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Data Insight

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Reliability Implications of Unexpected Tripping of Inverter-Based Resources

A recent KAPSARC Instant Insight examined the reliability crisis in electric power grids, and proposed policy measures that can mitigate these risks (Felder 2022). The specific causes for these severe outages and blackouts differ, but the causes of greatest concern are those that result in multiple failures of grid facilities. In 2022, the North American Electric Reliability Corporation (NERC)[1] examined the increasing risks to the grids in the United States (U.S.), in particular hazards to the North American bulk power system (BPS). NERC highlighted a special concern related to the increased deployment of inverter-based resources: the unexpected tripping of solar PV resources that could incapacitate large amounts of generation, resulting in reliability challenges. This issue is particularly important to Saudi Arabia as it pursues the deployment of widespread, large-scale solar power plants.

This data insight reviews recent major photovoltaic (PV) inverter tripping events that have occurred in the U.S. and the proposed technical solutions to ensure the reliability of its grid. The NERC reported four major PV-tripping events between 2016 and 2021 (Table 1). The first three events occurred in California due to faults on the transmission lines (220 kilovolts [kV] and 500 kV). The BPS cleared these faults, but the momentary change in frequency and voltage outside the normal operating curve led to the inverters that convert PV's direct current to alternating current before feeding it into the grid tripping (NERC 2017, 2018, 2019). This action was mostly due to the inverter's protective response to faults on the system. One issue that persisted was momentary cessation, which is when the inverter control ceases to inject current into the grid while the voltage is outside the inverter's continuous operating voltage range. Since the first disturbance report in June 2017, the NERC recommended that inverter-based resources should not use momentary cessation in order to minimize potential resource loss events (NERC 2017).

[1] The NERC is the electric reliability organization for North America. It develops and enforces reliability standards, annually assesses seasonal and long-term reliability, and monitors the bulk power system through system awareness.

Table 1. Events related to the reduction of solar PV power output.

The event:	Loss of solar PV power output (MW)	Fault location
1. Southern California U.S. 2016 Event	~1200	500 kV line
2. California U.S. 2017 Event	~900	220 kV line 500 kV line
3. California U.S. 2018 Event	~860	500 kV line
4. Texas U.S. 2021 Event	~1112	345 kV connection Station 138 kV connection station 69 kV bus

Sources: NERC 2017, 2018, 2019, 2021.

To address the tripping of inverter-based resources, in July 2020 the NERC updated its reliability standard, "Frequency and Voltage Protection Settings for Generating Resources," to address the issue of momentary cessation. Despite the updated reliability standard, another major loss of PV generation subsequently occurred in Texas on May 9, 2021 (NERC 2021). This time, a fault at a combined-cycle power plant caused by a failed surge arrestor led to voltage variations beyond the permissible limits at the 345 kV and 138 kV sub-stations. Although voltages in the area recovered quickly, a number of PV and wind resources had a sudden drop in output. Figure 1 shows the magnitude of the solar PV output reduction caused by this disturbance – approximately 1 gigawatt (GW).

The NERC noted that its guidelines are not being widely and comprehensively adopted. In its Summer 2022 report, it recommended that a comprehensive generator ride-through standard be implemented. It also recommends that detailed electromagnetic transient (EMT) studies[2] should be required as part of the interconnection study process to ensure that all resources can reliably operate once connected to the bulk power system.

The Institute of Electrical and Electronics Engineers (IEEE)[3] has also reviewed the standards for the performance requirements of inverter-based resources. In April 2022, the IEEE established the standard (2800-2022) to provide uniform technical minimum requirements for the reliable integration of inverter-based resources into the bulk power system, including voltage and frequency ride-through, power control, and system protection.

Continued tracking of PV-inverter failures and monitoring the development of technical standards by leading technical organizations are important first steps in understanding a power system's vulnerability to the unexpected tripping of inverter-based resources, and implementing technically and economically sound preventative and corrective measures.

A key takeaway from these events is the need for constant coordination between manufacturers, generators, grid operators, and regulators to comprehensively identify gaps in the implementation of the standards and address potential risks early before their impacts are propagated.

