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Distributed Energy Resource Strategy

Ensuring Reliability of the Bulk Power System with Growing Levels of Distributed Energy Resources

November 2022

Purpose and Background

Distributed energy resource[1] (DER) levels are rapidly growing across many areas of North America (see **Figure 1**) and are altering how the bulk power system (BPS) is planned, designed, and operated. This influx of DERs presents potential benefits as well as challenges for grid reliability, resilience, and flexibility as DERs are potentially impactful users of the BPS and Bulk Electric System (BES). NERC has proactively been working with industry stakeholders to identify BPS reliability risks associated with the increasing DER levels and has developed this document to identify the current and future strategic actions[2] necessary to ensure reliable operation of the BPS. While each individual DER is distribution-connected, NERC continues to study and assess the reliability impacts from these users of the BPS and BES (see **Figure 2**).

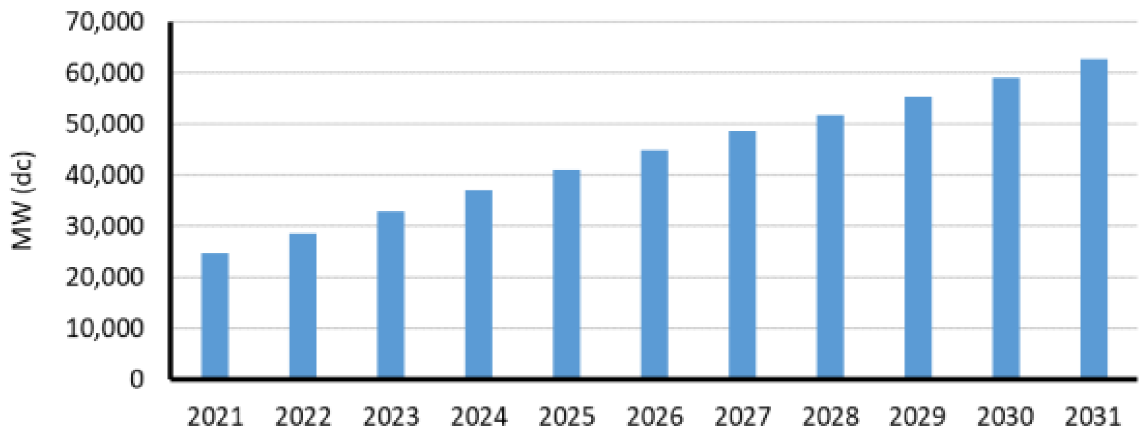


Figure 1: Cumulative Distributed Solar Photovoltaic Capacity[3]

[1] A DER is defined as "any Source of Electric Power located on the Distribution System," taken from https://www.nerc.com/comm/RSTC/SPIDERWG/SPIDERWG%20Terms%20and%20Definitions%20Working%20Document.pdf. This indicates that the strategy is focused on generation and not on load.
[2] https://www.nerc.com/pa/Documents/DER_Quick%20Reference%20Guide.pdf
[3] Information available here: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2021.pdf. This capacity equates to a penetration increase of DER in the whole NERC footprint from 2.8% to 6.4% with many areas more than doubling already installed capacity.

