20 Common Mistakes Installing PV Systems

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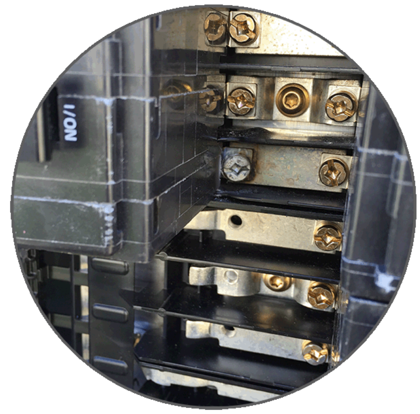


Introduction

Even the most experienced professionals make mistakes, and PV systems present many opportunities for errors. In this paper we list some of the more common issues we've seen or heard about often enough to be worth mentioning. Our intention is to be brand agnostic but where we couldn't resist the urge to put in our own propaganda *its in italics*. Enjoy!

Contents

Inverter Physical Mounting

1. Not Leaving Enough Room Around Inverters

The enemy here can be the desire to have everything looking neat in such a way that there is not enough room around the inverter to allow it to be accessed or removed by a service tech. Alternatively it can be not being aware of minimum spacing of inverters that need air circulation or access to change air filters. If there are minimum spacings for a particular inverter they will be specified in the installation manual.

2. Mounting in Direct Sunlight

Most inverters are rated for outdoor use. However, mounting string inverters on a south-facing or west facing wall is a common practice with possible negative consequences. Most inverters have a wide operating temperature range, but will de-rate as they exceed a particular temperature – so the impact is likely to be on energy harvest. In addition, many have fans, displays etc. that will degrade over time with temperature and/or UV exposure, requiring visits for repair or replacement. Overall it's recommended to mount inverters in a shaded location if possible. *TrueString™ inverters are sealed, have no displays, no fans or air filters and can be mounted under the array. Other than the normal power de-rating at high temperature our inverters can be mounted anywhere.*

DC-Side Electrical

3. Strings Aren't Connected

This can be very difficult to detect and diagnose with large string and central inverters, but this error is very common. *Easy to see with the TrueString inverters. For example,* Figure 1 *shows a graph comparing inverter outputs for an array (a); the lowest performer (#2766) is easy to identify (b). Looking at the performance summary for that specific inverter it is obvious that one string (String 1) is the culprit (c).*

