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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

BPS Reliability Perspectives for Distributed Energy Resource Aggregators

NERC System Planning Impacts from DERs Working Group
White Paper
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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.

- How ISO/RTOs consider the implementation of FERC Order No. 2222 could impact the ability of TPs to ensure BPS planning and operating models and simulations remain accurate as DERs continue to proliferate and participate in DER aggregations, particularly which entities are responsible for providing the data,[6] what data is being requested, and which entities receive the data[7]
- How ISO/RTOs ensure that the study cases used by TPs and PCs appropriately reflect the expected operating conditions of DERs and the results of implementing FERC Order No. 2222 (Particularly, determine what data is needed at various stages of these studies, and how the data is maintained at the distribution and transmission level)
- How ISO/RTOs consider the implementation of FERC Order No. 2222 ensures that Transmission Operators (TOPs) have sufficient visualization of aggregate DERs to operate within system operating limits (SOLs)

Background

The NERC SPIDERWG was established in December 2018[8] as a stakeholder forum to focus on the impacts and benefits that aggregate amounts of DERs may have on transmission planning and BPS reliability. SPIDERWG developed guidelines and recommended practices in the following areas: modeling, verification, studies, and coordination.[9]

With the continued integration of large amounts of DERs in many areas across North America and the projections of future DER growth, combined with the introduction of DER aggregation and the participation of DER aggregators in wholesale electricity markets, SPIDERWG believes it is necessary to shed some light on some key reliability-focused aspects of the new paradigm of grid planning, operations, design, and engineering. The FERC Order No. 2222 addresses the ISO/RTOs directly, and most of those companies are registered as a BA, RC, TOP, PC or a combination of the four. As such, the recommendations in this white paper may be directed at ISO/RTOs and to BAs, RCs, TOPs, and PCs and will sometimes address the same entity. This SPIDERWG white paper follows some of the key considerations of FERC Order No. 2222 and existing requirements related to DER interconnection (e.g., IEEE 1547-2018), and it also provides perspectives for helping ensure continued reliability, security, and resilience of the BPS.

Terminology

In FERC Order No. 2222, FERC amended the Open Access Transmission Tariff (OATT) by defining both “DER” and “DER aggregator” as shown here:

[6] MOD-032 currently has the TP and PC engage with the TO in order to obtain DP level data aggregated to an appropriate BPS bus. It is assumed for this question that the DER aggregator would engage with the DP in this same manner.
[7] Unclear procedures can impact the ability of the TP to gather appropriate data for their simulations. Specifying the data, who provides the data, and who receives the data makes a clear process for the DER aggregators to interface with.
[8] https://www.nerc.com/comm/RSTC/SPIDERWG/SPIDERWG%20Scope.pdf
[9] https://www.nerc.com/comm/RSTC/Pages/SPIDERWG.aspx

Distributed Energy Resource:[10] any resource located on the distribution system as well as any subsystem thereof or behind a customer meter

Distributed Energy Resource Aggregator:[11] the entity that aggregates one or more distributed energy resources for purposes of participation in the capacity, energy and/or ancillary service markets of the regional transmission organizations, and/or independent system operators

FERC clarified that for the purposes of the OATT, DERs may include, but are not limited to, "resources that are in front of and behind the customer meter, electric storage resources, intermittent generation, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment" as long as such resource is "located on the distribution system, any subsystem thereof or behind a customer meter."[12] FERC Order No. 2222 neither amended nor proposed to amend the Glossary of Terms used in NERC Reliability Standards nor the NERC Rules of Procedure. Furthermore, Order No. 2222 itself does not make any changes to the interconnection rules that the states oversee.

SPIDERWG maintains a set of working definitions related to DERs that inform reliability guidelines and recommended practices produced by SPIDERWG. SPIDERWG has defined "DER" to strictly refer to *sources* of electric power on the distribution system[13] (not inclusive of load resources). On the other hand, the definition presented in FERC Order No. 2222 defines DER as *any resource* located on the distribution system. The distinct difference between definitions is that the FERC definition is inclusive of demand response[14] and load elements; whereas, the SPIDERWG working definition excludes demand response as it is not considered a source of power. Rather, it is considered a load modifier in the set of SPIDERWG terms as it modifies load and energy consumption rather than being a source of power. The SPIDERWG aligns with the definition of DER presented in IEEE 1547-2018[15] and is considered appropriate for the purposes of reliability-centric discussions. Unless otherwise noted, this white paper uses definitions in the *SPIDERWG Terms and Definitions Working Document*.[16] It is understood that the definitions used in FERC Order No. 2222 are related specifically to electricity markets and that different definitions for DER-related activities can be used for the purposes of reliability-centric discussions around DER integration and aggregation.