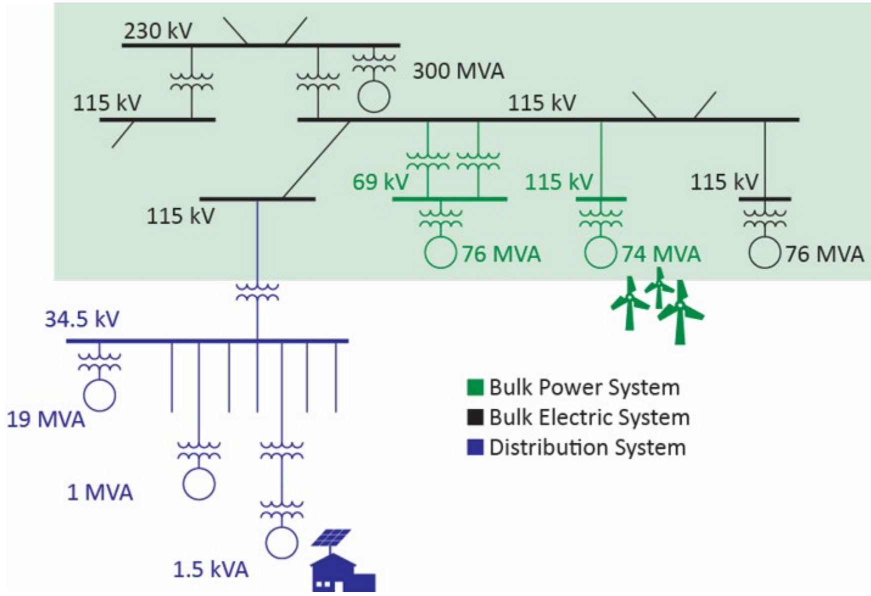


Figure 2: BES, BPS, and Distribution Graphical Examples[4]

Risk Framework

The NERC risk framework[5] guides the Electric Reliability Organization[6] (ERO) in the prioritization of risks and provides guidance on the application of ERO policies, procedures, and programs to inform resource allocation and project prioritization for mitigating those risks (see **Figure 3**). Additionally, the framework accommodates measuring residual risk(s) after mitigation is in place; this feedback enables the ERO to evaluate the success of its mitigation efforts and provides valuable input for improving future risk prioritizations, mitigation efforts, and programs. The successful reduction of risk(s) is a collaborative process between the ERO, industry, and the technical committees, including the Reliability and Security Technical Committee (RSTC) and Reliability Issues Steering Committee (RISC). The framework provides for a transparent process throughout with industry experts in parallel with ERO experts to identify the risk(s), deploy mitigation strategies, and monitor the success of the mitigations. Six specific steps have been identified that are consistent with risk management frameworks used by other organizations and industries:

1. Risk Identification
2. Risk Prioritization
3. Mitigation Identification and Evaluation
4. Deployment
5. Measurement of Success
6. Monitoring

[4] This figure is shown as a stylistic rendering for guidance purposes only and in no way should be used to decide if particular facilities are BES, BPS, or distribution facilities.
[5] The risk framework is defined and outlined in greater detail here: https://www.nerc.com/comm/RISC/Related%20Files%20DL/Framework-Address%20Known-Emerging%20Reliabilit-Securit%20%20Risks_ERRATTA_V1.pdf
[6] NERC is the ERO.

Each of these steps will require process development that includes stakeholder engagement, validation/triage approaches, residual risk monitoring, ERO's level of purview over a risk, etc. The graphical representation of the risk framework is depicted in **Figure 3**.

