Fire and Solar PV Systems – Recommendations for the Photovoltaic Industry

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1 Introduction

1.1 Background

Over the past few years, there have been a number of media reports linking photovoltaic power systems (PV) with fire. With the prevalence of PV systems now in the UK, an increase in incident reports is to be expected.

The National Statistics website[1] shows that, as of the end of November 2016, overall UK solar PV capacity stood at approximately 11 GW. Figure 1 shows the scale of the increase in deployment since 2010, when the feed-in tariff (FIT) was first introduced.

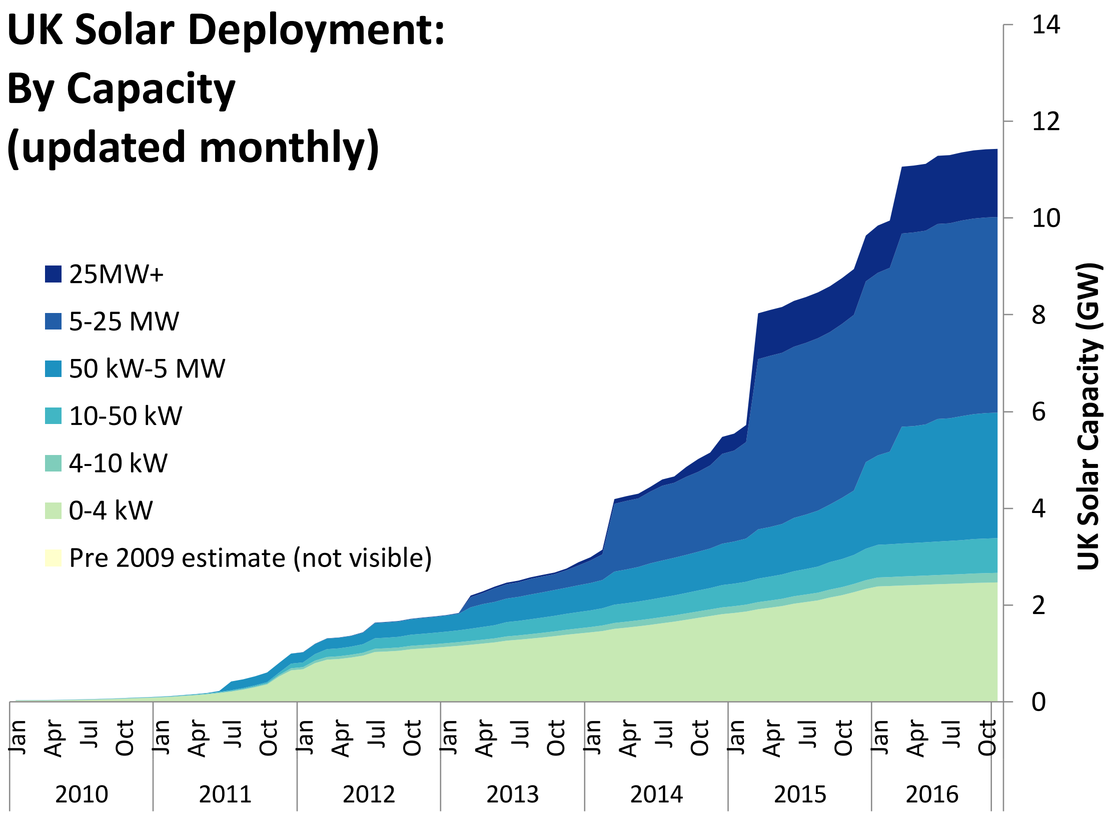

Figure 1: UK PV deployment to November 2016[1]

[1] www.gov.uk/government/statistics/solar-photovoltaics-deployment

At this point in time (November 2016), 48% (5,452 MW) of total installed solar PV capacity came from large scale installations greater than 5 MW, with 21% (2,453 MW) coming from small scale 0 to 4 kW installations, and the overall UK solar PV capacity stood at 11,429 MW across 898,029 installations (provisional figure). This is an increase of 28% (2,484 MW) compared to November 2015.

