Australian Government
Clean Energy Regulator

RENEWABLE ENERGY TARGET

Analysis of Small-scale Renewable Energy Scheme Inspection Data to Assess Photovoltaic System Residual Systemic Electrical Safety Risks

Contents

Executive Summary

The purpose of this report

The Clean Energy Regulator (the agency) administers the Renewable Energy Target (RET) including the Small-scale Renewable Energy Scheme (SRES), which provides incentives for households and businesses to install small photovoltaic (PV) systems, solar water heaters, wind, hydro and air source heat pumps.

Administration of the RET includes the SRES inspections program, which inspects a “statistically significant” number of small-scale PV systems installed each year where small-scale technology certificates (STC) have been created, for conformance with relevant standards. This is required by law. This program complements, *but does not replace*, the electrical safety laws and inspection/compliance programs administered by relevant regulators in each state and territory.

The Australian National Audit Office’s audit of the agency’s administration of the RET (December 2018) recommended:

> *The Clean Energy Regulator assess the extent to which its Renewable Energy Target scheme data shows any residual systemic electrical safety risks for small generation units installed under the scheme and inform those stakeholders in the best position to effect further treatments.*

This report addresses this recommendation. The report is publicly available and provided to state and territory electrical safety authorities and the Clean Energy Council (CEC – a PV system installer industry body). This report makes three recommendations for state and territory governments and industry bodies to consider to address residual safety risks as they are in the best position to effect further treatments.

Small-scale photovoltaic system electrical safety regulation

The states and territories regulate electrical safety, including licensing electricians. Their legislation calls up a number of Australian Standards.

Relevant Australian Standards committees typically have representation from state and territory electrical safety bodies, fire and other emergency services and industry. Hence, states and territories are well placed to influence the outcomes from the Standards process.[1]

While the agency administers the SRES inspections program, it is not an electrical safety regulator and it has no powers to enforce electrical and PV system safety.

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[1] States and territories and the agency are members of the standards committee EL-042, which is responsible for the standards in question - AS/NZS 5033 and AS/NZS 4777.

The Small-scale Renewable Energy Scheme

The SRES allows STCs to be created for the installation of PV systems up to 100 kW. The retailer selling the system typically provides a consumer an upfront discount on the cost of their system through the consumer assigning their right to create certificates to a registered agent.

To be eligible for the Commonwealth's STC entitlement the following requirements must be met, in addition to complying with state and territory electrical safety laws.

1. The system must be designed by a CEC accredited designer.
2. The installation must be installed by a licensed electrician who is a CEC accredited installer.
3. The PV panels and inverter used must be on the CEC's approved products list, which confirms they met Australian Standards.
4. The installer must follow the CEC's code of conduct, which requires following the CEC's design and installation guidelines.

The agency has inspected 1.4 per cent of the 2.1 million PV systems that have participated in the SRES since it began in January 2011.[2] The agency appoints inspectors, who check compliance with Australian standards for wiring, installation and components and the CEC's design and installation guidelines.

Adverse inspection findings are shared with state and territory electrical safety authorities who may have powers under their legislation to require rectification and/or to consider if an electrician has met their licensing requirements. The findings are also shared with the CEC, which can consider if an installer has met their accreditation requirements.

Analysis and expert input

The agency analysed data from 28,041 inspections to 20 June 2019 for systems installed from 2010 to 2018 inclusive (see **Section 4**). Steve Stern, Professor of Data Science at Bond University, reviewed and confirmed the agency's data and analysis. Since 2012, Professor Stern has conducted regular reviews of the sampling approach used for the inspections program.

As the agency is an economic regulator, Master Electricians Australia (MEA) was engaged for technical interpretation of our data and analysis of legislation and regulations governing rooftop PV installation. MEA is one of the agency's inspection service providers and is an electrical safety consultant.

Unsafe and potentially unsafe PV systems

"Unsafe" is the most adverse rating in the SRES inspections program and is the basis for identifying safety risks in this report. The agency defines an unsafe PV system as one that has a safety hazard which poses an imminent risk to a person or property.

[2] These numbers include small-scale PV systems installed in 2010 under the original RET, before the SRES started.

There is a small number of inspections where the PV system does pose an imminent safety risk, such as when there are exposed live parts and unsecure PV panels. However, the majority of PV systems classified as unsafe were due to water ingress in direct current (DC) isolators (a disconnect switch). Of these, the degree of water ingress varies and in most cases the DC isolator may become unsafe without timely maintenance but should not pose an imminent risk.[3] Nevertheless, this risk is more than would be attributable to a substandard system (see **Section 3.2**) and the practice has been to characterise such instances as unsafe.

For these reasons, this report distinguishes between PV systems that were unsafe at the time of the inspection and PV systems that were “potentially unsafe” at the time of the inspection.

Rooftop PV safety risks

Unsafe and potentially unsafe PV systems combined have declined from 5.5 per cent of inspections of systems installed in 2015 (0.7 per cent unsafe and 4.8 per cent potentially unsafe) to 1.7 per cent of inspections of 2018 installations (0.7 per cent unsafe and 1.0 per cent potentially unsafe) (**Figure 1**). Overall, for systems installed from 2010 to 2018 inclusive, 3.3 per cent of all systems inspected have been classified as unsafe (0.7 per cent) or potentially unsafe (2.6 per cent).

The most likely reasons for the reduction in unsafe results are the CEC modifying its design and installation guidelines and training in September 2015, as a result of inspection program findings.

[3] Notwithstanding this, some DC isolators have been reported as causing fires (see Section 4.8).

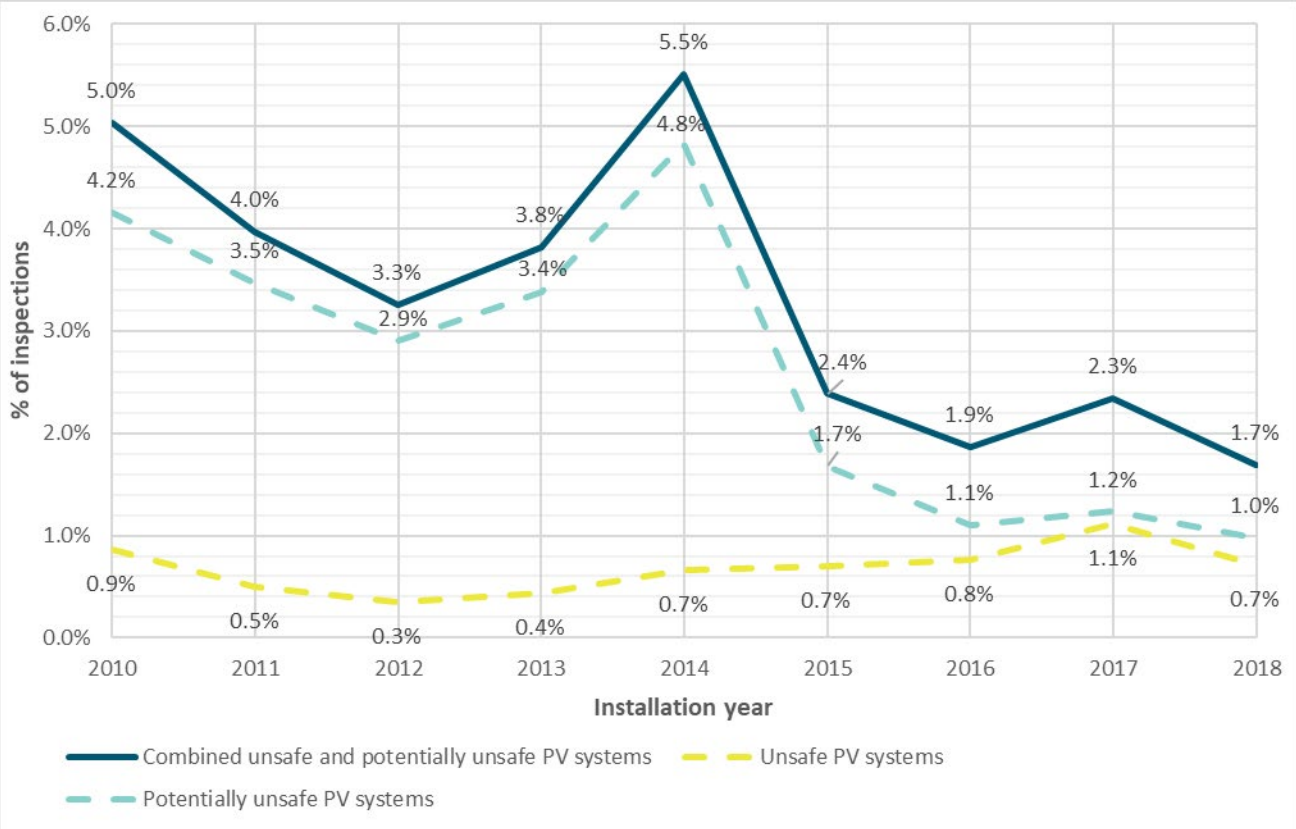

Figure 1 — Inspections where a PV system was unsafe or potentially unsafe

DC isolators are the most common cause of potentially unsafe PV systems

The agency’s analysis shows water ingress in rooftop DC isolators and DC isolators near the inverter is the most common cause of potentially unsafe PV systems (**Figure 2**). A small proportion of DC isolators were also incorrectly wired or installed.

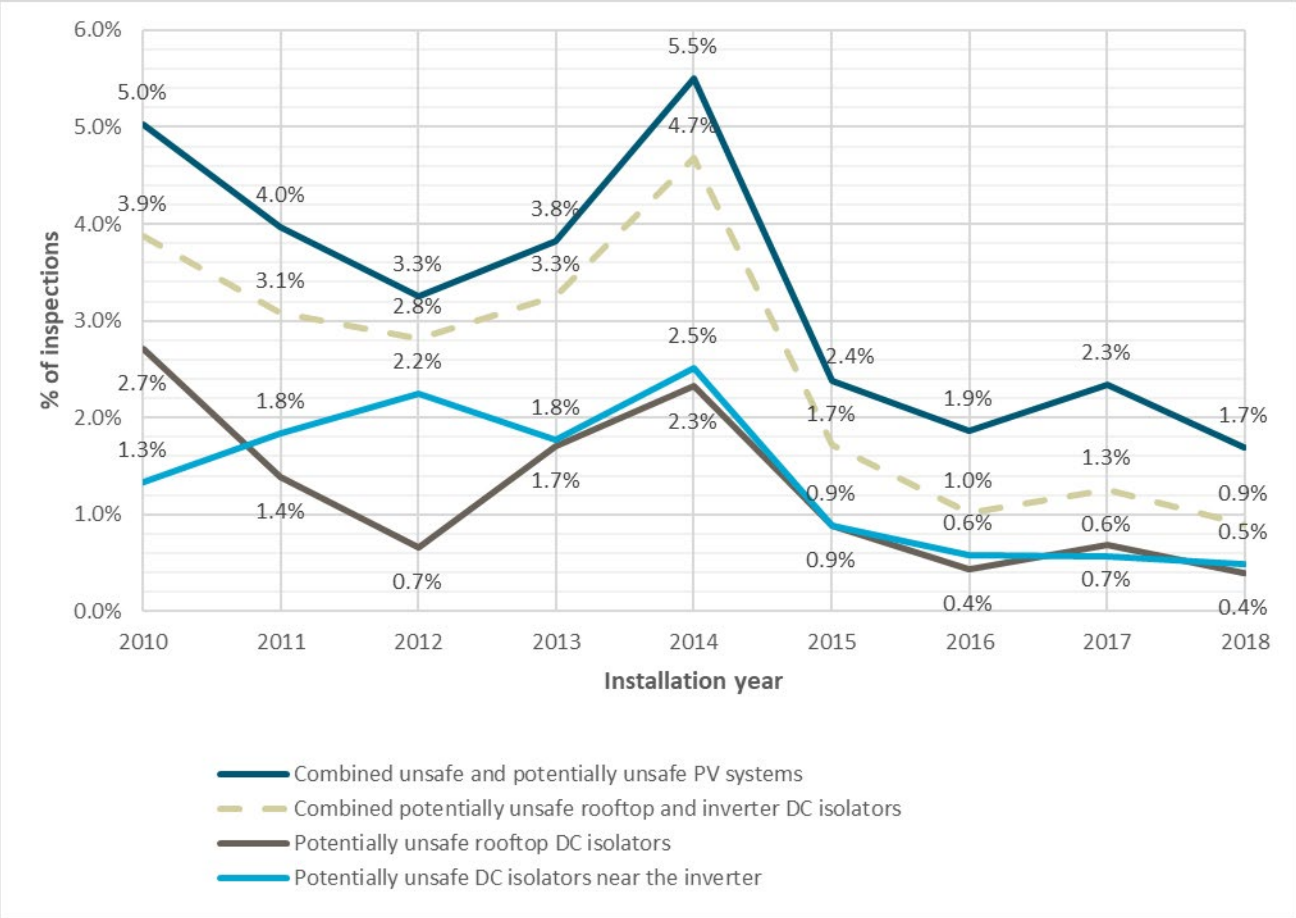

Figure 2 — Inspections where a PV system was potentially unsafe due to DC isolators[4]

Analysis of the limited publicly available PV system fire data suggests DC isolators have likely been a major cause of PV system fires (see **Section 4.8**).

Australia is the only country in the world requiring a rooftop DC isolator. This requirement was progressively introduced in some states and territories and formalised in the Australian Standard for PV installations (AS/NZS 5033) in October 2012. Records suggest the introduction was at the request of fire and emergency services, to enable their members to isolate the DC power, for example when attending an incident at a house where there may be live wires. However, a representative of the Metropolitan Fire Brigade in Victoria recently stated publicly DC isolators are a fire risk.[5]

[4] Percentages for potentially unsafe rooftop and inverter DC isolators combined are less than the sum of the individual percentages because some systems had both problems.
[5] Hobday, Liz and Gross, Sybilla, ‘Australia’s obsession with cheap solar is derailing the market, insiders say’, *ABC News,* 27 May 2019 *https://www.abc.net.au/news/2019-05-27/australias-obsession-with-cheap-solar-derailing-market-insiders/11139856*

In March 2015 a number of industry bodies proposed removing the rooftop DC isolator requirement from the Australian Standard but the two committees[6] considering the proposal could not agree a way forward and the proposal did not proceed.

The current review of the Australian Standard for PV installations is again considering whether to remove the rooftop DC isolator requirement. State and territory governments are on the Standards Australia committee for this review, and are best placed to decide whether, on the balance of risks, rooftop DC isolators should be required.

The CEC's view is requiring the DC isolator inside the inverter, rather than as a separate switch near the inverter, is the best solution to prevent water ingress into DC isolators near the inverter. MEA's view is the use of DC isolators inside the inverter could reduce the risk of a separate DC isolator near the inverter being water damaged. From the agency's discussions with inverter manufacturers, some inverter models already have an internal DC isolator.

The current review of the Australian Standard for inverters is considering requiring the DC isolator inside the inverter. Again, state and territory governments on the Standards Australia committee for this review and are best placed to decide whether current standards should be changed to require a DC isolator within the inverter rather than as a separate component near the inverter.

The need for regular PV system maintenance

AS/NZS 5033 recommends owners have their PV system inspected regularly and annually for many system components, including DC isolators. However, because this is only a recommendation, regular inspections are not required under state and territory electrical safety laws.

74 per cent of the inspections of PV systems installed from 2010 to 2018 have rooftop DC isolators and 84 per cent of these have DC isolators near the inverter.

MEA believes, from its experience, most consumers are not aware of PV system maintenance recommendations and there are very few subsequent inspections after the initial installation and commissioning.

It notes isolator components can degrade from environmental exposure due to specific installation methods and product type, increasing the likelihood of water ingress and ultra violet radiation damage and, as a result, DC isolators may need to be replaced within the life of the panels of a PV system, typically 25 years.

To maintain safety and reliability, MEA recommends a qualified person inspect a system one year after installation to check DC isolators and other components and recommend the frequency of future component inspections (see **Sections 4.3.1 and 4.11**).

[6] The Australian Standards subcommittees were EL042 - Alternative energy sub group and EL006 – Switchgear subgroup.

It would seem prudent for system owners to have their system, and DC isolators in particular, regularly inspected by a qualified person. The frequency, and whether or not inspections should be mandated or left to education, is best decided by state and territory authorities, and industry bodies.

The agency has information for consumers on PV system maintenance on its website.[7]

Other safety risks are at levels similar to general electrical work

Two safety risks can result in an unsafe PV system at the time of inspection:

- exposed live parts,
- unsecure PV panels.

One other safety risk can result in a potentially unsafe PV system at the time of inspection:

- water ingress in cable junction boxes.

Each of these three safety risks occurred in 0.2 per cent or less of inspections of PV systems installed in 2018. MEA advises these rates are similar to unsafe general electrical work due to human error and poor workmanship.

Recommendations

1. State and territory governments consider whether the potential safety risks from the requirement for a rooftop DC isolator outweigh the benefits and pursue this in the current review of AS/NZS 5033.
2. State and territory governments consider whether the requirement for a DC isolator near the inverter should be changed to require the isolator be inside the inverter and pursue this in the current review of AS/NZS 4777.
3. State and territory governments consider whether any of the recommendations for PV system inspections in AS/NZS 5033 should be mandated or education programs implemented to encourage owners to engage qualified persons to do regular inspections.

The agency is a member of the Standards Australia committee for AS/NZS 5033 and AS/NZS 4777. The agency has and will continue to advocate for the removal of the rooftop DC isolator requirement.

[7] http://www.cleanenergyregulator.gov.au/RET/Pages/Scheme%20participants%20and%20industry/Individuals%20and%20small%20business/Solar-panel-system-maintenance.aspx

Abbreviations and acronyms

AEMO	Australian Energy Market Operator
AS/NZS 4777	Australian Standard: Grid connection of energy systems
AS/NZS 5033	Australian Standard: Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 5139	Australian Standard: Electrical installations - Safety of battery systems for use with power conversion equipment
CEC	Clean Energy Council
DC	direct current
DNSP	Distribution Network Service Provider
kW	kilowatt
MEA	Master Electricians Australia
PV	photovoltaic
RET	Renewable Energy Target
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificate

1. Analysis and expert advice

The agency analysed inspection data from 28,041 inspections to 20 June 2019 for systems installed from 2010 to 2018 inclusive (see **Section 4**).

Steve Stern, Professor of Data Science at Bond University, reviewed and confirmed the agency's data and analysis. Since 2012, Professor Stern has conducted regular reviews of the sampling approach used for the inspections program. Details of Professor Stern's statistical analysis are given in **Appendix A**.

As the agency is an economic regulator and not a safety regulator, MEA was engaged for technical interpretation of our data, advice on safety issues and to analyse legislation and regulations governing rooftop PV installation. MEA is one of the agency's inspection service providers and is an electrical safety consultant.

2. Electrical Safety Regulation and the SRES

This section discusses the regulatory framework for small-scale PV systems. The framework is summarised in **Figure 3**.

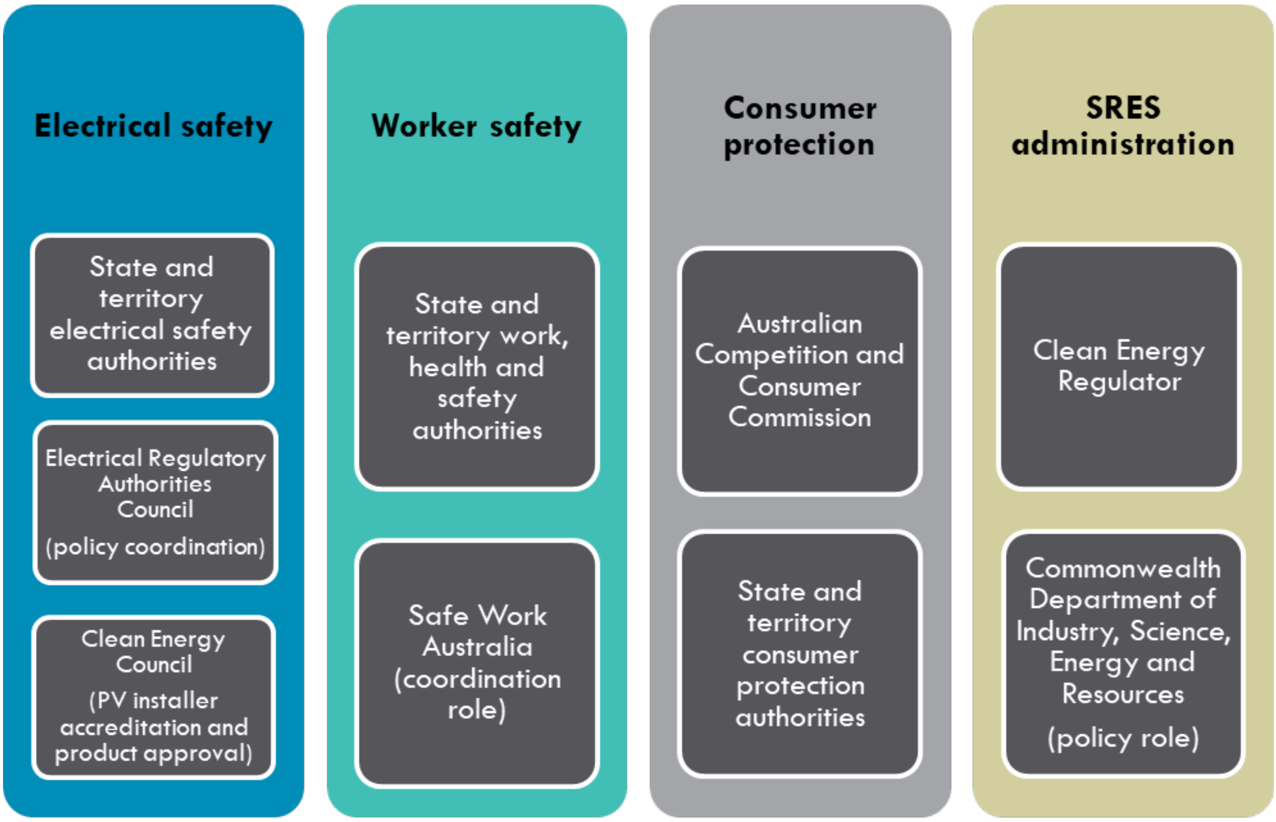

Figure 3 — Small-scale PV system regulation

2.1. State and territory electrical safety regulation

Electrical safety is the responsibility of state and territory governments. Each government has an electrical safety act, regulations and government authorities responsible for monitoring and enforcing electrical safety, licensing and worker safety. Some states and territories also have guidelines and advisory notes specific to PV installations. Each state and territory requires a PV system meet various Australian standards including:

- *Electrical Wiring Rules* (AS/NZS 3000)
- *Grid Connections of Energy Systems* (AS/NZS 4777)
- *Stand-alone power systems (Off Grid)* (AS/NZS 4509)
- *Installation of Photovoltaic Arrays* (AS/NZS 5033)

- *Installation of battery systems* (AS/NZS 5139)
- *Wind Loads* (AS/NZS 1170)

Standards development is overseen by Standards Australia and each standard is led by a committee with industry and state and territory government representatives.

A government agency inspects every new PV installation in the Australian Capital Territory and Tasmania. Victoria requires every installation be inspected by a licensed inspector. Other states and territories conduct random inspections. **Appendix B** summarises state and territory electrical safety frameworks.

2.2. The Clean Energy Regulator's role

The agency is an economic regulator with an environmental objective whose purpose is to the accelerate carbon abatement for Australia. In addition to the RET and its component schemes, the Large-scale Renewable Energy Target (LRET) and the SRES, the agency administers the Emissions Reduction Fund, the National Greenhouse and Energy Reporting scheme and the Safeguard Mechanism.

Under the RET, scheme participants must comply with the requirements of the *Renewable Energy (Electricity) Act 2000* (the Act) and the Renewable Energy (Electricity) Regulations 2001. The Act requires the agency to conduct random inspections on a "statistically significant" number of small-scale generation units which have had small-scale technology certificates created against them.

While the agency administers the SRES inspections program (see **Section 3**), it is not an electrical safety regulator and it has no powers to enforce electrical and PV system safety or worker safety.

The agency's electrical safety role is limited. It shares data from the SRES inspections program with state and territory electrical safety authorities and the CEC. This includes providing reports of PV systems that are unsafe and/or potentially unsafe and/or do not meet state, territory or local government requirements or Australian standards. The agency can also suspend PV system installers and designers with adverse inspection findings (see **Section 3**) from creating STCs for up to 12 months.

2.3. Small-scale Renewable Energy Scheme

The SRES is a voluntary scheme that allows STCs to be created for PV systems up to 100 kW. Entities that purchase wholesale electricity—electricity retailers and some large industrial users—are required to purchase STCs equal to a proportion of their wholesale purchases and surrender them to the agency as part of their RET obligations.[8]

STCs can be created following the installation of an eligible system and are calculated based on the size and location of a system and the deeming period specified in legislation. Generally, the purchaser assigns the right to create STCs to a registered agent in return for an upfront discount on their system. In 2019, a 7 kW system installed in Brisbane, Canberra, Sydney, Adelaide or Perth could create 116 STCs representing a discount in the order of $3,000, depending on how much the purchaser is paid for each STC.

[8] The Small-scale Technology Percentage (STP) determines this proportion for a given year. The STP is set by the Commonwealth Minister for Energy and Emissions Reduction each year. It is intended to create demand equal to supply.

A PV system must comply with state and territory electrical safety laws regardless of whether it participates in the SRES. These ensure a minimum level of system safety. To be eligible for the Commonwealth's STC entitlement the following requirements must be met, in addition to these laws:

1. The installation must be designed by a CEC accredited PV system designer.
2. The installation must be installed by a licensed electrician who is a CEC accredited installer.
3. The PV panels and inverter must be on the CEC's approved products list as meeting Australian Standards.
4. The installer must follow the CEC's code of conduct, which requires following the CEC's design and installation guidelines.

Consumers and installers are free to install a PV system that does not meet SRES requirements but they will be ineligible to create STCs. Consequently, the vast majority of PV systems installed in Australia participate in the SRES.

The SRES has enabled the agency to collect data on almost all PV systems installed in Australia including address, system size, PV panel make and model, inverter make and model, the installer's electrical license number and the installer's CEC accreditation details. The agency regularly provides SRES inspections data to state and territory electrical safety authorities and the Australian Energy Market Operator (AEMO) and provides data to state and territory emergency services on request.

It should be noted the SRES is in slow decline. From 2017 onwards the deeming period for STC creation decreases by one year each year. The deeming period is the time over which the electricity a PV system generates, and hence the number of STCs it creates, is calculated. In 2019 the deeming period is 12 years and in 2030, when the scheme ends, the deeming period will be 1 year. Participation will likely decline in later years as the financial incentive becomes too small to make participation worthwhile. The data capture and inspection program will also decline accordingly.

2.4. The Clean Energy Council

The CEC is a not-for-profit, membership based industry body for the clean energy in Australia. The CEC represents and works with its member bodies to support the development of renewable energy and energy storage. The CEC provides self-regulation programs, including the installer accreditation program, and a product assurance program for PV panels and inverters. CEC installer accreditation and CEC approved products are key parts of SRES eligibility requirements as set out in the Renewable Energy (Electricity) Regulations 2001.

CEC installer accreditation requires PV specific training and ongoing professional development and accredited installers must comply with the CEC's code of conduct and PV installation guidelines. The CEC can issue demerit points for installers who do not comply with these requirements and an installer's accreditation may be temporarily suspended or cancelled. The agency gives reports for unsafe/potentially unsafe inspections to the CEC.

A manufacturer must demonstrate its products comply with relevant Australian standards to be on the CEC's approved PV panel and inverter product lists. The CEC also represents its members in the development of Australian Standards.

3. The SRES Inspections Program

3.1. Overview

The Act[9] requires a "statistically significant selection" of PV systems installed in a year be inspected "for conformance with Australian standards and any other standards or requirements relevant to the creation of certificates".

The Act also requires the agency to provide information about failure to comply with Australian Standards and other standards and requirements to "state, territory or Commonwealth bodies with responsibility for the enforcement and administration of those standards or requirements".

Over 28,000 inspections have been conducted since the SRES inspections program started in January 2011 (see **Figure 4**). This is about 1.4 per cent of the 2.1 million PV systems that have been installed since 2010.[10] The agency randomly selects PV installations for inspection and inspections are voluntary.