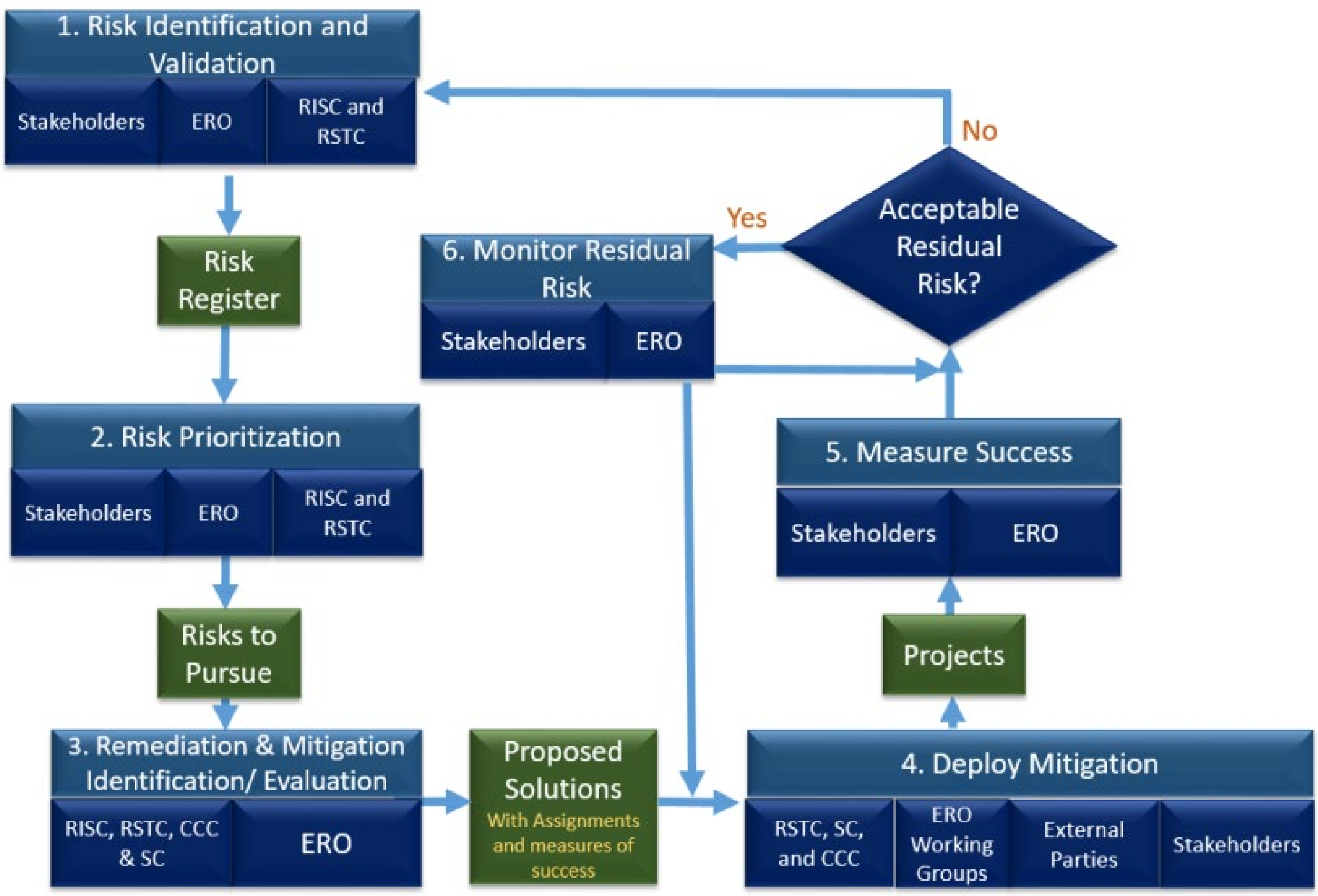


Figure 3: NERC Risk Framework[7]

Core Tenets of the DER Mitigation Strategy

The ERO Enterprise is dedicated to proactively identifying and addressing BPS reliability impacts with increasing DER levels and continues to work collaboratively with industry stakeholders to drive risk mitigation activities. **Figure 4** provides the core tenets of the current DER risk mitigation strategy: DER modeling capabilities, studies incorporating DERs, operational impacts of DERs, and regulatory considerations related to DERs.

[7] *2021 ERO Reliability Risk Priorities Report*: https://www.nerc.com/comm/RISC/Documents/RISC%20ERO%20Priorities%20Report_Final_RISC_Approved_July_8_2021_Board_Submitted_Copy.pdf

