NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Quick Reference Guide: Distributed Energy Resource Activities

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INSIDE THIS QUICK REFERENCE GUIDE

The electric power grid in North America is undergoing a significant transformation in technology, design, control, planning, and operation, and these changes are occurring more rapidly than ever before. Particularly, technological advances in inverter-based resources, inclusive of distributed energy resources (DERs), are having a major impact on generation, transmission, and distribution systems. IEEE Std. 1547-2018 defines a DER as "a source of electric power that is not directly connected to a bulk power system (BPS). DER includes both generators and energy storage technologies capable of exporting active power to an electric power system."[1] The NERC System Planning Impacts of DER Working Group (SPDIERWG) uses a similar definition of DER: "Any Source of Electric Power located on the Distribution System."[2] The SPIDERWG set of definitions is the preferred set of definitions when discussing reliability-based initiatives. Those resources specifically located on the distribution system are modeled as retail-scale DERs (e.g., rooftop solar photovoltaic (PV)) as well as utility-scale DERs (e.g., small combined heat and power and small solar PV power plants), abbreviated as R-DERs and U-DERs, respectively.

This document acts as a quick reference guide for the work that the ERO Enterprise has done regarding DERs over the past seven years to ensure the continued reliability of the North American power grid.

[1] IEEE Std. 1547-2018 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces: https://standards.ieee.org/standard/1547-2018.html.
[2] Document available here: https://www.nerc.com/comm/RSTC/SPIDERWG/SPIDERWG%20Terms%20and%20Definitions%20Working%20Document.pdf

Technical Reference Documents		
Published	**Title**	**Summary**
June 2021	Data Collection Approaches for Probabilistic Assessments Technical Reference Document	This document determined the general data input categories that are commonly used in loss-of-load probabilistic assessments across industry in order to build a technical reference for resource planners when performing their duties. These data categories include data considerations with a focus on parameters and collection methods for demand, thermal resources, energy-limited resources, emergency operating procedures (EOP), and transmission representations. Entities must consider procuring or obtaining enough data to accurately represent the model parameters or inputs to effectively develop and run a probabilistic reliability study. An entity wishing to conduct a probabilistic study should thoroughly review these data inputs, the technical nature and aspects of the model inputs in study, and the soundness of the results with all stakeholders as a standard operating practice. This document separates each of the major categories, (e.g., demand, generation, and transmission) in a resource adequacy study and highlights the types of data, possible sources for the data, and other qualifiers associated with the inclusion of such information in a probabilistic study. It specifically calls out not double counting of generation when including DER in the data gathering as some entities may report a reduction of gross load in the Demand section.
June 2020	SPIDERWG Terms and Definitions	This document provides a preferred set of working definitions and acts as a useful reference for terms describing or related to DERs. The document is intended to provide working definitions that should lead to consistent use of terms in NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG) deliverables and discussions. SPIDERWG recognizes that various sources use identical terms related to DERs with different context-specific meanings. This document contains the consensus driven terminology for reliability discussions and is the preferred set of definitions for NERC non-Reliability Standards documents.
March 2018	Brief on DER impact to NERC Functional Model	The Distributed Energy Resources Task Force (DERTF) of the Essential Reliability Services Working Group (ERSWG) previously produced a report, *Distributed Energy*

		Resources: Connection Modeling and Reliability Considerations, in December 2016. The report emphasized the need to understand the data that should be collected and shared at the interface of the distribution and transmission systems to ensure reliable operation of the grid. Since issuing that report, the task force continued to evaluate the entities and roles that are involved and the information that may need to be collected and shared. This document presents the results of this evaluation and makes recommendations for ongoing activities.

