TEXAS RE

Modeling and Model Verification

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July 30, 2025

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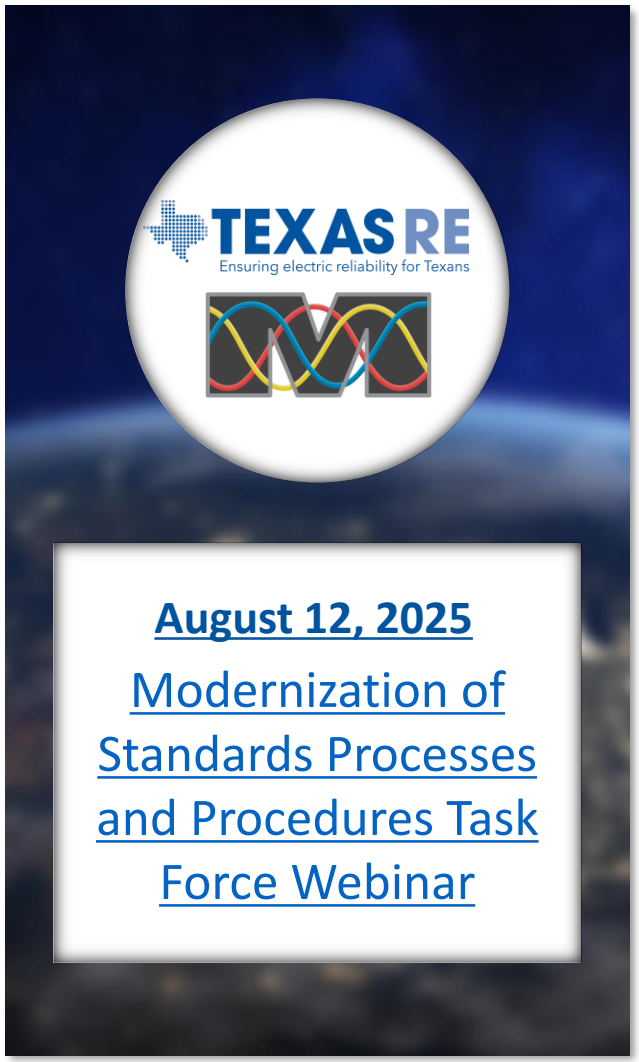
Upcoming Texas RE Events

August 5, 2025

Cybersecurity Threats



August 12, 2025

Modernization of Standards Processes and Procedures Task Force Webinar

August 19, 2025

CIP-003-8

Upcoming Texas RE Events

September 17, 2025

Q3 MRC and Board Meetings

October 1, 2025

Winter Weatherization Workshop

November 5, 2025

Fall Standards, Security, & Reliability Workshop

Upcoming ERO Enterprise Events

Date	Event
August 6	Protection System Workshop (RF)
August 7	Human Performance Workshop (RF)
August 12-14	Power System and Security Conference (WECC)
August 13	Inverter-Based Resource Webinar (MRO)