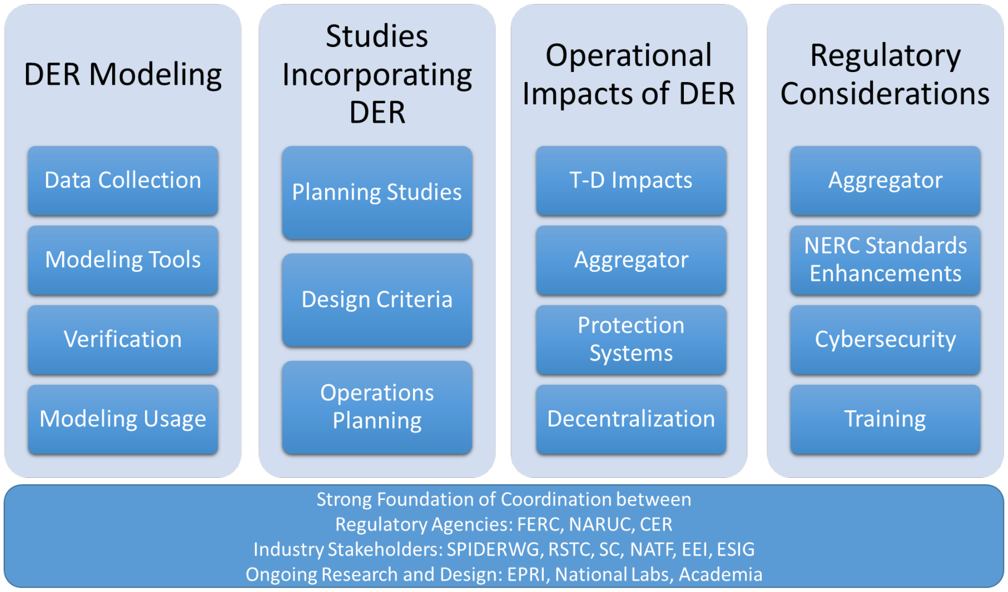
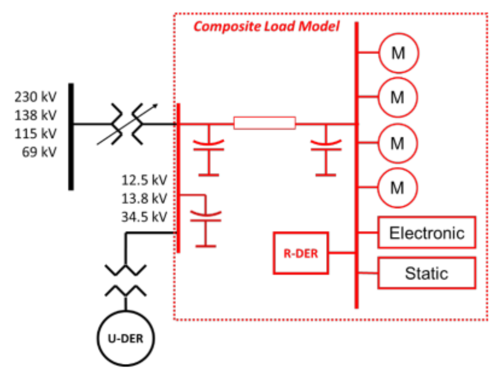


Figure 4: NERC DER Risk Mitigation Strategy

The following sections briefly describe each tenet of the risk mitigation strategy.

DER Modeling

The NERC System Planning Impacts from DER Working Group (SPIDERWG) surveyed industry experts and identified that a lack of DER modeling information, tools, and established planning practices is limiting the Transmission Planner's (TP) and Planning Coordinator's (PC) abilities to accurately incorporate DER models into planning assessments. To address this challenge, NERC and SPIDERWG developed clear reliability guidelines to support TPs and PCs develop DER models for use in reliability studies. The core guidance from the reliability guidelines and other white papers includes the following documents:



- **DER Data Collection*:*** Reliability guideline on *DER Data Collection for Modeling in Transmission Planning Studies*[8]
- **DER Modeling Capability and Parameterization:** Reliability guideline on *Parameterization of the DER_A Model*[9]
- **DER Model Verification:** Reliability guideline on *Model Verification of Aggregate DER Models used in Planning Studies*[10]
- **Multiple DER Types:** White paper on *Battery Energy Storage and Multiple Types of DER Modeling*[11]

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[8] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_Data_Collection_for_Modeling.pdf
[9] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_A_Parameterization.pdf
[10] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline%20_DER_Model_Verification_of_Aggregate_DER_Models_used_in_Planning_Studies.pdf
[11] White paper is in stakeholder process.

NERC will continue supporting industry to enhance DER modeling capabilities and practices while working with industry experts, TPs, PCs, distribution providers, and other relevant entities. The primary goal is for industry to have effective DER modeling practices and planning assessments that include aggregate representations of DERs. It is crucial to have the aggregate DER level represented in the transmission planning base cases, and NERC is assessing the validity and accuracy impacts of DER modeling thresholds. The NERC SPIDERWG is reviewing and updating the reliability guidelines as part of the triennial review process. NERC will also be assessing the quality of interconnection-wide study base cases regarding the use and parameterization of DER models.[12]

This aspect of the strategy focuses mainly on industry guidance and collaboration but also requires the enhancement of NERC Reliability Standards (e.g., MOD-032) to effectively ensure aggregate DER data is available to TPs and PCs for modeling purposes.