Key Recommendation

The SPIDERWG term for DER is considered appropriate for reliability-focused discussions and is used throughout this document unless otherwise noted. Regardless of any differences in the definition of DER, it is imperative that industry ensure a clear and appropriate definition of DER based on the specific context in which the term is being used for either reliability or market-related discussions.

[10] FERC Order No. 2222, page 93, P114
[11] FERC Order No. 2222, page 95, P118
[12] FERC Order No. 2222, page 93, P114
[13] These resources can also inject power to the BPS through the distribution system. This concept is covered in the various modeling reliability guidelines provided in the Modeling section of this white paper.
[14] FERC Order No. 2222, Paragraph 114, Page 93 of 290
[15] https://standards.ieee.org/standard/1547-2018.html
[16] https://www.nerc.com/comm/RSTC/SPIDERWG/SPIDERWG%20Terms%20and%20Definitions%20Working%20Document.pdf

Quick Overview of FERC Order No. 2222

This section provides a brief overview of the specific requirements[17] and facets in FERC Order No. 2222 that the SPIDERWG believes are particularly important to understand their impact on BPS reliability. Specifically, these focus areas include the following at a minimum:

- DER aggregations participating in RTO/ISO-organized wholesale electric markets
- Establishing DER aggregators as a type of market participant
- DER aggregators registering DER aggregations under one or more participation models that accommodate the physical and operational characteristics of the DER aggregations
- Establishing market rules that address the following technical considerations:
  - Minimum size requirement for DER aggregations that do not exceed 100 kW
  - Locational requirements for DER aggregations
  - Distribution factors and bidding parameters for DER aggregations
  - Information and data requirements for DER aggregations
  - Metering and telemetry requirements for DER aggregations
  - Coordination between the RTO/ISO, the DER aggregator, the distribution utility, and relevant electric retail regulatory authorities
  - Modifications to the list of resources in a DER aggregation
  - Market participation agreements for DER aggregators
- Bidding from DER aggregators where the DERs are customers of utilities that distributed more (as well as less) than four million MWh of energy in the previous fiscal year

These topics will be covered in the following sections, particularly in how they are being addressed by the NERC SPIDERWG and its focus on modeling, verification, studies, and coordination.

Key BPS Reliability Areas with the Introduction of DER Aggregators

The introduction of the DER aggregator will have an effect on BPS reliability, particularly in the way that BPS operations and planning will have to adapt to the DER aggregator. However, it is first important to understand that those impacts will differ from impacts that increasing interconnection of new DERs will simultaneously have on BPS reliability. Furthermore, the interconnection of new facilities[18] also encompasses modifications made to existing interconnections as changes to existing DER facilities require similar studies and coordination efforts as if the facility was adding a new generator. The key reliability areas that should be considered with the introduction of a DER aggregator in a TP/PC area include at least the following:

[17] The text of the order is available here: https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf

[18] This interconnection can occur under an aggregation operated by a DER aggregator or outside of an aggregation operated by a DER aggregator.