White Papers and Reports		
Published	**Title**	**Summary**
December 2021	Survey of DER Modeling Practices	The NERC SPIDERWG performed an informal survey of its membership regarding DER modeling practices. SPIDERWG consists of a wide range of industry experts and a cross-section of industry representation, and 45 entities participated in the survey. The survey was primarily geared towards understanding DER modeling practices of Transmission Planners (TPs) and Planning Coordinators (PCs), which are well-represented on SPIDERWG. Results from the survey were analyzed to identify any major trends in DER modeling practices, to characterize the level of detail that TPs and PCs are using for DER modeling, and to identify any potential gaps in these practices that should lead future efforts for SPIDERWG and industry.
October 2020	SPIDERWG Assessment of DER impacts on TPL-001	Many areas of the North American BPS are experiencing a transition towards increasing penetrations of DERs. NERC Reliability Standard TPL-001-41 was developed under a paradigm of predominantly BPS-connected generation, when penetrations of DERs were anticipated to be significantly lower than current and future projections, and without much impact on the BPS. Considering the current DER trend, the NERC SPIDERWG undertook the task of evaluating the sufficiency and clarity of the TPL-001 standard for considering DER as part of annual Planning Assessment. This white paper discusses the impacts of DER on the standard requirements in three distinct ways: 1. Is the requirement relevant for consideration of DER? 2. Does the existing requirement language preclude consideration of DER in any way? 3. Is the requirement language clear regarding consideration of DER?
February 2017	Distributed Energy Resource Connection Modeling and reliability Considerations	The North American electric power system is transforming to a resource mix that relies less on coal and nuclear while integrating more natural gas, wind, solar, distributed generation, and demand response resources. The NERC ERSWG is studying this transformation in the broader context of monitoring grid reliability and resiliency. This

		report discusses the potential reliability risks and mitigation approaches for increased levels of DER on the BPS.
August 2022	Recommendations for Simulation Improvement and Techniques Related to DER Planning	The NERC System Planning Impacts of Distributed Energy Resources Working Group (SPIDERWG) has developed a number of guidelines and studies relating to DER integration. Tracking DERs will add a significant level of complexity to the planning process, stressing data fidelity, modeling accuracy, and computational limitations. This document provides a distilled version of the NERC SPIDERWG recommendations that may be pertinent to power system software developers and outlines some of the related literature that may aid in developing further software improvements and techniques.
October 2022	DER Impacts to Under Voltage Load Shedding Program Design	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.
November 2022	DER Modeling Study: Investigating Modeling Thresholds	NERC is studying the differences found in the results of analysis that include DERs and comparisons with the same base case without including the impact of DERs defined below a percentage threshold as well as a numeric threshold. NERC is studying the concept of a bright line threshold for modeling DERs as a way to respond to stakeholder comments and in support of NERC's overall DER strategy.[3] Furthermore, the ERO RISC report has identified DERs to be a potential risk in its Grid Transformation category, and DER modeling is required in order to study DER's impacts on the bulk system. The study found that: • Each PC and TP should use available data gathering techniques to gather the total DER capacity[4] for their footprint.

[3] DER Strategy document available: https://www.nerc.com/comm/RSTC/Documents/NERC_DER%20Strategy_2022.pdf
[4] From review of these findings, ERO Enterprise engineers have identified the above information as typically provided during an interconnection process, and typically would not be available after signing of an interconnection agreement or energization of the facility.

		• Each PC and TP should determine modeling thresholds as appropriate for their local system. • Current and future standards projects relating to the gathering of Interconnection-wide modeling data (e.g., MOD-032) should incorporate the findings of this study when adding language to such standards for DERs[5].
December 2022	Battery Energy Storage and Multiple Types of Distributed Energy Resource Modeling	The NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG) investigated the potential modeling challenges associated with new technology types being rapidly integrated into the distribution system. SPIDERWG weighed updating or altering the recommended modeling framework and found that previous modeling guidance held in the face of two or more dominant technology types of distributed energy resources (DER) at a T–D Interface. Furthermore, SPIDERWG determined that control behavior rather than fuel sources is more appropriate for transient dynamic parameterization. This does not prevent the separation of DERs into two or more sets of dynamic transient models based on fuel source as necessary for a particular study application. 1 SPIDERWG also provided a set of sanity checks for Transmission Planners (TP) or Planning Coordinators (PC) to use two or more aggregate dynamic models to capture the totality of DERs behind a T–D interface. SPIDERWG developed recommendations when modeling more than one dominant control type behind a T–D interface

[5] Note that a zero MVA threshold is recommended for such standards activities that relate to the supply of DER data to TPs and PCs.

