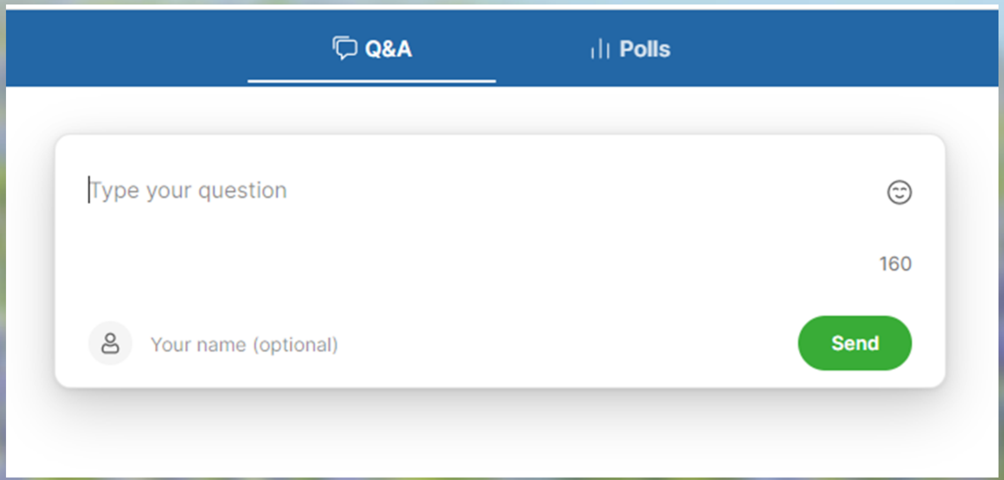
Texas RE Spring Standards, Security, & Reliability Workshop

April 23, 2025

AGENDA

- Welcome and Instructions
- Executive Welcome
- IBR Registration
- IBR Risk Elements
- IBR Modeling Challenges
- Preparing for Audits and Self-Reporting
- Low Impact BES Cyber Systems Risk Elements
- Physical Security – Emerging Risks and Considerations
- High Frequency Conduct and Change Management
- NERC Standards Abeyance Process

To submit questions during the workshop, please visit **slido.com** and enter today's participant code: **TXRE**



Welcome & Instructions

Matthew Barbour
Texas RE
Manager, Communications & Training

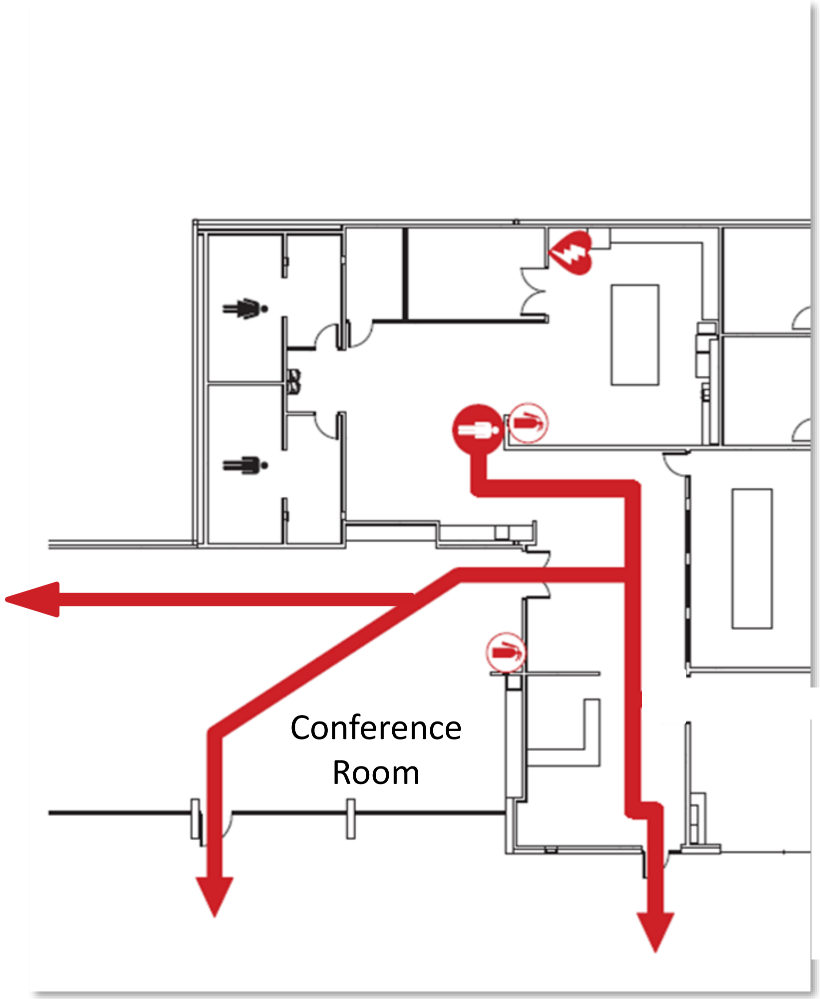
Antitrust Admonition

Texas Reliability Entity, Inc. (Texas RE) strictly prohibits persons participating in Texas RE activities from using their participation as a forum for engaging in practices or communications that violate antitrust laws. Texas RE has approved antitrust guidelines available on its website. If you believe that antitrust laws have been violated at a Texas RE meeting, or if you have any questions about the antitrust guidelines, please contact the Texas RE General Counsel.

Notice of this meeting was posted on the Texas RE website and this meeting is being held in public. Participants should keep in mind that the listening audience may include members of the press, representatives from various governmental authorities, and industry stakeholders.

Safety Moment

In case of emergency, evacuate through the nearest door



Rally point is in the front parking lot

Questions

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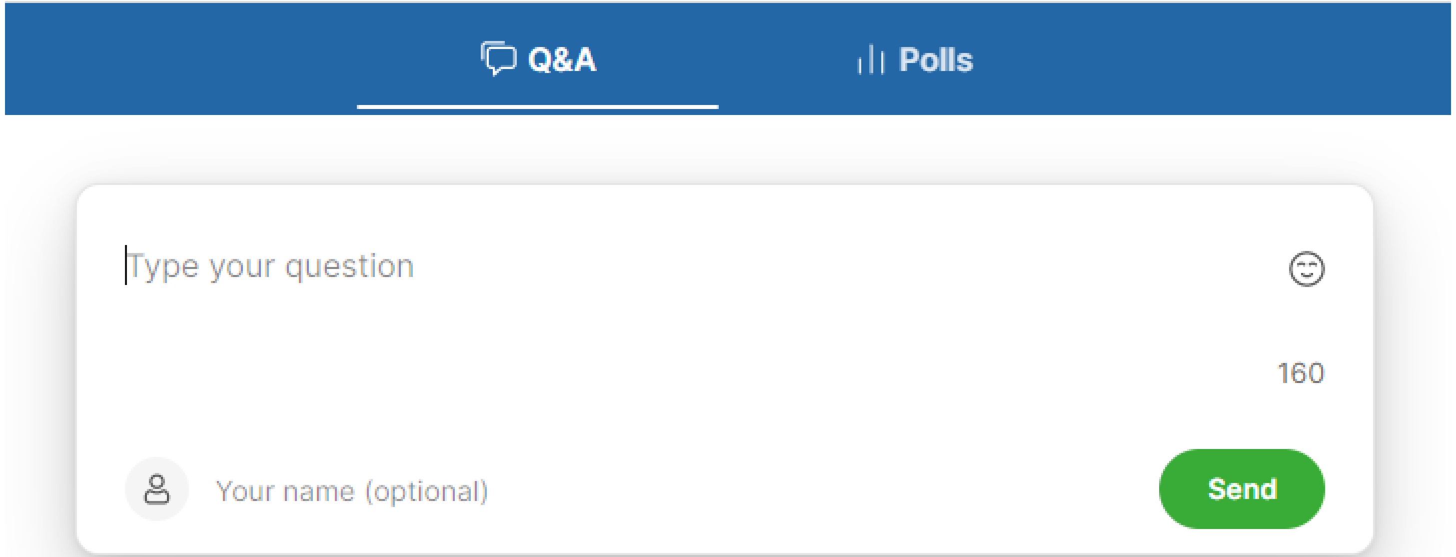

Training Page

HOME | ABOUT US | CAREERS | TRAINING

TEXAS RE
Ensuring electric reliability for Texans

COMPLIANCE ENFORCEMENT REGISTRATION RELIABILITY SERVICES STANDARDS

Texas RE offers training on a variety of compliance- and standards-related topics. Workshops and seminars are announced to subscribers of the Texas RE Information mailing list. To subscribe to our mailing list please visit Texas RE Mailing Lists.

For questions about training, please contact Texas RE Information.

Workshops

Talk with Texas RE

Align Training

Lessons Learned

Archived Presentations

Archived Presentations

All of Texas RE's outreach activities are free and open to the public. Past presentations delivered by Texas RE staff are available here. Please be aware that presentations will not be available indefinitely, and may be removed to comply with Texas RE's document retention policy.

ALIGN

Align Release 1 Training | Recording

Align Release 2 Periodic Data Submittal Training | Recording

Align Release 2 TFE and Self-Certification Training | Recording

Align Release 3 Training | Recording

Align Release 4 & 4.5 Training | Recording

Workshops

Women's Leadership in Grid Reliability and Security Conference | Recording

Understanding New Generator Obligations | Recording

Fall Standards, Security, and Reliat

2024 Fall Standards, Security, and Reliability Workshop | Recording

Spring Standards, Security, and Reliability Workshop

2025 Spring Standards, Security, and Reliability Workshop

MCLE Credit

This workshop is accredited for five Minimum Continuing Legal Education (MCLE) hours. To receive credit you may either:

- ❑ **Self-report the MCLE course number**
  - 174278760

OR

- ❑ **Email Information@texasre.org your attendee information**
  - Name
  - Bar Card Number
  - Hours Attended

Upcoming Texas RE Events

talk with TEXAS RE

May 20, 2025

Summer Outlook

talk with TEXAS RE

May 28, 2025

GOP Functions and Third-Party Control Centers

talk with TEXAS RE

June 11, 2025

Artificial Intelligence in the Electricity Industry

Social Media

/texas-reliability-entity-inc

@Texas_RE_Inc

/TexasReliabilityEntity

Executive Welcome

Joseph Younger
Texas RE
Vice President & Chief Operating Officer

IBR Registration

Katie Van Zee
Director, Enforcement and Registration

April 23, 2025

NERC IBR Strategy

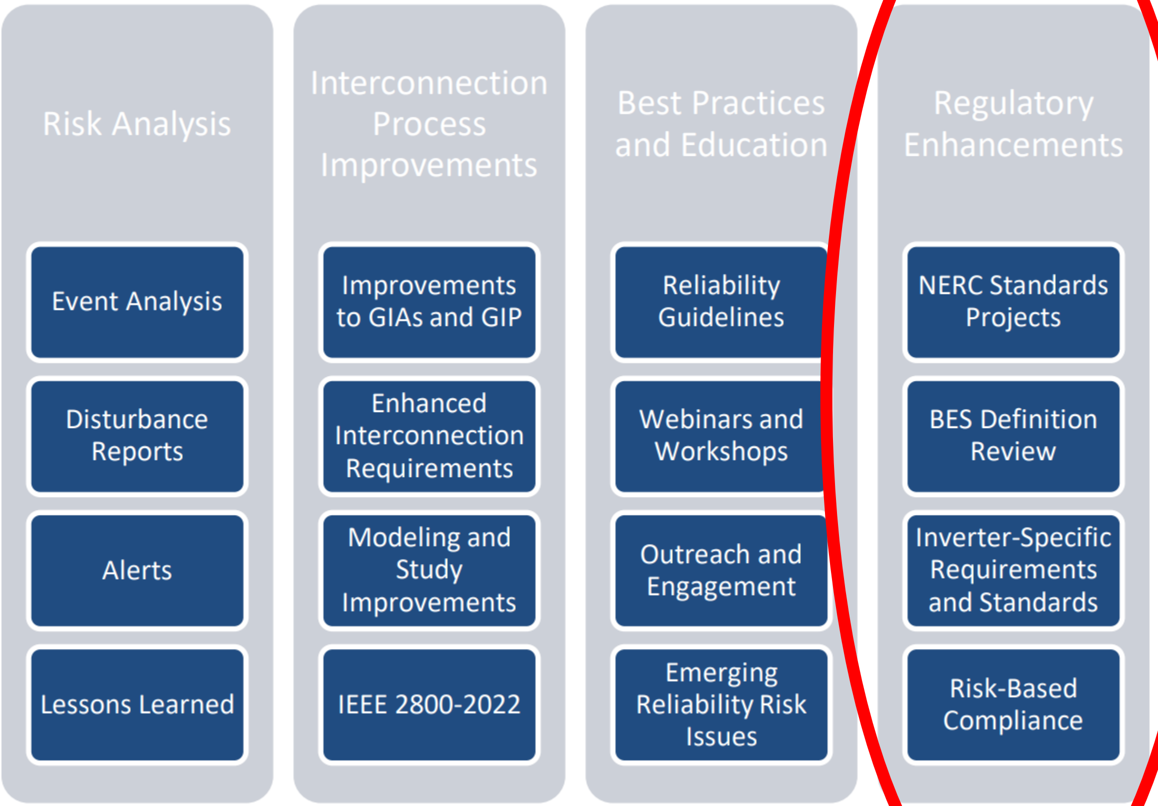

Figure 3: NERC IBR Risk Mitigation Strategy

Regulatory Enhancements

Two Projects Moving Contemporaneously

NERC IBR Quick Reference Guide

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

IBR REGISTRATION INITIATIVE

Quick Reference Guide: IBR Registration Initiative

March 2025

As part of its *Inverter-Based Resource Strategy*, NERC is dedicated to identifying and addressing challenges associated with inverter-based resources (IBR) as the penetration of these resources continues to increase. ERO Enterprise assessments identified a reliability gap associated with the increasing integration of IBRs as part of the grid in which a significant level of bulk power system-connected IBR owners and operators are not yet required to register with NERC or adhere to its Reliability Standards.

In response, FERC issued an order in 2022 directing NERC to identify and register owners and operators of currently unregistered bulk power system-connected IBRs. Working closely with industry and stakeholders, NERC is executing a FERC-approved work plan to achieve the Resources are also posted on the Registration page of the NERC website.

IBR Registration Milestones

Phase 1: May 2023–May 2024

- Complete Rules of Procedure revisions and approvals
- Commence Category 2 GO and GOP candidate outreach and education (e.g., through trade organizations)

Phase 2: May 2024–May 2025

- Complete identification of Category 2 GO and GOP candidates
- Continue Category 2 GO and GOP candidate outreach and education (e.g., quarterly updates, webinars, workshops, etc.)

Phase 3: May 2025–May 2026

- Complete registration of Category 2 GO and GOP candidates thereafter subject to applicable NERC Reliability Standards
- Conduct specific Category 2 GO and GOP outreach and education (e.g., quarterly updates, webinars, workshops, etc.)

LEARN MORE ABOUT NERC AND THE E-ISAC

Key Activities

- NERC submitted its quarterly work plan update to FERC on February 5.
- NEW NERC has released a guide—*Reliability Standards Compliance Dates for Generator Owners & Generator Operators*—providing finalized and pending Reliability Standard compliance dates applicable to Category 2 registration.

Available Resources

- ERO Enterprise IBR Event Tracking Graphic
- ERO Enterprise CMEP Practice Guide
- 101 Resource Document | IBR Video | Open Letter to New Registrants
- Q1 2024 Update | Q2 2024 Update | Q3 2024 Update | Q4 2024 Update
- NEW ERO Enterprise March 2025 Webinar: Slide Presentation and Recording
- ERO Enterprise November 2024 Webinar: Slide Presentation and Recording
- Quick Reference Guide: Candidate for Registration
- NERC Registration Page
- Standards Under Development Page | Milestone 3 Summary and Infographic

RELIABILITY | RESILIENCE | SECURITY

STANDARDS, SECURITY, & RELIABILITY SPRING WORKSHOP

IBR Registration Timeline

You are Here

May 2023 – May 2024

Complete Rules of Procedure (ROP) Revisions

May 2024 – May 2025

Identify candidates for registration

May 2025 – May 2026

Register candidates

ROP Changes

"Generator Operator" (GOP) means the entity that: 1) operates generating Facility(ies) and performs the functions of supplying energy and Interconnected Operations Services (Category 1 GOP); or 2) operates non-BES inverter based generating resources that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA, connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage greater than or equal to 60 kV (Category 2 GOP).

"Generator Owner" (GO) means an entity that: 1) owns and maintains generating Facility(ies) (Category 1 GO); or 2) owns and maintains non-BES inverter based generating resources that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA, connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage greater than or equal to 60 kV (Category 2 GO).

Identification Timeline Information

- June 27, 2024: ROP Revisions Completed
- July 9, 2024: RFI 1 Sent to TOs and BAs
- December 6, 2024: RFI 2 Sent (Texas RE)

RFI 1 – Gathering Contact Information

Contact Information

- RFI sent to all Transmission Owners and Balancing Authorities
- Identification of facilities
- Contact information for owners and operators of those facilities

RFI 2 – Identification & Prep for Registration

Necessary Data for Registration

- GO/GOP Asset Verification Form
- One-Line Diagram(s)
- Interconnection Agreement
- RARF/RIOO Information
- Third-Party Agreement(s), if applicable

NERC Registration Webinars

Webinar 1: Inverter-Based Resource Registration Initiative

- Webinar Recording
- Slide deck

Webinar 2: Application of the Registration Criteria for Category 2 Generator Owner and Generator Operator Inverter-Based Resources

- Document
- Webinar Recording
- Slide Deck

Additional Registration Resources

- ERO Enterprise Registration Procedure
- ERO Enterprise Entity Onboarding Checklist
- ERO Enterprise 101 Informational Package
- CORES End User Guide
- Texas RE Reliability 101 and 201 Webinar Series
- Understanding New Generator Obligations | Recording

Compliance Obligations

Compliance Obligations Expected to Begin May 2026

NEW!

Reliability Standards Compliance Dates for Generator Owners & Generator Operators

Order 901 Standards Development

Regulatory Enhancements

Two Projects Moving Contemporaneously

FERC Order No. 901 Summary

- IBR Data Sharing
- IBR Model Validation
- IBR Planning and Operational Studies
- IBR Performance Requirements

IBR Standards Work Plan

Milestone 1	Milestone 2	Milestone 3	Milestone 4
NERC Work Plan Filed on January 17, 2024	Performance Requirements and Post-Performance Validations	Data Sharing and Model Validation	Use of Performance Data in Operational and Planning Studies
	November 2024	November 2025	November 2026

Standards Development Mapping of FERC Order 901 Directives and Other Guidance to Standards Development Projects, Draft SARs, and Pending SARs

Get Involved with the Standards Process

NERC Standards Review Forum (NSRF)

- Texas RE stakeholder group to discuss upcoming effective standards as well as compliance topics

Reliability and Security Technical Committee (RSTC)

- NERC stakeholder committee to discuss various grid topics

Standard Drafting Team (SDT) Meetings

- Open meetings to participate in the standards development process

Contacts

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Questions?
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IBR Risk Elements: FAC-001-4 and FAC-002-4

Alexandra Huey
O&P Compliance Engineer

Rashida Caraway
Manager, Risk Assessment

Sli.do (#TXRE)

Slido Question

Does your registered entity have any IBR assets?

A. Yes

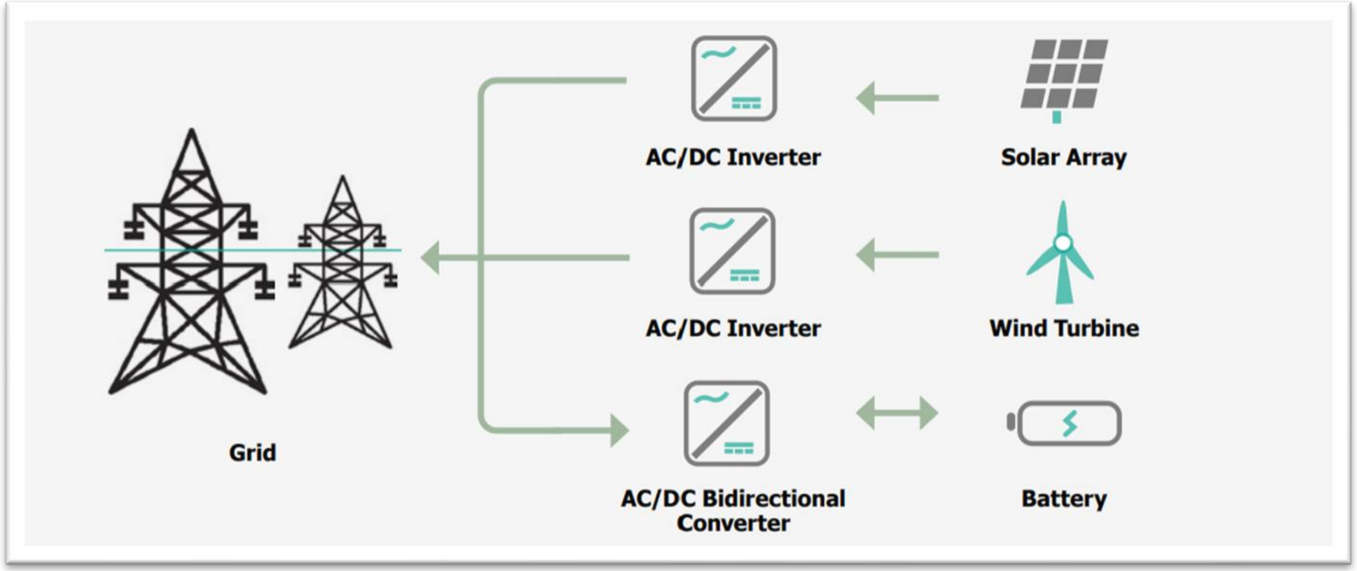
B. No

Inverter-Based Resource (IBR)

An inverter is a power electric device that converts direct current (dc) electricity to alternating current (ac) electricity.

IT'S A FACT

More than 102 GW of transmission-connected wind, solar, and battery energy storage capacity is expected to be installed on ERCOT's system by the end of 2025. Total IBR capacity has the potential to exceed 140 GW in 2027.*



******ERCOT Report on Existing and Potential Electric System Constraints and Needs***, December 2024

Key Takeaways

Purpose of FAC-001 and FAC-002

Risks of FAC-001 and FAC-002

Entities and the Risks

Compliance Engagement Approach

Impacts of IBRs related to FAC-001 and FAC-002

CMEP Feedback Loop

Different Types of Entities

New Registered Entity

Existing Registered Entity

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Slido Question

Who is FAC-001 applicable to?

A. Transmission Owners

B. Generator Owners

C. Distribution Providers

D. Both A & B

FAC-001-4 Facility Interconnection Requirements

Purpose: Ensures reliability of the Bulk Electric System (BES) by requiring Transmission Owners (TOs) and applicable Generator Owners (GOs) to have documented Facility interconnection requirements and make requirements available so that entities seeking to interconnect will have necessary information

- Update Facility interconnection requirements and make them available
- Facility interconnection requirements address the following: new interconnections or existing interconnections with a qualified change (TO only), notifying and confirming responsible parties

IT'S A FACT

Approximately 92% of ERCOT's new interconnection requests are IBRs.*

****ERCOT Report on Existing and Potential Electric System Constraints and Needs*, December 2024**

Sli.do (#TXRE)

Slido Question

What kind of study does FAC-002 require?

FAC-002-4 Facility Interconnection Studies

Purpose: Ensures that entities conduct adequate interconnection studies before connecting new or changed Facilities and assess the impact to the BES

Transmission Planner (TP) and Planning Coordinator (PC) shall study the reliability impact interconnecting new Facilities and existing interconnections	GO, TO, and Distribution Provider (DP) shall coordinate and cooperate on studies with TP or PC	PC shall maintain publicly available definition of qualified change

2025 CMEP Implementation Plan (CMEP IP)

Focus remains on IBRs due to their increasing grid presence

Ensures reliable integration

Need for identifying and mitigating potential reliability risks

Avoids reliability issues related to improper modeling or operational expectations

Specific Risks

Operational Risks

- Widespread issues affecting large portions of the grid system stability
  - Voltage issues, frequency response
- Potential system instability or cascading failures from inadequate integration
  - Incorrect models used in the study is a concern
  - Models used in the study must represent the behavior of the resources in real-world installations

How Does Texas RE Determine Risk?

Registration Function(s)

Inherent Risk

- New resources connected to system
- Planned facilities
- Transmission portfolio
- System modifications

Performance Risk

- System events
- Compliance history

Long-Term Studies/Assessments Risk Category

- Planning horizons are used to evaluate whether the system can reliably operate in Real-time
- Failure to do so will likely result in gaps and may compromise the integrity and reliability of the BPS

2025 ERO Enterprise CMEP Implementation Plan

Table 7: Inverter-Based Resources			
Rationale	**Standard**	**Req**	**Entities for Attention**
Clear and consistent interconnection requirements for IBRs	FAC-001-4	R1, R2	Generator Owner Transmission Owner
IBRs being adequately studied	FAC-002-4	R1, R2	Generator Owner Planning Coordinator Transmission Planner

FAC-001-4 and Impacts of IBRs

Federal Energy Regulatory Commission (FERC) Order No. 2023

Facility Interconnection Requirements and Availability

IT'S A FACT

At of the end of 2022, there were over 10,000 interconnection requests in queues throughout the United States. Delays in the study process have contributed to interconnection queue backlogs. Of the 2,179 interconnection studies completed in 2022, 68% were issued late.

*__Explainer on the Interconnection Final Rule__, www.ferc.gov, January 2025

FERC Order No. 2023

The rule lays out how FERC will reform processes used by transmission providers to study and connect generating facilities to the transmission system with three key components:

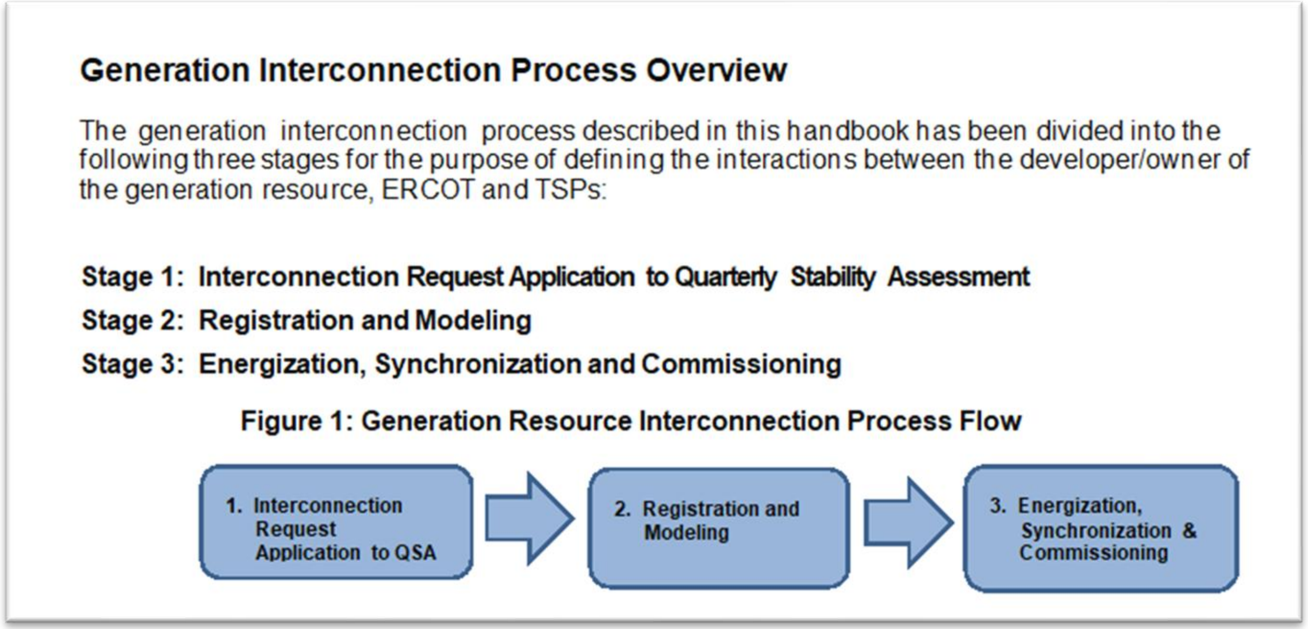
- Transitioning from a first-come-first-serve serial process to a first-ready-first-served cluster study process
- Increase the speed of interconnection queue processing
- Reforms to incorporate technological advancement in the interconnection process

Facility Interconnection Requirements and Availability

Ensure Facility interconnection requirements are documented

- Interconnection requirements shall address procedures for coordinated studies for new interconnections or existing interconnections seeking to make a qualified change

Ensure Facility interconnection requirements are available


Generation Interconnection Process Overview

The generation interconnection process described in this handbook has been divided into the following three stages for the purpose of defining the interactions between the developer/owner of the generation resource, ERCOT and TSPs:

Stage 1: Interconnection Request Application to Quarterly Stability Assessment

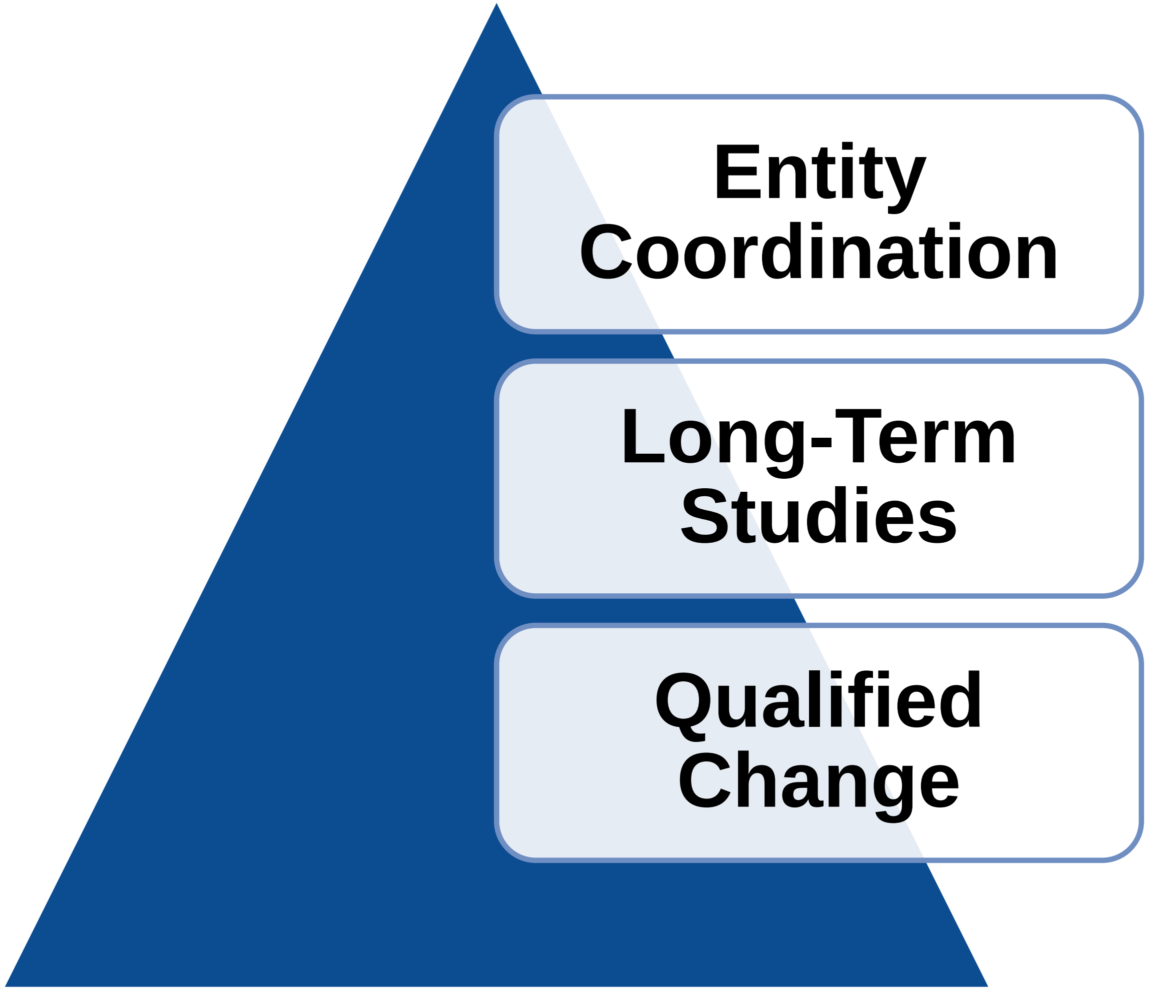
Stage 2: Registration and Modeling

Stage 3: Energization, Synchronization and Commissioning

Figure 1: Generation Resource Interconnection Process Flow

[ERCOT's Resource Integration Guides]

FAC-002-4 and Impacts of IBRs



Entity Coordination

Coordination, internally and externally (including third-party suppliers and contractors) before making changes to the system that have the potential to affect another entity and Bulk Power System (BPS) reliability and security

Resolve issues that could negatively affect system performance

Determine what constitutes a qualified change

Ensure timeliness of data submissions and reliability impact studies

Coordinate and provide data for reliability impact studies

Long-Term Studies

Ensure that all necessary studies for IBR connections are being performed (FAC-002 R1)

- Are IBRs explicitly addressed in the entity's interconnection study process?
- How does the entity ensure study assumptions and system performance considerations are adequate when determining the reliability impact of new IBR interconnections?
  - What is the review or approval process?
- To evaluate system performance:
  - Steady-state analysis, include IBRs
  - Dynamic stability analysis, evaluate behavior of IBRs during faults and frequency events
  - Short-circuit analysis, evaluate fault current contributions from IBRs

Public

Qualified Change

5.2 **General Provisions**

5.2.1 Applicability

(1) The requirements in Section 5, Generator Interconnection or Modification, apply to the following:

(a) Any Entity proposing to interconnect any generator with an aggregate nameplate capacity of one MW or greater, including but not limited to any Generation Resource or Energy Storage Resource (ESR), to the ERCOT System;

(b) Any Entity proposing to interconnect a Settlement Only Generator (SOG) to the ERCOT System; or

(c) Any Resource Entity seeking to modify a Generation Resource, ESR, or SOG that is connected to the ERCOT System by:

ERCOT PLANNING GUIDE – DECEMBER 12, 2024 5-1

PUBLIC

SECTION 5: GENERATOR INTERCONNECTION OR MODIFICATION

(i) Increasing the real power rating from that shown in the latest Resource Registration data by one MW or greater within a single year;

(ii) Changing the inverter, turbine, generator, or power converter associated with a facility with an aggregate real power rating of ten MW or greater, unless the replacement is in-kind;

(iii) Modifying any control settings or equipment of Inverter-Based Resources (IBRs) that impact the dynamic response (such as voltage, frequency, and current injections) at the Point of Interconnection (POI) in a manner that is deemed to require further study in accordance with the process outlined in paragraph (5) of Section 5.5, Generator Commissioning and Continuing Operations;

(iv) Changing or adding a POI to a facility with an aggregate real power rating of ten MW or greater; or

(v) Increasing the aggregate nameplate capacity of a generator less than ten MW to ten MW or greater.