With this rapid increase in the number of installations comes an inevitable increase in the number of faults with the potential to cause fires. Whilst some incidents have been reported by the press, others have only become known through word of mouth, and it seems likely that a larger number of fire incidents have not been reported, especially where installers have been able to contain and rectify the fault without intervention from the fire services. Previously, there appears to have been no detailed follow-up investigation in order to properly understand the causes of these fires, or how the presence of PV on a building may have influenced firefighting operations.

Despite the now significant number of PV systems installed in the UK and elsewhere, PV is still a relatively young technology. Consequently, the equipment and installation standards that control the industry remain in a process of evolution. The acquisition of incident data from the field, analysis of root causes and reporting is therefore vital to ensure that standards committees have the latest information to work with, creating the conditions for the standards to remain relevant and effective.

Furthermore, how PV systems can influence firefighting operations may be an essential input during the ongoing development of standards.

Since additional requirements within standards very often result in extra costs to be borne by the industry or consumers, understanding the likelihood of particular faults occurring and the severity of the consequences is essential for ensuring that any changes to standards are measured and properly justified.

This project has therefore been established in order to collate accurate information – both historical and contemporary – on fire incidents involving PV systems in the UK, and on relevant previous research.

To date (January 2017), the project team has completed the following work:

- a literature review
- a review of standards
- a review of training
- established a database of PV fire incidents
- conducted a series of on-site investigations and desk studies of contemporary incidents.

The public project description can be found on the NSC website: http://www.bre.co.uk/nsc/page.jsp?id=3676.

Please note that as far as possible, the authors have avoided reproducing any information of a personal or commercially sensitive nature in this report. The only identifiable references relate to the project team and associated fire investigation professionals.

2 Project outline

The project began in July 2015 and runs to 2018. This report is an output from work package (WP) 8, forming part of deliverable D6. A short outline of the project is presented below.

2.1 Organisations involved

The project team comprises the following organisations and individuals:

- BRE National Solar Centre (NSC)
- BRE Global Fire Safety Group
- Fire Investigations (UK) LLP (FI-UK)
- A representative of the Chief Fire Officer's Association (CFOA)
- A representative of Prometheus Forensic Services Ltd
- Individual PV experts.

The project is owned and funded by the Department for Business, Energy and Industrial Strategy (BEIS).

2.2 Programme

Table 1 gives a brief description of the complete three year project, formed from the following work packages (WP):

WP	Description	Status
1	Review of relevant literature. The literature review produced a total of 184 references, mainly from the PV industry, academia and fire services. The full report was submitted to BEIS 25/11/15.	Completed Nov 2015, modified March 2017
2	Surveys of standards and training. Standards were mainly international (e.g. IEC), whilst training courses were mainly domestic. The full report was submitted to BEIS 25/11/15 and incorporated into the literature review report.	Completed Nov 2015
3	Survey of historical incidents in the UK – the survey involved contacting installers, building owners, the fire services and DCLGs Incident Reporting System. 37 unique historical incidents of fire involving PV systems in the UK were identified. The output was reported as part of WP5.	Completed Jan 2016
4a	Investigations of live and recent PV fire incidents in the UK. WPs 1 – 3 and 5 laid the foundations for on-going investigations into incidents, as they arise (WP4).	On-going until Feb 2018
4b	Additional Work Package introduced as a variation to the contract to enable laboratory examinations of components suspected of causing fires	On-going

	on PV systems to be undertaken. The data from these examinations feed into WP4 and are stored within the database.	
5	Database development and initial population with historical records.	Completed Dec 2015
6	Fire and Solar PV Systems – *Literature Review, Including Standards and Training** derived from WP1 & 2).	Completed March 2017
7	Fire and Solar PV Systems – *Investigations and Evidence** (derived from WP3, 4 & 5).	Completed March 2017
8	Fire and Solar PV Systems – *Recommendations*:* a) *for PV Industry* (derived from WP6 & 7). This report. b) *for the Fire and Rescue Services* (derived from WP7 & 8)	Completed March 2017
9	Dissemination to BEIS and the solar and fire safety industries	Completion due February 2018

Table 1: Project work packages and status*

***** Note: Following a meeting with BEIS in November 2016, the outputs from work packages 6, 7 and 8 have been recast, as shown in the table. The original work packages were as follows:

WP6: Recommendations for improving design and maintenance standards

WP7: Recommendations for improving training

WP8: Recommendations for the safety of fire-fighters in the event of fires involving PV

2.3 Reports

The following reports form the published output from the project to date. The Investigation and Evidencence report will be revised and re-published in February 2018, following the collection of further data; this is also the scheduled end of the project.