Reliability Guidelines		
Published/Latest Revision	**Title**	**Summary**
December 2021	Recommended Approaches for UFLS Program Design with Increasing Penetrations of DERs	One of SPIDERWG's key activities is to "provide guidance on impacts that higher penetration of DER may have on system restoration, undervoltage load shedding, underfrequency load shedding (UFLS), and potential solutions or recommended practices to overcome any identified issues." This document finds that UFLS program design can be impacted by DER in the studies conducted by the PC as well as the arming of UFLS relays in the implementation of the program. While the arming of UFLS feeders plays an important role in the implementation of the program, the major decision points on quantity of load armed for UFLS, intentional time delays, and study case setup demonstrate the need for best practices in the study process in order to mitigate any potential risk DER may have on UFLS schemes.
March 2021	Model Verification of Aggregate DER Models used in Planning Studies	This guideline provides TPs and PCs with tools and techniques that can be adapted for their specific systems to verify that the created aggregate DER models are a suitable representation of these resources in planning assessments.
September 2020	DER Data Collection for Modeling in Transmission Planning Studies	The goal of this reliability guideline is to provide clear recommendations and guidance for establishing effective modeling data requirements on collecting aggregate DER data for the purposes of performing reliability studies.
March 2023	BPS Reliability Perspectives on the Adoption of IEEE 1547-2018	IEEE Standard 1547-2018 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces (IEEE 1547-2018) was published in April 2018 and significantly enhanced the performance and functional capability of DERs connecting specifically to primary and secondary distribution

		systems. This reliability guideline discusses the adoption of IEEE 1547-2018 and considerations that should be made during its adoption that reflect BPS reliability perspectives.
February 2023	Parameterization of the DER A Model for Aggregate DER	This guideline provides and combines background material on the recommended DER modeling framework, including the concepts of retail-scale DERs (R-DERs) and utility-scale DERs (U-DERs), information on relevant interconnection standards (IEEE Std. 1547-2003, IEEE Std. 1547a-2014, IEEE Std. 1547-2018, and CA Rule 21), and how the DER_A model parameters can be modified to account for a mixture of vintages of inverter-interfaced DER.

Webinars and Workshops	
Date	**Title**
December 2022	Distributed Energy Resource (DER) Virtual Workshop: Presentation | Webinar Recording
October 2021	DER Modeling Capabilities Improvements to Simulation Tools Informational Webinar: Presentation | Webinar Recording
January 2021	FERC Order 2222 Informational Webinar: Presentation
July 2020	DER Integration – Emerging System Security Challenges in South Australia: Presentation | Webinar Recording
November 2019	Parameterization of the DER_A model webinar: Presentation | Webinar Recording
August 2016	DER Task Force Workshop: Presentations

Key Presentations to NERC SPIDERWG	
Date	**Title**
February 2023	Combined Presentation: Distribution System Characteristics, Distribution Practices, and Relevance to DER and Composite Load Modeling; DER Gateways
August 2022	Voltage Fluctuations due to Solar DER and combined Presentations
May 2020	BPS Impacts from Behind the Meter DER: IEEE 1547-2018 Category II and III
May 2020	Kaua`i's Experience with DERs on an Islanded System
January 2020	Impact Analysis of High PV Penetration on Protection of Distribution Systems Using Real-Time Simulation and Testing – A Utility Case Study
January 2020	Hawai'i Island Planning and Operations Measures to Improve Reliability with High DER
October 2019	DER Trip Impact Study: Methods, Results, and Conclusions
January 2019	Hawai'i DER Experience Updates from Hawaii on DER Integration Issues
January 2019	Planning the Integration of DER in the Colombian Power Grid
January 2018	Distributed Energy Resources Video Explainer

Standards-Related Activities

Standards are one piece of the complex, dynamic endeavor of providing a comprehensive approach to reliability. NERC has various other tools to fulfill this mission, including guidelines, training, assessments, and alerts. This multi-pronged approach has resulted in a secure and reliable BPS for North America. New Reliability Standards begin with a Standards Authorization Request (SAR), which may be submitted by anyone but must have technical justification. SARs occasionally arise from other projects like informal development projects, periodic reviews, other standard projects, or if a reliability threat that may be mitigated by a standard arises.

