energysafe VICTORIA

Creating a safer state with electricity and gas

Enhancing the safety of direct current (DC) isolators in photovoltaic (PV) systems

Consultation paper

VICTORIA State Government

Who we are

Energy Safe Victoria is established under the *Energy Safe Victoria Act 2005* as Victoria's independent safety regulator for electricity, gas and pipelines. Our role is to ensure Victorian gas and electricity industries are safe and meet community expectations. We are also responsible for licensing and registering electricians and educating the community about energy safety.

More information is available on our website at www.esv.vic.gov.au.

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Abbreviations

the Act	Electricity Safety Act 1998
AC	alternating current
AS/NZS 5033	Australian Standard *Installation and safety requirements for photovoltaic arrays*
CEC	Clean Energy Council
CER	Clean Energy Regulator
CFA	Country Fire Authority
DELWP	Department of Environment, Land, Water and Planning
DC	direct current
EESS	Electrical Equipment Safety Scheme
ESV	Energy Safe Victoria
FRV	Fire Rescue Victoria
MFB	Metropolitan Fire Brigade, also known as the Metropolitan Fire and Emergency Services Board
PV	photovoltaic
the Regulations	*Electricity Safety (General) Regulations 2019*
SRES	Small-scale Renewable Energy Scheme

Summary

The Victorian government is encouraging the generation and use of renewable energy through various policies and programs. The Victorian Government's Solar Homes Program is a key initiative promoting the uptake of photovoltaic (PV) systems by households. Over 20 per cent of Victorian households have a PV system and more than 140,000 Victorian homes are expected to install new PV systems in the next two years.

While Victoria has a high level of safe PV system installations, the Clean Energy Regulator (CER), Solar Victoria and others have raised some concerns about the safety of wall-mounted direct current (DC) isolators used in PV systems. With the volume of PV system installations expected to increase, Energy Safe Victoria (ESV) is considering whether regulatory action should be taken to address the safety concerns.

What is the issue?

A DC isolator is a manual disconnection switch that stops electricity generated by a PV system flowing through the system to make the system safe in emergency situations or to allow for servicing and maintenance.

The Australian Standard AS/NZS 5033 (*Installation and safety requirements for photovoltaic (PV) arrays*) requires a DC isolator to be installed on the roof near the solar panels and a second DC isolator to be installed on a wall adjacent (or integrated) to the inverter where the inverter is not in the same location as the solar panels.

While DC isolators provide additional safety protection, they also introduce additional points of potential failure within a PV system and, in some cases, failure of DC isolators have resulted in fires. Failure of a wall-mounted DC isolator installed on a combustible surface such as weatherboards presents the greatest risk of damage or harm as this can lead to rapid spread of fire throughout the entire structure. Rooftop DC isolators are not generally installed on combustible surfaces.

Water ingress has been identified as the most common cause of failure in wall-mounted DC isolators. We issued industry guidance in early 2021 recommending the use of inverters with an integrated DC isolator, where the protective cover of the inverter reduces the risk of water entering the isolator. Where a DC isolator is instead installed separately on a wall adjacent to the inverter, we recommended installation on a non-combustible surface to reduce the risk of fire spreading.

Solar Victoria, which runs the Solar Homes Program, adopted our recommendations for PV systems installed through the program. However, there is an opportunity to formalise these requirements for all PV systems installations in Victoria through regulatory action.

What are we doing?

With the support of the Department of Energy of Environment, Land, Water and Planning (DELWP), we are considering if changes should be made to the *Electrical Safety (General) Regulations 2019* (the Regulations) to address the risks associated with wall-mounted DC isolators. Options that we believe could be readily implemented are:

- Mandating the use of inverters with integrated DC isolators for all new solar PV systems installed in Victoria.
- Mandating the installation of wall-mounted DC isolators on a non-combustible surface.

These options are not mutually exclusive and a combination could be used to apply to different situations (for example, new installations versus replacement of an inverter or DC isolator in an existing system). We are seeking stakeholder feedback on:

- whether regulatory action needs to be taken;

- the potential impacts of these options (for example, product and installation costs and market effects); and
- whether there are other options that should be implemented.

In parallel, the Standards Committee for AS/NZS 5033 is considering a revision to require wall-mounted DC isolators be mounted on a non-combustible and mechanically stable surface. We are also engaging in this process and a final decision is expected by the end of 2021.

We have identified some other options that could potentially be implemented, but we do not believe they specifically address the risks, are disproportionate to the risks, or are not practical to implement at this time. These options include using technology that could replace the function of DC isolators, using rapid shutdown mechanisms like those introduced in the United States and doing detailed investigation and testing of DC isolators to establish if certain models are more prone to failure. We invite stakeholder feedback on these options as well.

Making a submission

Stakeholders are invited to make submissions on the issues raised in this consultation paper **by 5pm on 8 October 2021**. Submissions can be emailed to **neil.jenkins@energysafe.vic.gov.au** or posted to:

Neil Jenkins
Senior Policy Officer
Energy Safe Victoria
PO Box 262
Collins Street West, Victoria 8007

Submissions will be treated as public and able to be published on our website unless we are advised that all or part of the submission is confidential.