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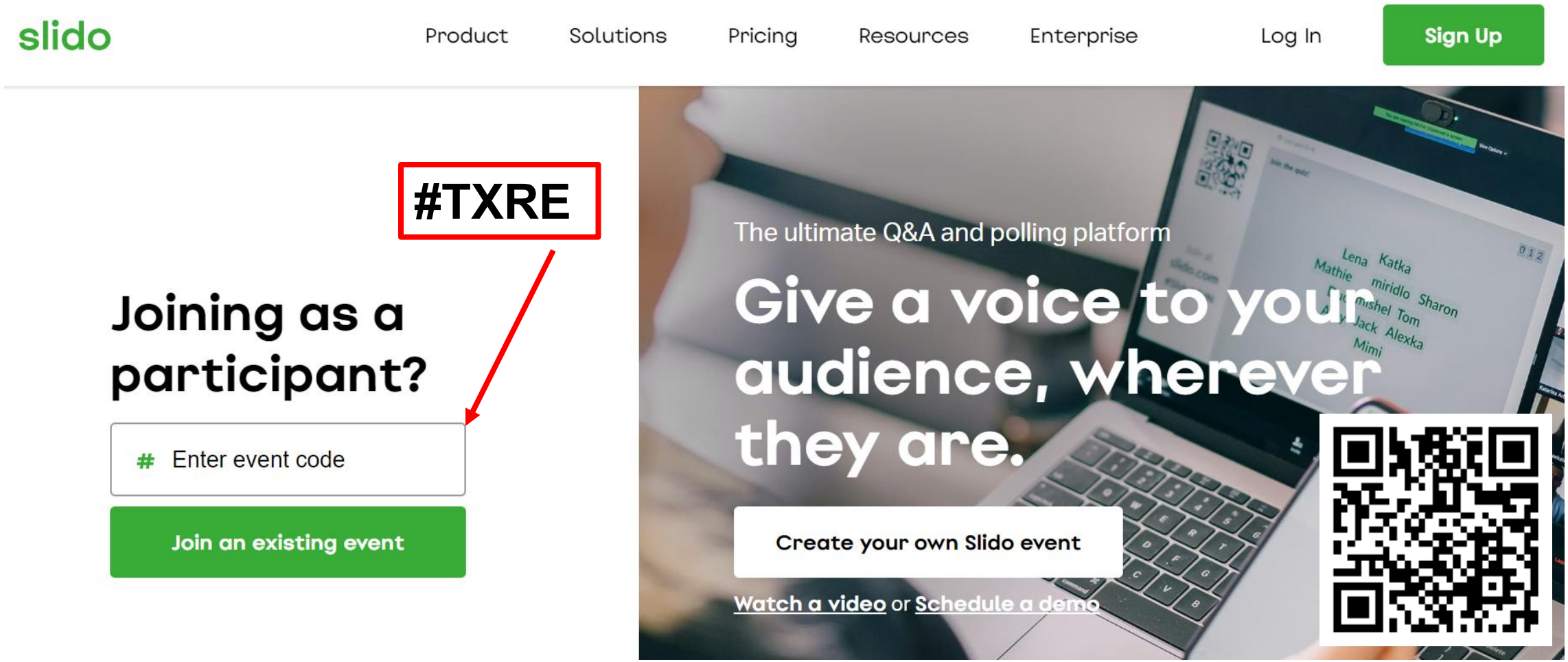
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Slido Question

Does your entity own or operate any inverter-based resources?

Agenda

- IBRs and the Importance of Modeling
- Proper Modeling
- MOD-026-1
- Volt-Var Controls
- Failure Points and Best Practices

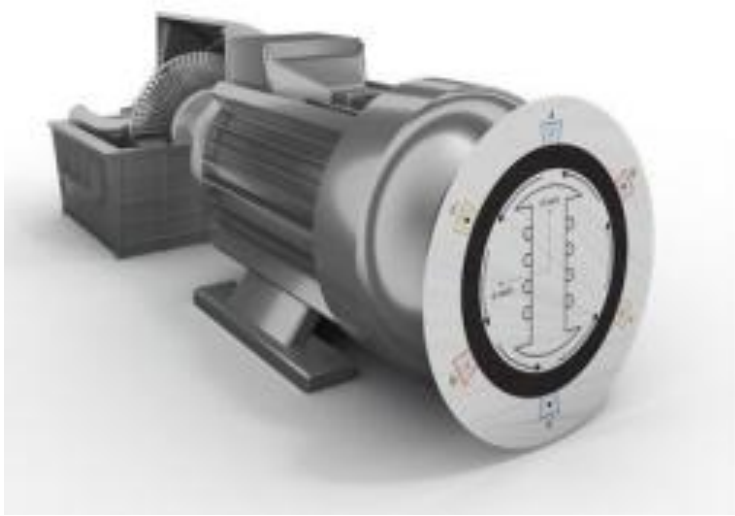
Synchronous Generation vs Inverter-Based Resources (IBRs)

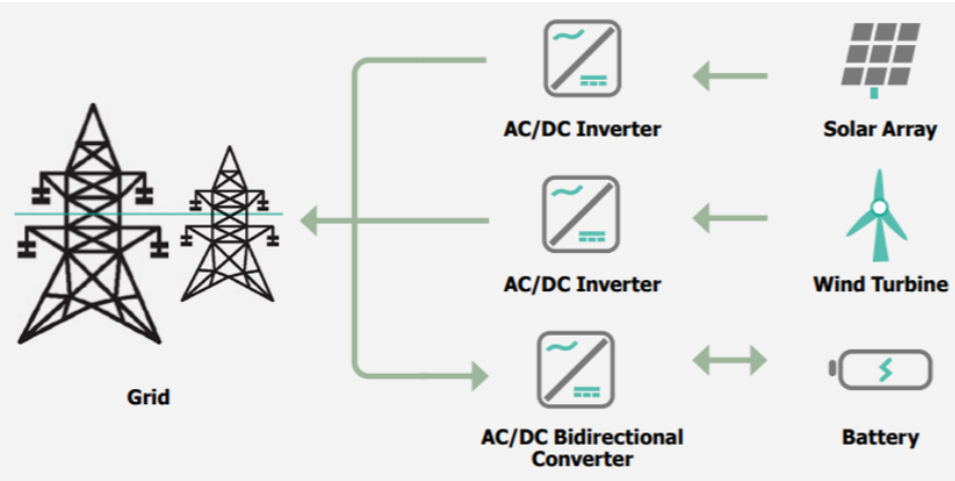
What are the differences between inverter-based resources and synchronous generation?

