

Industry Recommendation

Loss of Solar Resources during Transmission Disturbances due to Inverter Settings

Initial Distribution: June 20, 2017

NERC identified a potential characteristic exhibited by some inverter-based resources, particularly utility-scale solar photovoltaic (PV) generation, which reduces power output during fault conditions on the transmission system. An example of this behavior has been observed during recent BPS disturbances, highlighting potential risks to BPS reliability. With the recent and expected increases of utility-scale solar resources, the causes of this reduction in power output from utility-scale power inverters needs to be widely communicated and addressed by the industry. The industry should identify reliability preserving actions in the areas of power system planning and operations to reduce the system reliability impact in the event of widespread loss of solar-resources during faults on the power system.

For more information, see the [1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report](#)

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Status: Acknowledgement Required by Midnight Eastern on June 27, 2017
Reporting Required by Midnight Eastern on August 31, 2017



PUBLIC: No Restrictions

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Instructions: This recommendation provides specific actions NERC registered entities should consider taking to respond to a particular issue. Pursuant to Rule 810 of NERC's Rules of Procedure, NERC registered entities shall 1) acknowledge receipt of this advisory within the NERC Alert System, and 2) report to NERC on the status of their activities in relation to this recommendation as provided below. For U.S. entities, NERC will compile the responses and report the results to the Federal Energy Regulatory Commission.

This recommendation is not the same as a Reliability Standard and your organization will not be subject to penalties for a failure to implement. Issuance of this recommendation does not lower or otherwise alter the requirements of any approved Reliability Standard or excuse the prior failure to follow the practices discussed in the recommendation if such failure constitutes a violation of a Reliability Standard.

Distribution: **Initial Distribution:** Balancing Authority, Generator Operator, Generator Owner, Reliability Coordinator, Transmission Operator, Transmission Owner
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Primary Interest Groups: Generation Engineering, Generation Operations, System Operations—Transmission Engineering, System Operators, System Operators—System Protection, Transmission Planning, Reliability Coordinator, Transmission Service Provider, Transmission Planner, Planning Coordinator.

Recommendations:

All recipients are advised to review the [1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report](#) for more technical information and detailed description of the behavior of inverters during abnormal system conditions regarding these recommendations.

Recommendation Number 1: Generator Operators and Generator Owners should ensure that your installed inverter controls will not trip due to an erroneous instantaneous frequency measurement during transients on the power system.

Recommendation Number 2: If inverters are identified as among those that momentarily cease to inject current for voltages above 1.1 per unit or below 0.9 per unit during abnormal voltage conditions, Generator Operators and Generator Owners should ensure the time to restore output of the inverter to the state prior to the abnormal voltage conditions is as soon as practical but no greater than five (5) seconds. Inverters may continue producing real and reactive power outside of the ride through operation conditions defined by PRC-024-2 unless other actions are required as part of a special protection scheme, to protect the inverter from damage, or to isolate the faulted equipment directly connected to the inverter.

Recommendation Number 3: If the equipment identified in recommendations 1 and 2 are left unmitigated, Reliability Coordinators and Balancing Authorities should identify which inverter based plants, in the operating area, are unmitigated and consider in their daily resource plan the potential for the loss of these resources during transmission faults on the power system. Reliability Coordinators and Balancing Authorities should take appropriate mitigating measures.

Recommendation Number 4: Generator Operators and Generator Owners should provide their responses to the questions in this alert for each plant in service to NERC and to their Reliability Coordinator, Balancing Authority, and Transmission Operator for each respective site(s) area where the plant is located.

As required by the NERC Rules of Procedures, NERC registered entities are required to:

- Acknowledge receipt of this advisory within the NERC Alert System.
- Review and complete the Reporting Instructions below.

Reporting Instructions:

Initial acknowledgement of receipt is required by **June 27, 2017 Midnight Eastern** via the NERC Alert System. Responses to the questions below are required to be submitted via the NERC Alert System by **August 31, 2017 Midnight Eastern**. Once a response has been submitted follow-up or update responses will not be required.

All applicable registered entities (GO, GOP, RC, BA, TOP) are required to respond to the following questions A and B: (Transmission Owners are not required to submit a response to the questions below.)