Where confidential information is provided, we prefer that it is given in a separate document that is clearly marked 'In Confidence'. In the case of confidential information, we reserve the right share this information with DELWP and Solar Victoria.

Consolidated list of questions

As a guide for submissions, this consultation paper also includes a number of questions for stakeholders, which are consolidated here for ease of reference.

1. Do you believe there is a material risk of fires associated with wall-mounted DC isolators that warrants regulatory action? Where possible, please provide data to support your view (for example, the number wall-mounted DC isolators that you have identified at risk of failing during inspections and maintenance or have replaced due to failure).
2. Should the use of inverters with an integrated DC isolator be mandated in Victoria thereby removing the use of physically separate wall-mounted DC isolators? If so, should this apply to new installations only or should there also be requirements for existing installations where the inverter is being replaced? Please explain your reasoning.
3. Is there a material cost difference (for example, in product and installation costs) between the use of an inverter with a physically separate DC isolator, and an inverter with an integrated DC isolator? Please provide cost estimates and an explanation of your approach to those estimates to support your view.
4. What would be the market impacts (for example, on supply and competition) of mandating the use of inverters with integrated DC isolators? Should the requirements only apply to certain types of inverters, such as single phase inverters or those that are used in PV systems that are less than 10 kilowatt? Please explain your reasoning.
5. Are there any unforeseen risks or impacts that could arise from mandating the use of inverters with integrated DC isolators?

6. Should the installation of wall-mounted DC isolators on a non-combustible surface be mandated in Victoria for DC isolators that are not integrated in the inverter? If so, should this apply to new installations only or should there also be requirements for existing installations where the DC isolator is being replaced? Please explain your reasoning
7. Is it practical to require the use of micro-inverters at the location of individual solar panels? What are the cost implications of such an option? What would be the broader supply chain impacts? Would this stifle innovation or have adverse competition effects?
8. Are rapid shutdown mechanisms a feasible solution for use in Victoria?
9. Are there other options that ESV should consider to reduce the fire risks associated with wall-mounted DC isolators? If so, would these options be preferred over mandating the use of inverters with an integrated DC isolator and/or mandating installation of wall-mounted DC isolators on non-combustible surfaces?

Next steps

We will consider all submissions made to this consultation paper as we develop our recommendations for what regulatory action should be taken. If amendments to legislation or regulations are required to implement the recommended approach, we will undertake additional consultation with stakeholders through the regulatory impact statement process. We anticipate this consultation would occur in early 2022.

1 Background

1.1 Policy context

In the next two years, more than 140,000 Victorian homes are expected to install new PV systems, partly due to various government policies and programs encouraging the generation and use of renewable energy.[1] More than 500,000 or one in five Victorian homes have already installed a PV system and 15,000 also have a solar battery.[2]

The Victorian Government is encouraging the adoption of household solar and battery systems, including through the Solar Homes Program, which offers rebates to eligible households that install PV systems, batteries and solar hot water systems. The program is a key initiative in the government's commitment to reduce energy costs, boost energy supply, create new jobs in the renewables energy sector and tackle climate change. It is run by Solar Victoria, a portfolio entity within DELWP, and is expected to deliver installation of solar panels, solar hot water systems or batteries in 770,000 homes over 10 years.[3]

The Australian Government's Small-scale Renewable Energy Scheme (SRES), which offers financial incentives for households and businesses to install eligible small-scale solar, wind or hydro systems, solar water heaters and air source heat pumps, also encourages the generation and use of renewable energy by households. It is administered by the CER and is scheduled to run until 2030.[4]

Ensuring the safe installation and operation of these renewable energy systems is an enduring priority for the Victoria Government, and this is reflected in Solar Victoria's priority areas and guiding principles for the Solar Homes Program:

> *Ensure safety and quality installations*
> *This priority area is about improving the safety and quality of solar products by setting exceptional industry benchmarks. Our guiding principles to achieve this are:*
>
> *Guiding principle 1 – Adopt leading safety and performance specifications: Implementing leading eligibility criteria above industry minimum standards, and leading product warranties for key products such as PV modules, inverters, solar batteries, solar hot water and auxiliary equipment (such as connectors, DC isolators, protection, smoke detectors, earthing and bonding).*[5]

ESV, DELWP and Solar Victoria work together to consider regulatory and non-regulatory options to improve safety and quality within the solar industry in Victoria.

1.2 Legislative context

The primary legislation that regulates electrical safety in Victoria is the *Electricity Safety Act 1998* (the Act) and the Regulations.[6] The Act and the Regulations take a comprehensive approach to promote end-to-end safety when dealing with electricity.

ESV is Victoria's independent safety regulator for electricity, gas and pipelines and is responsible for monitoring and enforcing compliance with the Act and the Regulations.

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[1] Solar Victoria, https://www.solar.vic.gov.au/100000-solar-homes-and-many-more-come

[2] Solar Victoria, https://www.solar.vic.gov.au/victorians-embracing-solar-record-levels

[3] Solar Victoria, https://www.solar.vic.gov.au/what-we-do

[4] See: http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Small-scale-Renewable-Energy-Scheme

[5] State of Victoria, May 2021, *Solar Victoria Technology Guidelines*, DELWP, Melbourne, pp. 10-11

[6] There are other Acts and regulations that also promote electrical safety, such as the *Occupational Health and Safety Act 2004*.

