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Distributed Energy Resources Workshop

Hosted by NERC SPIDERWG

December 14th, 2022

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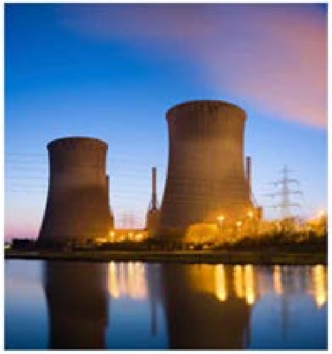

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Agenda

Topic	Presenter
NERC Antitrust Compliance Guidelines, Public Announcement, and Participant Conduct Policy	**Levetra Pitts, NERC**
Opening Remarks on Distributed Energy Resources	**Ryan Quint, NERC**
NERC DER Strategy and What is a DER?	**John Skeath, NERC**
BREAK	
SPIDERWG White Paper: BPS Perspectives on DER Aggregators	**Jose Cordova, EPRI**
Cybersecurity Posture and Certifications for DER and DER Aggregators	**Larry Collier, NERC** **Ryan Cryar, NREL**
DER Aggregator or VPP?	**Brian Chen, PG&E** **Kevin Joyce, Tesla**
BREAK	
SPIDERWG White Paper: NERC Reliability Standards	**Shannon Mickens, SPP**
SPIDERWG Technical Report: Beyond Positive Sequence Simulations	**Ransome Egunjobi, ENEL** **Karthikeyan, Balasubramaniam, ANL**
Upcoming SPIDERWG papers, projects, and goals	**Shayan Rizvi, NPCC**
Adjourn	

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https://www.slido.com/

Opening Remarks

Ryan Quint, NERC
Director, Engineering and Security Integration

NERC DER Strategy

What is a DER?

JP Skeath, Engineer II

DER Workshop

December, 2022

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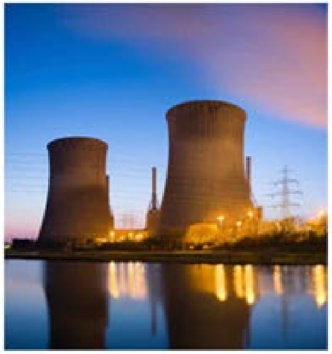
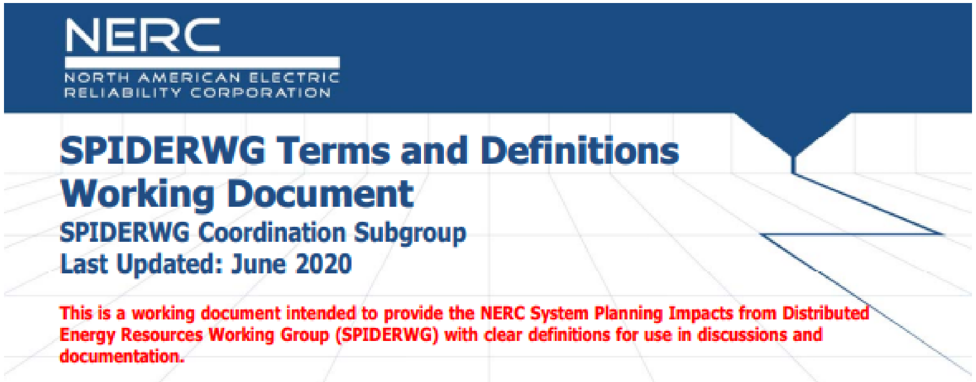


Building out what is a DER

- Distributed Energy Resource (DER)
  - Any Source of Electric Power located on the Distribution System.
- Source of Electric Power
  - Resources that inject or exchange power
- Distribution System
  - The electrical facilities that are located behind a transmission –distribution transformer that serves multiple end-use customers



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SPIDERWG Terms and Definitions Working Document

SPIDERWG Coordination Subgroup

Last Updated: June 2020

This is a working document intended to provide the NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG) with clear definitions for use in discussions and documentation.

https://www.nerc.com/comm/RSTC/SPIDERWG/SPIDERWG%20Terms%20and%20Definitions%20Working%20Document.pdf

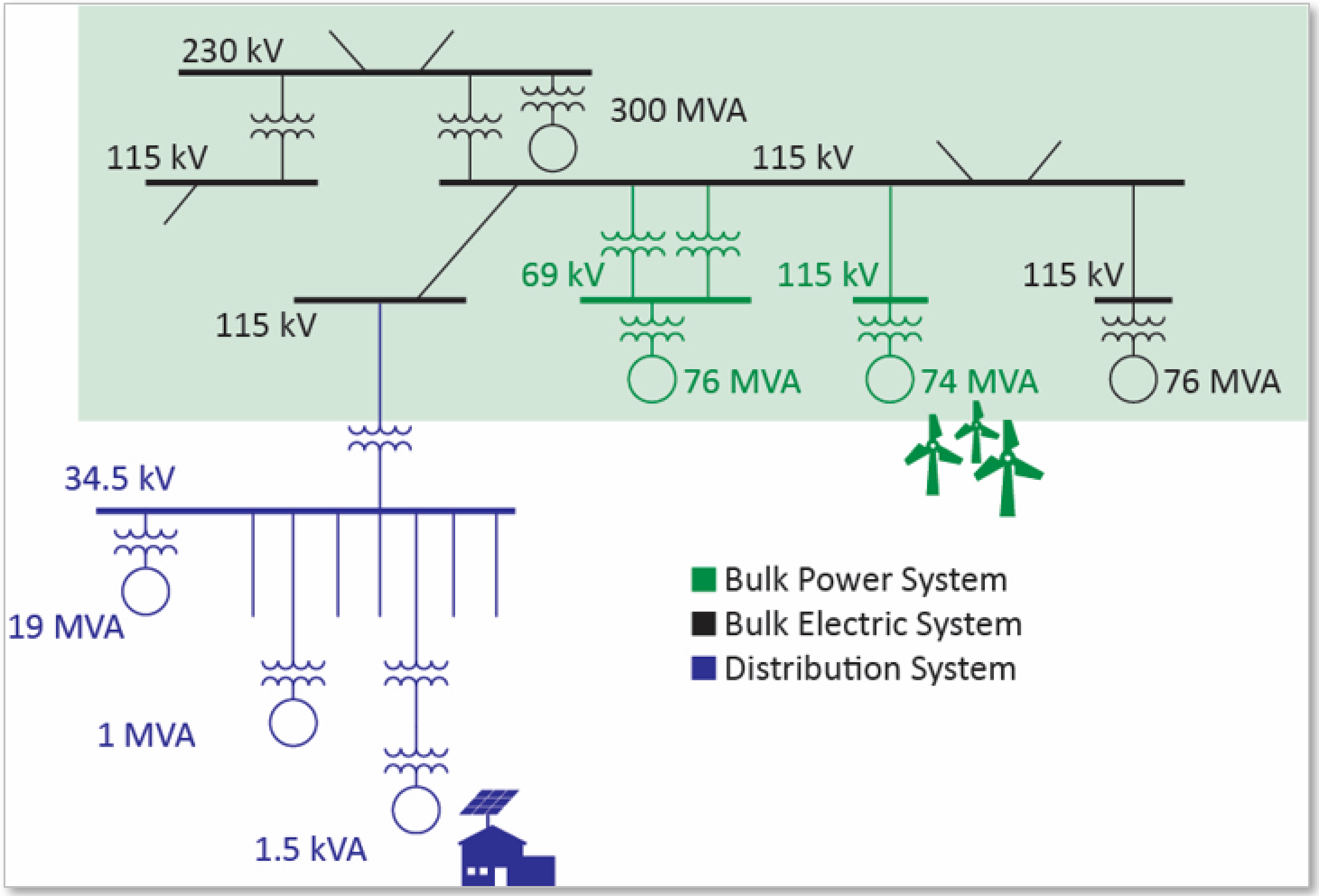
DERs

shutterstock.com · 1750483022

shutterstock.com · 2013427508

Not DERs

Where do DERs Live?



Why Now?

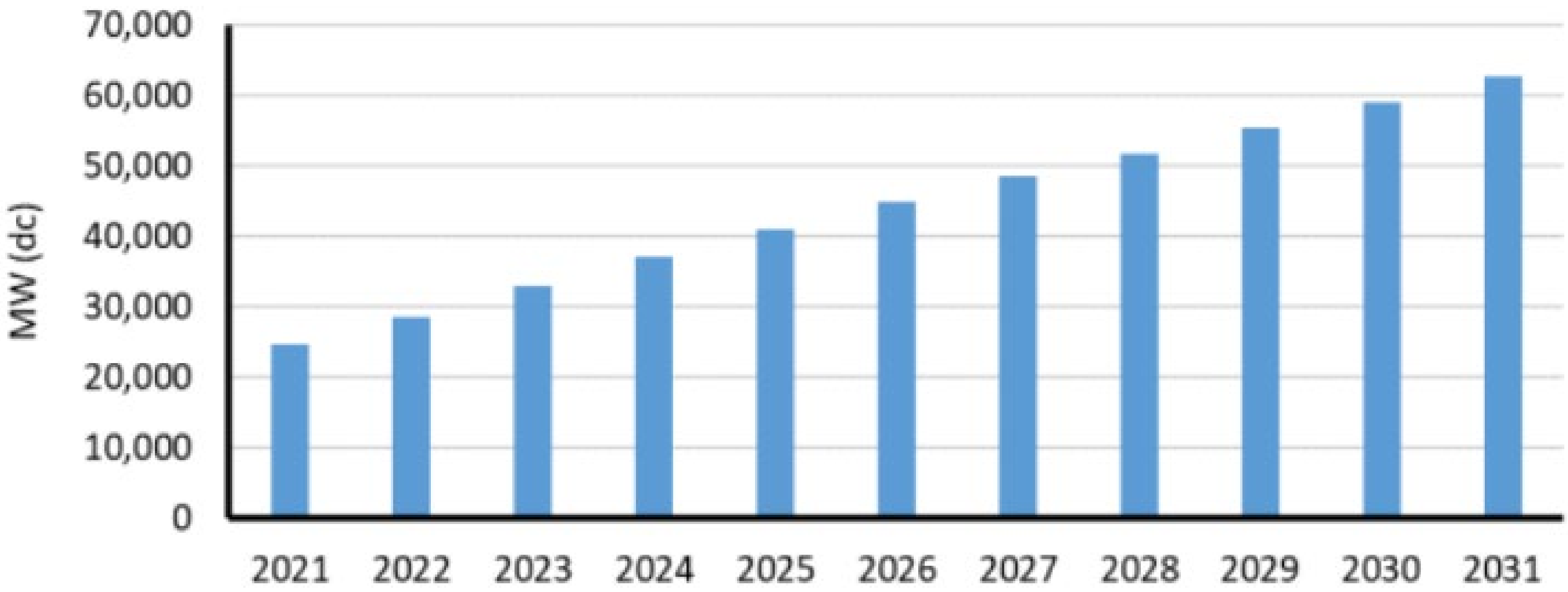


Figure 1: Cumulative Distributed Solar Photovoltaic Capacity[3]

https://www.nerc.com/comm/RSTC/Documents/NERC_DER%20Strategy_2022.pdf

NERC DER Strategy

DER Modeling
- Data Collection
- Modeling Tools
- Verification
- Modeling Usage

Studies Incorporating DER
- Planning Studies
- Design Criteria
- Operations Planning

Operational Impacts of DER
- T-D Impacts
- Aggregator
- Protection Systems
- Decentralization

Regulatory Considerations
- Aggregator
- NERC Standards Enhancements
- Cybersecurity
- Training

Strong Foundation of Coordination between
Regulatory Agencies: FERC, NARUC, CER
Industry Stakeholders: SPIDERWG, RSTC, SC, NATF, EEI, ESIG
Ongoing Research and Design: EPRI, National Labs, Academia

Impacts from DER

- Tripped offline during transmission faults
  - Angeles Forest - ~130 MW
  - Palmdale Roost - ~100 MW
- Lack of modeling information, typically
- Voltage schedule off nominal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April and May 2018 Fault Induced Solar Photovoltaic Resource Interruption Disturbances Report

Southern California Events: April 20, 2018 and May 11, 2018
Joint NERC and WECC Staff Report

January 2019

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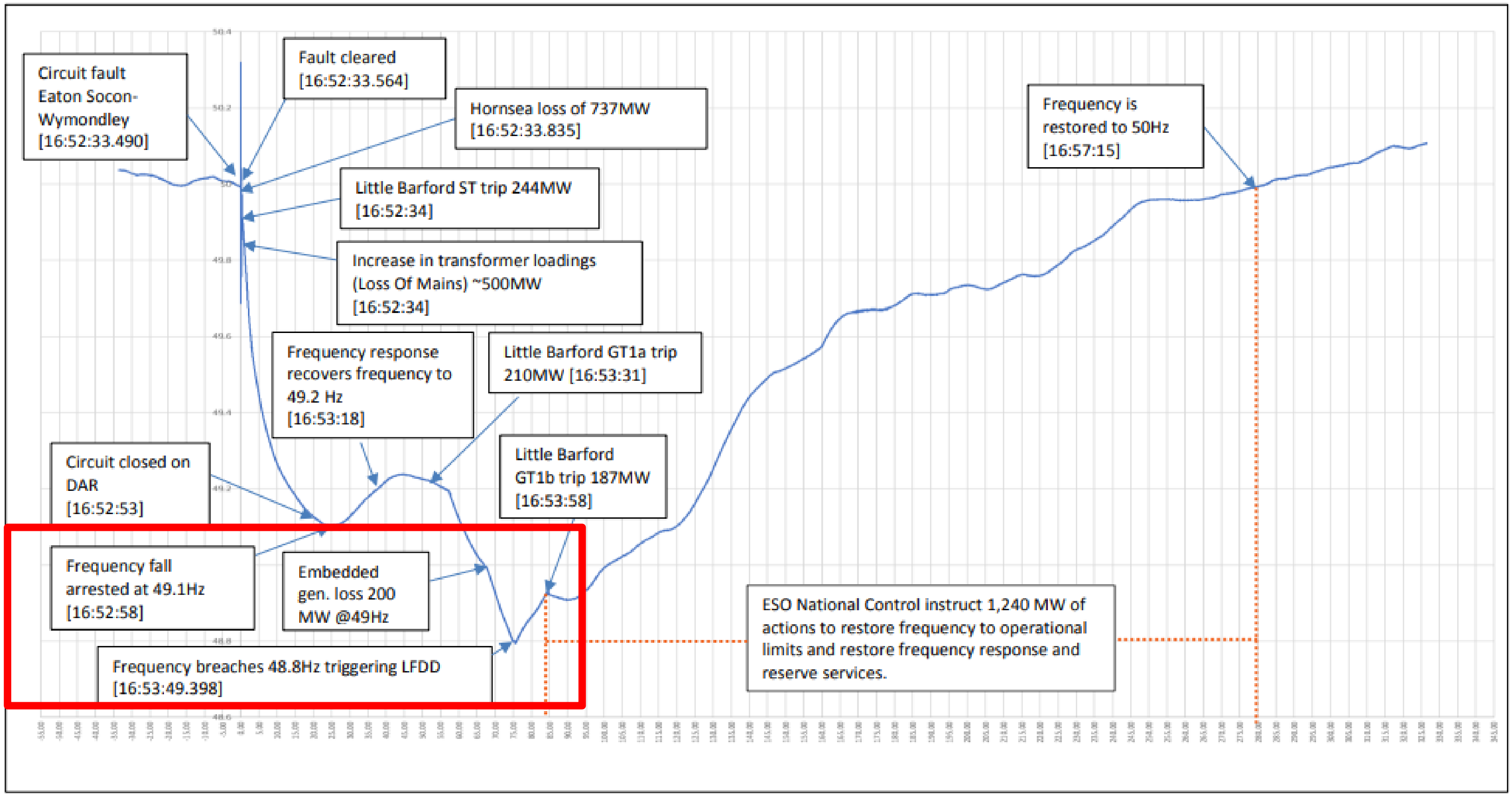
3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
404-446-2560 | www.nerc.com