Studies Incorporating DER

NERC Reliability Standard TPL-001 establishes "transmission system planning performance requirements within the planning horizon to develop a BES that will operate reliably over a broad spectrum of system conditions and following a wide range of probable contingencies." The base cases used to conduct these planning assessments include not only BES assets but a wider representation of the entire power system (including non-BES transmission and generation as well as representation of aggregate end-use loads). This is an critical aspect of accurate studies of BPS reliability during normal and contingent operating conditions in steady-state, dynamic, and short-circuit studies.[13] NERC and SPIDERWG are developing a reliability guideline to ensure TP and PC reliability studies account for growing DER levels in each of these studies.

Study impacts range from effects that include the pre-disturbance base case setup, the selection of credible contingencies, and the analysis of how the aggregate DERs will respond to large BPS disturbances (e.g., transmission faults).[14] NERC Project 2022-02[15] is revising MOD-032 and TPL-001 to ensure the standards requirements are adequate and clear on how to model, study, and assess how DER characteristics impact the results of planning assessments. While further enhancements to other NERC standards are likely needed, this project is a necessary step in clarifying how to account for and address impacts of DERs in models and planning studies. NERC is also focused on ensuring operations planning assessments and real-time assessments account for DERs ensuring accurate situational awareness and reliability in the operations time horizon. The NERC SPIDERWG is developing standard authorization requests in this area as part of NERC's strategy.

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[12] Modeling Assessment page is available here: https://www.nerc.com/pa/RAPA/ModelAssessment/Pages/default.aspx

[13] A past effort on looking at the steady-state, dynamic, and short circuit implications that DER may have was the NERC internal white paper *TPL Considerations under High Penetration of Distributed Energy Resources* that was presented to the NERC Operations Leadership Team (OLT) meeting in January 21st, 2022.

[14] NERC has identified aggregate DER tripping in multiple BPS fault events, such as the Palmdale Roost and Angeles Forest disturbances: https://www.nerc.com/pa/rrm/ea/Pages/April-May-2018-Fault-Induced-Solar-PV-Resource-Interruption-Disturbances-Report.aspx

[15] https://www.nerc.com/pa/Stand/Pages/Project2022-02ModificationstoTPL-001-5-1andMOD-032-1.aspx

Operational Impacts of DER: Major Decentralization

T–D Interface
A T–D Interface is the electrical point, commonly a transformer, where the transmission system ends and the distribution system begins.

NERC RISC has identified the changing resource mix as a high risk for the BPS that incorporates the shift toward more decentralized, distribution-connected generation. As the percentage of generation connected to the BPS is reduced, the reliability support provided may also be shifted to where the generation is connected (i.e., the distribution system) unless provided through other means. As this transition[16] occurs, NERC is proactively studying the possible risks associated with changes to the transmission–distribution (T–D) interface and determining possible mitigating measures. Recent regulatory changes have enabled these resources to be combined together for control by DER aggregators, further changing electrical characteristics of the T–D interface. SPIDERWG is developing a white paper that reflects the need for improved coordination between transmission and distribution entities in an effort to break down barriers that could negatively affect BPS reliability.

The trend from very large centralized power plants (e.g., > 300 MVA) to smaller BPS-connected plants (e.g., 25–100 MVA) to distribution-connected generators (e.g., 0.25–5 MVA[17]) indicates a major decentralization of generation. NERC continues to monitor this transition and is using data to assess how and when these changes could significantly affect BPS reliability. NERC will continue to provide guidance in many areas beyond modeling and studies to address operational impacts of increasing penetration of distribution-connected generation. These areas may include impacts on the following:

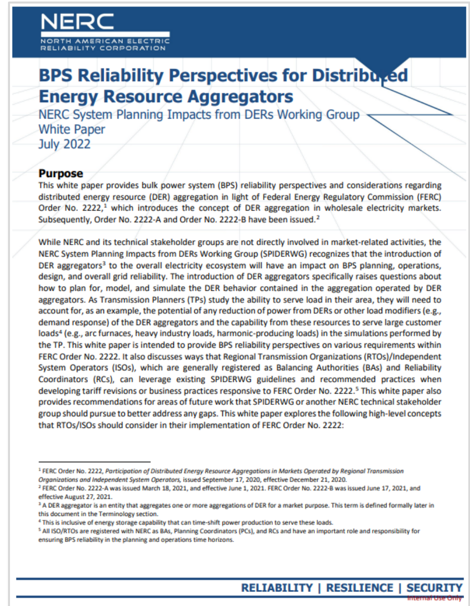
- BPS protective relaying
- Balancing Authority balancing and reserve allocation
- Transmission operations and state estimation
- TOP and RC situational awareness