- A review of relevant literature, standards and training [1]
- Fire and Solar PV Systems – *Investigations and Evidence* [2]
- Recommendations for the PV industry – this report [3]
- Recommendations for Fire and Rescue Services [4]

3 Summary of results of investigations

The details of the incident investigations and results can be found in the *Investigations and Evidence* document [2]. The summary of findings presented in this section is reproduced from the *Conclusions* section of that report.

To date (January 2017), a total of 58 unique incidents have been investigated and incorporated into the database:

- 33 are historical incidents, arising before the initiation of the project
- 13 of the incidents were investigated remotely ("desk investigations")
- 12 incidents were investigated on-site shortly after the incident had occurred
- 7 of the investigations include laboratory examinations of fire-damaged components

The severity of the fires varied. 17 of the incidents that were caused by PV systems were classified as 'serious' (i.e. difficult to extinguish and spreading beyond the PV system). 25 incidents were localised fires (affecting only PV components and the immediate area) or 'thermal events' (smoking or smouldering that did not develop into a fire).

In 10 incidents the cause was not thought to be the PV system and in 6 incidents, there was insufficient information to arrive at a reliable conclusion, so classified as 'cause unknown'.

In general, therefore, PV fires have caused damage to PV installations themselves and sometimes to the buildings on which they are mounted. Fortunately, to date, injuries appear to be minor: 5 cases of smoke inhalation (treated at scene), 1 minor burn, 1 case of shock and 1 minor knee injury.

There is 1 fatality recorded in the database, but the fire is known to have originated elsewhere in the house and not within the PV system.

The building types involved break down as follows:

- Domestic buildings 27 incidents
- Non-domestic buildings 26 incidents
- Solar farms 5 incidents

However, we strongly suspect a degree of under-reporting, especially amongst solar farms.

The review of international literature conducted under this project in 2015 [5], concluded that:

> *Where PV systems have been the cause of fires, some themes emerge. Much attention is paid to the phenomenon of electrical arcing, where a current flows across an air gap by ionising the air. High voltage arcs are extremely hot and can cause combustion of surrounding materials in less than a second. Arcing can occur where conducting parts become physically separated by mechanical movement or mis-alignment. Also, a build-up of contaminants (e.g. oxide) on electrical contacts can cause resistive heating, resulting in the breakdown of materials and subsequent arcing.*

Certain components, if incorrectly specified, poorly installed or contain manufacturing faults, are typical locations of electrical arcs:

- *DC connectors*
- *DC isolators*
- *Inverters*
- *PV modules, including by-pass diodes and junction boxes*

The experience of investigating 25 recent incidents and 33 historical incidents in the UK has resulted in some very similar findings. Of the 46 incidents that were either known or likely to have been caused by the PV system, our analysis shows that the PV components most likely to develop faults that lead to a fire incident are as follows:

- DC Isolators 16 - 18 incidents
- DC connectors 4 - 10 incidents
- Inverters 6 - 7 incidents
- DC cables 1 - 4 incidents
- PV Modules 1 - 2 incidents

In 4 cases, the origin of the fire was not traced to any particular component.

Approximately 36% of recorded incidents that were caused by PV systems were attributed to poor installation practices. 12% were attributed to faulty products[2] and 5% to system design errors. The causes of the remainder were unknown.

A summarised, anonymised listing of the database records can be seen in the *Evidence Report* [2].

There are anecdotal reports of power diverters presenting new fire and safety risks. These devices divert excess electricity generated by solar panels to a specific load, such as an immersion heater. However, within this project, we have yet to encounter a fire that appears to have been caused by one of these devices, so the results so far do not support this assertion.

Awareness of the project appears to be gradually building, especially amongst fire and rescue services and with the assistance of CFOA and MCS. This, coupled with seasonal effects, are likely to produce further PV fire incidents in the spring and summer.

[2] The research has shown that the majority of incidents are caused by poor workmanship rather then product failure. Product and component quality is continually improving and new failsafe mechanisms are being introduced as detailed in section 4.5

4 Recommendations for improving design and maintenance standards

4.1 Feeding in to existing standards and guidance

The wiring regulations, BS7671 [6] provide the rules for the installation of many types of domestic and non-domestic electrical system in the UK, including some of the basic aspects of PV installation (section 712). However, BS7671 does not contain the level of detail provided by the guidance that has been specifically written for the photovoltaics industry.