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





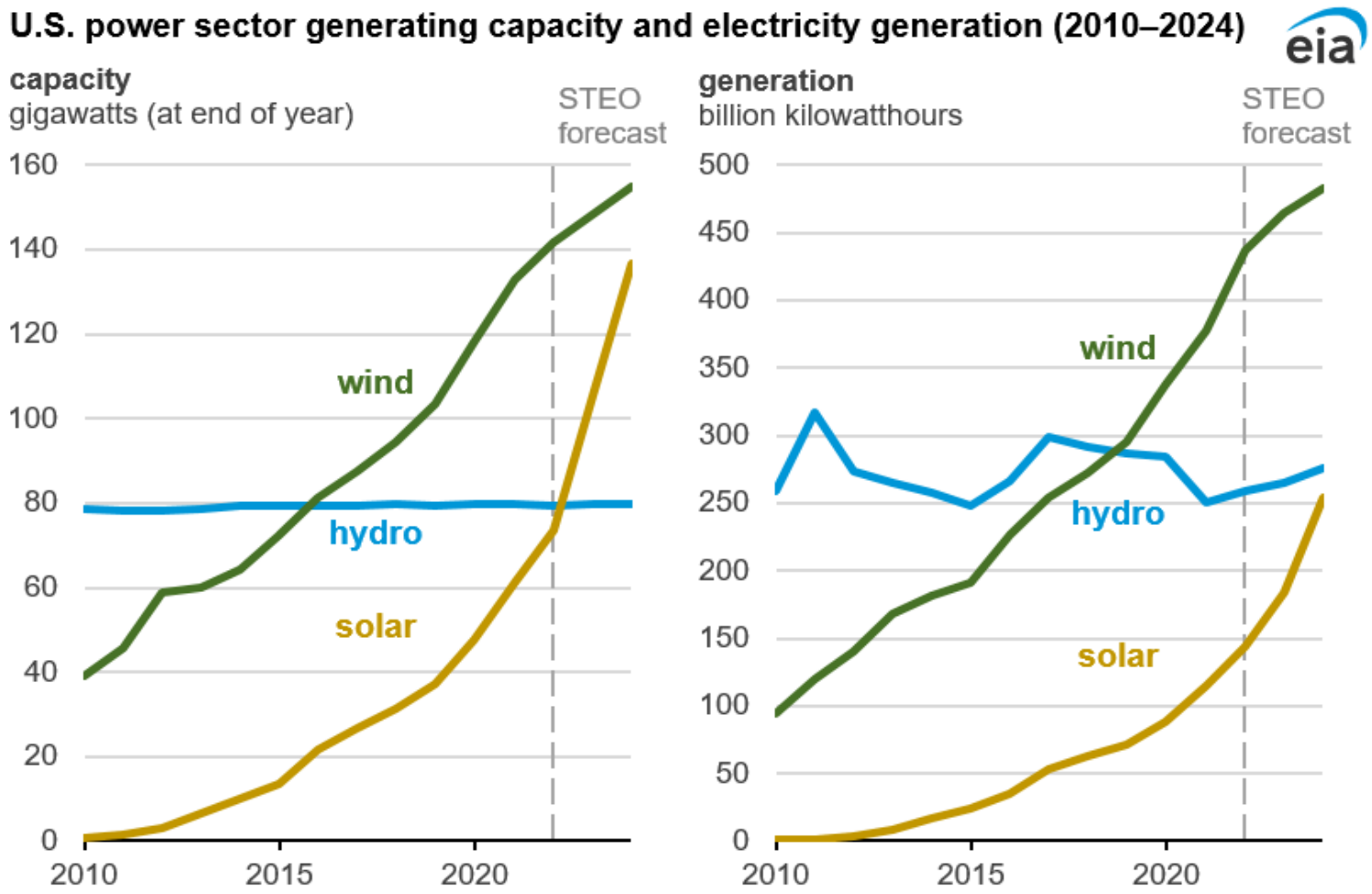
Source: NREL

Source: 2023_NERC_Guide_Inverter-Based-Resources

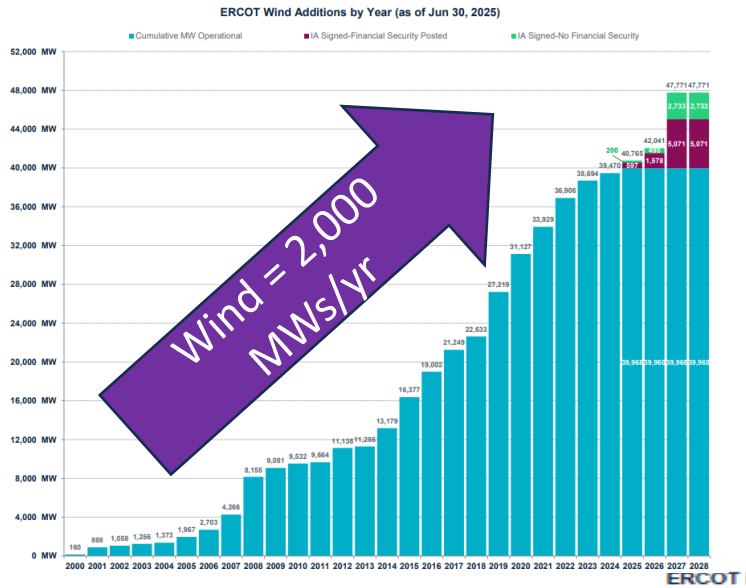
Growth of Inverter-Based Resources in the U.S.