- **Interconnection Standards:** These standards dictate the equipment requirements, specifications, and capabilities of the DER facility. Many of these standards deal with the electrical characteristics and equipment properties to help control things like inverter harmonics. IEEE 1547-2018 is a prominent standard that defines interconnection and interoperability requirements and verification processes for DERs connected to electric power systems.[19] SPIDERWG developed guidance[20] on IEEE 1547-2018. Such guidance sufficiently covers the DER aggregator,[21] so no revision of the standards with the introduction of a DER aggregator is required at this time.
- **Services Provided:** The NERC Essential Reliability Services Task Force enumerated a few services that a resource can offer to maintain BPS reliability.[22] The RTO and ISO may have markets available to procure enough resources in support of those services. The DER aggregator may be able to alter the type and quantity of a specific service for a specific aggregation of DER.
- **Electrical Characteristics at T–D Interface:** The transmission to distribution interface (T–D interface) is the point at which the distribution system meets the transmission system and is primarily modeled with a load at a BPS bus in positive sequence transmission models. The electrical characteristics at this interface are dictated by the equipment sinks or sources on either side of the interface (inclusive of DERs) and the operation of such equipment. Inverter settings and control logic from DER equipment impact the T–D interface. Such settings dictate the inverter behavior based on various monitored electrical quantities. The DER aggregator may be able to alter a few, none, or all of a specific inverter's settings, impacting how the DER facility[23] performs and resulting in changes to electrical characteristics of the T–D interface. As the electrical characteristics of the T–D interface change, the impact on BPS planning and operations will need to be altered to accommodate the new modes of operation created. DER aggregators may impact the procedures of BPS planning and operations through changes in the studies of the planning/operations area and the affect protection, automation, control, and communication systems as well. This may result in changes[24] for the interconnection (i.e., new or changed capacity or capabilities) and aggregation (i.e., grouping of facilities) process.

[19] Type testing and certification of devices to ensure that they meet requirements defined in the IEEE 1547-2018 is covered by the 3rd edition of UL1741.
[20] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Guideline_IEEE_1547-2018_BPS_Perspectives.pdf
[21] Depending on if the DER aggregator is able to control and operate equipment outside of the "distribution" system (i.e., not under IEEE 1547-2018) then other standards may be applicable such as IEEE p2800
[22] The 2015 ERSTF report can be found here:
https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Framework%20Report%20-%20Final.pdf
[23] Inverter settings have been identified as a reason bulk facilities have tripped due to disturbances. As solar PV is the largest type of DER today, it reasonably follows that a key reliability aspect of DER is also the inverter settings.
[24] This can include items like physical "metal-in-the-ground" changes to the system. All of these changes are a result of larger BPS planning and operations paradigm changes.

Key Takeaway

The introduction of a DER aggregator does not significantly alter interconnection of DER. Rather, the DER aggregator impacts the broader electrical characteristics at the T–D interface.

In general, the introduction of DER aggregators in a TP or PC's area does not significantly alter the current interconnection procedures for DERs nor does it significantly alter the need to account for DERs in planning assessments. However, the possible alteration of DER equipment (e.g., inverter) settings, services that DERs can provide, and the electrical characteristics of the DER aggregation operated by a DER aggregator[25] could create new impacts on the distribution system and BPS. These possible impacts shape the way a TP reviews an aggregation or performs coordination with their protection, automation, and control to ensure BPS reliability. Establishing control of existing DERs under a DER aggregator will likely undergo a different milder level of study by the TP than interconnection of new DER capacity.[26] Modeling, verification, and studies, including the DER aggregator as well as tight coordination between transmission and distribution entities, will be critical for maintaining a reliable, resilient, and secure BPS moving forward. The following sections will outline the important modeling, verification, studies, and coordination considerations regarding the incorporation of the DER aggregator.

Modeling

Figure 1 shows the paragraphs from FERC Order No. 2222 that are particularly relevant for the purposes of modeling aggregate DERs in reliability studies with the introduction of the DER aggregator.

Paragraph 142. *"We… require each RTO/ISO to revise its tariff to allow different types of distributed energy resource technologies to participate in a single distributed energy resource aggregation (i.e., allow heterogeneous distributed energy resource aggregations)."*

Paragraph 236. *"…we require each RTO/ISO to revise its tariff to (1) include any requirements for distributed energy resource aggregators that establish the information and data that a distributed energy resource aggregator must provide about the physical and operational characteristics of its aggregation; (2) require distributed energy resource aggregators to provide a list of the individual resources in its aggregation; and (3) establish any necessary information that must be submitted for the individual distributed energy resources."*

Paragraph 237. *"…we require the RTOs/ISOs to revise their tariffs to establish any necessary physical parameters that distributed energy resource aggregators must submit as part of their registration process only to the extent these parameters are not already represented in general registration requirements or bidding parameters applicable to distributed energy resource aggregations."*

Figure 1: Relevant Modeling Paragraphs

[25] To be clear, the information and settings to populate models remains important regardless of operation under a DER aggregator or not. When under the conditions of DER responding to local signals, use engineering judgement to determine inverter settings and how the equipment in aggregate performs. Under an entity that now allows for direct control over these settings, such settings can potentially fall under non-default settings defined by engineering judgement and should be considered important information to review and provide for an aggregation review.