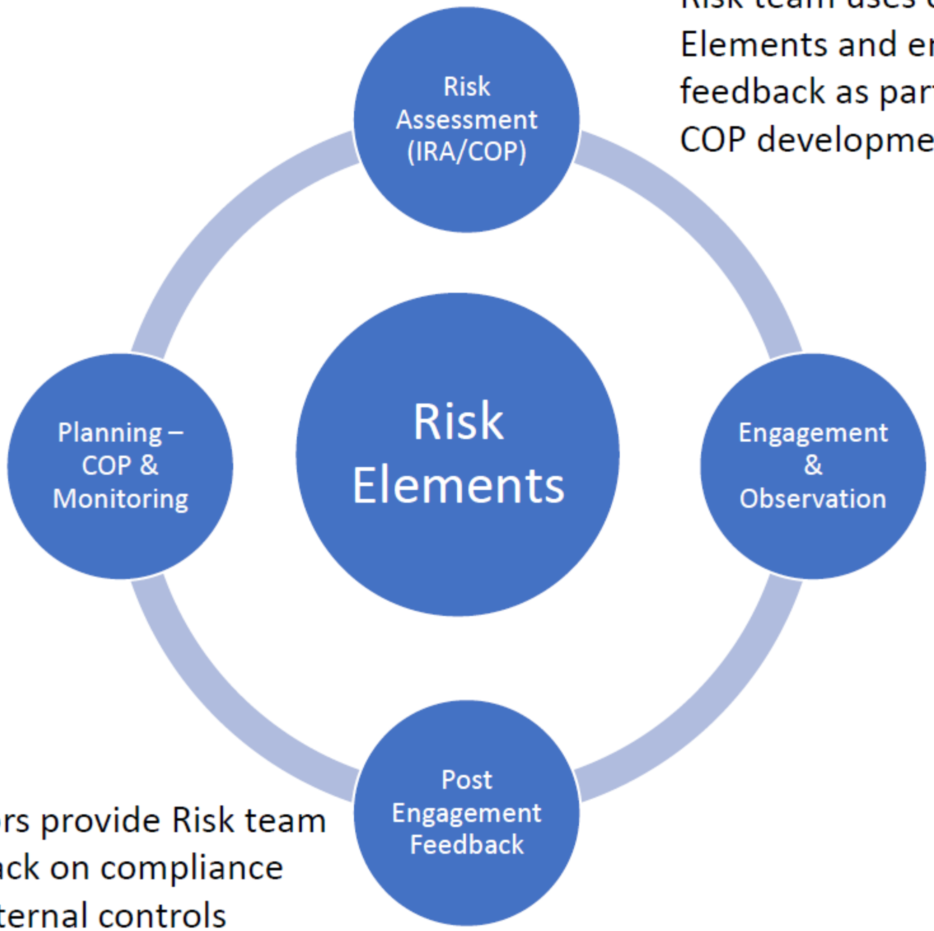
Implementation Guidance for FAC-002-4, R6

Modifying any control settings or equipment of inverter-based resources (IBRs) that impact the dynamic response (such as voltage, frequency, and current injections) at the Point of Interconnection (POI) in a manner that is deemed to require further study in accordance with the process outlined in paragraph (5) of Section 5.5, Generator Commissioning and Continuing Operations

ERCOT Planning Guide

CMEP Feedback Loop

Risk team uses current Risk Elements and engagement feedback as part of IRA and COP development process



Engagement feedback may impact monitoring interval, scope, method, or sampling

Auditors will sample and look at internal controls during engagements

Auditors provide Risk team feedback on compliance and internal controls

Resources and Guidance

Texas RE website

- Engagement common questions
- Training materials

ERCOT website

- Resource Interconnection Handbook
- ERCOT Planning Guide

NERC website

- One Stop Shop

Questions?

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Ensuring electric reliability for Texans

Texas RE Spring Standards, Security, & Reliability Workshop

Return at: 10:45 am

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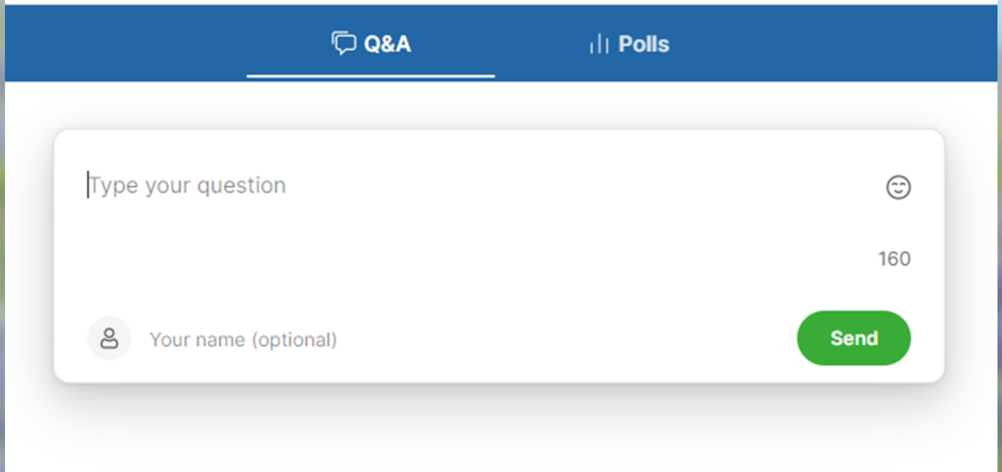
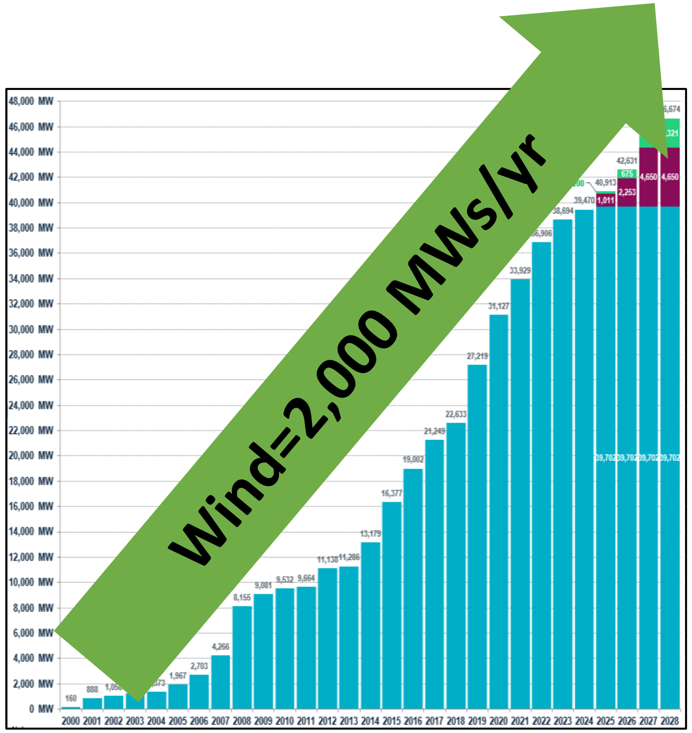


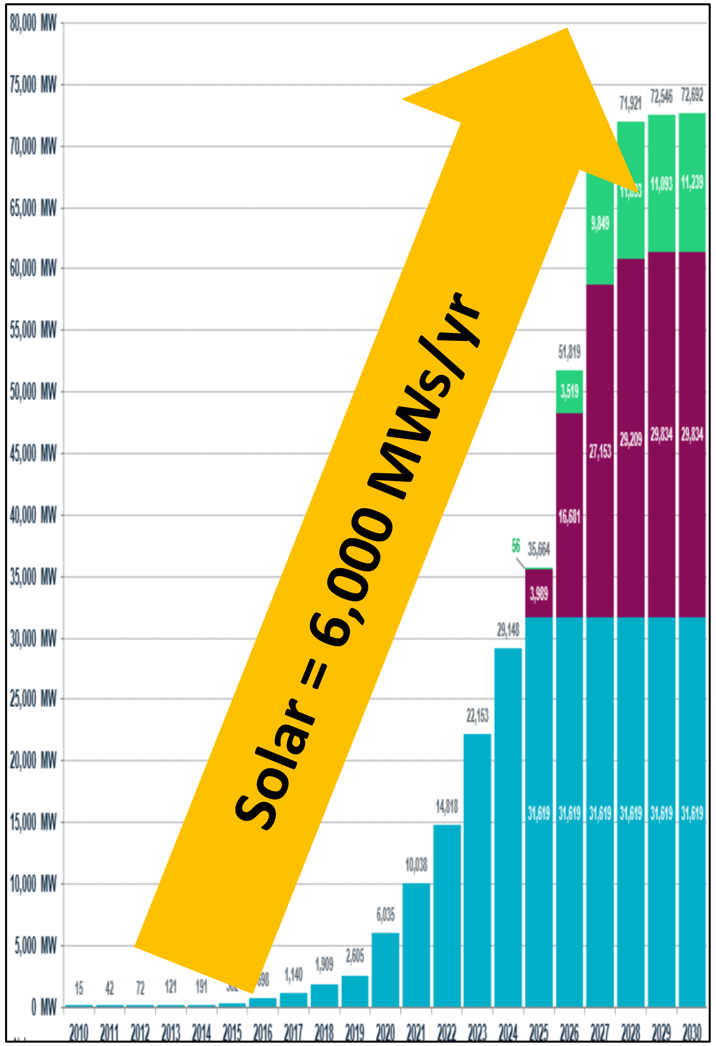
IBR Modeling Challenges

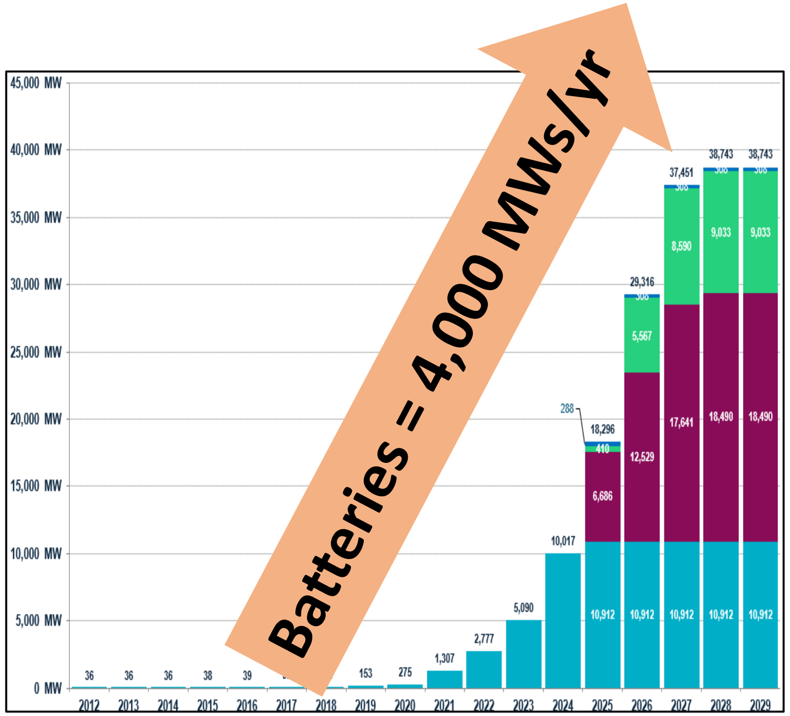
Brad Woods
Senior Reliability Engineer

Blair Giffin
Manager, O&P Compliance Monitoring

Growth of Inverter-Based Resources (IBRs) in ERCOT



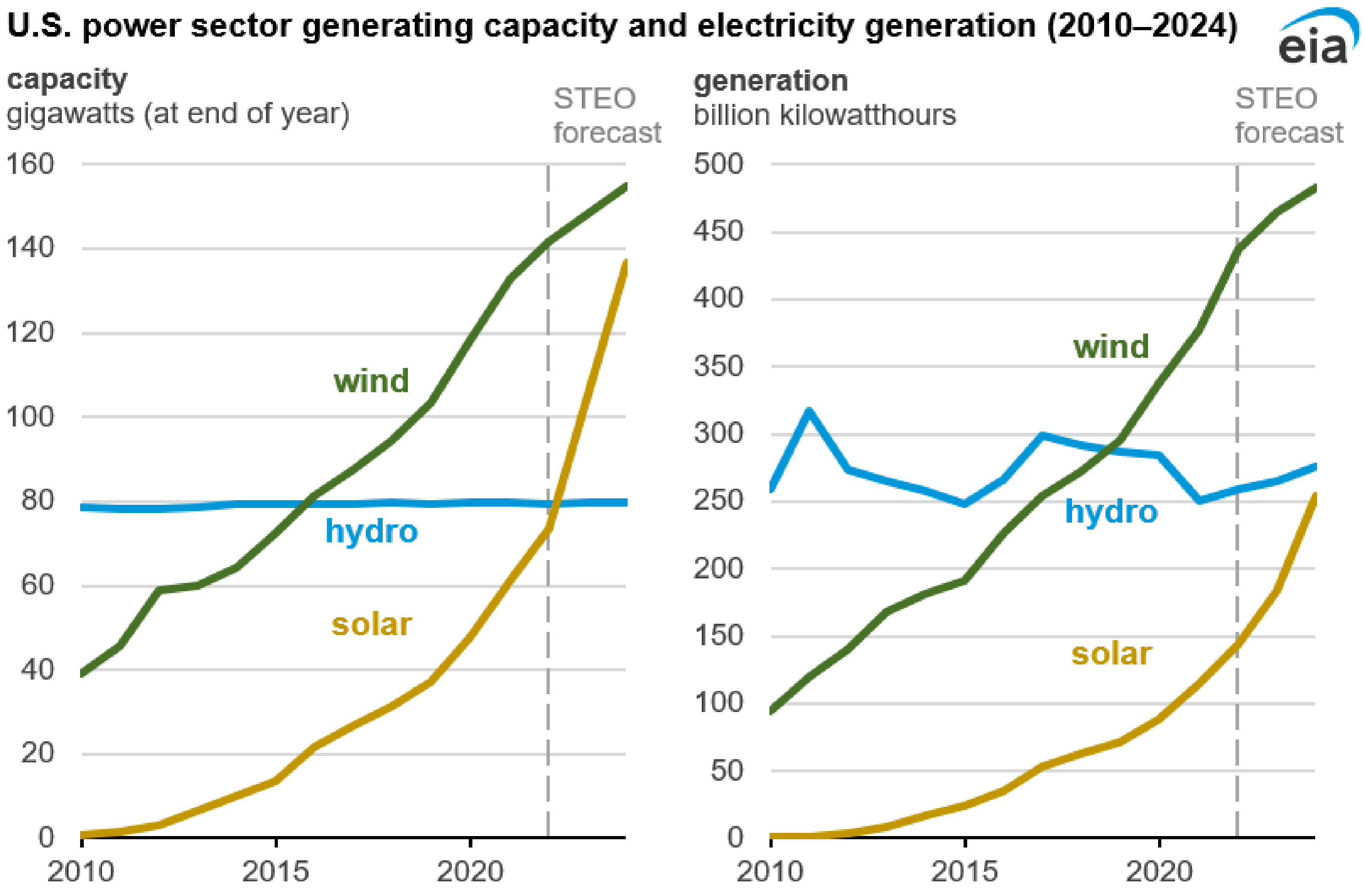




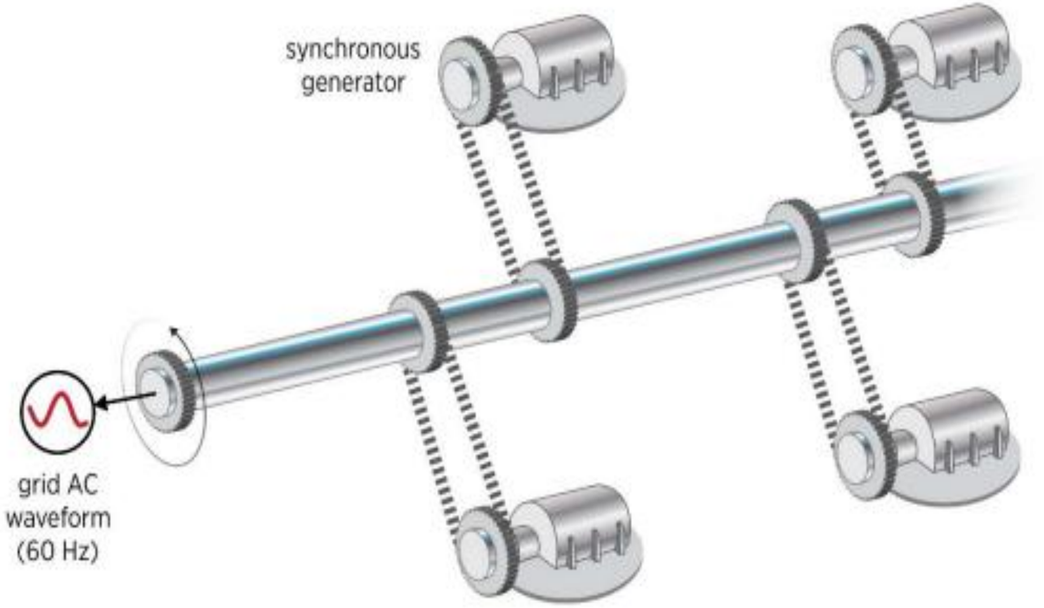
Growth of IBRs in the U.S.

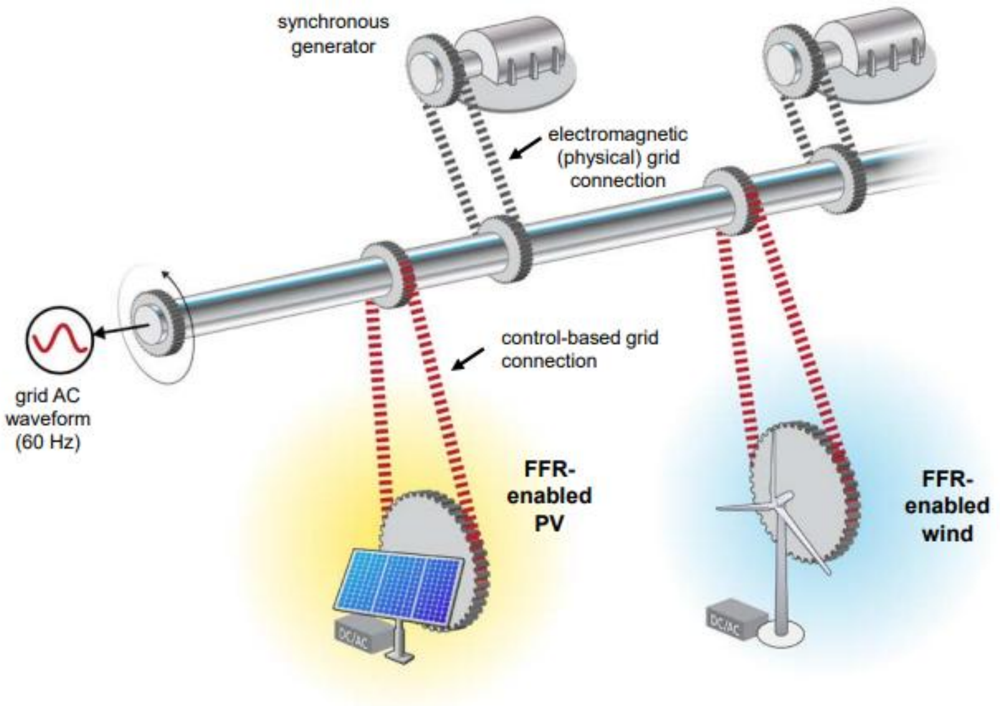
Wind=10,000 MWs/yr

Solar=16,000 MWs/yr



Transformation in Frequency Control





Source: [NREL: Inertia and the Power Grid: A Guide Without the Spin]

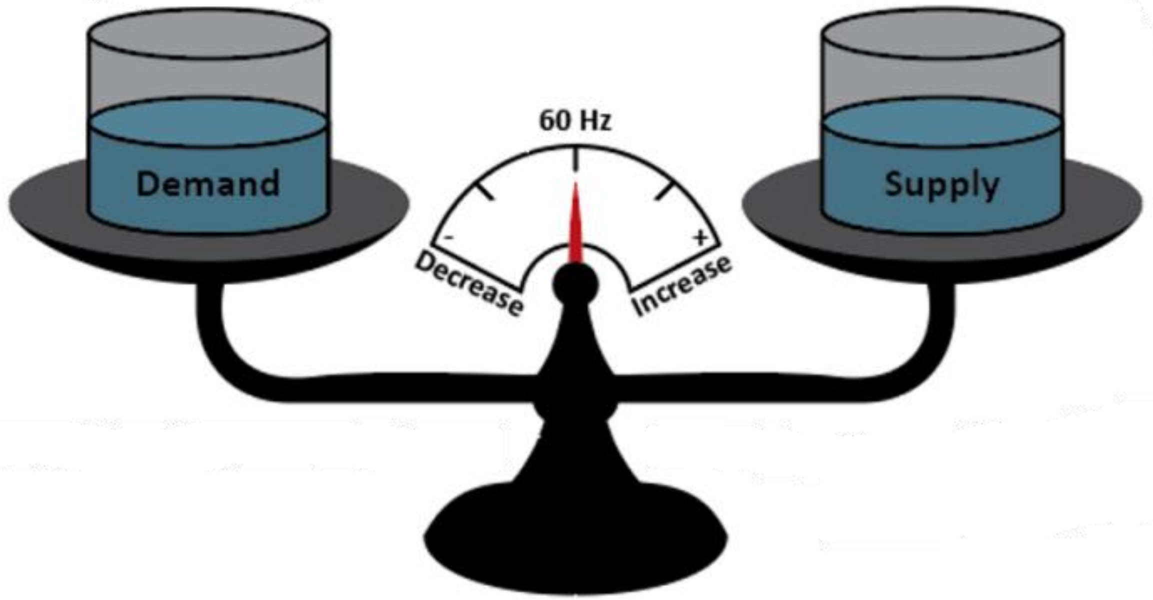
System Design (Frequency)

System is designed to operate at 60 Hz

Frequency depends on the balance between load and generation during both normal and contingency conditions

Generation must remain connected to the grid and continue to support grid frequency during disturbances

Frequency deviations larger than +/-0.05 Hz from 60 Hz can lead to cascading failures or system instability



Source: NERC Balancing And Frequency Control

Synchronous Generation vs IBRs

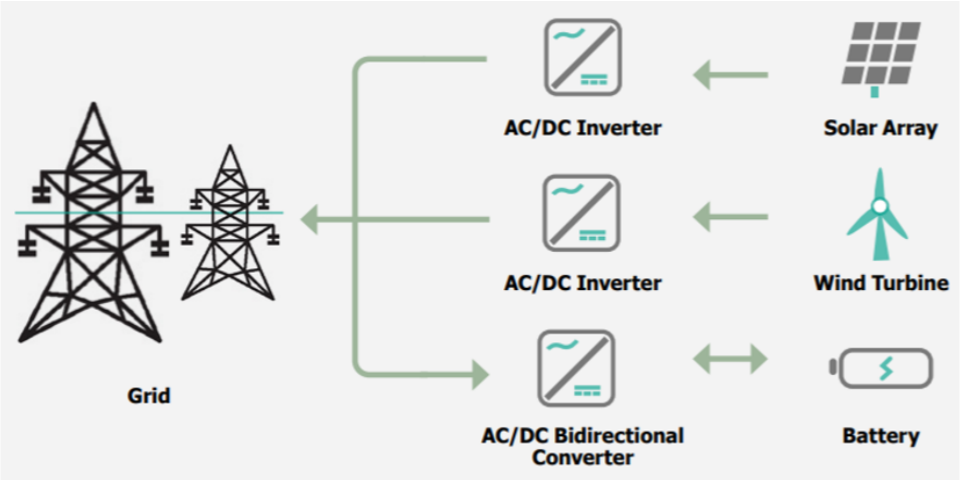
What are the differences between inverter-based resources and synchronous generation?

Both inverter-based resources and synchronous generation can provide essential reliability services to the BPS. However, the industry is facing challenges integrating significant levels of inverter-based resources because of the unique differences between technologies. BPS planning, design, protection, and operations practices will all need to evolve to ensure reliability and resilience of the BPS under this rapid pace of change.