The Regulations require PV systems to be installed in accordance with the Act and regulations, and for a licensed electrical inspector to inspect the installation to ensure this is the case.

PV systems installed in Australia must also meet various Australian standards, including:

- Electrical installations - electrical wiring rules (AS/NZS 3000)
- Grid Connections of energy systems via inverters (AS/NZS 4777)
- Stand-alone power systems (off-grid) (AS/NZS 4509)
- Installation and safety requirements for photovoltaic (PV) arrays (AS/NZS 5033)
- Electrical installations – safety of battery systems for use with power conversion equipment (AS/NZS 5139)

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

Of particular relevance to this consultation paper, AS/NZS 5033 currently requires PV systems to have a DC isolator installed on the rooftop adjacent to the solar panels. An additional DC isolator is required to be installed on a wall adjacent (or integrated) to the inverter where the inverter is more than 3 metres away and not visible from the rooftop isolator.

AS/NZS 5033 as published or amended from time to time is adopted in Victoria through the Regulations, which requires the installation to comply with AS/NZS 5033.[7]

[7] Regulation 202 requires electrical installations to comply with the Australasian/New Zealand Wiring rules, which require solar installations to comply with AS/NZS 5033. Regulation 243 requires the installation to be tested to verify that it complies with AS/NZS 5033.

2 Safety risks of DC isolators in PV systems

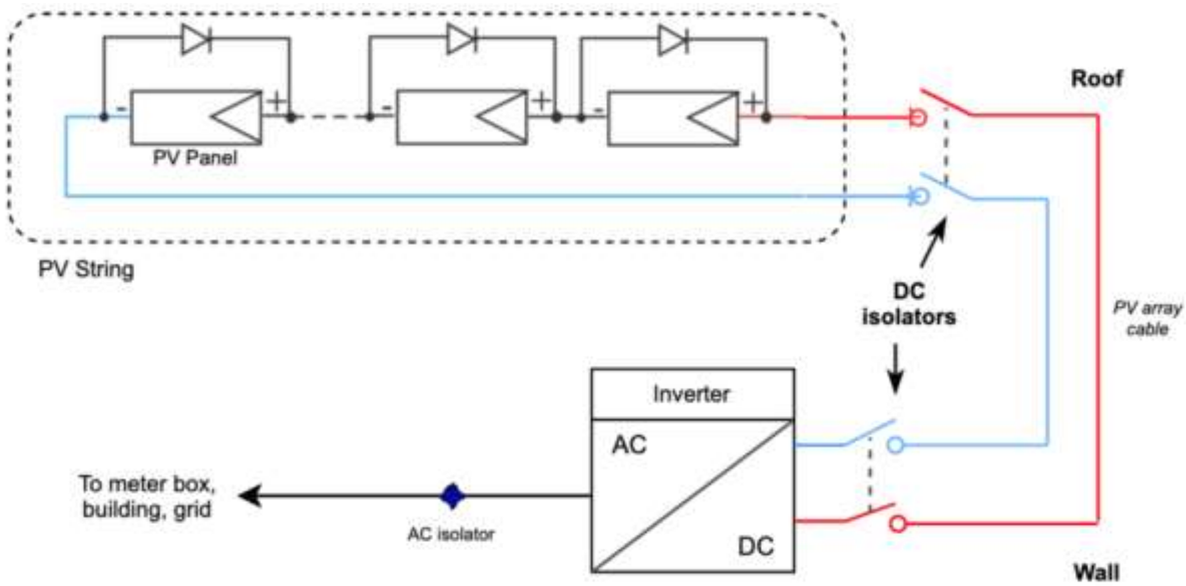
2.1 Purpose of DC isolators

When solar energy hits solar panels it creates a source of DC power, which must be converted to alternating current (AC) before it can be used in a premises or fed into the grid. This is done through an inverter, which is generally located on a wall. This means there is a source of DC power that flows across the solar panels and across the cables that connect the solar panels to the inverter.

Power from solar panels is not stopped by turning off the 'main switch' in a meter box. While a licensed electrician can shut off the flow of DC power between the solar panels and the inverter, there are many occasions where it is not practical to engage an electrician. For example, first responders to an emergency situation (e.g., fire officers) may need to de-energise power from solar panels as part of putting out fires or making properties safe. Another example is where tradespeople may need to do work on a premises (e.g., in the roof cavity) and it is desirable to remove the risk of electrical shock from PV systems.

A DC isolator is a manual switch that stops DC power flowing through the PV system. AS/NZS 5033 has mandated their use in PV systems since 2012 (see section 1.2). A typical PV system has two DC isolators, one installed on the rooftop near the solar panels and one installed on the wall adjacent (or integrated) to the inverter (see figure1).

Figure 1: A typical DC isolator configuration



Wall-mounted DC isolator

A wall-mounted DC isolator is usually located adjacent to the inverter (see figure 2). In an increasing number of inverter products, this type of DC isolator is integrated into the inverter itself. It allows isolation of the inverter for servicing or replacement without the need to access the roof.

