

DER Impacts to Under Voltage Load Shedding Program Design

NERC System Planning Impacts from DERs Working Group (SPIDERWG)

White Paper

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Purpose

SPIDERWG initially set out to provide guidance regarding the aggregate impacts of a distributed energy resource (DER) on under voltage load shedding (UVLS) programs. After a cursory review of industry UVLS practices, SPIDERWG recognized that there are very few (if any) currently active UVLS programs in place today. Therefore, SPIDERWG provides these general points for coordination of voltage-sensitive equipment.

Definition of UVLS

It is helpful to note that the UVLS program is defined in the NERC Glossary of Terms¹ and is different than other centrally controlled schemes to mitigate under voltage conditions. See the definition below:

“An automatic load shedding program, consisting of distributed relays and controls, used to mitigate undervoltage conditions impacting the Bulk Electric System (BES), leading to voltage instability, voltage collapse, or Cascading. Centrally controlled undervoltage-based load shedding is not included.”

Key Findings to DER Impact to UVLS Action

NERC Reliability Standard PRC-010² establishes an integrated and coordinated approach to the design, evaluation, and reliable operation of UVLS programs. It addresses the development of UVLS programs, their databases, and the study frequency for which the program needs to demonstrate its effectiveness to mitigate under voltage risks. Historically, many of these programs were designed to mitigate sustained low voltage conditions that could cause motor load to stall and subsequently continue to depressed voltage further.

Key Recommendation

UVLS Programs are not as prevalent as they were in the past. Furthermore, growing DER levels are not expected to significantly affect UVLS program design. However, Transmission Planners and Planning Coordinators should ensure that DERs are modeled appropriately in any UVLS studies and that possible DER tripping is reflected in those studies.

¹ NERC Glossary of Terms available here: https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf

² The standard is available here: <https://www.nerc.com/pa/Stand/Reliability%20Standards/PRC-010-1.pdf>

Many UVLS programs included lengthy time delays (i.e., many seconds) before tripping load, during which most DERs³ would trip prior to the action of the UVLS relay. While the voltage threshold of the UVLS program or relay may be set higher than the tripping threshold of DER (e.g., 0.9 p.u. at the UVLS relay versus 0.44 p.u. at DER terminals), and the intentional delay of the UVLS program is longer than some of the more rigorous ride-through requirements of current DERs. The subsequent system impact of such tripping can further reduce the voltage, signaling the need for coordination of various equipment settings. With the modernization of motor loads and the move toward energy efficient motor design and electronically-coupled motor loads, many of the concerns with low voltage noted by voltage dip and voltage recovery criteria found in TPL-001 are mitigated.⁴

Furthermore, as DERs are sources of electric power on the distribution system that inject power into the distribution system (offloading the net load consumed), DERs may help alleviate voltage reduction and stalling concerns when on-line. The primary focus with respect to DERs is their ability to withstand (i.e., ride through) depressed voltages to support bulk power system reliability. It becomes more critical to coordinate among the various voltage-sensitive equipment (i.e., between voltage relays and DERs) on the distribution system to ensure that the system remains stable with tripping or action of installed equipment and protection systems.

Recommendations Regarding Voltage Coordination

SPIDERWG recommends the following for a Transmission Planner and a Planning Coordinator when designing UVLS programs or when analyzing the performance of the bulk power system under depressed voltage conditions:

- Equipment response to depressed voltages (e.g., tripping of DERs on low voltage) should be accurately modeled and accounted for in study results. DER tripping can cause system voltages to reduce and potentially exacerbate a low voltage condition.
- If a new UVLS program is registered in a Planning Coordinator's footprint, the UVLS entities should ensure that the settings of voltage-sensitive equipment are shared with Transmission Planners and Planning Coordinators inclusive of voltage trip settings for DERs.
- Transmission Planners and Planning Coordinators should continue to perform a holistic coordination of protection equipment designed to trip load-serving transmission elements so that voltage excursions do not cause cascading, uncontrolled separation, or instability.⁵
 - This review should include normal and emergency operation procedures and high/low voltage trip points of protective relaying. Example procedures include programs related to emergency load management reductions through voltage reduction.⁶

³ This is predominantly distributed solar PV resources to-date.

⁴ The standard is available here: <https://www.nerc.com/pa/Stand/Reliability%20Standards/TPL-001-5.pdf>

⁵ The "N-0" state in TPL-001 does not allow for load loss. The combination of the planning criteria in TPL-001 and the coordination of voltage-sensitive equipment should not result in any load tripping due to normal system conditions.

⁶ Note that DERs providing voltage support under these type of emergency procedures may in fact nullify the procedure's intended effect. The coordination effort should also be used to identify the success of these procedures.