Differences between Inverter-Based Resources and Synchronous Generation

Inverter-Based Resources	Synchronous Generation
• Driven by power electronics and software	• Driven by physical machine properties
• No (or little) inertia	• Large rotating inertia
• Very low fault current	• High fault current
• Sensitive power electronic switches	• Rugged equipment tolerant to extremes
• Very fast and flexible ramping	• Slower ramping
• Very fast frequency control	• Inherent inertial response
• Minimal plant auxiliary equipment prone to tripping	• Sensitive auxiliary plant equipment
• Dispatchable based on available power	• Fully dispatchable
• Can provide essential reliability services	• Can provide essential reliability services

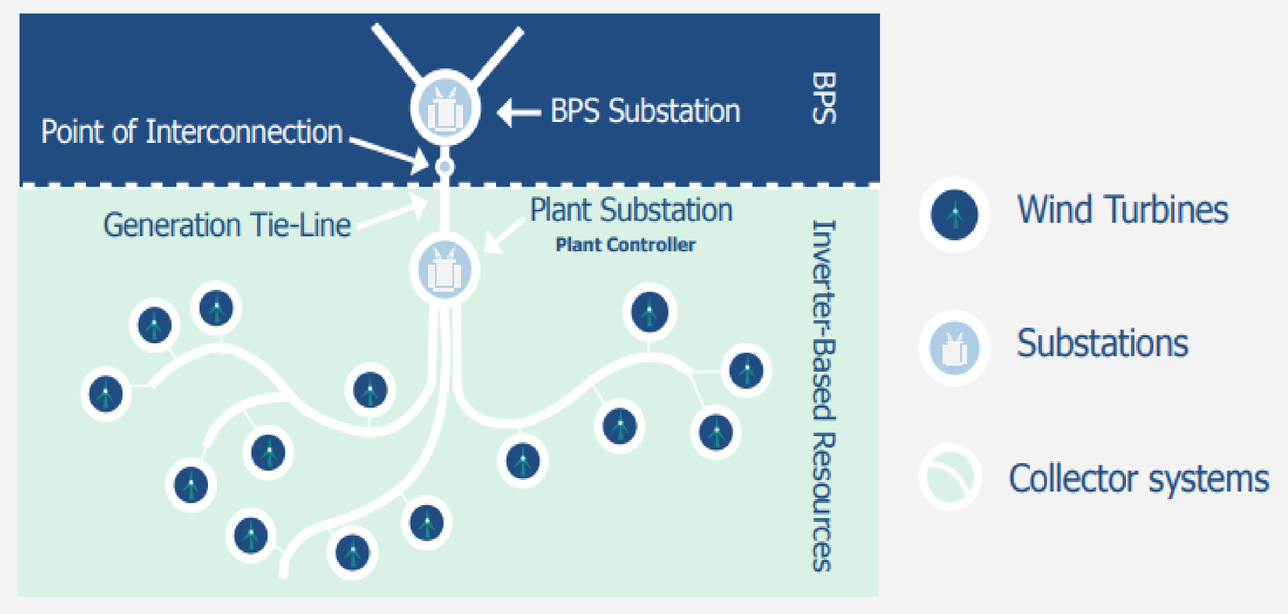
Source: NREL



Source: 2023_NERC_Guide_Inverter-Based-Resources

Key Components of IBR Models

- **Energy source:** Models the individual inverter-based resources like solar PV, wind turbines, or battery energy storage system
- **Inverter:** Models the power electronic device that converts the dc electricity into ac electricity, the software controls that dictate how the resource responds to grid events, and the inverter protections including overvoltage, bus voltage unbalance, and overfrequency/underfrequency.
- **Step-up transformer:** Models the transformers that step up or down the voltage for connection to the grid
- **Collector system/feeders:** Models the electrical network connecting the energy sources to the plant substation and protections for feeders
- **Protection Systems:** Models for various protections including overcurrent, low voltage/high voltage, DC Bus, PLL loss of synchromism, phase jump, and DC reverse current
- **Control Loops:** Models the inner current control loops and outer power/voltage control loops to regulate the IBR's output and interaction with the grid
- **Plant controller:** Models the central controller that manages the overall operation of the IBR plant, including grid support functions
- **Plant substation:** Models the buses where the collector system feeders aggregate and connects to the step-up transformer
- **Tie-line:** Models the tie line connecting the IBR plant to the bulk power system



Source: 2023_NERC_Guide_Inverter-Based-Resources.pdf

IBR Models Provided to Transmission Planners

When Planners Receive Models Prior to Commercial Operation

- Interconnection Study
  - Can be 1-5 years before commercial
  - Models provided represent the expected design (may not be site specific)
- Commissioning
  - Less than one year before commercial
  - Match control settings at the plant (as-built)

Model Review by Planners

- Check model information provided by GO
- Check performance of model for usability
  - Does the model work?
- Check performance of model during disturbance simulations
  - Model behaves as expected
- No ability to compare performance of models with plant during disturbances
  - Behavior of model vs plant

Commercial Operation

- Latest version of models used for planning studies
- Should represent expected behavior during disturbances

Why Accurate IBR Models Are Important for Planning

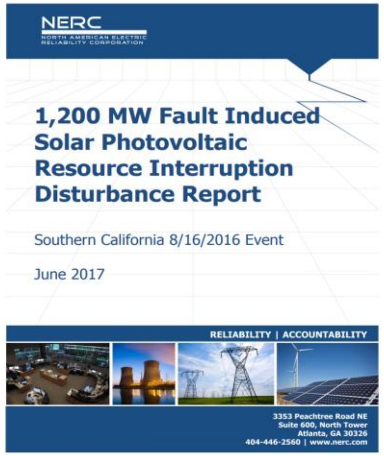
Growth of IBRs is Significant and IBRs are Needed for Frequency Control

IBRs are Different from Synchronous Generators

IBR Behavior During System Faults Needs to be Studied

Reliability Issues **may not be** Identified and Addressed if IBR Models are Not Accurate (Cascading / Instability)

IBR Events 2016 – 2023


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

Southern California 8/16/2016 Event

June 2017

RELIABILITY | ACCOUNTABILITY

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


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

Southern California Event: October 9, 2017
Joint NERC and WECC Staff Report

February 2018

RELIABILITY | ACCOUNTABILITY

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

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

RELIABILITY | ACCOUNTABILITY

3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
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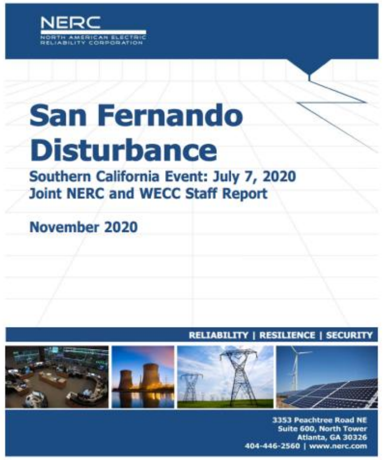
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San Fernando Disturbance

Southern California Event: July 7, 2020
Joint NERC and WECC Staff Report

November 2020

RELIABILITY | RESILIENCE | SECURITY

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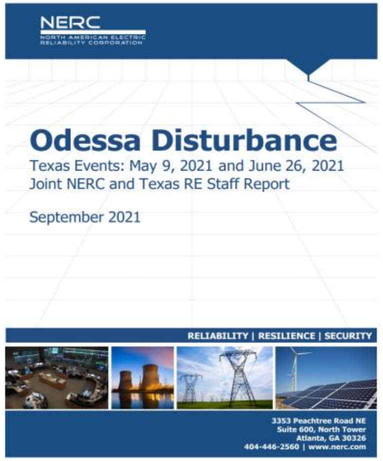
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Odessa Disturbance

Texas Events: May 9, 2021 and June 26, 2021
Joint NERC and Texas RE Staff Report

September 2021

RELIABILITY | RESILIENCE | SECURITY

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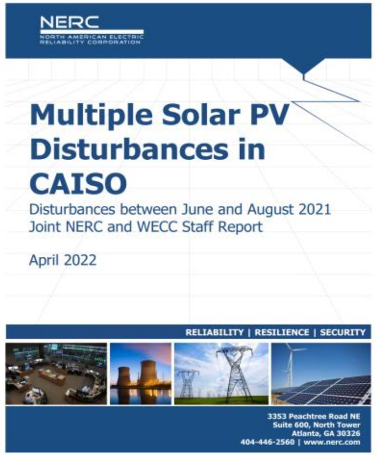
Atlanta, GA 30326
404-446-2560 | www.nerc.com


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Multiple Solar PV Disturbances in CAISO

Disturbances between June and August 2021
Joint NERC and WECC Staff Report

April 2022

RELIABILITY | RESILIENCE | SECURITY

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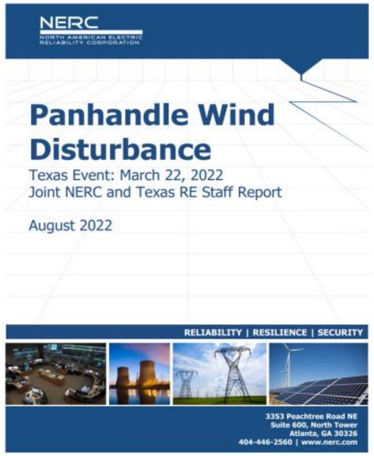
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Panhandle Wind Disturbance

Texas Event: March 22, 2022
Joint NERC and Texas RE Staff Report

August 2022

RELIABILITY | RESILIENCE | SECURITY

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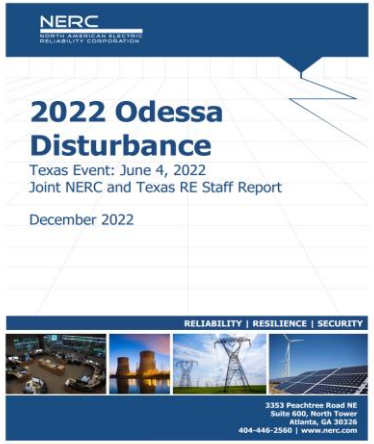
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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

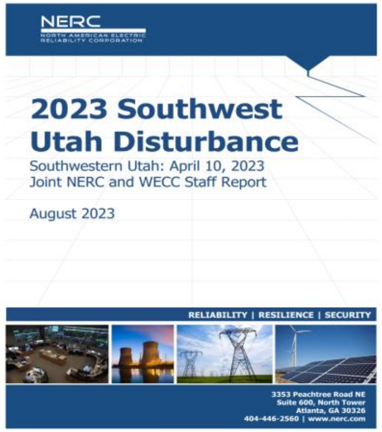
2022 Odessa Disturbance

Texas Event: June 4, 2022
Joint NERC and Texas RE Staff Report

December 2022

RELIABILITY | RESILIENCE | SECURITY

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


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2023 Southwest Utah Disturbance

Southwestern Utah: April 10, 2023
Joint NERC and WECC Staff Report

August 2023

RELIABILITY | RESILIENCE | SECURITY

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Suite 600, North Tower
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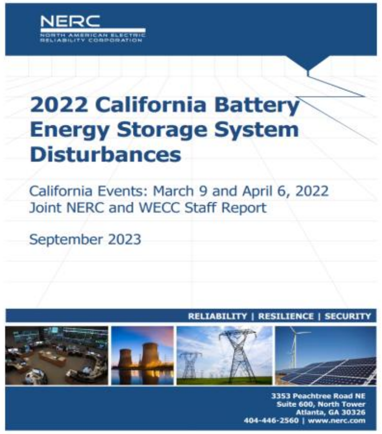
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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2022 California Battery Energy Storage System Disturbances

California Events: March 9 and April 6, 2022
Joint NERC and WECC Staff Report

September 2023

RELIABILITY | RESILIENCE | SECURITY

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Source: NERC Event Reports

2016 – Blue Cut Disturbance

On August 16, 2016, at 10:36 a.m. Pacific, the Blue Cut fire began in the Cajon Pass. The fire quickly moved toward an important transmission corridor that is comprised of three 500 kV lines and two 287 kV lines. By the end of the day, the transmission system experienced thirteen 500 kV line faults and two 287 kV faults as a result of the fire.

- IBR generation loss: approximately 1,200 MW was the largest
- IBR generation loss caused by:
  - Protection settings
  - Momentary cessation
- Lowest frequency = 59.867 Hz
- IBR models were **not** accurate

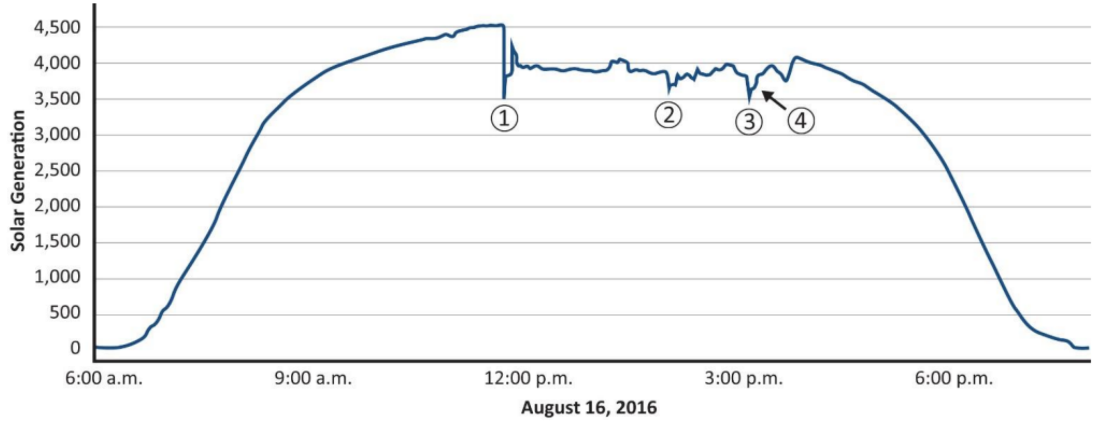
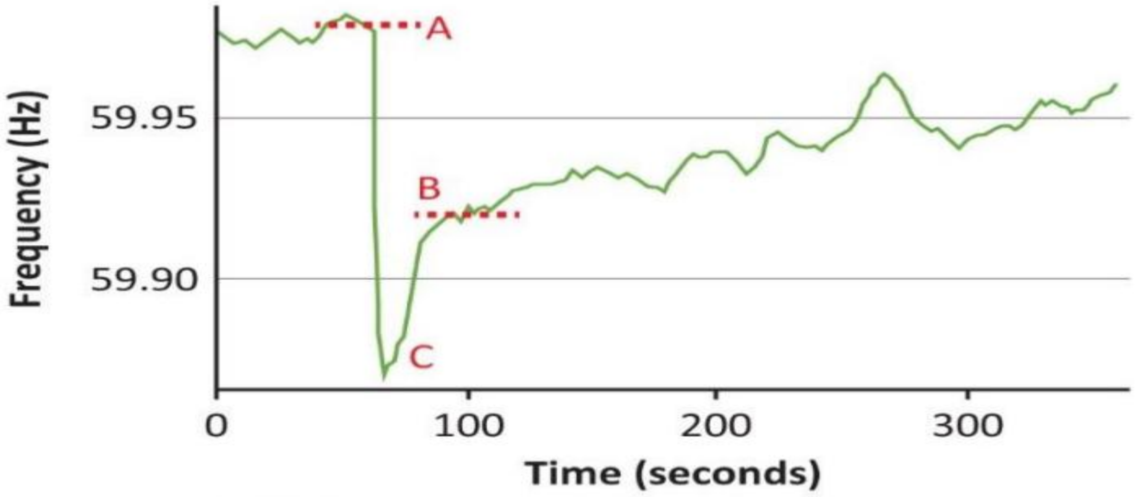


Figure 1.3: Utility-Scale Solar PV Output in SCE Footprint on August 16, 2016



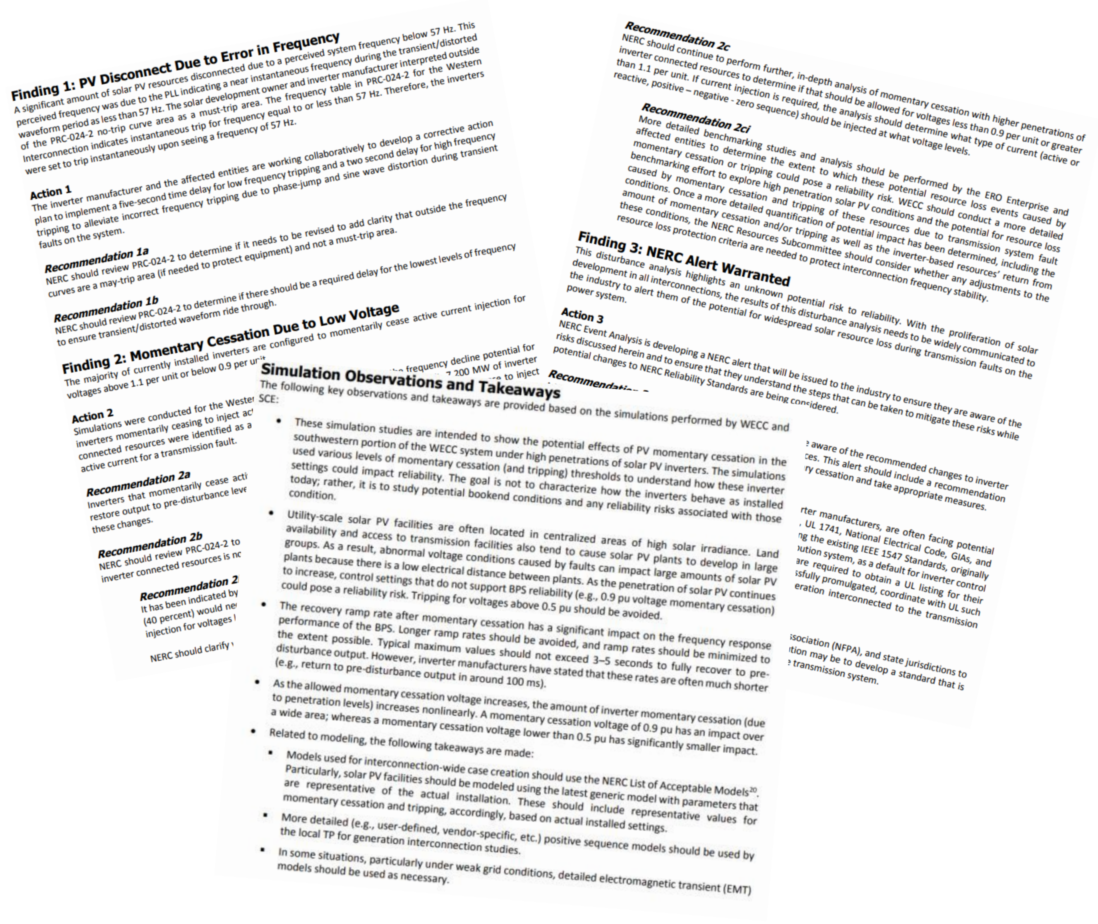
Recommendations

GOs

- Inverters that momentarily cease active power output for these voltage excursions should be configured to restore output to pre-disturbance levels in no greater than five seconds, provided that the inverter is capable of these changes

PCs and TPs

- Models used for interconnection-wide case creation should use the NERC List of Acceptable Models. Particularly, solar PV facilities should be modeled using the latest generic model with parameters that are representative of the actual installation. These should include representative values for momentary cessation and tripping based on actual installed settings
- More detailed (e.g., user-defined, vendor-specific, etc.) positive sequence models should be used by the local TP for generation interconnection studies
- In some situations, particularly under weak grid conditions, detailed electromagnetic transient (EMT) models should be used as necessary



Finding 1: PV Disconnect Due to Error in Frequency
A significant amount of solar PV resources disconnected due to a perceived system frequency below 57 Hz. This perceived frequency was due to the PLL indicating a near instantaneous frequency during the transient/distorted waveform period as less than 57 Hz. The solar development owner and inverter manufacturer interpreted outside of the PRC-024-2 no-trip curve area as a must-trip area. The frequency table in PRC-024-2 for the Western Interconnection indicates instantaneous trip for frequency equal to or less than 57 Hz. Therefore, the inverters were set to trip instantaneously upon seeing a frequency of 57 Hz.

Action 1
The inverter manufacturer and the affected entities are working collaboratively to develop a corrective action plan to implement a five-second time delay for low frequency tripping and a two second delay for high frequency tripping to alleviate incorrect frequency tripping due to phase-jump and sine wave distortion during transient faults on the system.

Recommendation 1a
NERC should review PRC-024-2 to determine if it needs to be revised to add clarity that outside the frequency curves are a may-trip area (if needed to protect equipment) and not a must-trip area.

Recommendation 1b
NERC should review PRC-024-2 to determine if there should be a required delay for the lowest levels of frequency to ensure transient/distorted waveform ride through.

Finding 2: Momentary Cessation Due to Low Voltage
The majority of currently installed inverters are configured to momentarily cease active current injection for voltages above 1.1 per unit or below 0.9 per u…

Action 2
Simulations were conducted for the Wester…
inverters momentarily ceasing to inject ac…
connected resources were identified as a…
active current for a transmission fault.

Recommendation 2a
Inverters that momentarily cease acti…
restore output to pre-disturbance leve…
these changes.

Recommendation 2b
NERC should review PRC-024-2 to…
inverter connected resources is nc…

Recommendation 2…
It has been indicated by…
(40 percent) would ne…
injection for voltages l…

NERC should clarify…

Recommendation 2c
NERC should continue to perform further, in-depth analysis of momentary cessation with higher penetrations of inverter connected resources to determine if that should be allowed for voltages less than 0.9 per unit or greater than 1.1 per unit. If current injection is required, the analysis should determine what type of current (active or reactive, positive – negative - zero sequence) should be injected at what voltage levels.

Recommendation 2ci
More detailed benchmarking studies and analysis should be performed by the ERO Enterprise and affected entities to determine the extent to which these potential resource loss events caused by momentary cessation or tripping could pose a reliability risk. WECC should conduct a more detailed benchmarking effort to explore high penetration solar PV conditions and the potential for resource loss caused by momentary cessation and tripping of these resources due to transmission system fault conditions. Once a more detailed quantification of potential impact has been determined, including the amount of momentary cessation and/or tripping as well as the inverter-based resources' return from these conditions, the NERC Resources Subcommittee should consider whether any adjustments to the resource loss protection criteria are needed to protect interconnection frequency stability.

Finding 3: NERC Alert Warranted
This disturbance analysis highlights an unknown potential risk to reliability. With the proliferation of solar development in all interconnections, the results of this disturbance analysis needs to be widely communicated to the industry to alert them of the potential for widespread solar resource loss during transmission faults on the power system.

Action 3
NERC Event Analysis is developing a NERC alert that will be issued to the industry to ensure they are aware of the risks discussed herein and to ensure that they understand the steps that can be taken to mitigate these risks while potential changes to NERC Reliability Standards are being considered.

Simulation Observations and Takeaways
The following key observations and takeaways are provided based on the simulations performed by WECC and SCE:

- These simulation studies are intended to show the potential effects of PV momentary cessation in the southwestern portion of the WECC system under high penetrations of solar PV inverters. The simulations used various levels of momentary cessation (and tripping) thresholds to understand how these inverter settings could impact reliability. The goal is not to characterize how the inverters behave as installed today; rather, it is to study potential bookend conditions and any reliability risks associated with those condition.
- Utility-scale solar PV facilities are often located in centralized areas of high solar irradiance. Land availability and access to transmission facilities also tend to cause solar PV plants to develop in large groups. As a result, abnormal voltage conditions caused by faults can impact large amounts of solar PV plants because there is a low electrical distance between plants. As the penetration of solar PV continues to increase, control settings that do not support BPS reliability (e.g., 0.9 pu voltage momentary cessation) could pose a reliability risk. Tripping for voltages above 0.5 pu should be avoided.
- The recovery ramp rate after momentary cessation has a significant impact on the frequency response performance of the BPS. Longer ramp rates should be avoided, and ramp rates should be minimized to the extent possible. Typical maximum values should not exceed 3–5 seconds to fully recover to pre-disturbance output. However, inverter manufacturers have stated that these rates are often much shorter (e.g., return to pre-disturbance output in around 100 ms).
- As the allowed momentary cessation voltage increases, the amount of inverter momentary cessation (due to penetration levels) increases nonlinearly. A momentary cessation voltage of 0.9 pu has an impact over a wide area; whereas a momentary cessation voltage lower than 0.5 pu has significantly smaller impact.
- Related to modeling, the following takeaways are made:
  - Models used for interconnection-wide case creation should use the NERC List of Acceptable Models[20]. Particularly, solar PV facilities should be modeled using the latest generic model with parameters that are representative of the actual installation. These should include representative values for momentary cessation and tripping, accordingly, based on actual installed settings.
  - More detailed (e.g., user-defined, vendor-specific, etc.) positive sequence models should be used by the local TP for generation interconnection studies.
  - In some situations, particularly under weak grid conditions, detailed electromagnetic transient (EMT) models should be used as necessary.

2017 – Canyon Disturbance

On October 9, 2017, the Canyon 2 Fire caused two transmission system faults near the Serrano substation east of Los Angeles. The first fault was a normally cleared phase-to-phase fault on a 220 kV transmission line and the second fault was a normally cleared phase-to-phase fault on a 500 kV transmission line. Both faults resulted in the reduction of solar PV generation across a wide region.

- IBR generation loss: Approximately 900 MW
- IBR generation loss caused by:
  - Protection settings
  - Momentary cessation
- Lowest frequency = 59.878 Hz
- IBR models were **not** accurate

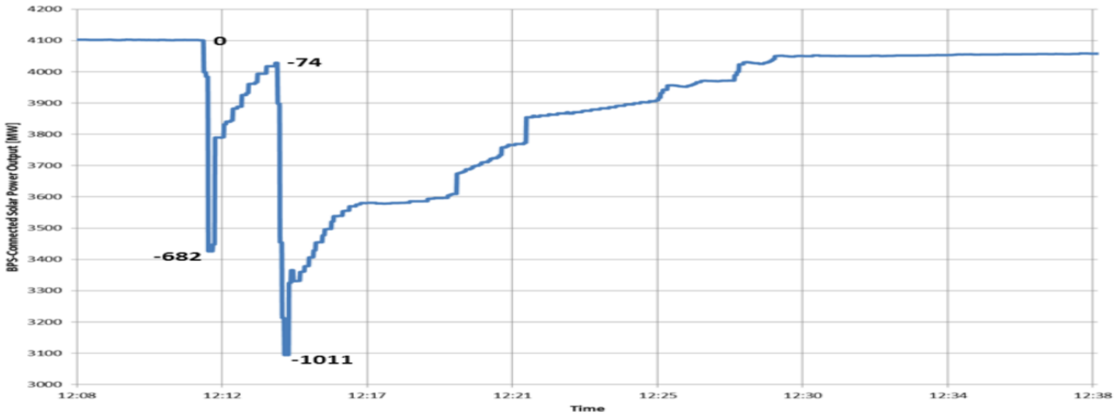
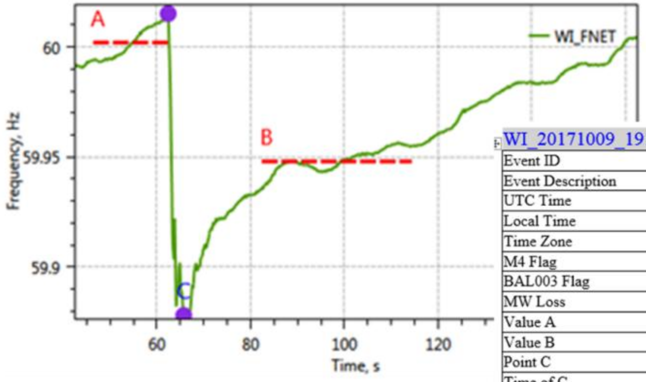


Figure 1.4: Solar PV Response during Canyon 2 Fire [Source: SCE]



WI_20171009_191428

Event ID	WI_20171009_191428
Event Description	"Solar Generation 900MW loss"
UTC Time	10/09/2017 19:14:28
Local Time	10/09/2017 12:14:28
Time Zone	PDT
M4 Flag	Yes
BAL003 Flag	Yes
MW Loss	900
Value A	60.002
Value B	59.948
Point C	59.878
Time of C	3.3
Point C'	-
Time of C'	-
A-B [mHz]	54
A-C [mHz]	124
FRM_B [MW/0.1Hz]	1667
FRM_C [MW/0.1Hz]	726

Figure 1.7: Western Interconnection Frequency during Second Fault

Blue Cut – Causes and Recommendations

GOs

- The use of momentary cessation is not recommended, should not be used for new inverter-based resources, and should be eliminated or mitigated to the greatest extent possible for existing resources connected to the BPS
- Existing inverters where momentary cessation cannot be effectively eliminated should not be impeded from restoring current injection following momentary cessation
- Voltage protection functions in the inverters should be set based on physical equipment limitations to protect the inverter itself and not based solely on the PRC-024-2 voltage ride-through characteristic. Within the “no trip” region of the curve, the inverters are expected to ride through and continue injecting current to the BPS. The region outside the curve should be interpreted as a “may trip” zone and not a “must trip” zone and protection should be set as wide as possible while still ensuring the reliability and integrity of the inverter-based resource
- Inverters should not trip for momentary PLL loss of synchronism caused by phase jumps, distortion, etc., during BPS grid events (e.g., faults)

PCs and TPs

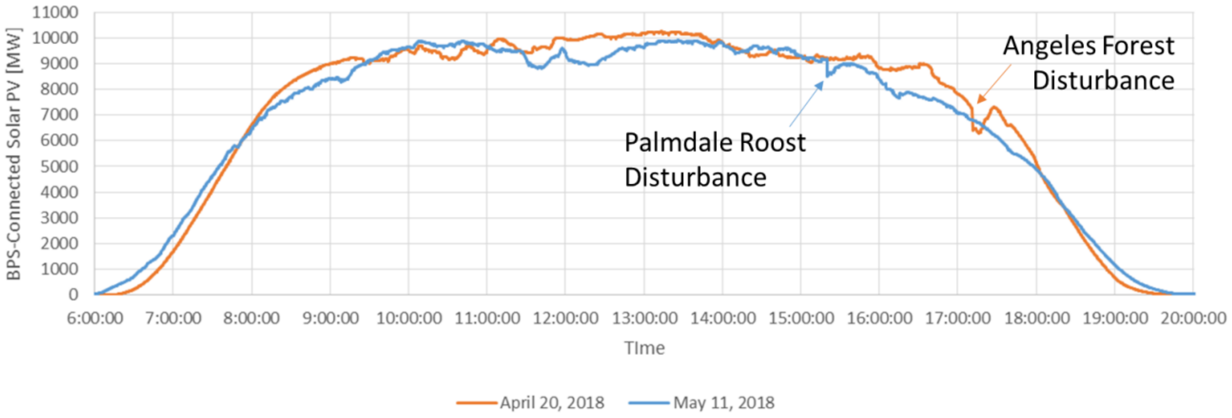
- EMT studies should be performed by affected GOPs in coordination with Transmission Owners (TOs) to better understand the cause of transient over-voltages resulting in inverter tripping
- Generic dynamic stability models used during the interconnection process for studying reliability of the BPS do not accurately reflect all aspects of the behavior of inverter-based resources. Model improvements should be prioritized by industry groups developing these models (e.g., WECC Renewable Energy Modeling Task Force) to ensure that stability models sufficiently reflect the behavior of inverter-based resources installed today and in the future

2018 – Angeles Forest and Palmdale Roost Disturbances

The Angeles Forest disturbance occurred on April 20, 2018, and was initiated by a 500 kV transmission line fault with a failed splice. The resulting phase-to-phase fault was cleared normally by line relay protection in 2.6 cycles.

Palmdale Roost disturbance occurred on May 11, 2018, and was initiated by a 500 kV transmission line fault due to insulator flashover caused by a buildup of bird nesting material. The resulting single-line-to-ground fault was cleared normally by line relay protection in three cycles.