Figure 2: A wall-mounted DC and AC isolator installed adjacent to the inverter

Rooftop DC isolator

However, even if the DC isolator at the inverter is switched off, there is still a live voltage at the solar panels and in the cable that runs between those panels to the isolator at the inverter. A rooftop DC isolator is located adjacent to solar panels as an additional safety mechanism (see figure 3). Manually operated, the switch shuts off DC power flowing between the solar panels and the inverter.

Figure 3: A rooftop DC isolator installed next to solar panels with shroud (protective cover)

2.2 Most common causes of failure leading to fires

The use of DC isolators introduces additional points of potential failure into the PV system. In addition to risks associated with product faults, DC isolators installed in the past have been known to fail due to incorrect installation, water ingress and deterioration due to sun exposure.

Solar Victoria has indicated that, of the 60 PV systems identified as unsafe during its audits of 1850 systems in 2018-19, more than half were found to be unsafe due to the DC isolators. Solar Victoria has noted combined issues of water damage within DC isolators and loose connection of low-voltage cables within the isolator enclosures as the leading causes.

The CER released reports in 2020 that also identified water entering into DC isolators as a common cause of unsafe solar PV systems. As at 30 June 2020, the CER had identified a total of 955 unsafe PV systems out of a total of 30,609 inspections that had occurred across Australia since 2011, stating that 'most were due to water ingress in DC isolators.'[8] In Victoria, the CER had identified 214 unsafe systems out of 6075 inspections. The CER observed that 'the degree of water ingress varies and in most cases the DC isolator will likely become unsafe without timely maintenance but does not pose an imminent risk.'[9] The CER has also identified incorrect wiring or installation as causes of unsafe solar PV systems.[10]

Failure of DC isolators can be merely a non-functioning circuit (for example, a homeowner may not be aware the connection failure means the solar panels are no longer providing power to their house and/or into the grid). More importantly, failure of DC isolators (for example, due to water ingress) can be a source of fire.

> *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.*[11]

Data obtained from Fire Rescue Victoria (previously the Metropolitan Fire Brigade (MFB), also known as the Metropolitan Fire and Emergency Services Board) shows that there were 48 fire incidents between January 2014 and January 2019 where the PV system was considered to be the cause of the fire. Of those incidents, 41 (85 per cent) were believed to be caused by DC isolators.[12] The Country Fire Authority (CFA) has also reported to ESV that DC isolators were believed to be the cause of 65 fire incidents out of a total of 188 fires involving solar installations between January 2015 and December 2020.

The risks associated with DC isolators are not unique to Victoria. Fire and Rescue NSW has previously commented that it has seen a significant increase in solar power system related fires in the five years to August 2020.[13] Fire and Rescue NSW reported 139 fire incidents associated with solar panels in 2020, compared to 22 in 2018 and 56 in 2019. It is stated as having attributed the majority of

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[8] Clean Energy Regulator, *Inspections update No. 19*, 30 June 2020, p. 2

[9] Clean Energy Regulator, *Inspections update No. 19*, 30 June 2020, p. 2

[10] Clean Energy Regulator, *Analysis of SRES inspection data to assess PV system residual systemic electrical safety risks*, 2020, p. 6

[11] Clean Energy Regulator, *Analysis of SRES inspection data to assess PV system residual systemic electrical safety risks*, 2020, p. 21

[12] Fire Rescue Victoria, *Response to letter from ESV asking for information and data relating to the safety of DC isolators used in PV systems*, 28 August 2020 (see Appendix A)

[13] https://www.fire.nsw.gov.au/news.php?news=2420

those incidents to DC isolators, a specifically 'water inflow caused by faulty installation or manufacture.'[14]

2.3 Risks of wall-mounted versus rooftop DC isolators

Failure of rooftop DC isolators has historically been more likely than wall-mounted DC isolators due to being more exposed to sun and rain. The CER reported that about 0.5 to 0.6 per cent of its inspections between 2016 and 2018 found potentially unsafe rooftop DC isolators.[15] Since 2018, a shroud (protective cover) has been required to be installed over rooftop DC isolators to reduce exposure (see figure 3).[16]

The use of a shroud does not entirely remove the risk of water ingress, deterioration due to extreme temperatures and radiation or other faults occurring in rooftop DC isolators. However, these outstanding risks can be mitigated by owners of properties with PV systems arranging regular inspection and maintenance of their systems, including the DC isolators, which we generally encourage.

Importantly, although failure of a rooftop DC isolator is more likely, data indicates that fires are usually localised due to the non-combustible material used for roofing and damage is generally limited to the isolator itself or the solar panels. In contrast, fires that start at a wall-mounted DC isolator can have major impacts, particularly where it is installed on combustible material such as weatherboards.

For example, the CFA has reported to ESV that detailed investigations of 11 fires involving the DC isolator switch between January 2015 and December 2020 found that the fire spread to the surrounding building structure due to the DC isolator being mounted either directly on an external combustible wall or on an internal wall of the building. Of the 48 fire incidents reported by the MFB between January 2014 and January 2019, 21 (44 per cent) involved wall-mounted DC isolators.[17]

2.4 Action taken to mitigate risks

Over the last five years or so, there has been greater focus on product quality, installation standards and practices to reduce the risk of fires and other safety concerns.

Following a high number of safety incidents in 2014-15, including non-compliant DC isolators catching fire, five brands of DC isolators that were commonly used in PV systems were recalled. More than 30 models of DC isolators have been recalled between 2014 and 2018 due to concerns about faults that could cause overheating or electrocution.