Standards-Related Activities	
Project and Purpose	**Status**
Project 2022-02 – Modifications to TPL-001-5.1 and MOD-032-1: This SAR revises requirements within the TPL-001-5 standard to provide clarity and consistency for how BPS-connected inverter-based resources are considered, modeled, and studied in planning assessments. The proposed revisions to TPL-001-5 will ensure industry is effectively and efficiently conducting planning assessments and that the requirements are equally suitable for inverter-based resources as they are for synchronous generation. This SAR proposes to revise MOD-032-1 to address gaps in data collection for the purposes of modeling aggregate levels of DERs in planning assessments. The goal is to provide clarity and consistency for data collection across PCs and TPs when coordinating with the DP to gather aggregate load and aggregate DER data.	Ongoing
White Paper: NERC Reliability Standards Review: The increasing penetration of DERs is already having an impact on BPS planning, operations, and design, and it is paramount that NERC Reliability Standards remain effective and efficient in ensuring an adequate level of reliability for the BPS. As a result, the SPIDERWG has evaluated the current body of NERC Reliability Standards and the requirements within those standards for their applicability and effectiveness to remain relevant with increasing levels of DERs. This white paper details the findings of the SPIDERWG review and makes recommendations for actions that should be taken to address identified issues. The SPIDERWG is seeking RSTC members to review and provide comment on the white paper.	Completed
Project 2020-01 – Modifications to MOD-032-1: With the penetration of DERs continually increasing across the continent, it is imperative that the risk DER pose to the reliability of the BPS be minimized by improving the modeling of aggregate DER in planning studies. The SPIDERWG reviewed MOD-032-1 Data for Power System Modeling and Analysis and developed a SAR requesting modifications be made to the standard to address the collecting and reporting of aggregate data for DER. The Standards Committee rejected the SAR during its December 9, 2020 meeting.	Discontinued

Other DER Activities		
Published	**Category**	**Title and Purpose**
June 2021	Active Standard	IEEE 2030 – IEEE Guide for Distributed Energy Resources Management Systems (DERMS) Functional Specification: The technical specifications for, and testing of, the interconnection and interoperability between utility electric power systems (EPSs) and DERs are the focus of this standard. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. It also includes general requirements, response to abnormal conditions, power quality, islanding, and test specifications and requirements for design, production, installation evaluation, commissioning, and periodic tests. The stated requirements are universally needed for interconnection of DER, including synchronous machines, induction machines, or power inverters/converters and will be sufficient for most installations. The criteria and requirements are applicable to all DER technologies interconnected to EPSs at typical primary and/or secondary distribution voltages. Installation of DER on radial primary and secondary distribution systems is the main emphasis of this document, although installation of DERs on primary and secondary network distribution systems is considered. This standard is written considering that the DER is a 60 Hz source.
September 2020	Final Rule	FERC Order 2222: FERC is amending its regulations to remove barriers to the participation of distributed energy resource aggregations in the capacity, energy, and ancillary service markets operated by Regional Transmission Organizations and Independent System Operators (RTO/ISO). See Key Presentations to NERC SPIDERWG section for a presentation made to SPIDERWG on this topic.
April 2018	Active Standard	IEEE 1547 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces: A key concept and requirement for an operational and effective deployment of a large number of DERs, which include sources of power and demand response, to enable the provision of flexibility and grid services, is the aggregation of DER. This aggregation function, as well as the functions required to enable grid services, are provided by DER management systems (DERMS). A functional specification for a DERMS and a description of the grid services that aggregated DER can provide the distribution and transmission systems is provided by this guide. Implementation issues and the interoperability requirements of a DERMS with its environment, including the transmission and distribution systems, and the communication and information infrastructure of modern grids are addressed by this guide.

June 2022	Final	**BPS Reliability Perspectives for Distributed Energy Resource Aggregators White Paper:** This white paper provides BPS reliability perspectives and considerations regarding DER aggregation in light of FERC Order No. 2222, which introduces the concept of DER aggregation in wholesale electricity markets. While NERC and its technical stakeholder groups are not directly involved in market-related activities, the NERC SPIDERWG recognizes that the introduction of the DER aggregator to the overall electricity ecosystem will have an impact on BPS planning, operations, design, and overall grid reliability. The introduction of the DER aggregator specifically raises questions on how to plan for, model, and simulate the behavior of the DERs contained in the aggregation operated by the DER aggregator. This paper provides high level concepts for ISO/RTOs to explore when implementing FERC Order No. 2222 and recommends some relevant SPIDERWG authored documents to consider (e.g., the modeling reliability guidelines that have been published over the past three years).
November 2022	Final	**ERO Enterprise CMEP Practice Guide - Modeling and Studies Involving Distributed Energy Resources**: The purpose of this Practice Guide is to provide areas of focus that CMEP Staff may consider in acquiring an understanding of how the registered entity has accounted for mitigating the aggregate impacts of distributed energy resources (DERs) in relation to certain Reliability Standards. In all cases, the determinations of compliance with Reliability Standards are to be made in light of the facts and circumstances of the individual registered entities and the language of the requirements