PV-specific standards for the design and installation of PV systems are available in the UK from the Microgeneration Certification Scheme (MCS), e.g. the MCS installation standard MIS 3002 [7]. However, the technical detail is not contained within the standard itself; instead it refers to guidance documents, such as the MCS guide for installers [8].

MCS 012 details the requirements for product certification of pitched roof installation kits. Products certified to this standard need to demonstrate fire performance of the roof meets the requirements of the building regulations.

Similarly, the more recent IET Code of Practice for Grid Connected Solar Photovoltaic Systems [9] provides technical guidance. This document links the technical content of over-arching standards by providing specific details of clauses from standards for each recommendation.

Thus, it is suggested that outputs from this project may well feed more naturally into guidance documents (such as MCS), rather than directly into the standards (i.e. British Standards), with the exception to maintenance standards which are not currently covered by MCS.

If, however, it was decided by industry (i.e. MCS working groups and BSI Standards Development committees) that PV *product* design and type approval standards should be amended, then, in principle, it would be possible to place supplementary clauses in appropriate MCS product standards that add requirements to the international standards upon which they rely.

In the short term, amendments to MCS product standards (proposed through the MCS Solar Photovoltaic Technical Working Group) may be faster to implement than making requests to international standards bodies (i.e. British Standards, through the BSI Standards Development committee GEL/82 Photovoltaic Energy Systems, which is under the direction of the British Electrotechnical Committee and the Standards Policy and Strategy Committee, who are responsible for the UK input to IEC TC 82 and CLC/TC 82).

The informing of guidance documents, rather than standards, means that recommendations for design and installation are likely to be mirrored within the recommendations for training.

4.2 Design and installation

Design and installation have been grouped together here because the scope of these functions can vary slightly between companies. For example, some companies would determine the cable runs at design stage, whilst others would leave that to the installation personnel.

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We believe it would be beneficial to research design techniques that would allow PV systems to be more easily made safe during an incident; currently, it seems that improvised approaches are being used by FRSs, PV installers or other engineers during fire incidents.

Techniques may involve the use of specific product types, for example, remote or automatic DC shut-off devices. However, there are currently no effective product standards for such devices, so the drafting of these would be a preliminary step.

4.2.1 Recommendations to improve design and installation standards and guidance

To allow access to PV modules and the roof for maintenance and firefighting activities, guidance on array layout, including distance between modules and the edge or ridge of pitched roofs, or access paths across flat roofs (MCS, [8], IET [9]) should be strengthened and enforced (this could also possibly be implemented in Building Regulations) – amendment to MCS Guide 3.7.1 [8].

4.3 DC isolators

Malfunctions within DC isolators (also described as PV array switch-disconnectors) have been highlighted by the incident data collected to be the most common cause of fires on PV systems [2]. However, the majority are due to poor installation practices rather than system or product design[3].

The investigations have highlighted a number of poor installation practices. Out of the 9 incidents that have been attributed to DC isolator faults as a result of poor installation, approximately half of these were due to ingress of water caused by incorrect practices for cable entry or mounting of the isolator. One incident was potentially as a result of the DC isolator being mis-wired and the remaining incidents showed evidence of poor connections within the isolators.

A common issue when inspecting DC isolators on site is that it is often difficult to determine the type and rating of the DC isolator(s) installed as there is rarely a rating label on the casing of the enclosure. Opening the isolator enclosure can expose an inspector to electrocution risk, as it is often the case that the DC cables upstream of the isolator cannot easily be isolated. Even if it is possible to safely open an isolator enclosure, the switch unit may be mounted too close to the sides of the enclosure to read the rating label.

Whilst identifying the isolator type has not been a specific problem within this project, where we have removed faulty equipment for inspection under laboratory conditions, a general issue with inspections has been noted in which isolator types are often not shown in the system documentation and are not easily identified in situ.