- Angeles Forest IBR generation loss: approximately 900 MW
- Palmdale Roost IBR generation loss: approximately 900 MW
- IBR generation loss caused by:
  - Protection settings
  - Momentary cessation
- Lowest Frequency = 59.86 Hz
- IBR models were **not** accurate



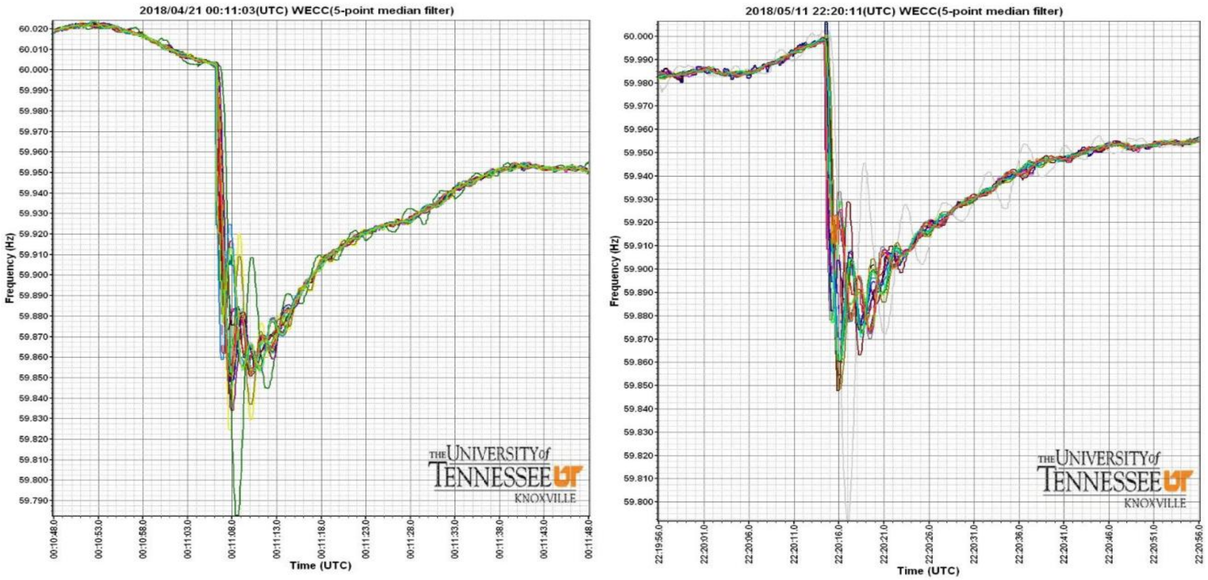


Figure 1.21: System Frequency during Both Disturbances [Source: FNET]

Recommendations

GOs

- Use of momentary cessation is not recommended, should not be used for new inverter-based resources, and should be eliminated or mitigated to the greatest extent possible for existing resources connected to the BPS
- Existing inverters where momentary cessation cannot be effectively eliminated should not be impeded from restoring current injection following momentary cessation
- Work with inverter manufacturers to set transient ac overvoltage protection as wide as possible while still protecting the integrity of the inverter and associated equipment
- Coordinate with inverter manufacturer to ensure that dc reverse current detection and protection are set to avoid tripping for dc reverse currents that could result during sub-cycle transient overvoltage conditions

PCs and TPs

- Ensure that momentary cessation of BPS-connected solar PVs is modeled correctly
- Follow up with applicable GOs to ensure that these changes are being made and that models are being updated to accurately reflect the dynamic behavior of solar PV resources connected to the BPS

2020 – San Fernando Disturbance

On July 7, 2020, the static wire on a 230 kV double circuit tower failed, causing a single-line-to-ground (SLG) fault on both the #1 and #2 parallel circuits. The fault was cleared normally in about three cycles. In addition, a nearby 230 kV line relay incorrectly operated for an external fault. For this first fault event, approximately 205 MW of power reduction was observed at BPS-connected solar PV facilities in the Southern California region. At 11:41 PDT, the #1 circuit was reenergized and held; however, at 11:41:31, the #2 line was re-energized and relayed back out. The cause of relaying back out was a low-impedance three-phase fault that was cleared normally in 2.3 cycles.

- IBR generation loss: approximately 1000 MW (second fault)
- IBR generation loss caused by:
- Lowest frequency = 59.84 Hz
- IBR models were **not** accurate

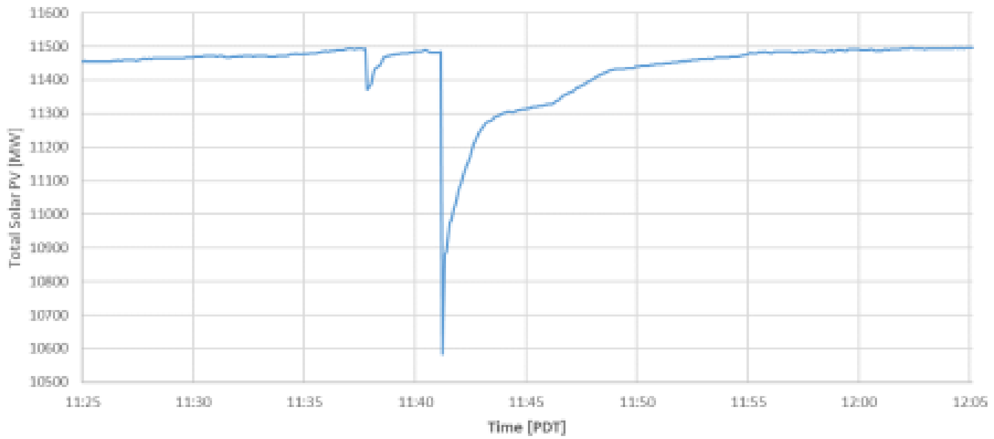


Figure 1.4: CAISO BPS-Connected Solar PV during Disturbance [Source: CAISO]

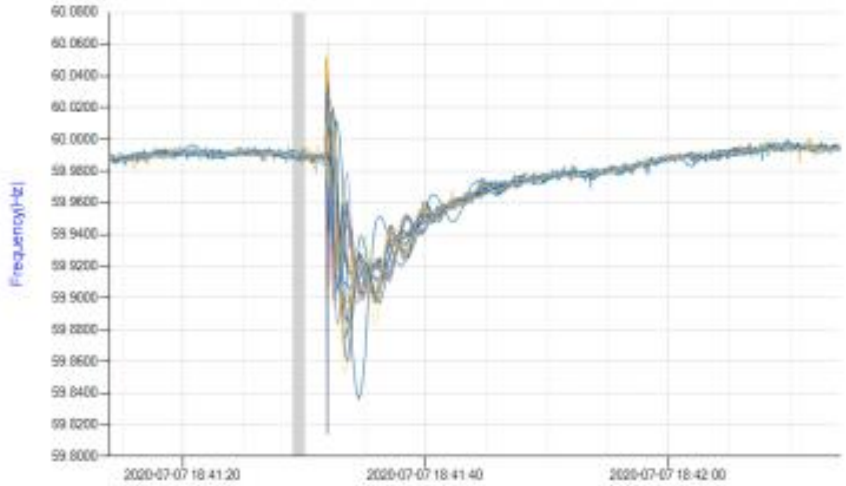


Figure 1.10: FNET Frequency Measurements for Event #2 [Source: UTK/ORNL]

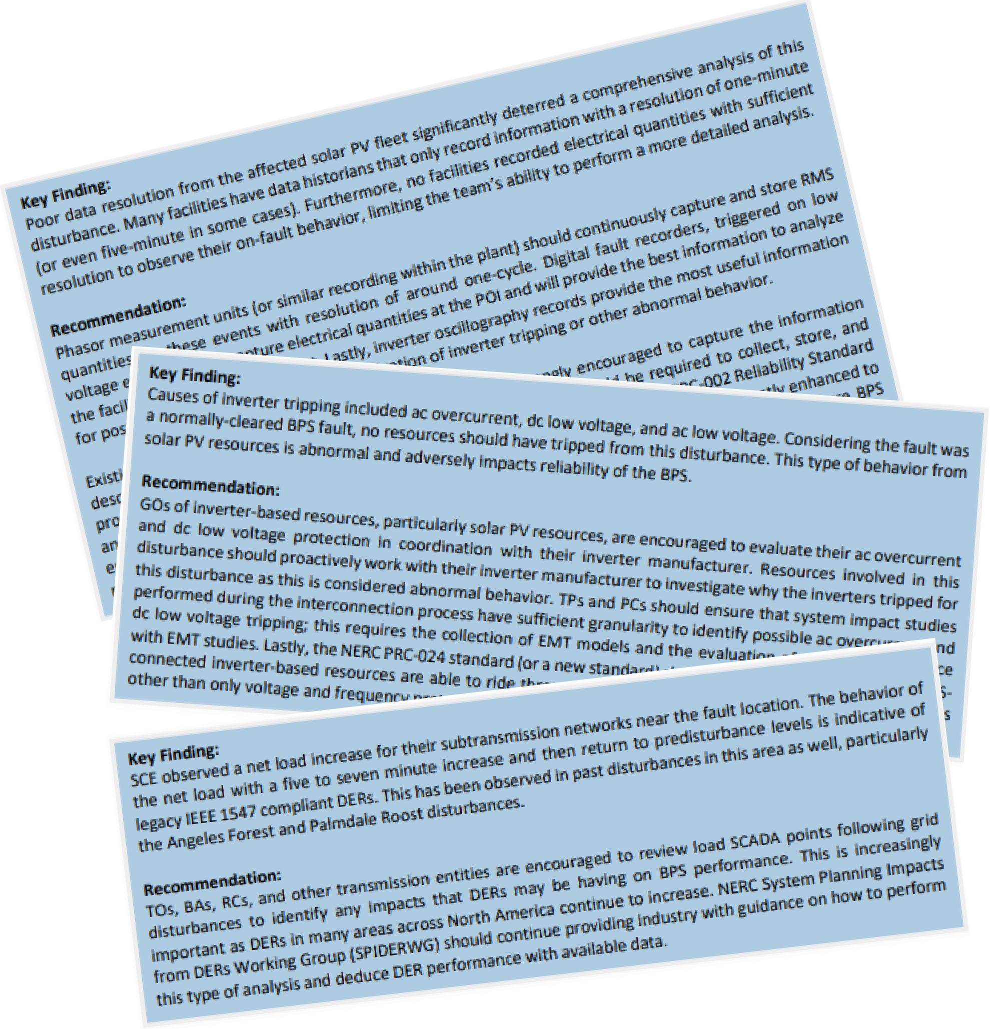
Recommendations

GOs

- All GOs and GOPs should ensure adequate data monitoring within their facilities for inverter-based resources to determine root causes of abnormal performance to BPS disturbances. This includes having access to inverter and plant-level settings, fault codes, oscillography records, digital fault recorder data, and archived plant data (i.e., SCADA data) with a resolution of one sample per second or faster. NERC Standards should be enhanced to ensure this data is available from all BPS generating facilities, as this continues to be a major issue limiting the ability to perform event analysis
- Should analyze partial tripping events and work with inverter manufacturers to mitigate inverter tripping to the extent possible
- Should ensure that any changes to plant-level settings, inverter settings, or facility topologies or ratings should be provided to the TP

PCs and TPs

- Ensure that the models provided during the interconnection study process are able to account for all forms of tripping by IBRs. This may require the collection of EMT models and the evaluation of system performance with EMT studies
- All models should be updated after plant commissioning and checked to ensure that the model matches the as-built, plant-specific settings, controls, and behavior
- All models should be updated after GOs make settings changes to inverters that affect its electrical output during steady-state or dynamic conditions


Key Finding:
Poor data resolution from the affected solar PV fleet significantly deterred a comprehensive analysis of this disturbance. Many facilities have data historians that only record information with a resolution of one-minute (or even five-minute in some cases). Furthermore, no facilities recorded electrical quantities with sufficient resolution to observe their on-fault behavior, limiting the team's ability to perform a more detailed analysis.

Recommendation:
Phasor measurement units (or similar recording within the plant) should continuously capture and store RMS quantities ... these events with resolution of around one-cycle. Digital fault recorders, triggered on low voltage ... capture electrical quantities at the POI and will provide the best information to analyze the facil... Lastly, inverter oscillography records provide the most useful information for pos... of inverter tripping or other abnormal behavior.

Key Finding:
Causes of inverter tripping included ac overcurrent, dc low voltage, and ac low voltage. Considering the fault was a normally-cleared BPS fault, no resources should have tripped from this disturbance. This type of behavior from solar PV resources is abnormal and adversely impacts reliability of the BPS.

Recommendation:
GOs of inverter-based resources, particularly solar PV resources, are encouraged to evaluate their ac overcurrent and dc low voltage protection in coordination with their inverter manufacturer. Resources involved in this disturbance should proactively work with their inverter manufacturer to investigate why the inverters tripped for this disturbance as this is considered abnormal behavior. TPs and PCs should ensure that system impact studies performed during the interconnection process have sufficient granularity to identify possible ac overcu... dc low voltage tripping; this requires the collection of EMT models and the evaluation ... with EMT studies. Lastly, the NERC PRC-024 standard (or a new standard) ... connected inverter-based resources are able to ride thr... other than only voltage and frequency ...

Key Finding:
SCE observed a net load increase for their subtransmission networks near the fault location. The behavior of the net load with a five to seven minute increase and then return to predisturbance levels is indicative of legacy IEEE 1547 compliant DERs. This has been observed in past disturbances in this area as well, particularly the Angeles Forest and Palmdale Roost disturbances.

Recommendation:
TOs, BAs, RCs, and other transmission entities are encouraged to review load SCADA points following grid disturbances to identify any impacts that DERs may be having on BPS performance. This is increasingly important as DERs in many areas across North America continue to increase. NERC System Planning Impacts from DERs Working Group (SPIDERWG) should continue providing industry with guidance on how to perform this type of analysis and deduce DER performance with available data.

2021 – Odessa Disturbance

On May 9, 2021, a single-line-to-ground (Phase A) fault occurred on a generator step-up (GSU) transformer at a combined-cycle power plant near Odessa, Texas. The fault was caused by a failed surge arrester at the combustion turbine (CT) during startup for testing. The circuit breaker for CT1 operated and cleared the fault within three cycles and the #2 unit experienced a partial trip followed by a run back for a total loss of 192 MW. The fault caused voltages in the area to drop to 0.72 pu at the 345 kV connecting station for the generation facility, 0.84 pu around Fort Stockton at a 138 kV station, and as low as 0.54 pu at a 69 kV bus near Alpine, Texas. Voltage in the area recovered to near pre-disturbance levels very quickly (within a couple electrical cycles) after the fault cleared.

- IBR generation loss: approximately 1100 MW
- IBR generation loss caused by:
- Lowest frequency = 59.805 Hz
- IBR models were **not** accurate

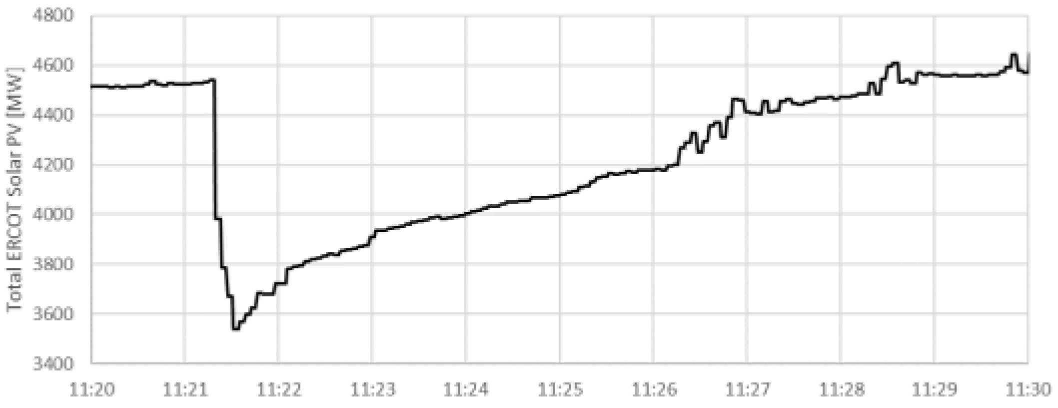


Figure I.5: ERCOT BPS-Connected Solar PV during Disturbance [Source: ERCOT]

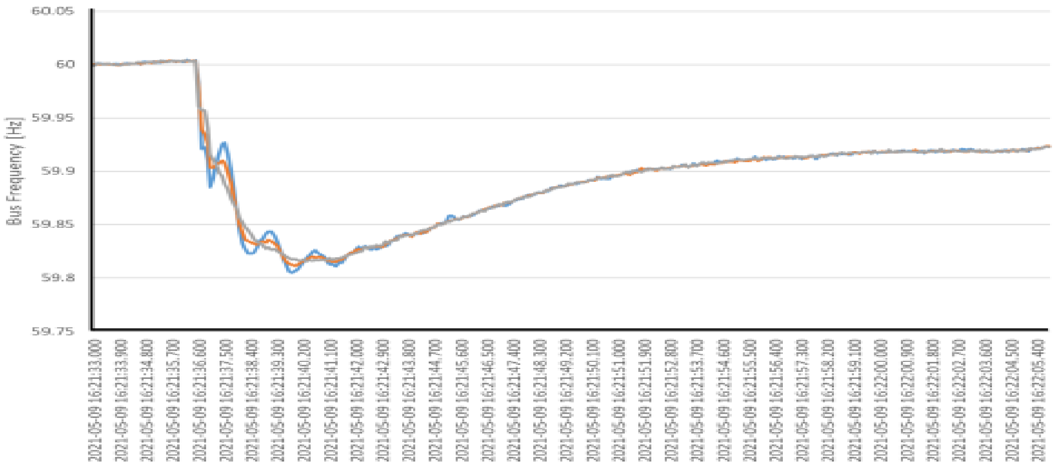


Figure I.6: System Frequency during Event [Source: UTK/ORNL]

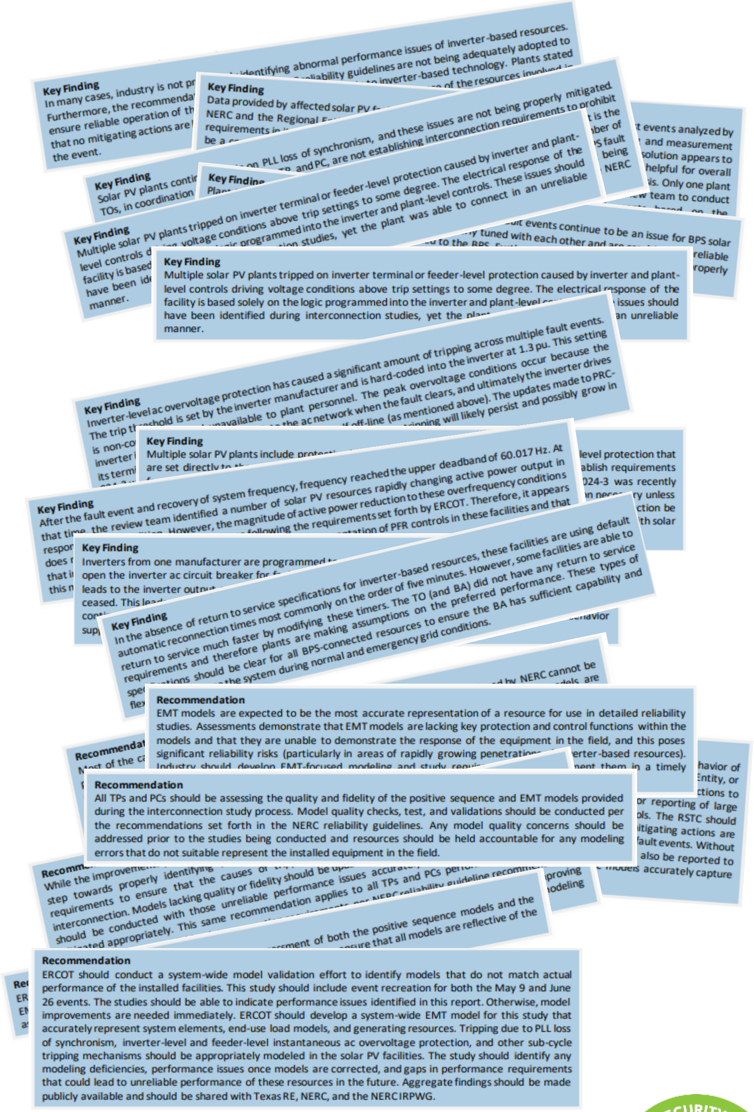
Recommendations

GOs

- Should adopt the performance recommendations provided in the NERC reliability guidelines

PCs and TPs

- High quality, vendor-specific EMT models are needed to identify the causes of tripping
- EMT studies should be required as part of the interconnection study process to ensure that all resources can reliably operate once connected to the BPS prior to the resource being interconnected
- Enhance modeling requirements to ensure that the causes of tripping can be accurately represented in studies prior to interconnection
- Assess the quality and fidelity of the positive sequence and EMT models provided during the interconnection study process
- Benchmark the positive sequence models and the EMT models against each other to ensure that all models are reflective of the as-built settings, controls, and protections that are installed
- Conduct a system-wide model validation effort to identify models that do not match actual performance of the installed facilities



2021 – Victorville, Tumbleweed, Windhub, and Lytle Creek Fire Disturbances

June 24, 2021, Victorville Disturbance: A 500 kV line relayed due to a phase-to-phase fault (3.5 cycle clearing).

July 4, 2021, Tumbleweed Fire Disturbance: A fire burned under some 500 kV transmission lines and heavy smoke caused faults on both the #1 and #2 lines.

July 28, 2021, Windhub Disturbance: A 500 kV line and the 500/230 kV transformer bank tripped on differential protection for a single-line-to-ground fault (3.5 cycle clearing).

August 25, 2021, Lytle Creek Disturbance: A fire burning in Lytle Creek caused a 500 kV line to trip.

- IBR generation loss:
  - 765 MW (Victorville)
  - 605 MW (Tumbleweed)
  - 511 MW (Windhub)
  - 583 MW (Lytle Creek)
- IBR generation loss caused by:
  - Protection settings
- Lowest Frequency = 59.91 Hz (July 4)
- IBR models were **not** accurate

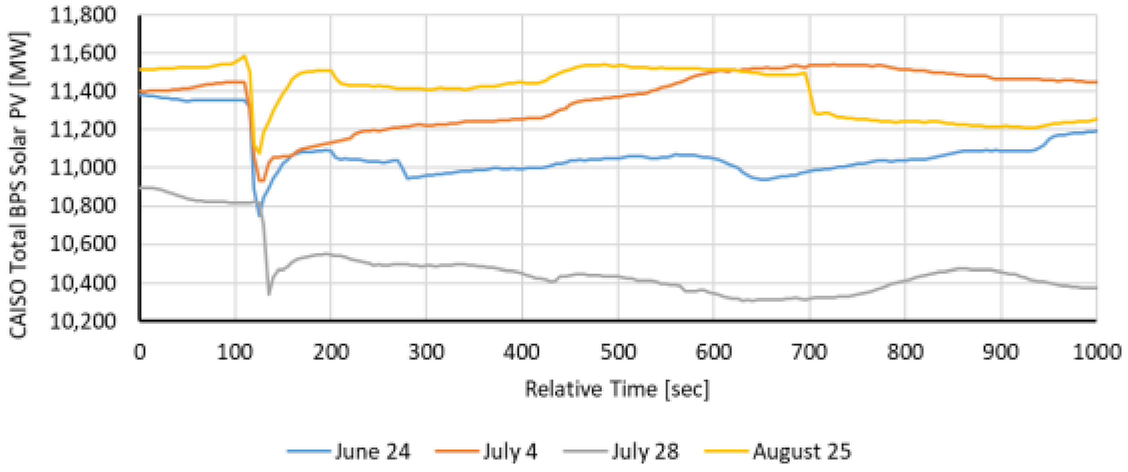


Figure 1.2: CAISO BPS-Connected Solar PV during Disturbance

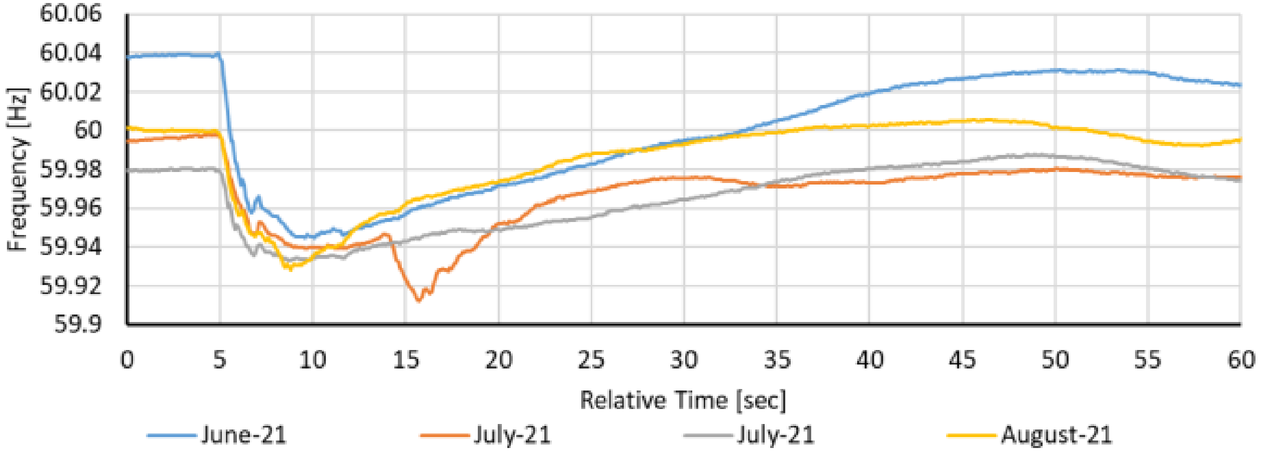


Figure 1.11: System Frequency Response for Each Disturbance [Source: UTK/ORNL]

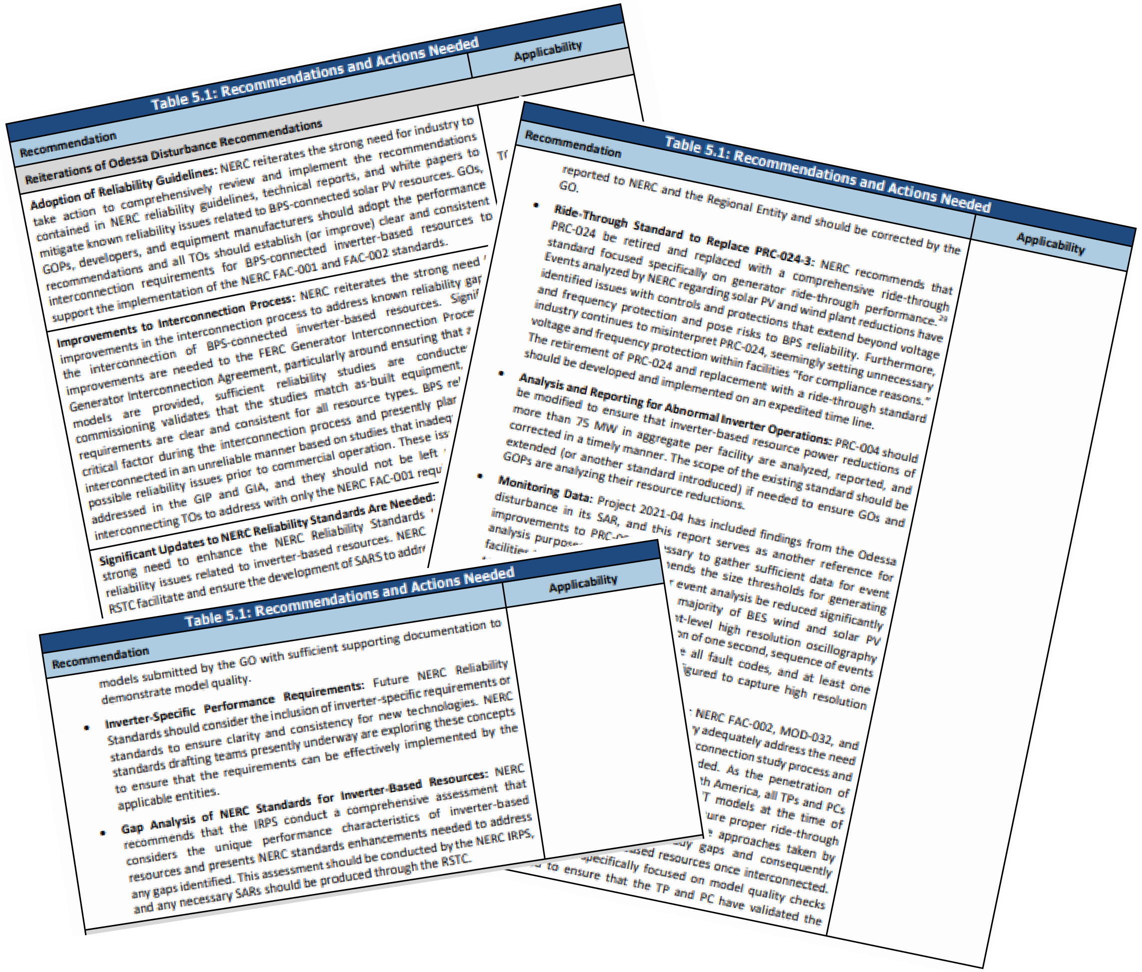
Recommendations

GOs

- Implement the recommendations contained in NERC reliability guidelines, technical reports, and white papers to mitigate known reliability issues related to BPS-connected solar PV resources (adopt the performance recommendations)

PCs and TPs

- Implement the recommendations contained in NERC reliability guidelines, technical reports, and white papers to mitigate known reliability issues
- Should have clear requirements to gather EMT models at the time of interconnection and execute EMT studies to ensure proper ride-through performance for BPS fault events
- Ensure that modeling requirements include accurate representation of the causes of tripping from these four disturbances and all past disturbances analyzed by NERC
- Implement model checks that ensure the models match actual equipment during the interconnection process and during commercial operation



2022 – Panhandle Wind Disturbance

Event 1: A phase-to-phase fault occurred on a radial 345 kV generator tie line that connects a wind plant to the ERCOT system. The fault cleared normally.

Event 2: Another normally-cleared phase-to-phase fault occurred on a 345 kV transmission circuit nearby.