[16] It does not need a full transition to 100% DER to have an identified risk associated with shifting generation from the bulk system to the distribution system. NERC's strategy is to be proactively identifying any risk associated with shifting generation from the bulk system to the distribution system.
[17] These ranges are a rule-of-thumb for broad categorization only. The trend is demonstrated via the resource additions found in the NERC LTRA, which is dominated by larger quantities of increasingly smaller capacity installations. The LTRA is available here: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2021.pdf

Regulatory Considerations

NERC is pursuing a broad spectrum of regulatory decisions and directions on the growing DER levels, including the following:

- **Introduction of the DER Aggregator:** The introduction of the DER aggregator with FERC Order 2222[18] presents unique operational benefits and challenges for grid planners and operators moving forward. The NERC SPIDERWG published a white paper on BPS reliability perspectives for electricity markets incorporating DER aggregators.[19] NERC stakeholder groups continue to highlight and study BPS reliability impacts, the possible need for NERC registration of DER aggregators, and possible applicability for DER aggregators to NERC Reliability Standards in the future. NERC is conducting assessments in this area to identify possible solutions.



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BPS Reliability Perspectives for Distributed Energy Resource Aggregators
NERC System Planning Impacts from DERs Working Group
White Paper
July 2022

Purpose
This white paper provides bulk power system (BPS) reliability perspectives and considerations regarding distributed energy resource (DER) aggregation in light of Federal Energy Regulatory Commission (FERC) Order No. 2222,[1] which introduces the concept of DER aggregation in wholesale electricity markets. Subsequently, Order No. 2222-A and Order No. 2222-B have been issued.[2]

While NERC and its technical stakeholder groups are not directly involved in market-related activities, the NERC System Planning Impacts from DERs Working Group (SPIDERWG) recognizes that the introduction of DER aggregators[3] to the overall electricity ecosystem will have an impact on BPS planning, operations, design, and overall grid reliability. The introduction of DER aggregators specifically raises questions about how to plan for, model, and simulate the DER behavior contained in the aggregation operated by DER aggregators. As Transmission Planners (TPs) study the ability to serve load in their area, they will need to account for, as an example, the potential of any reduction of power from DERs or other load modifiers (e.g., demand response) of the DER aggregators and the capability from these resources to serve large customer loads[4] (e.g., arc furnaces, heavy industry loads, harmonic-producing loads) in the simulations performed by the TP. This white paper is intended to provide BPS reliability perspectives on various requirements within FERC Order No. 2222. It also discusses ways that Regional Transmission Organizations (RTOs)/Independent System Operators (ISOs), which are generally registered as Balancing Authorities (BAs) and Reliability Coordinators (RCs), can leverage existing SPIDERWG guidelines and recommended practices when developing tariff revisions or business practices responsive to FERC Order No. 2222.[5] This white paper also provides recommendations for areas of future work that SPIDERWG or another NERC technical stakeholder group should pursue to better address any gaps. This white paper explores the following high-level concepts that RTOs/ISOs should consider in their implementation of FERC Order No. 2222:

[1] FERC Order No. 2222, *Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators*, issued September 17, 2020, effective December 21, 2020.
[2] FERC Order No. 2222-A was issued March 18, 2021, and effective June 1, 2021. FERC Order No. 2222-B was issued June 17, 2021, and effective August 27, 2021.
[3] A DER aggregator is an entity that aggregates one or more aggregations of DER for a market purpose. This term is defined formally later in this document in the Terminology section.
[4] This is inclusive of energy storage capability that can time-shift power production to serve these loads.
[5] All ISO/RTOs are registered with NERC as BAs, Planning Coordinators (PCs), and RCs and have an important role and responsibility for ensuring BPS reliability in the planning and operations time horizons.

