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NERC Issues Recommendations on Inverter-related Solar Outages

Morgan Lewis

Article By
J. Daniel Skees
Mark C. Williams
Morgan, Lewis & Bockius LLP
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Inverter disconnect events increasingly pose a reliability risk with the growth of solar generation.

On June 8, the ***North American Electric Reliability Corporation (NERC)*** released its report on the loss of 1,200 MW of solar generation in southern California during a system disturbance that unexpectedly caused inverters at solar generation facilities to trip or momentarily cease to operate. The report provides solar plant owners and engineers with recommendations to prevent future occurrences. According to NERC, inverter disconnect events pose an increasing reliability risk given the expansion of solar generation.

Growing solar penetration has made the response of solar generators to system disturbances more critical. If NERC and utility-scale solar generators adopt the report's recommendations, the likelihood of both recurrences and government-imposed regulations will be reduced. The Federal Energy Regulatory Commission's (FERC's) recent orders requiring renewable generation to promote frequency response (Docket No. RM16-6), reactive power (Order No. 827), and ride-through capability (Order No. 828) indicate a willingness to impose regulatory requirements on renewable generation where FERC sees it as necessary to preserve system reliability. Separate and apart from NERC action and any voluntary industry response, the report may lead FERC to consider such action.

Overview and Causes

On August 16, 2016, the Blue Cut fire ignited in southern California and spread toward an important transmission corridor containing four high-voltage lines. Faults on the four lines resulted in the loss of nearly 1,200 MW of solar generation.

NERC's subsequent investigation identified three contributors to the power loss.

1. The primary contributor was an incorrect perception by some inverters that system frequency fell below 57 Hz. At voltages below 57 Hz or above 63 Hz, an inverter automatically trips, ceasing to input current and remaining offline for five or more minutes, thus terminating the flow of power through that inverter and affecting related power flows. The affected inverters remained offline for seven minutes. While the drop in frequency during the faults was slight and never reached 57 Hz, the faults distorted voltage waveform momentarily, which caused the inverters to perceive a frequency below 57 Hz.

2. The secondary contributor was momentary cessation of power flow through some inverters due to system voltages operating outside their normal range. Outside the normal voltage ratio range of 0.9 to 1.1 per unit, inverters suspend current injection until the voltage normalizes. Many inverters momentarily ceased injecting current. Restoration began immediately, but it took two minutes to fully restore the lost power.

3. The tertiary contributor was that DC overcurrent protection tripped some inverters after they started the momentary cessation operation. The cause of this trip remains unknown and under investigation.

The investigation also revealed that similar inverter disconnects had occurred during other disturbances in the recent past.

Investigation Findings

NERC's investigation found that inverters that trip instantaneously based on near instantaneous frequency measurements may trip erroneously when faults distort waveform. While the PRC-024-2 Reliability Standard specifies a no-trip range for voltage and frequencies, solar generation owners and inverter manufactures do not generally consider the standard to prohibit momentary cessations. Further, owners and manufacturers generally believe that anything outside the no-trip range is in a must-trip range.

The investigation also found that most installed inverters will momentarily cease providing current immediately when voltages go outside their normal operating range. These inverters require major modifications or replacement to stop this inverter response, but some inverter manufacturers are no longer operating, suggesting a recognition that such modification or replacement might not be possible.

NERC's investigation then found that inverter manufacturers are using the IEEE 1547-2003 standard, which many generator owners believe they must meet—even though the IEEE standard conflicts with PRC-024-2.

The investigators concluded that this type of disturbance presents a previously

unknown reliability risk, which is expanding as the use of solar generation increases.

NERC's Recommendations

NERC's investigation resulted in several recommendations to mitigate or prevent future occurrences.

1. NERC should review PRC-024-2 to determine whether to revise the standard to (a) indicate that momentary cessation of inverter-connected resources is not allowed within the "no trip" area of the voltage curves, (b) clarify that outside the frequency curves is a "may trip" area, and (c) impose a required delay for the lowest levels of frequency. A revision to this standard could affect numerous utility-scale solar generating facilities.

2. NERC should alert registered Generator Owners and Generator Operators as to the risk and the recommended changes to inverter settings, especially given the proliferation of solar development. This alert would be directed only to those generating entities that are subject to NERC reliability regulation; it remains to be seen whether utilities or regulators will seek to alert or impose related requirements on smaller, non-NERC-regulated solar facilities.

3. NERC should perform more detailed studies with affected entities to determine (a) the extent of the risk posed by momentary cessation or tripping and (b) whether momentary cessation should be allowed in areas with higher penetrations of inverter-connected resources for voltages that are outside of their operating range.

4. NERC should work with FERC, IEEE, Underwriter Laboratories (UL), the National Fire Protection Association, and states to de-conflict inverter design and operation standards. NERC should also investigate whether it should develop an inverter standard for generators connected to transmission systems.

5. Manufacturers and operators should configure those inverters that momentarily cease operating when they sense conditions outside their operating range to restore to normal levels within five seconds. Design changes to inverter configuration would likely have to be approved by industry and insurance standard–setting entities, such as UL, before becoming effective. Manufacturing evolution of this nature is not unknown in the renewable power sector; for example, when wind generation technology was viewed as being subject to voltage irregularity, manufacturers developed new-generation turbines that possess low-voltage ride-through capability.

"Knowing that [the fault causing inverters to erroneously trip or momentarily cease] was not an isolated incident and considering the rapid increase in solar installations . . . these types of inverter disconnect events could be a potential reliability risk that needs to be analyzed and mitigated," NERC concluded.

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