The program does not inspect systems greater than 100 kW, which are SRES ineligible, or batteries installed with a system.[11]

Currently, the agency aims for up to 12 months between system installation and inspection. This allows for an agent to claim STCs, which may be created up to 12 months after installation, and gives time for safety issues, such as water ingress in equipment, to manifest.

[9] Section 23AAA of the Act.

[10] The inspections program inspected PV systems installed in 2010 under the original RET, before the SRES started.

[11] Where the PV system being inspected has a battery, information about the battery is recorded. See Section 4.10.

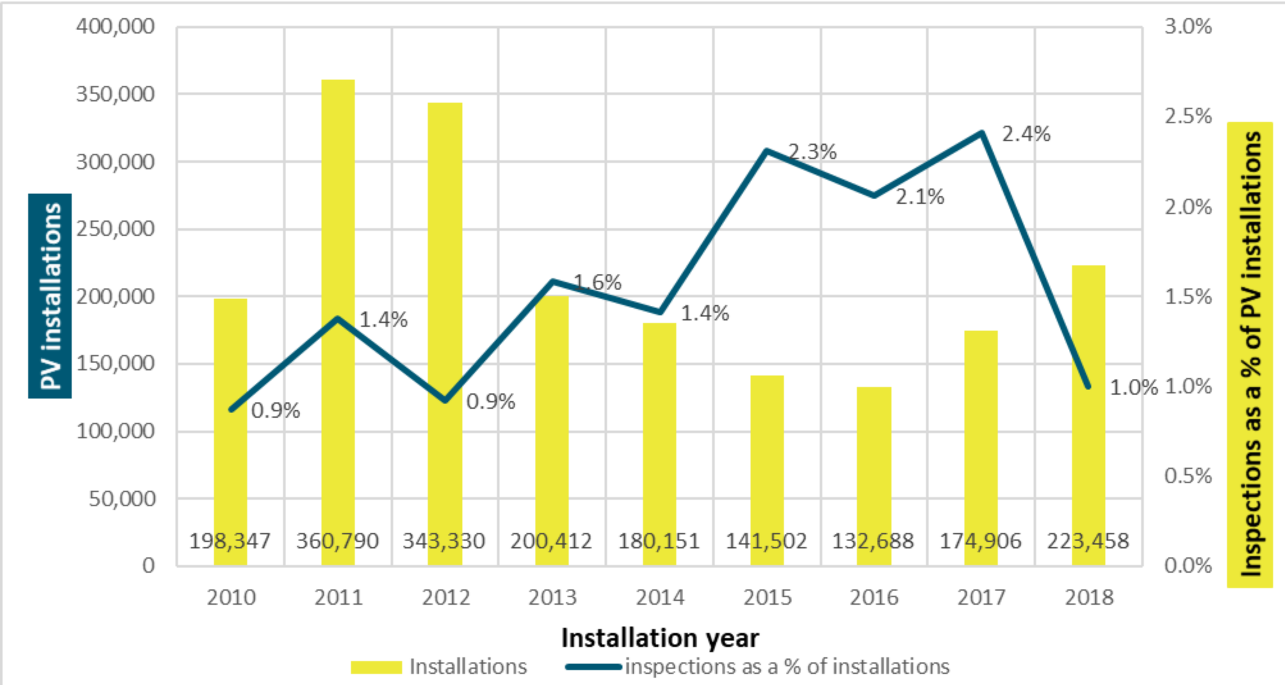

Figure 4 — SRES inspections and PV systems that have created STCs[12]

3.2. The inspection process

Site inspections

Inspectors appointed by the agency inspect a PV system against a checklist of 103 items (see **Appendix C**).[13] These items check compliance with specific requirements in Australian electrical, PV and building standards and CEC design and install guidelines. An inspection includes checking PV panels and wiring on the roof, and opening and inspecting equipment, such as DC isolators and cable junction boxes.

The inspector gives each checklist item a rating. The ratings vary depending on the importance of an item and include: *compliant, non-regulatory issue, minor non-compliance, medium non-compliance, not sighted, not applicable and, for items relating to system safety, rectification work required and unsafe.*

Based on these ratings, the inspector gives the system one of five overall ratings: *industry best practice*; *complies*; *adequate*; *substandard*; and *unsafe*. **Table 1** gives a definition of each rating.

Five checklist items are critical to the safety of a PV system. If any one of these receives an unsafe rating, the PV system automatically receives an overall rating of unsafe. An inspector can also give a system an unsafe

[12] Data at 20 July 2019. The majority of inspections of 2018 installations have been completed.

[13] Inspector requirements include: an unrestricted electrical licence in the jurisdiction they are conducting inspections; CEC accreditation for the design and installation of PV systems; inspector training; and knowledge of the *Renewable Energy (Electricity) Act 2000*.

rating if none of these five are unsafe but the inspector considers a combination of non-compliant issues, such as a number of wiring issues, make the system unsafe overall.

When an on-site inspection finds a PV installation is unsafe, the inspector is required to render the system safe if it is safe to do so, which may include shutting down the system. The inspector is required to immediately notify the state or territory electrical safety regulator, the Distribution Network Service Provider (DNSP), the agency and building occupier. The inspector does not rectify defects, which are the responsibility of the installer.

Overall Inspection rating	Definition
Industry best practice	The system complies with all relevant standards and requirements for installation. No safety, performance or documentation issues have been identified. The workmanship and equipment layout are of a high standard. No rectification work is required.
Complies	The system complies with almost all of the standards and requirements for installation. No safety or significant performance issues have been identified. There have been some low risk documentation and/or minor workmanship issues identified. The system owner may wish to contact the installation company to follow up on the issues identified for improvement.
Adequate	The system complies with the majority of standards and requirements for installation. No safety or significant performance issues have been identified. Some medium risk documentation and workmanship issues have been identified. The system owner should consider contacting the installation company to follow up on items listed for improvement.
Sub–standard	The system does not meet key clauses in the standards and requirements for installation and may lead to premature equipment failure or other issues. The relevant state or territory regulatory authority has been advised by the inspector of the nature and extent of the identified issues. The installation work and or equipment should be improved. The system owner should contact the installation company or a qualified installer to rectify the items listed for improvement.
Unsafe	The system has a safety hazard which may pose an imminent risk to a person or property. The system has been shut down or rendered safe by the inspector. The relevant state or territory regulatory authority has been advised by the inspector of the nature and extent of the safety risk. The system owner should contact the installation company or a qualified installer to rectify the items listed for improvement.

Table 1 — SRES inspection ratings

3.3. Providing inspections data to state and territory electrical safety authorities and the CEC

Following an on-site inspection, the inspector submits a draft report in the agency's SRES inspections portal. If the draft report identifies any potential safety risks or other non-compliance issues, the inspector gives the system designer and the installer (who are often the same person) the opportunity to comment on the findings. The inspector must take account of any comments provided when finalising the report.

The agency provides a copy of the final report to the system owner, the premises occupier, the system designer, the installer, the person who created STCs for the system, the state or territory electrical safety authority and the CEC.

State and territory safety authorities and the CEC can access the details of every inspection through the agency's SRES inspections portal.

3.4. Managing SRES non-compliance

In addition to inspections, the agency applies an intelligence-led risk-based approach to compliance. The agency monitors the ability and willingness of participants to meet their obligations, as well as their operating environment. This approach includes helping participants understand how to comply, educating those who want to do the right thing, and a commitment to deter, detect and respond to non-compliance and misconduct.

The agency considers the behaviour and motivations of SRES participants—for example was the non-compliance accidental, opportunistic or intentional—in determining the appropriate response to non-compliance. The agency prioritises stopping and preventing harm. Where non-compliance occurs, enforcement action can range from administrative penalties (such as removing high risk parties from the SRES) to substantive civil penalties and criminal sanctions for dishonest and fraudulent behaviour.

3.5. Unsafe and potentially unsafe PV systems

The unsafe rating has been used since the SRES inspections program began. Unsafe is the most adverse rating in the program and is the basis for identifying safety risks in this report. The agency's experience has shown there is a small number of inspections where a PV system does pose an imminent safety risk at the time of inspection, such as when there are exposed live parts or unsecure PV panels.

However, the majority of PV systems found to be unsafe do not pose an imminent safety risk. Most were due to water ingress in DC isolators (see **Section 4.3**). Of these, the degree of water ingress varies and in most cases the DC isolator may become unsafe without timely maintenance but should not pose an imminent risk[14] (see **Section 4.3**). Nevertheless, this risk is more than would be attributable to a substandard system and the practice has been to characterise such instances as unsafe.

[14] Notwithstanding this, some DC isolators have been reported as causing fires (see Section 4.8).

For these reasons, this report distinguishes between PV systems that were unsafe at the time of the inspection and PV systems that were potentially unsafe at the time of the inspection.

The categorisation of unsafe and potentially unsafe was determined based on advice from MEA.

PV systems with any of the following checklist items marked unsafe have been categorised as unsafe:

- exposed live parts, and
- PV panels not securely mounted to the roof.

PV systems can also be rated unsafe due to other reasons that do not have a specific checklist item (see **Section 4.6**). For example, a system may have a number of non-compliant wiring checklist items that individually are not a safety risk but together make a system unsafe. These systems are also categorised as unsafe.

PV systems with the following items marked unsafe have been categorised as potentially unsafe:

- water ingress in the DC isolator enclosure near the inverter
- water ingress in the rooftop (array) DC isolator enclosure, and
- water ingress in cable junction boxes.

4. PV System Safety Risks

4.1. SRES Inspections data

The agency analysed SRES inspection data for PV installations from 2010 to 2018 inclusive. This covers 28,041 inspections from mid-May 2011, when the inspections program began, to 20 June 2019. Professor Steve Stern of Bond University reviewed and confirmed the agency's analysis and MEA provided analysis of technical regulations governing PV installations and advice on PV system safety (see **Section 1**).

4.2. PV system safety risks

Figure 5 shows unsafe and potentially unsafe PV systems combined have declined from a peak of 5.5 per cent for 2014 installations to 1.7 per cent of inspections in 2018 installations. Trends for each state and territory are given in **Appendix D**. **Section 3.5** explains the categorisation of unsafe and potentially unsafe PV systems.

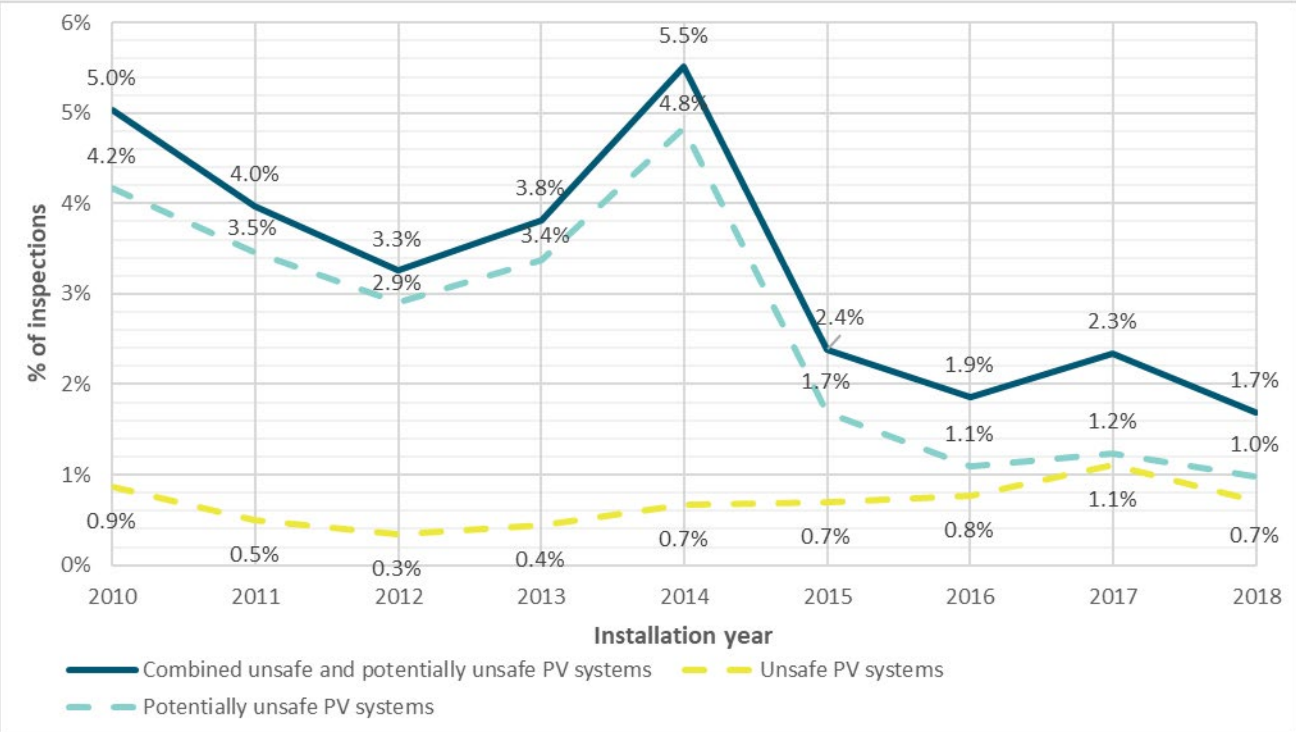

Figure 5— Inspections where the PV system was unsafe or potentially unsafe

Figure 6 shows the causes of unsafe and potentially unsafe PV systems for inspections of systems installed in 2018.[15] These will be examined individually in the following sections.

[15] Based on 2,242 inspections to 20 June 2019.

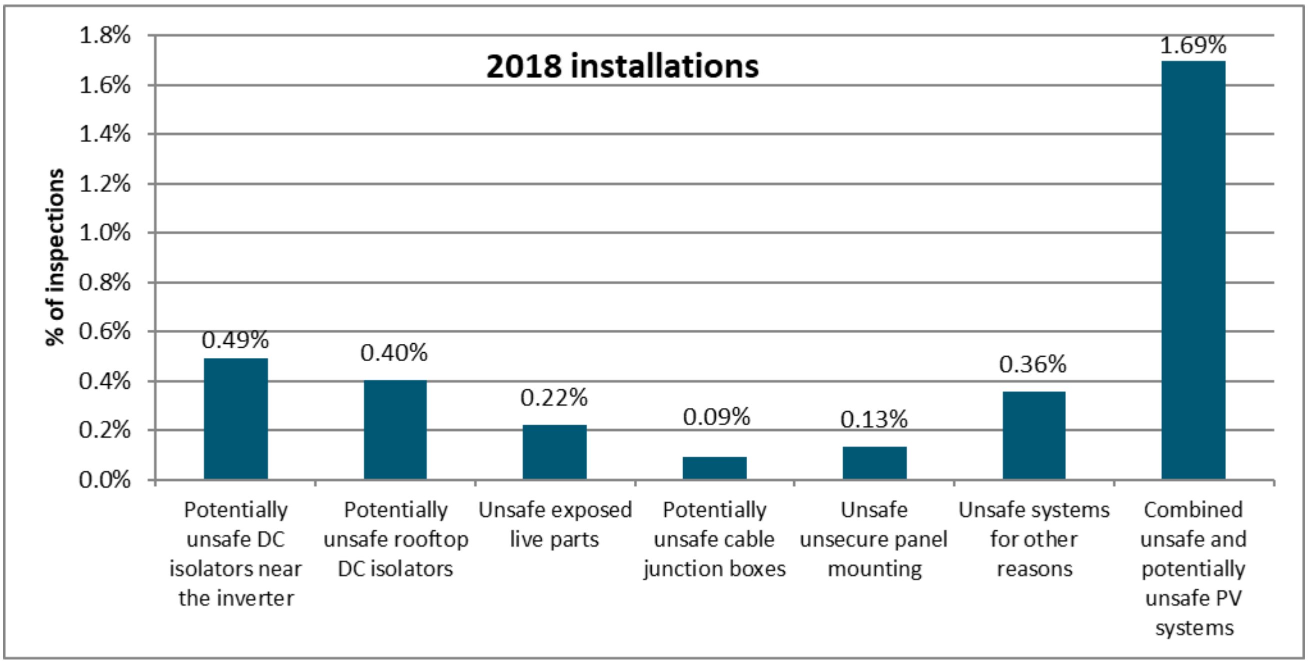

Figure 6 — Causes of unsafe and potentially unsafe PV systems for inspections of systems installed in 2018

4.3. Water ingress in DC isolators

A DC isolator is a disconnection switch that stops electricity generated by a PV system flowing through the circuit of a system. It makes a system safe for maintenance and emergency workers, for example attending an incident at a house where there may be live wires. A rooftop DC isolator is installed next to the PV array (PV panels) and an inverter DC isolator is installed on a wall near the inverter.

Water causes corrosion on the terminals and contacts of the switch mechanism inside the isolator enclosure. Water comes from rain and from condensation from air drawn in and out of the enclosure as it warms during the day and cools at night. This corrosion reduces the area of the switch mechanism through which the current passes. This increases resistance, causing the switch to heat up when electricity flows through it. In most cases the contact will melt and may fail "open circuit", disconnecting the array and making the PV system inoperable. However, in some circumstances the contact becomes "welded" closed. In these cases the temperature rises to the point where the switch casing melts and, in the worst case, catches fire.

Since the SRES inspections program started, in every installation year, water ingress in the rooftop DC isolator and in the DC isolator near the inverter together have occurred in more than half of the inspected PV systems that were unsafe or potentially unsafe. In some years these two risks together have been responsible for 80–90 per cent of unsafe and potentially unsafe PV systems (see **Figure 7**). Also, analysis of inspection comments for potentially unsafe systems due to other reasons (see **Section 4.6**) shows 53 per cent of these inspections were rated unsafe for reasons related to rooftop and inverter DC isolators**.**

While the two isolators are on separate parts of a PV system, water in a rooftop isolator can lead to water in the isolator near the inverter (see **Section 4.3.2**).

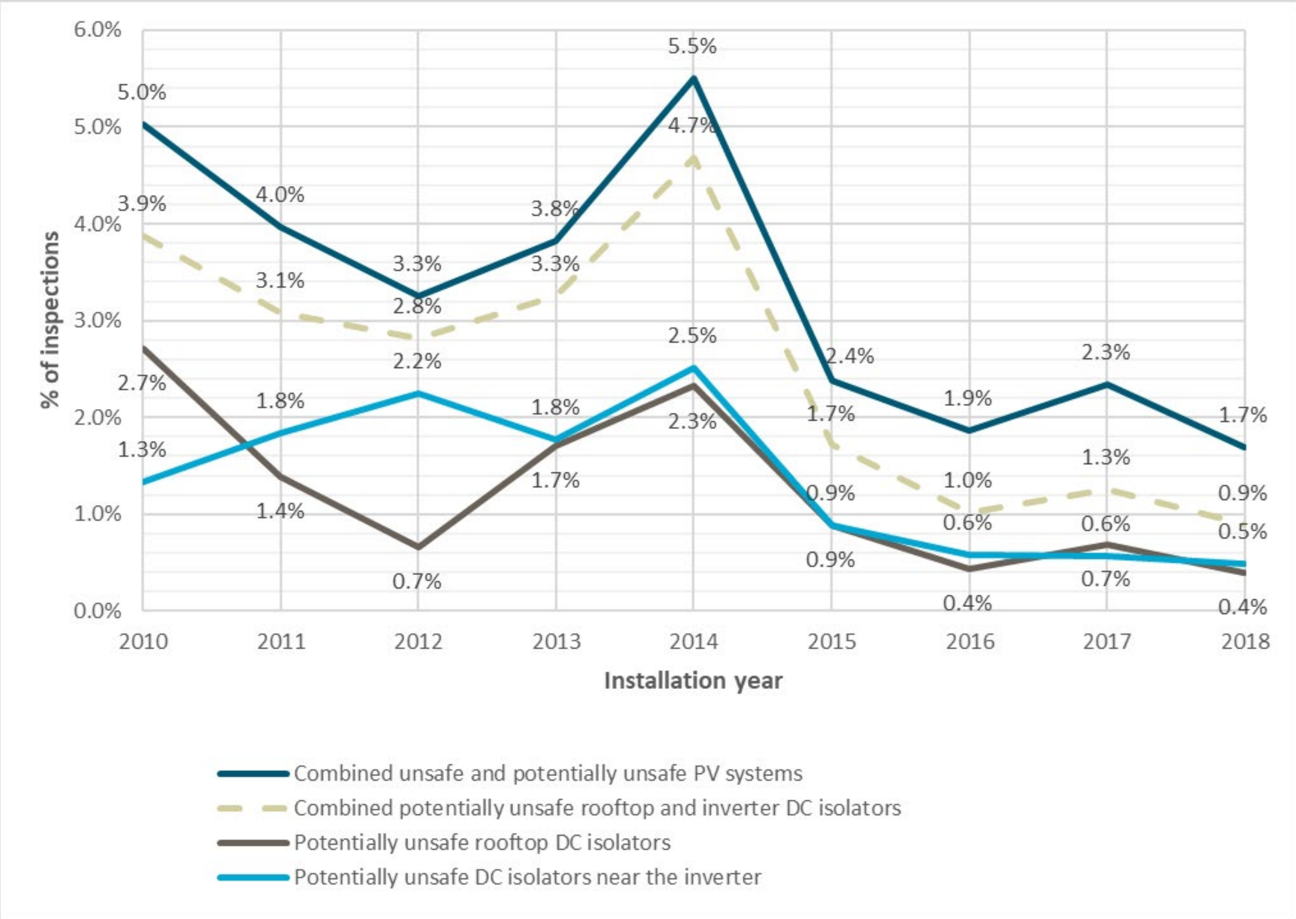

Figure 7 — Inspections where the PV system was potentially unsafe due to rooftop DC isolators and DC isolators near the inverter

4.3.1. Rooftop DC isolators

Figure 7 shows the trend for inspections of potentially unsafe PV systems due to rooftop DC isolators. Potentially unsafe PV systems due to rooftop DC isolators peaked at 2.7 per cent of inspections for 2010 installations and declined to 0.4 per cent of inspections for 2018 installations. The following is a brief history of the rooftop DC isolator and its effect on potentially unsafe PV systems, provided by MEA.

Rooftop DC isolators were first explicitly mentioned in 2007 when Victorian regulations recommended them. This was to address the *Australian Standard AS/NZS 3000 Electrical Wiring Rules* requirement that equipment can be isolated from a power source for maintenance and removal.

In 2010 the Melbourne Metropolitan Fire Brigade and the Fire Fighters Union of Australia publicly said there was a need for rooftop DC isolators.[16]

From 2011 Victoria required rooftop DC isolators and some national PV system retailers adopted the requirement in all the states and territories in which they operated, to align with Victoria. In the same year the ACT and Tasmania adopted the requirement. An update to the CEC's *Install and Supervise Guidelines for Accredited Installers* (guidelines), that came into effect December 2011, recommended rooftop DC isolators.

From 16 October 2012 the Australian Standard *AS/NZS 5033:2012 Installation and safety requirements for photovoltaic (PV) (the Standard)* required rooftop DC isolators. Most state and territory governments were on the Standards Australia committee for this update and likely supported this requirement.

The electrical safety legislative framework of every state and territory refers to this standard (see **Section 2.1**) and this change effectively mandated rooftop DC isolators for all jurisdictions. Notably, New Zealand adopted its own version of the standard to avoid this requirement. MEA advises Australia is the only country in the world that mandates rooftop DC isolators.[17]

Following the revised standard, potentially unsafe rooftop DC isolators increased steadily and peaked at 2.3 per cent of inspections in 2014 installations. Two other factors may have contributed to this peak:

- Firstly, in 2014 the Australian Competition and Consumer Commission (ACCC) recalled five brands of DC isolators with faults that could cause overheating or electrocution. MEA says they were common brands and estimate the recall would likely have been in the thousands.[18]
- Second, there were only three-and-a-half months between publishing the Standard (16 July 2012) and it coming into effect (16 October 2012). MEA notes this shorter timeframe, which was normally six months, may have contributed to potentially unsafe PV systems as it did not allow enough time for training.

In 2012 and 2015 the agency's RET Inspections Advisory Committee (RIAC)[19] discussed the impact of rooftop and DC isolators near the inverter, on system safety. In early 2015 over 80 per cent of inspections where the PV system was potentially unsafe were related to these two DC isolators and most of these were due to water ingress. Outcomes from the committee included supporting the CEC to develop a proposal for Standards Australia to review the rooftop DC isolator requirement in AS/NZS 5033.

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[16] Dusch, Christopher T.J., 'The firefighter device putting solar systems – and homes – at risk', *The Australian,* 10 June 2015 https://www.theaustralian.com.au/business/business-spectator/news-story/the-firefighter-device-putting-solar-systems--and-homes--at-risk/408992f49b61b3c9cddffe923c4d352d

[17] Some states in the USA mandate a rooftop DC isolator using a remote switch located in the inverter and not next to array.

[18] The ACCC has had further recalls for the same issue, most recently in June 2018.

[19] RIAC was formed and Chaired by the Clean Energy Regulator. Participants were state and territory electrical safety authorities and industry bodies including Master Electricians Australia, the Clean Energy Council, the Australian Solar Council (now the Smart Energy Council) and the Energy Networks Association (now Energy Networks Australia).

In 2015 the agency's Chair also wrote to state and territory electrical safety regulators regarding inspections program data showing a high level of potentially unsafe PV systems, the majority of which were due rooftop and inverter DC isolators.

MEA explains rooftop DC isolator installation defects include poor sealing where cables enter the isolator enclosure, poor sealing around screw holes and incorrect enclosure orientation. To address sealing issues, on 1 September 2015 the CEC specified in its guidelines a multi-hole gland[20] for cables entering cable junction boxes and DC isolator enclosures at the array and the inverter to prevent water ingress. The guidelines also banned silicon sealant and using single-hole glands for multiple cables.

The CEC also added the requirement of an isolator shroud (protective covering) when the isolator was mounted next to an array. This aims to shade the isolator from direct sunlight to minimise UV degradation and reduce the temperature inside the enclosure. If the isolator was mounted under the array, which was common practice, it was shielded from direct sunlight and the shroud was not required. However, some installers were placing the isolator too far under the array, making it inaccessible.

MEA notes the guidelines do not specify the shroud's design or orientation and many installations just use a sheet of metal. MEA's view is this offers little protection and, as a result, the shroud likely has had a little effect.[21]

A subsequent CEC guidelines update came into effect 30 June 2017 banning installing isolators under panels mounted parallel to a roof.[22]

Potentially unsafe rooftop DC isolators fell to 0.9 per cent of inspections in 2015 installations and have levelled out at 0.5 to 0.6 per cent of inspections of 2016, 2017 and 2018 installations. **Figure 8** shows SRES inspections where the PV system had a rooftop DC isolator or a DC isolator near the inverter or both. MEA notes systems without rooftop isolators in later years are due to systems installed on the ground or with micro-inverters,[23] which are not required to have a rooftop isolator. The agency estimates 74 per cent of the PV systems it has inspected have rooftop DC isolators.

Requiring a shroud and not permitting installation under panels parallel to the roof were added to AS/NZS 5033 and came into effect on 1 January 2019.

MEA notes, without regular maintenance, the safety risk of DC isolators may increase as components, such as rubber seals around screw holes, degrade from exposure to water, heat and UV radiation, increasing the likelihood of water ingress (see **Section 4.11**).

[20] A gland is a round, solid plastic column with a separate hole for each cable entering the enclosure, providing a seal around the cable.

[21] Tasmania recently added guidance on shroud design to its regulations.

[22] The CEC's guidelines allow isolators to be installed under panels that are tilted relative to the roof.

[23] Micro-inverters are located with panels on the roof and negate the need for a single large inverter for the whole system.