[26] This is not to discount the need to account for older facility performance in the studies. To clarify, this statement is discussing the process by which the TP studies the information, emphasizing the difference between aggregation of existing capacity under a new control scheme versus interconnection of new (or added) capacity. Each requires study work with models representing the capability of the equipment.

For BPS reliability studies, DERs should be modeled in aggregate[27] at the BPS bus consistent with SPIDERWG recommended practices. The introduction of the DER aggregator is likely to have an impact on DER modeling practices in the future, particularly in how TPs and PCs will model[28] or represent how aggregate DER levels perform when under control of a DER aggregator. However, this change does not impact the major recommended modeling practices of SPIDERWG at this time. SPIDERWG's guidance on representing DERs in aggregate at the BPS bus in an explicit way is not altered from the introduction of a DER aggregator. Conversely, the parameterization and adaption of the model framework to suit the operational characteristics of an aggregation may change.

Key Recommendation
Aggregating DER in the context of the OATT will not have a significant impact on recommended SPIDERWG modeling practices.

Representing all of the components of equipment controlled by a DER aggregator may require separating the capacity of generation from load capacity in the DER aggregation. For example, the characteristics of the inverter-based residential DER (modeled as retail-scale DERs, or for short R-DER[29]) may need to be modeled in one component of a load model; the characteristics of electric vehicles in another component of a load model (see **Figure 2** as an illustration). After determining each "group" or component of the DER aggregation, TPs and PCs can develop modeling assumptions to describe the expected operational characteristics of the various components and will need sufficient data to make these modeling decisions for reliability studies.

[27] For clarity, modeling DER in aggregate is the way SPIDERWG generally recommends the installed DER be represented in studies opposed to the explicit representation of the distribution system and each DER installation in a transmission level study. This is not in reference to the DER aggregations, which can span more than one BPS bus for areas with multi-node DER aggregators. In such areas, the control of two or more generation records is directed by one DER aggregator at two or more BPS buses. This does not change the modeling practice of modeling all DER in an aggregate model that electrically connects to the T–D interface at a BPS bus in simulation.

[28] Furthermore, as equipment under DER aggregators can include components of Load, the information provided by a DER aggregator may be useful in the development of the composite load model. The SPIDERWG recommendation to model DERs in aggregate at the BPS bus (i.e. through a T–D interface) is consistent with the evolution of the composite load model performed by other industry groups.

[29] Details on the model distinctions between R-DER and U-DER available in the following three NERC Reliability Guidelines: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_-_Modeling_DER_in_Dynamic_Load_Models_-_FINAL.pdf, https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_A_Parameterization.pdf, and https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_Data_Collection_for_Modeling.pdf