Both MCS [8] and IET [9] require the system designer to specify the type and ratings of isolators to be used, usually to be noted on the electrical schematic, along with the selection of other components. This does occur in some instances, but from our experience, in many cases, the isolators are selected by the

[3] Only 1 incident examined may have been caused by poor contact design, this evidence was anecdotal so not considered a solid basis to recommend amendment to product standards.

installation engineer, and any as built changes are not necessarily updated in the documentation handed over to the client.

Therefore, there is a compliance issue at the design stage i.e. isolators not being specified on design documentation. This, coupled with the difficulty of in-situ inspection noted above, results in a lack of transparency of the type and rating of isolators that are a) specified and b) fitted.

4.3.1 Recommendations to improve standards and guidance with respect to DC isolators

It is recommended that MCS Annex C - PV Array Test Report [8] is updated to reflect the inclusion of more detailed 'Array Isolator' information, as detailed in Annex C of BS EN 62446-1:2016 [10]. This will provide a record at commissioning stage of the equipment specification that can then be referred to throughout the life of the PV system.

The following additional points are recommended to provide better guidance to system designers and installers, and should be considered for incorporation into existing standards and guidance:

- Choice of mounting location, including taking account of nearby flammable surfaces – amendment to MCS Guide 2.1.12.2 [8].

- Precautions for outdoor mounting of electrical enclosures. Even though it would normally fall under general good workmanship, specific clauses on maintaining the environmental protection of electrical enclosures may be necessary e.g. siting, not drilling through inappropriate areas in IP rated enclosures and correct use of cable glands (locating them on the underneath of enclosures and with only one cable per gland) – amendment to MCS Guide 2.1.12.2 [8].

- All AC and DC isolators should have labels on their enclosures, specifying the exact make and model of switch used within the enclosure. The requirement should include a provision for the installer's signature to be added for installation verification purposes. This label should then be replaced during a periodic verification of the system, similar to a PAT testing label – amendment to MCS Guide section 5 and 6.2 [8].

4.4 DC Connectors

Based on our analysis, the number of incidents in the study judged to have been caused by DC connectors is 4 – 10, out of a small sample size of 46 incidents that are either known or likely to have been caused by the PV system.

Current guidance [8] [10] is clear on the requirements to not mix plug and socket DC connector halves of different types or from different manufacturers. In theory one option to overcome this issue would be to standardise DC connectors, however there are a number of manufacturers of components with different designs and therefore this option may not be feasible.

Correct and timely identification of the make and model of connectors fitted by PV module manufacturers is making it difficult for installers to comply with this guidance. In addition it is not possible to remove the DC connectors supplied with PV modules without voiding product warranties.

At present, the method on how to comply is not clear within published guidance [8]. DC connector manufacturers will not confirm compatability with other products as this contravenes a condition of their product warranty. It is recommended that DC connector and PV module manufacturers are engaged in finding a suitable resolution to this problem. This will require further research and may not be solvable within this project.

4.4.1 Recommendations to improve standards and guidance with respect to DC connectors

Correctly specifying and installing these components is paramount to the safe operation of PV systems. An on-site quality control process should be developed and introduced into standards and/or guidance. As a minimum, standards should require a documented process, the details of which can be determined by the installer – amendment to MCS Guide 2.1.7 [8].

4.5 Inverters

The number of inverter fires seen so far is 6 – 7 out of a small sample size of 46 incidents that are either known or likely to have been caused by the PV system. Inverters are tested to specific manufacturing standards and have to be CE marked, implying that they are safe for normal use.

Most modern inverters include sophisticated fault detection circuitry and are capable of raising an alarm of some sort (e.g. the closing of a relay, sending a text message or email, or being remotely interrogated). For example, the breakdown of insulation resistance, which can be the precursor to more serious problems, can be detected and an alarm message sent. Guidance should explain this and strongly advocate the use of this important diagnostic tool.

4.5.1 Recommendations to improve standards and guidance with respect to inverters

One improvement to standards and guidance requirement that could easily be implemented would be to require inverters to be mounted on a fire retardant surface. Some inverter manufacturers specify this in their installation instructions, but it is not universal. Many are mounted on wooden board, which can act as a fuel if a localised fire breaks out in the inverter – amendment to MCS Guide 2.3.4.1 [8].