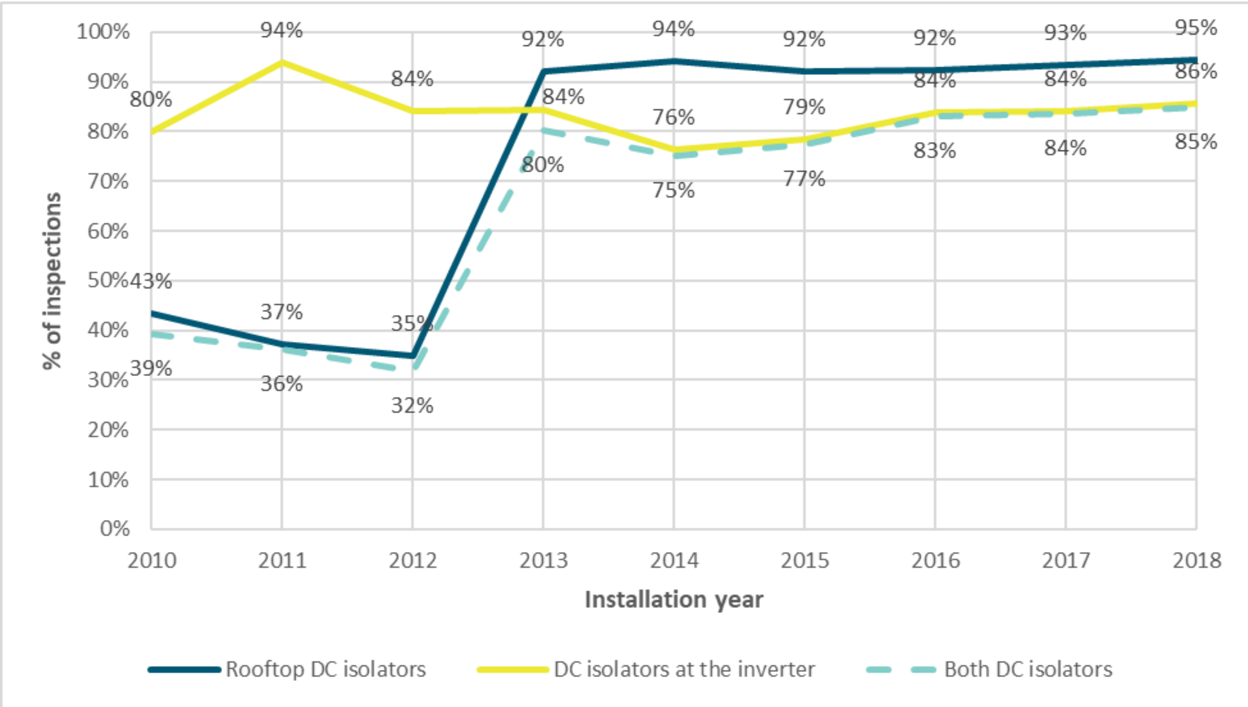

Figure 8 — Inspections where the PV system had a rooftop and/or inverter DC isolator

4.3.2. DC isolators near the inverter

Like rooftop isolators, an inverter isolator disconnects PV panels and stops electricity flowing through the system. The inverter DC isolator was introduced into AS/NZS 5033 in 2005.

Potentially unsafe PV systems due to DC isolators near the inverter peaked at 2.5 per cent of inspections in 2014 installations and have declined to between 0.5 and 0.6 per cent of inspections for 2016, 2017 and 2018 installations.

MEA notes the majority of PV installations use the same DC isolator at the array and the inverter. As a result DC isolators near the inverter have the same installation issues including poor sealing where cables enter the isolator enclosure, poor sealing around screw holes and incorrect enclosure orientation. They have also been affected by ACCC product recalls.

MEA notes a correlation from 2013 onwards between water ingress in rooftop DC isolators and water ingress in DC isolators near the inverter. In addition to mandating the rooftop DC isolator discussed above, the 2012 update to AS/NZS 5033 required external wiring be in high density conduit (plastic tubing). An unintended consequence was it enabled water entering a rooftop isolator to flow down the conduit into the isolator near the inverter, which linked potentially unsafe DC isolators near the inverter to how well rooftop isolators were installed (see **Figure 7**). However, it is not possible to say with any certainty what proportion of potentially unsafe DC isolators near the inverter was due to the connection to rooftop DC isolators.

As with rooftop DC isolators, the CEC's revised sealing requirements in its guidelines appear to have helped reduce potentially unsafe DC isolators near the inverter.

4.4. Water ingress in cable junction boxes

A cable junction box is typically used to connect cables from multiple PV panel arrays, usually on a roof. MEA advises they were common for installations in the early 2010s but are now mostly used in installations greater than 10 kW on commercial buildings. As with rooftop and inverter DC isolators, water ingress can result in corrosion where the cables connect and the increased resistance can cause overheating and fire in the worst case.

Inspections where a PV system was potentially unsafe due to water ingress in cable junction boxes peaked at 0.5 per cent for 2010 installations and have occurred in zero to 0.15 per cent of PV systems for installations in 2015 to 2018, due in large part to their reduced use (see **Figure 9**). MEA advises these rates are similar to unsafe general electrical work due to human error and poor workmanship.

MEA advises that, similar to DC isolators near the inverter, the requirement for cables to be in high density conduit in AS/NZS 5033:2012 enabled water to flow between the rooftop DC isolator and a cable junction box. The trends for potentially unsafe PV systems due to cable junction boxes tracks potentially unsafe PV systems due to rooftop DC isolators from 2013.

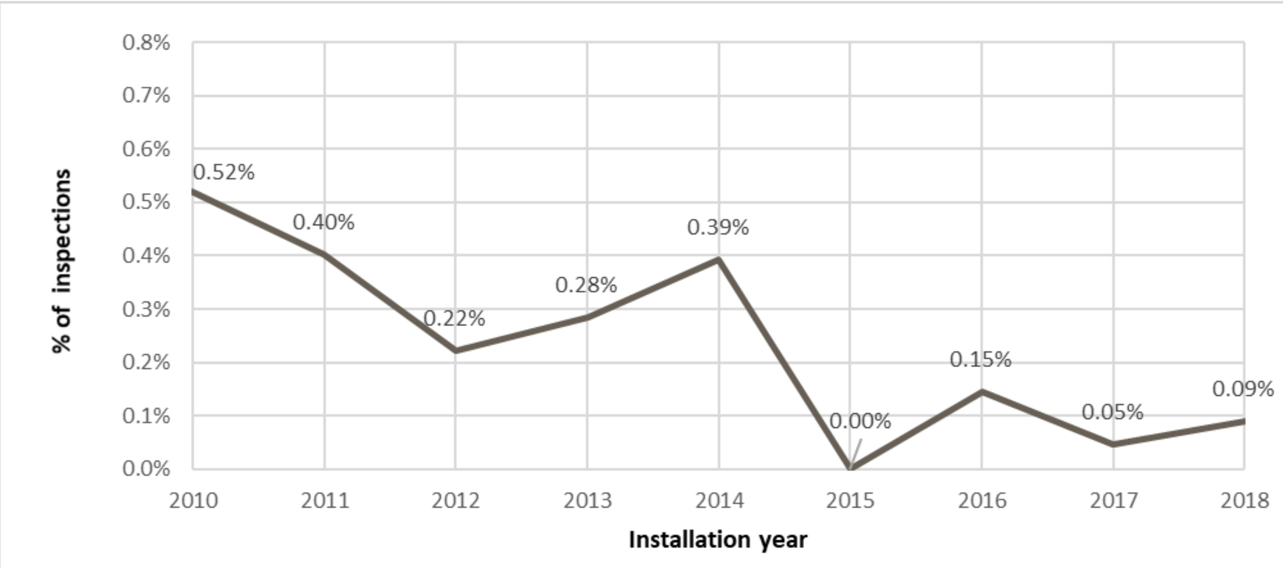

Figure 9 — Inspections where the PV system was potentially unsafe due to water ingress in cable junction boxes

4.5. Exposed live parts and unsecure panel mounting

PV systems with exposed live parts (**Figure 10**) or unsecure panel mounting (**Figure 11**) are categorised as unsafe at the time of inspection (see **Section 3.5**). Each has been a minor cause of unsafe and potentially unsafe PV systems overall. Exposed live parts peaked at 0.5 per cent of inspected systems for 2010 installations and have been between 0.07 and 0.22 per cent for installations in 2015 to 2018.

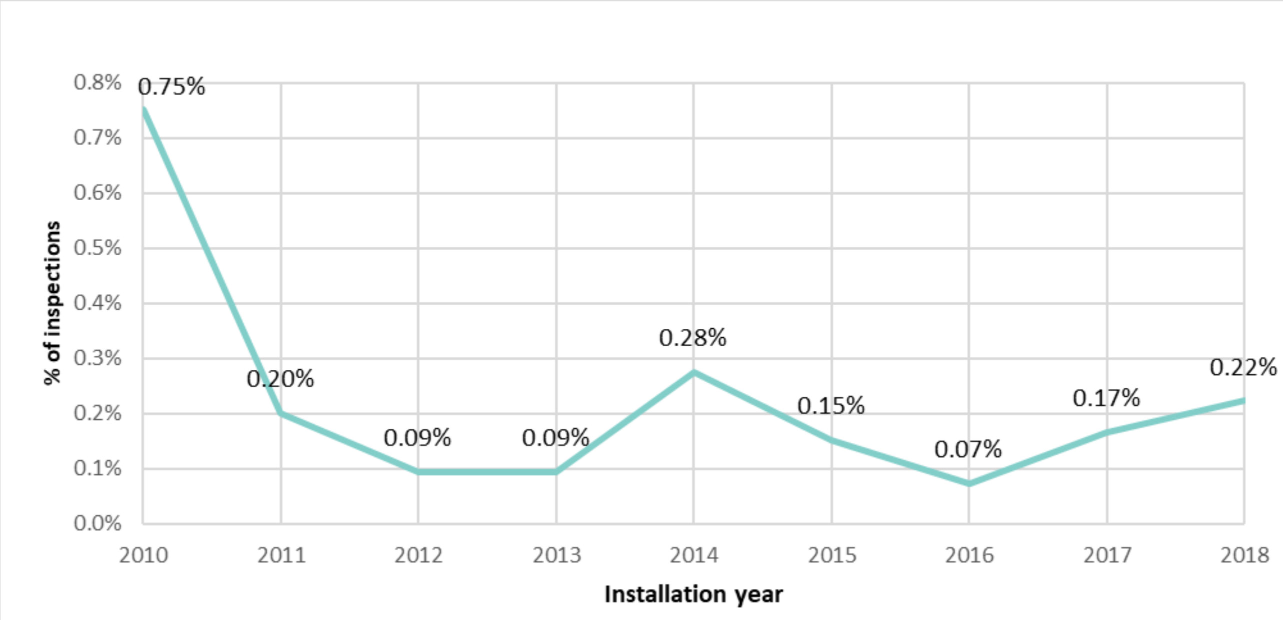

Figure 10 — Inspections where the PV system was unsafe due to exposed live parts

Unsecure panel mounting has occurred in between 0.03 and 0.30 per cent of inspections (**Figure 11**).

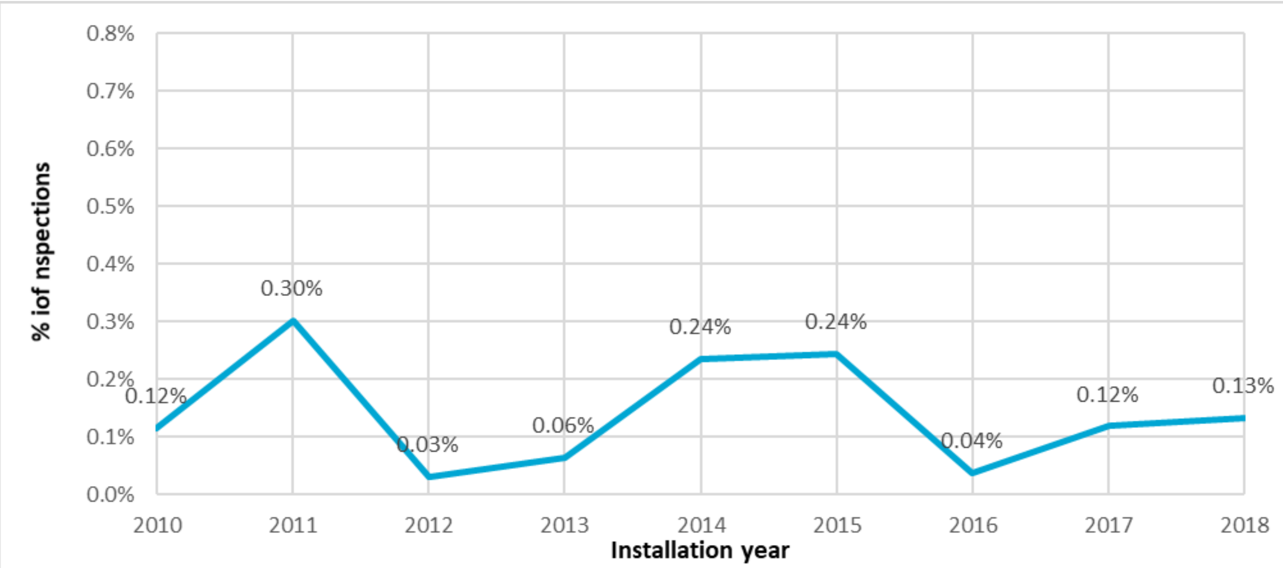

Figure 11 — Inspections where the PV system was unsafe due to unsecure panel mounting

Exposed live parts and unsecure PV panels each occurred in 0.2 per cent or less of inspections of 2018 installations. MEA advises these rates are similar to unsafe general electrical work due to human error and poor workmanship.

4.6. Unsafe PV systems due to other reasons

A PV system can receive an unsafe rating for reasons other than the 5 safety risks discussed so far. For example, an inspector might consider a number of minor wiring issues combined make a system unsafe. For unsafe/potentially unsafe categorisations used in this report, MEA recommended these PV systems be categorised as unsafe (see **Section 3.5**). **Figure 12** shows inspections where PV systems were unsafe for other reasons.

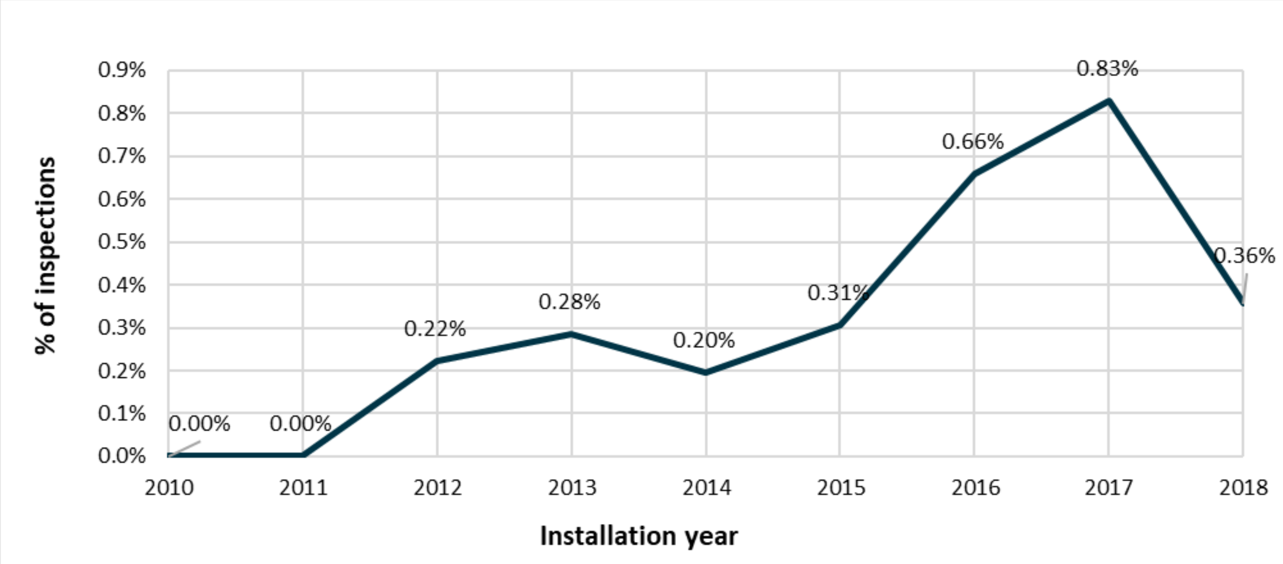

Figure 12 — Inspections where the PV system was unsafe due to other reasons

MEA analysed inspector comments for these inspections and found 53 per cent were due to issues related to rooftop and inverter DC isolators, 42 per cent were due other reasons such as earthing faults and 5 per cent were due to AC isolator matters.

4.7. Substandard PV systems

As discussed in **Section 3**, the agency defines substandard as a system not meeting key clauses in the standards and requirements for installation that may lead to premature equipment failure or other issues.

While substandard systems do not pose a safety risk, they can indicate emerging installation issues and help identify installers who consistently do not comply with Australian Standards or the CEC's guidelines. **Figure 13** shows inspections where a PV system was rated substandard. Substandard PV systems reached a low of 8.7 per cent for inspections of 2012 installations.

MEA advises new wiring and installation requirements in AS/NZS 5033 came into effect in October 2012 and resulted in more SRES inspections checklist items that could result in a substandard inspection.

One of these was the requirement that all DC cabling be in heavy-duty conduit (see **Section 4.3**). Substandard inspections increased to 18.0 per cent for 2013 installations and 12.4 per cent of these inspections did not comply with the new heavy-duty conduit requirement. For 2014 installations, 20.7 per cent of inspections were substandard and 13.6 per cent of these inspections were substandard for the same reason. Compliance with the heavy-duty conduit requirement has since improved (2 per cent of inspections did not comply for 2018 installations).

For 2018 installations, 18.1 per cent of inspections were substandard. The only gradual decline is due to the addition of two more checklist items in 2015 that could result in a substandard inspection and a broader spread of substandard checklist items.

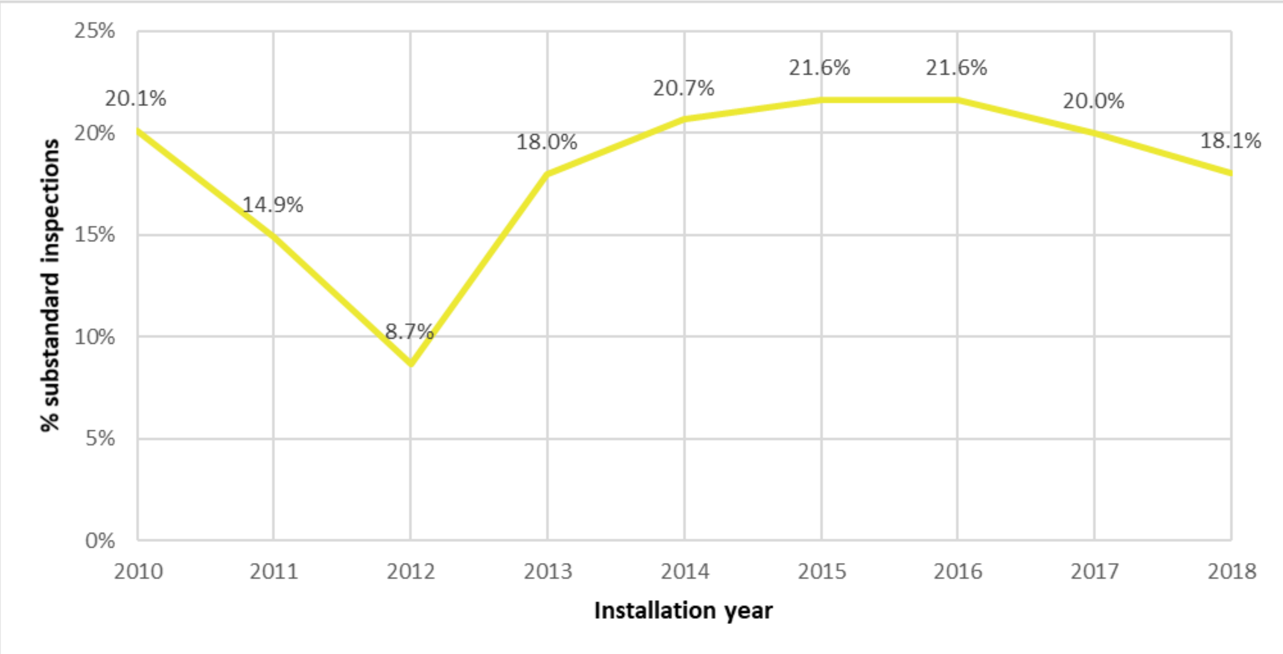

Figure 13 — Substandard inspections by installation year

4.8. The impact of potential PV safety risks

A key question is the extent to which PV safety risks have resulted in harm or damage. MEA advises, in most states and territories safety incidents are only reported to electrical safety authorities if the damage is above a certain monetary threshold (e.g. in Queensland the threshold is $5,000)—accordingly, publicly available data for incidents related to PV systems is limited.

The Australian Fire Authorities Council advised it is currently working with its state and territory members on standard reporting of PV system fires, but it has no publicly available data at this time.

The agency monitors PV-related incidents reported in the media. Since October 2016, the agency noted 13 potential fire and worker safety incidents involving residential and commercial PV systems. Of these, seven relate to fires potentially caused by a PV system with the media reporting possible causes as being:

- DC isolators (3 incidents)
- inverters (2 incidents), and
- defective panels (2 incidents).

These findings are based only on the information in the media articles and the agency has not confirmed these causes.

In 2019, Melbourne's Metropolitan Fire Brigade said DC isolators are a risk for PV system fires.[24] The Queensland Fire and Emergency Service (QFES) provided data on 100 PV system fires from 2014 to 2018 inclusive (see **Table 2**).[25]

Cause	Instances
DC isolator	54 (the data did not distinguish between rooftop and inverter DC isolators)
PV panel[26]	16
Unknown	13
Inverter	8
Switchboard	5
Battery	4

Table 2 — Causes of Queensland PV system fires 2014 to 2018

[24] Hobday, Liz and Gross, Sybilla, 'Australia's obsession with cheap solar is derailing the market, insiders say', *ABC News,* 27 May 2019 *https://www.abc.net.au/news/2019-05-27/australias-obsession-with-cheap-solar-derailing-market-insiders/11139856*

[25] The QFES advised their data is indicative only, is not exhaustive and there may be differences in how each fire service reports incidents. The data involved additional qualitative analysis and include only incidents where both the comments and codes entered in the incident report confirm the involvement of a PV system.

[26] MEA advised, from their experience with PV fire investigations, in the vast majority of cases where there has been a fire involving a PV panel, the cause has been something other than the panel, such as a cable fault or DC isolator.

4.9. Unapproved PV panels

The PV panels and inverter used for a PV system must be on the CEC's approved product lists to be SRES eligible. A manufacturer must show the CEC evidence its product complies with Australian safety standards, to be on these lists. This includes providing a certificate showing the panel has been tested in a laboratory approved under the IECEE scheme[27] and meets AS/NZS 5033 fire safety requirements that minimise a PV panel spreading fire.

Only some states, territories and DNSP's require PV panels be CEC approved, so while CEC unapproved panels are legally used, they are not SRES eligible.

MEA advises PV panels not meeting AS/NZS 5033 fire safety requirements are a safety risk and fire could propagate through the panels should the building or a PV system component, such as a DC isolator, catch fire.

SRES inspections data show the installation of PV panels not on the CEC's approved products list peaked at 5.3 per cent of inspections in 2010 installations and declined to 0.2 per cent of inspections in 2018 installations (see **Figure 14**).[28]

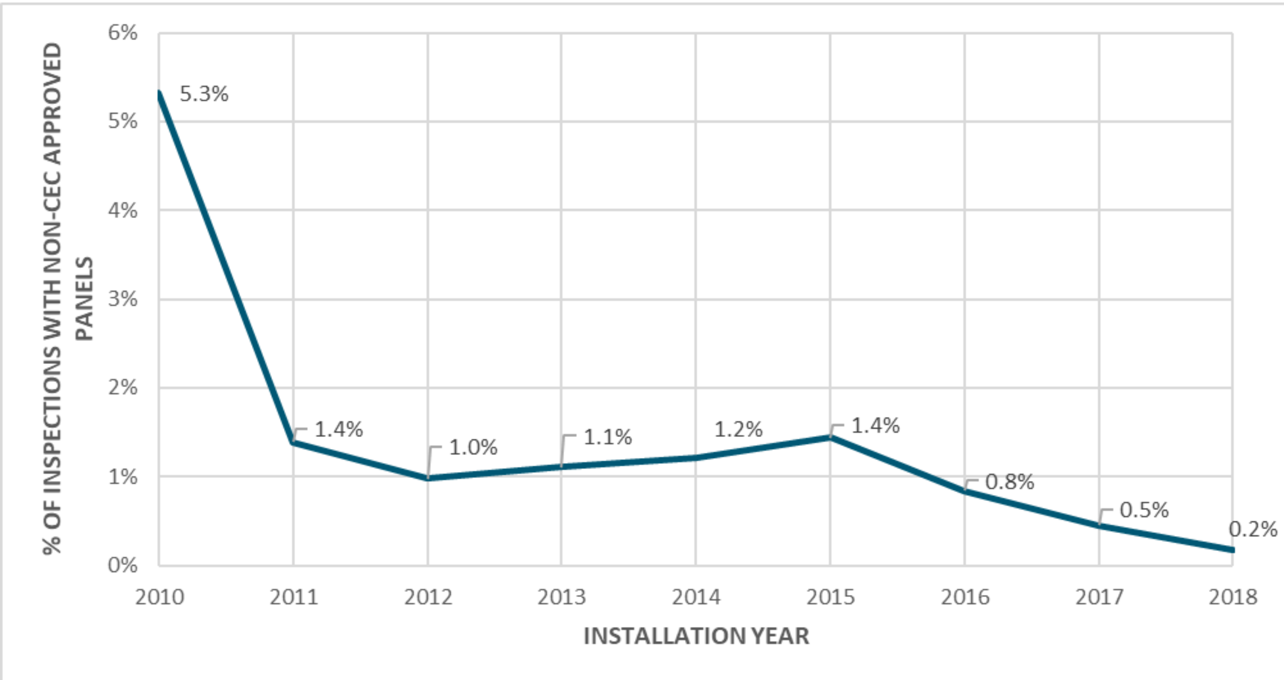

Figure 14 — Inspections with non-CEC approved PV panels

[27] International Electrotechnical Commission System for Conformity Assessment Schemes for Electrotechnical Equipment and Components.

[28] The SRES commenced January 2011 and required PV panels be on the CEC approved products list. It was not a requirement for the PV systems installed in 2010 under the RET.

Solar Panel Validation Initiative

The agency has partnered with industry to establish the Solar Panel Validation (SPV) Initiative. The SPV Initiative is a system of apps developed by industry, connected to PV panel serial number data provided by manufacturers. Installers use an app to verify PV panel serial numbers on-site.

The SPV Initiative gives installers and consumers a simple way to confirm PV panels are genuine, meet Australian standards, are backed by a manufacturer's warranty and are eligible for STCs.

The agency encourages SPV use by:

- processing faster STC claims that use SPV, and
- increasing processing times for STC claims without SPV or alternative evidence of serial number verification (such as manufacturer confirmation).

4.10. Battery safety

Australia's small-scale battery market is nascent but growing. Bloomberg New Energy Finance estimates a total of just over 43,000 residential and commercial batteries were installed up to 2018 inclusive, mostly with PV systems, and projects total installations will nearly triple by 2020.[29] This compares to approximately 223,000 PV systems installed in 2018.

The SRES does not incentivise batteries but some state and territory schemes do. When a SRES inspection is conducted on a PV system, if the system has a battery, data about the battery is gathered[30] but there is no systematic safety inspection.

The agency ran a pilot battery inspection program with MEA in early 2018 as part of the SRES inspections program. MEA considered some of the 32 batteries it inspected to be substandard, noting there was no definition of a substandard battery installation, and they considered none to be unsafe. The most common problem was no sign on the switch board to show a battery is connected and no sign to show the battery shut down steps.

It is worth noting *AS/NZS 5139:2019 Electrical Installations – Safety of battery systems for use with power conversion equipment* will replace *AS/NZS4086 Secondary batteries for use with standalone power systems* and the previous version of AS/NZS 5139. This is a major revision that covers lithium ion batteries (it

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[29] Edmonds, Williams, 12 June 2019, 2019 Australia Behind-the-Meter Forecast, *Bloomberg New Energy Finance*.

[30] Data include brand, model number, chemistry, storage capacity, location on the building and whether there is emergency procedure signage.

previously only covered lead-acid and NiCad batteries), among other things. It is expected to come into effect in all states and territories by mid 2020.

4.11. Recommendations

The agency's analysis shows water ingress in rooftop DC isolators and DC isolators near the inverter is the most common reason for unsafe and potentially unsafe PV systems.

There are initiatives to address this. The current review of *AS/NZS 5033 Installation and safety requirements for photovoltaic (PV) arrays* proposes making rooftop isolators voluntary. The revised standard is expected to come into effect in late 2021. State and territory governments are on the committee[31] for this review and are best placed to decide whether, on the balance of risks, rooftop DC isolators should be required.