August 9, 2019 UK Disturbance

3.4. Impact on Frequency

Figure 2 – Annotated Frequency Trace of the Event



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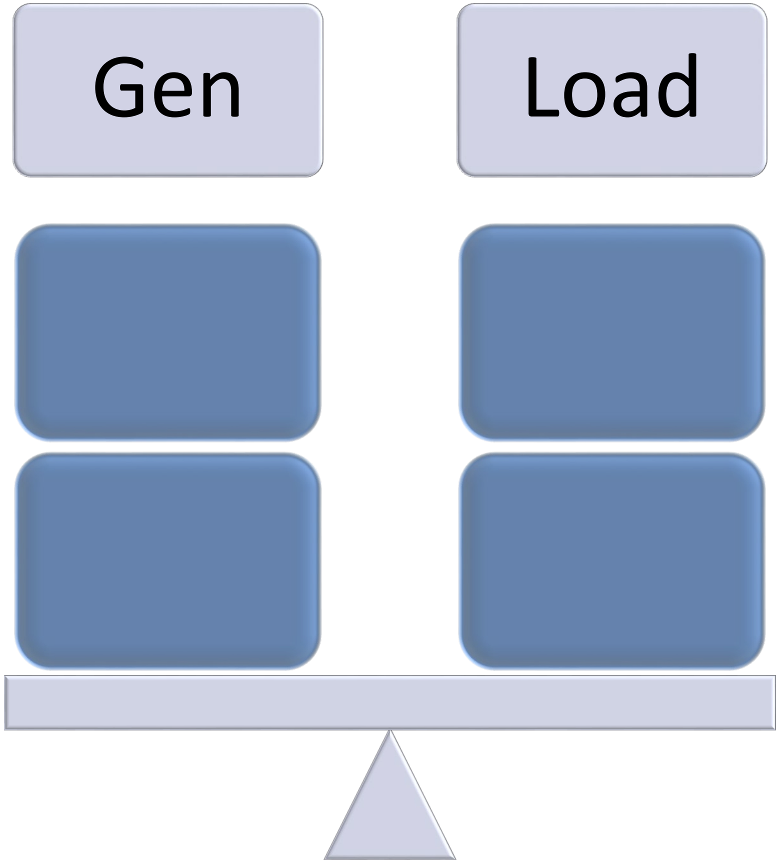
https://www.ofgem.gov.uk/publications/investigation-9-august-2019-power-outage

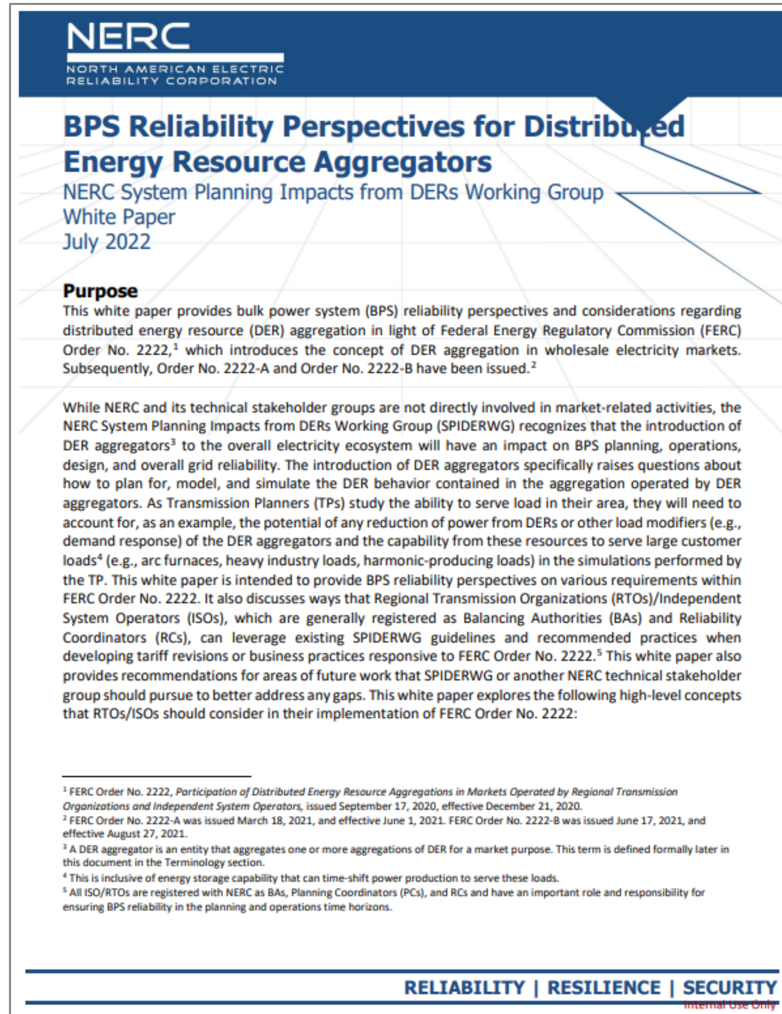
Electrical Impacts of DER

- Starting to see DER participate in bulk grid electrical disturbances.
- Large enough to see an impact = potential aggregate attack vector.
  - Emerging technology lends itself for focus of potential attackers



DER Aggregators

- Introduced by FERC Order 2222
- Allow for DER to participate in wholesale markets
  - SPIDERWG identified key player in providing data and models to transmission
- What do these entities look like?



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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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Questions and Answers

BREAK

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SPIDERWG White Paper: BPS Perspectives on DER Aggregators

Jose Cordova, EPRI

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BPS Reliability Perspectives for Distributed Energy Resource Aggregators

NERC SPIDERWG - White Paper

Jose Cordova
SPIDERWG Coordination Subgroup Co-lead, Grid Operations & Planning (**EPRI**)

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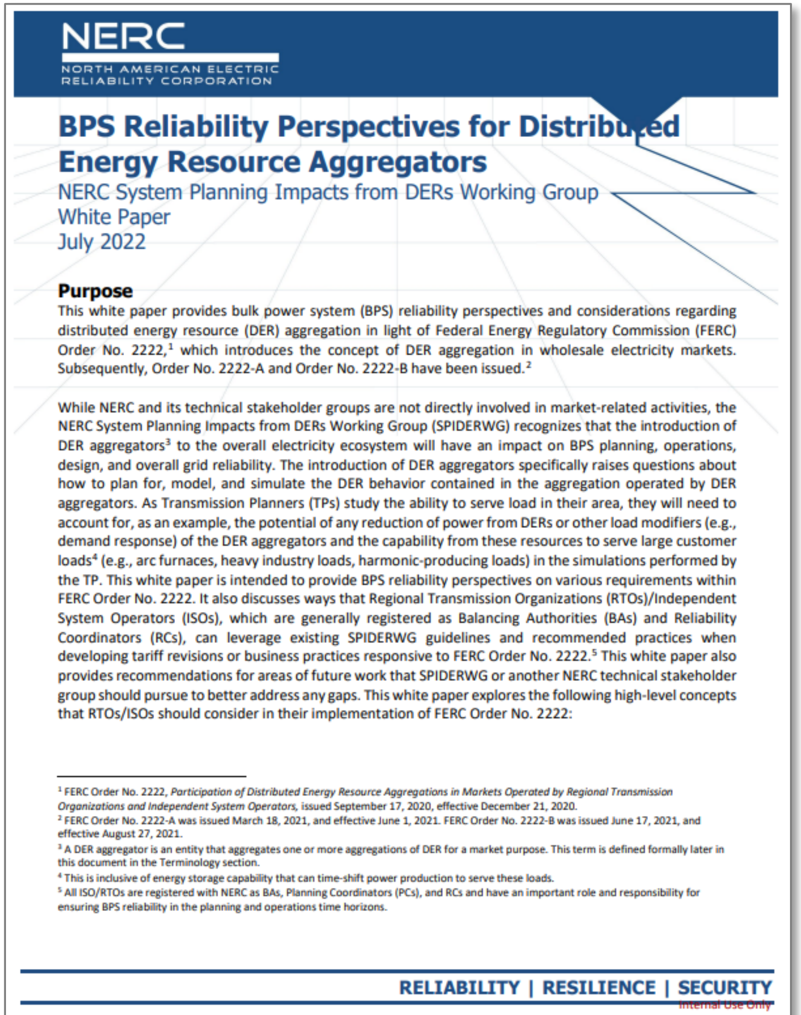
White Paper



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BPS Reliability Perspectives for Distributed Energy Resource Aggregators [link]

- Started in Q3 2021
  - ~50 Comments from industry and RSTC
  - SPIDERWG Coordination Sub-group comment resolution
- Published in July 2022

Purpose

Provide BPS reliability perspectives on various requirements within FERC Order No. 2222

Present existing SPIDERWG guidelines and recommended practices when developing tariff revisions or business practices responsive to FERC Order No. 2222 for Regional Transmission Organizations (RTOs)/Independent System Operators (ISOs) to leverage

Provide recommendations for areas of future work that SPIDERWG or another NERC technical stakeholder group should pursue to better address any gaps.

Purpose

- How ISO/RTOs consider the implementation of FERC Order No. 2222 could impact the ability of Transmission Planners (TPs) to ensure BPS planning and operating models and simulations remain accurate.
  - Particularly, which entities are responsible for providing the data, what data is being requested, and which entities receive the data
- How ISO/RTOs ensure that the study cases used by Transmission Planners (TPs) and Planning Coordinators (PCs) appropriately reflect the expected operating conditions of DERs and the results of implementing FERC Order No. 2222.
  - 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)

Definitions

- In FERC Order No. 2222, FERC amended the Open Access Transmission Tariff (OATT) by defining both “DER” and “DER aggregator” as shown here:
  - Distributed Energy Resource (DER): any resource located on the distribution system, any subsystem thereof or behind a customer meter.
  - Distributed Energy Resource Aggregator (DER aggregator): 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.

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.*

FERC Order No. 2222, page 93, P114
FERC Order No. 2222, page 95, P118

O2222 Overview

FERC ORDER 2222

A High Level Overview

ELECTRIC POWER RESEARCH INSTITUTE

What is a DER? What is a DER Aggregator?

***DER**: any resource located on the distribution system, any subsystem thereof or behind a customer meter*

***DERA**: Entity that aggregates one or more DER for purposes of participation in RTO and ISO markets*

What are the Key Implementation Challenges?

Operational Coordination → Aggregator Management → Metering and Telemetry → Market Design

How Does 2222 Enable DER to Participate in ISO/RTO Markets?

Key Eligibility Requirements

- All DER technologies can **heterogeneously** aggregate to meet RTO/ISO requirements, if aggregation is at least **100 kW** in size
- Existing and/or new **participation models**
- Aggregation as ***geographically broad as technically feasible***
- Data, bidding, metering, and telemetry for *DERAs* **balanced** with existing requirements, but reduce burden on *DERs*
- Limit compensation for the **same service** in other programs

ORDER 2222 enables DER participation in ISO/RTO Markets

Who does this impact?

Customers
DER
Aggregators
Distribution Utilities
RTOs/ISOs
Regulators

How Will Market Participation Be Coordinated?

- **Main market interface:** RTO/ISO ↔ AGGREGATOR
- **Key Elements of Coordination**
  - Distribution utility **preclears** DER to join an aggregator
  - Distribution utility may **override** DERA schedule to ensure distribution system safety and reliability
  - **Data sharing** practices between all parties
  - **Retail rate authorities** involved in coordination
  - Allow regional **flexibility,** no explicit **coordination framework**

What is the Timeline?

ISO tariff modifications due within 270 days. (7/19/21)though most extended to 2022. Implementation date part of each RTO/ISO proposal.

Relevant EPRI Research Areas

Grid Operations & Planning | DER & DER Integration | Information & Communications | Energy Utilization

Source: EPRI

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Key BPS Reliability Areas

- **Interconnection Standards:** These standards dictate the equipment requirements, specifications, and capabilities of the DER facility. This can ready DERs that may participate in the wholesale market via a DER Aggregator.
  - BPS Perspective on IEEE 1547-2018 adoption [link]
- **Services Provided:** The RTO and ISO may have markets available to procure enough resources in support of those services. The Distributed Energy Resource Aggregator may be able to alter the type and quantity of a specific service for a specific aggregation of DER.
  - NERC Essential Reliability Services Task Force (ERSTF) [link]
- **Electrical Characteristics at T-D Interface:** The electrical characteristics at this interface are dictated by the equipment sinks or sources on either side of the Interface, inclusive of DER, and the operation of such equipment. Inverter settings and control logic from the DER equipment impact the T-D Interface.

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.

Modeling

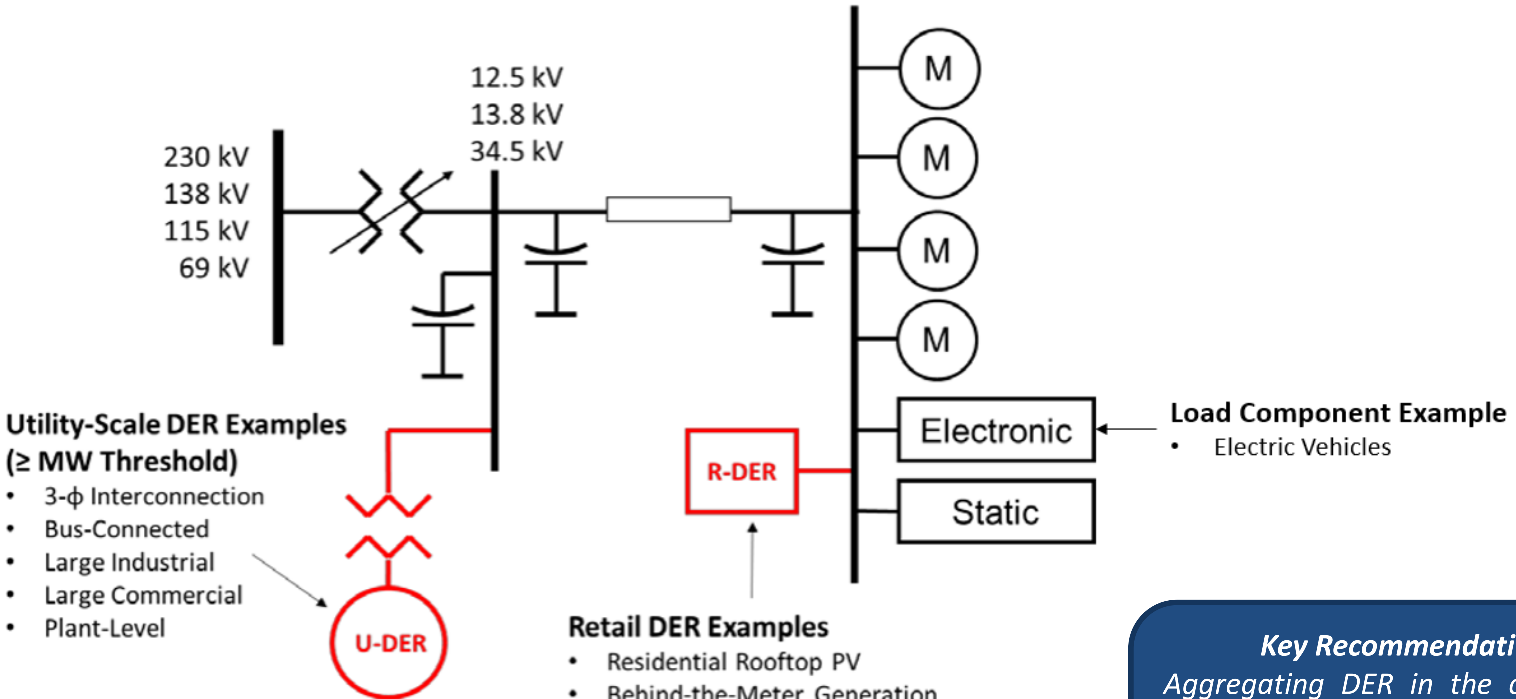


Figure M.2 DER Modeling Framework with DER Components and Load Components

Key Recommendation

Aggregating DER in the context of the Open Access Transmission Tariff (OATT) will not have a significant impact on recommended SPIDERWG modeling practices.

NERC Reliability Guidelines on Modeling: Reliability Guideline - Modeling DER in Dynamic Load Models, Reliability Guideline DER_A Parameterization, and Reliability Guideline DER Data Collection for Modeling

Verification

When developing telemetry requirements, SPIDERWG recommends that RTOs/ISOs consider using the *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies* as well as established interconnection requirements to determine the technical specifications of electrical metering and the electrical locations for the equipment.