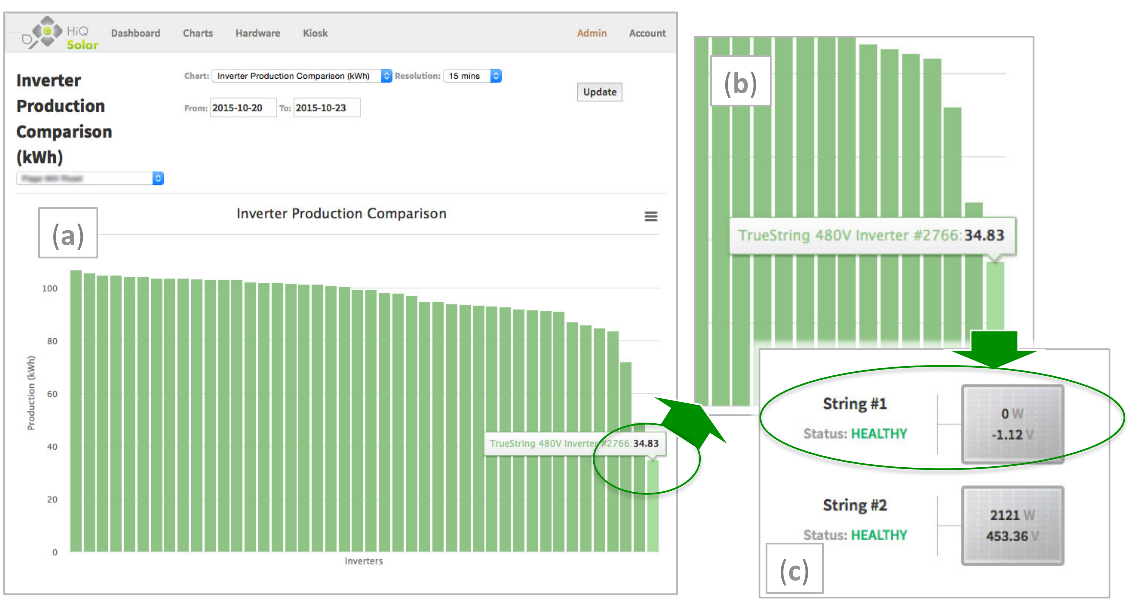


Figure 1: Identifying the lowest performing inverter in an array

4. String Wires Reversed

Very common where custom jumpers are used, can even have same gender connectors on each end. In addition to the string not producing power, it is possible that this can damage the inverter. Errors like this are less likely if wiring is clearly identified, such as in the installation of Figure 2 below.

Figure 2: Clearly identified string polarities make miswiring harder

5. Swapped Strings

This is less common, but we have seen it – plus and minus wires of unrelated strings connected to each input. For large string inverters with many strings bundled together it can even be each side of a string connected to different inverters. As with the previous point, clear labeling at each end of wiring runs is usually worth the time.

With individual string monitoring and two separate inputs only, it is easier to see on the TrueString inverter than with large string inverters with many strings wired in parallel.

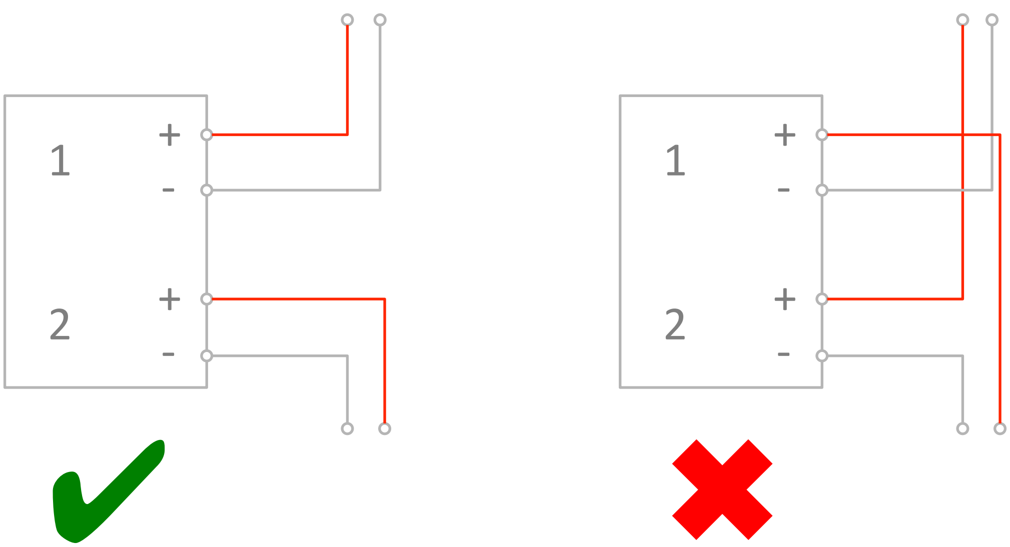


Figure 3: Connecting wires from unrelated strings

For inverters that use two or more strings in parallel per DC input, it is also possible to accidentally connect the strings in series instead of parallel. This often damages the inverter.

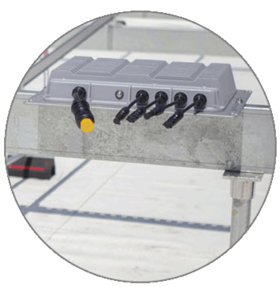
6. Poor Quality Crimping

Use of the wrong tool to crimp connectors can cause overheating of terminals, open circuits and burning of connectors. Use of the wrong tool is very common, but use of a crimper other than that specified by the connector manufacturer will violate code.

7. Connectors Not Latched

An obvious one, but difficult to see visually. If the connection is not made it can be easy to see with good monitoring; the more dangerous situation is where the center conductors are not fully mated and over time start to arc.