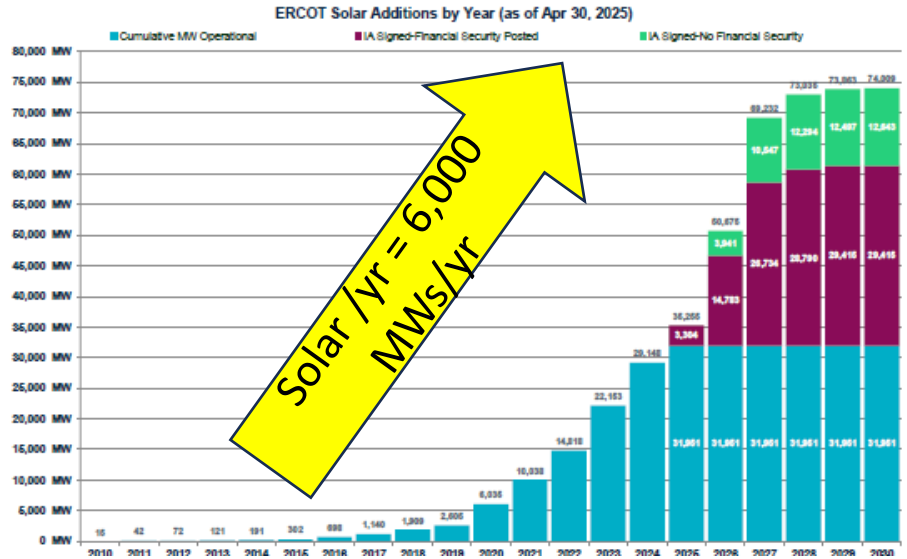
Wind=10,000 MWs/yr

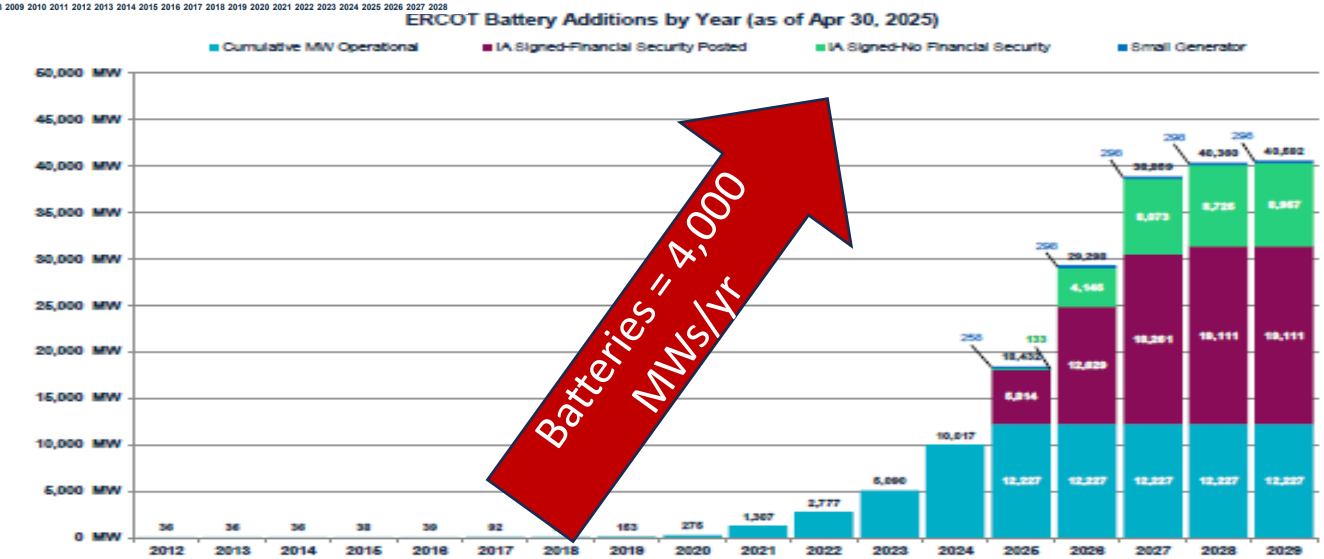
Solar=16,000 MWs/yr



Growth of Inverter-Based Resources in ERCOT







Courtesy of ERCOT

Importance of Accurate Inverter-Based Resource Modeling

1. Enhanced Grid Reliability and Stability

- Predict and mitigate instabilities to ensure grid stability
- NERC Reliability Standards—the "MODs"

2. Effective Performance Validation

- Validates IBR behavior during grid disturbances
- Improved Planning and Operational Studies
  - FERC Order No. 901
  - Support IBR integration into the Bulk Power System (BPS)

[Project 2020-06 Verifications of Models and Data for Generators]

Compliance Monitoring and Enforcement Program Implementation Plan

MOD-026-1 plays a role in risk elements identified by the CMEP/IP in both 2024 and 2025.

Table 1: 2024 and 2025 ERO Risk Elements	
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

ERO CMEP Implementation Plan v2.0 - 2025

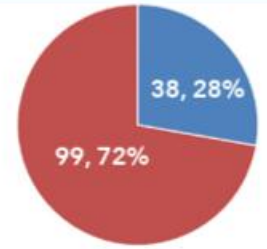
Known and Emerging Risks for 2025

Texas RE 2024 Reliability Performance and Regional Risk Assessment

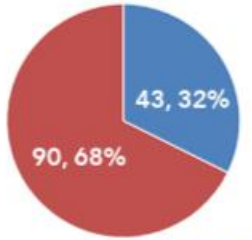
RISK LEVEL			
LOW	MODERATE	HIGH	VERY HIGH

CONSEQUENCE/ IMPACT		LIKELIHOOD (L)				
		L1	L2	L3	L4	L5
		VERY LIKELY	UNLIKELY	POSSIBLE	LIKELY	ALMOST CERTAIN
C5	SEVERE					
C4	MAJOR			Supply Chain		
				Energy Availability	Disorganized Integration of Large Loads	
			Extreme Weather & Resource Weatherization	Gas Supply Restrictions During Cold Weather	IBR Ride-Through	
C3	MODERATE		Provision of Essential Reliability Services from a Changing Resource Mix	Remote Access		