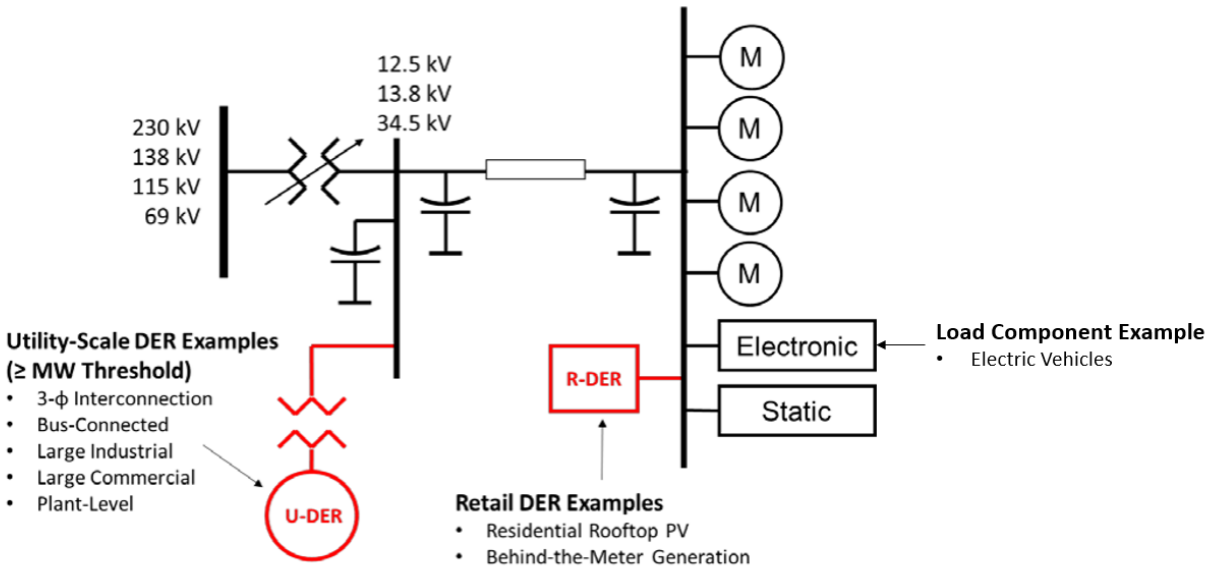

Figure 2: DER Modeling Framework with DER Components and Load Components

Consideration should be given to providing model information to the responsible Distribution Planners (DP), TPs, and PCs for inclusion in their studies and how often that information is exchanged. The method for information flow between and among a DER aggregator, DP, TP, and PC will vary based on the market structure. At a minimum, interconnection agreements should use the information provided in Appendix B of the *Reliability Guideline: DER Data Collection for Modeling in Transmission Planning Studies*[30] as a baseline for the specific modeling information[31] provided. For more information on these physical parameters, RTOs/ISOs should see the discussion on the steady-state (Chapter 2), dynamics (Chapter 3), and short circuit (Chapter 4) data requirements in the document. As DERs interconnect into the distribution system,[32] their aggregate response needs to be clearly understood by the DPs, TPs, and PCs who study its response in the planning horizon. Furthermore, the response will impact TOPs and BAs as well in the operation horizon. Both horizons require modeling information to represent the aggregate response of DERs controlled by a DER aggregator as well as those not under such control.

In other words, DER aggregators and their respective DP(s) should be identified as key sources of data for BPS planning studies (e.g., steady state, dynamics, short circuit). Furthermore, RTOs/ISOs should take care to ensure that any defined locational requirement for DER aggregators be appropriately reflected in the dispatch and parameterization of the DER models in the various base cases. As the DER aggregator and DP geographic areas can be different, there is a need for the DP to obtain data for the Interconnection by

[30] Available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_DER_Data_Collection_for_Modeling.pdf
[31] In particular, the composition and control logic of the aggregation under a DER aggregator is important to send to the responsible DPs, TPs, and PCs to include in their models in order to accurately perform their studies. It is further emphasized that there is a potential for the control logic to change in real-time and such changes need to be reflected in the operational model when the change occurs.
[32] Sometimes the injection is through the distribution system into the bulk system, resulting in bulk system injection.

interfacing with DER aggregators in their area, so the DP is the logical choice to be involved with DER aggregators and to provide data to the TP or TOP where appropriate.

Based on the SPIDERWG discussion, the modeling, verification, and study of DERs in aggregate will need verifiable data flowing to TPs and PCs that perform those functions. DER aggregators are key entities that can provide information and should be sending detailed information for study to the DP, and the DP should send aggregate information to its respective TP and PC.

Verification

Figure 3 shows the paragraphs from FERC Order No. 2222 that are particularly relevant for the purposes of verification activities with the introduction of the DER aggregator.

Paragraph 267: *"…we provide flexibility to RTOs/ISOs to propose specific metering requirements, including any that may apply to individual distributed energy resources that the RTO/ISO demonstrates are needed to obtain any required performance data for auditing purposes and to address double compensation concerns. Similarly, we provide flexibility to the RTO/ISO as to whether to propose specific telemetry requirements for individual distributed energy resources in an aggregation. The need for such requirements may depend, for example, on whether the RTO/ISO allows multi-node aggregations or how multi-node aggregations are implemented. By providing flexibility while also requiring that the RTO/ISO explain why any proposed metering and telemetry requirements are necessary, we allow the RTO/ISO to obtain the metering and telemetry information it needs without burdening the distributed energy resource aggregator to provide data that may not be necessary."*