- IBR generation loss = 765 MW (Event 1)
- IBR generation loss caused by:
  - Tie line tripping to clear the fault
  - Protection and control settings
- Lowest frequency = 59.90 Hz
- IBR models were **not** accurate

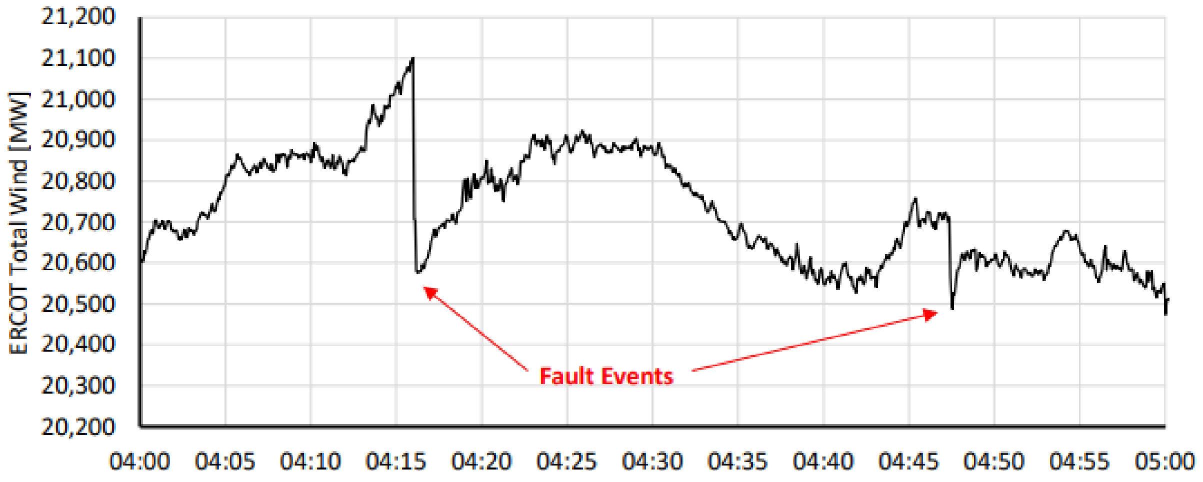


Figure I.5: ERCOT Wind Output during Disturbances

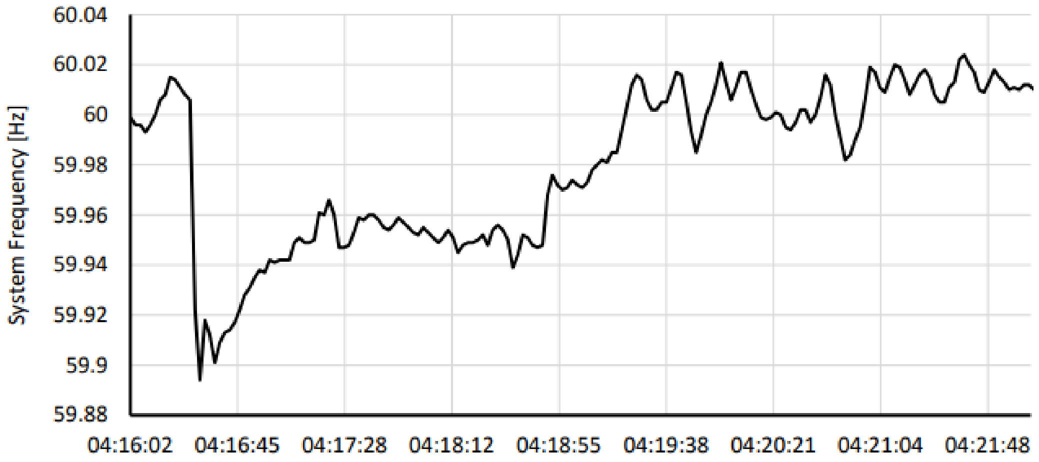


Figure I.6: System Frequency Response for First Fault Event

Recommendations

GOs

- High-resolution monitoring equipment at the plant POI and on collector feeders
- Plant SCADA data with 1–2 second resolution
- Plant-level controller measurements, set points, control settings, and other quantities
- Synchrophasor data at the POI
- Inverter-level fault codes
- Inverter-level oscillography data
- Time-synchronized measurements
- Sufficient retention
- Provide models that include any control or protection function that can trip the facility

PCs and TPs

- Perform detailed model quality review for all IBRs connected to the BPS
- Compare both positive sequence and EMT model performance with actual plant performance

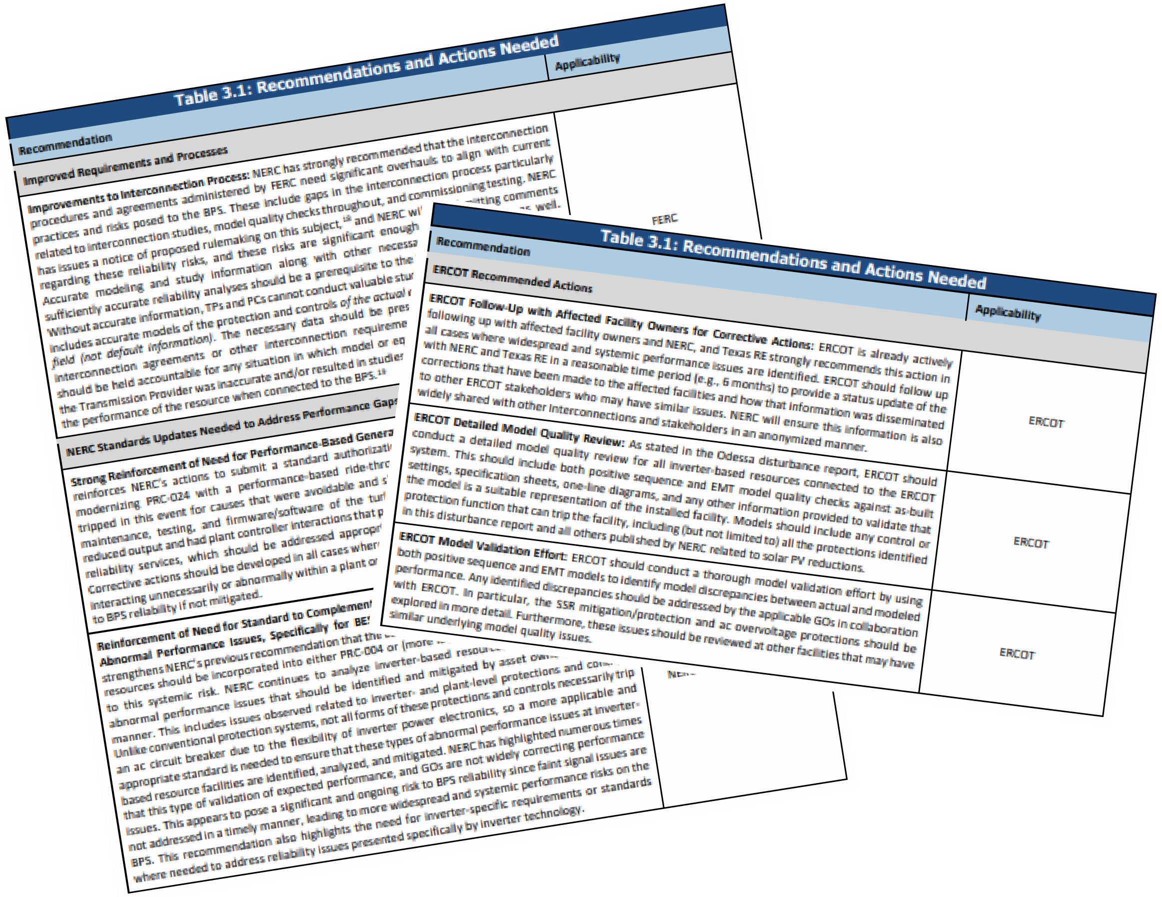


Table 3.1: Recommendations and Actions Needed

Recommendation	Applicability
ERCOT Recommended Actions	
ERCOT Follow-Up with Affected Facility Owners for Corrective Actions: ERCOT is already actively following up with affected facility owners and NERC, and Texas RE strongly recommends this action in all cases where widespread and systemic performance issues are identified. ERCOT should follow up with NERC and Texas RE in a reasonable time period (e.g., 6 months) to provide a status update of the corrections that have been made to the affected facilities and how that information was disseminated to other ERCOT stakeholders who may have similar issues. NERC will ensure this information is also widely shared with other Interconnections and stakeholders in an anonymized manner.	ERCOT
ERCOT Detailed Model Quality Review: As stated in the Odessa disturbance report, ERCOT should conduct a detailed model quality review for all inverter-based resources connected to the ERCOT system. This should include both positive sequence and EMT model quality checks against as-built settings, specification sheets, one-line diagrams, and any other information provided to validate that the model is a suitable representation of the installed facility. Models should include any control or protection function that can trip the facility, including (but not limited to) all the protections identified in this disturbance report and all others published by NERC related to solar PV reductions.	ERCOT
ERCOT Model Validation Effort: ERCOT should conduct a thorough model validation effort by using both positive sequence and EMT models to identify model discrepancies between actual and modeled performance. Any identified discrepancies should be addressed by the applicable GOs in collaboration with ERCOT. In particular, the SSR mitigation/protection and ac overvoltage protections should be explored in more detail. Furthermore, these issues should be reviewed at other facilities that may have similar underlying model quality issues.	ERCOT

2022 – Odessa Disturbance

On June 4, 2022, a surge arrestor failed at a synchronous generation facility in Odessa, Texas, causing a B-phase-to-ground fault on the 345 kV system. The fault cleared in three cycles.

- IBR generation loss: approximately 1700 MW
- IBR generation loss caused by:
  - Protection settings
  - Momentary cessation
- Lowest frequency = 59.7 Hz
- IBR models were **not** accurate

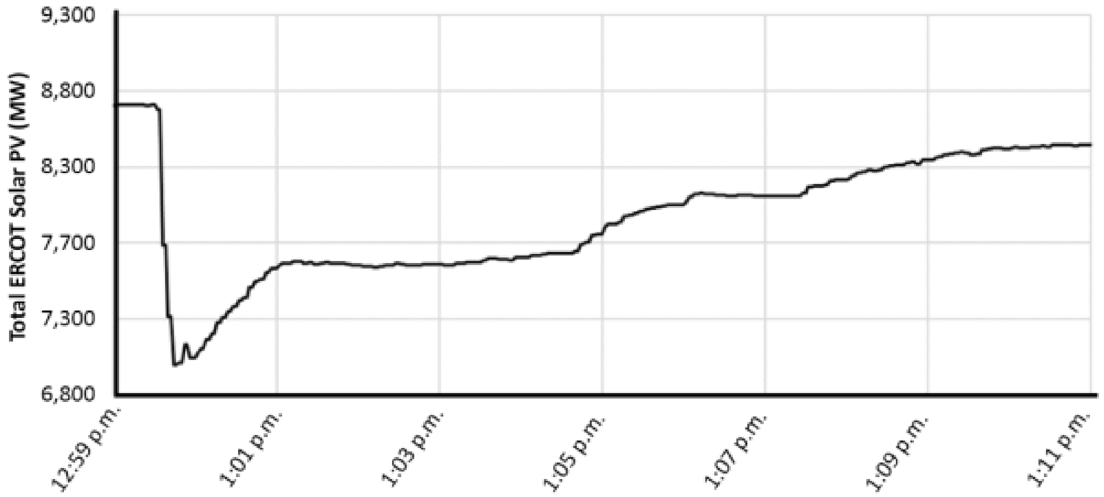


Figure I.4: ERCOT BPS-Connected Solar PV Generation during Disturbance [Source: ERCOT]

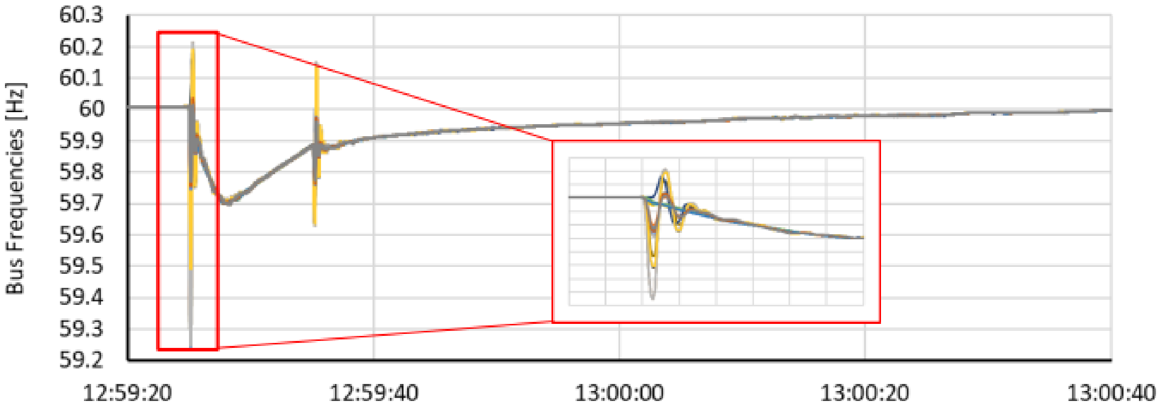


Figure I.5: ERCOT System Frequency

Recommendations

GOs

- Should mitigate any abnormal performance issues identified in the 2021 or 2022 Odessa disturbances and have evidence of accurate facility modeling when compared to actual facility performance and as-built control settings and parameters
- Should ensure that all studies performed for their facility include models that are as representative of the facility as possible
- Should ensure that the models and as-built settings match throughout the entire interconnection and commissioning process; any changes to planned equipment should be reported to the transmission entity immediately

PCs and TPs

- Perform detailed model quality reviews for all IBRs connected to the BPS
- Compare both positive sequence and EMT model performance with actual plant performance
- Create explicit and detailed requirements for product performance, model quality, and model validation and verification
- Should require GOs to provide verification reports that show that all parameters affecting facility performance and ride-through capability are captured in the model
- Should focus on obtaining positive sequence and EMT models verified by the equipment manufacturer and confirm that they contain accurate reflections of the controls, settings, and protections installed (or to be installed) on-site

Key Takeaway
The abnormal performance issues observed by all affected solar PV facilities should have been identified during the interconnection study process, during plant design, or during commissioning. The occurrence (and systemic recurrence) of performance issues demonstrates a failure of the interconnection studies, commissioning practices, and periodic plant performance review.

Key Takeaway
The majority of solar PV facilities involved in the 2021 Odessa Disturbance were also involved in the 2022 Odessa Disturbance. Some facilities made changes to mitigate the causes of reductions after the first event but subsequently tripped on other unexpected forms of protection in the second event.

Key Takeaway
Significant deficiencies exist for inverter-based resources both in positive sequence and EMT models. This includes the use of standard library models that cannot match actual inverter controls, incorrect parameterization of the models, insufficient model fidelity (i.e., missing protections or controls), and lack of model quality checks.

Key Takeaway
Inverter manufacturers highlighted that many of the modeling and study issues stem from a lack of clear modeling requirements. They also emphasized a disconnect during the commissioning process that likely leads to inaccurate models due to insufficient "true up" during commissioning and trial operation. Lastly, the manufacturers strongly advocated for the use of user-defined models (where necessary) since the standard library models often have deficiencies in accurately representing the inverter controls.

Key Takeaway
Model quality tests intended to check model accuracy are mixed with plant performance tests against interconnection requirements. This appears to incentive inaccurate models that pass performance criteria and disincentives model accuracy throughout the interconnection process.

2023 – Southwest Utah Disturbance

At 08:51 Pacific time, a single-line-to-ground fault occurred on a 345 kV transmission circuit in the Southern Nevada/Southwest Utah area. Protective relaying cleared the fault normally in 3.5 cycles.

- IBR generation loss: Approximately 900 MW
- IBR generation loss caused by:
  - Protection settings
  - Control settings
- Lowest frequency = 59.89 Hz
- IBR models were **not** accurate

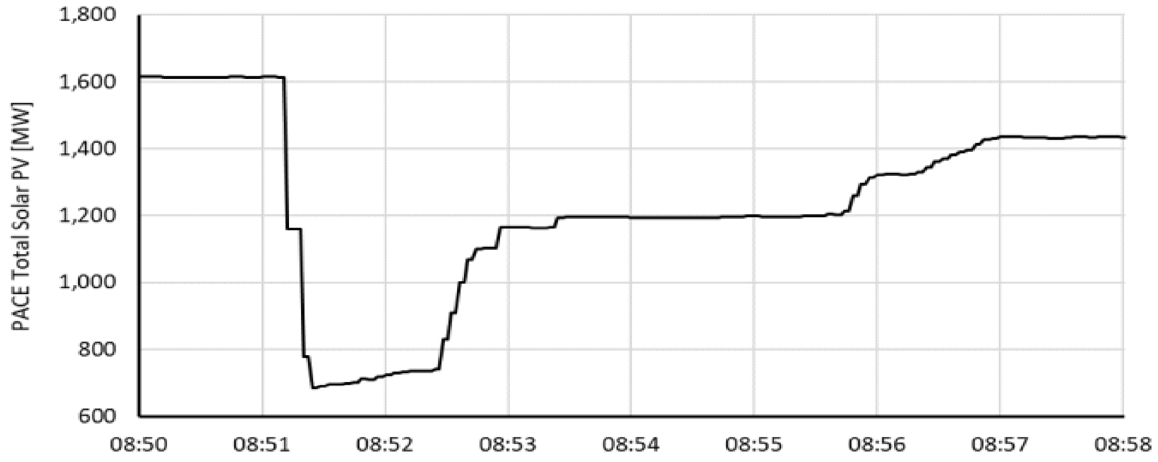
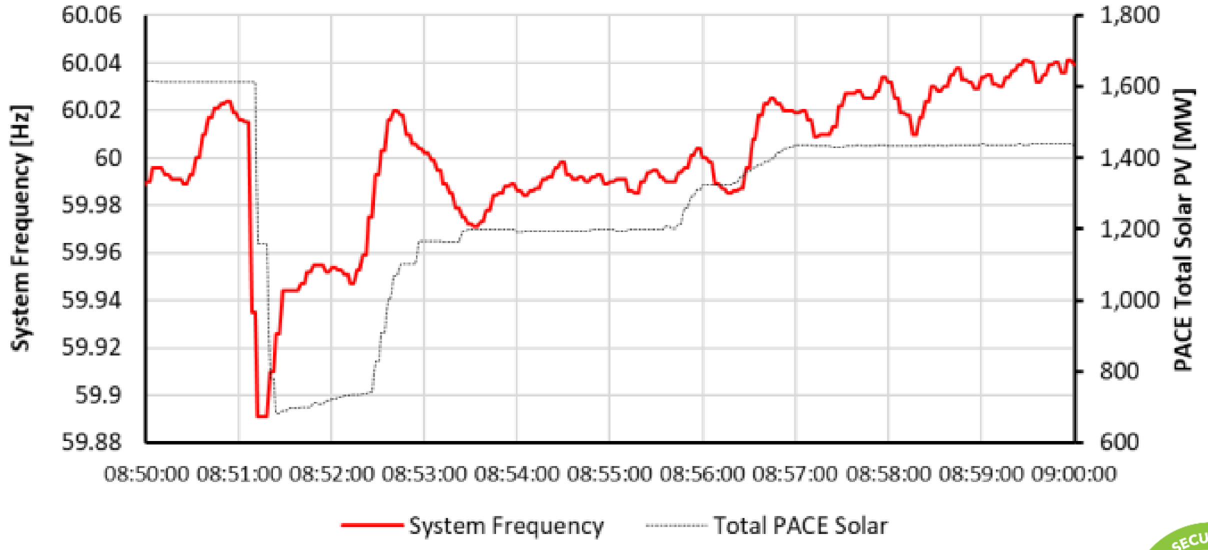


Figure I.2: PACE BPS-Connected Solar PV during Disturbance



Recommendations

GOs

- Should conduct an assessment of their facility's anti-islanding settings and identify any potential performance issues that could arise from disabling these functions. Anti-islanding protection should generally not be used for BPS-connected inverter-based resources and should be coordinated with the interconnecting TO to determine appropriate setting
- Should work with OEMs to proactively implement corrective actions to eliminate the performance issues with their inverters

PCs and TPs

- Should implement modeling requirement enhancements as early as possible to gather high-quality and accurate models for newly connecting facilities

Key Findings and Recommendations

The findings from this analysis and in the context of past disturbance reports for inverter performance issues highlight the following:

- **Reiterated Need for NERC Project 2023-02 to Ensure Proactive Risk Mitigation:** This report, along with past reports, illustrates and reiterates the strong need for inverter-based resource performance issues to be addressed by Generator Owners (GOs) in a timely manner. GOs are often not addressing performance issues that latently exist within the existing fleet. All of the causes of abnormal performance in this event have been previously documented by NERC in past reports; however, actions were not taken either by the GOs or by the inverter original equipment manufacturers (OEM) to mitigate these known risks. Project 2023-02[6] is addressing this reliability risk by "requiring analysis and mitigation of unexpected or unwarranted protection and control operations from inverter-based resources following the identification of such a performance issue." The goal is to minimize the number of large-scale widespread resource loss events through more proactive performance improvements at individual facilities.
- **Reiterated Need for Performance-Based Comprehensive Ride-Through Standard:** This report, along with past reports, further emphasizes the need for a comprehensive ride-through standard in lieu of NERC PRC-024-3. Project 2020-02[7] is currently addressing this risk issue by replacing PRC-024-3 "with a performance-based ride-through standard that ensures generators remain connected to the BPS during system disturbances." The standard authorization request specifically addresses the myriad of protection and controls beyond voltage and frequency protection that have affected ride-through performance in numerous large-scale events such as this. This project remains a top priority for NERC to address persistent inverter-based resource performance issues and the elevated risk to BPS reliability posed with the rapidly changing resource mix.
- **Reiterated Need for Level 2 NERC Alert Regarding Inverter-Based Resource Performance Issues:** This event illustrates that equipment installed in the field for many years have latent performance issues that are not identified until certain grid conditions and disturbances result in a widespread resource loss event. With the rapidly growing inverter-based resource mix, it is imperative that newly connecting facilities not have these known performance deficiencies. NERC issued a Level 2 alert to industry to share key findings and recommendations regarding solar PV performance issues as well as to gather information regarding extent of condition of risk. The data submission deadline was extended to July 31, 2023, to provide entities with additional time to gather and submit high-quality data. NERC will be conducting an assessment of the data received and will report key findings and recommendations to industry based on the assessment of the data submitted.

2022 – California Battery Energy Storage System Disturbances

On March 9, 2022, a generator bus was faulted when a generator circuit breaker had an internal failure at a natural-gas-fired, simple-cycle facility in Riverside County, California, causing a C-phase-to-ground fault on the 220 kV system. Generator units relayed, disconnecting the natural gas generators that were carrying 694 MW. The fault was cleared in approximately 4.5 cycles

On April 6, 2022, a B-phase-to-ground fault occurred on a 220 kV bus at a new BESS plant that was undergoing testing. The fault was cleared in approximately four cycles

- IBR generation loss:
  - March: 408 MW (123 MW BESS)
  - April: 498 MW
- Protection settings caused the IBR generation loss
- Lowest frequency = 59.92 Hz
- IBR models were **not** accurate

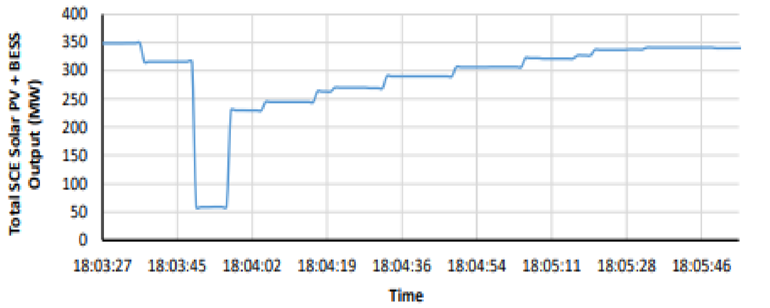


Figure 1.3: SCE BPS-Connected Solar PV + BESS during March 9 Disturbance [Source: SCE]

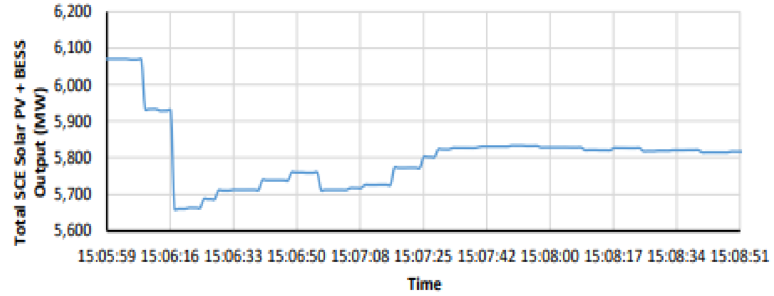


Figure 1.4: SCE BPS-Connected Solar PV + BESS during Disturbance on April 6 [Source: SCE]

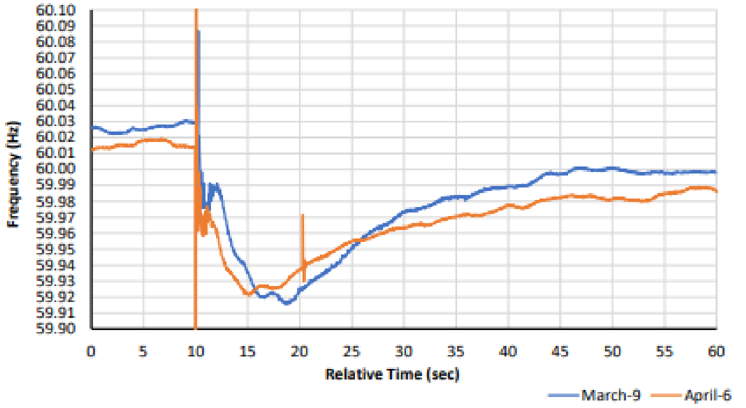


Figure 1.5: WECC System Frequency for Each Disturbance [CAISO]

Summary – Models Not Accurate

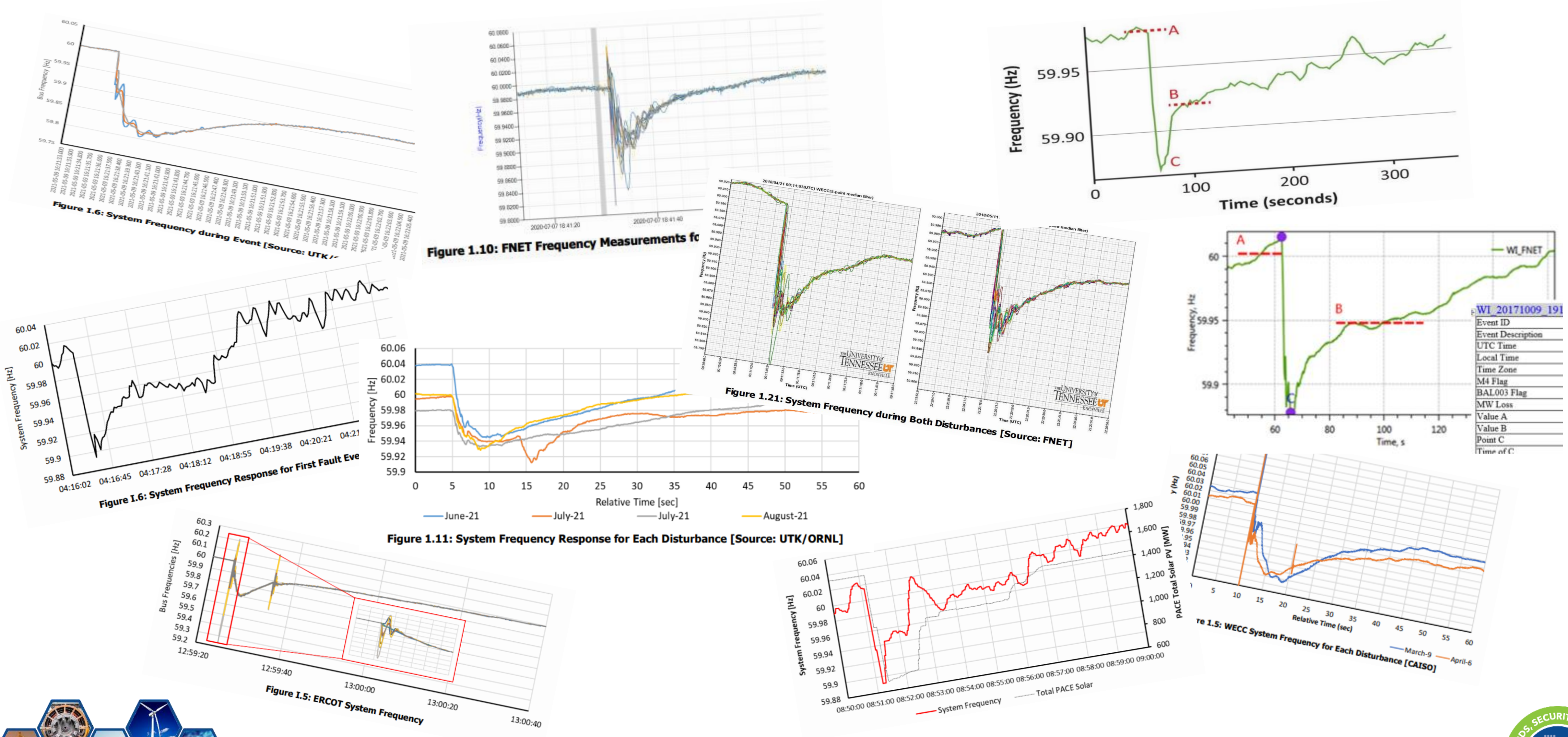


Figure I.6: System Frequency during Event [Source: UTK/

Figure 1.10: FNET Frequency Measurements fo

Figure 1.21: System Frequency during Both Disturbances [Source: FNET]

Figure I.6: System Frequency Response for First Fault Eve

Figure 1.11: System Frequency Response for Each Disturbance [Source: UTK/ORNL]

re 1.5: WECC System Frequency for Each Disturbance [CAISO]

Figure I.5: ERCOT System Frequency

FERC Order 901 – Response to Disturbances

- **At least 12 disturbance reports on the Bulk-Power System (BPS) show IBRs acting unexpectedly and adversely in response to normally cleared transmission line faults on the BPS, each highlighting one or more common mode failures of IBRs of various sizes and voltage connection levels**
  - An average of approximately 1,000 MW of IBRs entering into momentary cessation or tripping in the aggregate
- **Imperative for NERC to develop new or modified Reliability Standards as directed in this final rule to address reliability concerns related to IBRs at all stages of interconnection, planning, and operations**
- **FERC directed NERC to develop new or modified Reliability Standards addressing reliability gaps pertaining to IBRs in four areas:**
  - Data sharing
  - Model validation
  - Planning and operational studies
  - Performance requirements

FERC Order 901: Data Sharing

The Reliability Standards must require that Generator Owners, Transmission Owners, and Distribution Providers share validated modeling, planning, operations, and disturbance monitoring data for all IBRs with Planning Coordinators, Transmission Planners, Reliability Coordinators, Transmission Operators, and Balancing Authorities so that the latter group has the necessary data to predict the behavior IBRs and their impact on the reliable operation of the Bulk Power System

- Currently effective Reliability Standards do not ensure that BPS planners and operators receive disturbance monitoring data regarding all generation resources capable of having a material impact on the reliable operation of the BPS, including registered IBRs. Such data is needed to adequately assess disturbance events (e.g., a fault on the line) and the behavior of IBRs during those events. Without adequate monitoring capability, the disturbance analysis data for a system event is insufficient to effectively determine the causes of the system event
- Limitations on the availability of event data have hampered efforts by NERC, stakeholders, and industry to determine the causes of various events since 2016
- NERC has found that the existing disturbance monitoring equipment is not sufficient (e.g., lack of high-speed data captured at the IBR or plant level controller and low-resolution time stamping of inverter sequence of event recorder information) to analyze the widespread system events that have become more common since 2016

FERC Order 901: IBR Model Validation

The Reliability Standards must require that all IBR models are comprehensive, validated, and updated in a timely manner, so that Planning Coordinators, Transmission Planners, Reliability Coordinators, Transmission Operators, and Balancing Authorities can adequately predict the behavior of IBRs and their impacts on the reliable operation of the BPS.