It is important to involve the TOP in the definition of metering and telemetry devices used for the resources aggregated by a DER aggregator.

Key Recommendation

Utilize the *Reliability Guideline: Model Verification of Aggregate DER Models used in Planning Studies* [*link*]

Studies

FERC declines to exercise jurisdiction over DERs in DERA, does not require any specific DER procedures and agreement terms, but requires ISOs/RTOs to incorporate into their tariffs a DERA coordination process with distribution utilities

Section IV.H.2.c (Role of Distribution Utilities), Paragraph 294, Page 226f: *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.*

Section IV.I.2.c (Modifications to List of Resources in Aggregation), Paragraph 337, Page 254: *[…] require each RTO/ISO to establish market rules that address modification to the list of resources in a distributed energy resource aggregation. […] Because the impacts of modifications may often be minimal, **an abbreviated review process should be sufficient** for the distribution utility to identify the cases where an addition to the list of resources might pose a safety or reliability concern.*

Ensuring no adverse effect on reliability and operations

- *ISOs/RTOs need to (continue to) work with distribution utilities to collect the information needed to study the impact of DERA on the transmission system*
  - *NERC (2020): Reliability Guideline on DER Data Collection for Modeling in Transmission Planning Studies (link)*
- *Limit the scope of, and the time needed for, the DERA transmission impact study to essentials*
  - *For simplicity and out of precaution, may limit DERA to single transmission nodes or Sub-LAPs*
  - *Use the generic DER_A (link to NERC) model to represent inverter-based generation and storage with regional URPs*
- *Development of new methods and tools to study the transmission impact of multi-node DERA*
  - *Unclear value of "distribution factors" for multi-node DERA exchanging power across more than one transmission node*

Source: DER Aggregation Participation in Electricity Markets: EPRI Collaborative Forum Final Report and FERC Order 2222 Roadmap. EPRI. Palo Alto, CA: 2022. 3002020599. [link online]

Studies

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 , coordination of data, information, models, practices, etc., will have to be updated consistently to ensure the DER aggregation is reflected properly in operational, near-term, and long-term studies.

DER aggregators may also impact regional and inter-regional planning practices like UFLS required by PRC-006-5 - *SPIDERWG's Reliability Guideline: Recommended Approaches for UFLS Program Design with Increasing Penetrations of DERs* [link]

Coordination

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 operation of the BPS.

- 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

Key Recommendation

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.*

Summary

Interconnection Requirements

1

- Adoption of IEEE 1547-2018 with flexibility provided by 1547a-2020
- Require inverters to be certified under UL 1741 SB starting Jan 1, 2023

DER Data & Settings

- Collection and exchange of DER data across T&D interface

2

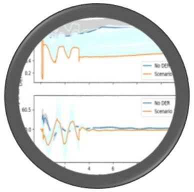
- Coordinate and verify DER functional *settings* that can impact bulk system reliability

DERA Transmission Impact Screening

3

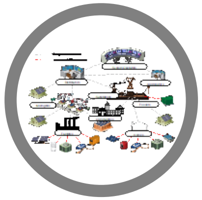
- Conduct Simplified Screening Tests during DERA Transmission Technical Review/ Registration
- Confirm DERA members' functional settings

Modeling & Simulation



- Utilize advanced DER and DERA models and appropriate parameterization
- As needed, use of Aggregate DER (DER_A) model or OEM-provided models, see also: https://www.epri.com/pvmod

DERA Integration into Grid Operations



- Further develop NERC and IEEE models and standards
- Consider registering DER Aggregators as a NERC entity

***More Information:* DER Aggregation Participation in Electricity Markets: EPRI Collaborative Forum Final Report and FERC Order 2222 Roadmap. EPRI. Palo Alto, CA: 2022. 3002020599. [Online] https://www.epri.com/research/products/000000003002020599**

Future Work

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 & 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 of the DER aggregator for NERC standards.	Various	SPIDERWG	TBD

Cybersecurity Posture and Certifications for DER and DER Aggregators

Larry Collier, NERC
Ryan Cryar, NREL

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Cybersecurity Posture and Certifications for DER and DER Aggregators

Larry Collier, North American Electric Reliability Corporation (NERC)
Ryan Cryar, National Renewable Energy Laboratory (NREL)

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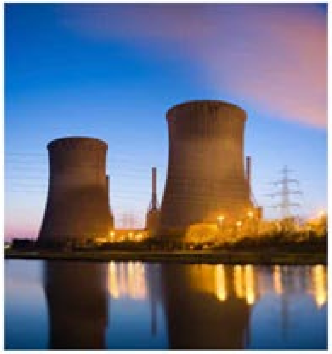
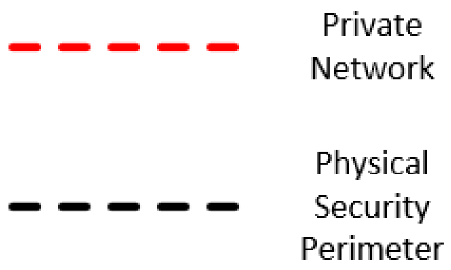
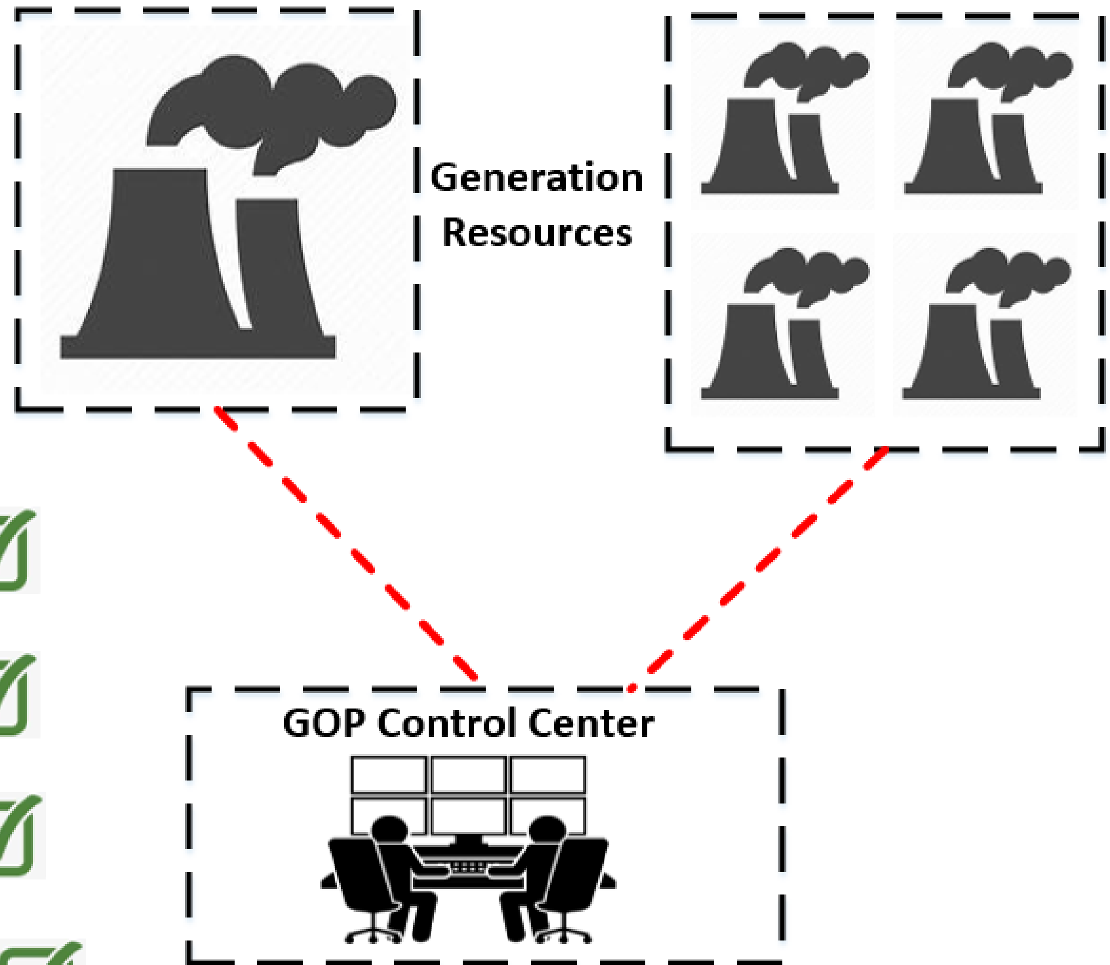


BPS Generation Operator



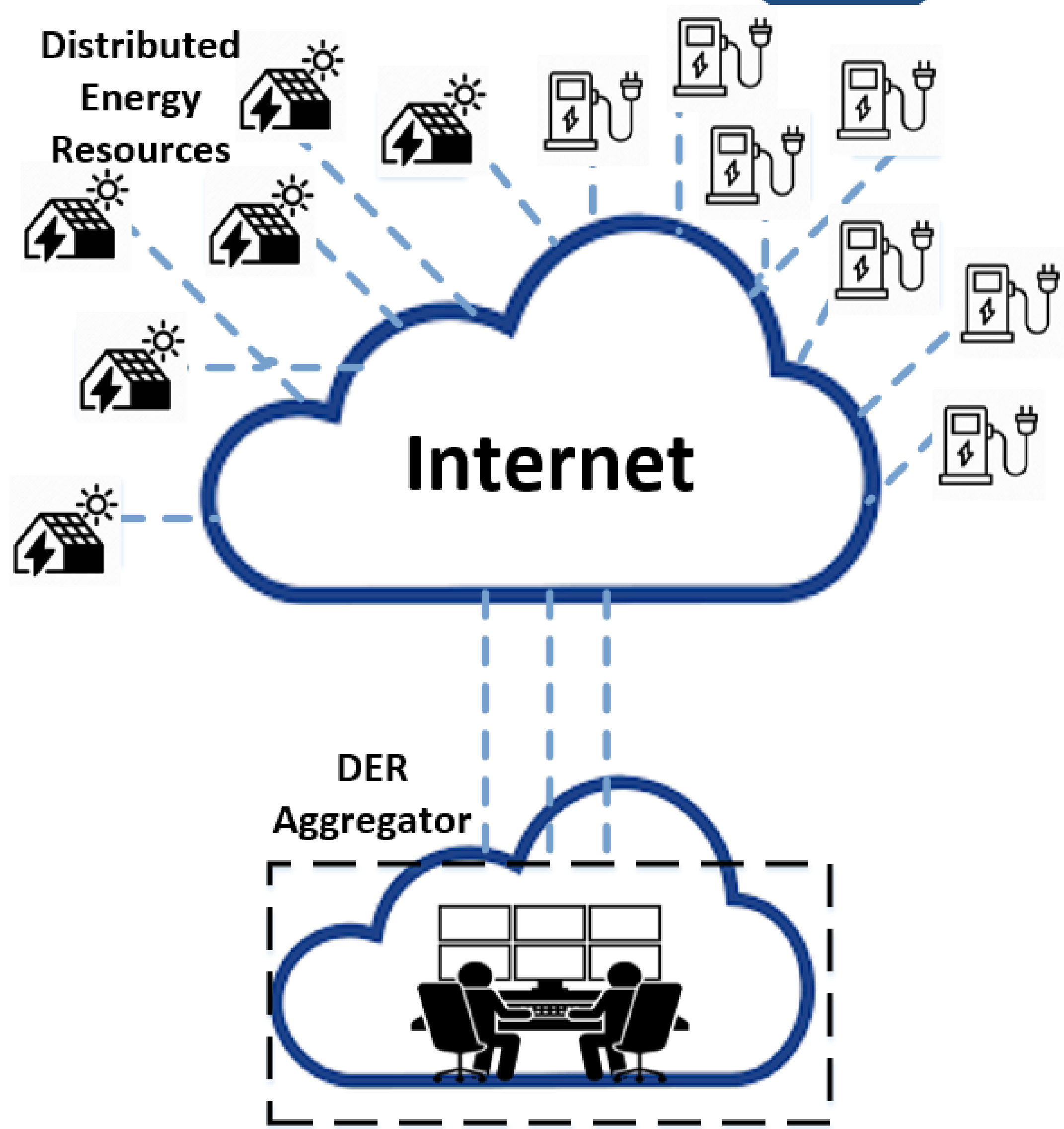


- Physically Secured ☑
- Private Networks ☑
- Security Standards ☑
- Compliance Oversight ☑

DER Aggregator

Public Network

Physical Security Perimeter



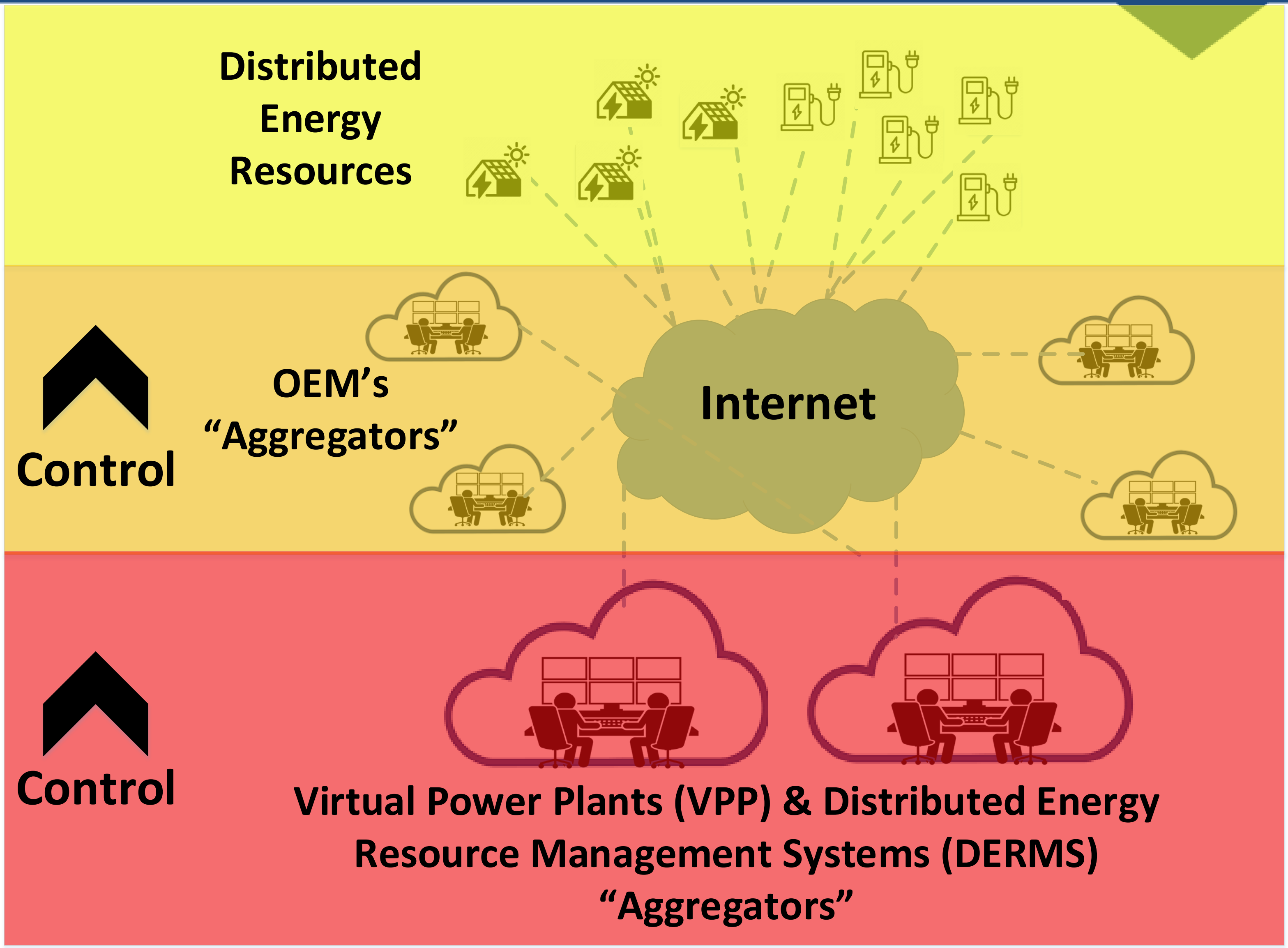
Physically Secured ✓

Private Networks ✗

Security Standards ✗

Compliance Oversight ✗

Follow The Control



Securing DER - Challenges

- DER controllers that are Industrial Internet of Things (IIoT) - internet connected, independently owned, and de-centralized
- Grid innovation is trending towards smarter devices and protocols with more connectivity and control functionality (1547-2018)
- Diverse DER hardware and diverse communication protocols including vulnerable legacy protocols (DNP3, Modbus) and numerous proprietary protocols
- Distributed Denial of Service (DDoS) resiliency needed for grid dependent, internet-accessible services
- Ownership of incident response & recovery of DER’s – Imagine thousands of endpoints infected by malware – precedent with present IoT devices infected and added to botnets

Need For Controls

Controls Needed

- Access Controls & Authorized Connections Only
- Authentication
- Encrypted Communications
- Data Integrity Verification
- Logging
- Certification Request / Renewal
- Security Patching
- VPP Network Self-Healing and Self-Quarantining
- *Secure* Open Standard Communication Protocol for VPP

Innovation Areas

- DER Device Level
- Protocol Security
- Security Gateway Devices

Approved SITES Whitepaper Summary

- Cybersecurity for DER & DER Aggregators - Approved by RSTC Dec 06, 2022
  - SITES Whitepaper
    - Highlights:
      - Potential risks to the BPS from DER Aggregators
      - Lack of NERC CIP applicability
      - IEEE 1547-2018 + UL 1741 for DER interconnection & interoperability
      - IEEE 1547.3 + New UL certification for DER device level security
  - Recommendations:
    - Potential registration of DER Aggregators as a NERC registered entity
    - Callout for industry to support and adopt IEEE 1547.3 and UL certification for device level security
    - Interconnection authorities to establish cyber security requirements for DER

SPIDERWG + SITES Joint Whitepaper

- Privacy and Security Impacts of DER and DER Aggregators – In Progress

Joint SPIDERWG/SITES Whitepaper

- Proposed Outline
  - Survey the current distribution landscape of security controls for DER and DER Aggregators
  - Identify cyber risk scenarios including data confidentiality
  - Identify security controls and their mitigation of risk scenarios
  - Understand DER Aggregator reliability impact to BES with CIP-002 as inspired guidance
  - Make recommendations:
    - Security controls for DERs
    - Security controls for DER Aggregators

Cybersecurity Certification – Why Now?