4.6 Maintenance

Maintenance of a PV system is not covered by the MCS Guide [8]. Currently some guidance is offered by the IET [9], but this is rather limited in scope and detail. Solar Power Europe has recently released a useful document: O&M Best Practices Guidelines [11] and the Solar Trade Association is currently running a working group on operation and maintenance with a view to producing guidance. BS EN 62446-1: 2016 provides a detailed requirements for testing, documentation and maintenance of PV systems. Section 6 recommends that periodic verifications are completed in line with IEC 60364-6: 2016 [10].

Emerging from this investigation of PV fires is the need for routine checks on the DC systems of PV arrays. This could consist of annual electrical testing of string integrity, based on existing commissioning procedures e.g. short circuit current, open circuit voltage, insulation resistance and earth impedance (if relevant).

Thermography can also be a useful tool for discovering overheating components before situations arise. However, it may be difficult to make this test mandatory as it requires a reasonably sunny day to obtain reliable results. Nevertheless, it is such an effective technique that its use should be encouraged.

Regular maintenance checks on inverters would seem to be an overlooked opportunity at present. As mentioned above, many modern inverters contain fault detection circuitry and interrogating the inverter logs can provide clues to the existence of minor issues before they become serious. Some explanation of the purpose of these functions is provided by the IET [9]. However, accessing and interpreting inverter logs is not always straightforward, and each manufacturer has their own method. Thus, some general guidance as to how to go about this could be useful for maintenance engineers.

4.6.1 Recommendations to improve maintenance standards and guidance

At present the MCS Guide [8] does not cover the maintenance of PV systems. It is recommended that a new document, or additional section is added, covering the requirements of maintenance to achieve ongoing performance and safe operation, covering the requirements as detailed in BS EN 62446-1: 2016.

The data supports some specific recommendations to provide improved standards for maintenance:

- Inspection of internals of DC isolators (sampling if there are a large number), checking for signs of overheating, moisture and loose terminals – amendment to BS EN 62446-1: 2016 5.2.8.
- Methodology for sampling inspections of any site-assembled DC connectors (connectors assembled under factory conditions are less likely to be an issue) – amendment to BS EN 62446-1: 2016 5.2.8.

4.7 Compliance with standards

In order for PV installation companies to comply with MCS they must demonstrate good working practices through a documented Quality Management System (QMS). The QMS must cover a number of operational processes including; products/ materials and their installation, training and competence, health and safety, as well as internal quality reviews, corrective and preventive actions. During the application stage, or annual renewal of certification, the Certification Body will complete a surveillance visit. The visit will include an audit against MCS 001 and generally a site visit to an installation. Any non-conformances are documented and corrective actions agreed, which must be completed within 12 weeks.

5 Recommendations for improving training

As discussed in BRE's literature review on Fire and Solar PV Systems [1], system designers may be in a position to reduce fire risks and risks to firefighters, PV systems and buildings by implementing appropriate precautions.

In the review, available training courses have been compiled and categorised under the following headings: formal, unaccredited, other, and PV courses for fire-fighters. Since the original review, only one more additional unaccredited course has been noted, and does not seem to contain any particular focus on health and safety or the fire risks of solar PV systems.

5.1 Current solar designer/ installer training

MCS guidance should be followed for all systems installed with a capacity of less than 50 kW. MCS 025 Installer Certification Scheme Competency Criteria Guidance [12] details the competency requirements for different roles within a company applying to become an MCS Contractor.

The MCS assessment process judges MCS Contractors for their competence through evidence of compliance with MIS 3002 [7] and application of the MCS Guide [8]. The MCS Competency Checker Tool recognises specific solar PV installation courses awarded by 8 providers. A level 3 N/SVQ in electrical installation or similar, to BS 7671 - 17^{th} edition [6], is a pre-requisite/ entry requirement for the specified courses [9].

In October 2016, MCS introduced an Experienced Workers' Route (EWR) which allows companies to demonstrate competence without the need for formal qualifications. EWR 002 specifically applies to companies wishing to undertake Solar PV installations. The EWR process places more emphasis on the Certification Body to determine if the evidence provided by the applicant, in the form of a completed self-assessment, meets the EWR criteria. Evidence may include prior proven learning, guided learning hours and Continual Professional Development (CPD). EWR also removes the requirement for applicants to complete qualification refresher courses every 5 years, as long as sufficient levels of upskilling can be evidenced.