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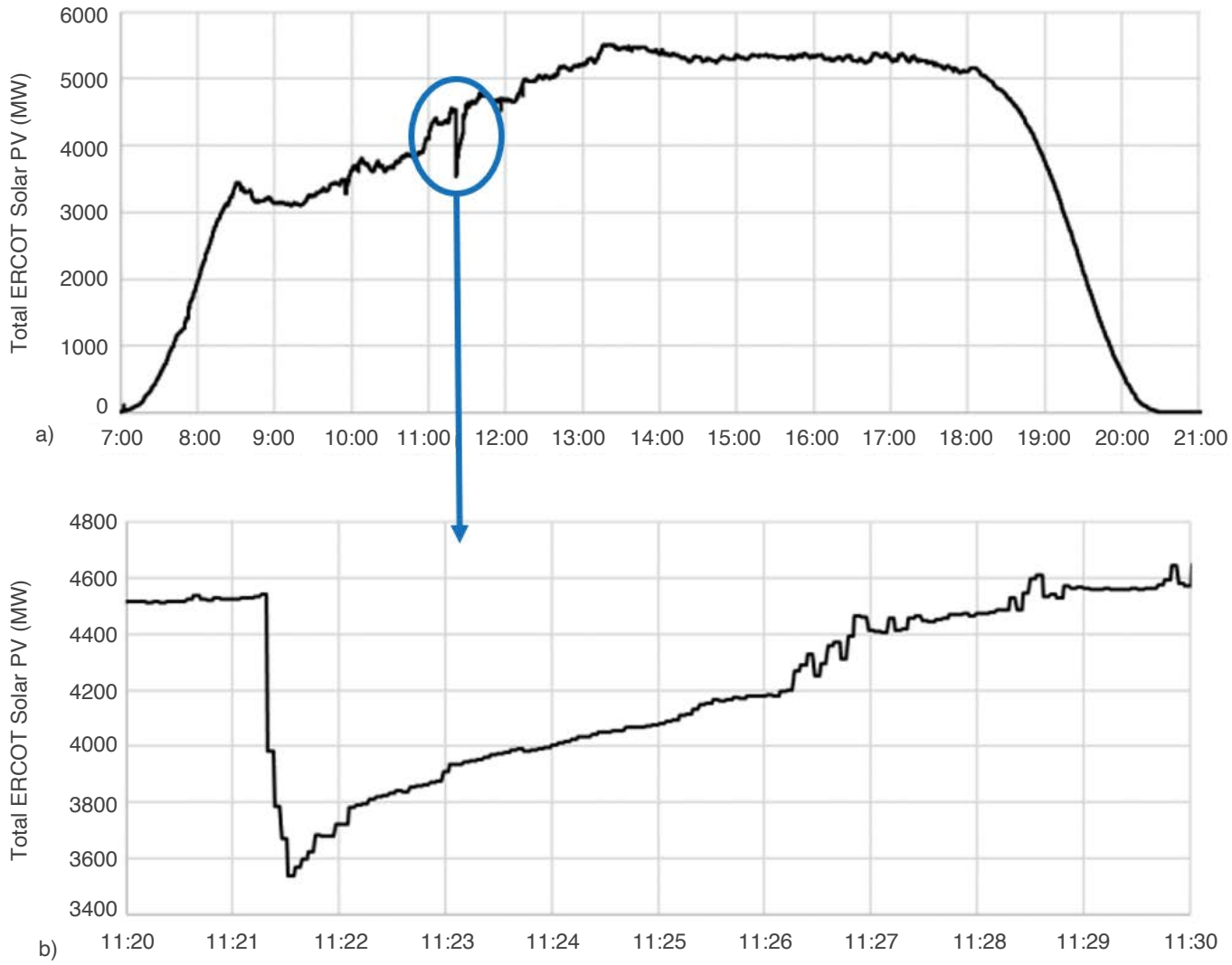
[2] EMT models provide an accurate representation of a resource when creating detailed analyses of EMT power systems.
[3] The IEEE is a leading consensus building organization that facilitates standards development and collaboration.

Figure 1. Texas event. (a) solar PV profile for May 9, 2021 showing the unexpected reduction of PV power output and (b) zooming Into the reduction in solar PV resources during the disturbance.



Source: NERC (2021).

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