- Why should we care about developing DER cybersecurity certification now?
- Solar is 3% of todays electricity generation
- Rooftop and small solar in the Western Interconnection is approximately 30,000 MW
- This represents about 65% of all solar in the west, none of which is required to follow NERC CIP

Photo by Dennis Schroeder, NREL 22168

A national or international cybersecurity certification standard can aid industry stakeholders to evaluate and validate the cybersecurity posture of the DER devices before they are connected to the electric grid.

CNN

Biden administration says solar energy has the potential to power 40% of US electricity by 2035

Nilsen, Ella. CNN.com, September 8, 2021. url

Reuters

Solar energy can account for 40% of U.S. electricity by 2035, according to DOE

Volcovici, Valeri. Reuters.com, September 8, 2021. url

NBC

Nearly half of U.S. electricity could come from solar by 2050, Biden administration

Lederman, Josh. NBC.com, September 8, 2021. url

NERC

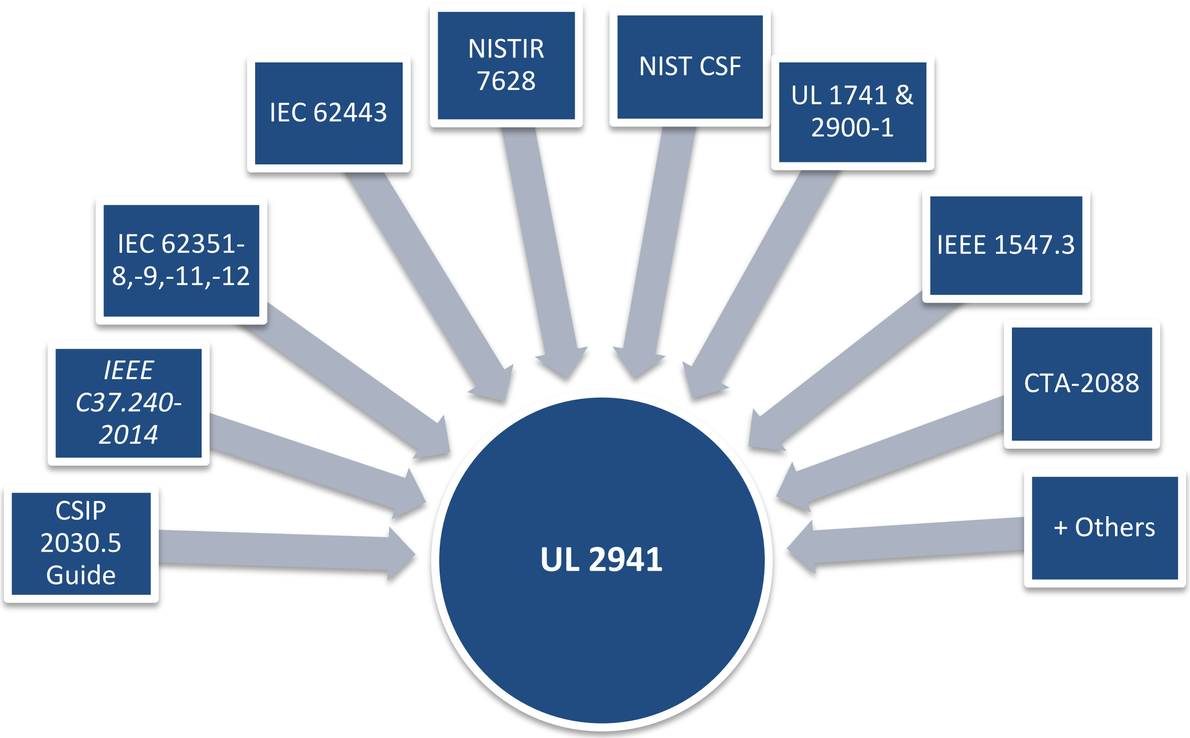
Variable-energy resources ….continue to be a significant component of new capacity

NREC Planning Committee Meeting, June 6, 2017. url

UL 2941: An Introduction

The UL cybersecurity certification standard will:

- Build on past work
- Map and leverage security requirements from industry best practices for hardware and software
- Provide an information hub for DER Industry stakeholders
- Establish "Security by Design"
- UL will lead development of the cybersecurity certification standard.



Note: All these standards serve a different purpose.
The UL cybersecurity certification standard will not replace them by any means.

Outline of Investigation (OOI)

PRESS RELEASE

UL and NREL Announce Cybersecurity Testing Recommendations for Distributed Energy Resources and Inverter Based Resources

UL and the National Renewable Energy Laboratory will complete an Outline of Investigation as a precursor to the first cybersecurity certification standard for distributed energy resources.

Home > News > UL and NREL Announce Cybersecurity Testing Recommendations for Distributed Energy Resources and Inverter Based Resources

March 7, 2022

NORTHBROOK, Illinois – March 7, 2022 – UL, a global safety science leader, has released a report, co-authored with the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL), titled "Cybersecurity Certification Recommendations for Interconnected Grid Edge Devices and Inverter Based Resources." The report includes recommendations that enable distributed energy resources (DER) and inverter based resources (IBRs) to maintain a strong cybersecurity posture.

With support from DOE's Solar Energy Technologies Office, UL will continue working with NREL on developing requirements to support cybersecurity certification standards for DERs and IBRs. NREL and UL are currently working on an Outline of Investigation for a standard that will apply to energy storage and generation technologies on the distribution grid, including photovoltaic inverters, electric vehicle chargers, wind turbines, fuel cells and other resources essential to advancing grid operations. These new requirements will prioritize cybersecurity enhancements for power systems dealing with high penetration inverter-based resources, including those interfacing with bulk power systems for periods of instantaneous high wind, solar and hybrid/storage generation. It will also help ensure cybersecurity is designed into new IBR and DER systems.

"Currently, there are no cybersecurity certification requirements to which manufacturers and vendors can certify their DER and IBR devices against an established and widely adopted cybersecurity certification program. The development of these new cybersecurity certification requirements will provide a single unified approach that can be taken as a reference for performing the testing and certification of DERs before being deployed and while in the field," said Kenneth Boyce, senior director for Principal Engineering, Industrial, group at UL. "Drafting comprehensive certification requirements with peer review requires effective leadership and stakeholder participation. We are pleased to be working with NREL in this effort to bring additional performance-based security to electrical grid infrastructure."

- The requirements will provide a single unified approach for testing and certification of DERs in *advance* of deployment.
- The certification will be applicable to generation and energy storage technologies.
- UL and NREL are actively developing the OOI.
- Feedback was received from 10 manufacturers, a few utilities, and three national labs
- Publishing version 1 of OOI by end of year
- In calendar year 2023, will have one more round of formal feedback sonication
- To receive news and information, please visit UL news.

Process from OOI to Certification Standard

1. Research existing standards, guides, and competitive technologies in the market.
2. Define and translate industry needs into requirements for inclusion in the standard.
3. Draft the Outline of Investigation (OOI).
4. Circulate draft OOI with relevant experts.
5. Publish the Outline of Investigation.
6. Request an American National Standard designation from ANSI.
7. Assemble a balanced committee for a Standards Technical Panel (STP).
8. STP edits OOI and votes on the draft.
9. Draft is published as an ANSI Standard

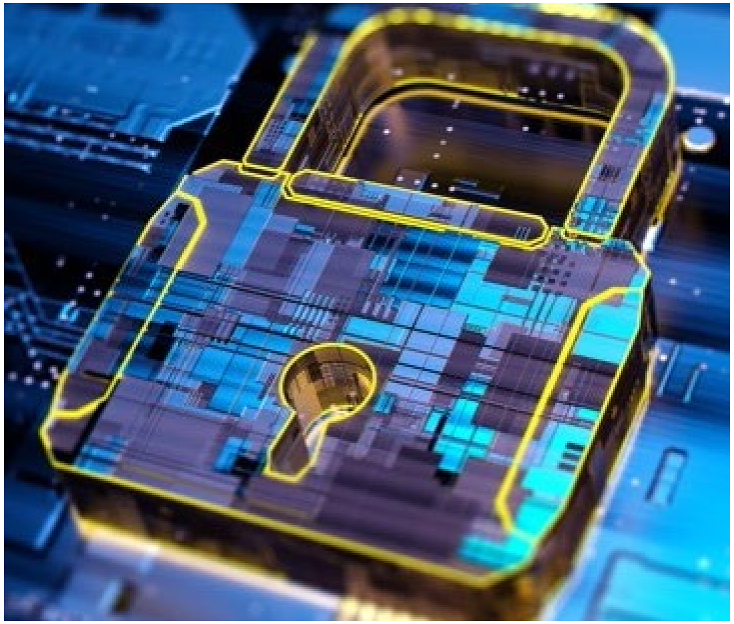
Organization and Engagement

CONTENTS

* Draft, subject to change

- Draft v6
- Testable requirements categorized into 11 domains
- Addressed comments from industry, in final reviews for v1
- v1 publication end of December
- Feedback from manufacturers, installers/aggregators, utilities, and national labs
- Controls on public key infrastructure, access control, and remote management
- **UL will serve on the advisory board** and help drive select committees and working groups to advance key cybersecurity objectives.
- **UL's goal** is to structure cybersecurity and promote adoption of the cybersecurity certification standard.

Benefits of a Cybersecurity Certification Standard



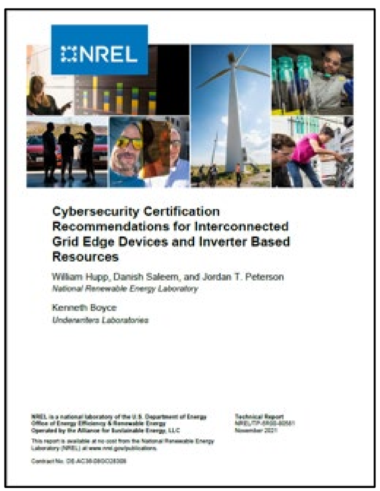
- Ensures DER devices have all five pillars of cybersecurity: confidentiality, integrity, availability, authentication, and non-repudiation
- Supports federal and state mandates
- Establishes security by design in new DER systems
- Creates an environment where the baseline security posture of the DER industry will be elevated

What Needs To Be Done

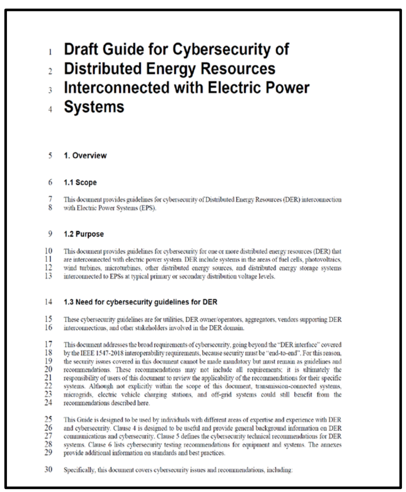
- Better coordination between government agencies and industry stakeholders to enhance DER Security.
- Acceleration of public awareness, education, and training for stakeholders about risks associated with DERs.
- Identification of risks and addition of incentives-based programs to incorporate DER security.
- Development of a cybersecurity certification to ensure “security by design” for new DER systems.

Outcomes of Cybersecurity Standards Initiatives

Provides a baseline for device-level security and informs the development of a cybersecurity certification standard for DER stakeholders



Provides cybersecurity guidelines for one or more distributed energy resources that are interconnected with electric power system



Provides cybersecurity certification requirements that IBR equipment shall support in a way that the choice of implemented technology is at the manufacturer's decision.

Provides engagement activities to bring together individuals across industry, academia, and government to exchange ideas and learn.

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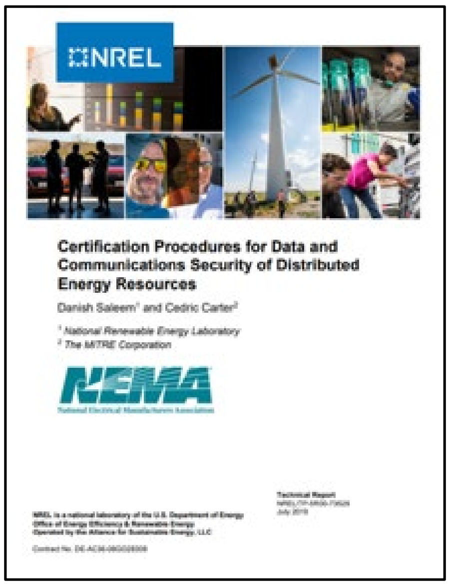
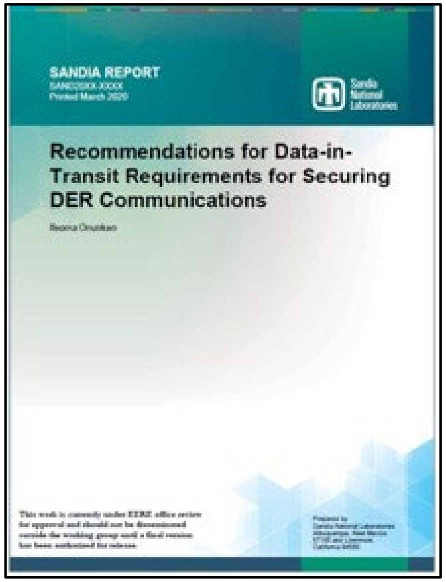
Outcomes of Cybersecurity Standards Initiatives Cont.

Provides test cases that can be used to check, verify and validate cybersecurity posture of DERs

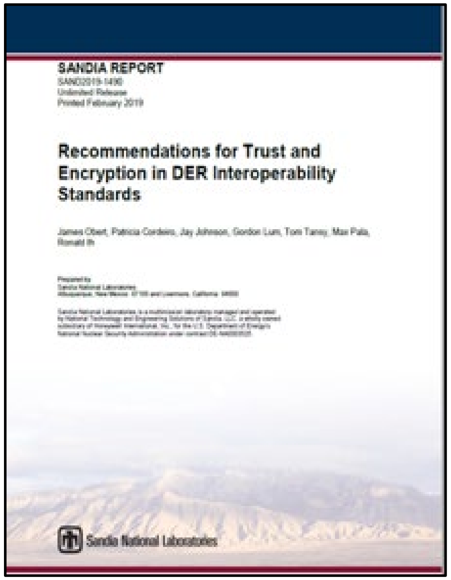


Provides practical cybersecurity requirements pertaining to the network components supporting DERs.