The Clean Energy Council modified its design and installation guidelines and training for rooftop and wall-mounted DC isolators in 2015 as a result of the CER's PV system inspections to address sealing issues and add a requirement for a shroud (protective covering) for rooftop DC isolators. According to the CER, these changes were the most likely reason for a decrease in the overall number of unsafe and potentially unsafe PV systems found through audits by the CER, from 5.5 per cent in 2015 to 1.7 per cent in 2018.[18] The CER's latest findings report as at 30 June 2020 indicates that this

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[14] https://www.smh.com.au/national/nsw/the-irony-s-not-lost-on-me-solar-panel-safety-device-led-to-500-per-cent-rise-in-rooftop-fires-20210129-p56xtp.html

[15] Clean Energy Regulator, *Analysis of SRES inspection data to assess PV system residual systemic electrical safety risks*, 2020, p. 22

[16] AS/NZS 5033

[17] Fire Rescue Victoria, *Response to letter from ESV asking for information and data relating to the safety of DC isolators used in PV systems*, 28 August 2020(see Appendix A)

[18] Clean Energy Regulator, *Analysis of SRES inspection data to assess PV system residual systemic electrical safety risks*, 2020, p. 5

downward trend is continuing.[19] In 2018, Standards Australia published a modified adoption of the International Electrotechnical Commission (IEC) standard 60947-3 (AS 60947.3), where testing must show that there is no water in the switch after testing. Additionally, DC isolators were re-classified from level 1 in-scope electrical equipment (low risk) to level 3 in-scope electrical equipment (high risk). This classification means a DC isolator must meet the following requirements before being offered for sale:

- be electrically safe and meets the relevant standard AS 60947.3;
- be marked with the regulatory compliance mark;
- have a valid Certificate of Conformity showing that it complies with the relevant standard AS 60947.3; and
- be registered in the national Electrical Equipment Safety Scheme (EESS) database and linked to the registered responsible supplier.[20]

The installation standard has also been revised over the years to improve product design and ensure that DC isolators can withstand the harsh Australian climate. For example, amendments made to AS/NZS 5033 that took effect in 2015 required all equipment exposed to the outdoor environment to meet a certain protection ratings from dust and water. Amendments made to AS/NZS 5033 that took effect in 2018 and 2019 introduced the requirement for a shroud for rooftop DC isolators, required all DC isolators to be specifically classified and approved for outdoor solar use and included additional installation requirements at cable junction boxes and isolator enclosures with the aim of preventing water ingress into such enclosures. The amendment also required the effect of temperature on an isolator's rating be considered when selecting isolators. The amendment specifies the expected ambient temperature depending on if the isolator is located: indoors, outdoors in a fully shaded location, or outdoors exposed to sunlight.

ESV has raised awareness of the potential risks associated with DC isolators through public campaigns and we have highlighted these issues during site visits and industry presentations, providing guidance on installation practices to minimise the risks. In early 2021 we provided industry guidance specifically aimed at addressing remaining concerns about water ingress in wall-mounted DC isolators and the risk of fires:

> *ESV strongly recommends using inverters that contain an integrated DC isolator.*
>
> *…*
>
> *When using an adjacent and physically separate DC isolator, due to the inverter not having an integrated isolator or the integrated isolator not meeting the requirements outlined above, ESV recommends the DC isolator is installed on a non-combustible surface.*[21]

Solar Victoria published a new Notice to Market which came into effect on 1 July 2021 that adopted our industry guidance and requires wall-mounted DC isolators to either be incorporated into the inverter, or if an external DC isolator is installed, then it must be installed on a non-combustible surface. [22] This applies to PV systems installed under the Solar Homes Program, which covers around 80 per cent of systems being installed in Victoria.[23]

Solar Victoria has also identified ten opportunities to improve safety and quality across all Solar Homes Program installations and made available training modules from the Smart Energy Council and Solar Victoria.[24]

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[19] Clean Energy Regulator, *Inspections update No. 19*, 30 June 2020, p. 2

[20] https://www.eess.gov.au/wp-content/uploads/2019/06/LC-Info-Notice-Direct-current-DC-isolators.pdf

[21] See: https://esv.vic.gov.au/technical-information/electrical-installations-and-infrastructure/electrical-technical-guidelines-and-determinations/pv-dc-isolator-installation/

[22] See: https://www.solar.vic.gov.au/notice-to-market

[23] Solar Victoria, Notice to Market 2021-22, p. 3

[24] See: https://www.solar.vic.gov.au/safety-and-quality-rectification-tips-solar-industry

2.5 Residual risks

Solar Victoria has advised that ongoing work to improve the installation and operation of DC isolators has reduced the risk of water ingress, but there remains a small percentage of installations where DC isolators continues to suffer water ingress. This corresponds with the CER's findings that unsafe and potentially unsafe PV systems have declined from 5.5 per cent of inspected systems installed in 2015 to 1.7 per cent in 2018, with potentially unsafe rooftop and wall-mounted DC isolators found in around 0.6 per cent.[25] The CER inspected 2234 PV systems installed in 2018, meaning that around 38 were found to be unsafe or potentially unsafe and 13 of those were due to DC isolators.