Recommendation 1: State and territory governments consider whether the potential safety risks from the requirement for a rooftop DC isolator outweigh the benefits and pursue this in the current review of AS/NZS 5033.

The CEC's view is requiring the DC isolator inside the inverter, rather than as a separate switch near the inverter, is the best solution to prevent water ingress into DC isolators near the inverter. MEA's view is the use of DC isolators inside the inverter could reduce the risk of a separate DC isolator near the inverter being water damaged. From discussions the agency has had with inverter manufacturers, some inverter models already have an internal DC isolator.

MEA also notes requiring an internal inverter isolator may reduce but won't eliminate rooftop DC isolator water ingress causing internal inverter DC isolator water ingress (see **Section 4.3.2**).

The current review of *AS/NZS 4777 Grid connection of energy systems* proposes requiring the DC isolator inside the inverter. State and territory governments are on the committee for this review and are best placed to decide whether current standards should be changed to require a DC isolator within the inverter rather than as a separate component near the inverter.

Recommendation 2: State and territory governments consider whether the requirement for a DC isolator near the inverter should be changed to require the isolator be inside the inverter and pursue this in the current review of AS/NZS 4777.

AS/NZS 5033 recommends owners get their PV system inspected regularly and it recommends annual inspections for many system components, including DC isolators. However, because this is only a recommendation, regular inspections are not required under state and territory electrical safety laws.

MEA believes, from its experience, most consumers are not aware of PV system maintenance requirements and there are very few inspections after the initial installation and commissioning.

It notes isolator components can degrade from environmental exposure due to specific installation methods and product type, increasing the likelihood of water ingress and ultra violet radiation damage and, as a result, DC isolators may need to be replaced within the life of the panels of a PV system, typically 25 years.

[31] The agency and MEA are members of standards committee EL-042, which is reviewing AS/NZS 5033 and AS/NZS 4777.

To maintain safety and reliability, MEA recommends a qualified person inspect a system one year after installation to check DC isolators and other components and recommend the frequency of future component inspections.

The agency has information for consumers on PV system maintenance on its website.[32]

Recommendation 3: State and territory governments consider whether any of the recommendations for PV system inspections in AS/NZS 5033 should be mandated or educational programs implemented to encourage owners to engage qualified persons to do regular inspections.

[32] http://www.cleanenergyregulator.gov.au/RET/Pages/Scheme%20participants%20and%20industry/Individuals%20and%20small%20business/Solar-panel-system-maintenance.aspx

Appendix A: SRES inspections analysis standard errors for Australia overall

Combined unsafe and potentially unsafe PV systems

	Installation year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
% of inspections	5.0%	4.0%	3.3%	3.8%	5.5%	2.4%	1.9%	2.3%	1.7%
Standard error	0.5%	0.3%	0.3%	0.3%	0.5%	0.3%	0.3%	0.2%	0.3%

Causes of unsafe and potentially unsafe PV systems

		Installation year								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
Inverter DC isolators	**% of inspections**	1.3%	1.8%	2.2%	1.8%	2.5%	0.9%	0.6%	0.6%	0.5%
	Standard error	0.3%	0.2%	0.3%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%
Rooftop DC isolators	**% of inspections**	2.7%	1.4%	0.7%	1.7%	2.3%	0.9%	0.4%	0.7%	0.4%
	Standard error	0.4%	0.1%	0.1%	0.2%	0.3%	0.2%	0.1%	0.1%	0.1%
Exposed live parts	**% of inspections**	0.75%	0.21%	0.09%	0.09%	0.28%	0.15%	0.07%	0.17%	0.22%
	Standard error	0.21%	0.06%	0.05%	0.05%	0.10%	0.07%	0.05%	0.06%	0.10%
Cable junction box water ingress	**% of inspections**	0.52%	0.40%	0.22%	0.28%	0.39%	0.00%	0.15%	0.05%	0.09%
	Standard error	0.17%	0.09%	0.08%	0.09%	0.12%	0.03%	0.07%	0.03%	0.06%
Unsecure panel mounting	**% of inspections**	0.12%	0.30%	0.03%	0.06%	0.24%	0.24%	0.04%	0.12%	0.13%
	Standard error	0.08%	0.08%	0.03%	0.04%	0.10%	0.09%	0.04%	0.05%	0.08%

Unsafe systems due to other reasons	**% of inspections**	0.00%	0.00%	0.22%	0.28%	0.20%	0.31%	0.66%	0.83%	0.36%
	Standard error	0.06%	0.02%	0.08%	0.09%	0.09%	0.10%	0.15%	0.14%	0.13%

Appendix B: State and territory regulatory frameworks for small-scale PV systems

State or territory	Electrical regulator	Electrician licensing	Electrical safety laws	PV system safety inspection regime	Were rooftop DC isolators required before being mandated in the 2012 Australian Standard?
ACT	Access Canberra		Electrical Safety Regulation – 2004	Every new system is inspected by Access Canberra.	Required from 2011
NSW	NSW Fair Trading		Gas and Electricity (Consumer Safety) Regulation 2018	A sample of systems are inspected by NSW Fair Trading.	No
QLD	Electrical Safety Office		Electrical Safety Regulation 2013	A sample of systems are inspected by the Electrical Safety Office.	No
NT	NT WorkSafe		NT Electricity Act	A sample of systems are inspected by NT WorkSafe.	No
SA	Office of the Technical Regulator	Consumer and Business Services	SA Electricity Act (1996)	A sample of systems are inspected by the Office of the Technical Regulator.	Recommended, not required.
TAS	WorkSafe Tasmania	Consumer, Building & Occupation Services	TAS Electricity Act	Every new system is inspected by WorkSafe Tasmania	Required from 2011.

VIC	EnergySafe Victoria	Electrical Safety Installation Regulations 2009	Every new system must be checked by a licensed inspector.	Recommended from 2007. Required from 2011
WA	The Department of Mines, Industry Regulation and Safety	Electricity Licensing Regulations 1991	A sample of systems are inspected by the network operator as part of new electrical work inspections.	Recommended, not required

Appendix C: SRES inspections checklist

This checklist was current at 20 June 2019. It has since been revised. The checklist is revised as Australian standards and Clean Energy Council guidelines change.

Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
Major components		
Solar PV system is capable of producing electricity at the installation address without the need for any additional parts to be incorporated	CER1	Renewable Energy (Electricity) Regulations 2001
Solar Modules are listed on the CEC's list of approved products at the time of the system's installation	CER2	Renewable Energy (Electricity) Regulations 2001
Inverter/s are listed on the CEC's list of approved products at the time of the system's installation	CEC11	Renewable Energy (Electricity) Regulations 2001; CEC Install and Supervise Guidelines
Compliance with standards and guidelines		
The array's minimum Vmp (at maximum temperature) is greater than 1.1 x minimum Vdc of the inverter's voltage operating window	CEC15	CEC Design Guidelines
The array's maximum voltage Varray max (at minimum temperature) is less than the maximum VDC of the inverter's voltage operation window	CEC16	CEC Design Guidelines
Roof penetrations and/or the roof top components used in the wiring system including secondary shields, isolator shrouds, conduits and conduit glands are suitably installed, sealed and waterproof	CEC1	CEC Install and Supervise Guidelines
The PV Array structure allows sufficient clearance to facilitate self-cleaning of the roof to prevent any build-up of leaves and other debris	CEC3	CEC Install and Supervise Guidelines
Any timber used for the array structure is suitable for long term external use and fixed so that trapped moisture cannot cause corrosion of the roof and/or rotting of the timber.	CEC5	CEC Install and Supervise Guidelines

Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
If timber is used, the expected product life and/or therefore average time to replacement are stated in the system documentation	CEC6	CEC Install and Supervise Guidelines
The array structure's roof penetrations are suitably sealed and waterproofed for the expected life of the system or if this is not possible then it is detailed in the system's Maintenance Timetable	CEC8	CEC Install and Supervise Guidelines
DC PV Wiring Losses are less than 3%	CEC9.1	CEC Install and Supervise Guidelines
AC wiring losses are less than 1% between the inverter and the point of connection to the grid	CEC9.2	CEC Install and Supervise Guidelines
The DC cables connecting to the inverter are mechanically secured in such a manner that they cannot be inadvertently unplugged from the inverter	CEC12	CEC Install and Supervise Guidelines
The installation of modules that are used as building material e.g. roof tiles, building walls, sun-screens, have been installed by a suitably qualified tradesperson for that building element.	CEC14	CEC Install and Supervise Guidelines
Inverter is of appropriate IP rating for its location	COMPONENTS1	AS/NZS 3000:2007, Cl 4.1.3
There are no visible loose connections in LV cables	COMPONENTS2	AS/NZS 3000:2007, Cl 3.7.2
The DC enclosure/s at the inverter have the required IP rating (minimum IP 54 if outdoors) and have been correctly installed to prevent water ingress	DC1.1.1.1.1	AS/NZS 3000:2007, Cl 4.1.2 & 4.1.3; AS/NZS 5033:2014, Cl 4.3.3.1
The DC enclosure/s at the inverter have the required IP rating (minimum IP54 if outdoors) and have been correctly installed to prevent water ingress and have no signs of water damage	DC1.1.2.1	AS/NZS 3000:2007, Cl 4.1.2 & 4.1.3; AS/NZS 5033:2014, Cl 4.3.3.1
The load breaking DC isolator located adjacent to the inverter is correctly rated for actual required DC voltage and current in accordance with AS/NZS5033	DC1.2.1.1.1	AS/NZS 3000:2007, Cl 2.4.2; AS/NZS 5033:2014, Cl 4.3.1
The isolator [or C/B] at the inverter, connected to the array is DC rated	DC1.3.1.1	AS/NZS 3000:2007, Cl 2.2.4.2; AS/NZS 5033:2014, Cl 4.3.1
The DC isolator [or DC C/B] is mounted close to inverter input and the inverter is not in sight or more than three metres from the array	DC1.4.1	AS/NZS 5033:2014, Cl 4.4.1.2, 4.4.1.3 & 4.4.1.5
The DC isolator [or DC C/B] is lockable in the off position	DC1.5.1	AS/NZS 3000:2007, Cl 2.3.6.3
The DC isolator at the inverter is correctly wired	DC1.6	AS/NZS 3000:2007, Cl 4.1.2
The DC isolator at the inverter is not polarised and activates in all active conductors	DC1.7	AS/NZS 5033:2014, Cl 4.3.5.2

Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
The DC isolator/s at the inverter are readily available	DC1.8	AS/NZS 5033:2014, Cl 4.3.3.2
If multiple DC isolators are installed at the inverter, they are grouped and ganged so they operate simultaneously or grouped in a common location	DC1.9	AS/NZS 5033:2014, Cl 4.4.1.4
The DC enclosure/s at the array have a minimum IP 55 rating, have been correctly installed to prevent water ingress and have no signs of water damage	DC2.1.1.1	AS/NZS3000:2007, Cl 4.1.2 & 4.1.3; AS/NZS 5033:2014, Cl 4.3.3.1
The DC enclosure/s at the array have a minimum IP 55 rating and have been correctly installed to prevent water ingress	DC2.1.2.1	AS/NZS3000:2007, Cl 4.1.2 & 4.1.3; AS/NZS 5033:2014, Cl 4.3.3.1
The load breaking DC isolator located immediately adjacent to the array is correctly rated for actual required DC voltage and current	DC2.2.1	AS/NZS 5033:2014, Cl 4.3.1
The DC isolator adjacent to the array is correctly wired	DC2.3	AS/NZS 3000:2007, Cl 1.7.1
A load breaking DC isolator is located immediately adjacent to the array	DC2.4	AS/NZS 5033:2014, Cl 4.4.1.5
The DC isolator/s at the array are readily available	DC2.5	AS/NZS 5033:2014, Cl 4.3.3.2
DC isolators are compliant with requirements of state or territory where system is located	DC2.6	(CEC Install and Supervise Guidelines; AS/NZS 4417.2:2012 Amd. 4)
PV cable junction boxes have minimum IP 54 rating [IP 55 if mounted on the array], have been correctly installed to prevent water ingress and have no signs of water damage	WIRING10	AS/NZS 5033:2014, Cl 4.3.3.1
PV cable junction boxes have an IP 54 rating [IP 55 if mounted on the array], and have been correctly installed to prevent water ingress	WIRING10.1	AS/NZS 5033:2014, Cl 4.3.3.1
Connection of AC and DC components in same enclosure are segregated i.e. there must be physical separation between AC and DC in an enclosure where wiring from both components are terminated	WIRING11	AS/NZS 5033:2014, Cl 4.4.4.3
The installation shall be such that it minimises the spread of any fire which might result within the system. Any new circuit breaker holder, junction box or similar must not allow any fire to escape the enclosure onto any combustible material e.g. circuit breaker box	WIRING12	AS/NZS 3000:2007, Cl 3.9.9 & 1.5.12

Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
The PV array cabling is distinctively marked PV in permanent, legible and indelible English, or where the cable is not distinctively marked, distinctive coloured labels marked 'SOLAR' attached at intervals not exceeding 2 metres	WIRING13.1	AS/NZS 5033:2014, Cl 5.3.1
Any DC wiring located in the AC switchboard complies with the segregation, insulation and labelling requirements of AS/NZS 3000 and AS/NZS 5033	WIRING14	AS/NZS 3000:2007, Cl 3.9.8
All electrical equipment for the system is installed in accordance with AS/NZS3000	WIRING15	AS/NZS 3000:2007, Cl 1.6 & 1.7
Array wiring and wiring to the inverter is protected from mechanical damage. This requires a visual inspection of all cables related to the system and therefore might require checking on the roof.	WIRING16.1	AS/NZS 3000:2007, Cl 3.9.4.1; AS/NZS 5033:2014, Cl 4.3.6.3.1
Array wiring and wiring to the inverter is protected from UV. This requires a visual inspection of all cables related to the system and therefore might require checking on the roof.	WIRING16.2.1	AS/NZS 3000:2007, Cl 1.5.14; AS/NZS 5033:2014, Cl 4.3.6.2
Double insulation has been maintained between any live conductor and any earthed or exposed conductive part	WIRING17	AS/NZS 5033:2014, Cl 3.2
All DC cable installed within the ceiling space, wall cavity or floor is enclosed in heavy duty [HD] conduit	WIRING18	AS/NZS 5033:2014, Cl 4.3.6.3.2
All DC connectors are of the same type/model from the same manufacturer where they are married at a connection point	WIRING19	AS/NZS 5033:2014, Cl 4.3.7
All cables/wiring in the installation are securely fixed in place to minimise any movement of the cable.	WIRING2.1	AS/NZS 3000:2007, Cl 3.9.3.3 & 3.3.2.8; AS/NZS 5033:2014, Cl 4.3.6.3.1
Any conduit is installed such that they are protected from UV or the conduit is UV stabilised	WIRING3	AS/NZS 3000:2007, Cl 1.5.14
Array wiring and wiring is protected from fauna where deemed necessary	WIRING4	AS/NZS 3000:2007, Cl 1.5.14
Array wiring and wiring to inverter is rated for the voltage and current	WIRING5.1	AS/NZS 3000:2007, Cl 3.1; AS/NZS 5033:2014, Cl 4.3.6.1
If there is not a clear line of sight between the switchboard connected to the inverter and any person working on the inverter, an AC isolator is provided at the inverter	GENERAL1	AS/NZS 3000:2007, Cl 7.3.4.1 A
Inverter [or any heavy part of system] is installed/mounted safely and there appears no imminent risk of the item falling	GENERAL2	AS/NZS 3000:2007, Cl 1.7.1 & 1.7.2
Inverter has been installed in a location that has safe access and adequate working space	GENERAL2.1.1	AS/NZS 3000:2007, Cl 1.7.2

Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
Modules in the same string are installed in the same orientation within +/- 5 degrees	GENERAL3	AS/NZS 5033:2014, Cl 2.1.6
The maximum voltage of the array does not exceed 600 VDC	GENERAL4	AS/NZS 5033:2014, Cl 3.1
The entire PV array and associated wiring and protection have restricted access where the maximum voltage of the array exceeds 600 VDC in a non-domestic installation.	GENERAL4.1	AS/NZS 5033:2014, Cl 3.1
There is adequate clearance around the inverter in accordance with inverter manufacturer's recommendation with adequate space and ventilation	GENERAL5.1	AS/NZS 3000:2007, Cl 1.7.1
AC circuit breaker on switchboard is lockable	INSTALL1.1	AS/NZS 4777.1:2016 3.4.3
An AC circuit breaker is mounted within the switchboard to act as main switch for the PV / inverter system and to protect the cable from the switchboard to the inverter	INSTALL2.1	AS/NZS 4777.1:2016, Cl 3.4.1; AS/NZS 3000:2007, Cl 7.3.5.2 & 7.3.8.2.2
The AC circuit breaker is correctly rated to protect the AC cable installed between the inverter and switchboard to which it is connected	INSTALL3.1	AS/NZS 4777.1:2016, Cl 3.4.1; AS/NZS 3000:2007, Cl 2.5.2
The AC cables installed between the inverter and the switchboard to which it is connected are rated at a minimum of the inverter's maximum output current	INSTALL4.1.1	AS/NZS 4777.1:2016, Cl 3.3.1
PV mounting structure and attachment to roof visually inspected and appears to be secure	MECH1.1	AS/NZS 5033:2014, Cl 2.2
Any freestanding PV structure was visually inspected and appears to be secure	MECH2.1	AS/NZS 5033:2014, Cl 2.2
All array supports, brackets, screws and other metal parts are either: (a) of similar material or stainless steel to minimise corrosion; or (b) where dissimilar metals that can have a galvanic reaction are used, that they are galvanically isolated	MECH3	AS/NZS 5033:2014, Cl 2.2.7
Where there is a number of PV array strings and could result in a potential fault current in any one string greater than reverse current of an individual module - appropriate string protection is provided. [e.g. Fuses or non-polarised circuit breakers]	PROTECTION1.1	AS/NZS 5033:2014, Cl 3.3.4
If lightning protection has been installed, it has been installed in accordance with AS1768	PROTECTION3.1	AS/NZS 5033:2014, Cl 3.5

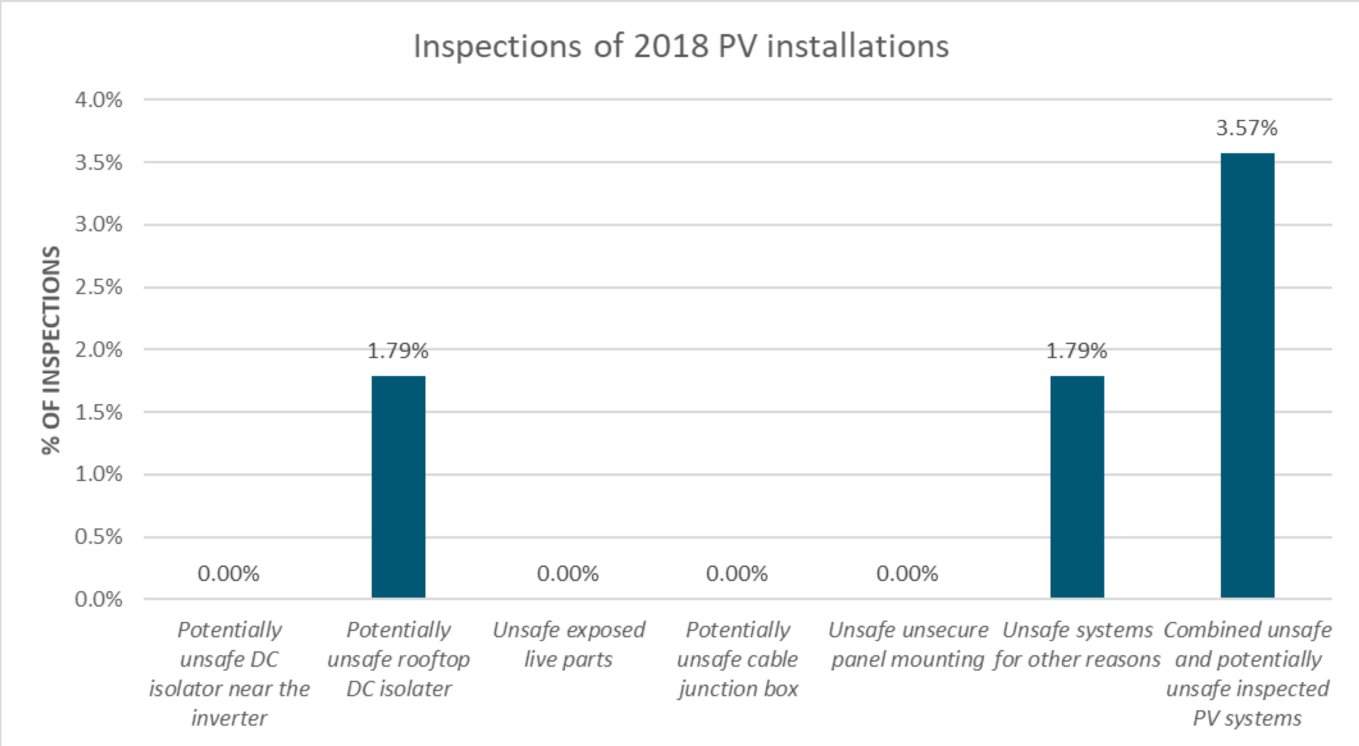
Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
If a transformer-less inverter [non-galvanically isolated] is installed, a functional earth is not connected to the DC positive or negative	PROTECTION4.1	AS/NZS 5033:2014, Cl 3.2
If string protection is installed, it is rated for DC application and appropriate current	PROTECTION2.1	AS/NZS 5033:2014 3.3.5.1; AS/NZS 3000:2007 2.2.4
The PV array mounting frames and modules have an equipotential bond connected to the earthing terminal on the switchboard/distribution board to which the inverter is connected, either directly or via the inverter main earth conductor.	PROTECTION5	AS/NZS 5033:2014, Cl 4.4.2
The PV array frame and/ module earthing connections and methods comply with standards requirements	PROTECTION5.1	AS/NZS 5033:2014, Cl 4.4.2.2
If string protection is installed, the fuse holders have a current rating equal to or greater than the corresponding fuse	PROTECTION6	AS/NZS 5033:2014, Cl 4.3.8.2
If the PV array has direct functional earthing, an Earth Fault Interrupter is installed.	PROTECTION7	AS/NZS 5033:2014, Cl 4.4.3.1
PV cable junction boxes are labelled 'WARNING: HAZARDOUS DC VOLTAGE'	SIGN1.1	AS/NZS 5033:2014, Cl 5.3.2
If multiple DC isolators are installed at the inverter the correct warning sign indicating the need to operate all DC isolators to isolate the equipment is present	SIGN10	AS/NZS 5033:2014, Cl 5.5.2
Shutdown procedure is correct and is permanently fixed at inverter and/or on main switchboard	SIGN2.1	AS/NZS 5033:2014, Cl 5.5.3
If the solar system is connected to a distribution board, the following sign is located on the main switchboard and all intermediate distribution boards "WARNING MULTIPLE SUPPLIES ISOLATE INVERTER SUPPLY AT DISTRIBUTION SWITCHBOARD AT (LOCATION)"	SIGN3.1	AS/NZS 4777.1:2016, Cl 6.3
The AC Circuit breaker in the switchboard is labelled: "MAIN SWITCH (INVERTER SUPPLY)"	SIGN4.1	AS/NZS 4777.1:2016, Cl 6.2 (b)
Sign – 'WARNING MULTIPLE SUPPLIES ISOLATE ALL SUPPLIES BEFORE WORKING ON THIS SWITCHBOARD' is located on the switchboard	SIGN5.1	AS/NZS 4777.1:2016, Cl 6.2 (a)
Where the inverter is not adjacent to the main switchboard, inverter location information should be displayed on the switchboard to which the inverter system is directly connected.	SIGN6.1	AS/NZS 4777.1:2016, Cl 6.2
Fire Emergency information is correct and is permanently fixed next to the meter box (if one exists) and the buildings main switchboard. 'SOLAR ARRAY ON … [location] …' : sign and includes the correct PV array Voc and Isc ratings	SIGN7.1.1	AS/NZS 5033:2014, Cl 5.4

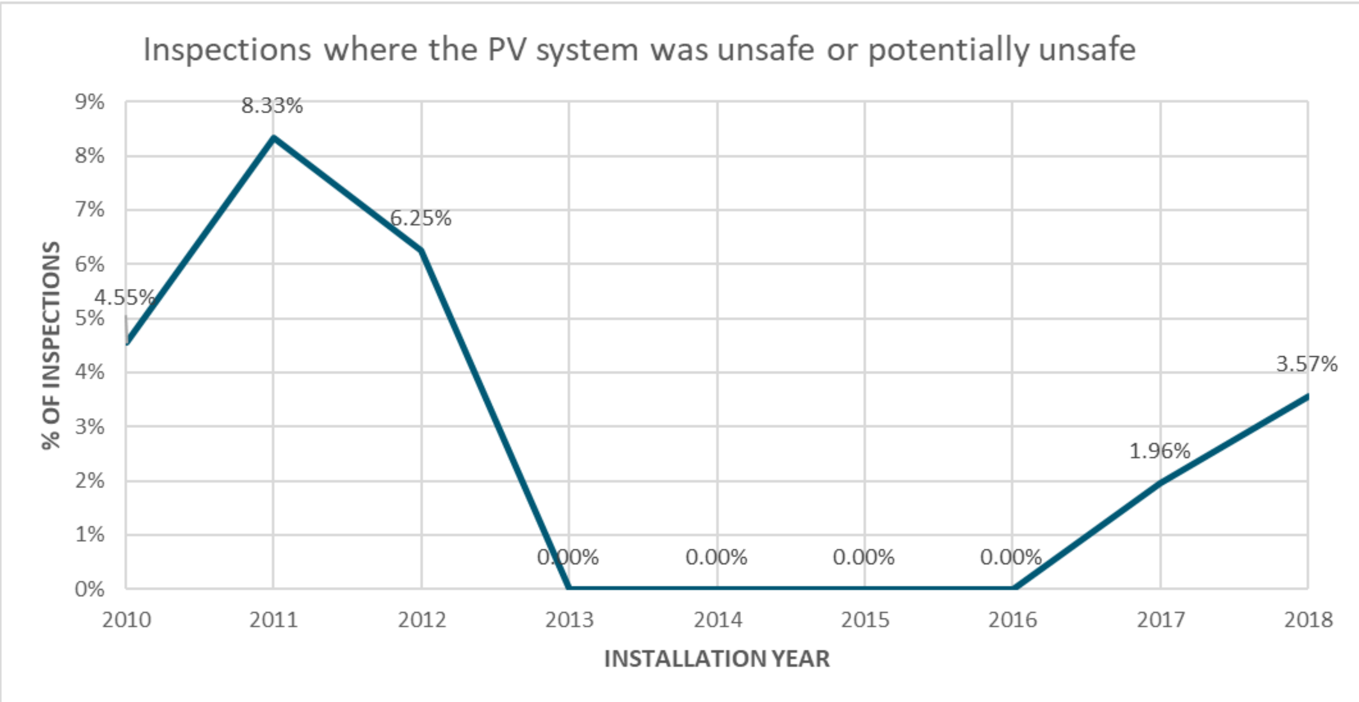
Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
Signage that is a circular green reflector at least 70mm in diameter with the letters "PV" is installed immediately on or adjacent to the meter box and switchboard and is readily available to be seen by approaching emergency workers	SIGN7.2	AS/NZS 5033:2014, Cl 5.4
DC isolator near inverter is appropriately signed	SIGN8.1	AS/NZS 5033:2014, Cl 5.5.2
Grid supply main switch is labelled 'MAIN SWITCH (GRID SUPPLY)' or similar.	SIGN9.1.1	AS/NZS 4777.1:2016, Cl 6.2 (c); AS/NZS 3000:2007, Cl 7.3.8.2.2
Signage "WARNING HAZARDOUS VOLTAGE - AUTHORIZED ACCESS ONLY" is installed if the system voltage is greater than 600VDC on a non domestic installation	SIGN9.1	AS/NZS 5033:2014, Cl 5.5.4
Documentation		
The owner of the system has been provided a copy of the shutdown and isolation procedure for emergency and maintenance	DOC1.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a basic system connection diagram that includes the electrical ratings of the PV array, and ratings of all overcurrent devices and switches as installed.	DOC10.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a commissioning sheet/s and installation checklist	DOC11.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a list of actions to be taken in the event of an earth fault alarm	DOC12.1	AS/NZS 5033:2014, Cl 5.7
The owner has been provided a recommended maintenance procedure and timetable with safety warnings	DOC13.1	AS/NZS 5033:2014, Cl 5.7
The owner has been provided warranty Information [equipment and installation]	DOC14.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided manufacturer's documentation [data sheets, handbooks, etc]	DOC2.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a copy of the engineering certificate stating that the array frame is certified to AS1170.2 for the location	DOC3.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a short description of the function and operation of installed equipment	DOC7.1	AS/NZS 5033:2014, Cl 5.7
The owner of the system has been provided a system performance [energy output] estimate	DOC8.1	AS/NZS 5033:2014, Cl 5.7