			Facility Ratings	Inaccurate Resource Modeling		
			Artificial Intelligence		Physical Security	
C2	MINOR					
C1	NEGLIGIBLE					

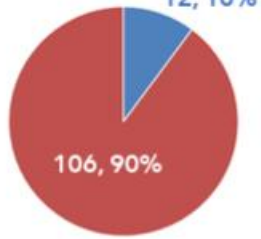
High Voltage Threshold Settings Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	38	28%
As-left control setting does not match model parameter	99	72%
Total	137	100%



Low Voltage Threshold Settings Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	43	32%
As-left control setting does not match model parameter	90	68%
Total	133	100%



Frequency Deadbands Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	12	10%
As-left control setting does not match model parameter	106	90%
Total	118	100%



As-left control setting matches model parameter

As-left control setting does not match model parameter

Proper Modeling

- **How to set up the simulation properly?**
  - Model the simulation at the same point as it is monitored in the field
- **Simulation tools model individual components and their control systems**
- **Models are the basis of power system studies in planning and operations**
- **Importance of accuracy**

NERC Acceptable Models List

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 (GO)
- Transmission Planner (TP)

Volt-Var Controls—Technical Aspects of IBR Controllers

Comparing off-line model to Real-time response

IBRs rely on sophisticated controllers to interact with the grid. Evaluating how these controllers perform is crucial for maintaining a reliable power system. This involves comparing their behavior in off-line models with their actions in actual, Real-time scenarios.