Examines the cybersecurity requirements for DER comms protocols, per IEEE 1547-2018 revision



Provides near and long-term recommendations to improve trust and encryption mechanisms for DER comms



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Roadmap of Next Steps

- Publish the Outline of Investigation.
- Develop appropriate third-party conformity assessment programs for DER cybersecurity testing and certification.
- Develop white papers, a press release, industry webinars, and related activities to increase awareness.
- Organize and host a DER cybersecurity summit for thought leaders and key stakeholders from national laboratories, utilities, and the energy and renewables industries to establish practical and actionable plans to move forward.

Thank you

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Transforming ENERGY

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Questions and Answers

DER Aggregator or VPP?

Brian Chen, PG&E
Kevin Joyce, Tesla

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PG&E and Tesla Virtual Power Plant

Brian Chen, Senior Program Manager, Pacific Gas & Electric Co.
Kevin Joyce, Staff Product Manager, Tesla Energy

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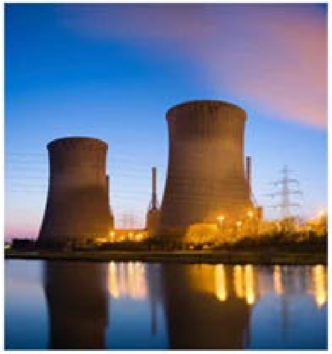


The California Context

- Extreme heat waves over the past few years have strained reliability
  - Aug. 2020 – CAISO orders LSEs to implement Rotating Outages
  - Sep. 2022 – new CAISO peak load of 52 GW set
- CA and PG&E have ambitious goals on GHG reduction and Electrification
  - Senate Bill 100 – Carbon free electricity by 2045
  - CA Air Resources Board – 100% new car sales are ZEV by 2035
  - PG&E pledges net-zero emissions by 2040
  - VPPs are critical tool in PG&E’s demand-side true north strategy

Background and Objectives of the VPP

- Initial engagement started as a study in 2021 under the Demand Response Emerging Technology (DRET) program
  - Assess the ability to enroll existing battery owners into a study to use their battery for grid needs in exchange for payments
  - Determine ex-post load impacts of the batteries when dispatched under varied event conditions
  - Assess whether and how much batteries are able to export to the grid during an event.
  - Assess the ability of the existing dispatch algorithms to deliver a flexible, controllable grid resource.
- VPP Characteristics
  - Out-of-Market demand-side resource
  - Comprised of residential customers
  - Underlying DERs are solar and battery storage
  - 1,300 enrolled participants/ 11.74 MW nameplate for VPP

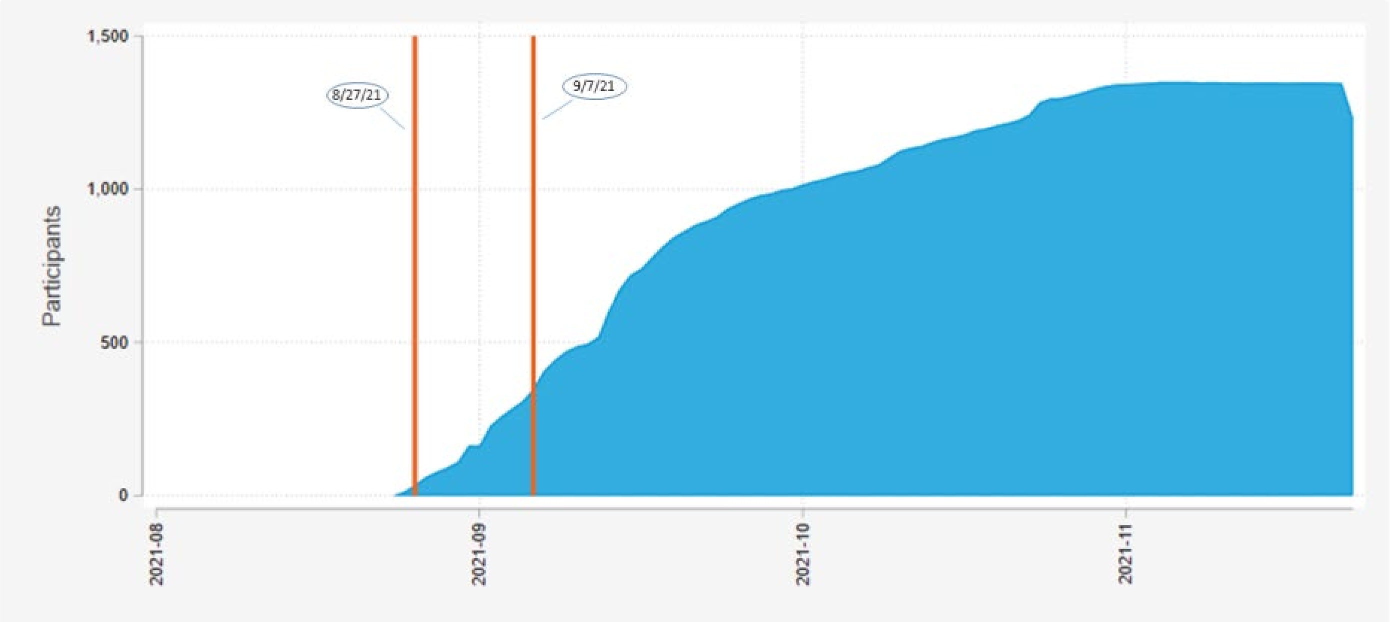
VPP Characteristics

- Out-of-Market demand-side resource
- Comprised of residential customers
- Underlying DERs are solar and battery storage
- 1,300 enrolled participants/ 11.74 MW nameplate for VPP

Customer Experience for VPP

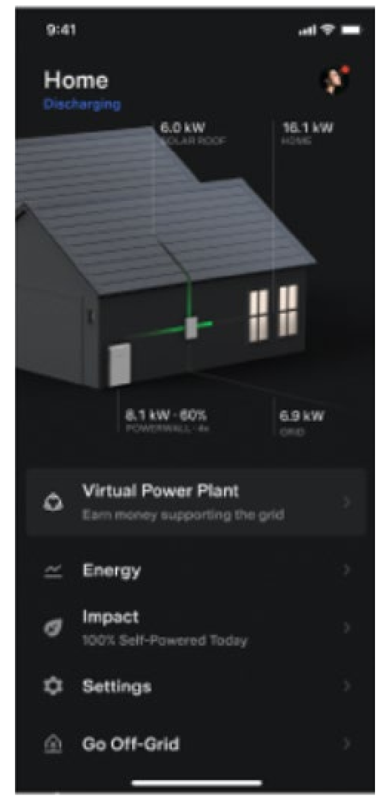
- Targeted recruitment of 7,000 residential customers with Powerwalls via Tesla App
- 1,300 enrollments (~19% enrollment rate)
    - Eligibility: has solar, Powerwall, interconnection agreement, no conflicting DR program

Enrollment Trend Through Study

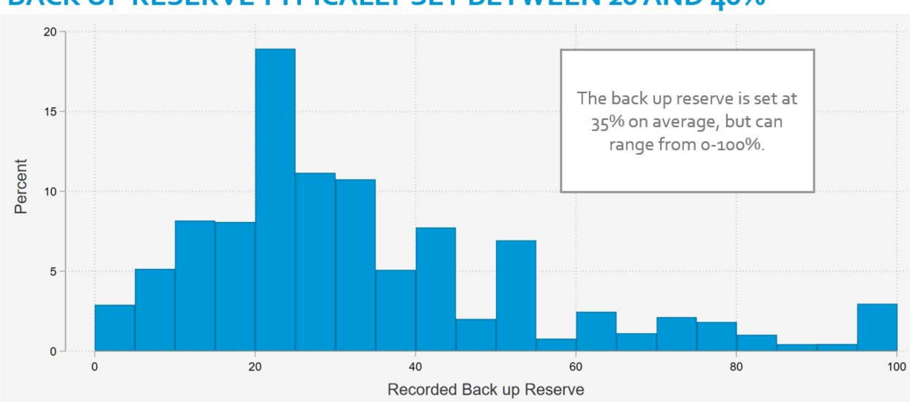


Customer Experience for VPP

- Tesla App is central experience for participants to interact with their Powerwall and the Study.
  - Event Notifications
  - Event Opt-outs
  - Capacity Reservation Level
- Customer incentive: $1/kWh for incremental discharge



BACK UP RESERVE TYPICALLY SET BETWEEN 20 AND 40%



Operations of VPP

- Event Triggers for the Study
  - CAISO Energy Emergency Alerts
  - Market-Informed Price Trigger
- Event Days

Event No.	Date	Average Event Temperature (F)	Daily Max Temp(F)	Event Start	Event Duration (hours)	Weekday or Weekend
1	10/19/2021	60.0	67.0	6:00 PM	3	Weekday
2	10/20/2021	61.6	65.0	5:00 PM	3	Weekday
3	10/27/2021	63.9	71.3	6:00 PM	3	Weekday
4	10/28/2021	67.4	75.7	5:00 PM	3	Weekday
5	10/29/2021	68.7	75.3	4:00 PM	3	Weekday
6	11/3/2021	63.0	71.3	6:00 PM	3	Weekday
7	11/6/2021	58.7	63.4	5:00 PM	3	Weekend

Performance of VPP

			AMI			Battery		
Date	Event Start	Average Event Temperature (F)	Hour 1	Hour 2	Hour 3	Hour 1	Hour 2	Hour 3
10/19/2021	06:00PM	60.0	3.01	2.08	0.22	3.33	2.36	0.40
10/20/2021	05:00PM	61.6	3.04	0.84	-0.31	3.22	0.77	-0.40
10/27/2021	06:00PM	63.9	5.09	2.89	0.22	5.08	2.86	0.15
10/28/2021	05:00PM	67.4	5.21	2.95	0.05	5.18	2.91	-0.03
10/29/2021	04:00PM	68.7	5.07	3.27	0.32	5.00	3.29	0.13
11/3/2021	06:00PM	63.0	5.63	4.10	0.76	5.31	4.43	0.62
11/6/2021	05:00PM	58.7	5.62	3.90	0.64	5.15	3.66	0.95
Average Event Day (05:00-08:00PM)	**05:00PM**	**62.6**	**4.62**	**2.56**	**0.13**	**4.52**	**2.45**	**0.17**
Average Event Day (06:00-09:00PM)	**06:00PM**	**62.3**	**4.58**	**3.03**	**0.40**	**4.57**	**3.21**	**0.39**

- Load impacts estimated using premise-level Smart Meter (AMI) interval data comparable to Battery level interval data
- Consistent performance across consecutive day dispatches as well as weekdays vs weekends
- Net exports to the grid found: average 3.27 kW over 2 hours
- DRET Study ended in 2021 and report published on findings and results.
  - Full Study available from Emerging Technologies Coordinating Council webpage: etcc-ca.com

Current and Future Efforts

- Learnings and processes from Study have been carried over to create new VPP under the Emergency Load Reduction Program (ELRP) pilot.
  - ELRP conceived post August 2020 Rotating Outages
  - Emergency, reliability DR program
- Key Parameters of the ELRP
  - Out-of-Market demand-side resource
  - Availability: May – Oct., 7 days a week between 4-9pm
  - Event Triggers: Flex Alert, EEA Watch, EEA 1/2/3
  - Customer Incentive: $2/kWh for incremental discharge
- The VPP Today
  - 4,400 enrolled participants/21 MW capacity
  - Areas of improvement:
    - Customer engagement and experience enrolling and participating in the VPP
    - Ability to deliver at targeted capacity level over longer durations

The VPP in Action

- VPP called to action during week-long heat wave
  - CA Governor's Emergency Proclamation
  - New CAISO peak load of 52 GW set
- Customer applications and enrollments accelerated through the heat wave
  - Supported concurrent statewide conservation messaging with prospective and current participants
  - Participants remained engaged (e.g. event opt-outs, updating reservation levels)
- Performance during key event hours were firm and reliable.
  - No signs of conventional *fatigue* despite customer control (consistent with DRET findings)

Event No.	Event Date	Start Time	Event Duration	Event Type	Participants	Peak EEA Stage	Peak Capacity (MW)
1	8/17/2022	4:00 PM	5	Day Ahead	2,200	Flex Alert	14
2	8/31/2022	5:00 PM	3	Day Of	2,700	EEA 1	16
3	9/1/2022	6:00 PM	1	Day Ahead	2,800	EEA Watch	18
4	9/3/2022	6:00 PM	2	Day Ahead	2,900	EEA Watch	18
5	9/4/2022	5:00 PM	3	Day Ahead	3,300	EEA Watch	20
6	9/5/2022	5:00 PM	4	Day Ahead	3,500	EEA 2	21
7	9/6/2022	4:00 PM	5	Day Ahead	3,550	EEA 3	20
8	9/7/2022	4:00 PM	5	Day Ahead	3,600	EEA 2	21
9	9/8/2022	4:00 PM	5	Day Ahead	3,700	EEA 2	22
10	9/9/2022	4:00 PM	4	Day Ahead	3,800	EEA 1	22

Questions and Answers

BREAK

Interact with us at Slido!

Use the QR Code here to join the poll or enter #DERWorkshop at

https://www.slido.com/

SPIDERWG White Paper: NERC Reliability Standards

Shannon Mickens, SPP

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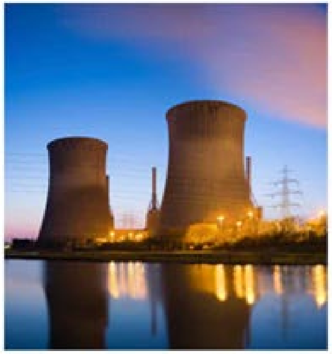
SPIDERWG White Paper

NERC Reliability Standards Review

Shannon V. Mickens, Senior Reliability Standards Engineer
NERC DER Workshop

RELIABILITY | RESILIENCE | SECURITY

Background

- NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG) wanted to conduct an review of the NERC Reliability Standards to determine the potential impact of Distributed Energy Resources (DERs)
  - There were 78 NERC Standards that were reviewed except CIP and NUC based on SME knowledge in SPIDERWG
- During that review process, SPIDERWG realized that a technical white paper could be developed and serve as a technical gap analysis document (white paper)

Timeline

- Early 2020
  - The sub-teams started the review of the NERC Standards
- MID 2020-2021
  - The sub-teams worked on the white paper development, SPIDERWG (over all group) reviewed of the document as well as initial outreach with industry was conducted
  - 2022
    - SPIDERWG leadership made their presentation at the RSTC March Meeting Requesting Reviewers
    - SPIDERWG sub-teams Reviewed RSTC members Response, implemented suggestions and re-circulated the document through the SPIDERWG (over all group)
    - SPIDERWG leadership requested and received RSTC approval at their September Meeting.