- Any generation resource model's performance must be verified by the Generator Owner using real-world data to confirm that the generation resource model adequately reflects actual, as-built settings, historic performance, and/or field-testing data
- Once the Generator Owners for registered IBRs, Transmission Owners for unregistered IBRs, and Distribution Providers for IBR-DERs in the aggregate verify plant models, BPS planners and operators must validate and update system models (i.e., planning and operation transmission area models as well as interconnection-wide models) by comparing the provided data and resulting system models against actual system operational behavior

FERC Order 901: IBR Planning and Operational Studies

The Reliability Standards must require that planning and operational studies include validated IBR models to assess the reliability impacts of IBRs on the reliable operation of the BPS. The Reliability Standards must require that planning and operational studies assess the impacts of all IBRs within and across planning and operational boundaries for normal operations and contingency event conditions.

FERC Order 901: IBR Performance Requirements

The Reliability Standards must ensure that registered IBRs will provide frequency and voltage support during frequency and voltage excursions in a manner necessary to contribute toward the overall system needs for essential reliability services

The Reliability Standards must establish clear and reliable technical limits and capabilities for registered IBRs to ensure that all registered IBRs operate in a predictable and reliable manner during normal operations and contingency event conditions

The Reliability Standards must require that the operational aspects of registered IBRs contribute toward meeting the overall system needs for essential reliability services

The Reliability Standards must include post-disturbance ramp rates and phase lock loop synchronization requirements for registered IBRs

NERC must submit new or modified Reliability Standards that establish IBR performance requirements, including requirements addressing frequency and voltage ride through, post-disturbance ramp rates, phase lock loop synchronization, and other known causes of IBR tripping or momentary cessation

New or modified Reliability Standards must require disturbance monitoring data sharing and post-event performance validation for registered IBR

ERCOT Actions to Address IBR Modeling Issues – Model Tests

Requirement	Applicable Facilities	Required Tests[1]	When to Update	Responsible Entity	Planning Guide Language
Model Quality Test for PSS/E, TSAT, and PSCAD Models (A single report should show the PSS/E, TSAT, and PSCAD model responses overlaid on the same plot axes.)	All Resources and Inverter-Based Transmission Elements • TSAT required if utilizing a user-defined model (UDM) • PSCAD generally required for Inverter-based Resources (IBRs) and Inverter-based Dynamic Transmission Elements	Flat start, small and large voltage disturbance, small frequency disturbance, and system strength tests (system strength test is only required for inverter-based devices) When running PSCAD MQT, also include: • Phase angle jump test	A new or updated PSS/E, TSAT, or PSCAD model. Model updates are required: 1. When there is a change at the facility (refer to flow chart on previous page). 2. To enter QSA. 3. Before requesting Part 3 approval. 4. Within 30 days of Part 3 approval. 5. Completing MOD-026/027 studies.	Facility owner (RE, IE, or TSP)	PG 6.2(5)(c), PG 6.2.1, PG 5.5(6)(b) PG 5.5(4), DWG Procedure Manual 3.1.5
Unit Model Validation for PSCAD Model[2]	Inverter-based Resources (IBRs)	Step change in voltage, large voltage disturbance, system strength, phase angle jump, and subsynchronous tests	A new PSCAD model provided after 3/1/21. (UMV reports should not need updating for model parameter updates.)	Facility owner (RE or IE)	PG 6.2(5)(d), DWG Procedure Manual 3.1.6
Model Parameter Verification ("Verification Report")	All Resources and Inverter-Based Transmission Elements	Provide evidence that tunable model parameters match what is implemented in the field. Evidence can take the form of screenshots, nameplate photographs, signed manufacturer commissioning reports, etc.	A report is required: 1. Within 30 days of Part 3 approval, 2. Within 12 to 24 months after Part 3 approval. (Projects built before March 1, 2021, required by March 1, 2023), 3. A minimum of every ten years, and 4. Within 30 days of implementing a change at the facility.	Facility owner (RE, IE, or TSP)	PG 5.5(5) PG 5.5(6)(c), PG 6.2(5)(b)

Source: ERCOT Model Quality Guide

ERCOT Actions to Address IBR Modeling Issues – Ride-Through Requirements

New frequency and voltage ride-through requirements for IBRs in the ERCOT system have been approved to enhance grid reliability

The requirements aim to ensure that IBRs can remain connected to the grid during voltage sags and frequency disturbances, preventing cascading outages

The requirements mandate maximizing ride-through capabilities through software upgrades, hardware modifications, and parameterization adjustments, while also requiring specific reports and certifications to demonstrate compliance

Summary

IBRs play a crucial role in maintaining grid stability

Accurate IBR models are needed to ensure reliability (accurate models = accurate study results)

Existing and proposed requirements will help improve the accuracy of IBR models

Sli.do (#TXRE)

Slido Question

What kind of facility does your entity have?

A. Category 1
B. Category 2
C. Both Category 1 and Category 2
D. Not Applicable

Category 1 IBR GO/GOP
- Aggregate nameplate capacity >75 MVA connected at >100 kV
- BES IBRs

Category 2 IBR GO/GOP
- Aggregate nameplate capacity >20 MVA connected at >60 kV
- Non-BES IBRs 1

Project 2020-06: Definition of Inverter-Based Resource (IBR)

A plant/facility consisting of individual devices that are capable of exporting Real Power through a power electronic interface(s) such as an inverter or converter, and that are operated together as a single resource at a common point of interconnection to the electric system. Examples include, but are not limited to, plants/facilities with solar photovoltaic (PV), Type 3 and Type 4 wind, battery energy storage system (BESS), and fuel cell devices.

Significance of Accurate IBR Modeling

Enhanced Grid Reliability and Stability

- Predict and mitigate instabilities, ensuring grid stability
- NERC Reliability Standards – the "MOD" family

Effective Performance Validation

- Validates IBR behavior during grid disturbances

Improved Planning and Operational Studies

- FERC Order No. 901
- Support IBR integration into the BPS

MOD-026-1 Overview

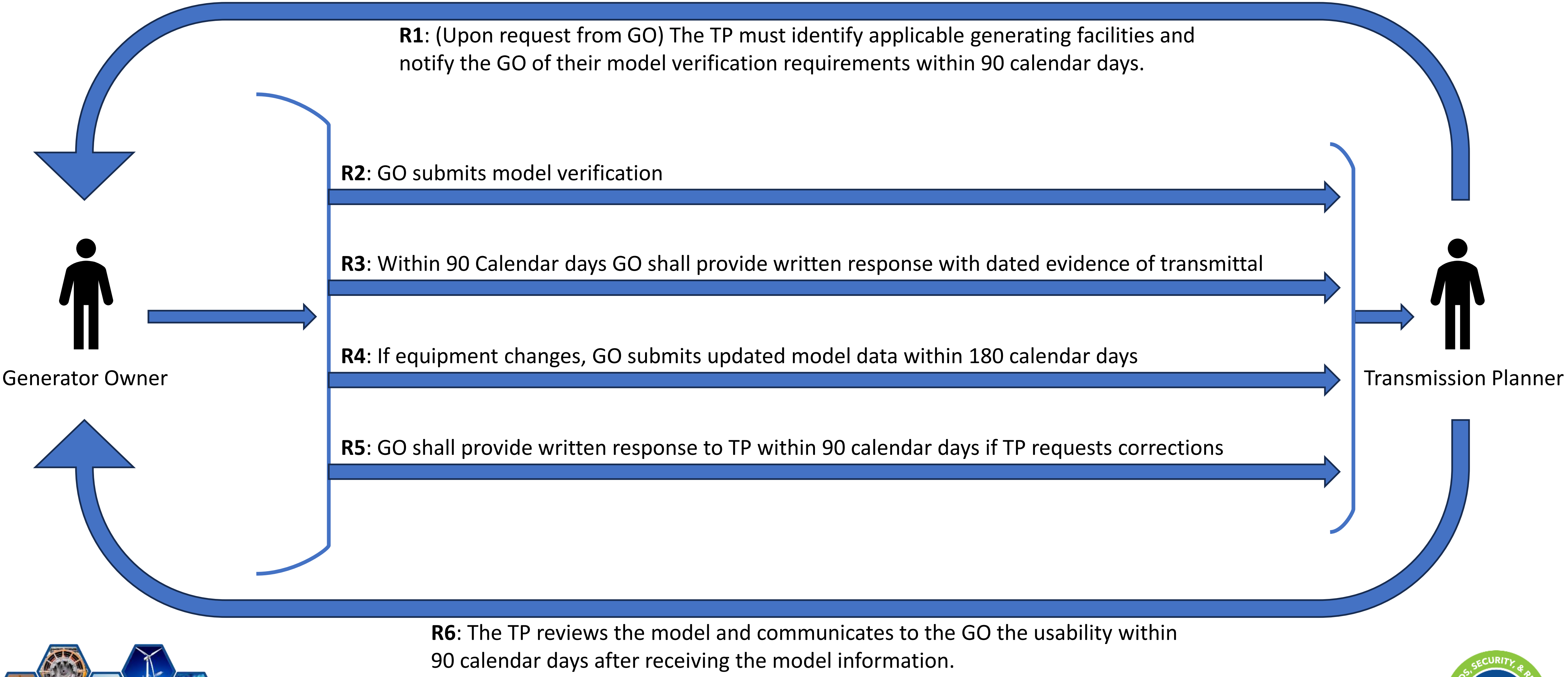
Purpose

- Verify that the generator excitation control system or plant volt/var control function model and the model parameters used in dynamic simulations accurately represent system behavior when assessing BES reliability

Applicability

- Generator Owner
- Transmission Planner

MOD-026-1 Flowchart



MOD-026-1 Internal Controls

Documentation and Record Keeping

- Formal documented process for verifying models and data
- Ensure responses are given/received within required timeline. Doing so will help ensure models are usable and timely
- Request recipients, confirm receipt, and acknowledge deadlines

Verification and Quality Assurance

- Internal reviews of model accuracy before submission
- Confirm software version and compatibility

MOD-032-1 Overview

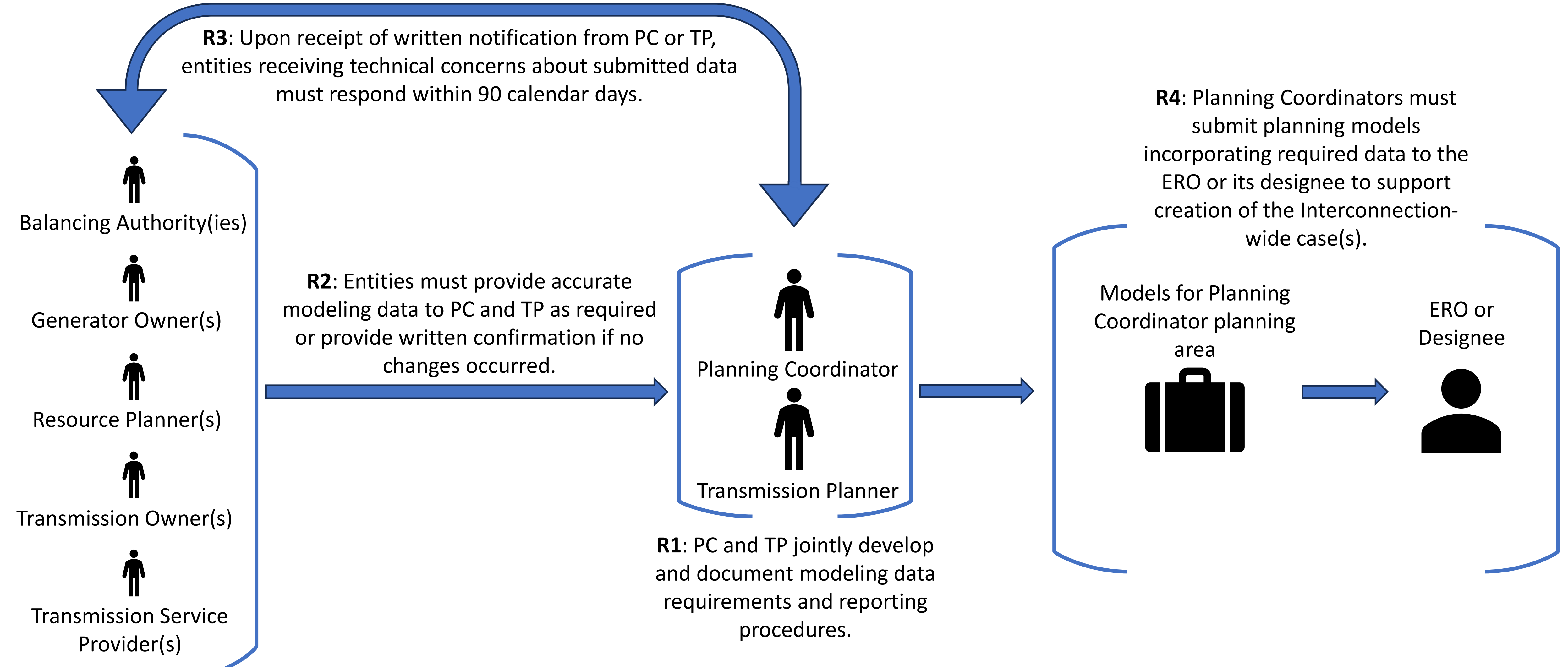
Purpose

- Establish consistent modeling data requirements and reporting procedures for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system.

Applicability

- Balancing Authority
- Generator Owner
- Load Serving Entity
- Planning Authority and Planning Coordinator
- Resource Planner
- Transmission Owner
- Transmission Planner
- Transmission Service Provider

MOD-032-1 Flowchart



MOD-032-1 Internal Controls

Data Verification and Validation

- Implement processes to verify and validate modeling data accuracy

Defined Reporting Procedures

- Establish clear procedures for data submission and communication protocols with PCs and TPs

Documentation and Record Keeping

- Request recipients, confirm receipt, and acknowledge deadlines
- Ensure responses are received within required timeline
- Retain evidence, such as email records or postal receipts

MOD-033-2 Overview

Purpose

- To establish consistent validation requirements to facilitate the collection of accurate data and building of planning models to analyze the reliability of the interconnected transmission system

Applicability

- Planning Coordinator
- Reliability Coordinator
- Transmission Operator

MOD-033-2 Flowchart

Requirement 1: Each PC shall implement a documented data validation process that includes the attributes in subparts 1.1-1.4 of R1.

Documentation

Planning Coordinator (PC)

Reliability Coordinator (RC)

Transmission Operator (TO)

Requirement 2: Each RC and TO shall provide actual system behavior data (or a written response that it does not have the requested data) to any PC performing validation under R1 within 30 calendar days of written request.

Additional Resources

Information to be Considered by CMEP Staff Regarding Inverter-Based Resources:

ERO Enterprise CMEP Practice Guide

NERC Projects related to FERC Order 901:

Project 2020-06 Verifications of Models and Data for Generators

Project 2022-02 Uniform Modeling Framework for IBR


Questions?
TEXAS RE
Ensuring electric reliability for Texans

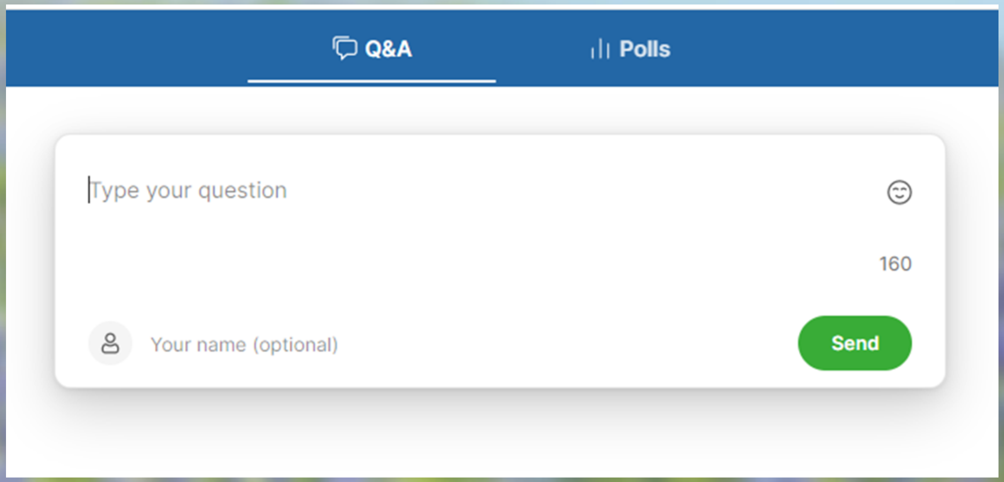
Texas RE Spring Standards, Security, & Reliability Workshop

Return at: 12:30 pm

AGENDA

- Welcome and Instructions
- Executive Welcome
- IBR Registration
- IBR Risk Elements
- IBR Modeling Challenges
- **Preparing for Audits and Self-Reporting**
- Low Impact BES Cyber Systems Risk Elements
- Physical Security – Emerging Risks and Considerations
- High Frequency Conduct and Change Management
- NERC Standards Abeyance Process

To submit questions during the workshop, please visit **slido.com** and enter today's participant code: **TXRE**



Preparing for Audits and Self-Report

Texas RE – Spring Workshop

4/23/2025

John Zerwas
Vice President, Regulatory

Eric Shaw
NERC Compliance Manager

Basic Prerequisites

- Formal Compliance Program
- Subject Matter Experts
- Baseline Current State of Program
- Strong Internal Controls

Compliance Program

Establishes Framework

Creates Accountability

Fosters Engagement

Encourages Ethical Conduct

Promotes Strong Culture of Compliance

Standards Owner Matrix

- **Allocates Responsibilities for Each Applicable Standard and Requirement**
  - Standard Owner
  - Requirement Owner
  - Program Sponsor / Stakeholder

Standard	Standard Version	Req. Number	Standard Owner	Requirement Owner	Program Sponsor Stakeholder
CIP-002	CIP-002-5.1a	R1.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	1.1.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	1.2.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	1.3.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	R2.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	2.1.	Director or Manager	Subject Matter Expert	VP or Director
CIP-002	CIP-002-5.1a	2.2.	Director or Manager	Subject Matter Expert	VP or Director

Developing a Baseline

- Review Processes for all Standards
  - Deep Dive Review / Gap Analysis
  - Internal Review by SMEs and Compliance Personnel
  - Utilize Consultants
  - Identify Opportunities for Continuous Improvement

Internal Controls

POLICIES

PROCESSES

PLANS

PROCEDURES

GRC TOOL

Preparing for Audit

270-Day Audit Notice Received

Audit

- Approach Audit with Goodwill
- Cooperative and Responsive
- Organize/Package Responses
- Openness and Transparency
- Quickly Resolve any Issues

Audit

Rally the Team

- Communicate Details of the Audit Notice
- Ensure Full Support from all Levels of the Organization
  - Verify that everyone understands the assignment
  - Keep everyone informed throughout the process
- Establish Expectations
  - Emphasize the importance of meeting due dates
  - Ensure availability of team members
    - Scheduling around vacations and other absences

Audit

Develop a Clear Audit Strategy

- Schedule Key Dates
  - Initial RSAW drafts
  - Management/Legal reviews
  - Final edits
  - Final due dates
  - Block calendars for known or anticipated audit dates

Quick Tip

CIP Evidence Tool

- Be familiar with the tool
- Know how to transfer data and populate fields
- Prepopulate and keep up-to-date if possible

Developing RSAWs

Drafting the Narrative

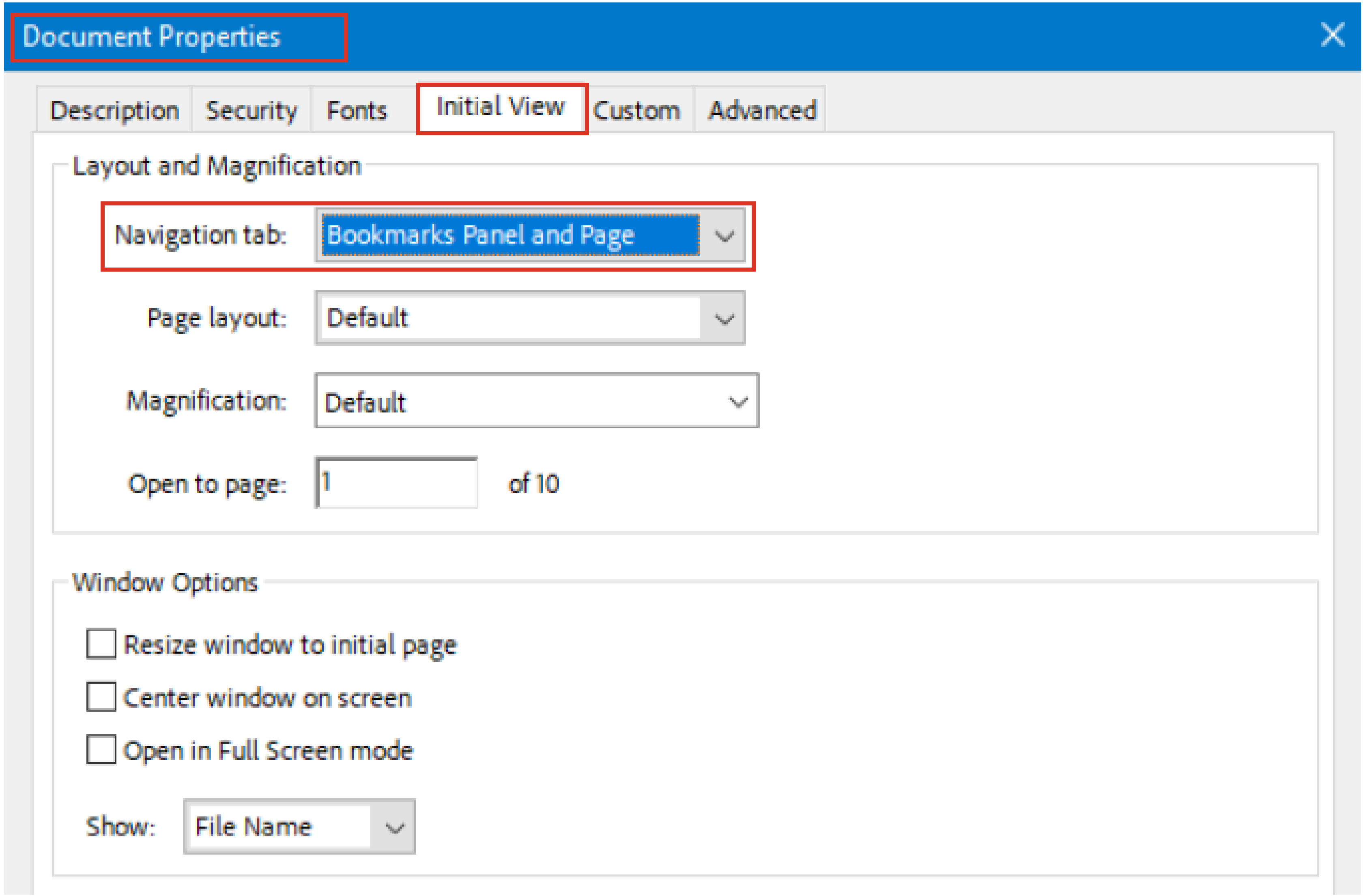
- Describe in Detail how the Entity Maintains Compliance
- Utilize Internal Policies, Processes, Procedures, Plans
- Narrative Should Answer:
  - “Auditors Notes” in the RSAW
  - “Engagement Common Questions” on Texas RE’s Website

Packaging Evidence

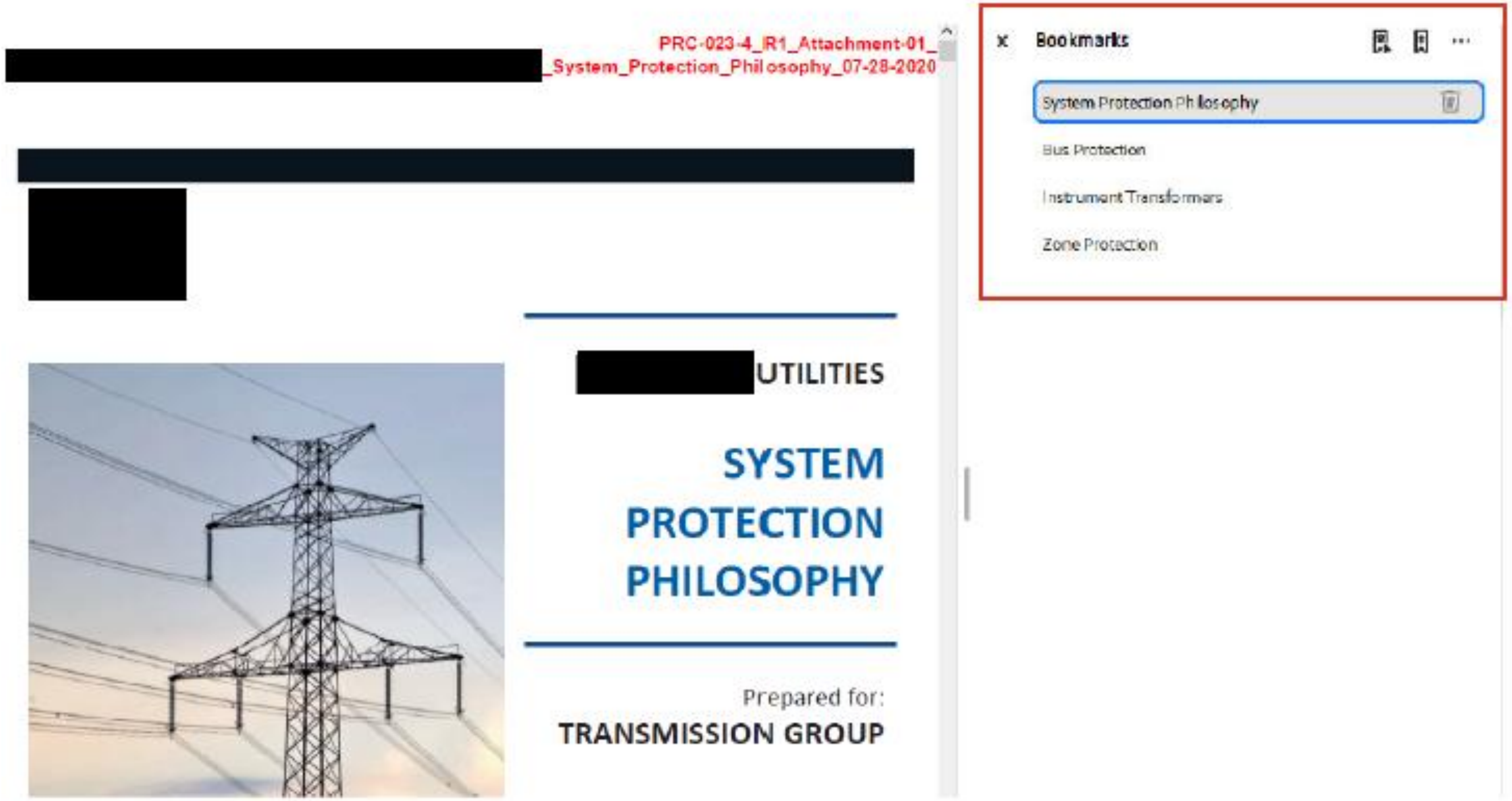
Preparing Evidence for Submittal

- PDF
- Bookmark
- Annotate

Bookmark Settings



Bookmarks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_System_Protection_Philosophy_07-28-2020
[redacted]
[redacted] UTILITIES
SYSTEM
PROTECTION
PHILOSOPHY
Prepared for:
TRANSMISSION GROUP
Bookmarks
System Protection Philosophy
Bus Protection
Instrument Transformers
Zone Protection

Packaging Evidence

Example of Annotations

Analog Channels

A#	Phase	Analog Channel Description	Type	CT/PT	Full Scale	Chassis#	If Virtual
A1	Va	138kV [redacted] Line Ph A Pot	v(Vac)	1200.000	200.000	1-1	
A2	Vb	138kV [redacted] Line Ph B Pot	v(Vac)	1200.000	200.000	1-1	
A3	Vc	138kV [redacted] Line Ph C Pot	v(Vac)	1200.000	200.000	1-1	
A4	Ia	138kV [redacted] Line Ph A Curr	c(Aac)	240.000	100.000	1-2	
A5	Ib	138kV [redacted] Line Ph B Curr	c(Aac)	240.000	100.000	1-2	
A6	Ic	138kV [redacted] Line Ph C Curr	c(Aac)	240.000	100.000	1-2	
A7	In	138kV [redacted] Line Ph Neut Curr	c(Aac)	240.000	100.000	1-3	
A8	Va	138kV [redacted] Line Ph A Pot	v(Vac)	1200.000	200.000	1-3	
A9	Vb	138kV [redacted] Line Ph B Pot	v(Vac)	1200.000	200.000	1-3	
A10	Vc	138kV [redacted] Line Ph C Pot	v(Vac)	1200.000	200.000	1-4	
A11	Ia	138kV [redacted] Line Ph A Curr	c(Aac)	300.000	100.000	1-4	
A12	Ib	138kV [redacted] Line Ph B Curr	c(Aac)	300.000	100.000	1-4	
A13	Ic	138kV [redacted] Line Ph C Curr	c(Aac)	300.000	100.000	1-5	
A14	In	138kV [redacted] Line Ph Neut Curr	c(Aac)	300.000	100.000	1-5	
A15	Va	138 kV [redacted] Line Ph A Pot	v(Vac)	1200.000	200.000	1-5	
A16	Vb	138 kV [redacted] Line Ph B Pot	v(Vac)	1200.000	200.000	1-6	

[redacted] and [redacted] Voltage and Current configuration for measurements on the low side of the [redacted].