Paragraph 268: *"…we expect that RTOs/ISOs will base any proposed metering and telemetry hardware and software requirements for distributed energy resource aggregations on the information needed by the RTO/ISO while avoiding unnecessary requirements that may act as a barrier to individual distributed energy resources joining distributed energy resource aggregations or to distributed energy resource aggregations participating in the wholesale markets."*

Paragraph 269: *"…we note that any additional RTO/ISO metering and telemetry requirements would not change those required by state or local regulatory authorities and would be required solely to assist with settlements and audits of activity in RTO/ISO markets, or to provide RTOs/ISOs with the real-time information needed to reliably and efficiently dispatch their systems."*

Figure 3: Relevant Verification Paragraphs

When developing telemetry requirements, SPIDERWG recommends that RTOs/ISOs consider using the *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies*[33] as well as established interconnection requirements to determine the technical specifications of electrical metering and the electrical locations for the equipment. It is also important to recognize that new tariffs that allow DER participation in aggregate will present unique challenges not seen with more traditional resources,[34] so consideration of TP and TOP needs when establishing metering and telemetry requirements to monitor and verify the aggregate DER need to be clear for participating DERs. For use by the TP and TOP, metering

[33] Available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline%20_DER_Model_Verification_of_Aggregate_DER_Models_used_in_Planning_Studies.pdf

[34] Primarily the monitoring of a single point of interconnection does not provide the one to one mapping used to verify resource models using disturbance based playback.

equipment should support the ability to capture waveforms[35] for playback in order to verify the performance of the DER aggregation in disturbance-based model verification or through event analysis. While individual DER data is not as important to transmit, providing data from where the individual resource aggregates to the transmission system will help TPs develop and study how the DER aggregator may alter the electrical characteristics of the T–D interface and verify the TP and PC's representation of those changes in their set of models. Furthermore, it is important to determine root causes and electrical responses of equipment that can affect the BPS in event analysis. TPs should take care to evaluate whether different hardware and software types within an aggregation warrant separate reporting channels as the differing technologies have unique electrical responses.

How the DER aggregation performs will affect whether data gets reported in the aggregate for particular instances. Refer to the previously mentioned reliability guideline for the use of recordings for model verification and event analysis concerning DER. The metering and telemetry mentioned in **Figure 3** are typically market-related but may have a need to be used by the TOP to maintain situational awareness for the BPS, which is discussed in the coordination section of this white paper. As such, it is important to involve the TOP in the definition of metering and telemetry devices used for the resources aggregated by a DER aggregator.

Studies

Figure 4 shows the paragraphs from FERC Order No. 2222 that are particularly relevant for the purposes of performing reliability studies with the introduction of DER aggregators.

Paragraph 99: *"…In response to increased demand for distributed energy resource aggregations for wholesale market participation, some state or local authorities may choose to voluntarily update their distribution interconnection processes to assess the impacts of distributed energy resource aggregations on the distribution system at the initial interconnection stage, while other state and local authorities may not. In the latter scenario, it may be both necessary and appropriate for the RTO/ISO, in coordination with affected distribution utilities, to conduct separate studies of the impact on the distribution system after a distributed energy resource joins a distributed energy resource aggregation."*

Paragraph 99: *"…we expect that modifications to the list of resources in a distributed energy resource aggregation could occasionally indicate changes to the electrical characteristics of the distributed energy resource aggregation that are significant enough to potentially adversely impact the reliability of the distribution or transmission systems and justify restudy of the full distributed energy resource aggregation; therefore, RTOs/ISOs and distribution utilities may perform such aggregation restudies if necessary…"*

Paragraph 294: *"…this final rule in no way prevents state and local regulators from amending their interconnection processes to address potential distribution system impacts that the participation of distributed energy resources through distributed energy resource aggregations may cause. In addition, coordination between RTOs/ISOs, distributed energy resource aggregators, relevant electric retail regulatory authorities, and distribution utilities during the registration and distribution utility review processes should provide RTOs/ISOs with the information they need to study the impact of distributed energy resource aggregations on the transmission system."*

Figure 4: Relevant Studies Paragraphs

[35] For specifics, see Chapter 1 of the *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies* that discusses the placement of devices and data collection for model verification. In general, the focus for waveform capture is at the T–D interface.