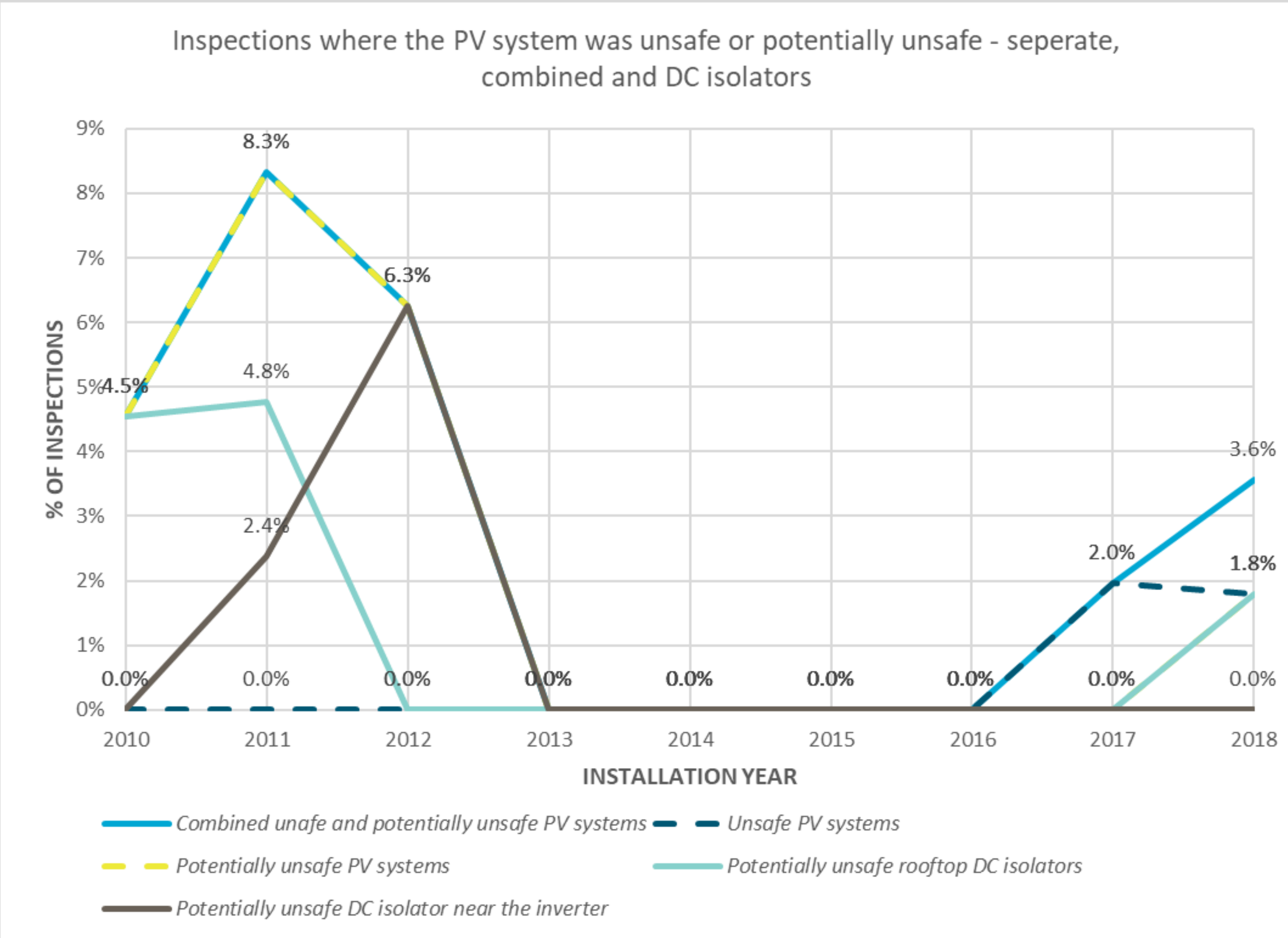
Checklist item	Checklist clause	Australian standard or Clean Energy Council guideline the item refers to
The owner of the system has been provided a list of equipment supplied	DOC9.1	AS/NZS 5033:2014, Cl 5.7
Performance of systems		
Modules have sufficient ventilation space to minimise temperature rise.	SYSTEM1	AS/NZS 5033:2014, Cl 2.1.9
General wiring and installation work		
There are no exposed LV live parts on any installed equipment	WIRING1	AS/NZS 3000:2007, Cl 1.5.3.1
All joints in cables are enclosed e.g. in junction boxes and/or comply with the exceptions of AS/NZS3000 Clause 3.7.3	WIRING6	AS/NZS 3000:2007, Cl 3.7.3
Double insulation has been maintained between the positive and negative conductors/terminations within all enclosures	WIRING6.1	AS/NZS 5033:2014, Cl 4.4.4.1
There is no evidence of mechanical damage to LV cables	WIRING7	AS/NZS 3000:2007, Cl 3.9
Wiring from array to isolator/inverter is single conductor cable both insulated and sheathed	WIRING8.1	AS/NZS 5033:2014, Cl 4.3.6.2
All array cables are (i) temperature rating to the application; or UV resistant if exposed to the environment; or (iii) flexible (multi-stranded) to allow for thermal/wind movement of arrays/modules	WIRING8.2	AS/NZS 5033:2014, Cl 4.3.6.2
LV array and inverter cables are not installed near building surfaces as per AS/NZS 3000 requirements	WIRING9	AS/NZS 3000:2007, Cl 3.9.4

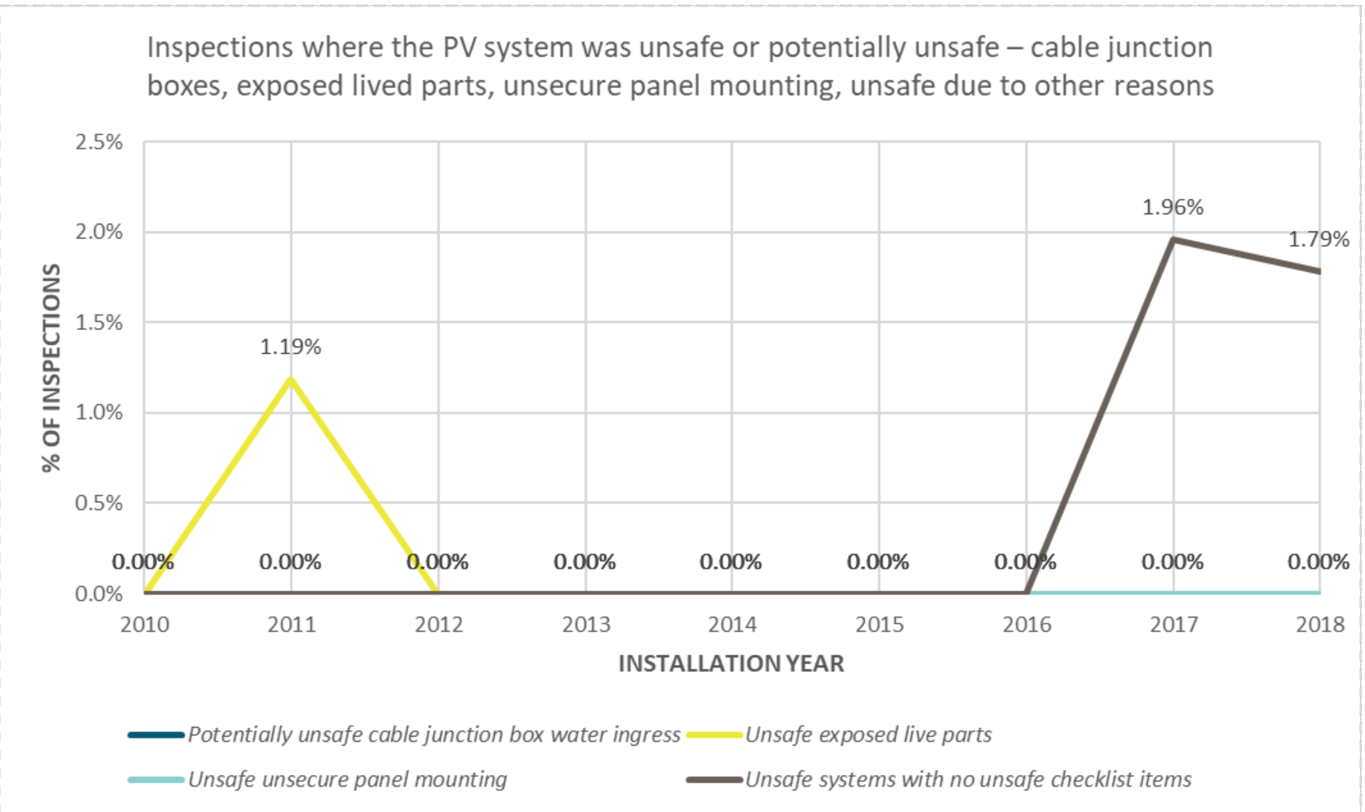
Appendix D: Inspection findings for each state and territory

Australian Capital Territory

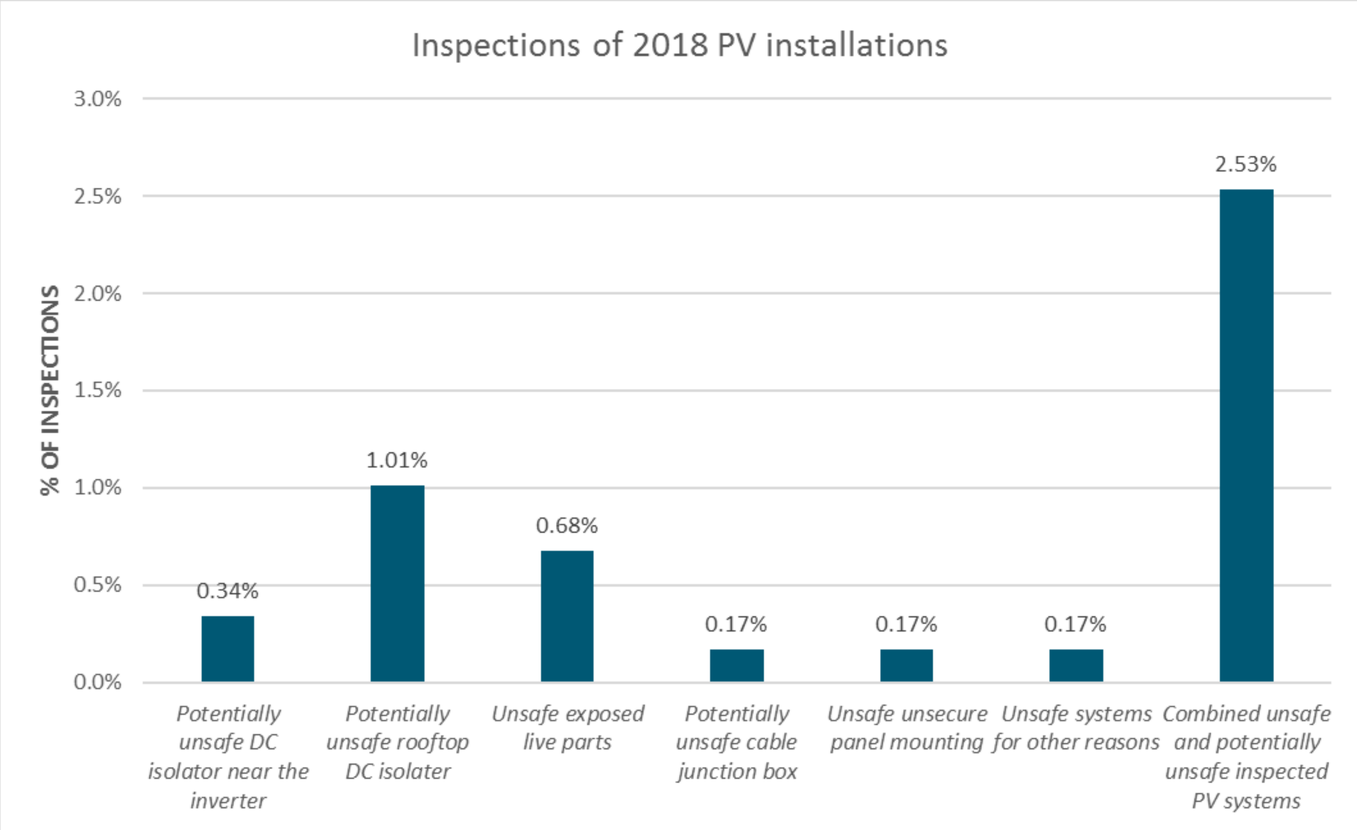


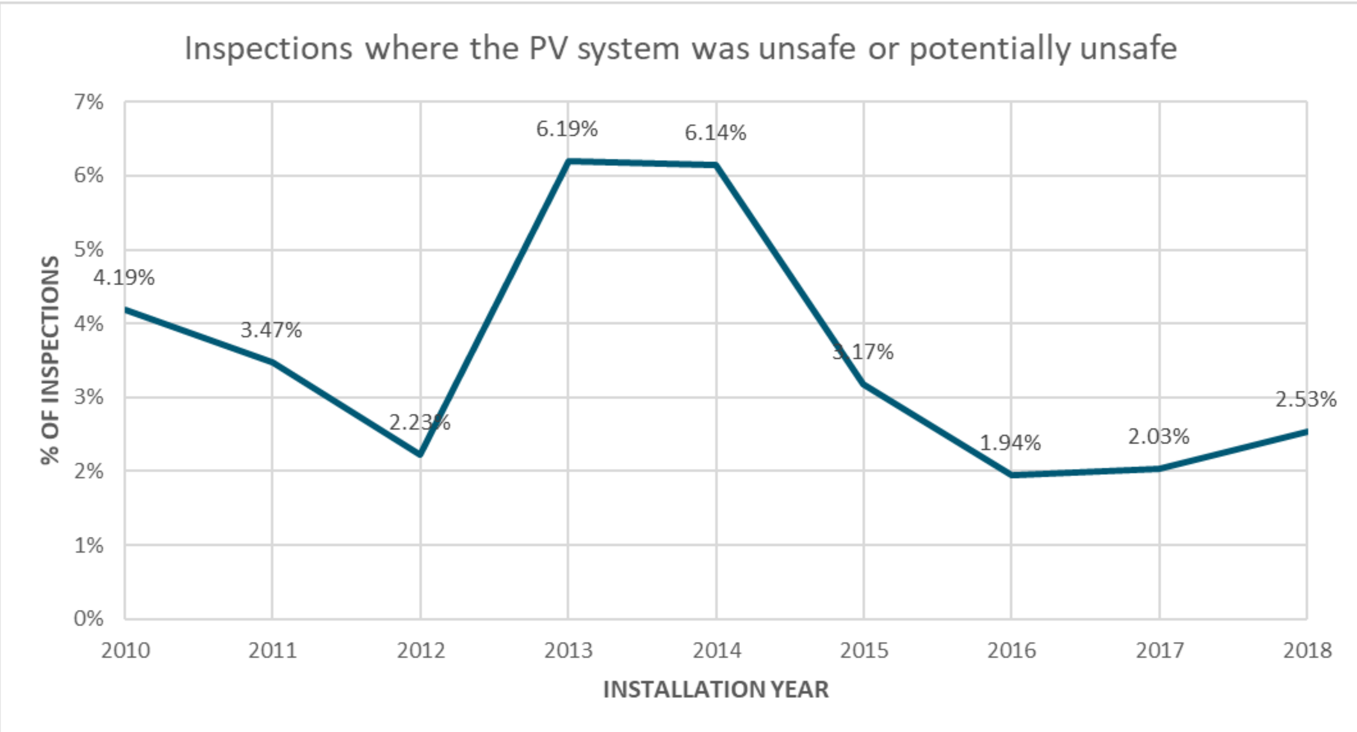



Inspections where the PV system was unsafe or potentially unsafe - seperate, combined and DC isolators
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
% OF INSPECTIONS
8.3%
6.3%
4.5%
4.8%
2.4%
3.6%
2.0%
1.8%
0.0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter

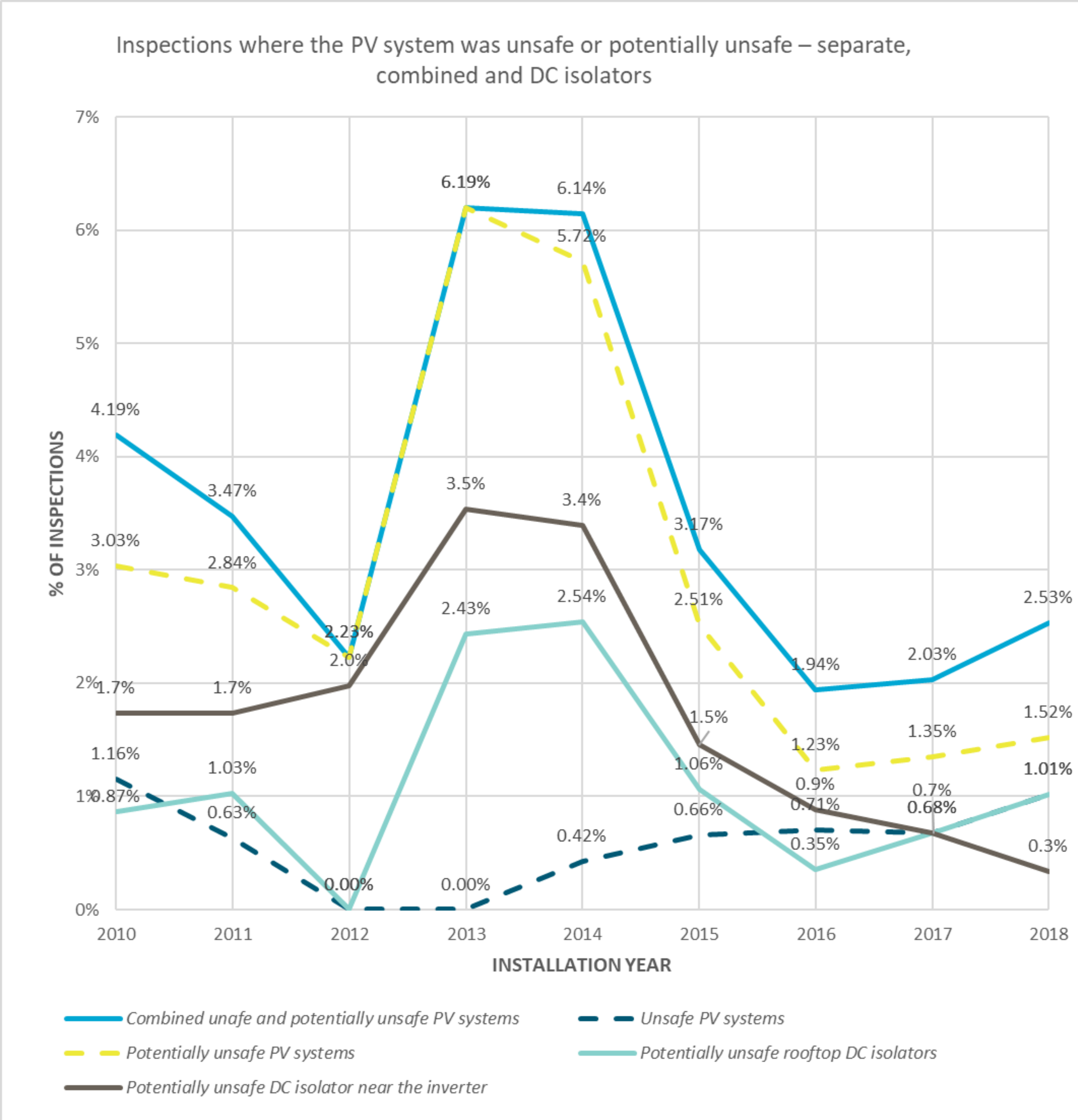

Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
% OF INSPECTIONS
1.19%
1.96%
1.79%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems with no unsafe checklist items

New South Wales

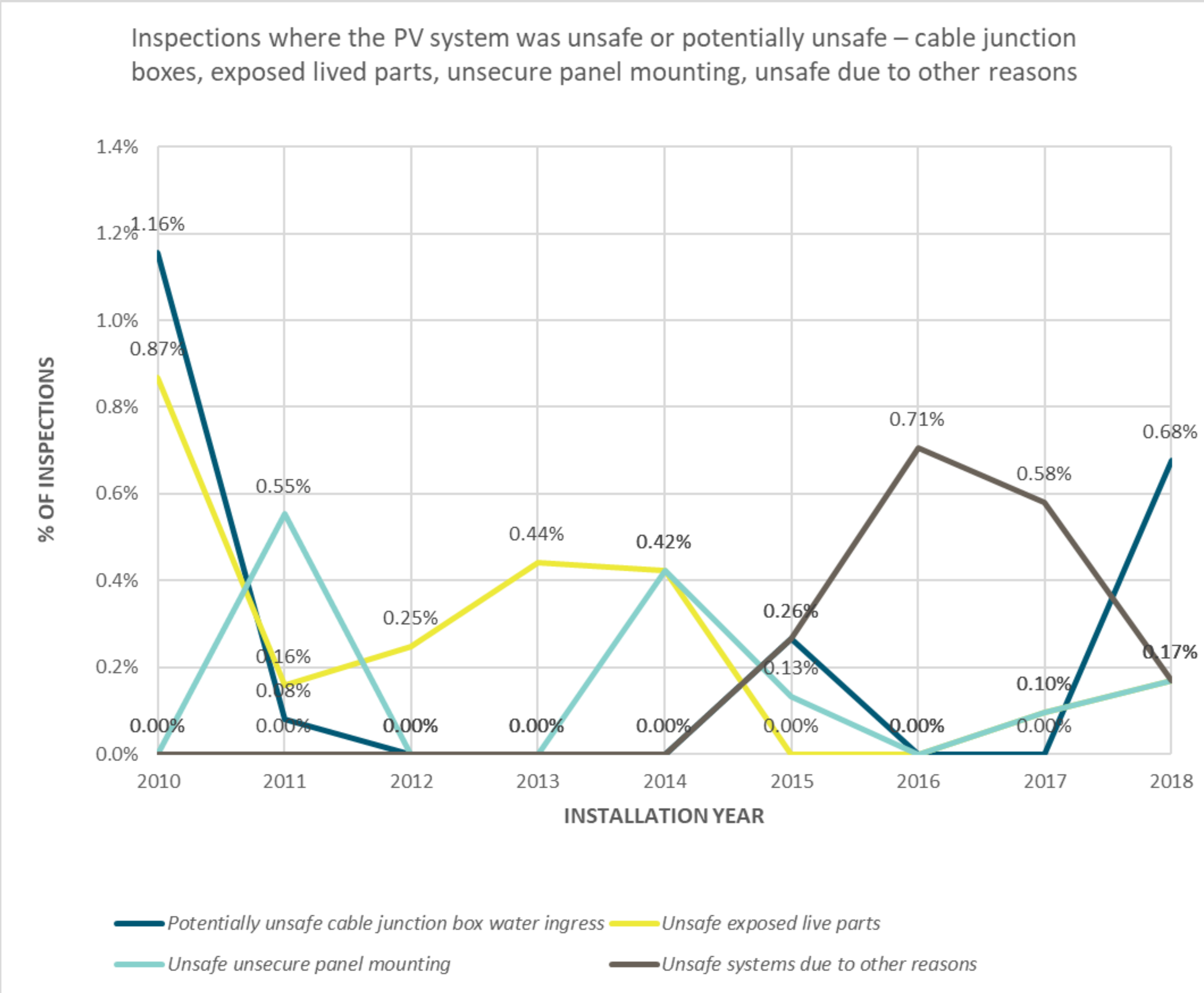




OFFICIAL

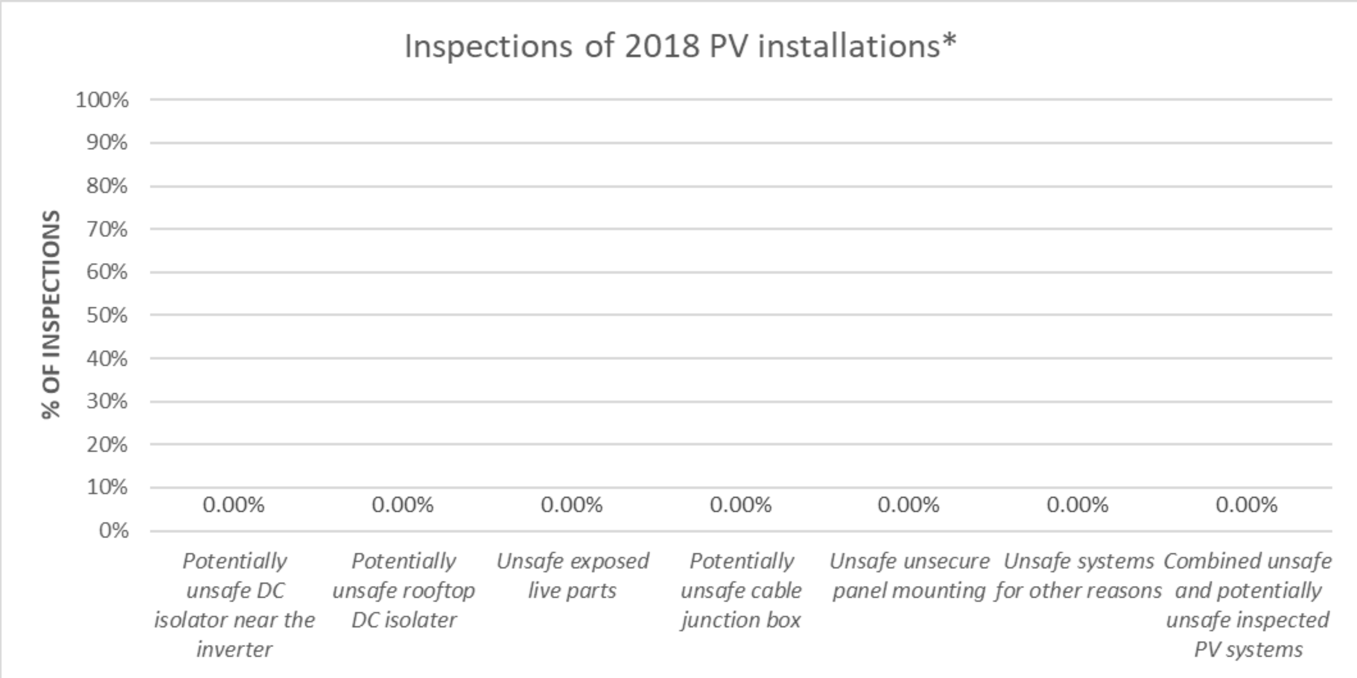


Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
7%
6%
5%
4%
3%
2%
1%
0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
4.19%
3.47%
2.23%
6.19%
6.14%
3.17%
1.94%
2.03%
2.53%
3.03%
2.84%
2.0%
5.72%
2.51%
1.23%
1.35%
1.52%
1.7%
1.7%
3.5%
3.4%
1.5%
0.9%
0.7%
0.3%
0.87%
1.03%
0.00%
2.43%
2.54%
1.06%
0.35%
0.68%
1.01%
1.16%
0.63%
0.00%
0.42%
0.66%
0.71%
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter

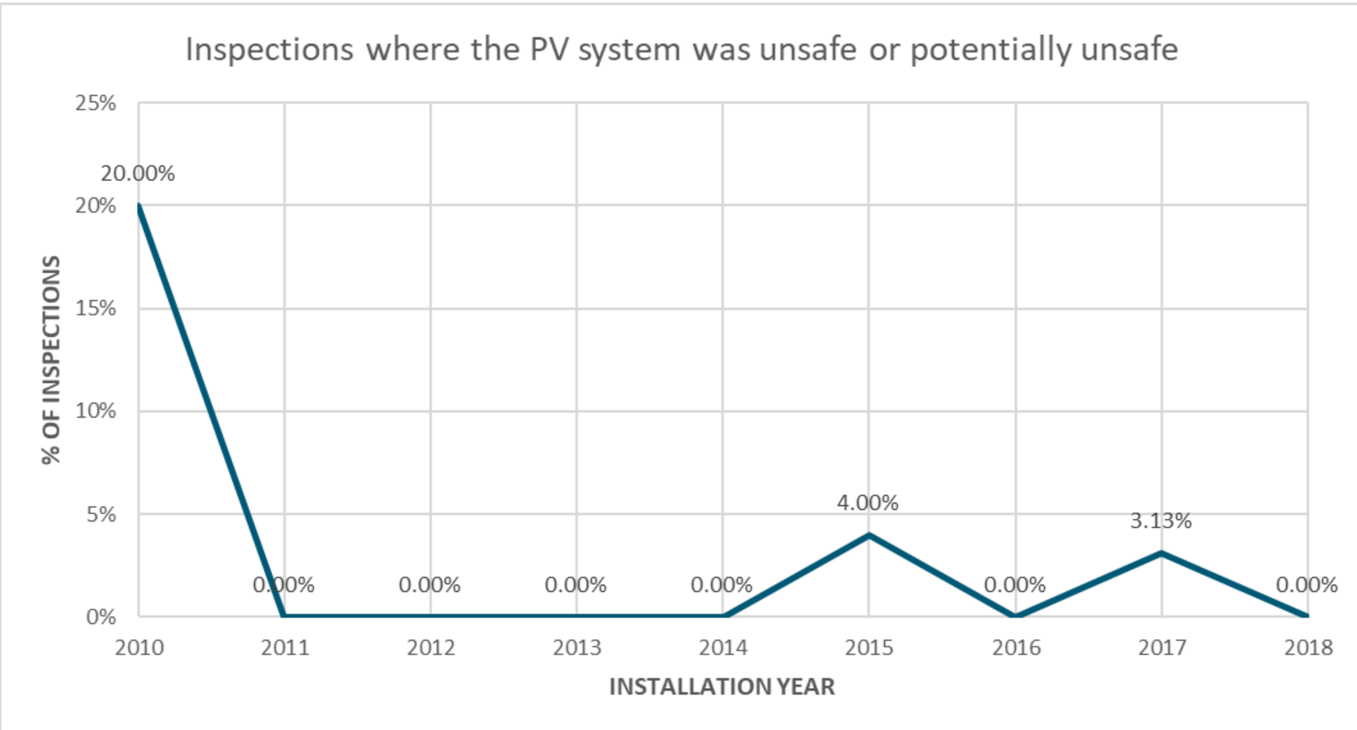


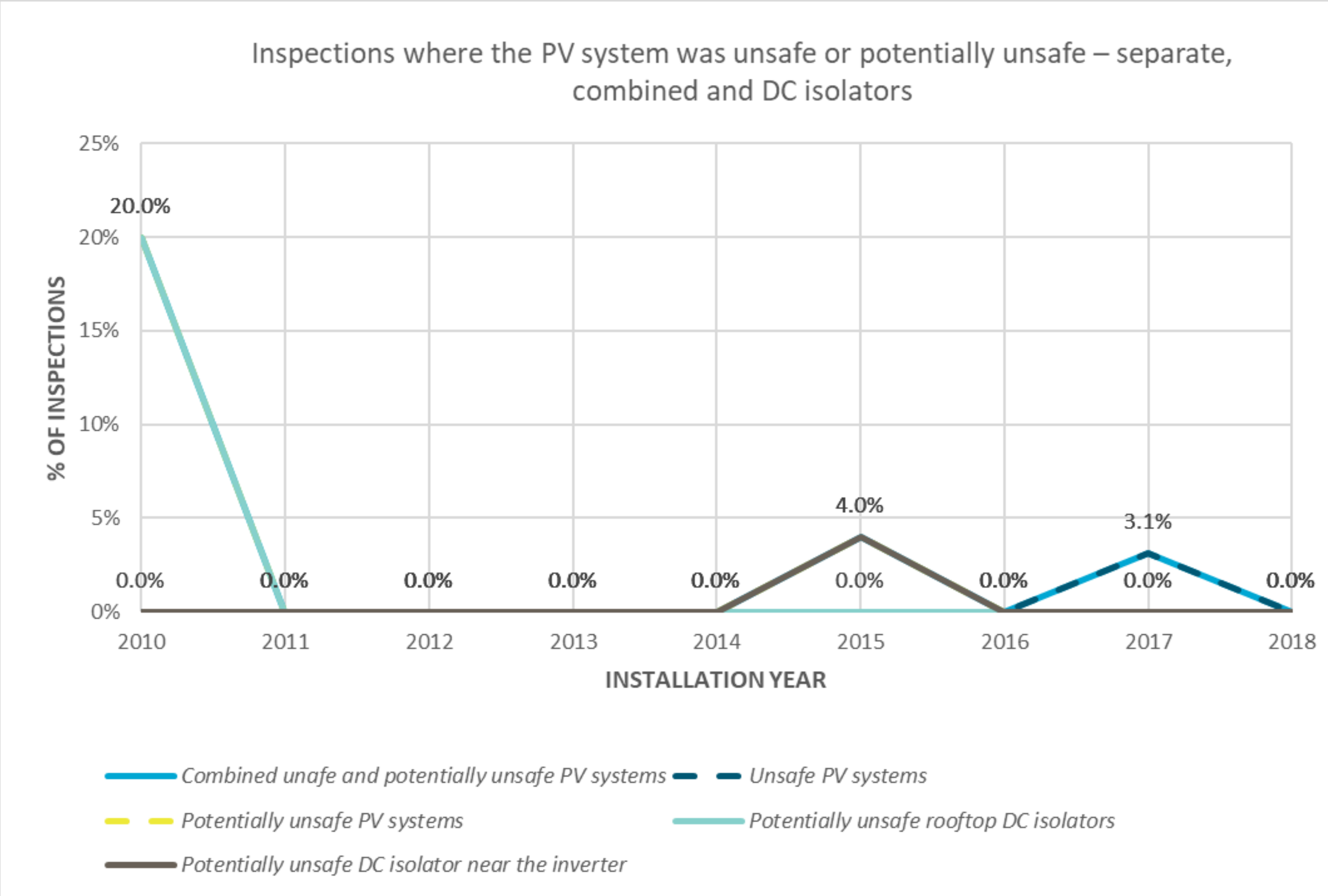
Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
INSTALLATION YEAR
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
1.16%
0.87%
0.55%
0.44%
0.42%
0.25%
0.26%
0.16%
0.08%
0.13%
0.71%
0.58%
0.68%
0.17%
0.10%
0.00%
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

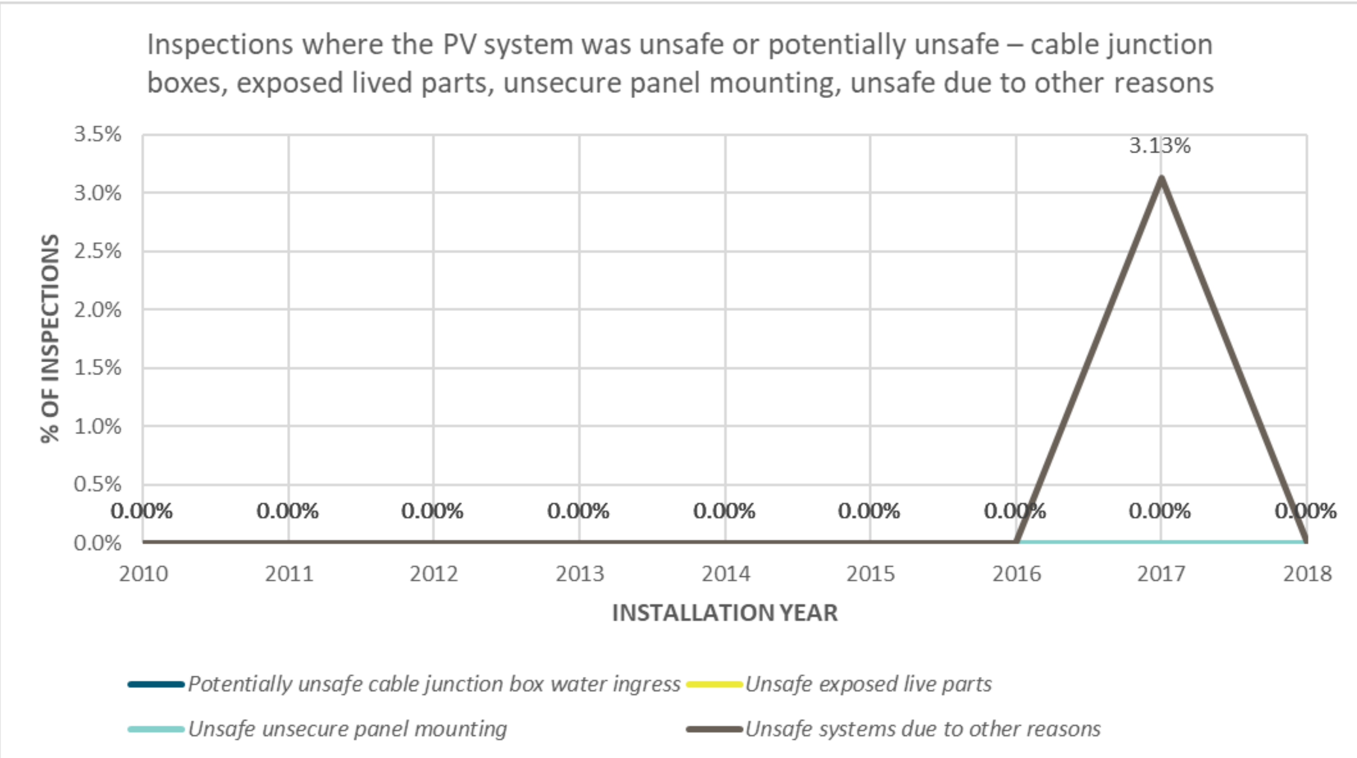
Northern Territory



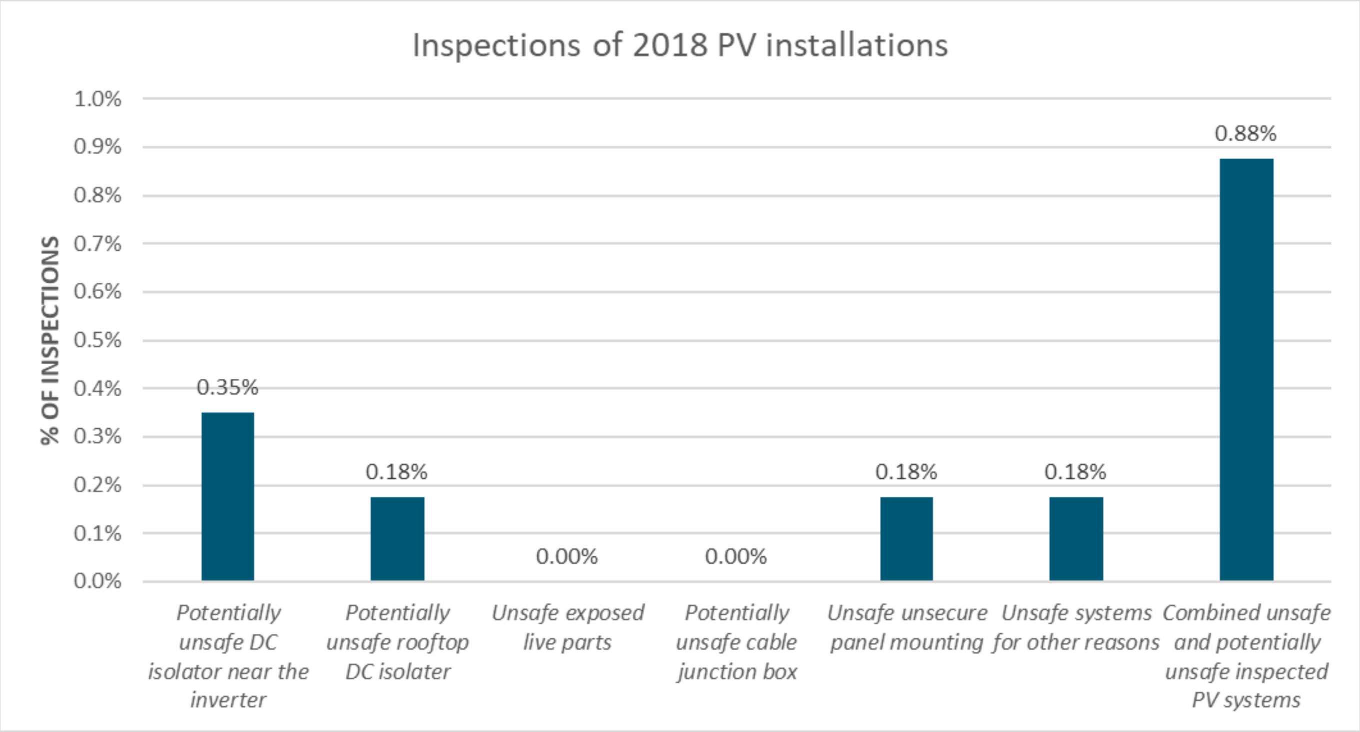
*No unsafe or potentially unsafe PV systems were found in the NT in 2018 PV installations, based on 19 inspections.



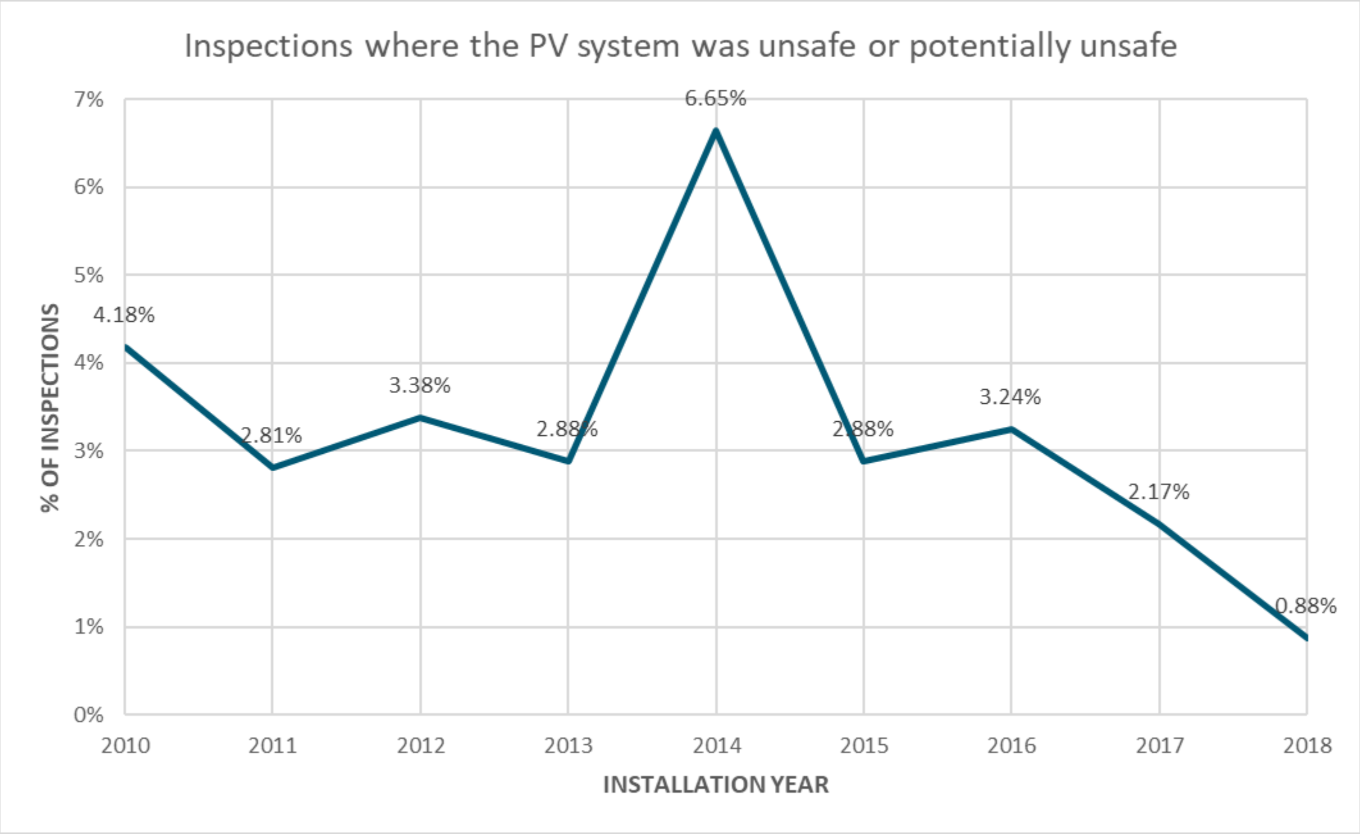

Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
25%
20%
15%
10%
5%
0%
20.0%
4.0%
3.1%
0.0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter


Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
3.13%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

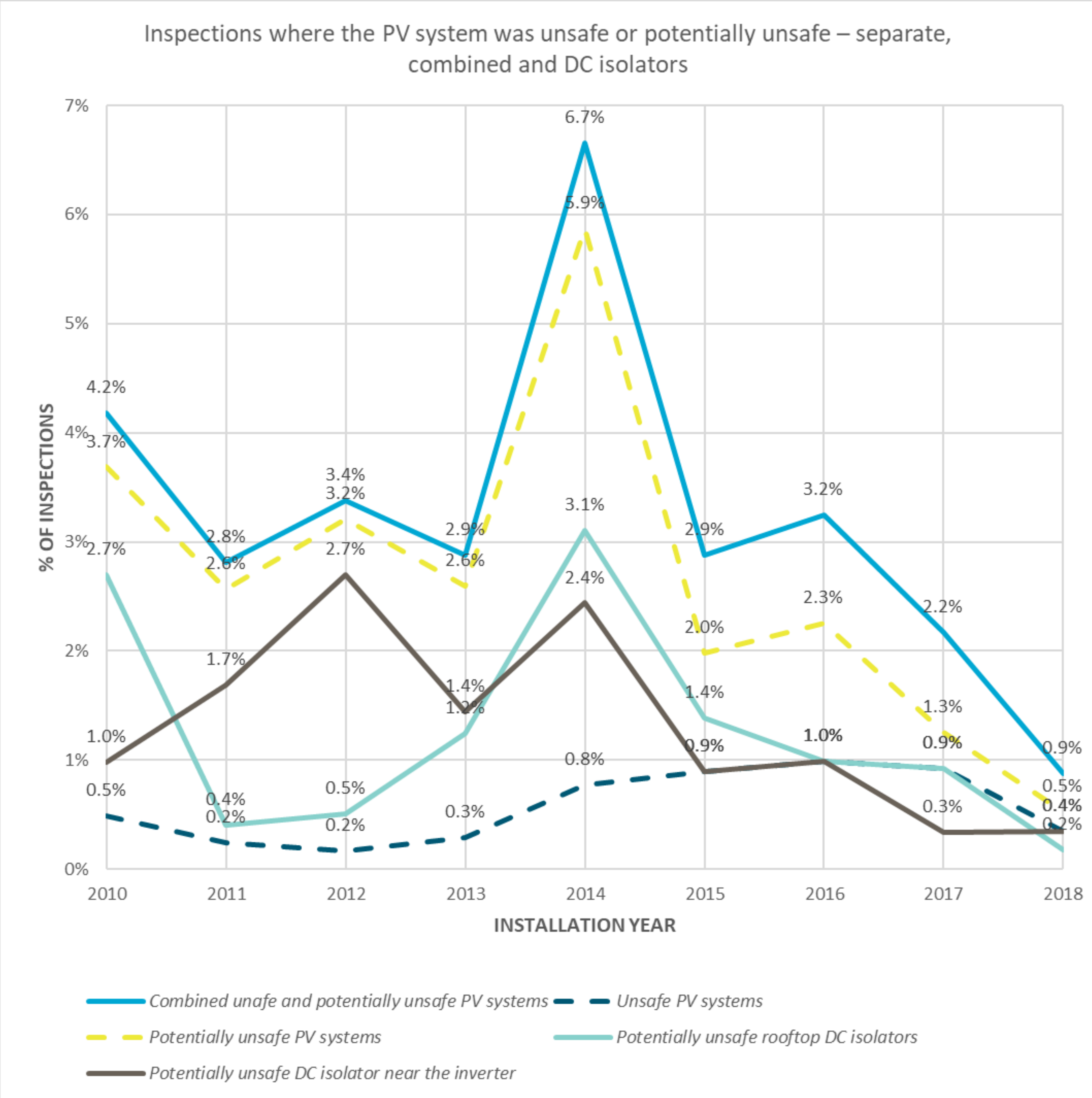
Queensland



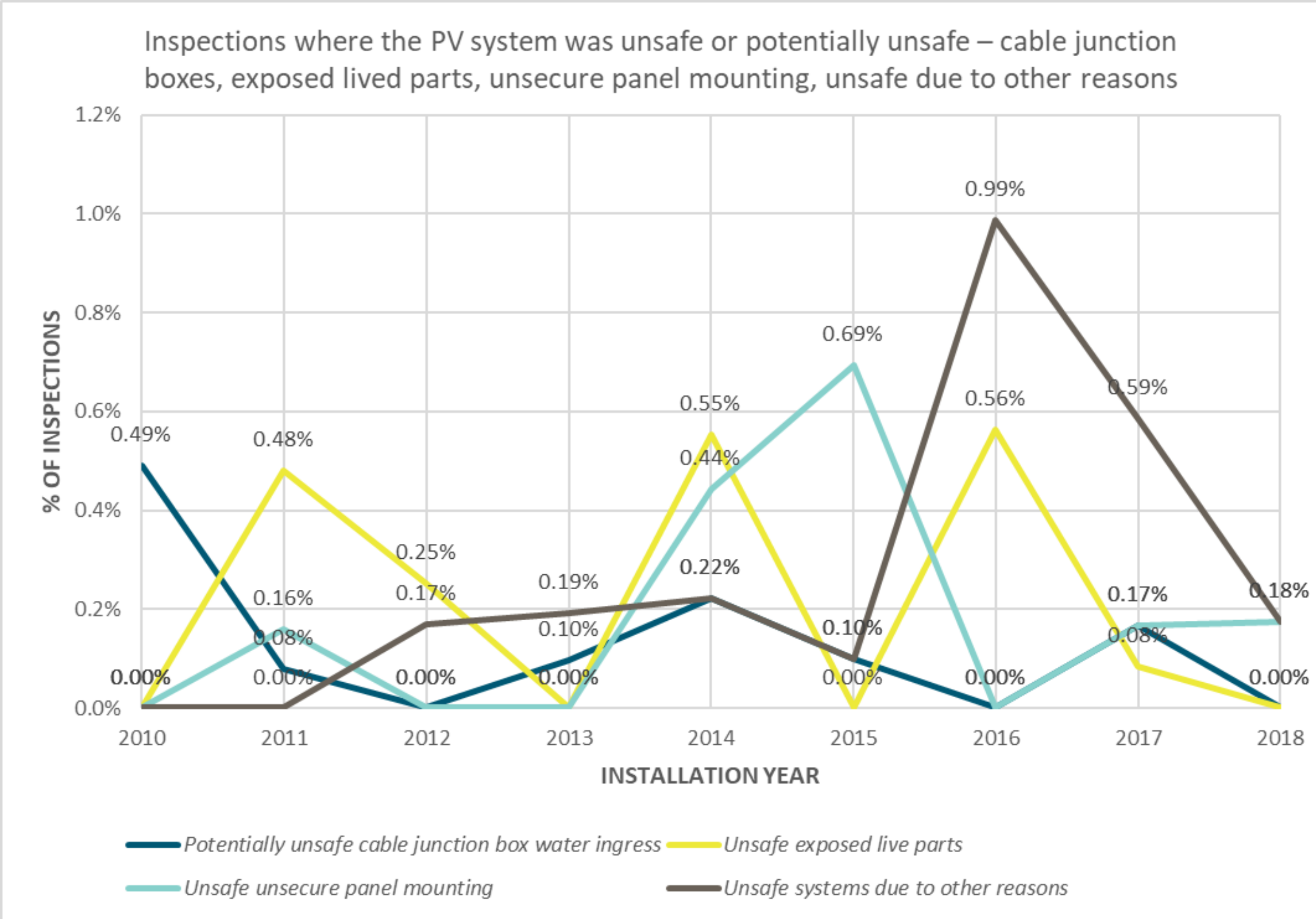
Inspections of 2018 PV installations
% OF INSPECTIONS
1.0%
0.9%
0.8%
0.7%
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
0.35%
0.18%
0.00%
0.00%
0.18%
0.18%
0.88%
Potentially unsafe DC isolator near the inverter
Potentially unsafe rooftop DC isolater
Unsafe exposed live parts
Potentially unsafe cable junction box
Unsafe unsecure panel mounting
Unsafe systems for other reasons
Combined unsafe and potentially unsafe inspected PV systems



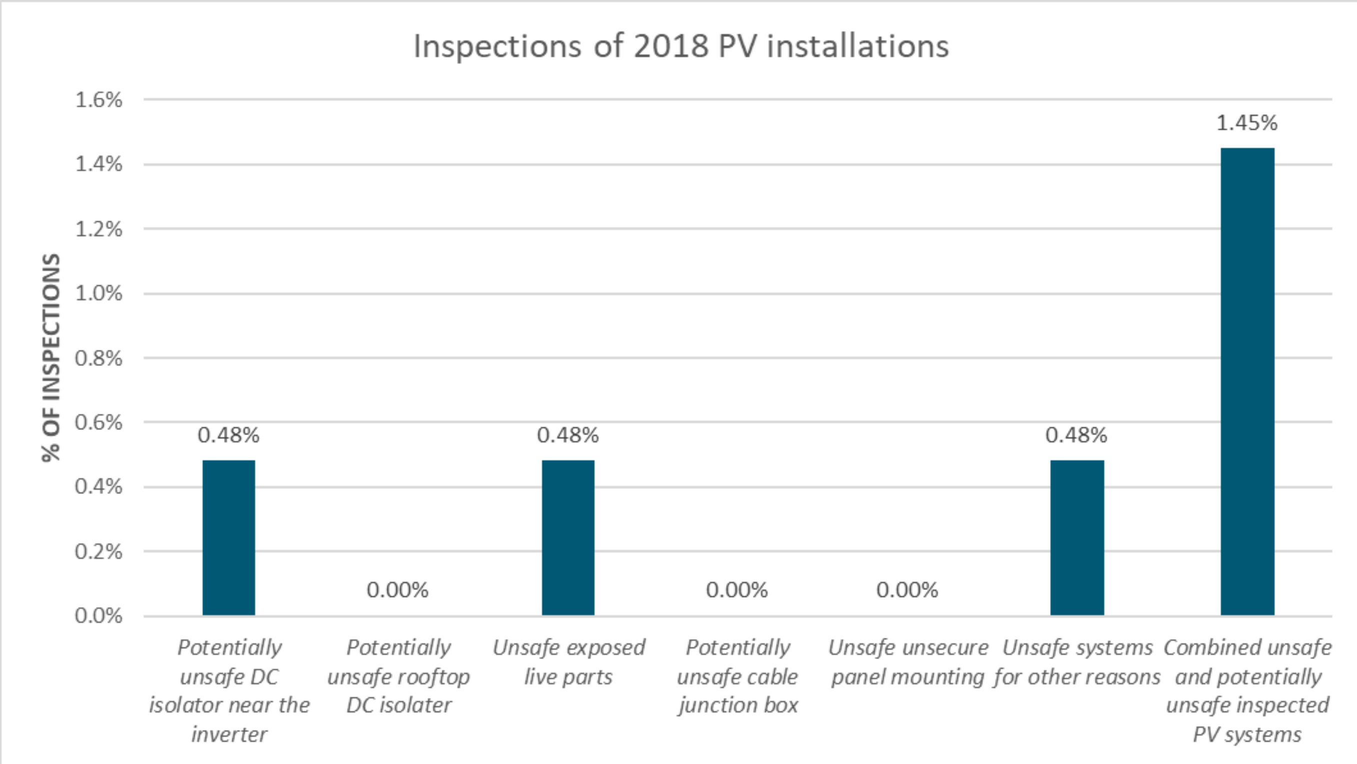
Inspections where the PV system was unsafe or potentially unsafe
% OF INSPECTIONS
7%
6%
5%
4%
3%
2%
1%
0%
4.18%
2.81%
3.38%
2.88%
6.65%
2.88%
3.24%
2.17%
0.88%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR

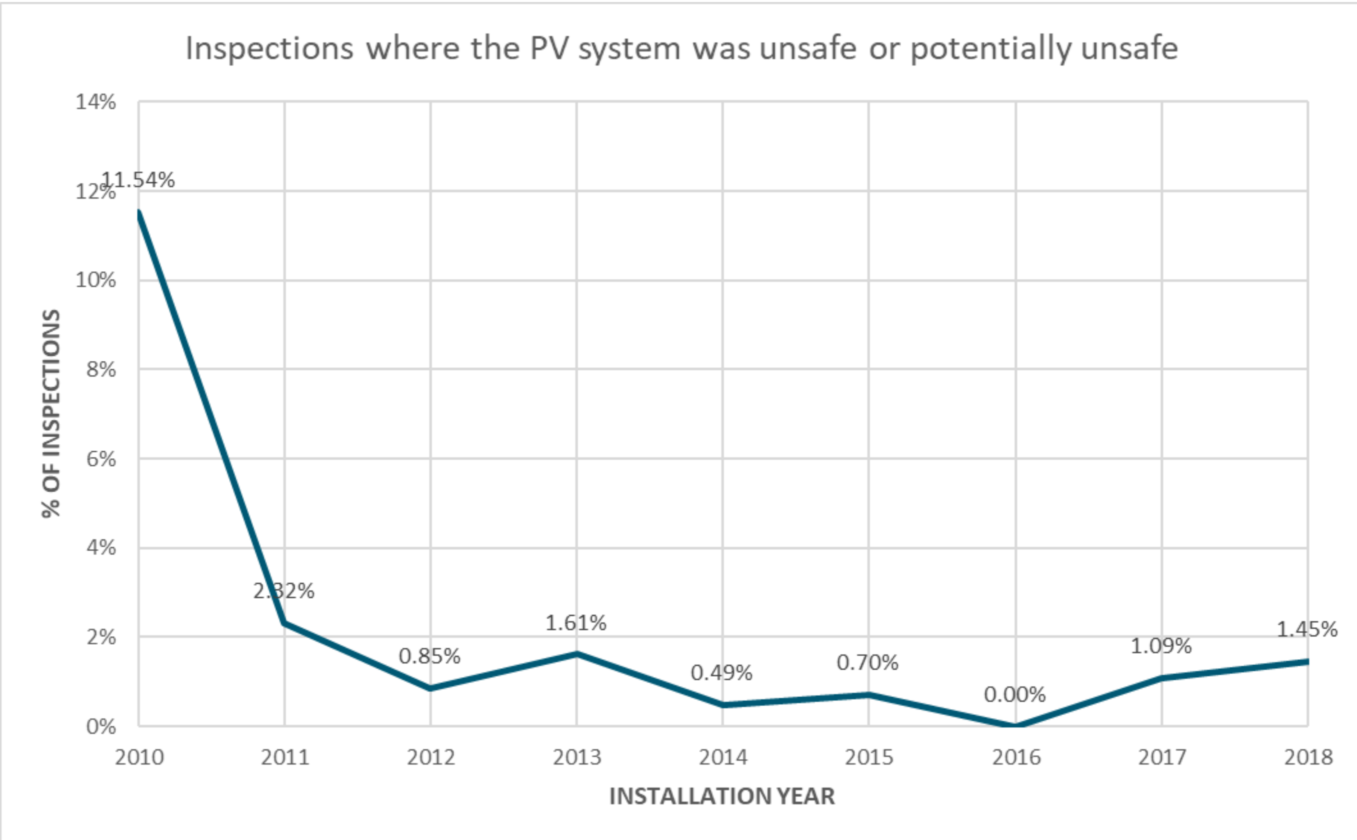


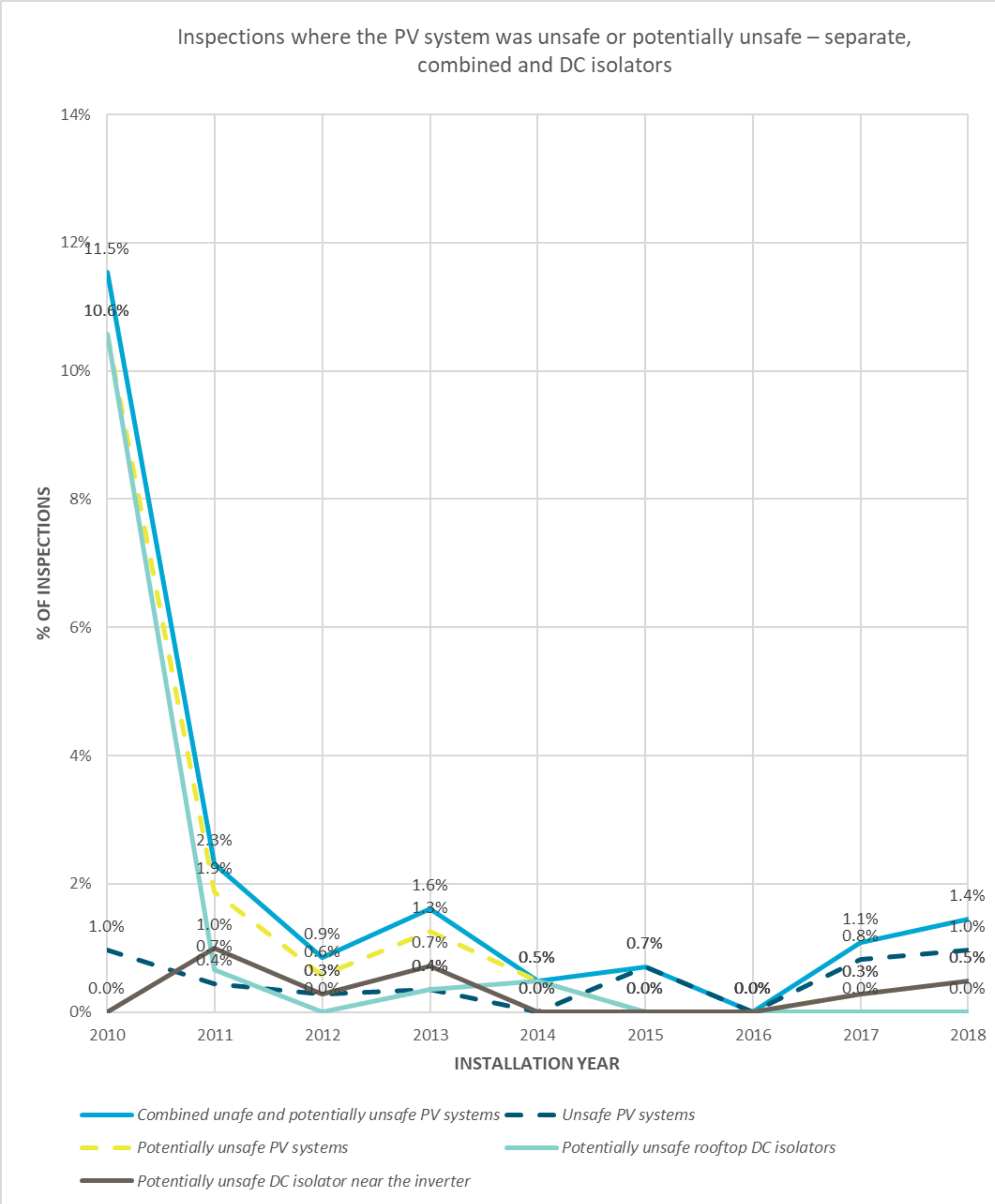
Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
0%
1%
2%
3%
4%
5%
6%
7%
2010
2011
2012
2013
2014
2015
2016
2017
2018
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter


Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
INSTALLATION YEAR
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
0.49%
0.48%
0.25%
0.19%
0.55%
0.44%
0.22%
0.69%
0.99%
0.56%
0.59%
0.16%
0.17%
0.10%
0.08%
0.17%
0.18%
0.00%
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

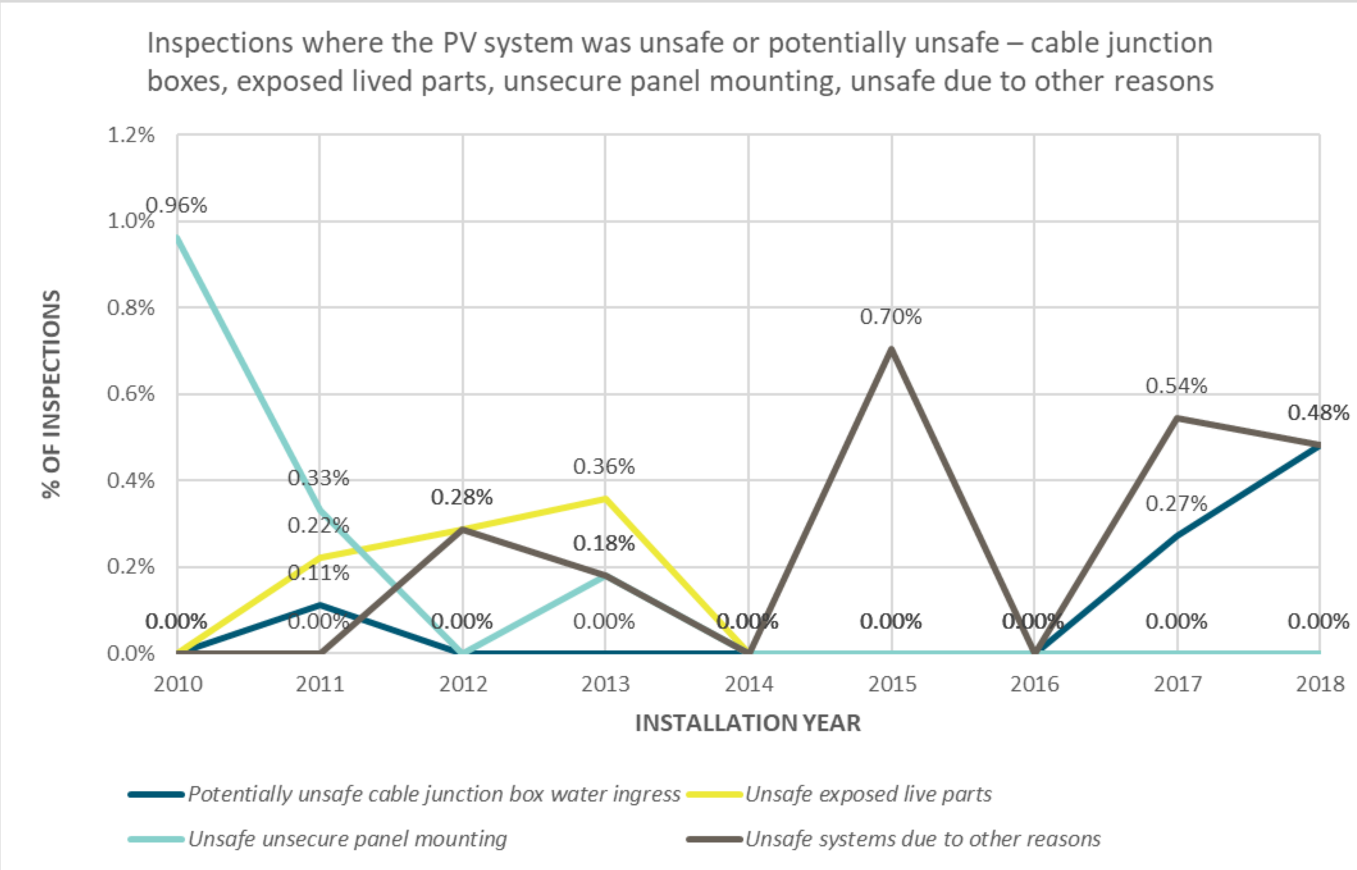
South Australia





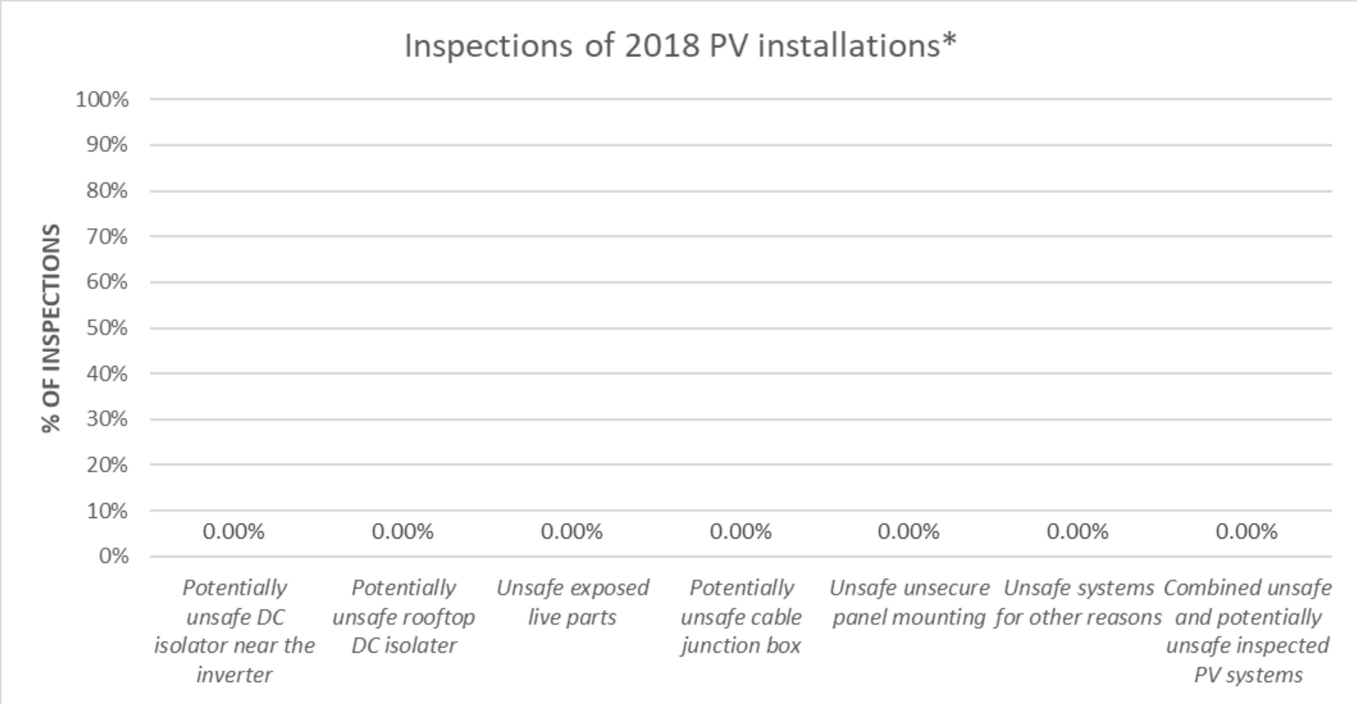


Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter

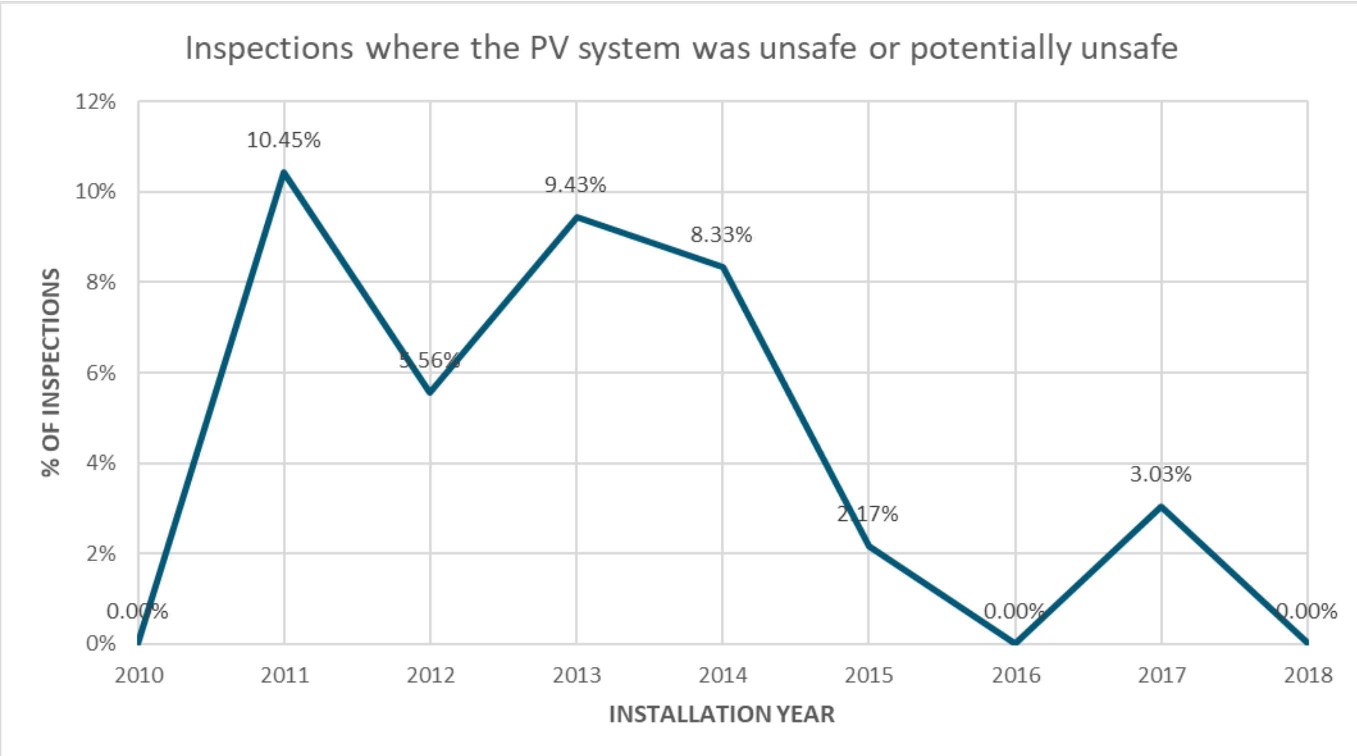


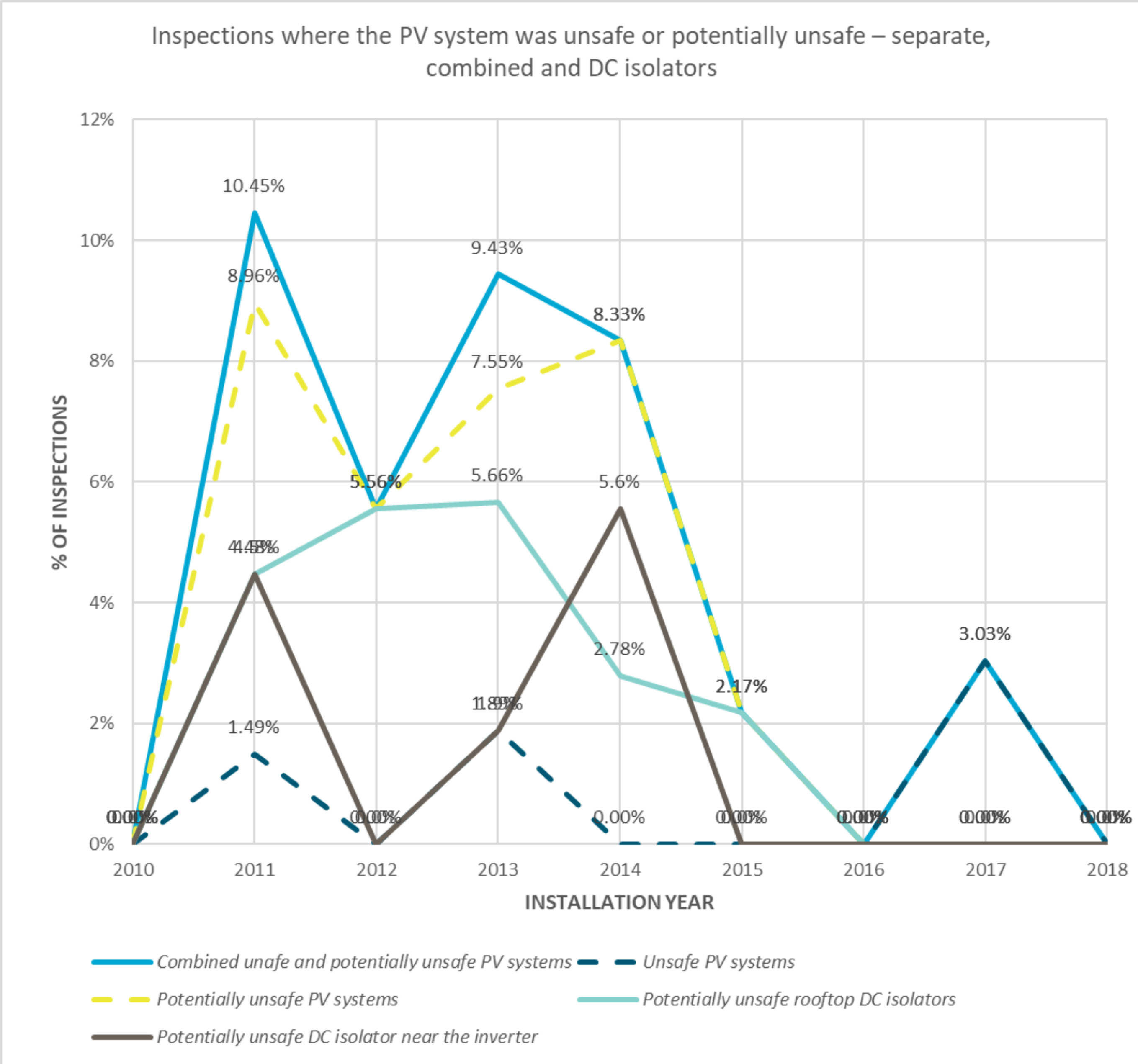
Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
0.96%
0.70%
0.54%
0.48%
0.33%
0.36%
0.28%
0.22%
0.27%
0.18%
0.11%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

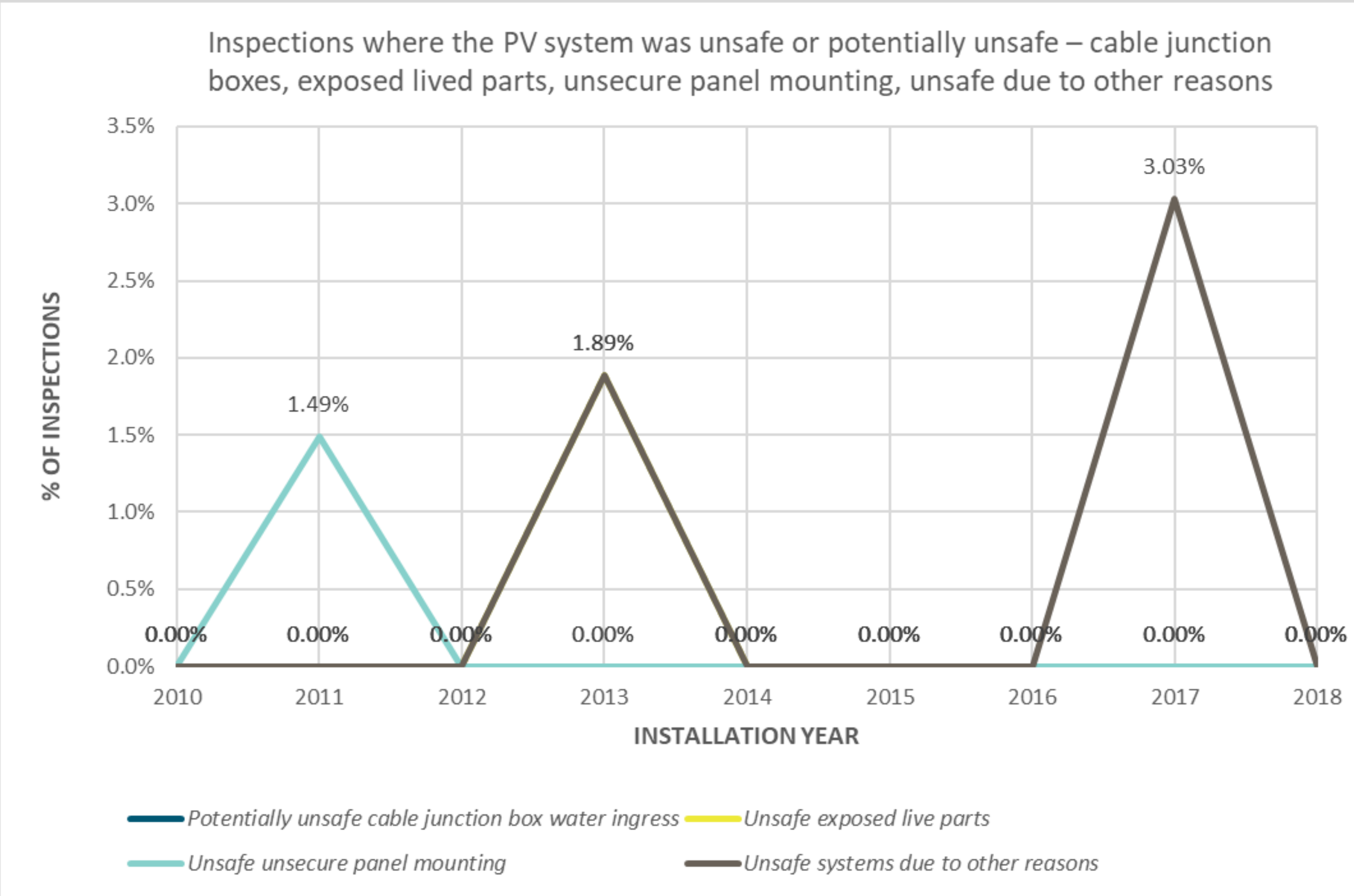
Tasmania



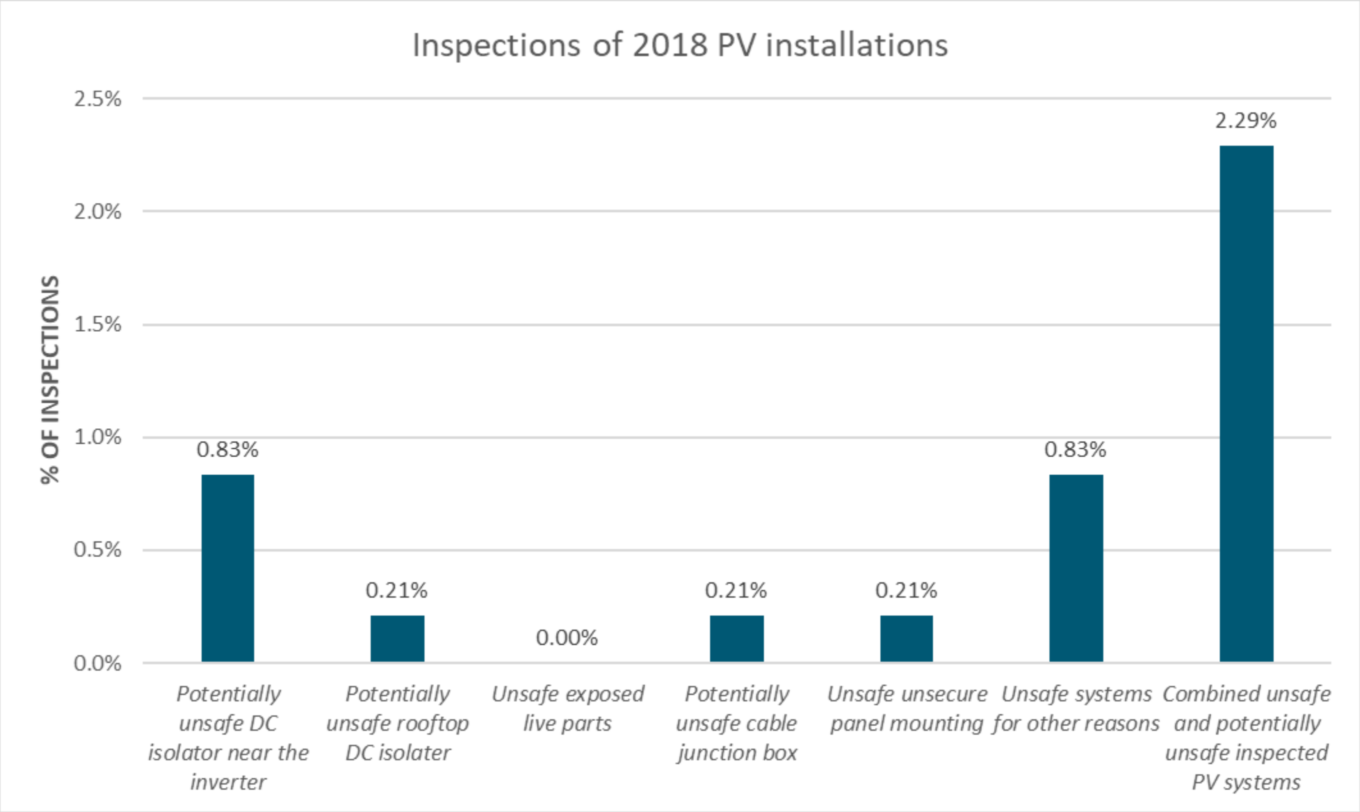
*No unsafe or potentially unsafe PV systems were found in Tasmania in 2018 PV installations, based on 19 inspections.