- A. **For GOs and GOPs:** Do you own or operate any solar generation plants that are registered in the Bulk Electric System (BES)? (Yes, No, Not Applicable)
- B. **For RCs, BAs, and TOPs:** Do you consider the potential for widespread solar resource loss during transmission faults on the power system within your Reliability Coordinator or Balancing Authority Areas in daily plans? (Yes, No, Not Applicable)

The following questions should be answered and submitted in the attached worksheet for those entities that answered yes in question A

above. Use the “Add Additional Document” link in the NERC Alert System response web page to submit the completed worksheet. Use a separate row on the worksheet and answer each question for each Manufacturer and Model number of inverter.

1. Enter the manufacturer name of the inverter (e.g., ABC).
2. Enter the model number of the inverter (e.g., DEF-123 or 45678).
3. Enter the name plate MW rating of inverter (e.g., 25 MW).
4. Enter the total number of inverters you have for each Manufacturer and Model number of inverter (e.g., 3).
5. Is each solar inverter currently susceptible to erroneous frequency calculations as described in the [1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report](#) (Consult with your manufacturer)? (Yes, No, Not Applicable)
6. If you answered “Yes” to (question 5), have you reviewed and implemented manufacturer recommendations to this inverter’s control settings to ensure that the inverter will not trip due to an erroneous frequency measurement during transients on the power system? (Yes, No, Not Applicable)
7. Does the solar inverter momentarily cease output during abnormal voltages on the power system? (Yes, No, Not Applicable)
8. If you answered “No” to (question 7):
 - a. Are you regulating to a voltage schedule? (Yes, No, Not Applicable)
 - b. Are you regulating to a VAR schedule? (Yes, No, Not Applicable)
9. If you answered “Yes” to (question 7):
 - a. At what lower voltage level (in per units) does momentary cessation occur (e.g., 0.9)?
 - b. If you answered “Yes” to (question 7), at what upper voltage level (in per units) does momentary cessation occur (e.g., 1.1)?
 - c. If you answered “Yes” to (question 7), what is the maximum delay (in seconds) for this inverter to resume previous output levels (after voltage has returned to normal and including any delay and ramp rate) (e.g., 3.5 seconds)?
 - i. If your answer is greater than five (5) seconds in (9c), can this inverter’s settings be changed to make the

maximum delay no greater than five (5) seconds?
(Yes, No, Not Applicable)

1. If you answered “Yes”, to (9ci), have you made the recommended changes to this inverter's settings to ensure that the maximum delay to return to current injection is no greater than five (5) seconds following system conditions requiring momentary cessation(including any delay and ramp rate)? (Yes, No, Not Applicable)
10. Have you provided your response to the questions in this alert to your Reliability Coordinator, Balancing Authority, and Transmission Operator? (Yes, No, Planned)

Background:

NERC reviewed several events involving faults on the transmission system that resulted in the loss of a significant amount of solar photovoltaic generation. The most significant event resulted in the loss of ~1,200 MW of utility-scale solar photovoltaic generation. The facilities ceased output in response to the transient fault on the system.

Based on information provided by the inverter manufacturers, solar development owners and operators, and the registered entities, the largest percentage of the resource loss was attributed to an incorrectly calculated low frequency condition, to which the inverter responded by “tripping” (ceasing to inject current into the grid for a period of approximately five (5) minutes). The inverters used a method that resulted in erroneous instantaneous frequency calculation.

The second largest significant contributor was determined to be inverter “Momentary Cessation” due to system voltage reaching the low-voltage ride through setting of the inverters. In momentary cessation, the inverter control ceases to inject current into the grid while the voltage is outside the continuous operating voltage range of the inverter. When the system voltage returns within the continuous operating range, the inverter will resume current injection after a short delay. The present recommendations are to return to injection in less than five (5) seconds.

Actions may be needed by Reliability Coordinators and Balancing Authorities to preserve and protect bulk power system reliability such as adjustments in operating reserves. NERC encourages entities to develop and implement a systematic approach to mitigate the undesired actions of the inverters.

Recommendations to mitigate these conditions are the subject of this alert. For more information, see the [1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report](#).

Although this alert pertains directly to BES-connected inverter resources, the same potential susceptibility to frequency and voltage perturbations during transmission faults exist for all utility grade, and perhaps some larger commercial grade solar installations, regardless of the interconnection voltage. Owners and operators of those facilities are encouraged to consult their inverter manufacturers and review the settings utilized in their inverters to determine if the inverters are susceptible.

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