Even where water ingress is detected, this does not necessarily pose an immediate risk of fire. All components of PV systems can be vulnerable to weather exposure and deterioration and require ongoing inspection and maintenance to ensure safety. However, while the rate of failure in DC isolators as a percentage of total PV installations is relatively low, the consequences of a fire can be significant and present a safety risk.

Removal of the requirement for the use of DC isolators in PV systems would remove the source of risk of fires from DC isolators. However, DC isolators serve an important purpose as a safety mechanism to reduce the risk of electrocution during installation, routine maintenance and emergencies. The continued use of DC isolators in PV systems and whether the overall benefits outweigh the risks would be best considered through a review of AS/NZS 5033. This would include input from emergency services, regulators, manufacturers, installers and consumer representatives to arrive at a consensus view that can be adopted nationally.

The risk of damage or harm is greater for wall-mounted DC isolators located adjacent to the inverter where they are installed on a combustible surface as this can cause rapid spread of fire throughout the entire structure. With the volume of PV installations expected to continue to increase, there appears to be a stronger case for regulatory action to be taken with respect to these DC isolators. As discussed in section 3 of this consultation paper, there are options that could be implemented now to address the residual risk of fires associated with wall-mounted DC isolators. However, the benefits will need to be weighed against the costs and we are seeking information from stakeholders to assist this assessment.

Residual risks associated with rooftop DC isolators are likely to be largely mitigated through regular inspection and maintenance. AS/NZS 5033 recommends owners get their PV system inspected regularly and recommends annual inspections for many system components, including DC isolators. We also encourage this through our community education and awareness campaigns.[26]

Question for stakeholders

1. Do you believe there is a material risk of fires associated with wall-mounted DC isolators that warrants regulatory action? Where possible, please provide data to support your view (for example, the number wall-mounted DC isolators that you have identified at risk of failing during inspections and maintenance or have replaced due to failure

[25] Clean Energy Regulator, *Analysis of SRES inspection data to assess PV system residual systemic electrical safety risks*, 2020, pp. 5, 24 and 25

[26] For example, https://esv.vic.gov.au/news/solar-safety-with-servicing/

3 Options to address residual risks

We have identified two options that we believe could be readily implemented to address the residual risk of fires associated with wall-mounted DC isolators used in PV systems. We have also identified some other options but we do not believe they specifically address the risks, are disproportionate to the risks, or are not practical to implement at this time. These are summarised in table 1 and discussed in more detail below.

These options are not mutually exclusive and a combination could be used to apply to different situations (such as new installations versus replacement or and inverter of DC isolator in an existing system). They are included to enable stakeholders to provide any relevant information that may assist us to consider the feasibility and merits of the options, or identify alternative approaches, if action is to be taken.

Table 1: Options to address residual risks of fires from wall-mounted DC isolators

Option	Description
Options that could be implemented now	
Mandating the use of inverters with an integrated DC isolator	Removal of the DC isolator adjacent to the inverter reduces the risk because the protective cover of the inverter limits the potential for water ingress in the integrated isolator. This could be achieved through amendments to the Regulations.
Mandating the installation of wall-mounted DC isolators on a non-combustible surface	It is a requirement that all installations through the Solar Homes Program are installed on non-combustible materials in accordance with our industry guidance. This option would formalise that requirement for all PV systems in Victoria. It could be achieved through amendments to the Regulations.
Other options	
Requiring the use of micro-inverter technologies that eliminate the need for DC isolators	
Mandating remote rapid shutdown mechanisms like those introduced in the United States	
Testing of DC isolators to establish if certain models are more prone to failure ahead of re-certification	

3.1 Mandating the use of inverters with an integrated DC isolator

The Regulations could be amended to require the use of inverters with an integrated DC isolator, removing the need for a separate wall-mounted isolator adjacent to inverters. The removal of the DC isolator adjacent to the inverter eliminates a source of fire risk as this minimises the number of DC connections during the installation and the protective cover of the inverter limits the potential for water ingress.

This option could be applied to new PV systems and to instances where the inverter is being replaced in an existing PV system.

Solar Victoria reported that approximately 80 per cent of inverters installed through the program in 2020 have an integrated DC isolator or use technology that do not require a DC isolator (such as micro-inverters).[27] This suggests there is already a reliable supply of inverters that would meet this requirement and that the cost differential between installing an inverter with an integrated DC isolator or installing one with a physically separate DC isolator is likely small. However, there may be market impacts by restricting the use of inverters that do not include integrated DC isolators, which may lead to supply constraints in the short term and/or upward pressure on prices.

Questions for stakeholders

2. Should the use of inverters with an integrated DC isolator be mandated in Victoria thereby removing the use of physically separate wall-mounted DC isolators? If so, should this apply to new installations only or should there also be requirements for existing installations where the inverter is being replaced? Please explain your reasoning.
3. Is there a material cost difference (for example, in product and installation costs) between the use of an inverter with a physically separate DC isolator, and an inverter with an integrated DC isolator? Please provide cost estimates and an explanation of your approach to those estimates to support your view.
4. What would be the market impacts (for example, on supply and competition) of mandating the use of inverters with an integrated DC isolator? Please explain your reasoning.
5. Are there any unforeseen risks or impacts that could arise from mandating the use of inverters with an integrated DC isolator?