8. Connectors Exposed to Moisture While Open



This applies to modules, home runs and inverters. The project is partially finished then delayed, then a rainstorm comes through, it snows or whatever. Homeruns have the connectors crimped but not mated together, and moisture wicks into the wire jacket and this causes corrosion and performance and reliability issues long after the install is over. *The picture shows a HiQ TrueString inverter in the process of being installed. The inverter ships with caps on all connectors to protect them from moisture ingress during installation.*

9. Excessively High Resistance on DC Side

Damage or manufacturing defects in modules such as bubbling in a thin-film module can cause high resistance to occur; the voltage seems ok until the inverter the tries to draw power from the module, then the voltage collapses and the inverter shuts off. The inverter tries to restart and the cycle repeats.

10. Not Accounting for Differential Thermal Expansion

In the pursuit of a professional and neat looking install, string wiring is pulled tight and zip-tied to the racking, but without any thermal expansion margin. Hotter days and colder nights combined with the fact that the thermal expansion of copper is 2x that of aluminum racking can lead to:

- i) Connector pins being pulled out of sockets leading to disconnection and/or arcing
- ii) Wire crimps being pulled apart
- iii) Strain reliefs being broken
- iv) Abrasion of insulation repeatedly over time leading to shorting and possible fire (Bakersfield fire, for example)

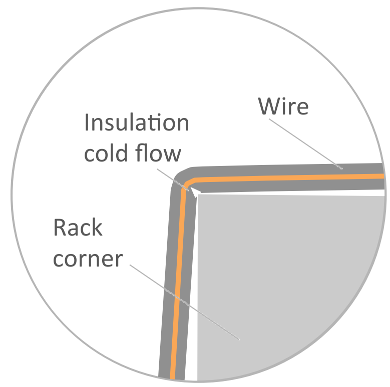
The longer the wiring run, the bigger the effect.

11. Wires Not Long Enough

Similarly, cutting wires to the exact length to reach the inverter can be a problem. Firstly, it costs flexibility for later in the install when it is discovered that any string miswiring issues have occurred, and there isn't enough spare length to swap the wires to the correct terminals. It can also be a problem later when the service tech has to swap an inverter out to a different design. The NEC requires a 'Service Loop' of between half and one turn of wire inside a junction box precisely for serviceability later.

12. Insulation Cold Flow

Where wires are tightly and neatly secured to a module frame or racking member pass over a sharp corner, over a period of months or years the pressure of the corner against the insulation can cause the insulation to flow away from the pressure until the conductor shorts against the metal frame.



AC-Side Electrical

13. Problems with Grounding

Many issues are possible here, ranging from code violations to significant safety issues. Most installations require the DC side to be ungrounded now that non-isolated (TL) inverters are common, which simplifies things. A few less obvious ones:

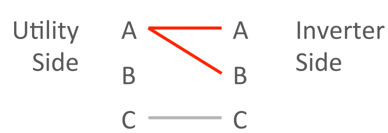
- Grounding using dissimilar metals – can be metals with very different galvanic values[1] such as bare copper wires touching aluminum frames; can be metals with similar (but not identical) galvanic values such as copper and tin plus the addition of coastal moisture with salt over a longer period. The result is obviously corrosion. In the case of coastal conditions, coating with dielectric grease is messy but effective
- Painted enclosures can either be grounded to racking etc. with fasteners listed as 'paint cutting', or the paint must be cleared off the grounding point during installation

14. Phase Wiring Issues

A Phase Not Connected
Usually relatively easy to detect.

Neutral Connected to Hot Phase
Again, usually relatively easy to detect.

Two Hot Phases Connected to One
See picture, two phases of the inverter output might accidentally connect to the same grid phase. Commonly leads to an inverter fault.



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[1] *http://inspectapedia.com/BestPractices/Galvanic_Scale_Corrosion.php*

15. Phase Power Imbalance

Can be a design issue, or an electrician issue. With a maximum imbalance allowed of 6 kW, this can be an issue in commercial installs particularly with single-phase inverters. *Obviously an inherently 3-phase inverter such as our TrueString does not have this issue.*