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- **NERC Reliability Standards Enhancements:** The NERC RSTC recently approved a white paper[20] that documents revisions needed to NERC Reliability Standards with the growth of DERs. A number of standards revisions were proposed to ensure clarity and consistency with growing DER levels, and the RSTC and SPIDERWG are actively developing standard authorization requests to address this issue. The forward looking nature of these revisions ensures reliability with growing DER levels and solidifies the work produced from other core tenets of the DER strategy. NERC will facilitate future standards projects in an agile manner to effectively address the issues at a pace commensurate with the change resource mix and growing DER levels.

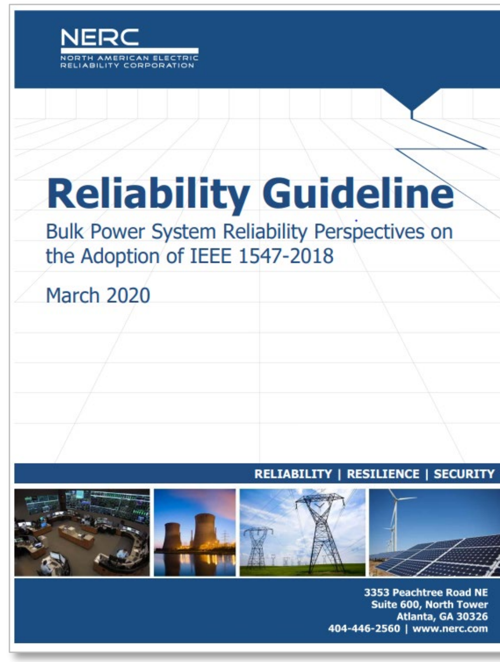
- **Cyber Security Concerns with DERs and the DER Aggregator:** The growing DER levels and the introduction of the DER aggregator present significant challenges for ensuring the security of the overall electricity ecosystem. DERs are often internet connected and have little to no cyber security requirements imposed on them. In particular, the DER aggregator could control hundreds or thousands of individual devices, aggregating control of significant amounts power. These entities are not presently subject to any of the NERC critical infrastructure protection standards or back-up control centers. NERC is considering these possible risks in its actions related to DER aggregators.[21] NERC is also working with industry stakeholders, including the national laboratories, Underwriters Laboratories, and the Institute of Electrical and Electronic Engineers to support the advancement of equipment standards and certification inclusive of cyber security provisions. The overall goal is for DERs to have adequate security controls and for the DER aggregator to be applicable to necessary operational standards when its aggregate impact affects the BES.

- **Training and Education:** NERC is also focused on ensuring stakeholders across the ERO Enterprise and industry have adequate training and education concerning DERs. This includes operator training, planning engineer training, and education materials for policymakers, regulators, and other decision makers regarding DER impacts on the BPS.

[18] https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet
[19] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/SPIDERWG_White_Paper_-_BPS_Persepectives_on_DER_Aggregator_docx.pdf
[20] White paper available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Whitepaper_SPIDERWG_Standards_Review.pdf
[21] White paper is in stakeholder committee process. Anticipated approval in 2023.

Industry Engagement, Outreach, Education, and Collaboration

NERC is committed to ensuring collaboration and coordination with industry stakeholders in the area of DER impacts on the BPS. All DER-related activities are now located under the Distributed Energy Resource Activities page under the Initiative tab on the NERC webpage.[22] The NERC SPIDERWG is an excellent forum where industry experts come together to share experience and practices as well as to meet quarterly to discuss its numerous work products and activities. NERC is also working closely with the U.S. Federal Energy Regulatory Commission and National Association of Regulatory Utility Commissioners to ensure alignment with federal- and state-level requirements. NERC is also working with Canadian counterparts[23] for those portions of each Interconnection to ensure Interconnection-wide reliability. NERC has strong partnerships with organizations that include the Electric Power Research Institute, the North American Transmission Forum, the North American Generation Forum, the Energy Systems Integration Group, National Laboratories, academic institutions, and the U.S. Department of Energy to help advance industry practices.