Preparing a Self-Report

Self-Report

Initiate Investigation

Contact Texas RE
For Guidance

- Confirm non-compliance
- Identify potential solutions to end non-compliance

- Enforcement Attorney
- Self-Log or Self-Report

Self-Report

Perform Root Cause Analysis

- Gather all available information/data
- Drill past the symptoms
- Address the root cause

Mitigation

- Focus on ending non-compliance
- Short-term and long-term mitigation activities

Implement Internal Controls to Prevent Reoccurrence

- Reinforce existing Internal Controls
- Develop new Internal Controls

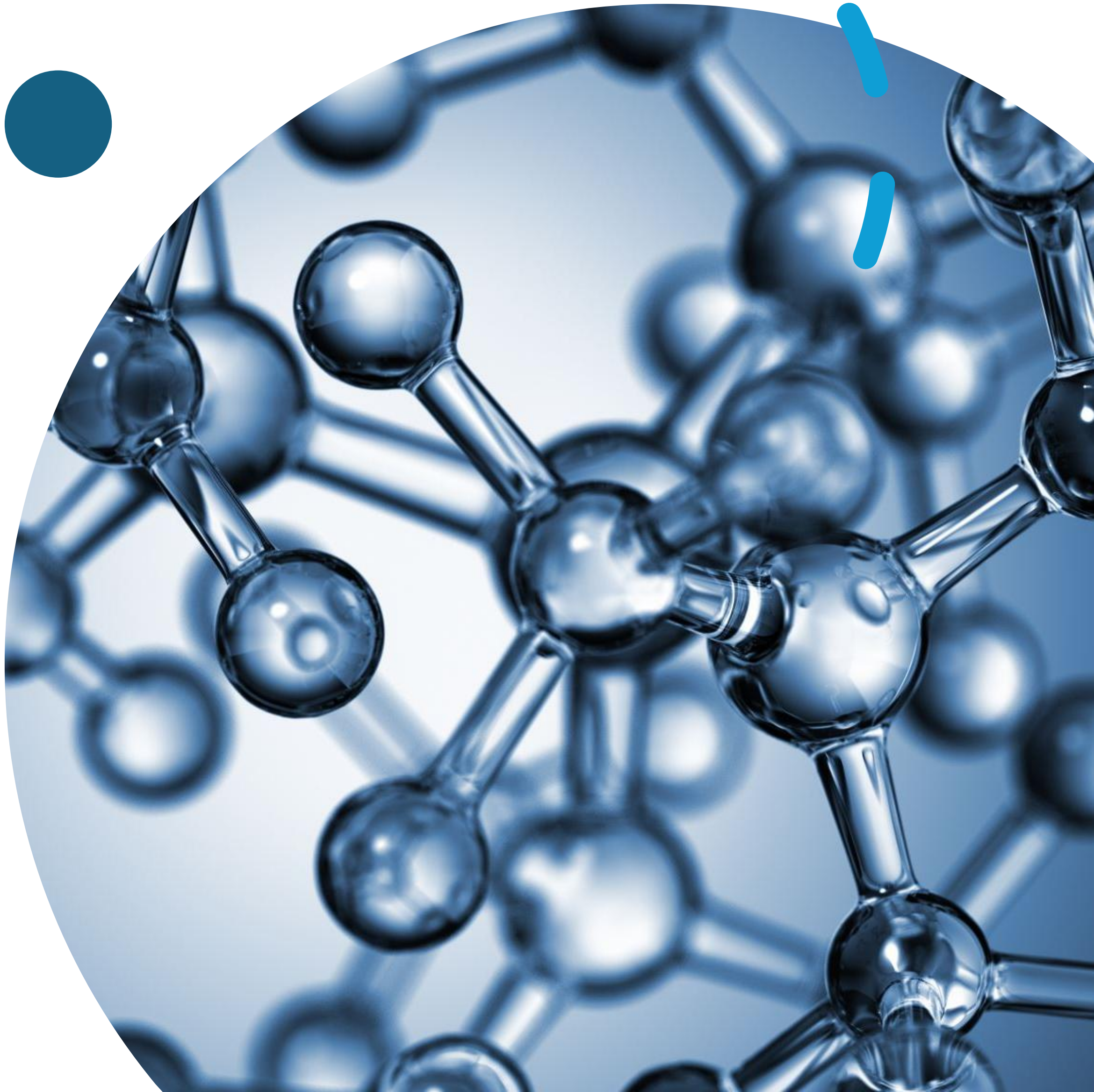
Maintain Communication

Have Questions or Need Clarification?

- Act Quicky
  - Audit – reach out to lead auditor
  - Self-Report – reach out to enforcement attorney
- Schedule meetings or interviews

Key Takeaways From Audit or Self-Report

- Opportunities for Continuous Improvement
- Lessons Learned
- Implement Recommendations from Auditors
- SME – Gain Knowledge & Experience
- Strengthened Compliance Program



Questions

Low Impact BES Cyber System Risk Elements: Remote Connectivity, Physical Security, and Incident Response

Devin Ferris
Manager, CIP Compliance Monitoring

2025 CMEP IP

2024	2025
Remote Connectivity	Remote Connectivity
Supply Chain	Supply Chain
Physical Security	Physical Security
Incident Response	Incident Response
Stability Studies	Transmission Planning and Modeling
Inverter-Based Resources	Inverter-Based Resources
Facility Ratings	Facility Ratings
Extreme Weather Response	Extreme Weather Response

CIP-003-8 – Security Management Controls

R1. Each Responsible Entity shall review and obtain CIP Senior Manager approval at least once every 15 calendar months for one or more documented cyber security policies that collectively address the following topics: *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*

1.1. For its high impact and medium impact BES Cyber Systems, if any:

1.1.1. Personnel and training (CIP-004);

1.1.2. Electronic Security Perimeters (CIP-005) including Interactive Remote Access;

1.1.3. Physical security of BES Cyber Systems (CIP-006);

1.1.4. System security management (CIP-007);

1.1.5. Incident reporting and response planning (CIP-008);

1.1.6. Recovery plans for BES Cyber Systems (CIP-009);

1.1.7. Configuration change management and vulnerability assessments (CIP-010);

1.1.8. Information protection (CIP-011); and

1.1.9. Declaring and responding to CIP Exceptional Circumstances.

1.2. For its assets identified in CIP-002 containing low impact BES Cyber Systems, if any:

1.2.1. Cyber security awareness;

1.2.2. Physical security controls;

1.2.3. Electronic access controls;

CIP-003-8

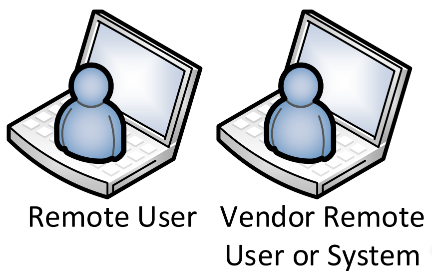
R2. Each Responsible Entity with at least one asset identified in CIP-002 containing low impact BES Cyber Systems shall implement one or more documented cyber security plan(s) for its low impact BES Cyber Systems that include the sections in Attachment 1.

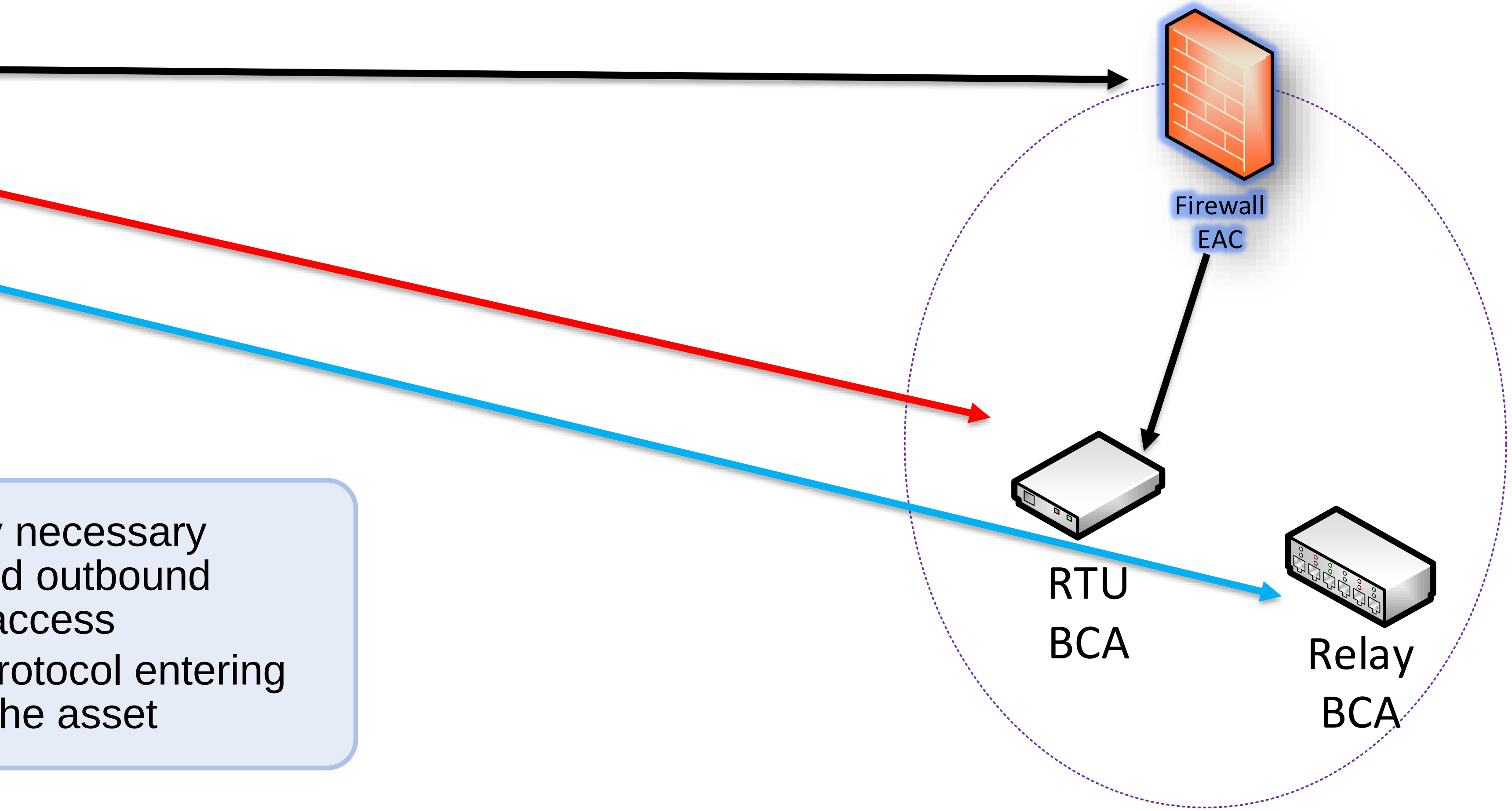
CIP-003 – Attachment 1

Cyber Security Plans

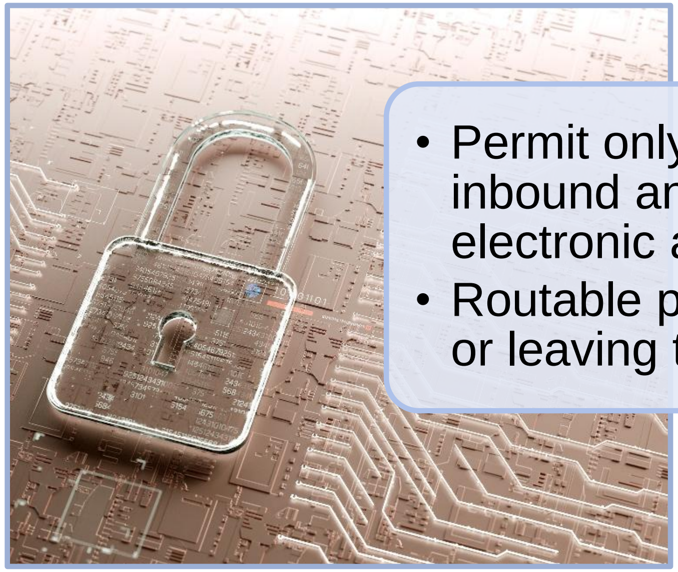
- Section 1: Cyber Security Awareness
- Section 2: Physical Security Controls
- Section 3: Electronic Access Controls
- Section 4: Cyber Security Incident Response Plan (CSIRP)
- Section 5: Malicious Code Risk Mitigation
- Section 6: Coming Soon

Risk Element – Remote Connectivity



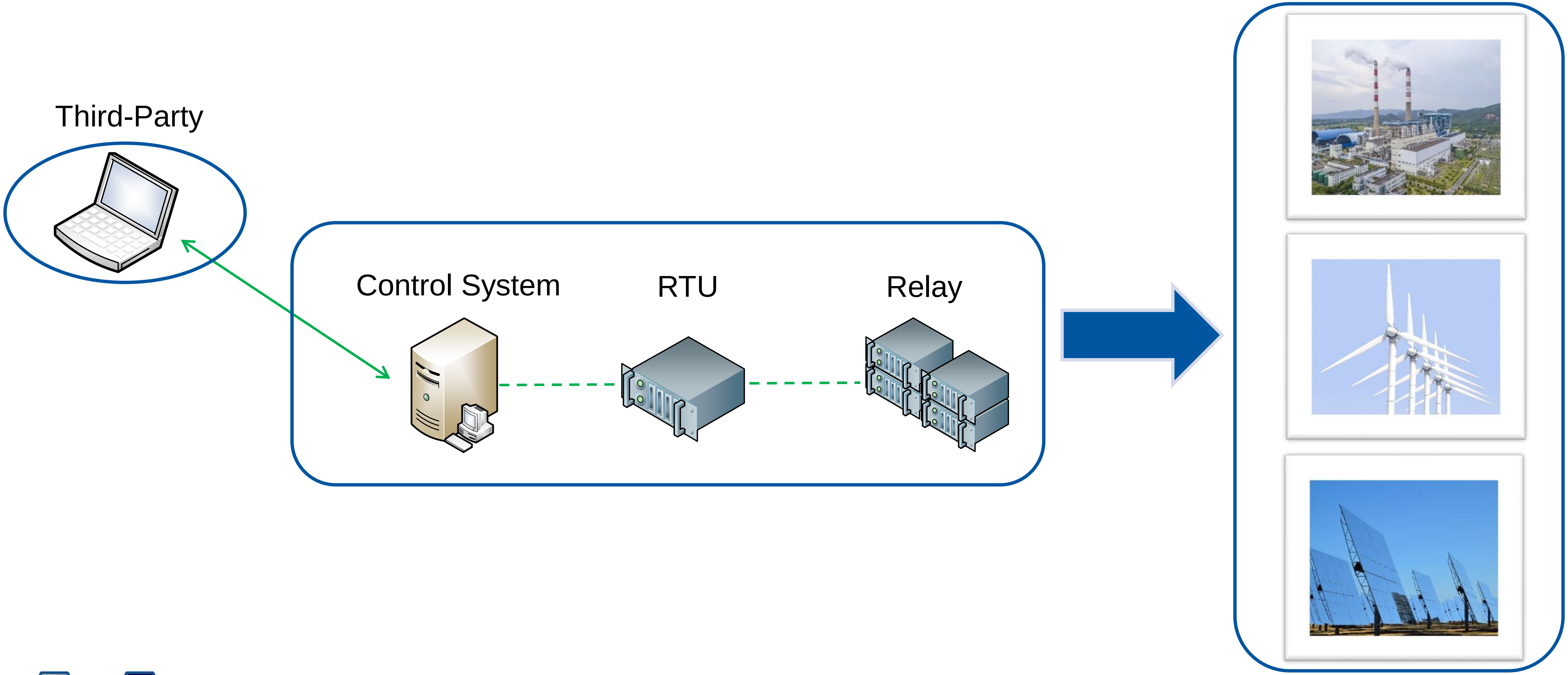


Electronic Access Controls



- Permit only necessary inbound and outbound electronic access
- Routable protocol entering or leaving the asset

Third-Party Monitoring and Control



Risks

Phishing and Social Engineering

Supply Chain Compromise

Human Error

Credential Harvesting

Escalation of Privilege

Malware

Ransomware

Unauthorized Access

Lack of Visibility and Control

Expanded Attack Surface

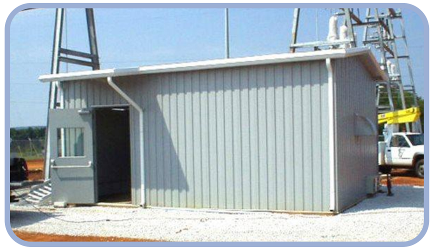
Data Loss

Best Practices & Internal Controls

- Least Privilege
- Network Segmentation
- Zero Trust
- Endpoint Protection
- Encryption
- Intrusion Detection System (IDS)
- Multi-Factor Authentication (MFA)
- Privileged Access Management (PAM)
- Patch Management
- Change Control
- Password Management and Enforcement
- Identity and Access Management

Risk Element – Physical Security

Control physical access, based on need as determined by the Responsible Entity, to:



1) the asset or the locations of the low impact BES Cyber Systems within the asset, and

2) the Cyber Asset(s) providing electronic access controls implemented for Section 3.1, if any

Risks

- Theft
- Disruption
- Compromise
- Malware
- Civil Unrest or Violence
- Damage

Best Practices & Internal Controls

Key management

Layered Security

Intrusion Detection

Walkthroughs

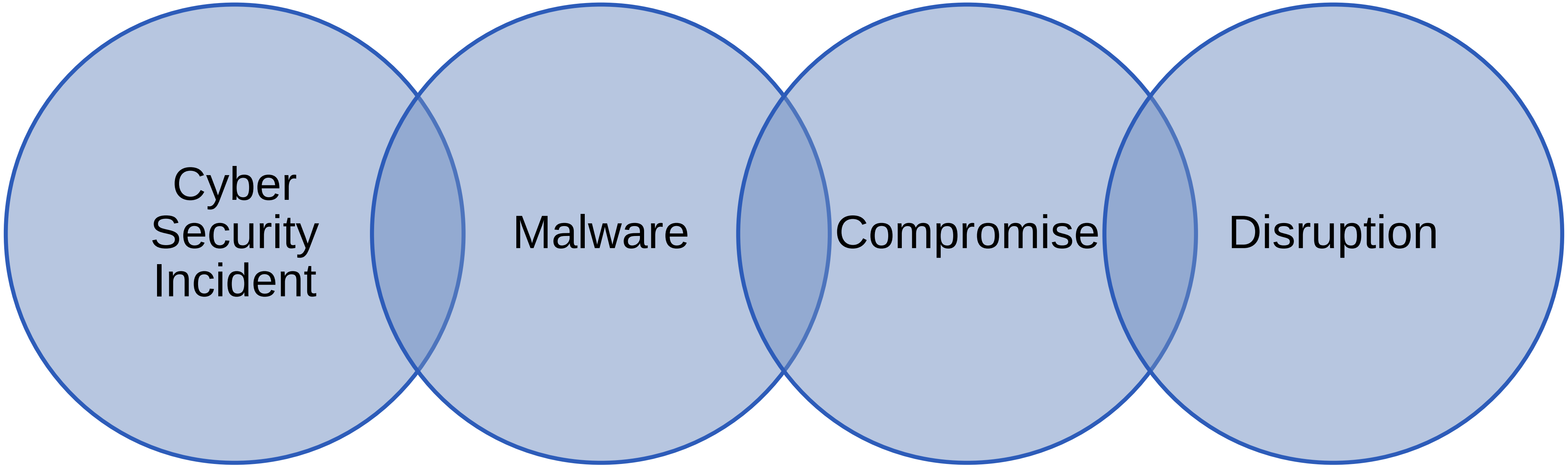
Risk Element – Incident Response

Identify, Classify, and Respond

Determination of Reportable Cyber Security Incident and Notification

Testing & Maintenance

Risks



Best Practices & Internal Controls

Test Frequently

Simulate Real-Life Cyber Security Incidents	Participate at Grid Security Exercise (GridEx)	Involve Local, State, and Federal Government	Incorporate Lessons Learned	Stress the Plan

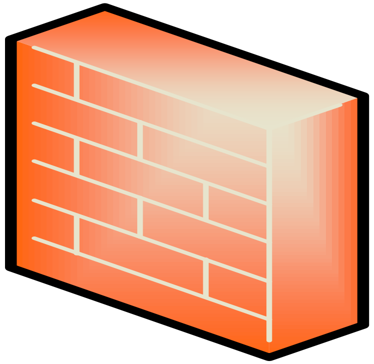
CIP-003-9: Effective Date

Vendor
Electronic
Remote Access
Security Controls

April 1, 2026

Section 6 – Vendor Electronic Remote Access Security Controls

3.1 - Electronic Access Controls



Routable Protocol:

Entering <u>or</u> Leaving

Section 6. Vendor Electronic Remote Access Security Controls: For assets containing low impact BES Cyber System(s) identified pursuant to CIP-002, that allow vendor electronic remote access, the Responsible Entity shall implement a process to mitigate risks associated with vendor electronic remote access, where such access has been established under Section 3.1. These processes shall include:

6.1 One or more method(s) for determining vendor electronic remote access;

6.2 One or more method(s) for disabling vendor electronic remote access; and

6.3 One or more method(s) for detecting known or suspected inbound and outbound malicious communications for vendor electronic remote access.

Questions?

TEXAS RE
Ensuring electric reliability for Texans

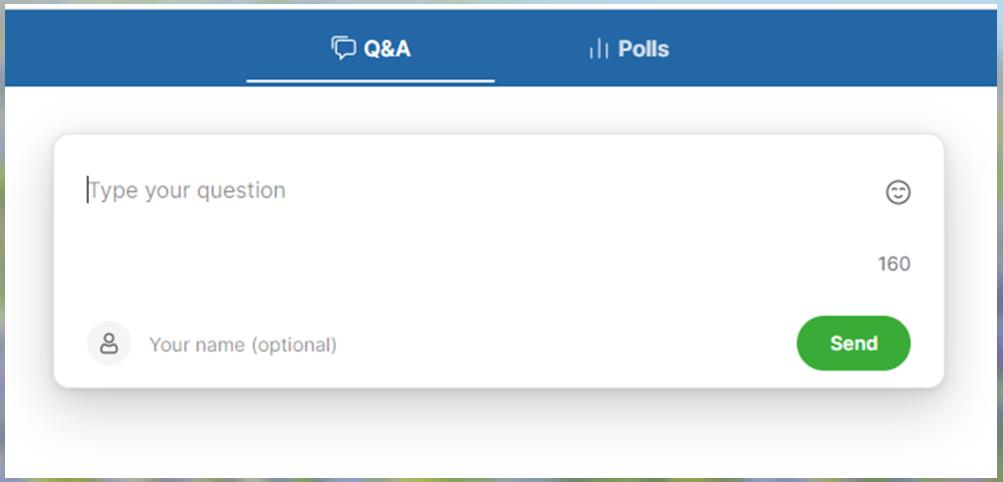
Texas RE Spring Standards, Security, & Reliability Workshop

Return at: 1:45 pm

AGENDA

- Welcome and Instructions
- Executive Welcome
- IBR Registration
- IBR Risk Elements
- IBR Modeling Challenges
- Preparing for Audits and Self-Reporting
- Low Impact BES Cyber Systems Risk Elements
- Physical Security – Emerging Risks and Considerations
- High Frequency Conduct and Change Management
- NERC Standards Abeyance Process

To submit questions during the workshop, please visit **slido.com** and enter today's participant code: **TXRE**



A DIVISION OF NERC
E-ISAC
ELECTRICITY
INFORMATION SHARING AND ANALYSIS CENTER

Physical Security: Emerging Risks and Considerations

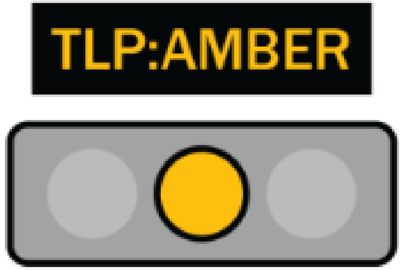
Texas RE - Spring Standards, Security, and Reliability Workshop
April 23, 2025

Sofia Weir, E-ISAC Senior Physical Security Analyst

TLP:AMBER // FOUO

RELIABILITY | RESILIENCE | SECURITY



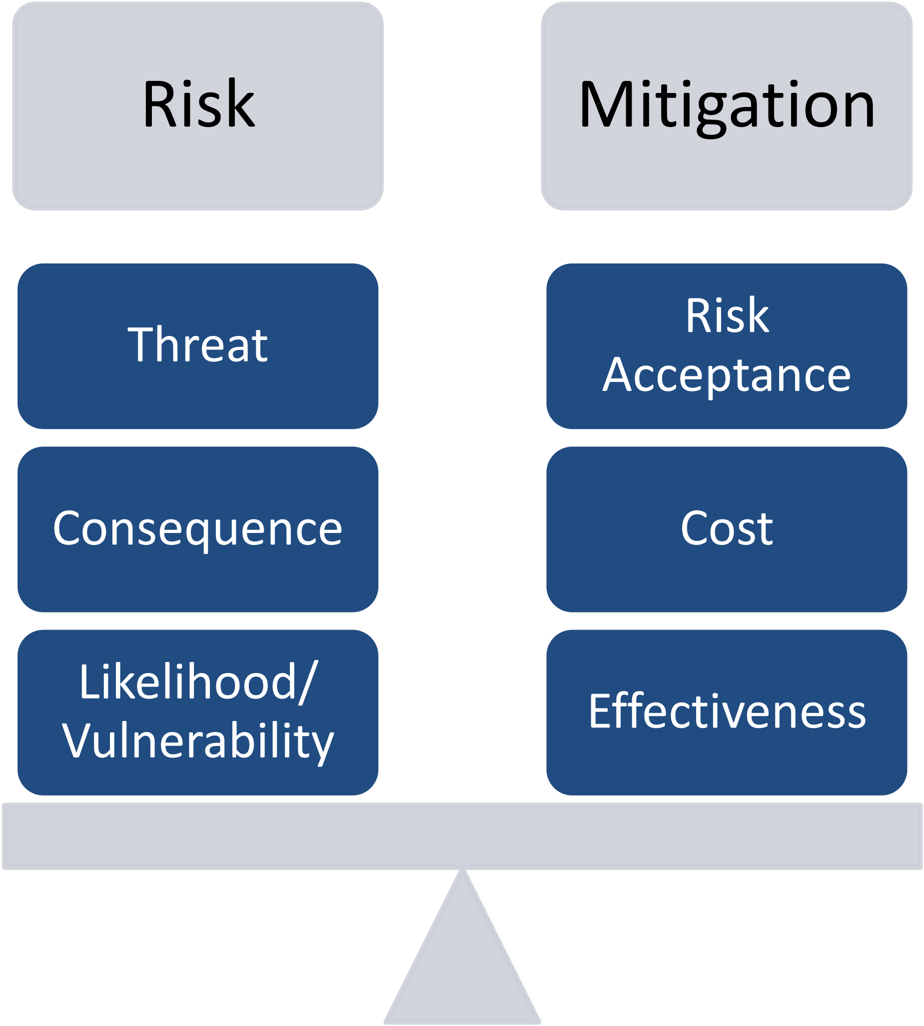
TLP: Amber

Limited disclosure, restricted to participants' organization and its clients (see Terminology Definitions).

Agenda

- Existing/static risks to sector
- Emerging Risks
  - New Assets Affected by Operational Disruptions
  - Increasingly Impactful Persistent Threats
  - Supply Chain Challenges Converge with Geopolitics
  - Disruptive Action Following Public Discontent
- Final Considerations for AOOs and Planners
- Q&A

Risk Management

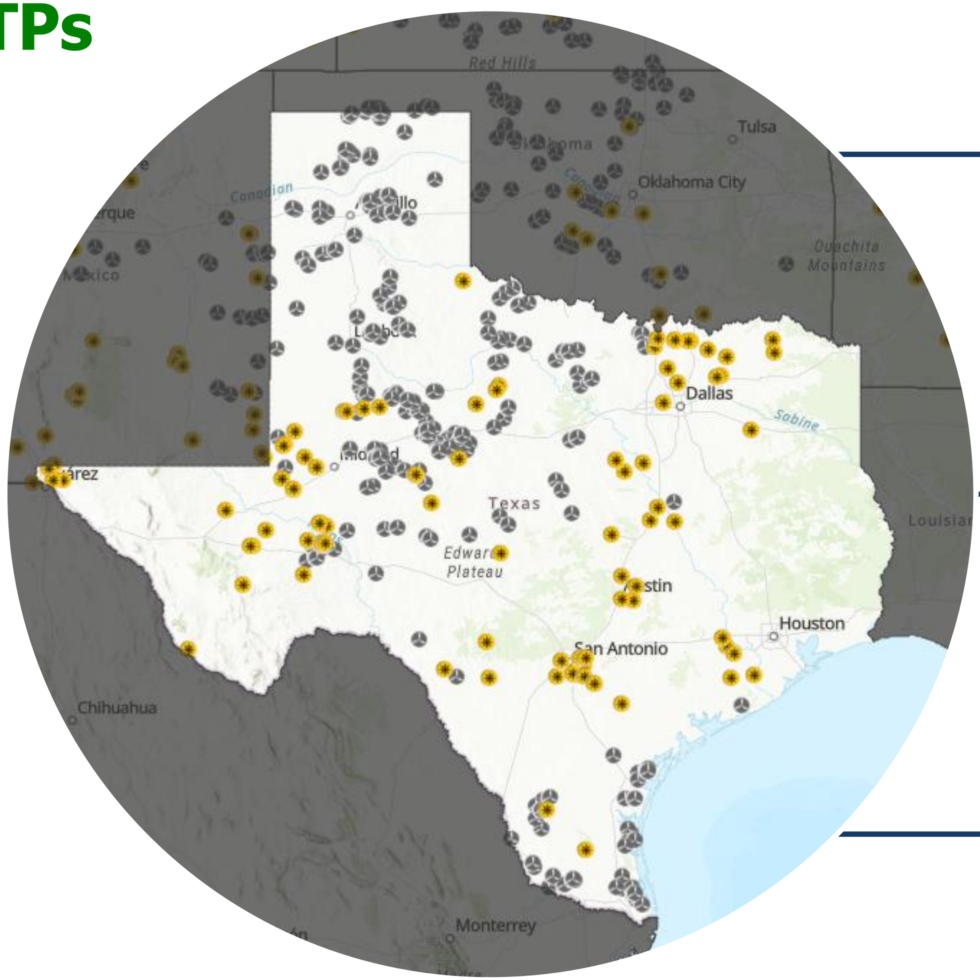


E-ISAC Perspective on Existing Risks to Reliability

- *Extremists advocating for sabotage against the grid*
- *Monetary impacts related to theft of copper, tools, vehicles, and more*
- *Disruptive or destructive activism*
- *Surveillance of critical assets*
- *Insider threat*
- *Operational impacts to generation, transmission, or distribution of electricity*
- *Workplace violence, risk to organization and personnel, especially field workers*

New Assets Affected by Operational Disruptions

#1: New TTPs



Third Party Infrastructure & Communications

Wind Generation

Solar Generation

Considerations - New Assets Affected by Operational Disruptions

#1: New TTPs

Considerations	For AOOs	For the State
Could your assets be affected?	Owners of wind and solar sites or other assets with operational dependencies on communication infrastructure	EIA: In 2023, Texas wind accounted for 28% of all U.S. wind-sourced electricity.
Are your critical facilities vulnerable to operational disruptions?	Are redundant communications in place? Is wind/solar operational critical?	EIA: TX industrial sector, accounts for more than half of the state's energy consumption and for 24% of the nation's total industrial sector energy use.
Are you already tracking these types of tactics within your fleet?	Develop or borrow physical security incident tracking methodology.	Encourage entities in Texas to track and share incidents.

#2: Impactful Thefts or Attempts

- Theft of Installed Copper
- Cut Wires
- Felling Infrastructure

#2: Impactful Thefts or Attempts

Considerations	For AOOs	For the State
What are your unacceptable consequences related to theft?	Loss of industrial load? Loss of ### customers? Loss of $$$ worth of copper? Safety impacts of ungrounded equipment?	Support discussion.
Impact-chain of criminal environment and copper markets on operations.	High copper prices have strong bearing on thefts of copper.	Coordination between utilities, comms providers, copper recyclers, law enforcement, fusion center, state enhances response effectiveness.
Information sharing and benchmarking.	Share incidents with E-ISAC at operations@eisac.com or 202-790-6000 (24/7).	Encourage benchmarking – requires a mature incident tracking program.