16. Issues with External Voltage Translation Transformers

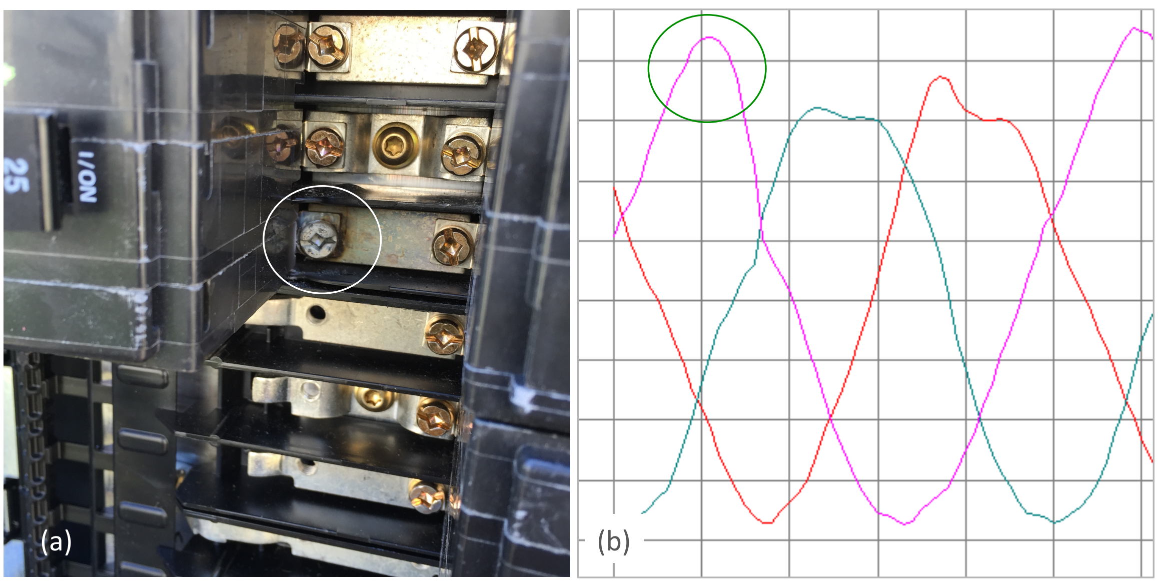
The lack of cost-effective 208V inverters until recently has meant the use of transformers. Some possible issues:

- Neutral not carried through the transformer. If communications between inverter and gateway is over powerline, this can inhibit them talking if the gateway is on the other side of the transformer
- Transformers have parasitic losses 24 hours a day, so it is common to disconnect them overnight, controlled by a timer. If power to the timer is interrupted the array can have productive hours wasted for months or years if nobody notices that the time is offset.

17. High Resistance

Grid voltage measures ok until power is exported from the inverter – because of the high resistance the voltage then rises, and can cause overvoltage tripping of the inverter.

The picture shows one phase of a 3-phase breaker not torqued down properly, which resulted in a high resistance and overvoltage tripping of the inverter.



18. Breaker Issues

In addition to the example above, breakers can fail in a lot of ways on their own, although this is more common in older systems – they can fail open or closed, or just one phase can fail open or closed when the handle indicates all three phases are closed or vice versa. Very dangerous, always de-energize and test, test again before touching – don't trust the label on the handle.

Of course there is also selecting the right breaker in the first place – sizing it, physical form factor for the panel board, having the right interruption rating which is something that doesn't come up until it's called upon to stop the building catching on fire. The OCPD Interrupt Rating must be sized to be the same or greater than the short circuit current capability of the utility connection. Then coordinating with the other overcurrent protection devices.

19. Problems with Terminations

When you have a lot of them or they're big, there's a lot to get right. These can be terminals, inverters, splice boxes, other conductors. Are the connections tight, let alone torqued properly, at least tight? For stranded conductors, are there any wayward strands that could occasionally arc over to the next conductor? For breakers are the wires terminating properly, and then is the breaker terminating properly on the bus bars? And there can be an issue with cold flow. After a connection is torqued, and over time, the soft copper or aluminum conductor "gives way" and causes the connection to loosen. It is always advisable to do a follow-up retorqueing of major connections some months after installation.

Communications

20. Customer Internet Connections

Using the customer's internet connection to keep track of the system performance is a low cost approach, but can be fraught with issues later. These can include delays getting the system connected at the beginning while the local IT department drags its feet opening the right ports on the router. It can catch you later when they take on a new IT guy, or change security policy and close all the ports that don't directly affect them. From this point of view cellular modems that are entirely independent of the customer seem expensive but are probably worth the cost.

For cellular modems in faraway areas it can be a good idea to have them on an AC timer to automatically and regularly power cycle them in case of lock-up.

Acknowledgements

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