The process is currently being piloted by 3 EWR Providers in the UK [13]. It has not been possible to ascertain how many organisations have applied using EWR and what potential effect the new route to MCS will have on the standard and safety of installations going forward.

5.2 Incident database evidence

It can be seen from the incidents recorded in the database (section 3 and ref [2]) that there are a number of areas where solar designers/ installers are not following current standards or published good practice guidance, and where additional training may be required, or improvements need to be made to existing training offerings.

Out of a total of 58 incidents logged in the database (January 2017), up to 17 might have been avoided if current design and installation guidance was followed correctly. As detailed in the *Investigations and Evidence* Report [2], 13 - 15 incidents were attributed to poor installation practices and a further 1 - 2 to system design errors.

The discussion above highlights that current training provisions most likely do not sufficiently emphasise, or draw attention to, the fire risks associated with solar PV and how these can be reduced through following good installation practices as detailed in BS 7671 [6] and the IET Guide [9].

5.3 Training recommendations

From the evidence collected so far, it would appear that training for PV system designers, installation engineers and maintenance contractors should be improved in the following areas:

Recommendation	**Supporting incident references**
Fire awareness training on PV systems: identifying and assessing fire risks on new designs and existing solar installations	All where PV was causal
Correct specification and siting of DC isolators	PVF0037, PVF0047, PVF0049
Correct assembly and weather protection of DC and AC isolators	PVF0003, PVF0005, PVF0039, PVF0041, PVF0058
Correct wiring of DC isolators	PVF0047, PVF0053
Correct selection, assembly and installation of DC connectors	PVF0042, PVF0048, PVF0050, PVF0053, PVF0054, PVF0055, PVF0056
Correct selection of appropriate cable routes and installation of DC cables	PVF0035, PVF0042, PVF0055
Correct placement of warning labels	PVF0052, PVF0053, PVF0054, PVF0055, PVF0057, PVF0058, PVF0059
Research to identify a safe, practical, standardised method of isolating systems upstream of the DC isolators in emergency situations would be beneficial. Training on this would be to both PV installers and FRSs	Feedback from FRSs
The keeping of training records and quality assessment processes for all of the above activities	For audit purposes

6 Conclusions

To date (January 2017), a total of 58 unique incidents have been investigated and the details incorporated into a database. Analysis of the data has allowed the distillation of some of the causal factors and point the way to some recommendations.

Key conclusions for improvement of design and maintenance standards are as follows:

- Amendment to MCS Guide 3.7.1 [8] to provide additional guidance on array layout, including distance between modules and the edge or ridge of pitched roofs, or access paths across flat roofs. This could also possibly be implemented in Building Regulations.
- Amendment to MCS Annex C - PV Array Test Report [8] to include more detailed 'Array Isolator' information.
- Engagement with DC connector and PV module manufacturers to define improved guidance on a method of compliance with ensuring the integrity, functionality and safety in instances where PV systems have been fitted with mixed DC connectors.
- Amendment to MCS Guide 2.1.7 [8] to include an on-site quality control process to ensure consistent high quality of site-assembled DC connectors.
- Amendment to MCS Guide 2.3.4.1 [8] to include the requirement for inverters to be mounted on a fire retardant surface.
- Development of a new MCS Guidance document covering the requirements of maintenance to achieve ongoing performance and safe operation, covering the requirements as detailed in BS EN 62446-1: 2016.
- Amendment to BS EN 62446-1: 2016 5.2.8 to include inspection of internals of DC isolators, checking for signs of overheating, moisture and loose terminals, and using labels to show an inspection has taken place.
- Amendment to BS EN 62446-1: 2016 5.2.8 to include methodology for sampling inspections of any site-assembled DC connectors.

Training for PV engineers and technicians should be improved in the following areas:

- Fire awareness training on PV systems.
- Correct selection and installation of DC isolators: ratings, electrical connection integrity and environmental factors.
- Safe locations for installation of DC isolators.
- Selection of DC connectors – the rules and how to comply.
- Pitfalls to avoid during assembly and installation of DC connections.
- The keeping of training records for all of the above activities.

There may be benefit in further publicising the project by carefully targeted communications or events, raising awareness and improving the flow of reporting to the project. Also, collaboration with the insurance industry and other interested groups would be useful.

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