Supply Chain Challenges Converge with Geopolitics

#3: Supply Geopolitics

#3: Supply Geopolitics

Considerations	For AOOs	For the State
Critical supply chain inputs.	Analyze supply chain inputs for each asset type in fleet.	Enhance conversation by providing guidance on expected growth needs.
Geopolitical factors and their influence on supply chain inputs.	What regions face a concentration of risk?	What were the lessons learned from the pandemic supply chain shock? How can these be leveraged to increase resilience to future geopolitically-themed shocks?
Other complexities.	What other complexities might your org face related to supply chain and geopolitical constraints?	How can the state help inform owners on this front for long time horizon issues?

DOE: "Many critical components supporting the power grid have limited to no domestic manufacturing capacity and face complex challenges in supporting a rapid expansion of the grid to meet multiple objectives, including decarbonization goals."

ER #4: Disruptive Action Following Public Discontent

#4: Flashpoints

Examples

COVID-19 pandemic and 5G conspiracy	New extremist publications	Israel-Palestine Conflict
Tesla and Elon Musk	Unrest in the PNW	Dissatisfaction with new pipeline construction
Major U.S. Elections	U.S./Canada Tariffs	Ukraine-Russia War

ER #4: Disruptive Action Following Public Discontent

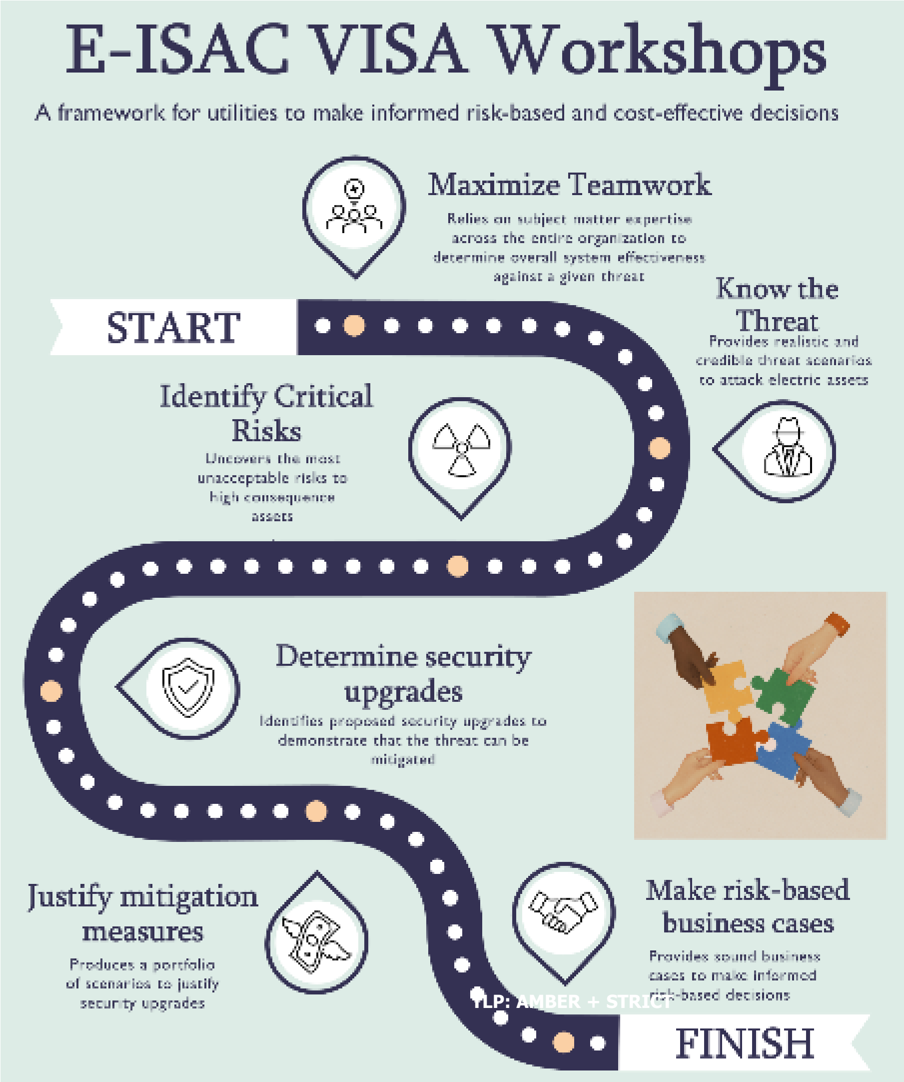
#4: Flashpoints

Considerations	For AOOs	For the State
Determining potential flashpoint events.	What types of assets in your fleets are most at risk from a public discontent perspective? Are there any events that could serve as inflection points?	How can state messaging support security and safety of grid assets?
Indicators	Monitor these closely and programmatically.	Continue to support coordination with law enforcement and intelligence partners by advocating for our sector.
Mitigations	Build flexibility into security posture, shields up when needed to minimize exposure.	Discuss unacceptable consequences for critical infrastructure from the state perspective with respect to public discontent and disruptive action.

Final Considerations for AOOs and Planners

Planners		AOOs		
Guide and enable sensible solutions	Monitor the medium to long term horizon	Mitigate ongoing predictable risks	Leverage partners to support prioritization	Maintain awareness of longer-term horizon

E-ISAC VISA Workshops



VISA Workshop Benefits

- Cost-effective methodology
- Relies on subject matter expert input to determine overall system effectiveness
- Adaptable to all types of utilities, ideal for small/medium entities with limited resources
- Promotes developing sound business case to make informed risk-based decisions
- Provides confidence that a threat can be mitigated
- Helps utilities produce a portfolio of scenarios to justify upgrades

2025 Efforts

7 E-ISAC workshops…no cost

1. SnoPud (Snohomish, WA): April
2. ConEd (New York): July
3. EPCOR (Alberta, CA): Q2-Q3 TBD
4. Excel (Minnesota): Q2-Q3
5. Littleton & NEPPA (Boston, MA): Sept
6. HydroOne (Toronto, CA): Nov
7. Pending (NPCC): Q3-Q4

More workshops available at direct cost

What’s next

- Grow VISA into a regional based program
- Tailored for small/medium utilities with limited budgetary resources

Slido Question

What physical security risk keeps you up at night?

Questions and Answers

High Frequency Conduct and Change Management

Katie Van Zee
Director, Enforcement and Registration

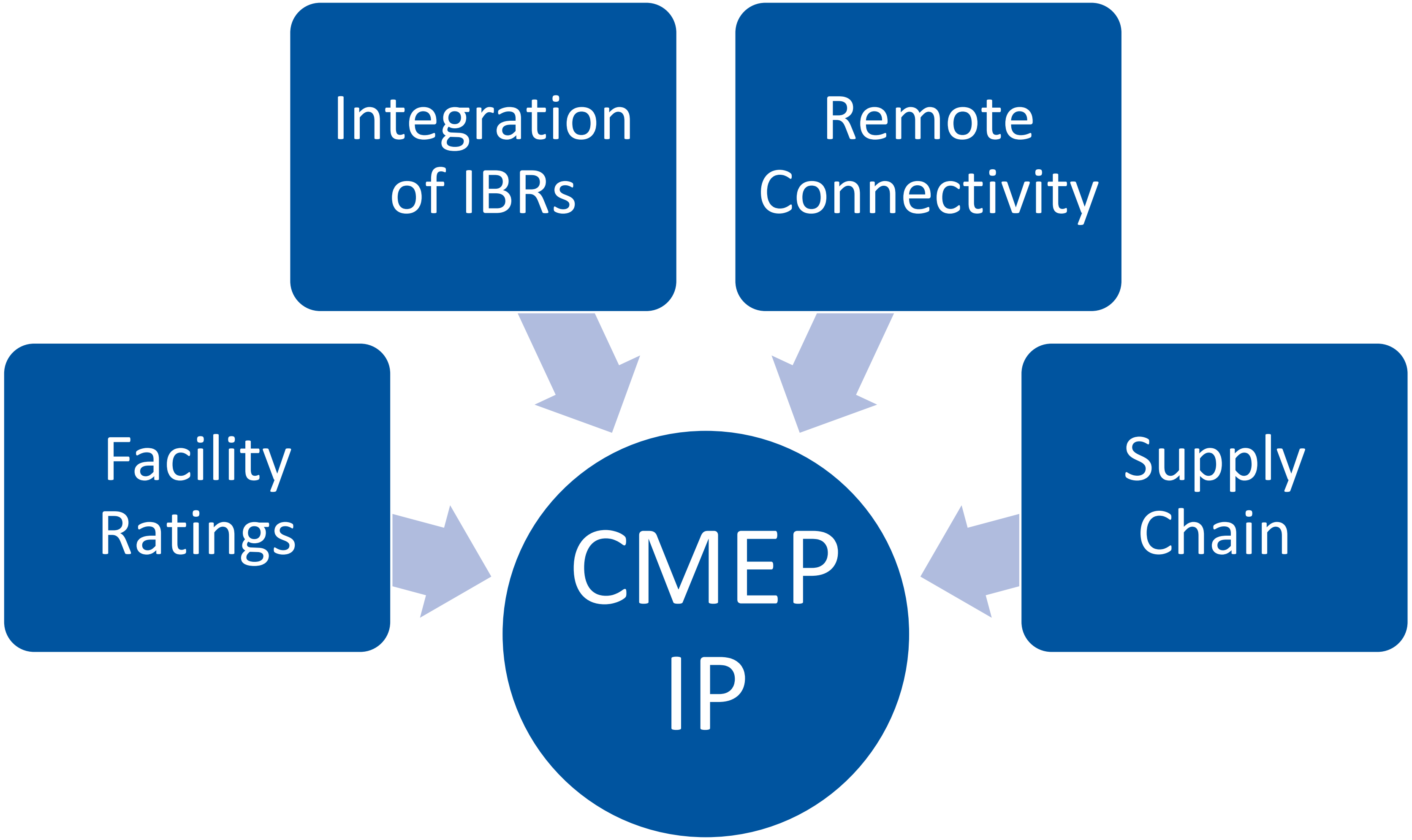
Roadmap

The CMEP IP and High Frequency Conduct

Root Cause and Change Management

Reliability Standards and Best Practices for Internal Controls

2025 CMEP Implementation Plan



CMEP IP Link to Reliability Standards

Facility Ratings	• FAC-008 R6
Integration of IBRs	• PRC-005-6 R3
Remote Connectivity	• CIP-004-7 R4 & R5
Supply Chain	• CIP-010-4 R1

High Frequency Conduct

FAC-008 R6

- Facility Ratings must be updated for new or modified Facilities

PRC-005-6 R3

- Time-based maintenance program(s) for Protection System(s), Automatic Reclosing, and Sudden Pressure Relaying Components

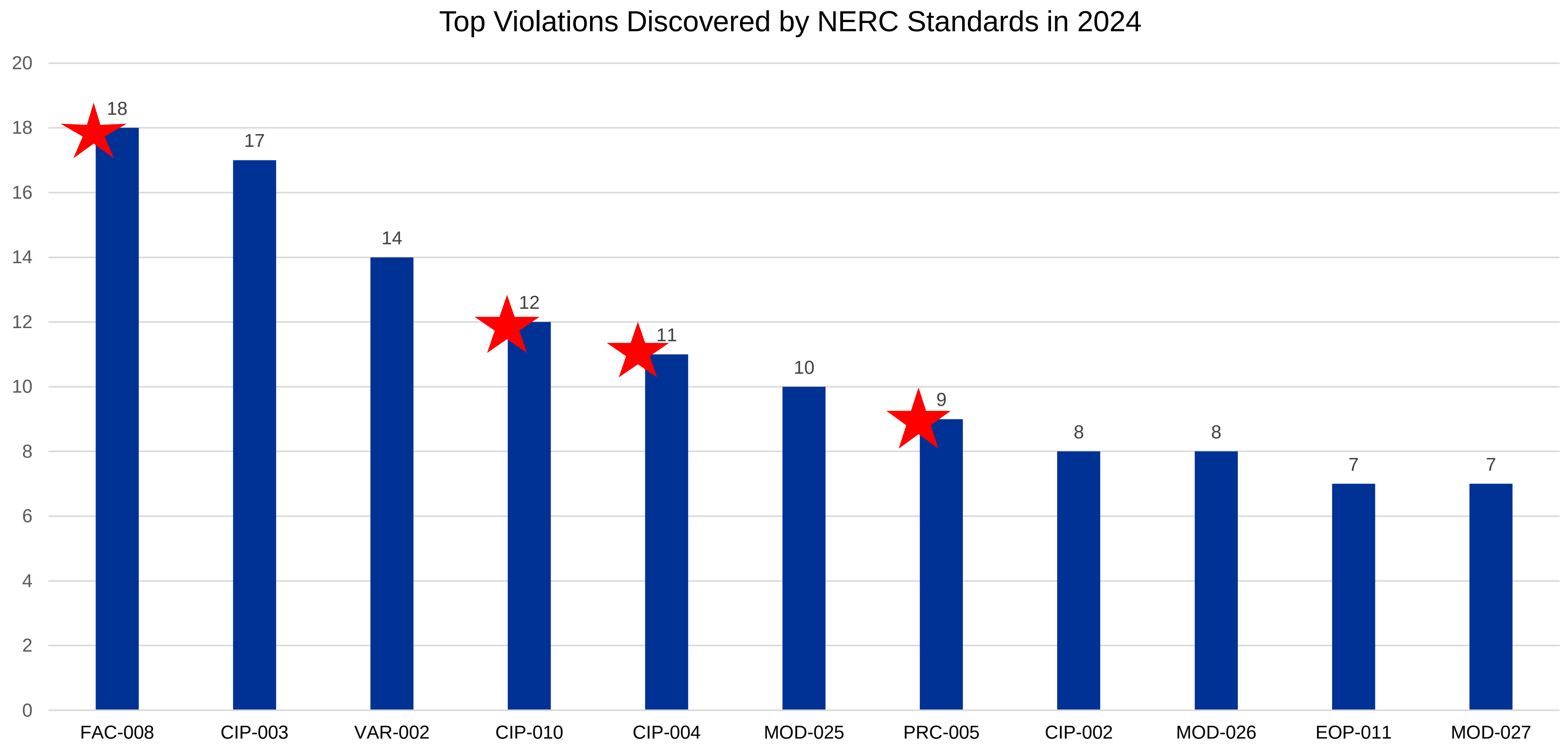
CIP-004-7 R4 & R5

- Access management programs that require periodic verification of authorization
- Revocation of access upon employee termination or transfer

CIP-010-4 R1

- Baselining documentation needs to reflect current configurations for BES Cyber System and associated EACMS, PACS, and PCAs
- Changes must be tracked, authorized, verified, and tested if possible

Enforcement Tracking



Refresher on Root Cause

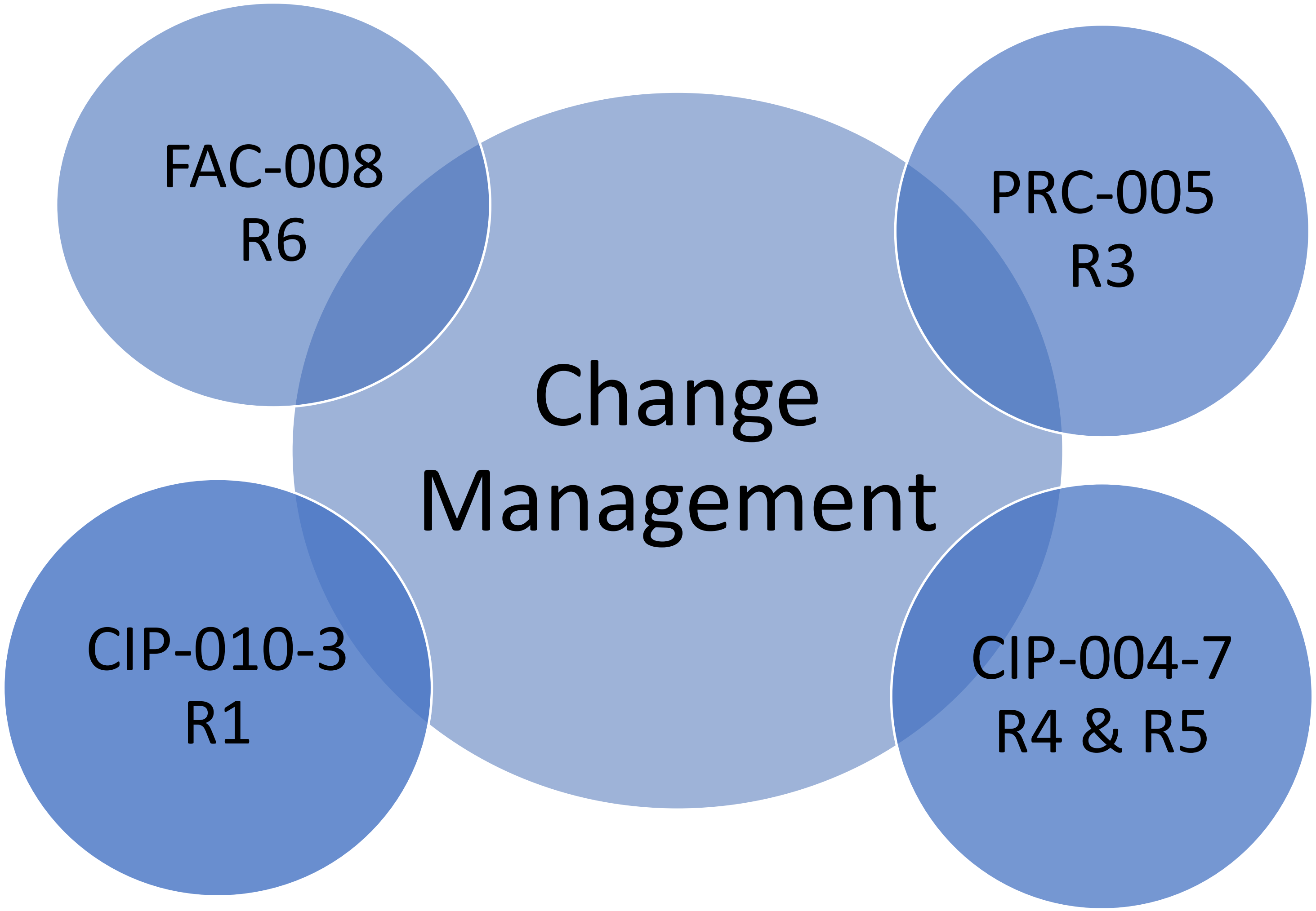
The Importance of Root Cause

Essential to Prevention of Reoccurrence

- Mitigation activities must address the Root Cause

Root Cause	Prevention of Recurrence
Insufficient validation control	Updated validation control
Unclear process document	Revised process document
Ineffective system design	Updated system design

Change Management and High Frequency Conduct



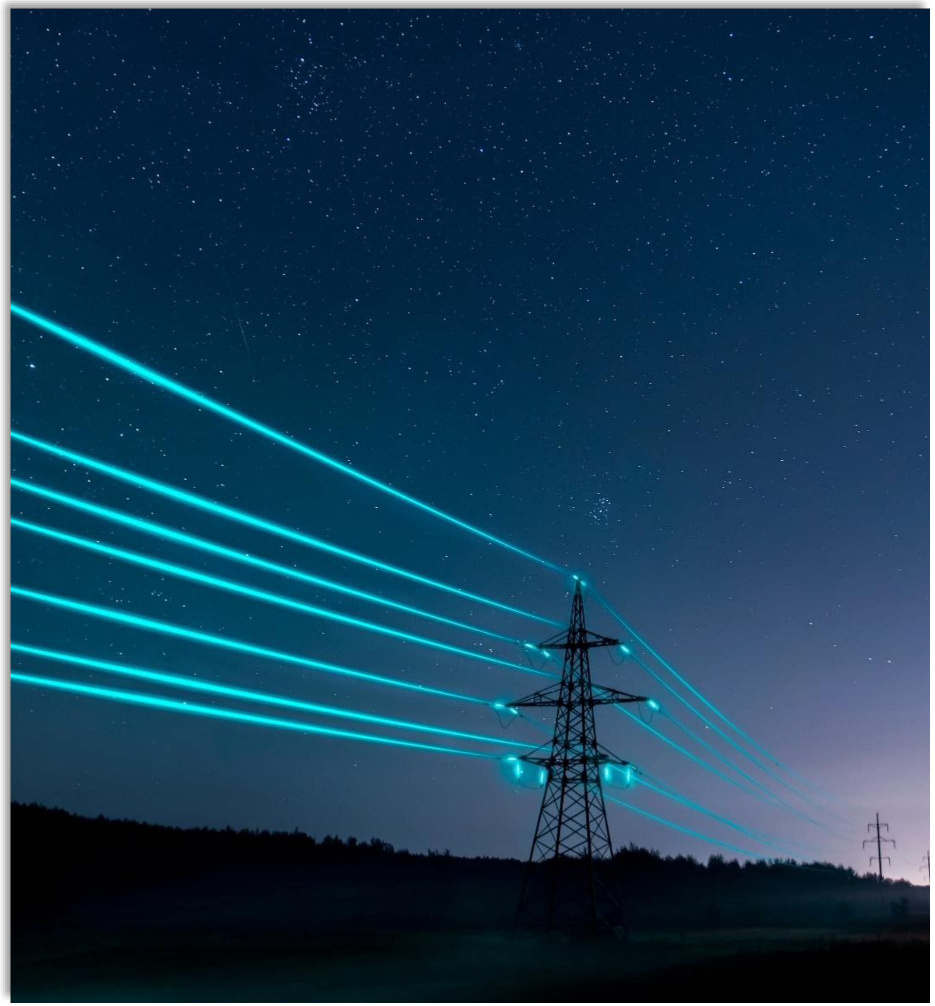
FAC-008-5

R1: Facility Ratings Methodology

R6: Facility Ratings consistent with methodology and must correctly identify Most Limiting Series Element (MLSE)

R8: Providing correct and current Facility Ratings to RC, PC, TP, TO, and TOP

Sampled FAC-008-5 R6 Noncompliance



Incorrect MLSE

Why?

- Equipment Replacement
- Omitted Equipment
- Field Changes different from Design

Why?

Root Cause Analysis

Failure to Update Facility Ratings Post Equipment Replacement/Upgrade

- Why?

Field Change Different from Design

- Why?

Omitted Equipment

- Why?

Ineffective Change Management Procedures

FAC-008-5 R6 Effective Change Management Procedures

- A requirement for data entry verification
- A clearly outlined approval process prior to changes
- Notification to update inventory after a change
- Confirmation that a change is implemented as planned
- Checklist to verify Facility Ratings following a change
- Validation through periodic reviews
- A change process flowchart

FAC-008-5 R6 Best Practices

- Don’t limit change management process to planned work
- Include changes that occur during emergency repairs
- Include changes following post storm or extreme weather restoration
- Do include planned projects
- Do include acquired facilities

PRC-005-6 R3 Time Based Maintenance Programs

Maintenance must be performed as described in the tables within the Standard

In accordance with:

- Minimum maintenance activities (what and how)
- Maximum maintenance intervals (how often)

Maintenance intervals depend on component attributes

- 4 Calendar Months
- 18 Calendar Months
- 6 Calendar Years
- 12 Calendar Years

Sampled PRC-005-6 R3 Noncompliance

Missed Testing

Why?

- Inventory Deficient

Why?

Root Cause Analysis

Incomplete inventory after ownership/management transition

- Why?

Inventory records unorganized

- Why?

New/upgraded equipment not added to inventory

- Why?

Ineffective Change Management Procedures

PRC-005-6 R3 Effective Change Management Procedures

- PSMP with master inventory
- Periodic review of procedure and checklists
- Training
- A clearly outlined approval process prior to changes
- Notification to update inventory after a change
- Confirmation that a change is implemented as planned
- A change process flowchart
- Validation of inventory through periodic reviews

PRC-005-6 R3 Best Practices

Incorporate oversight into processes

- Secondary review of compliance task

Periodic review of completed PRC-005 paperwork to identify “lessons learned” to inform training

Verification of inventory for acquired Facilities

CIP-004-7

R4	Access Management Program	
4.2	At least quarterly, verify authorization records	
4.3	At least every 15 months, verify access is correct and necessary	

R5	Access Revocation
5.1	Revoke physical access and Interactive Remote Access within 24 hours of termination
5.2	By end of next calendar day, revoke access for transfers when its determined access is no longer required
5.3	Within 30 days, for termination, revoke non-shared user accounts that are not covered in 5.1.
5.4	Within 30 days, change password to shared account(s)

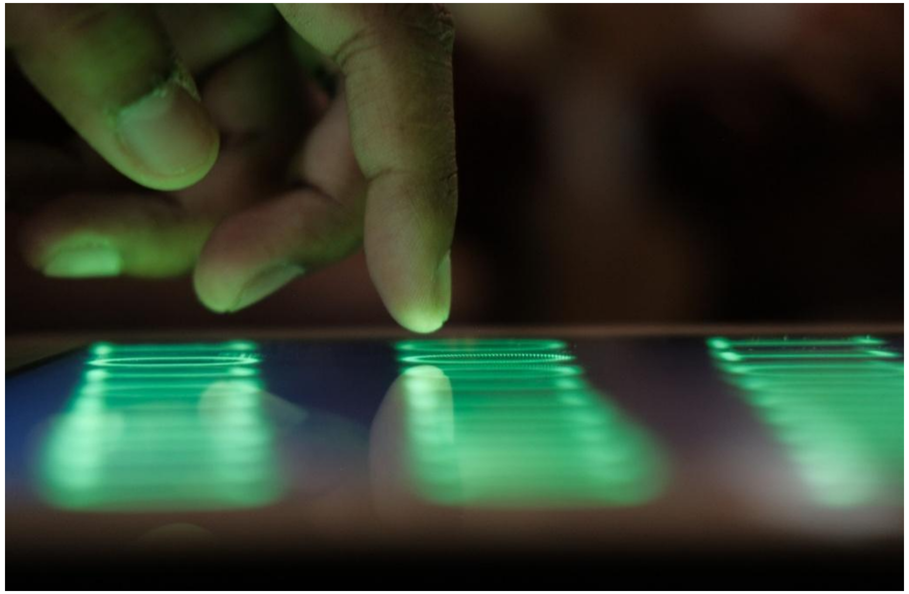
Sampled CIP-004-7 R4 Noncompliance and Root Cause

Individuals Have Unnecessary Access

Why?

- Cross-department coordination
- Failure to follow process
- Generic access

Why?



Ineffective Change Management Procedures

CIP-007-6 R4 & R5 Effective Change Management Procedures

Track CIP access requests

Additional verification steps in process

- Management oversight
- Peer review
- Analysis of linked or shared accounts

A clearly outlined approval process prior to changes

Confirmation that a change is implemented as planned

A change process flowchart

CIP-007-6 R4 & R5 Best Practices

Additional verification steps in process

- Management oversight
- Peer review
- Analysis of shared accounts

Periodic access reviews

CIP-010-4 R1

R1.1
Baseline

R1.2
Authorization of changes

R1.4
Impact analysis and verification

R1.5 and 1.6
If possible, verify source and test prior to implementation

R1.3
Updated baseline within 30 days of change

Sampled CIP-010-4 R1 Noncompliance and Root Cause

Ineffective Change Management Procedures

Baseline Not Accurate

Why?

- New Cyber Assets
- Software Source Wrong or Outdated
- Real-Time Changes not Reflected
- Missing Cyber Asset

Why?

CIP-010-4 R1 Effective Change Management Procedures

- Create tasks and reminders
- Training
- Monitor software vendors
- A clearly outlined approval process prior to changes
- Confirmation that a change is implemented as planned

CIP-010-4 R1 Best Practices

Additional verification steps in process

- Management Oversight
- Peer Review

Verification of inventory

- Periodic Sampling

Questions?

TEXAS RE

Ensuring electric reliability for Texans

NERC

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NERC Supplemental Filing: Abeyance

Lonnie Ratliff, Director of Compliance Assurance and Certification

Texas RE Spring Standards, Security, and Reliability Workshop

April 23, 2025

NERC
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Supplemental Filing: Abeyance

What is the initial criteria for abeyance consideration?

- A high priority project given risks being addressed
- A new Reliability Standard or a modified Reliability Standard undergoing significant revisions
- It involves one or more of the following attributes:
  - new technology likely will be needed to implement the Reliability Standard;
  - new, emerging reliability issue with no consensus on specific best practices or
  - a high level of technical complexity

Example of current usage:

- Project 2024-03 Revisions to EOP-012-3 (Cold Weather) *
  - *"From the effective date of **Reliability Standard EOP-012-3 until October 1, 2027**, the Compliance Enforcement Authority will not pursue an action under Sections 4A.0 or 5.0 of Appendix 4C to the Rules of Procedure for a failure to comply with **Reliability Standard EOP-012-3 Requirement R1 Part 1.1** with respect to the **calculation of the Extreme Cold Weather Temperature** for an applicable generating unit, or any other failure to comply resulting from an incorrect calculation of the Extreme Cold Weather Temperature for that generating unit, against any entity acting in good faith to comply with the standard in accordance with the relevant implementation plan."*

https://www.nerc.com/pa/Stand/Pages/Project-2024-03-Revisions-to-EOP-012-2.aspx

Supplemental Filing: Abeyance

What is the value of abeyance?	• To enhance NERC standards development process agility that the ERO Enterprise and industry have focused on the past few years • Help reduce the concern over compliance risk during standards development so that the focus can be on addressing risks to reliability
When is abeyance considered?	• During the Standards Drafting process
What is the purpose of abeyance?	• Develop insights from initial implementation of the standard that can then be fed back to NERC and industry to further refine standards as needed
Who determines which Standards/Requirements/Parts for abeyance consideration?	• The ERO Enterprise will consider the candidates for the abeyance period

Abeyance – What it is NOT

Abeyance is NOT

- A free pass
- An extension of the implementation plan
- Time to sit and ***wait*** for feedback

What should you be doing?

- Working with your Region
- Talking with your peers

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Abeyance: Common Questions

- Will all Standards / Requirements have an abeyance period?
- Where will the abeyance language be within the Standard?
- What if I’m not audited during the abeyance period?
- What current Standards or Projects have been flagged for abeyance?
- Will the supplemental filing impact the self-logging process?

Abeyance: Common Questions, cont.

How does the information feed back to Standards for possible enhancements?

How will industry receive updates during the abeyance period?

Can a SAR be introduced during the abeyance period?

What is “good faith”?

Questions and Answers

Wrap-Up

Thank you for coming!

You will receive a short survey via e-mail. Please complete it to help Texas RE develop future outreach.