3.2 Mandating the installation of wall-mounted DC isolators on a non-combustible surface

The extent of damage caused by failed DC isolators adjacent to inverters has been linked to its proximity to combustible material.

While Solar Victoria has adopted our industry guidance for the Solar Homes Program, requiring wall-mounted DC isolators not integrated in the inverter to be installed on non-combustible surfaces, this does not apply to all PV systems installed in Victoria.

The Standards Committee for AS/NZS 5033 is considering a revision to require wall-mounted DC isolators be mounted on a non-combustible and mechanically stable surface. A final decision is expected by the end of 2021. The standard as published or amended from time to time is adopted in Victoria through the Regulations, which requires the installation to comply with AS/NZS 5033.[28]

Regardless, the Regulations could be amended to adopt our industry guidance for all new PV systems installed in Victoria. This would ensure that all PV systems installed in Victoria have adequate protection so that, if a fire does start, it is less likely to present a safety risk or spread to the surrounding structure.

This option could also be applied to instances where the DC isolator is being replaced in an existing PV system.

[27] Solar Victoria, Notice to Market 2021-22, p. 24

[28] Regulations 202 and 243

Questions for stakeholders

6. Should the installation of wall-mounted DC isolators on a non-combustible surface be mandated in Victoria for DC isolators that are not integrated in the inverter? If so, should this apply to new installations only or should there also be requirements for existing installations where the DC isolator is being replaced? Please explain your reasoning.

3.3 Other options identified but considered not feasible at this time

There are a range of other options that we have identified but believe do not specifically address the identified risks, are disproportionate to the risks, or are not practical to implement at this time. However, we welcome any feedback from stakeholders on these or other potential options.

Requiring the use of micro-inverter technology

Micro-inverters convert the DC power to AC at the solar panels level, removing the need for any DC isolators in the system. Typically one micro-inverter is installed for each solar panel, although there are some models where one is installed for every two solar panels.

However, the number of potential failure points increases as more micro-inverters are installed, and they can be hard to replace as they are installed under the solar panels.

There is also a power limitation as the micro-inverters must have an input not more than 350W based on the applicable Australian standard). Solar panels are getting larger with greater power (>400W) but the micro-inverters could limit the size of the solar panels able to be used. AS/NZS 4777 also limits the voltage increase on the AC cable, which could be problematic if the switchboard is a long way from the solar panels.

We have also been told anecdotally that use of micro-inverters would increase the cost of the overall PV system by between 10 and 25 per cent.

Mandating remote rapid shutdown mechanisms

The Standards Committee for AS/NZS 5033 has identified mandating rapid shutdown mechanisms like those introduced in the United States as an option. This requires fitting inverters with arc fault detection and a remote isolation point installed at the solar panel. The mechanism automatically prevents power going to the grid if it detects that the grid is not working. It also automatically shuts down the system when heat from a fire is detected and enables non-electricians to manually shut down the solar installation without the need to access the roof.[29] The US first introduced rapid shutdown in 2014 and improved it in 2017.

Solar Victoria has advised that many inverters available in Australia are capable of arc fault detection, but fitting remote isolation could increase costs by about 10 per cent and may reduce competition in the market. Other anecdotal information suggests the inclusion of remote isolation would add around $300 to the overall cost of the PV system.

There is also a concern about whether the technology is ready. For example, the International Electrical Commission is yet to publish a product standard on module-level power electronics that covers this technology. Without a product standard, there is a risk of low-quality products that do not work as intended.[30] The Electrical Safety Office (Queensland) has also noted that remote isolation mechanism adds a further device into circuits already containing many possible connections for failure, and that there is a lack of clarity on the maturity of the applicable safety standards.

[29] https://gosolargroup.com/solar-inverter/how-the-automatic-shut-off-switch-works/

[30] https://www.ecogeneration.com.au/installers-need-to-take-dc-isolators-seriously-heres-why/

Testing and re-certification of DC isolators

If we formed a view that certain models of DC isolators are more prone to failure than others, then we could act to prohibit the sale and supply of those specific models. However, we do not currently have this information and would need to conduct detailed investigation and testing of DC isolators.

It would likely take 12 months or more for us to conduct a robust analysis of DC isolators that have suffered water ingress or other failure to identify models more prone to failure, and these products would then need to be tested and the outcome of the testing evaluated before a decision about appropriate actions could be made. It costs an average of between $7,000 and $15,000 to test a DC isolator.

We could also require that all products available on the market in Victoria be re-certified to the latest edition of the DC isolator standard. DC isolators were reclassified as level 3 (high risk) electrical equipment in 2018, which requires mandatory certification and registration on the EESS database before being offered for sale. This would take into account the latest information issued by the Standing Committee of Officials (SCO) in relation to the way the product is required to be assessed in the standard. However, this would also be a costly exercise for industry and there may be some shortage of products if there are multiple products that do not comply with the latest EESS bulletin. These costs may drive an increase in product price that ultimately impacts on consumers.

