accomplices at ground level. If there is no CCTV monitoring activity at roof level, it may be that a whole system is stripped of its cabling during the night.

In the case of farm-based solar installations, solar roofs may be unmanned. Bolder thieves may pose as solar maintenance engineers and deceive site staff who could think they are legitimate personnel. A certain degree of specialist electrical and other knowledge may also be needed in order to steal solar equipment, which could imply the involvement of people within the solar industry.

There are practical measures owners of rooftop PV systems can consider implementing. These include:

- Securing modules with anti-theft fixings. Your installer will be able to advise on these
- Ensuring the modules are secured together, making them more difficult to remove
- Installing CCTV
- Installing movement detector alarms and/or lighting
- Marking modules and other vulnerable equipment with a forensic signature making them uniquely identifiable and less attractive to thieves. Fitting the

accompanying deterrent signage will also decrease the risk of a theft on a rooftop system
- Restricting access – for example, this could be as simple as ensuring ladders are not available

If you are unfortunate enough to encounter thieves in the act of stealing your system, safety should always be your first priority. DO NOT approach them. Call the police, observe from a safe distance and, if it is possible to do so safely, record anything that may help the police identify those responsible.

If you have had property stolen, advise the police of any identifying information, particularly the presence of forensic marking.

Solar Energy UK takes solar theft very seriously and is working on an initiative to report crime to the police. Solar Energy UK members should contact Solar Energy UK for more information on how to contribute to this.

11. Warranties and claims

11.1. Recommendations:

- Ensure that all communications and documentation relating to a solar system are kept in a clearly organised system.
- Document all O&M and other activity carried out on a solar system.

A key aspect of the rooftop Operations and Management process ties into the warranty specified in the contract signed with designated manufacturers, suppliers and third parties. Based on the warranty, a person or company can make a claim for different issues. These will vary according to the relevant terms and conditions.

A summary of claim types is included in the table below. In general, the claims process will involve writing to the manufacturer, including pictures, receipts and other evidence as required.

The page references further to the expanded version of this table, which is included in the Appendix. Note that the information on warranties in this document refers to equipment and not workmanship issues.

	Key claim types		
Product	**Manufacturer**	**Installer**	**End customer**

Solar panels	Power outage issues Material & workmanship fault defects Module performance warranty (e.g. defects) Loss of Panel delivery Unlawful unloading Manufacturer insolvency Mis-sold panels	Approved MCS Installer Installer Fault issues Contact Installer first to resolve. Then the Certification body via MCS site. Lastly the Energy Ombudsman.	Refer to Credit Card company or Insurer for manufacturer insolvency, contract breach or misrepresentation Roofing Manufacturer permission for installs (i.e. fit for purpose)
Mounting systems	Defects or parts issues Transport damage issues Repair of product, replacement or reimbursement	Modified install or assembly Damaged goods on arrival Manufacturers safety & quality Storage pre & post assembly Follow Manufacturer's maintenance manual Install in location as in the contract Testing of services Check NRCA's policies & guidelines & membrane manufacturer	Approved installer. Validate via certifications Check H&S certificates or standards Roofing manufacturer permission (i.e. fit for purpose)
Inverters	Validity of Manufacturer Protection of warranty funds Positive Industry feedback Warranty Terms and Conditions	No use of manufacturer's sizing tools Install per manufacturer's instructions (i.e. surge protection, clear vents) Delivery is unopened or damaged Device is not subject to water ingress Remote monitoring for fault issues Check Units warranty status Communicate issues to customer	Regular system checks Manufacturer trained installer for repairs Clear Unit of obstructions or dust

		Exchange inverter, return in correct package	
Batteries	Validity of Manufacturer Protection of warranty funds Positive industry feedback Warranty T&Cs Charging Cycles or throughput information Monitoring or Internet Connection requirements	Install per manufacturer's warranty Delivery is unopened or damaged Install per manufacturer's instructions (i.e. clear vents, correct torque) Device is not subject to water ingress Operating temperature is outside range Remote monitoring for fault issues Check unit warranty status Communicate issues to customer	Regular system checks Manufacturer trained installer for repairs Clear Unit of obstructions or dust

Future editions

Solar Energy UK hopes that this guide helps inform safe company policies and practices across the solar industry. Not all issues related to rooftop O&M have been covered in the second edition of these Best Practice Guidelines, and those which have may need further adjustment and expansion. Standards, legislation and practices constantly change, and the next edition of these Guidelines will change accordingly. Solar Energy UK intends to include additional relevant information on the topics included in this edition, as well as more information about how PV system design can help address the issues raised. This will aim to include, for example, information on new monitoring techniques, and emerging solar installations such as floating solar.

Those with expertise on relevant topics are encouraged to contact Solar Energy UK to support future work in these areas.

Solar Energy UK is a trading name of Solar Trade Association Limited, registered in England and Wales, company number 01372316. Registered office Chapter House, 22 Chapter St, London, SW1P 4NP.

Solar Energy UK