RTO/ISO consideration of DER aggregators should ensure that study boundaries depicting the DERs aggregated by a DER aggregator are well-defined and understood by TPs and PCs. More specifically, if the DERs aggregated by a DER aggregator spans across multiple TP/PC footprints,[36] coordination of data, information, models, practices, etc., will have to be updated consistently to ensure the DER aggregation is reflected properly in operational as well as near- and long-term studies. Furthermore, the proliferation of DER aggregators may also impact regional and interregional planning practices (e.g., underfrequency load shedding programs[37] required under PRC-006[38] or the determination of the most single severe contingency for an Interconnection). RTOs/ISOs should ensure that data is exchanged between TPs/PCs and used appropriately. Considering these transformative operational models for DER aggregators, model and study quality as well as fidelity are just as important now as ever.

SPIDERWG encourages RTOs/ISOs to proactively study the impact DER aggregators have on regional and local transmission systems, specifically SPIDERWG encourages RTOs/ISOs to study the reliability impact these resources have on the BPS. Study results, through ample coordination and communication of identified impacts, should be communicated to all impacted system operators with an eye toward mitigating any impacts DER aggregations might cause.

All entities must coordinate to ensure studies adequately represent the behavior of the aggregations under the control of a DER aggregator. For example, care should be taken to determine whether the DER can safely participate in the proposed markets through a fully vetted interconnection study. Furthermore, all entities should coordinate and perform adequate studies (coordination of protection settings, operational day-ahead, etc.) to ensure the reliability of the BPS for aggregations operated under DER aggregators. This paradigm shift may also require software vendors to provide adequate tools for TPs and PCs to represent the operational characteristics of the aggregations under the control of DER aggregators.

Additionally, while production cost modeling is typically not the focus of TPs and PCs, SPIDERWG's recommendations may be relevant for simulation in those practices. Any dispatch assumptions that come from production cost modeling need to be fully understood by the TOP, TP, and PC as those dispatches are included in their reliability studies.

Coordination

Figure 5 shows the paragraphs from FERC Order No. 2222 that are particularly relevant for the purposes of coordination activities with the introduction of the DER aggregator.

[36] This is possible to occur through a DER aggregator spanning a single RTO or ISO, but the boundary is across two or more areas planned by differing TPs.
[37] SPIDERWG's *Reliability Guideline: Recommended Approaches for UFLS Program Design with Increasing Penetrations of DERs* for this particular practice can be found at the RSTC website here: https://www.nerc.com/comm/Pages/Reliability-and-Security-Guidelines.aspx
[38] PRC-006-5 is available here: https://www.nerc.com/files/PRC-006-5.pdf

Paragraph 292: *"…each RTO/ISO must coordinate with distribution utilities to develop a distribution utility review process that includes criteria by which the distribution utilities would determine whether (1) each proposed distributed energy resource is capable of participation in a distributed energy resource aggregation; and (2) the participation of each proposed distributed energy resource in a distributed energy resource aggregation will not pose significant risks to the reliable and safe operation of the distribution system. To support this review process, RTOs/ISOs must share with distribution utilities any necessary information and data… about the individual distributed energy resources participating in a distributed energy resource aggregation. In addition, the results of a distribution utility's review must be incorporated into the distributed energy resource aggregation registration process."*

Paragraph 310: *"we… require each RTO/ISO to revise its tariff to (1) establish a process for ongoing coordination, including operational coordination, that addresses data flows and communication among itself, the distributed energy resource aggregator, and the distribution utility; and (2) require the distributed energy resource aggregator to report to the RTO/ISO any changes to its offered quantity and related distribution factors that result from distribution line faults or outages."*

Paragraph 324: *We further note that possible roles and responsibilities of relevant electric retail regulatory authorities in coordinating the participation of distributed energy resource aggregations in RTO/ISO markets may include, but are not limited to: developing interconnection agreements and rules; developing local rules to ensure distribution system safety and reliability, data sharing, and/or metering and telemetry requirements; overseeing distribution utility review of distributed energy resource participation in aggregations; establishing rules for multi-use applications; and resolving disputes between distributed energy resource aggregators and distribution utilities over issues such as access to individual distributed energy resource data.*