Project 2020-06 Verifications of Models and Data for Generators

Volt-VAR control

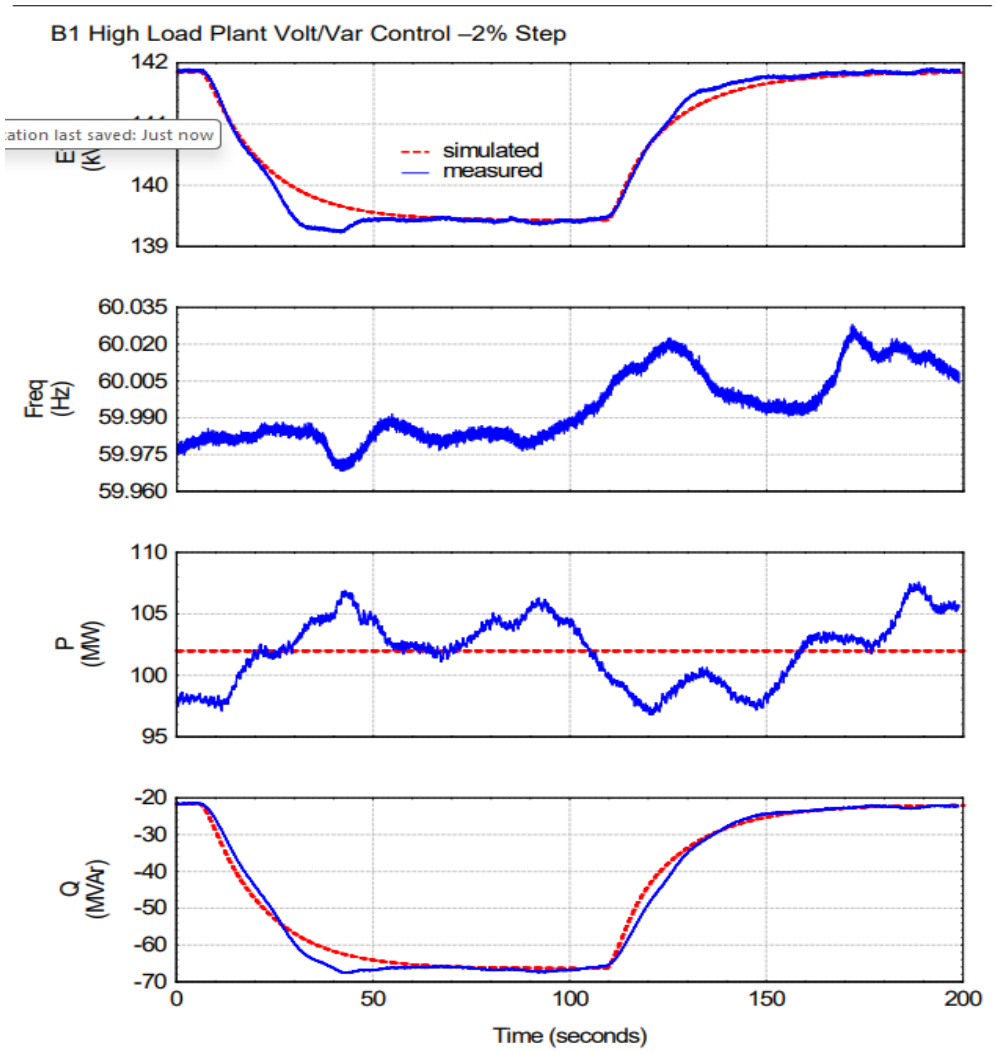
Reactive Power Management: In Volt/VAR mode, IBRs automatically adjust their reactive power (VAR) absorption or injection in response to changes in the voltage at their point of interconnection (POI).

Voltage Regulation: The goal is to maintain the grid voltage within acceptable operational limits. This is accomplished through power system controllers.