Questions for stakeholders

7. Is it practical to require the use of micro-inverters at the location of individual solar panels? What are the cost implications of such an option? What would be the broader supply chain impacts? Would this stifle innovation or have adverse competition effects?
8. Are rapid shutdown mechanisms a feasible solution for use in Victoria?
9. Are there other options that ESV should consider to reduce the fire risks associated with wall-mounted DC isolators? If so, would these options be preferred over mandating the use of inverters with an integrated DC isolator and/or mandating installation of wall-mounted DC isolators on non-combustible surfaces?

Appendix A

FIRE RESCUE VICTORIA

Your Ref: CM-9721
FRV Ref: 1497628

28 August 2020

Ms Marnie Williams
Director of Energy Safety
Energy Safe Victoria
PO Box 262
Collins St West VIC 8007

Via email: [redacted]

Dear Ms Williams,

RE: DIRECT CURRENT (DC) ISOLATORS CONNECTED TO DOMESTIC SOLAR PHOTOVOLTAIC (PV) SYSTEMS

Thank you for your letter of 30 July 2020 and the opportunity for Fire Rescue Victoria to participate and contribute information in relation to the safety and risks associated with DC isolators.

Solar Direct Current (DC) Isolators Connected To Domestic Solar Photovoltaic (PV) Systems

Direct current isolators are mechanical switching devices that provide a method to isolating the source of generated DC power from the rooftop solar arrays which feed into the system invertor. Current Australian standards require two DC isolators to be installed on the DC side of the inverter wiring, per string (group) of solar arrays and an AC isolator for the output of the inverter.

The DC circuit requires one isolator to be installed as close as practical to the power source, typically mounted on the first cell per string on the roof. The second isolator is on the same circuit prior to the invertor. Isolators are double pole, meaning there are two internal contacts that open simultaneously when the isolator is operated, breaking both the positive and negative circuit path.

Incident Data involving DC Isolators

The data gathered from the MFB system, prior to FRV, of solar system fires attended, shows us that 85.5% of calls involved DC isolators as the causation of the fire. A combination of rooftop and ground level switches make up this figure (refer to Table 1).

Fire Rescue Victoria
ABN 28 598 558 561
456 Albert Street
East Melbourne
Victoria Australia 3002
T 1300 367 617
frv.vic.gov.au

VICTORIA State Government

Table 1 – Incidents Involving Solar Systems (Jan. '14 – Jan. '19) Within the MD

Description	No. of Incidents	% of Total
No. of incidents involving wall mounted DC Isolators adjacent to Inverters	21	43.8
No. of incidents involving DC isolators mounted on rooftops	17	35.4
No. of incidents involving DC isolators (Undetermined wall or rooftop installation)	3	6.3
No. of Incidents involving Inverters	0	0
No. of Incidents Involving Solar Cells	2	4.2
No. of Incidents Involving Other Solar System Components	5	10.4
Total number of incidents	**48**	**100**

Safety of emergency personnel

These isolators are installed to remove the electrical hazard by disconnecting the arrays from the system for trade's people working on the systems, as well as the emergency responders as part of their operational requirements.

When a Fire Service attends a fire incident at a structure, there is a process of conducting a risk assessment which requires identified risks to be mitigated as part of the approach to deal with the emergency. Isolation of the services is one of the risk reduction strategies implemented to allow the crews to get to work and deal with the call. FRV has trained their first responders to isolate the electrical supply to the structure by means of removing the service fuse and isolating the main switch, then calling on distribution companies to validate the isolations. These actions are not always possible due to the fire being in close proximity to this infrastructure, or the damage that has occurred rendering it inoperable.

With the introduction of solar technology, another consideration for the responders is the isolation of these systems. The training provided is to isolate the AC isolator, followed by the DC isolator/s which are located adjacent to the invertor. The training also covers rooftop isolators, but due to a number of factors it would not be common practice to get onto the roof to operate. These factors include, roof integrity, electrical shock risk which is elevated if the roof cladding is sheet metal, and at an active fire, rescue and extinguishment is a higher priority at a first instance resource lacking fire fight.

Unfortunately we do not have any data available to highlight the number of times the isolators have been operated by our fire crews at incidents. This is not information captured in our reporting systems.

FIRE RESCUE VICTORIA

Risks Associated with DC isolators

As isolators start to age and deteriorate, mostly due to UV exposure and weather impact, the potential for an increase of failure is more likely. The data has shown us they are failing, and not failing safely, meaning the fire isn't being contained within the isolator enclosure and propagating to combustibles in close proximity.

An issue that FRV do come across on a regular occurrence is once the distribution company has isolated the AC electrical supply to the structure, the solar arrays are potentially still generating a DC voltage risk. Distribution companies have no jurisdiction as it isn't their infrastructure, so the risk is left unattended. On most occasions the occupant /owner isn't in a position to engage a solar accredited electrician. Insurance companies have make-safe crews attend some time later after the fire is extinguished. If the property is uninsured another layer of complexity is added.

Potential Options

A solution to this issue could be:

- to set up a state-wide register of solar accredited electricians that can be called upon to isolate as required by any emergency agency; and
- a life span for DC isolators be established and regulated.

I hope this information assists. Should you have any further questions please contact [redacted], Deputy Commissioner Fire Safety [redacted] or (03) [redacted].

Yours sincerely,

[redacted]

Ken G. Block
Fire Rescue Commissioner

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