Figure 5: Relevant Coordination Paragraphs

Having clear data exchange processes between the DER aggregators, the distribution utility, transmission entities (primarily TOPs), and the RTO/ISO (which are registered as BAs and RCs) are critical for ensuring reliable BPS operation. This includes real-time data exchange, expected performance into future operating conditions (for studies), clearly defined data models, data quality/exchange protocols, and coordinated decision making protocols on both sides of the T–D interface. SPIDERWG recommends tight coordination among DER aggregators, DPs, TPs, TOPs, and other entities across the T–D interface in order to ensure the reliability of the Bulk Electric System. When discussing which specific information sharing processes the DER aggregators, DPs, TPs, TOPs, and other relevant entities use, it is important to consider the reliability needs of the BPS and the distribution system as well as coordinated operational decision making.

Furthermore, RTOs/ISOs should develop requirements to ensure DER aggregators have a process to submit clearly defined information[39] from every individual DER in the aggregation for the purposes of representing the equipment in operational or planning studies. BAs and RCs should ensure performance requirements exist to provide system operators confidence in the capabilities of DER aggregations such that operators maintain their system awareness. The BAs and RCs should ensure that proper communications and coordination are performed so that implemented requirements are able to meet both transmission and distribution needs. As more DER aggregators come on-line, SPIDERWG will monitor the impacts and discuss recommended changes in future work. A few topics are mentioned in the following section for such future efforts.

[39] Having information on each DER in the aggregation allows for the engineer to allocate each DER and its capabilities to a BPS bus in the simulation.

SPIDERWG anticipates that DER aggregators will have multiple transmission entities where data is sent to ensure reliability of the Bulk Electric System in effort coordination.

FERC 2222-A, FERC 2222-B, and Possible Future Rulings

After FERC Order No. 2222 issues, such as demand response, opt-outs, and the jurisdiction of state regulators, were raised to FERC. The SPIDERWG is not specifically focusing on the content of these subsequent releases other than to reiterate the guidance mentioned above. SPIDERWG recommends that RTOs and ISOs adopt the recommendations contained within the reliability guidelines to ensure that appropriate measures are in place, particularly with the inclusion of DER aggregators. SPIDERWG recognizes that the DER aggregator introduced in the releases is not within the current NERC functional model of registered entities, so this could lead to challenges in maintaining essential reliability services in a future with more DERs controlled by DER aggregators, sharing off-line or real-time information for planning or operations, and introduce security vulnerabilities into the electricity ecosystem. These issues should be considered and addressed in the near-term. SPIDERWG recommends adding items to its work plan to provide perspectives on the registration of the DER aggregator as a NERC entity.

Recommendations for SPIDERWG Work Plan Additions

FERC Order No. 2222 identified topics considered out-of-scope for Order No. 2222 in Paragraph 362, and industry identified these as areas of concern where future work may be needed. SPIDERWG reviewed these topics and has provided recommendations for future work as well as the applicable group within the RSTC that could lead those efforts (see **Table 1**).

Table 1: Proposed Future Work

Topic	Deliverable	RSTC Group	Timeline
Impacts on BPS variability and uncertainty due to the introduction of the DER aggregator	White Paper	SPIDERWG	2023+
Recommended practices for modeling DER aggregators (and parameterizing those models) in BPS reliability studies and practices for modeling multiple DER aggregators behind a T–D interface	White Paper	SPIDERWG	2023+
Understanding the BPS planning and operations impacts of DER management systems (DERMS) and other aggregator functions after complete implementation and operation	White Paper	SPIDERWG	2023+
Privacy and security (cyber or physical) concerns for the BPS with the introduction of DERs and DER aggregators	White Paper	SPIDERWG and SITES	2023+
Sharing data collection and data sharing practices with the introduction of the DER aggregator	White Paper	SPIDERWG	2023+
Technical impacts on the potential NERC registration[40] of the DER aggregator for NERC standards	Various	SPIDERWG	TBD

[40] This item's deliverable and timeline is dependent upon the total amount of work it will take to demonstrate the impact of a DER aggregator and what documentation is required to adjust the registration criteria.