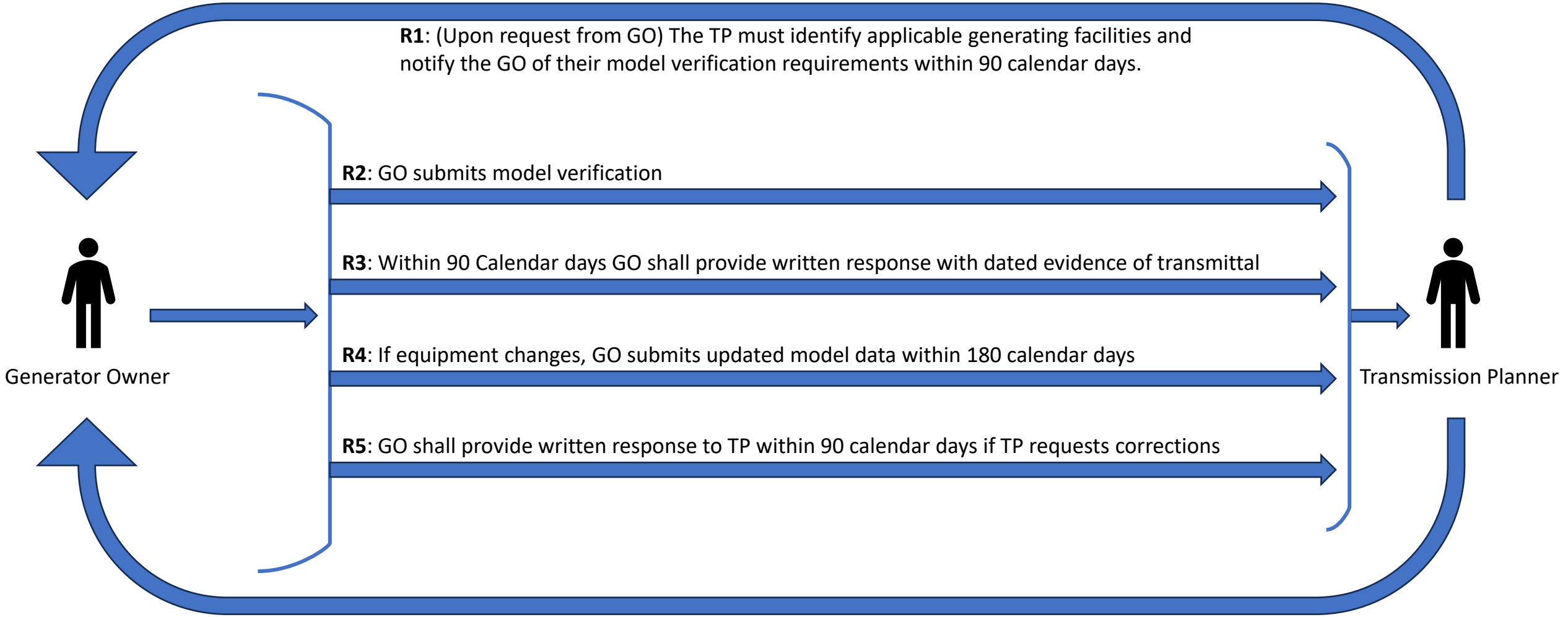
Power Control System Model Verification

Plant controller model configured to regulate voltage at the Point of Interconnection (POI) bus voltage level.

Simulations confirm the model values are sufficient for the purpose of modeling the plant's voltage reactive power controls.



MOD-026-1 Process



R6: The TP reviews the model and communicates to the GO the usability within 90 calendar days after receiving the model information.

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Slido Question

What internal controls does your entity plan on using to track responses within the 90 calendar days requirement?

Control Objectives

- VERIFY
- ENSURE
- INFORM

Importance of Internal Controls

Verification and Quality Assurance

- Review model accuracy in detail before submission
- Confirm software version and compatibility

Documentation and Record Keeping

- Have a formal documented process in place for verifying models and data
- Ensure responses are given/received within required timeline. This helps ensure models are usable and timely.
- Request recipients confirm receipt and acknowledge deadlines

Subject Matter Experts (SMEs)

Quality Assurance/Quality Control (QA/QC)

Compliance Failure Points

- Failure to provide instructions on how to obtain the list of acceptable control function models or model library block diagrams and/or data sheets within 90 days of receiving a written request.
- **Failure to provide required current modeling data within 90 days of receiving a written request.**
- Failure to provide verified generator excitation control system or plant volt/var control function model and supporting documentation per the periodicity specified in MOD-026-1 Attachment 1.
- Failure to include documentation of model verification according to R2.1.
- **Failure to respond within 90 days to comments regarding model response accuracy or usability.**
- Failure to provide revised model data or plans to perform model verification within 180 calendar days of making changes to the excitation control system or plant volt/VAR control function that alters the equipment response characteristic.
- Failure to respond within 90 calendar days to request from the Transmission Planner to perform a model review.
- Failure to respond within 90 calendar days that the Generator Owner's verified excitation control system or plant volt/VAR control function model is or is not usable.

