Solar installations: where are we going wrong?

Under the Renewable Energy Target (RET) requirements, solar photovoltaic (PV) power systems must be installed to relevant Australian standards and Clean Energy Council (CEC) guidelines in order to receive Small-scale Technology Certificates (STCs). To monitor this, the Clean Energy Regulator's RET inspection program has been running since 2010. Global Sustainable Energy Solutions (GSES) is an experienced PV inspections company, and since the start of this program GSES has seen the solar industry rapidly develop and the quality of PV installations improve as system installers and designers increase their knowledge and experience.

One of the major benefits of the RET inspections is that the industry is given a chance to reflect on what is being done well and what aspects require closer attention. As a result, better outcomes have been delivered by installers to homeowners, and the industry as a whole has been reaping the benefits. This improvement is demonstrated in the data published by the Clean Energy Regulator (Figure 1). During the RET inspections program, the percentage of systems found to be substandard decreased from 22.3% to 5.7% and the percentage of systems deemed to be unsafe decreased from 5.2% to 2.6%. The Clean Energy Regulator defines a substandard system as one requiring rectification work and an unsafe system as a possible safety hazard that poses an imminent risk of damage to property or persons.

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In October 2012, a major update of the solar photovoltaic standard AS/NZS 5033 was implemented. This update (AS/NZS 5033:2012) included new requirements, such as heavy-duty conduit for DC wiring and DC isolators on roofs. For systems installed after this time, there was a significant increase in the percentage of systems considered to be substandard and unsafe. As long as the RET inspection program continues, the quality of installations will most likely improve once more. Although there was a minor update of AS/NZS 5033 in 2014, it is unlikely to cause as big an effect on inspection outcomes.

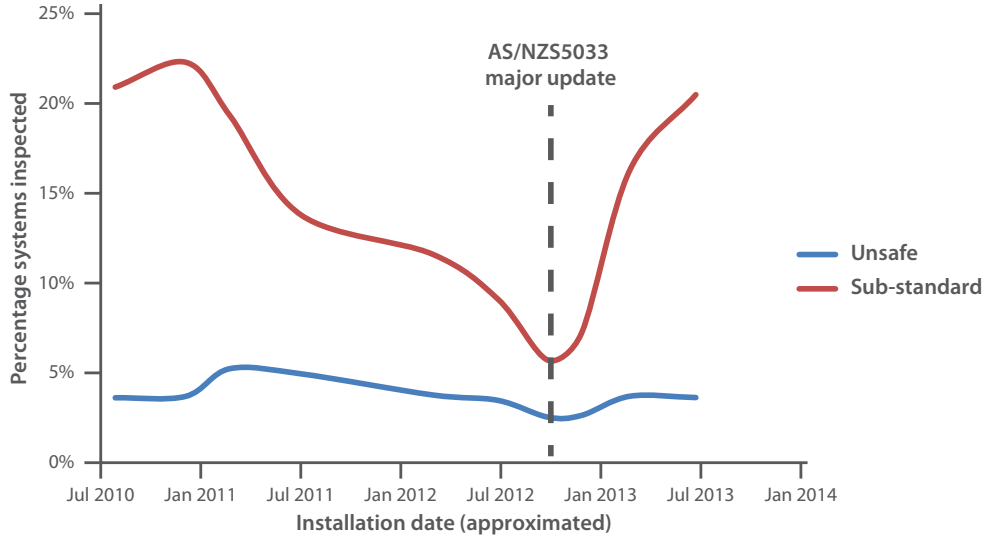

Figure 1: *This graph demonstrates the improvement in quality of PV installations between the start of the RET inspection program and the release of AS/NZS 5033:2012.*

Another avenue for ongoing improvement is the accreditation of solar installers and designers. A requirement for receiving STCs is the installer and designer being accredited by the CEC. This requires initial training and ongoing professional development. If the RET were removed and STCs ceased, the incentive for solar training would be removed and the RET inspections, which provide vital feedback to installers, would no longer take place. To counter this, regulation would need to be put in place that requires independent inspections and relevant training for installers in order to maintain the quality of work that is necessary for solar installations.

Following is a summary of installation practices commonly requiring revision by solar installers.

General electrical work in solar

The quality of workmanship when installing any electrical system is always important, owing to the dangers associated with electricity. This is why standards and regulatory authorities have been put in place to guide and monitor the work that electricians do. However, until only a few years ago, electrical work was nearly always associated with AC power, especially for domestic installations.

In 2010, when the current RET was adopted, solar module installations and, subsequently, DC electrical work started to become common tasks for electricians. DC electricity behaves differently from AC electricity. For example, electrical arcs formed between conductors in a DC solar system are very difficult to extinguish and have the potential to keep arcing as long as there is sunlight on the modules. Therefore, this transition to working with DC power has resulted in an even greater importance in the quality of workmanship and has increased the requirements for adequate protection and isolation.

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A general requirement in all electrical work is to secure cabling in such a way that it will be adequately protected. Inspections of solar systems over the last few years have shown that installers do not always adhere to this basic requirement, despite being even more important to protect solar DC wiring. Solar wiring installed on a roof needs to be well-secured under the modules so that it does not rub against the roof surface (Figure 2). In the majority of cases, solar arrays will be installed on a roof for more than 10 years and, although a bit of wind will not cause much damage at first, over the life of a system it can significantly wear away the cable insulation, potentially causing the dangerous situation of live conductive surfaces.

Figure 2: *Cables resting of the roof can rub over time and wear away the cable insulation.*

Other problems with general electrical work range from not protecting earth connections against corrosion to not labelling neutral cables. Although these problems may seem minor, they can lead to serious safety concerns for electricians returning to the site for upgrades or maintenance. These sorts of problems are ongoing issues with standard electrical work and, as not all work is inspected, they will most likely continue. Although requiring all electrical work to be inspected would solve this problem, it would greatly increase the cost. An alternative option would be to require training, such as refresher courses to earn professional development points for renewing electrical licences.