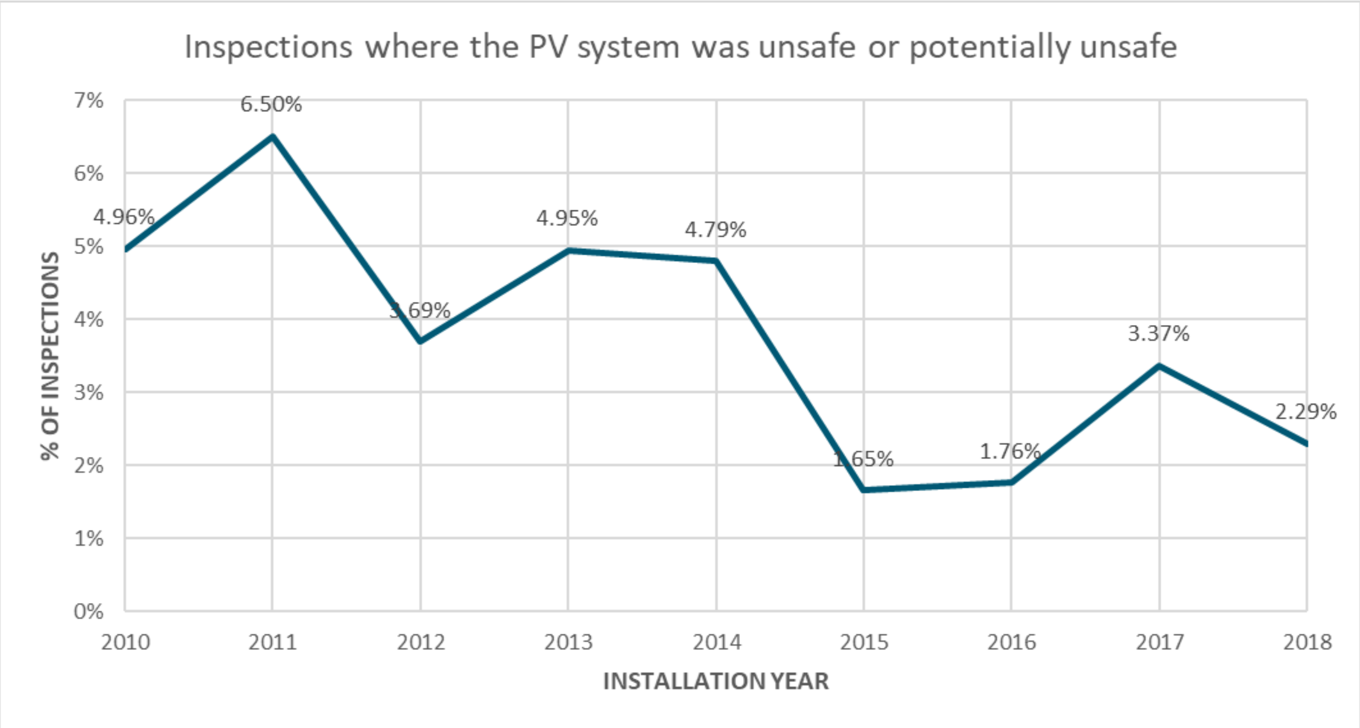

Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
10.45%
9.43%
8.96%
8.33%
7.55%
5.56%
5.66%
5.6%
2.78%
2.17%
3.03%
1.49%
0.00%
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter


Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1.49%
1.89%
3.03%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

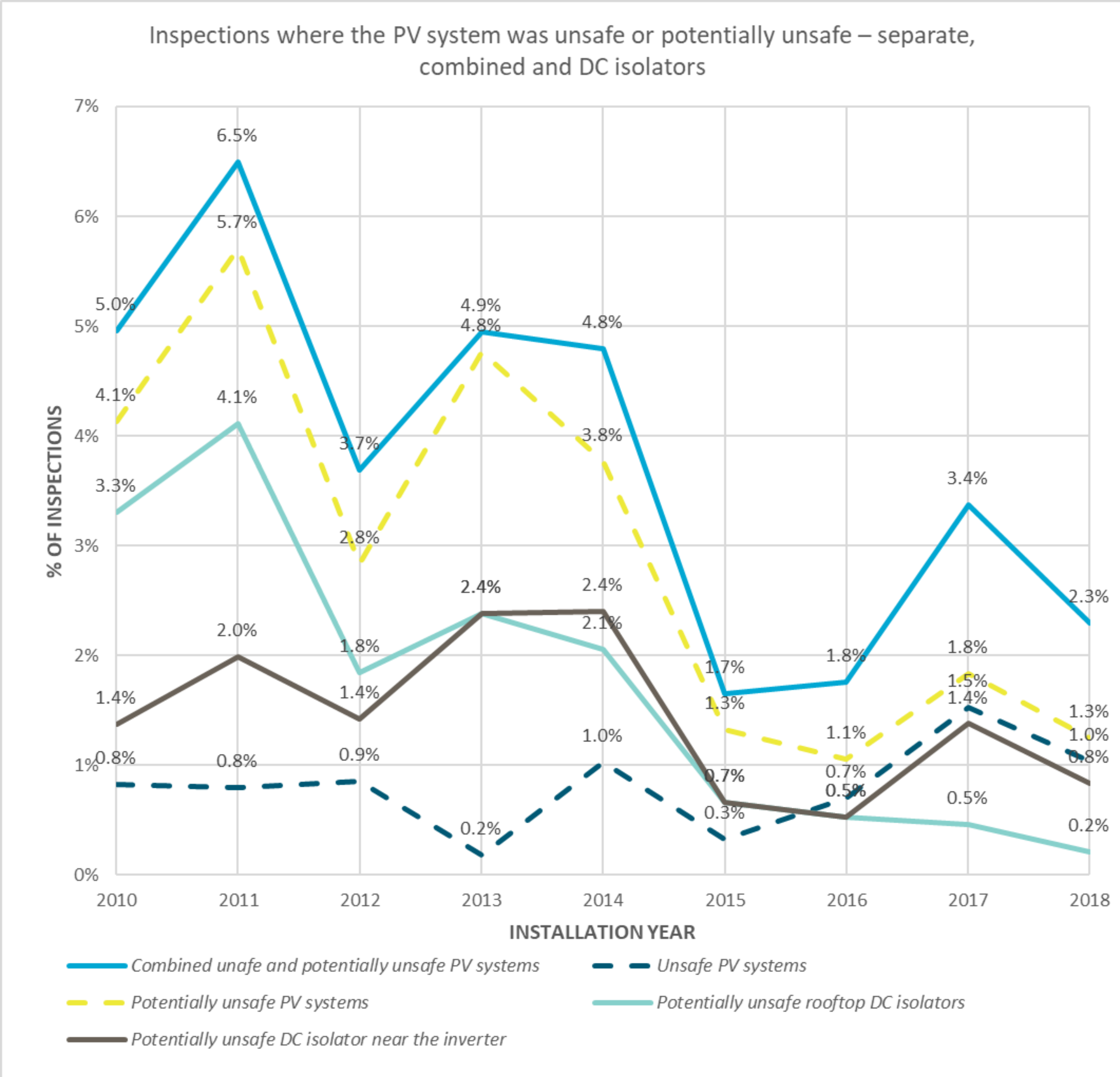
Victoria

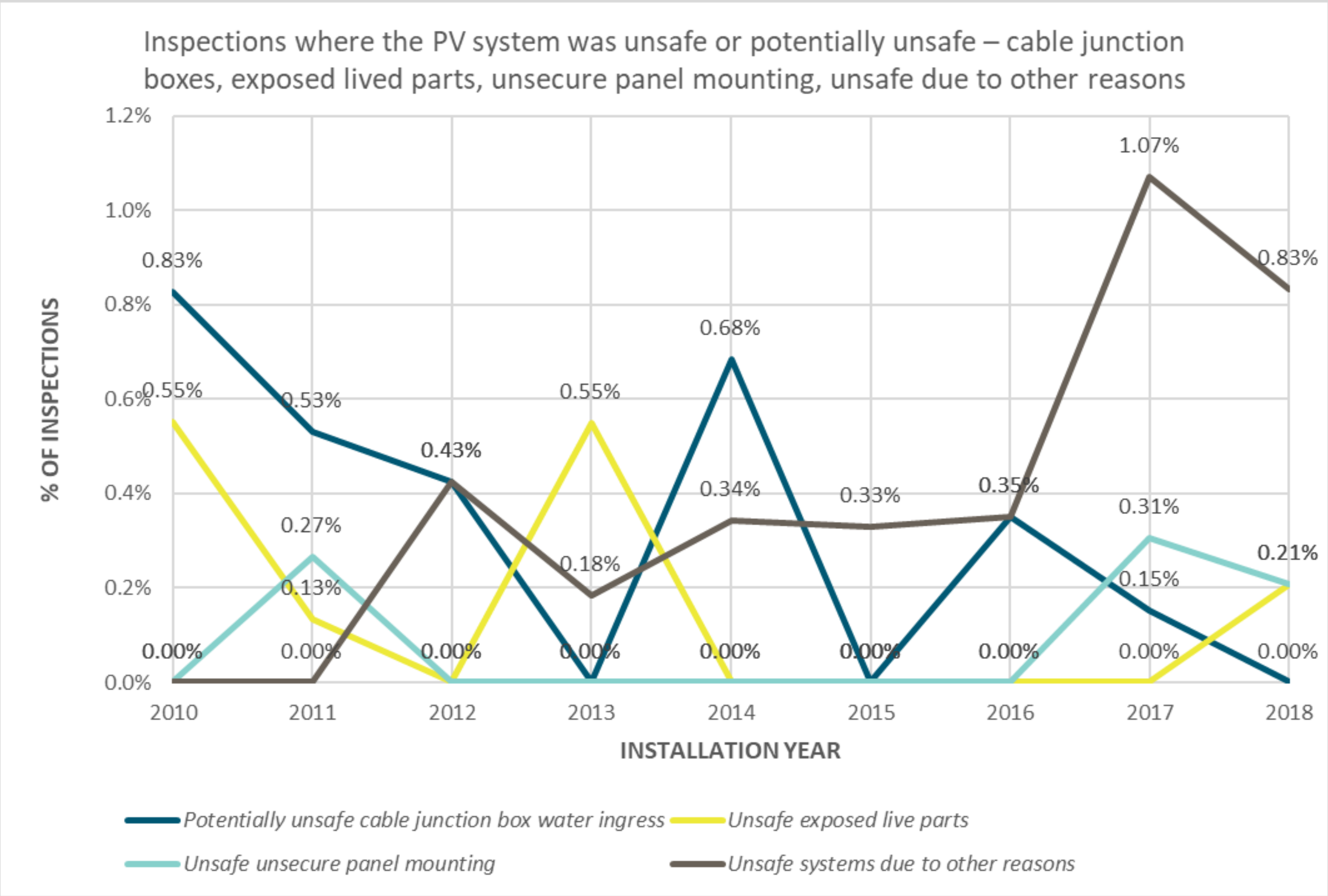


Inspections of 2018 PV installations
% OF INSPECTIONS
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
0.83%
0.21%
0.00%
0.21%
0.21%
0.83%
2.29%
Potentially unsafe DC isolator near the inverter
Potentially unsafe rooftop DC isolater
Unsafe exposed live parts
Potentially unsafe cable junction box
Unsafe unsecure panel mounting
Unsafe systems for other reasons
Combined unsafe and potentially unsafe inspected PV systems

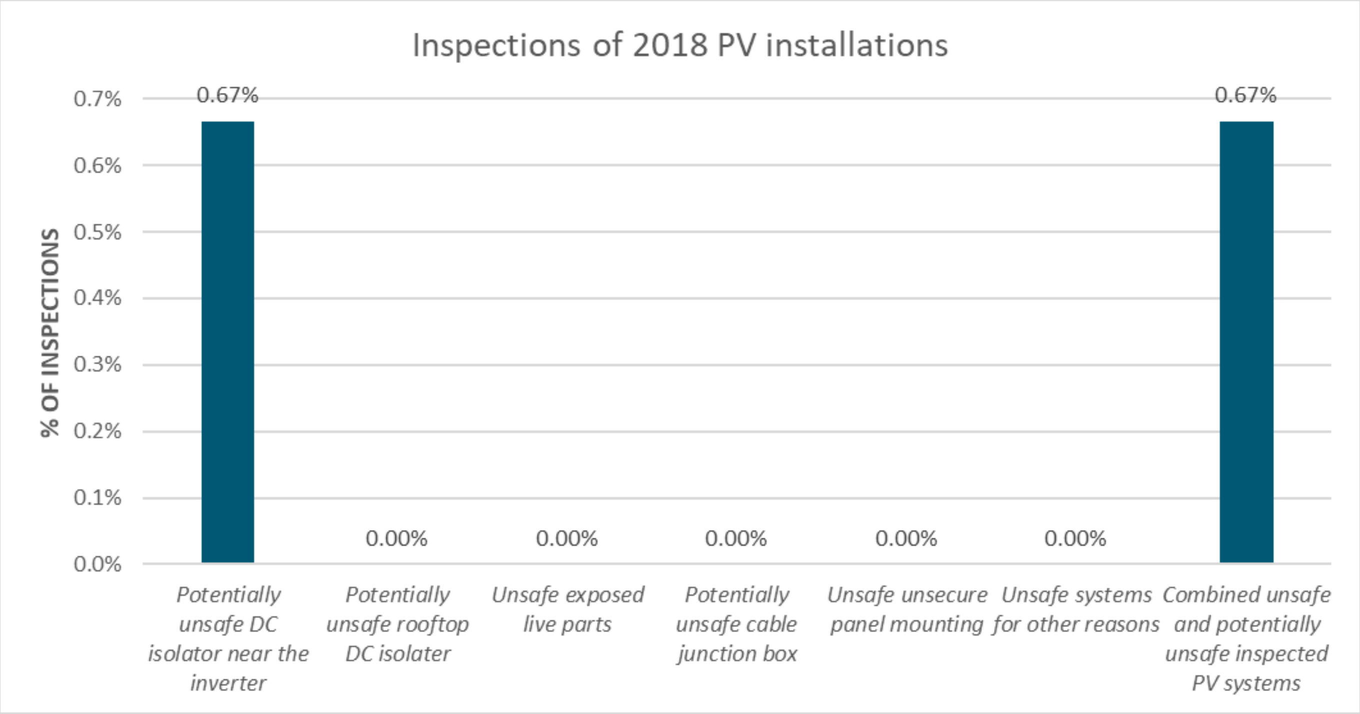


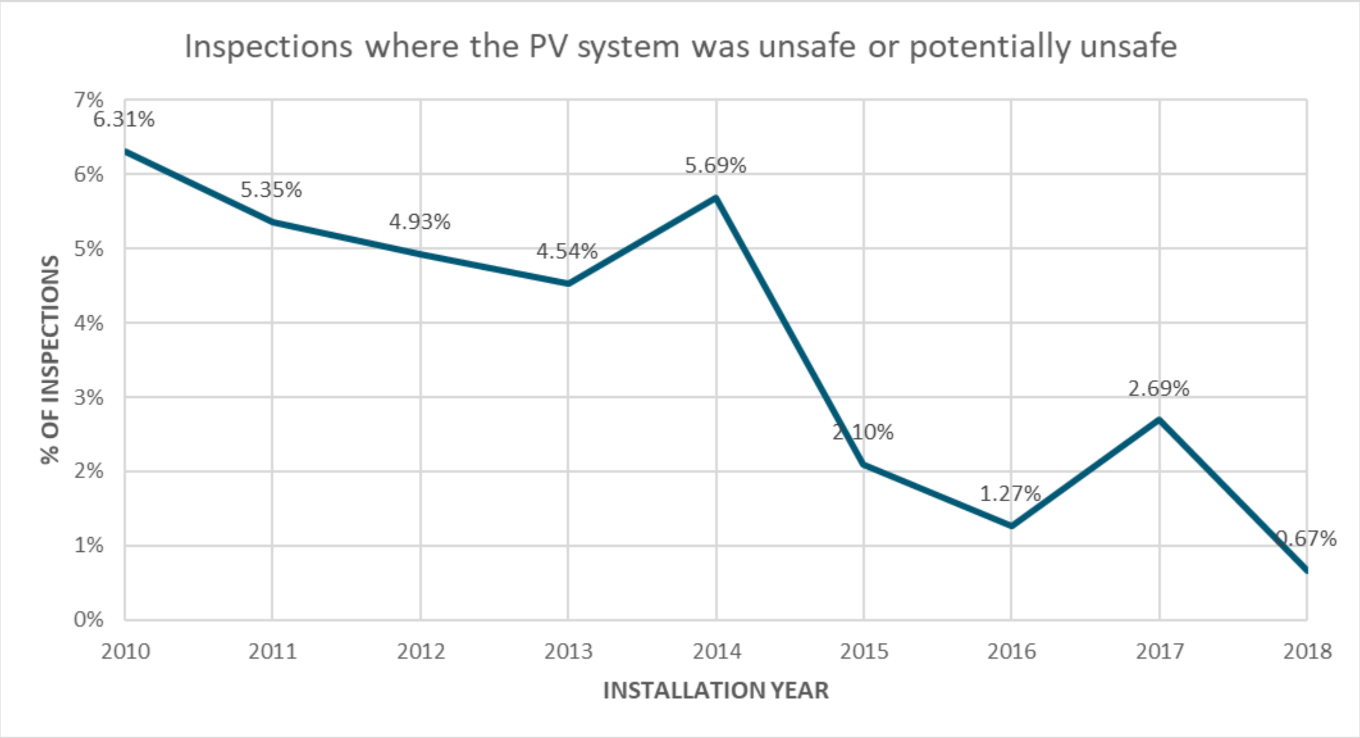
Inspections where the PV system was unsafe or potentially unsafe
% OF INSPECTIONS
7%
6%
5%
4%
3%
2%
1%
0%
4.96%
6.50%
3.69%
4.95%
4.79%
1.65%
1.76%
3.37%
2.29%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR

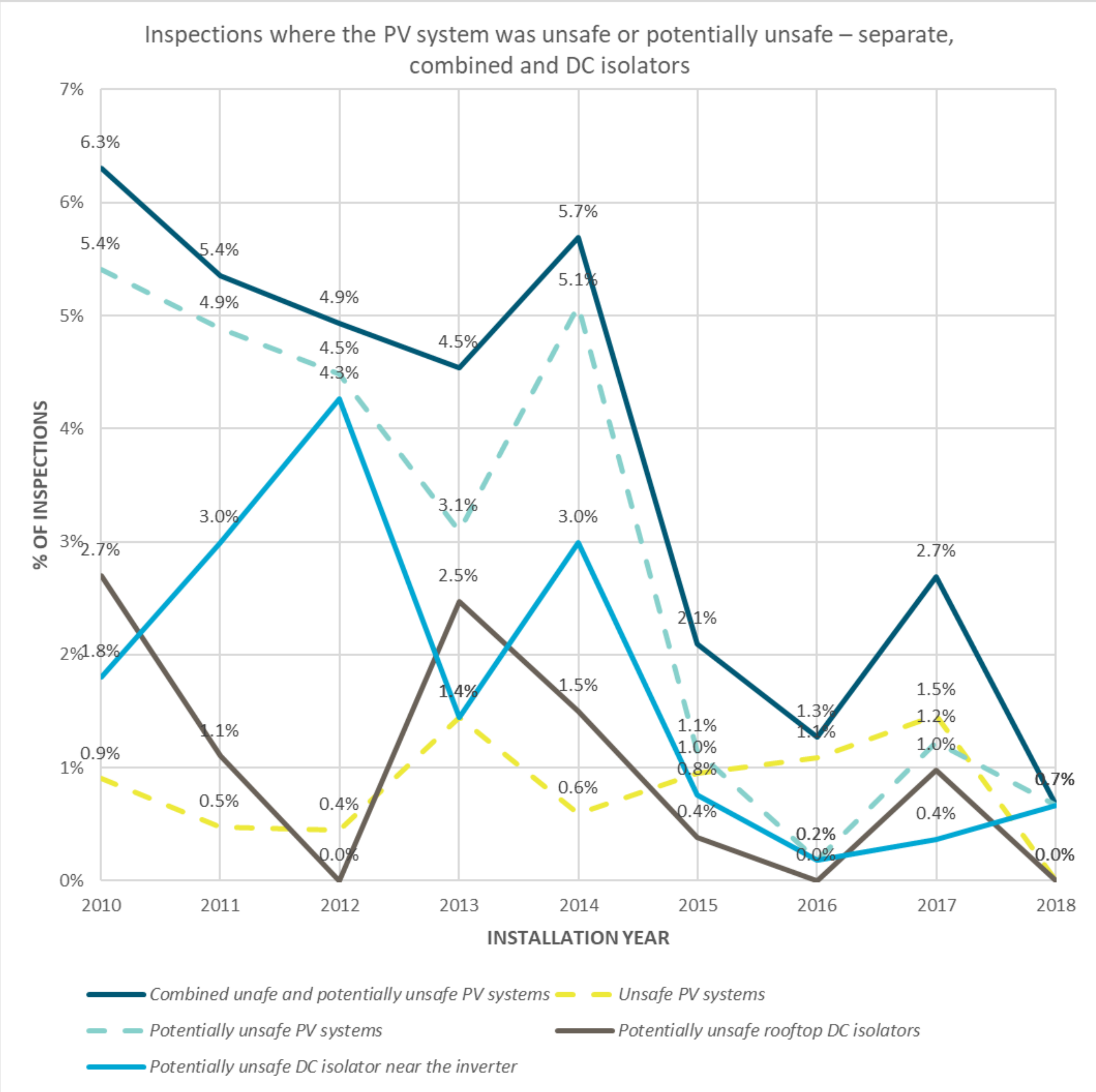

Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
7%
6%
5%
4%
3%
2%
1%
0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
6.5%
5.7%
5.0%
4.1%
4.1%
3.3%
3.7%
2.8%
1.8%
4.9%
4.8%
4.8%
3.8%
2.4%
2.4%
2.1%
2.0%
1.4%
1.4%
0.8%
0.8%
0.9%
0.2%
1.0%
1.7%
1.3%
0.7%
0.3%
1.8%
1.1%
0.7%
0.5%
3.4%
1.8%
1.5%
1.4%
0.5%
2.3%
1.3%
1.0%
0.8%
0.2%
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter

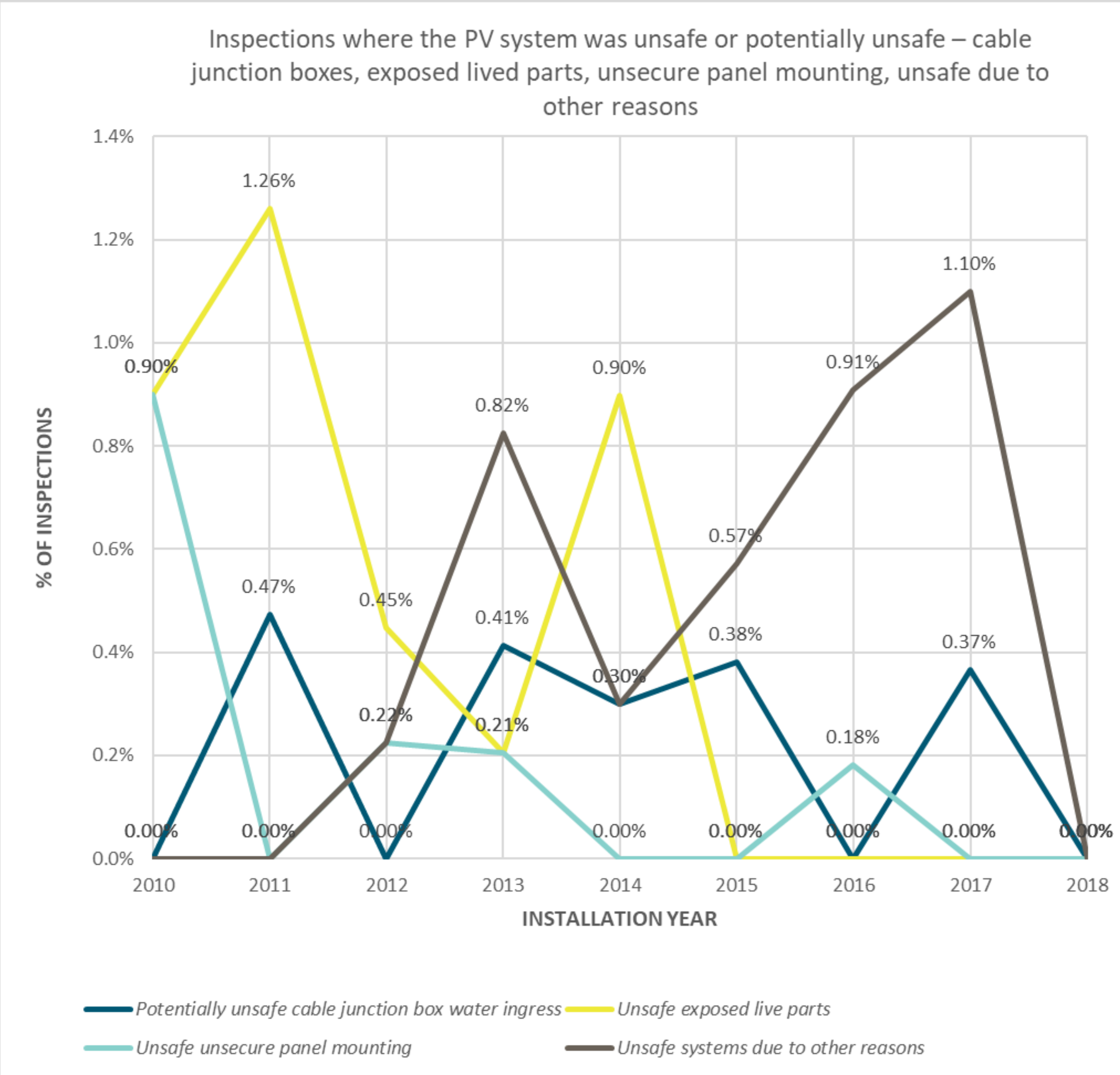

Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
0.83%
0.55%
0.53%
0.43%
0.55%
0.68%
0.34%
0.33%
0.35%
1.07%
0.83%
0.27%
0.13%
0.18%
0.31%
0.15%
0.21%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

Western Australia






Inspections where the PV system was unsafe or potentially unsafe – separate, combined and DC isolators
% OF INSPECTIONS
INSTALLATION YEAR
0%
1%
2%
3%
4%
5%
6%
7%
2010
2011
2012
2013
2014
2015
2016
2017
2018
Combined unafe and potentially unsafe PV systems
Unsafe PV systems
Potentially unsafe PV systems
Potentially unsafe rooftop DC isolators
Potentially unsafe DC isolator near the inverter



Inspections where the PV system was unsafe or potentially unsafe – cable junction boxes, exposed lived parts, unsecure panel mounting, unsafe due to other reasons
% OF INSPECTIONS
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
1.26%
1.10%
0.90%
0.90%
0.91%
0.82%
0.57%
0.47%
0.45%
0.41%
0.38%
0.37%
0.30%
0.22%
0.21%
0.18%
0.00%
2010
2011
2012
2013
2014
2015
2016
2017
2018
INSTALLATION YEAR
Potentially unsafe cable junction box water ingress
Unsafe exposed live parts
Unsafe unsecure panel mounting
Unsafe systems due to other reasons

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