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Inverter Retrofit for 600 VDC Legacy Utility Scale PV Systems

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Background: Up until the mid-2000s, PV panels were rated for a maximum system voltage of 600 VDC. This voltage matched the maximum rated voltage for readily available wire and electrical equipment. After that time it was realized that PV systems could be operated more efficiently at higher voltages. First 1,000 VDC and the 1,500 VDC systems became available. Electrical equipment was developed to handle these higher voltages. As of this writing 600 VDC PV plants are no longer installed in utility scale systems.

PV panels last a long time. Electronic components not so much. If you have a PV plant with viable panels but dead or dying inverters, you face a problem finding replacement inverters. Your PV panels may be rated only up to 600 VDC but most new utility scale inverters (above about 25 kW) are built to operate with PV voltages of greater than 600. Your old panels are wired together to operate at less than 600 volts and it is unsafe to rewire then to create voltages above 600 volts. Your legacy utility scale PV plant will not work with most new inverters.

There are some options, however. I group these into two categories that I call “Drop-in replacement” and “DC-DC converter.”

Drop-in replacements are 1,000 VDC rated inverters that will operate efficiently at less than 600 VDC. Not all 1,000 volt inverters will do this. DC-DC converters are electronic devices installed between the PV panels and 1,000 or 1,500 VDC inverters to jack up the PV voltage into the inverters. Below is some discussion on both categories.

All of the inverters I have researched are equipped to output 480 VAC, nominal.

Drop-in replacement inverters. There are some issues to consider with these inverters: Efficiency, input architecture, current limits, bonding and arc faults.

Efficiency: Not all 1,000 volt inverters can operate efficiently at voltages less than 600. Not all inverter manufacturers publish efficiency values for a wide range of MPPT voltages. MPPT voltage is the voltage at which a series string of solar panels operates most efficiently. This voltage will vary somewhat based on environment factors. If an inverter you are considering publishes the efficiency value at the MPPT voltage your system will operate, and the efficiency is acceptable, then that inverter is a viable option.

Input Architecture: Many inverters have built in string combiners. These allow individual PV string wiring circuits to be brought to the inverter chassis within which they are combined after passing through required fuses. Often these combined inputs are grouped into two or three input circuits, each circuit being able to automatically adjust to the optimal MPPT voltage. If the existing PV plant already has combiners that you wish to use, the combiner built into these inverters may get in the way. This situation may not be a problem if you plan on installing a new inverter where an existing combiner is located. You simply remove the old combiner and install the inverter/combiner combo chassis in its place. If, however, you wish to install the new inverter at a location removed from the existing combiner, you would need to remove the old combiner and pull new string wiring to the inverter location. This is expensive and time consuming. Solis is one brand of inverter that has reasonable efficiency at sub-600 volt operation but has non-bypassable, built-in combiners.

There is at least one inverter line on the market that will operate sub 600 VDC at reasonable efficiency and also has the capability of bypassing the built-in combiners and wire directly to the MPPT inputs. These are made by Chint Power System (CPS). In addition, these inverters allow you to gang MPPT inputs together to allow more power from a given combiner or group of combiners.

Input Current Limitations: These Drop-in inverter candidates are normally operated at greater PV voltages than we are considering here. At lower voltages, in order to input PV power to the inverter at name-plate power rating, input currents need to be higher. These inverters have input current limits and your PV feeders may reach or exceed these limits before you get much above a DC/AC ratio of 1:1. Careful design review will reveal this limitation and allow you to stay below the limit.

Bonding: 600 VDC limited inverters were often transformer equipped. In these inverters one polarity of the PV input, usually the negative, was bonded in the inverter. Replacement inverters to be considered do not bond either polarity. This is generally not a technical issue but rather a code issue. The 2017 NEC does not require overcurrent protection in both PV polarities like some previous code iterations, but you are required to provide disconnecting means for both poles.

Arc faults: This relates to the quality of your PV plant. If the PV back-sheets, trace wiring or PV leads have insulation issues, new inverters might generate arc fault shut-downs. It is suggested you evaluate the condition of your PV plant carefully before committing to an inverter replacement.

DC-DC converters: There are two manufacturers of DC-DC converters that I am aware of: SolarEdge and Alencon. I offer a brief discussion of both options below.

SolarEdge provides electronic devices that install at each one, two or four PV panels. These optimizers, as they are called, isolate the PV panel from higher string voltages, allowing longer series strings to bring the DC voltage up to a higher level for input into SolarEdge high input voltage inverters. The disadvantage to this system is the cost of parts and labor required to purchase and install all of the optimizers.

Alencon provides larger scale DC-DC converters. These come in units of four converter circuits that can be paralleled to provide the rating to convert the entire output of an existing combiner. These devices can be expensive and complicated to integrate.

Conclusion: Upgrading inverters in a 600 VDC limited PV plant is not impossible. There are many factors to consider before choosing a product. I hope this paper points out the factors you need to consider in designing a replacement inverter system.