Solar-specific problems

The two main characteristics that cause problems for solar installations are exposure to weather, in particular sun and rain, and a higher danger of DC faults compared to AC.

The most significant negative impact that weather has on solar installations is rain getting inside electrical enclosures. Even a small amount of water getting into a DC isolator enclosure can cause short-circuiting or corrosion of connections; this can create hot joints or arcing, potentially leading to fires. Although the enclosures selected by installers generally have the correct ingress protection (IP) rating, the enclosures are not always installed in a way that maintains the IP rating. The most common practices that negatively affect IP rating are:

- Multiple cables being installed through a single cable gland (Figure 3)
- Conduit connections and ends not being sealed
- Enclosure mounting screws not being sealed.

See the GSES Technical Paper *Isolator Enclosures: more than just a box* for more information on the correct installation methods to maintain IP ratings.

Protection from the weather also includes protecting equipment from ultraviolet (UV) radiation. It is essential that cabling and conduit installed outdoors are UV stabilised and installed out of direct sunlight where possible. Even equipment that is not in direct sunlight may still need to be

Figure 3: *Water is known to run along cabling, so it is important that glands fit tightly around each cable. If a single cable gland is used for multiply cables, like in this picture, water might be able to leak through.*

> ***"The most significant negative impact that weather has on solar installations is rain getting inside electrical enclosures."***

UV resistant. For example, conduit and cable ties installed under the modules may be exposed to reflected UV during the day and to direct UV in the early morning or late afternoon. Non-UV resistant conduit, such as orange heavy-duty conduit and plastic cable ties, may not be adequately protected from this UV radiation (Figure 4).

Figure 4: *Non-UV resistant conduit under PV modules is exposed to reflected UV, and the conduit may degrade over time.*

To combat the high danger of DC faults in PV systems, the 2012 release of AS/NZS 5033 introduced the requirement for all DC cabling within buildings to be installed in heavy-duty conduit. The main difficulty that installers have with this is dealing with the transition between heavy-duty conduit in the roof space and UV resistant conduit as it exits the building. The most effective way to deal with this is to install a short length of conduit that is both heavy-duty and UV resistant at the penetration point. However, installers have frequently opted to use either medium-duty UV resistant conduit for this transition length or simply continuing non-UV resistant heavy-duty conduit through the penetration and outside without any UV protection. These methods do not adequately address the safety risk of DC faults and the risk of degradation

from exposure to UV. Associated with this increase in conduit use, another problem that GSES has observed is conduit connections coming apart and exposing cabling (Figure 5). This can be caused by pulling on cables during or after installation and the connections not being adequately glued and fixed in place.

Figure 5: *This is a common problem found with conduit work. Conduit connections need to be glued and firmly fixed in place so that they will not come apart.*

An additional safety requirement for DC power is that cable connectors need to be mated with those of the same type and from the same manufacturer (Figure 6). Adhering to this requirement reduces the risk of a resistive joint, which could potentially lead to melting of connectors, arcing or live parts being exposed. As the connectors that come preinstalled on inverters and solar modules vary, it can be difficult to always have the correct connectors on hand. Therefore, it is important to ensure that the correct connectors are supplied when designing

Figure 6: *These connectors mated together are from different manufacturers. This may lead to a dangerous hot joint.*

> ***"cable connectors need to be mated with those of the same type and from the same manufacturer"***

a system or ordering a system package. It is also important to be aware that removing connectors from module cables to change them can void the module's warranty.

To ensure components withstand the intense environment experienced on a roof and the hazards of DC voltage, it is important that appropriate products are selected. One way to achieve this is to use an experienced manufacturer and to choose products that have been around for a while. Over the past few years, many DC isolators have been recalled owing to safety concerns (Figure 7). This results in suppliers and installers having to deal with the expensive ordeal of replacing recalled products. Following the above advice will decrease the risk of a product failing and, even though it may be more expensive to purchase, it may save money in the long run.

Figure 7: *These products have been recalled owing to safety concerns. It is important to choose products carefully to reduce the risk of having to replace faulty products.*

To ensure the array will withstand any winds that could reasonably be expected within the system's lifetime, the array frame needs to be certified by an engineer. Instead of each solar installation being certified individually, certification is generally provided for array frame systems on the condition that the manufacturer's installation instructions are strictly followed. However, GSES has observed many installations where the manufacturer's instructions have not been followed. The most common problem is roof fixings being too far apart, meaning that the number of fixings may not be enough to withstand strong winds. Installers should never go against the manufacturer's instructions

unless they have obtained engineering certification for what they have done. It is not worth the safety risk or the possibility of property damage. There are also instances in which installers have not carefully followed instructions for securing clamps and roof fixings (Figure 8). If clamps are not properly aligned, or the specified screws or bolts are not used, then the modules may not be adequately secured to the roof.

Figure 8: *An incorrectly installed keystone. It is vital the clamps are properly aligned when they are installed or they will not adequately secure the modules.*

Ongoing training

To continue improving the quality and safety of solar PV installations, the industry must continue receiving ongoing feedback and training. As products change and standards are updated, it is vital that the solar industry makes appropriate adjustments to keep up. The RET brings with it PV inspections and CEC accreditation with ongoing training, so as long as it continues, it will help the industry stay strong.

GSES PD Days

Ongoing training is essential for installers to stay on top of industry changes; GSES offers *Professional Development Days* to help improve solar knowledge and installation standards.

GSES welcomes feedback on Technical Papers and other resources available on www.gses.com.au, please contact GSES by email at info@gses.com.au or by telephone on 1300 265 525.