Standards Review Approach

- A comprehensive review was conducted by applying a review template with relevant information to ensure consistency across review teams.
- Consideration during review
  - Should the standard applicability section be updated to consider aggregate DERs?
  - If the standard uses the terms “Load” or “Demand”, are these terms still clear with the consideration of DERs so that no changes to the standard requirements are needed?
  - Will the effectiveness of the standard be affected by increasing levels of DERs?
  - Would the collection of DER data affect the implementation of the standard (i.e., would the ability to gather DER data affect the ability to fulfill the purpose of the standard)?
  - Will the increasing penetration of DERs require entities to change the methods they use to implement the standard requirement.
  - Other comments

White Paper Structure

- Prioritization- High, Medium, and Low
  - Priority determinations are given to the help guide the Standards Committee (SC) in deciding which items take precedent and will likely lead to reliability issues in the near-term
- Recommendations of the white paper are divided into tables identifying:
  - Standards needing revision
  - Standards needing supplementary reliability guidelines
  - Standards that need revision and supplementary reliability guidelines
  - Standards considered for future revision
  - Standards that do not need any revision or any other further actions
  - Acknowledging standards that have been retired

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RSTC Review Response

- Received mainly clarification and justification feedback; SPIDERWG responded by:
  - Providing connection to SPIDERWG glossary of terms to understand use of “DER”
  - Added language for specificity and to further describe reasoning/rationale
    - Provided links to RSTC approved SPIDERWG work plan items such as reliability guidelines, white papers, etc., work encompassing areas of
      - Modeling
      - Verification
      - Forecasting
  - Re-prioritization of recommendation
    - High priority -> Medium priority
  - Recommended action revision
    - Standard revision -> no action needed
- Addressing DER Aggregator Registration

Statistics

- Standards recommended for revision
  - 11 Standards

Standard Type	Count	Priority
BAL	1**	Low
EOP	2**	Medium (2)*
FAC	2	High (2)
MOD	1	High (1)
PRC	1	Low (1)
TOP	4	Low (4)

*Indicates priority change based on RSTC review feedback

**Indicates that the review team also identified the need for a reliability guideline on the general subject

Recommendations/Finding

- **High Level**
  - FAC-001-3 - Revise the standard to include the DP in the Applicability section
  - FAC-002-3- Revise the standard to ensure responsible entities perform study when aggregate DERs cause material modifications to electricity end-user facilities
  - MOD-031-2- Revise the standard to ensure that existing and forecasted DER data is provided by DPs or Transmission Planners (TPs) to the Planning Coordinator (PC) upon request7 Allow TPs to be an intermediary to provide data from DPs to the PC

Recommendations/Finding

- **Medium Level**
  - EOP-004-4*- Revise the standard to ensure proper reporting of the loss of aggregate DERs to NERC with defined thresholds.6
  - EOP-005-3*- Revise the standard to establish telemetry requirements for DERs and/or distribution providers (DP)

Recommendations/Finding

- **Low Level**
  - BAL-003-2*- Revise the standard to ensure consistent accounting of DERs in balancing calculations
  - PRC-006-3 -Revise R3 of the standard to specify whether net or gross load is required for underfrequency load shedding (UFLS) studies Low
  - TOP-001-4- Revise the operational planning analysis (OPA) and real-time analysis (RTA) definitions to explicitly enumerate aggregate DER or non-Bulk Electric System (BES) generation output levels Low

Recommendations….Continued

- **Low Level**
  - TOP-002-4- Revise the OPA definition to include aggregate DER or non-BES generation output Levels Low
  - TOP-003-3- Revise the OPA and RTA definitions to include aggregate DER or non-BES generation output levels Low
  - TOP-010-1(i) - Revise the RTA definition to include aggregate DER or non-BES generation output levels

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Statistics

- Standards recommended for supplemental reliability guidelines
  - 11 Standards

Standard Type	Count
BAL	3**
EOP	3**
IRO	1
MOD	1
PRC	3**

*Previously twelve (12) recommended reliability guidelines, changed to eleven (11) based on RSTC review feedback

**Indicates that the review team also identified the need to revise the standard in addition to developing a guideline (1 BAL, 2 EOP)

***Previously four (4) PRC standards recommended for reliability guidelines, changed to three (3) based on RSTC review feedback

Recommendations/Findings

- BAL-002-3- Reliability guideline on approaches to DER accounting in reserve management
- BAL-003-2*- Reliability guideline on managing adequate levels of frequency response with increasing levels of DERs
- BAL-005-1- Reliability guideline on approaches to DER accounting in reserve management
- EOP-004-4*- Reliability guideline on detection and calculation of aggregate DER loss during and after an event to facilitate accurate reporting
- EOP-005-3*-Reliability guideline on coordination and data exchange between the Transmission Operator(TOP) and DP for development of restoration plans, including information regarding aggregate DER levels and expected operating characteristics

Recommendations….Continued

- EOP-011-1-Reliability guideline on how load shedding schemes may need to consider the amount of DERs impacted by such load shedding practices to ensure minimal power system impact and that load can be effectively shed without the loss of considerable levels of generation
- IRO-018-1(i)- Reliability guideline for telemetry, communication, data handling capability coupled with data quality issues associated with increasing DERs
- MOD-033-1- Reliability guideline providing industry recommended practices for collection and validation of DER and distribution level characteristics should be developed
- PRC-010-2 SPIDERWG is presently working on a white paper emphasizing that under-voltage load shedding(UVLS) programs should be coordinated with DER ride-through capabilities

Recommendations….Continued

- PRC-012-2 -Reliability guideline discussing the impact of DERs on Remedial Action Scheme (RAS) design and performance
- PRC-027-1- Reliability guideline discussing the impact of “nuisance” trips of aggregate amounts of DER for BPS faults due to miscoordination of DP-owned protection systems

Statistics

- Standards Considered for Future Revision
  - 2 Standards

Standard Type	Count
FAC	1
IRO	1

  - SPIDERWG is documenting these considerations and issues that may warrant possible standards projects as the integration of DER continues.

Recommendations/Findings

- FAC-011-3-Revise the standard to address potential system operating limit (SOL) inaccuracies caused by the variability or uncertainty of DERs and the change of power flows at the transmission–distribution interface
- IRO-001-4 - Revise the standard requirements focused on managing reliability impacts from aggregate DERs

Statistics

- Standards with No Action Needed
  - 54 Standards

Standard Type	Count
BAL	1
COM	2
EOP	3
FAC	5*
INT	4*
IRO	7
MOD	10*
PER	3
PRC	16
TPL	1
VAR	2

*Indicates that this standard was retired –1 FAC, 2 INT, 1 MOD

Next Steps

- SPIDERWG Coordination
  - Has taken the initiative to creating three (3) SARs pertaining to the Standards with high recommendation for revision
  - FAC-001, FAC-002 and MOD-031
    - FAC-001 and FAC-002 SARs were on the RSTC December 2022 meeting agenda to request RSTC reviewers of the SARs. The request was approved.
  - SPIDERWG intents are to have the RSTC feedback implemented into the document and approved by the SPIDERWG (over all group) as well as have SARs in front of the NERC RSTC and SC by Quarter 1 2023
- SPIDERWG Analysis (Subcommittee)
  - Has taken the initiative to creating two (2) SARs pertaining to the Standards with medium recommendation for revision
  - EOP-004 and EOP-005

SPIDERWG Technical Report: Beyond Positive Sequence Simulations

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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Technical Report: Beyond Positive Sequence Simulation

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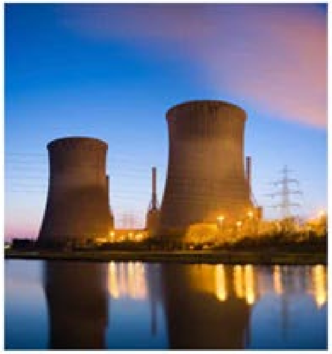
Karthikeyan Balasubramaniam, ANL

NERC DER Workshop

December 14, 2022

RELIABILITY | RESILIENCE | SECURITY



Presentation Outline

- Introduction
- Why this technical Report?
- Approach
- Case Studies
- Now what for Planning Engineers and industry?
- Questions

Why "Beyond Positive Sequence Simulation?

- Unbalanced faults impact of DERs on BPS
- No consideration for detailed representation of distribution system dynamics in Positive sequence simulation
- Distribution studies typically does not involve dynamic studies of DER control instability and interactions
- The problem of masking individual behavior of DERs on distribution system due to Aggregation
- DER tripping
- Limitations to capture voltage variations of DERs at the distribution levels in positive sequence simulation

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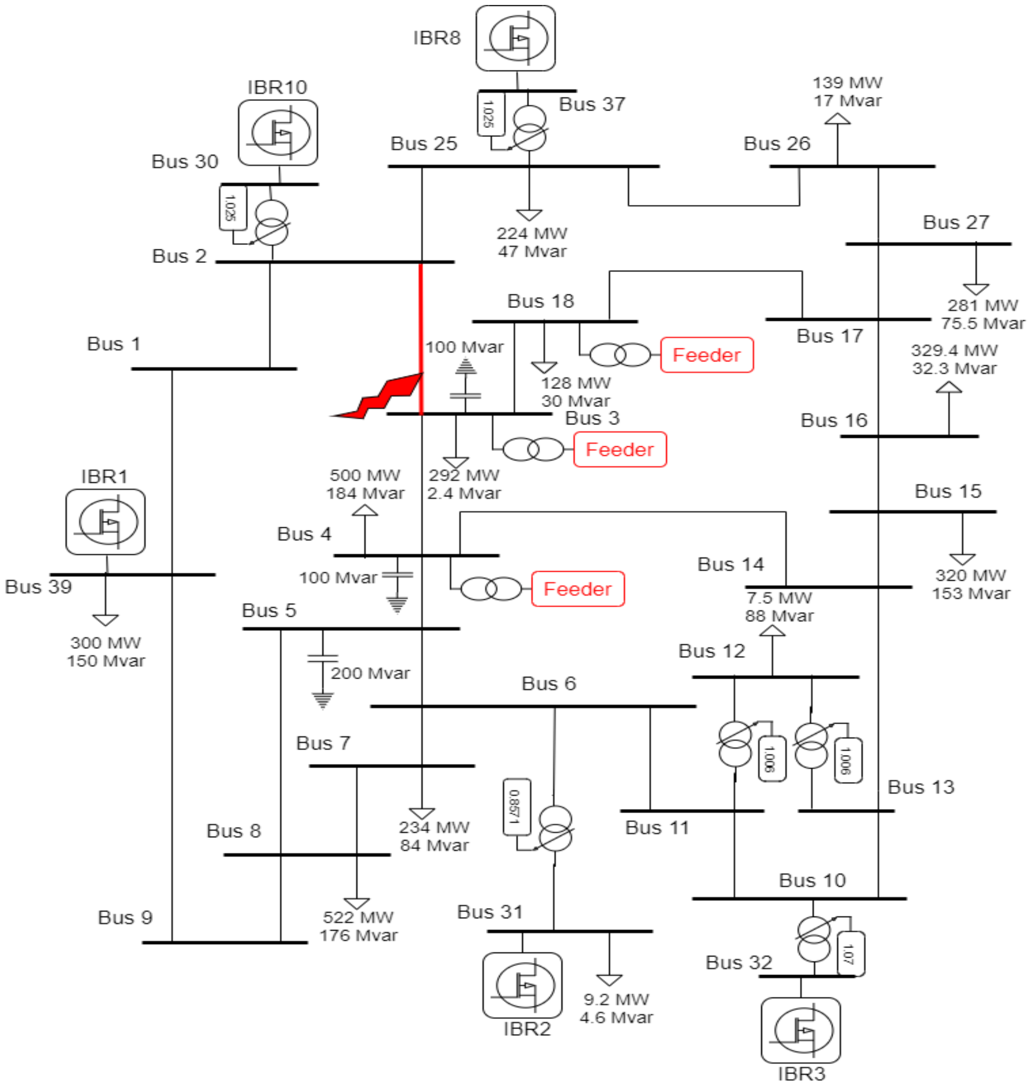
Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

- How much variation in impact is observed between balanced and unbalanced faults?
- Does presence of DER have an impact on 1 – Φ induction motors?
- Would dynamic voltage support (DVS) from 3 – Φ DERs benefit 1 – Φ induction motors?
  - Would aggressive DVS be beneficial?
- Are there interactions between Tx and Dx system?
- Can existing positive sequence aggregate models capture the behavior observed?

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery



Roughly half the New England 39 bus system.

All sources are represented by IBRs

- With maximum current of 1.1pu,
- Q priority and automatic voltage control

Detailed feeder and motor models placed on Buses 3, 4, and 18

Table 2.1: DER Scenarios Studied

Case	DERs	DER %	DVS	Scenarios
0	OFF	0%	N/A	LLL-G fault, L-G fault
2	ON	200%	OFF	LLL-G fault
9	ON	300%	ON	LLL-G fault, L-G fault

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

LLL-G fault

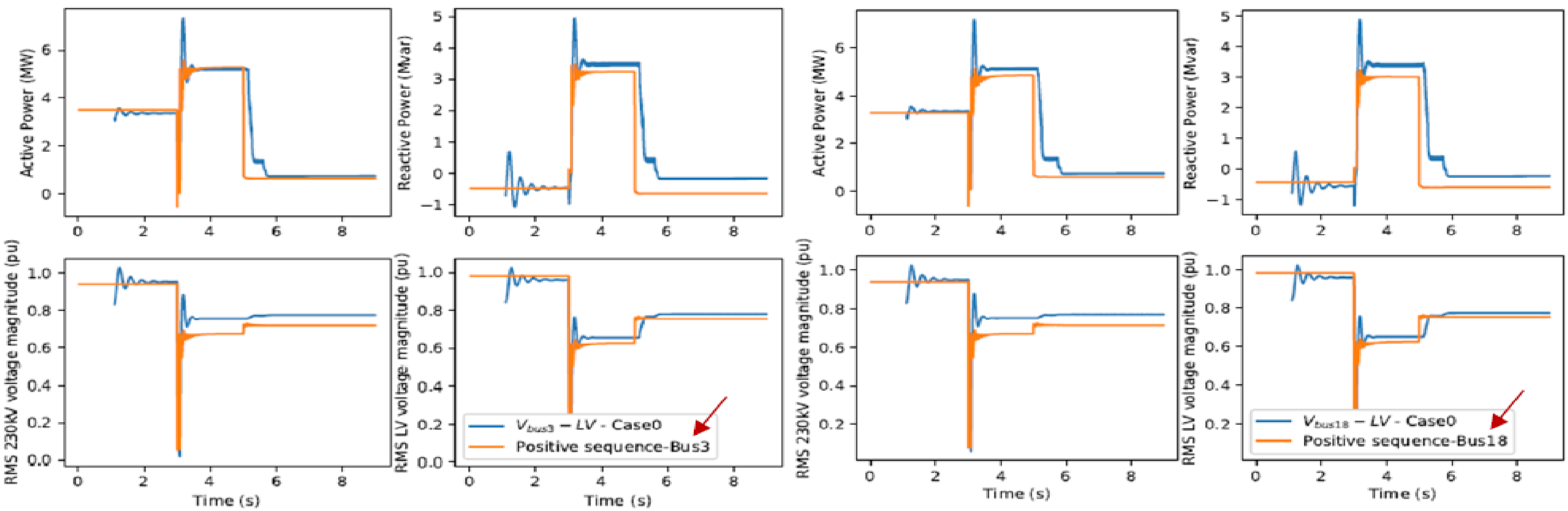


Figure 2.2: Case 0—Bus 3 and Bus 18

- Sustained FIDVR at all three buses even without DER
- Greater difference observed on low voltage side
- Load pocket depresses 230kV voltage
- Positive sequence response is able to provide similar trend of response

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

LLL-G fault

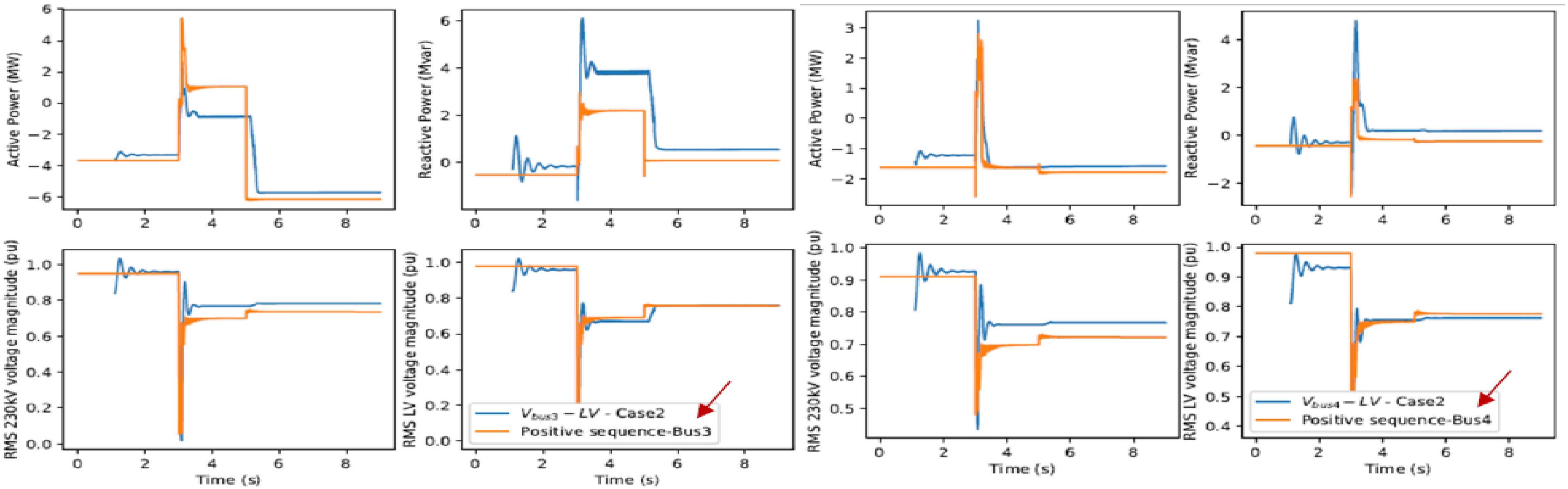


Figure 2.3: Case 2—Bus 3 and Bus 4

With 200% DER, positive sequence tools can show more conservative response with more motor stalling