Best Practices

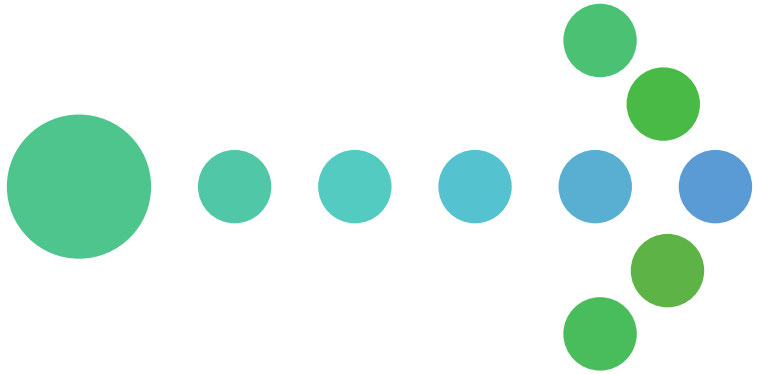
Periodically verify that the generator excitation control system or plant Volt/VAR control function model and the model parameters used in dynamic simulations accurately represent system behavior.

- Ensure data is suitable in acceptable models
- Ensure the model data matches actual system behavior and accurately represents generator response (GO)
- Revise model data for changes that alter the equipment response characteristics

Best Practices

Ensure all received data is technically sound and usable

Review data for usability (TP)



Best Practices

Inform connected entities of verification activities

- Inform TP when unit does not require verification
- Request corrected data as needed
- Send a response when notified of concerns with data submitted (GO)

MOD-026-1 Top Recommendations

Industry-approved Standard library positive sequence phasor domain (PSPD) models are sufficient for use in Interconnection-wide base-case creation. Models should be validated at the individual inverter and plant level to ensure that the performance of the plant model matches the expected performance of the in-service IBR plant

- Generally, Standard library models that have not been verified by the equipment manufacturer should not be used for local reliability studies or generation interconnection studies, particularly in and near the study area due to a lack of sufficient model accuracy and fidelity to represent the actual equipment controls and protections

MOD-026-1 Top Recommendations

All models should be detailed and accurate representations of expected or as-built facilities across all expected operational conditions. Changes to any model parameters, including plant controller parameters that change the performance of the IBR plant, should be studied to ensure BPS reliability before implementation

- Models should be validated at the individual inverter and plant level to ensure that the performance of the plant model matches the expected performance of the in-service IBR plant

MOD-026-1 Top Recommendations

Equipment-specific models should be used for detailed reliability studies. These equipment-specific models should be considered acceptable by a Transmission Planner (TP) or Planning Coordinator (PC) if the following usability requirements are met

- A unit model validation report should be produced by the equipment manufacturer that compares the actual equipment performance against the performance of the EMT model, equipment-specific positive sequence model, and positive sequence Standard library model is provided. The GO should request this benchmarking report from the equipment manufacturer(s) for each inverter type for each IBR plant.
- The equipment-specific model includes compiled .dll files such that no additional compilation is required by the end user.

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 generator behavior when assessing BPS reliability

Resources

- ✓Best practices as outlined in NERC Reliability and Security Technical Committee guidelines for synchronous machines and inverter-based resources:
  - PPMV_for_Inverter-Based_Resources
  - Reliability_Guideline_-_PPMV_for_Synchronous_Machines_-_2018-06-29
  - Reliability_Guideline_BESS_Hybrid_Performance_Modeling_Studies
  - Reliability_Guideline-EMT_Modeling_and_Simulations
- ✓ NERC Acceptable Models List
- ✓ERO CMEP Implementation Plan v1.0 - 2024
- ✓ERO CMEP Implementation Plan v2.0 - 2025
- ✓Project 2020-06 Verifications of Models and Data for Generators
- ✓April 23, 2025 Texas RE Spring Standards, Security, & Reliability Workshop
- ✓Texas RE 2024 Reliability Performance and Regional Risk Assessment

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