For example, in 2020, NERC published *Reliability Guideline: Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018*,[24] which strongly recommended beginning the stakeholder process for each Authority Governing Interconnection Requirements (e.g., province or state) to adopt the technical requirements in IEEE 1547-2018 so future DER installations support the reliable operation of the BPS. This effort was in coordination with the National Association of Regulatory Utility Commissioners issuing a resolution[25] that recognized the BPS impacts of growing DER levels and the need for provinces or states to proactively take action to adopt IEEE 1547-2018.

Monitoring Success of Mitigation Activities

Per the ERO risk framework, an important aspect of mitigation is measuring the effectiveness of mitigation activities. A portion of this DER strategy is accomplished through ERO event analysis; however, the reporting form in EOP-004 does not distinguish between bulk generation loss, distribution generation loss, or net load jumps; this may need to be revised in the future (identified by NERC's SPIDERWG in its white paper). Alternatives are being reviewed that may provide this information swiftly without the need for a standard revision. This knowledge will ensure that widespread loss of DER events are reported quickly and analyzed effectively by the ERO. NERC is also focused on measuring the success of industry actions based on the recommendations outlined in NERC reliability guidelines, focused in this case specifically on DER modeling and studies improvements. NERC further monitors the success of mitigation activities via its Compliance Monitoring and Enforcement Program. NERC is also developing its Compliance Monitoring and Enforcement Program practice guide on *Modeling and Studies Involving Distributed Energy Resources*.[26]

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[22] https://www.nerc.com/pa/Documents/DER_Quick%20Reference%20Guide.pdf

[23] For example, the Canada Energy Regulator (CER)

[24] Available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Guideline_IEEE_1547-2018_BPS_Perspectives.pdf

[25] https://pubs.naruc.org/pub/4C436369-155D-0A36-314F-8B6C4DE0F7C7

[26] In progress via stakeholder committee.

Milestone Plan

In support of NERC's DER strategy, the following deliverables from SPIDERWG (and other relevant technical subgroups) are planned to be submitted to the NERC RSTC:

- **Standard Authorization Requests for DERs:** As a follow-up to the approved comprehensive review[27] of NERC Reliability Standards, SPIDERWG is developing Standard Authorization Requests for applicable NERC Reliability Standards to address any risk issues identified

  Expected completion by Q1 2023 – Q1 2024

- **Reliability Guideline, BPS Studies under Increasing Penetrations of DERs:** Guidance for TPs and PCs conducting transmission planning assessments with increasing DER levels

  Expected completion by Q3 2023

- **White Paper, Security impacts of DER and the DER Aggregator:** Paper documenting the technical details of failure modes and security vulnerabilities by DERs and DER aggregators (coordinated with NERC Security Integration and Technology Enablement Subcommittee)

  Expected completion by Q3 2023

- **White Paper, Modeling BESS and Multiple DER Types:** Brief paper investigating battery energy storage on the distribution system and providing modeling guidance for multiple technology types behind a T–D interface

  Expected completion by Q1 2023

- **Technical Report, Beyond Positive Sequence (Approved):** Technical report on the need for using more advanced simulations tools to study DERs and their impact to the BPS

  Expected completion by Q3 2022

- **White Paper, Modeling of DER Aggregator and DERMS Functional Impacts:** A set of modeling recommendations related to specific functions provided by DER aggregators and DER management systems

  Expected completion by Q3 2023

- **White Paper, Communication and Coordination Strategies for Transmission Entities and Distribution Entities regarding Distributed Energy Resources:** Considerations for coordination strategies between transmission and distribution entities for growing DER levels

  Expected completion by Q2 2023

- **White Paper, Variability, Uncertainty, and Data Collection for the BPS with DER Aggregators:** Documenting lessons learned from interacting with DER aggregators related to the gathering of DER modeling information

  Expected completion by Q3 2022

- **Reliability Guideline, Balancing the Bulk System with Distributed Energy Resources:** Guidance for Balancing Authorities on how to account for DERs in the many functions a Balancing Authority provides in their Interconnection

  Expected completion by Q4 2023

[27] Available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Whitepaper_SPIDERWG_Standards_Review.pdf