Parameterization of composite load model in positive sequence can become more challenging with even further DER percentage

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

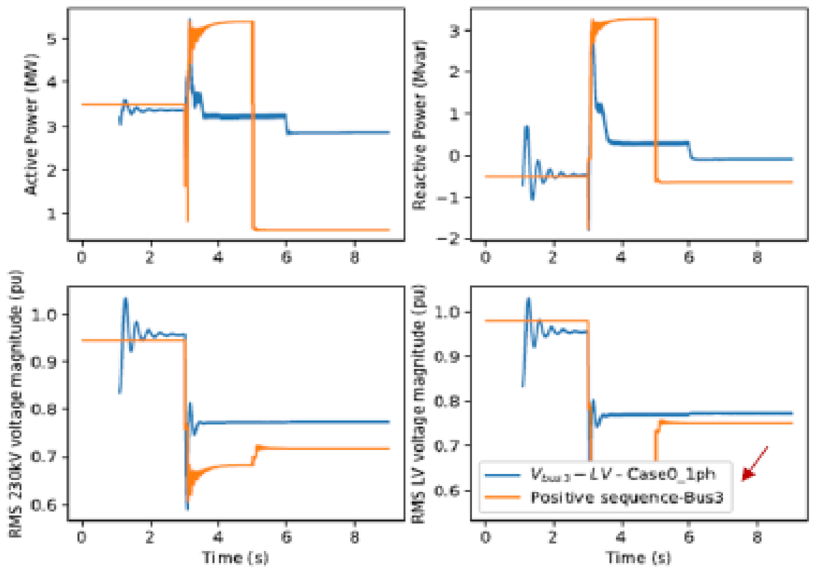
Table 1.1: Voltages at Bus 5 for Different Scenarios of Unbalanced Faults and Transformer Winding Connections

Fault Impedance	Fault Type	Quantity	Voltage (p.u.)	Voltage (p.u.)	Voltage (p.u.)
		T1/T2 Configuration	Y-Y/Y-Y	Y-Y/Δ(30)-Y	Δ(30)-Y/Y-Y
Zf = 0	L-G at Bus 1	V_a	0.05	0.57	0.58
		V_b	0.95	0.56	0.56
		V_c	0.97	0.96	0.96
		V_+	0.656667	0.6966667	0.7
	L-L at Bus 1	V_a	0.55	0.85	0.85
		V_b	0.55		
		V_c	0.97	0.85	0.85
		V_+	0.69	0.68	0.6766667
	L-L-G at Bus 1	V_a	0.29	0.58	0.58
		V_b	0.29	0.34	0.34
		V_c	0.96	0.58	0.57
		V_+	0.513333	0.5	0.4966667

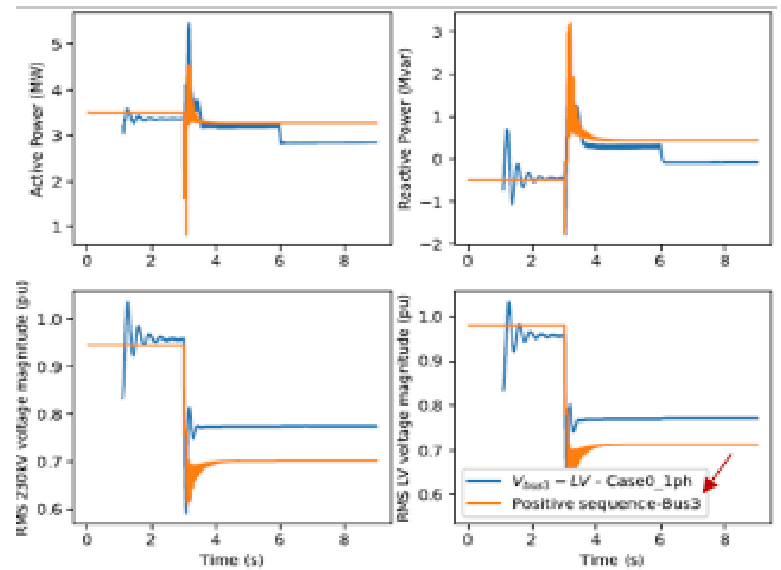
- One potential method to parameterize DER_A to capture tripping in positive sequence due to unbalanced fault is proposed
- Assumptions of transformer winding configuration may differ from one feeder to another and should be considered during parameterization

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

L-G fault



Use of motor settings for three phase fault

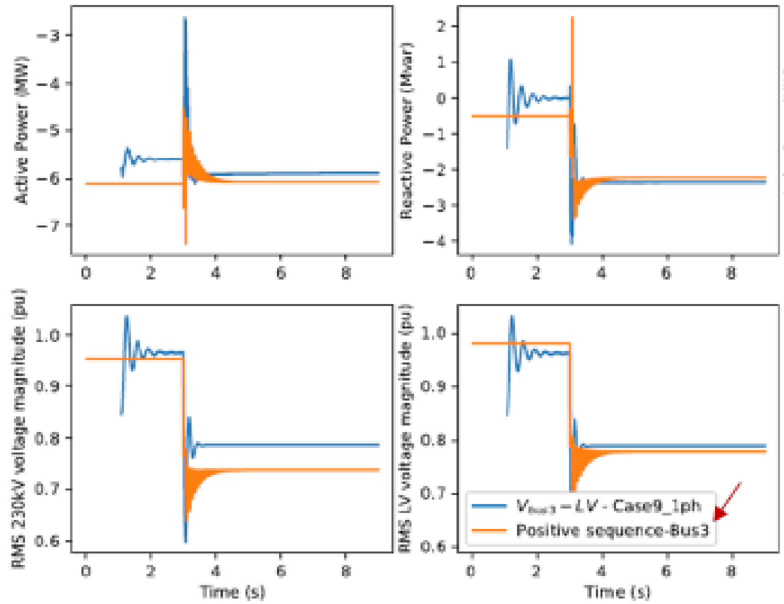


After change of motor settings based on expected behavior for single phase fault

- Positive sequence composite load models are <u>aggregated performance</u> based models
- Depending on type of fault being studied, it may be needed to use a different performance characteristic

Case 1: Using T & D Co-Simulation in Motor Stalling and Load Recovery

L-G fault



After change of motor settings based on expected behavior for single phase fault

Increase in DER percentage doesn't require a change in motor performance characteristic.

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Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Topics of interest

- If aggregated models are to be used for assessing the impact of DERs, then we need to identify under what conditions deficiencies arises.
- Are these deficiencies edge cases?
- T&D co-simulation is a tool that can be used for this baseline comparison against state-of-the-art transmission-only simulation.
- This use case is designed to provide insights to questions such as, are aggregated models adequate under the scenarios of interest?

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Studies

- Three phases to address the topics of interest outlined previously.
- In all phases, the post-disturbance equilibrium condition is of interest.
- Phase 1
  - Exploratory phase, where transmission-only setup was compared with hybrid T&D case. Where, hybrid refers to modeling only a subset of T-D interfaces that are of interest.
  - Help establish baseline
    - Does the initial conditions match between the transmission-only and T&D hybrid approach?

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System Studies

- Phase 2
  - Phase 2 will allow to further examine whether a hybrid approach as described in phase 1 is a reasonable setup with regards to determining the edge cases.
  - Help validate if the patterns observed in phase 1 hold true in phase 2.
  - Explore different ways in which DERs can be represented such that the aggregated approach (i.e., using DER_A) produces results that are comparatively closely aligned with the detailed model.
  - <u>Assess what happens if voltage zones for different standards in a mixed vintage scenario are to be different.</u>

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

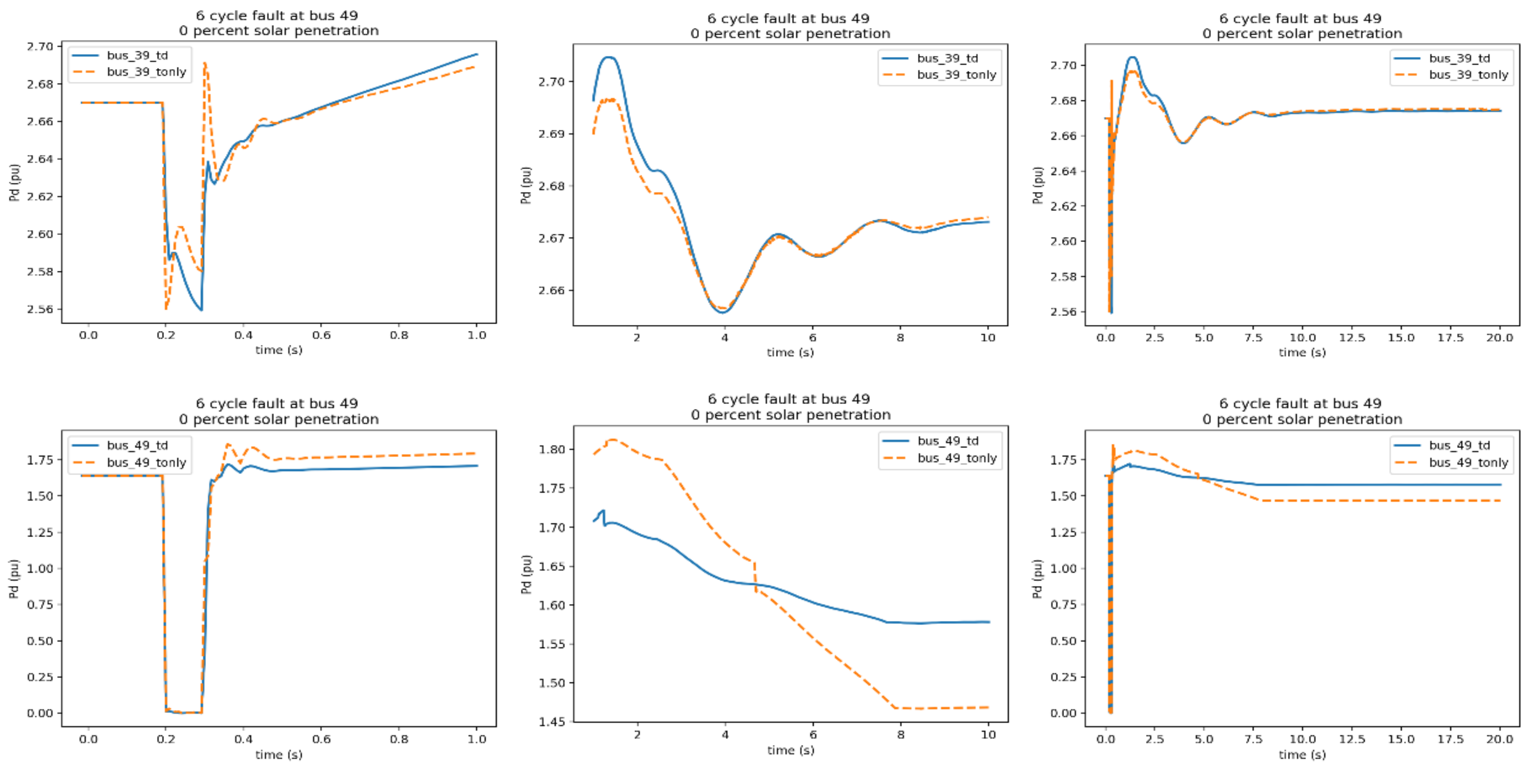
Studies

- Phase 3
  - In phase 2, the impact of having different voltage settings (i.e. vl0 and vl1) but the same timer settings for mixed vintages of DER was explored.
  - In phase 3, a similar setup where the voltage settings were same but the <u>timer settings were different</u> were explored.

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Key Observations

- Buses that are electrically distant from disturbance location tend to show a behavior that is very similar during the disturbance and their post-disturbance steady state values are also similar.
- Buses that are close to the disturbance location show a behavior that is adequately different to warrant further examination.



Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Key Observations

- Partial trip characteristics of DER_A works adequately well under tested conditions, across all three phases.
  - The voltage zone between vl0 and vl1 i.e. vdrop ranges from 2-8% with a reasonable value of 5%.
  - Differences because of partial trip characteristics can arise at a given DER_A model if voltage is within this zone and if the DERs are not linearly distributed along the length of the feeder.
  - Even under such conditions the difference will be marginal and is dependent on how the DERs are distributed in the feeder

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Key Observations

- Mixed vintages of DERs can be represented using a single DER_A model with appropriate parameters when voltage and frequency zones, and associated timers involved are the same between the different standards that are being represented.
- In the event that the voltage and frequency zones are different such as the one presented in phase 2 results, there can be difference in the observed DER behavior.
- Within this context, the observed behavior implies the amount of power produced by the DERs in post disturbance steady state condition.

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

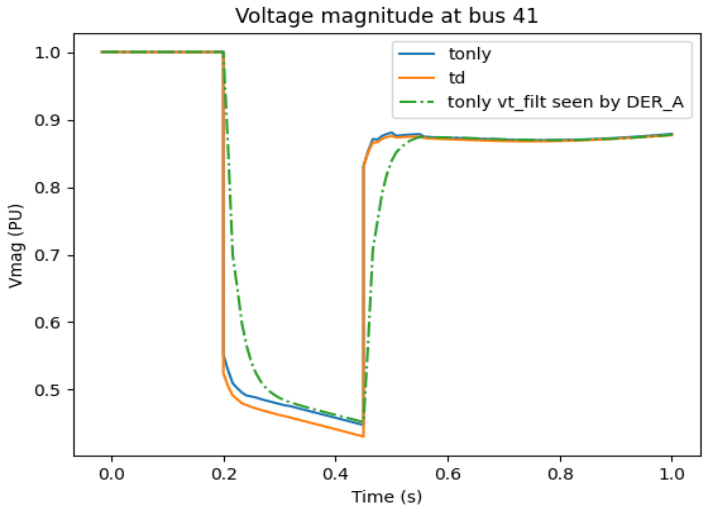
Key Observations

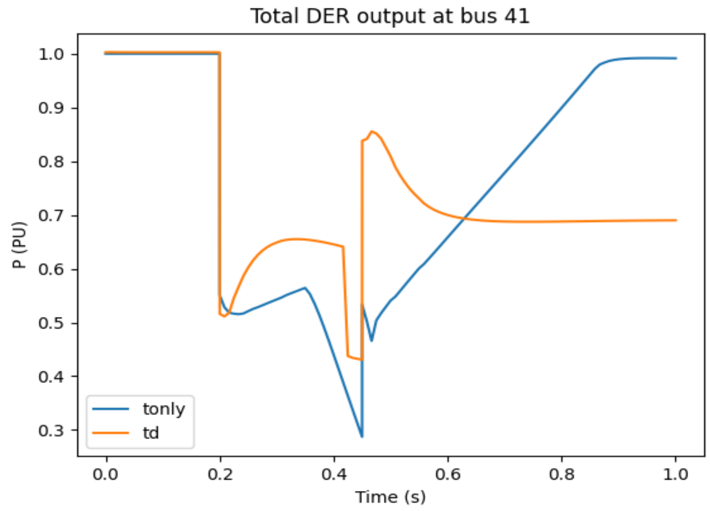
- In the event that the timers associated with voltage and/or frequency zones are different such as the one presented in phase 3 results, there can be difference in the observed DER behavior. Within this context, the observed behavior implies the amount of power produced by the DERs in post disturbance steady state condition.
- For completeness, the scenario where both voltage zones and timers associated with it are different was also studied i.e. combination of phase 2 and 3. The observation made in phase 2 and 3 holds.
- The above issue is not a limitation of DER_A model but rather a limitation of how DER_A is represented under mixed vintage scenario. This issue can be mitigated by modeling DER_A individually.
- In general, modeling different voltage and/or frequency zones with different timers between the standards that make up mixed vintage scenario, for example 30% IEEE 1547-2003 and 70% IEEE 1547-2018 standards, with a single mixed vintage model is difficult.

Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Key Observations

- In the event that the timers associated with voltage and/or frequency zones are different such as the one presented in phase 3 results, there can be difference in the observed DER behavior. Within this context, the observed behavior implies the amount of power produced by the DERs in post disturbance steady state condition.
- Mixed vintages of DER -- 30% IEEE 1547-2003 and 70% IEEE 1547-2018, modeled using single DER_A.
- Voltage zones are different.

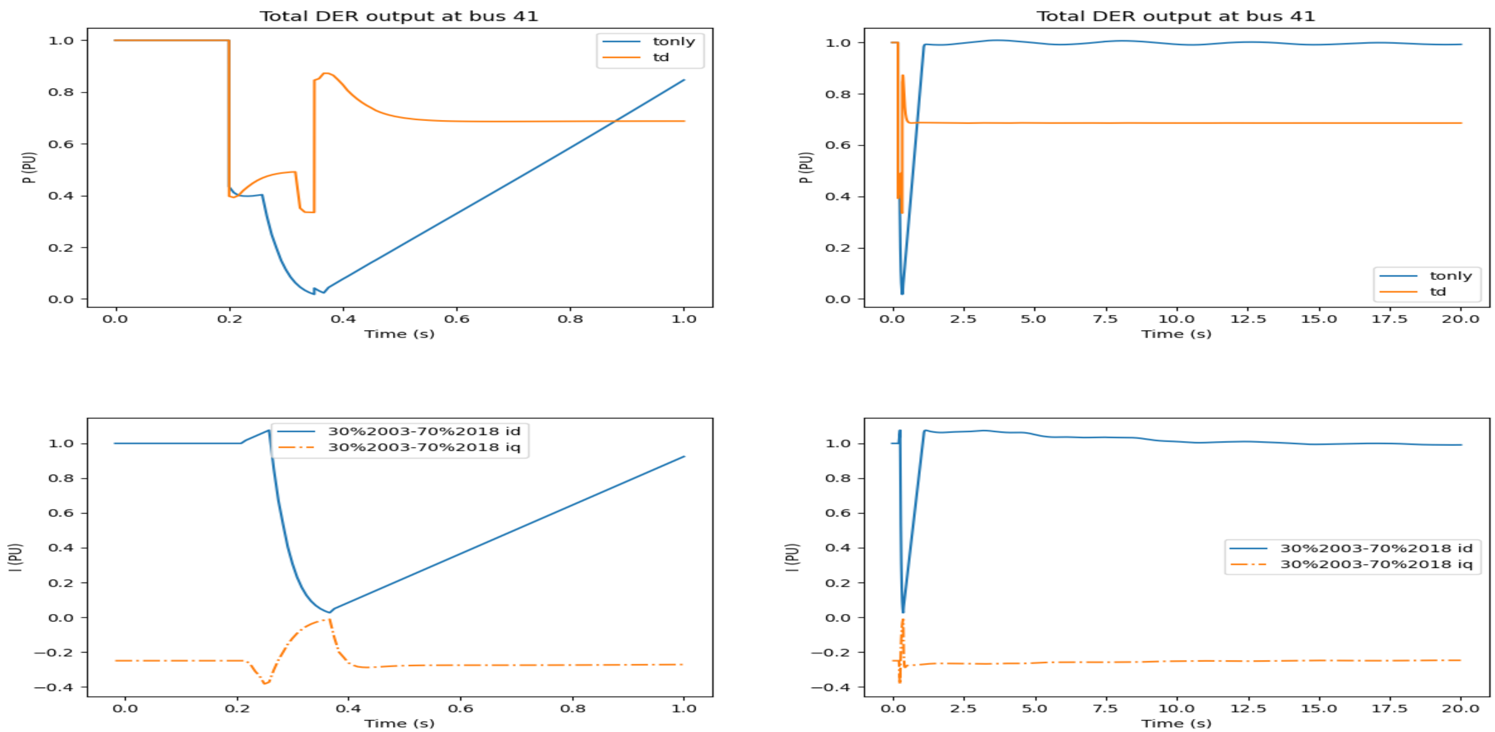




Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

Key Observations

- In the event that the timers associated with voltage and/or frequency zones are different such as the one presented in phase 3 results, there can be difference in the observed DER behavior. Within this context, the observed behavior implies the amount of power produced by the DERs in post disturbance steady state condition.
- Timers are different.



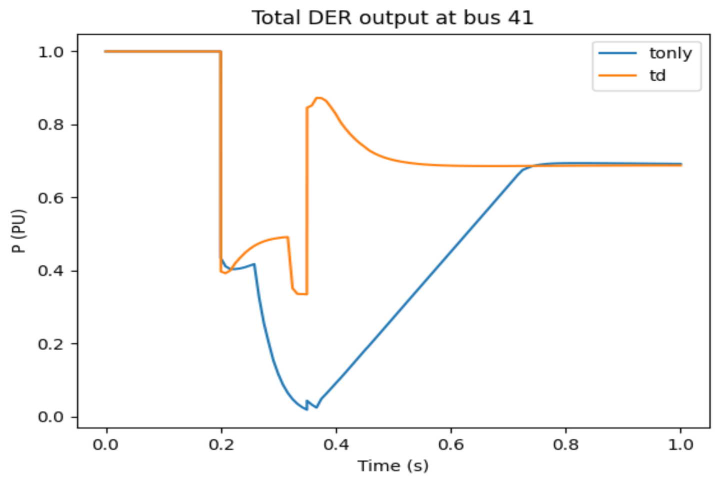
Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

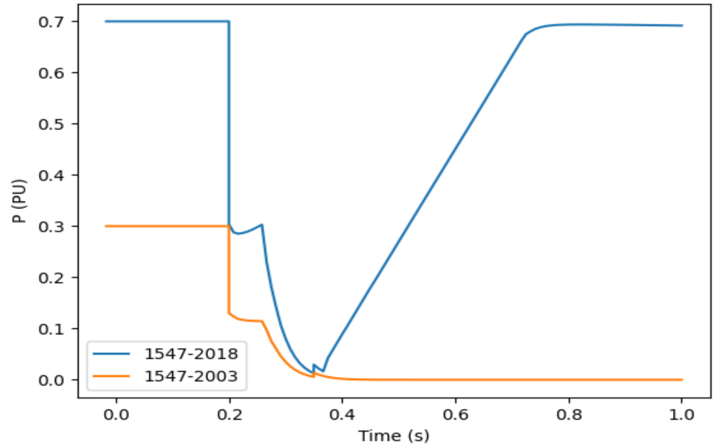
Key Observation

- In the event that the timers associated with voltage and/or frequency zones are different such as the one presented in phase 3 results, there can be difference in the observed DER behavior.

Recommendation

- Model individual standards using individual DER_A models.





Case 2: Using T & D Co-Simulation Modeling in Aggregate over Full Distribution System

For complex systems, empirical analysis is almost never truly complete

- It is worth pointing out that the results provided here for the mixed vintages of DERs scenarios does not rule out the possibility of a set of parameters that will result in appropriate response of single DER_A model used to represent mixed vintages. The rationale to explore alternative means of modeling stems from,
  - Potential challenge in deriving generic and universal parameter values, especially the parameters associated with voltage and/or frequency zones and associated timers.
  - Simulation of scenarios where there could be more than two interconnection standards in mixed vintages of DERs. Here, while engineering judgement could be used with the use of a single DER_A model to provide a transmission planner with the trend of the response, need for increase accuracy in simulation results can warrant use of multiple DER_A models.

Now what for planning engineers? How do I apply this to my day-to-day work?

Recommendations

- Based on fundamental understanding of the models and their representation, backed by limited but significant results, it is reasonable to explore alternative ways to represent existing models within the existing positive sequence simulation tools.
- While Engineering judgement is a viable tool, leveraging approaches such as T&D co-simulation to understand aggregate model usage, representation, and parameterization will further our understanding of the system behavior and additionally augment our engineering judgement.

Questions and Answers

Upcoming SPIDERWG Papers, Projects, and Goals

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System Planning Impacts from Distributed Energy Resources Working Group

Upcoming Papers, Projects, Goals

Shayan Rizvi, Senior Engineer Reliability Assessments and Performance Analysis, NPCC & NERC SPIDERWG Chair

NERC DER Workshop

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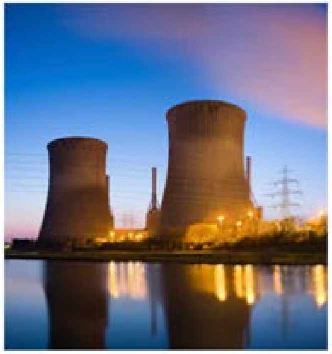
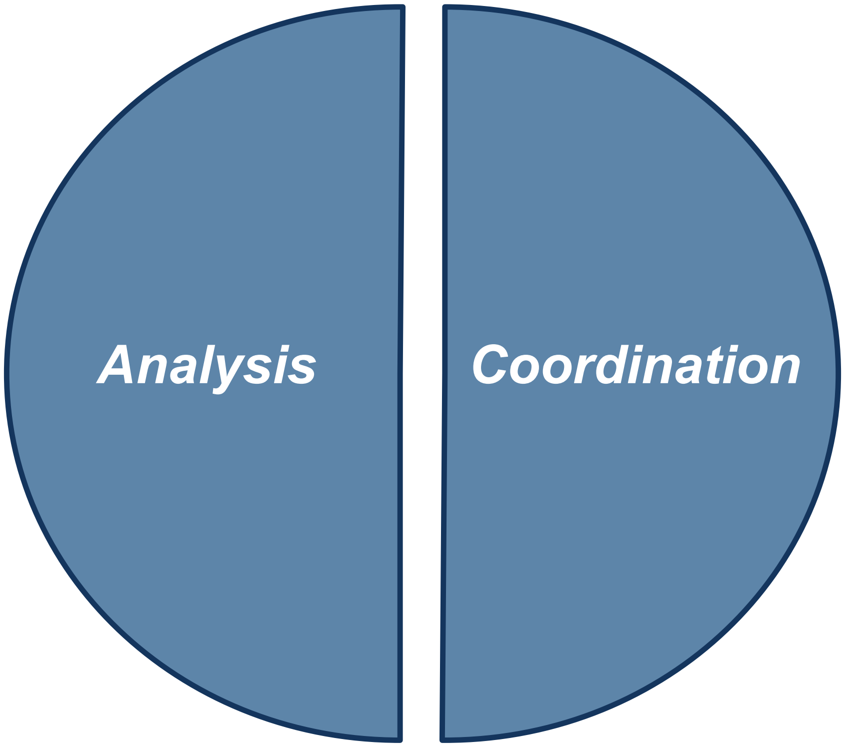


SPIDERWG Overview



System **P**lanning **I**mpacts from **D**istributed **E**nergy **R**esources **W**orking **G**roup

- NERC stakeholder forum for focusing on DERs from the transmission planning and system analysis perspectives (~300 industry participants)
- Provide leadership through Technical Reference Documents, White Papers, Reliability Guidelines, & Standards activities (SARs)

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2022 SPIDERWG Accomplishments

Reliability Guideline:

- DER Forecasting Practices and Relationship to DER Modeling for BPS Planning Studies
- Parameterization of the DER_A Model

White Paper:

- BPS Reliability Perspectives for Distributed Energy Resource Aggregators
- NERC Reliability Standards Review
- Recommendations for Simulation Improvement and Techniques Related to DER Planning
- DER Impacts to Under Voltage Load Shedding Program Design
- Battery Energy Storage and Multiple Types of DER Modeling

Technical Report:

- Beyond Positive Sequence RMS Simulations for High DER Penetration Conditions

RSTC Reliability Guideline Reviews

Tranche 2 Review

Analysis Sub-Group

- Modeling DER in Dynamic Load Models
- Distributed Energy Resource Modeling
- Parameterization of the DER_A Model

Tranche 3 Review

Coordination Sub-Group

- BPS Reliability Perspectives on the Adaption of IEEE 1547-2018

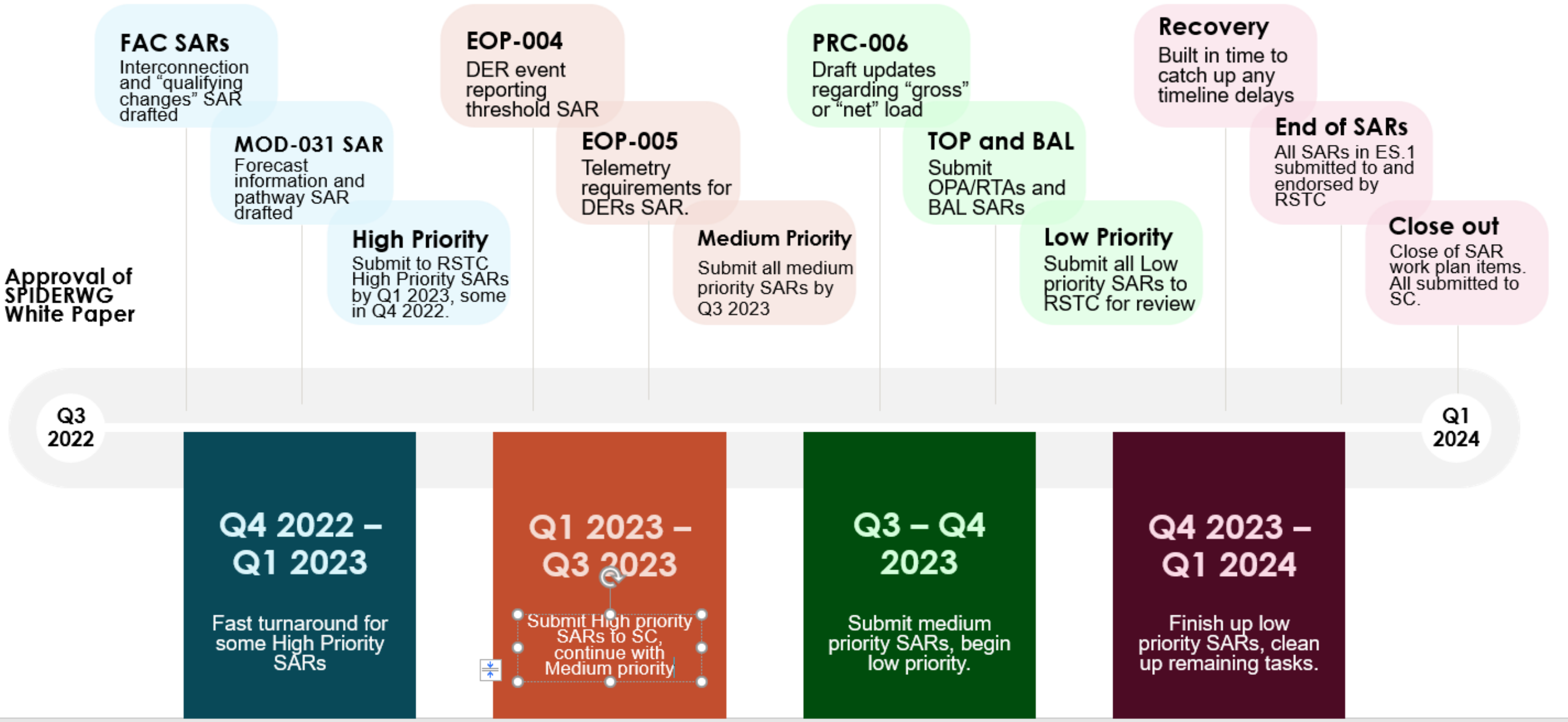
Analysis Sub-Group

- DER Data Collection for Modeling in Transmission Planning Studies
- Model Verification of Aggregate DER Models use in Planning Studies

SAR Development Roadmap

SPIDERWG Planned SAR Development

Roadmap for Work Plan Additions



SPIDERWG Outlook

- Cyber Security
- Operations
- SAR Development
- DER Aggregation
  - DERMS
  - Cyber + Physical Security
  - T-D Interface
  - Data Collection
  - Data Sharing
- Continued industry engagement through development of technical documents focused on reliability
  - Reliability Guidelines
  - White Papers
  - Technical Reference Documents
  - SAR development

Questions and Answers

Adjourn

Watch your Inbox for Post-Workshop Survey!

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