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RELIABILITY CORPORATION

Solar PV Disturbances

*What We Need to Do to Get Ready for
High Penetration Conditions*

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ESIG Webinar Series – December 2021

RELIABILITY | RESILIENCE | SECURITY





https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf

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Odessa Disturbance

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

September 2021

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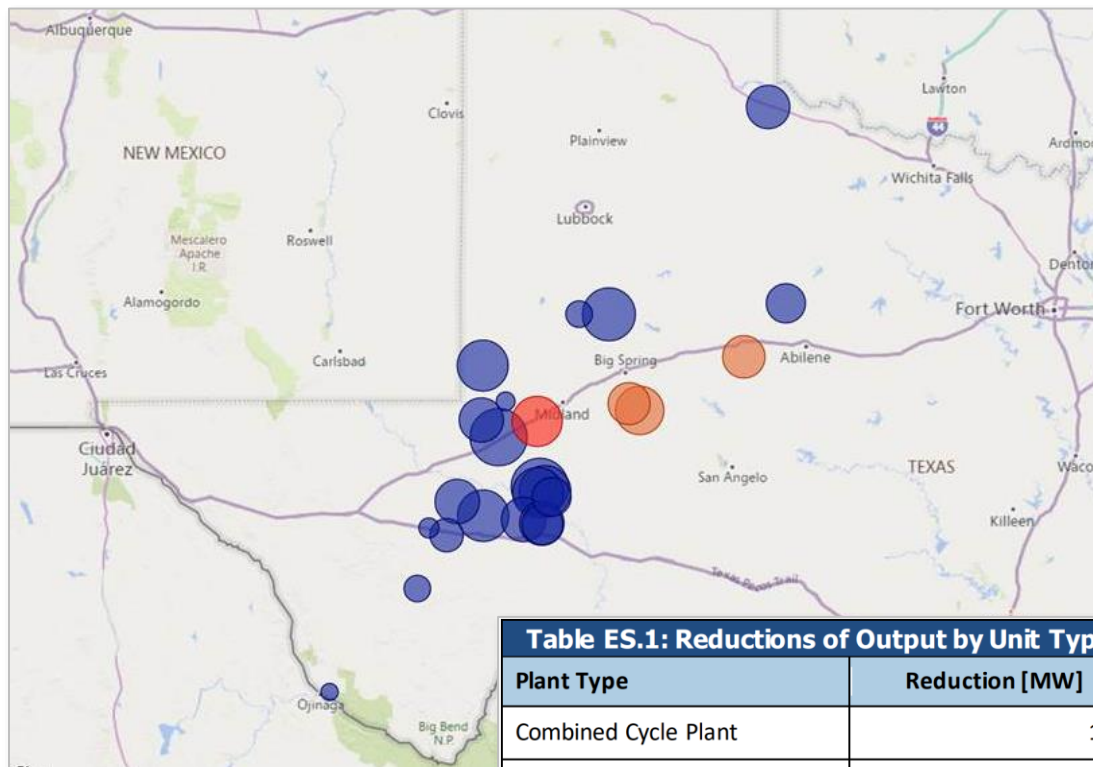


Table ES.1: Reductions of Output by Unit Type

Plant Type	Reduction [MW]
Combined Cycle Plant	192
Solar PV Plants	1,112
Wind Plants	36
Total	1,340

May 9 Solar PV Profile and Reduction

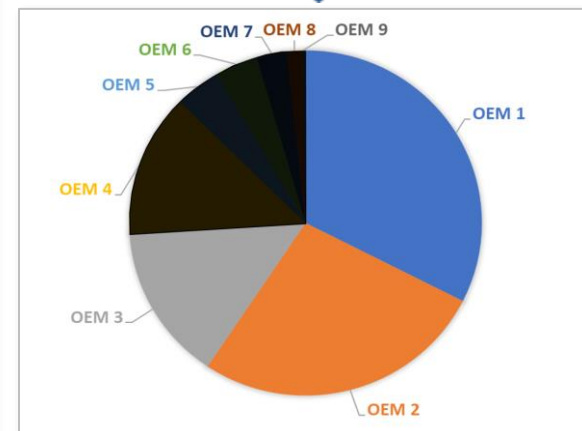
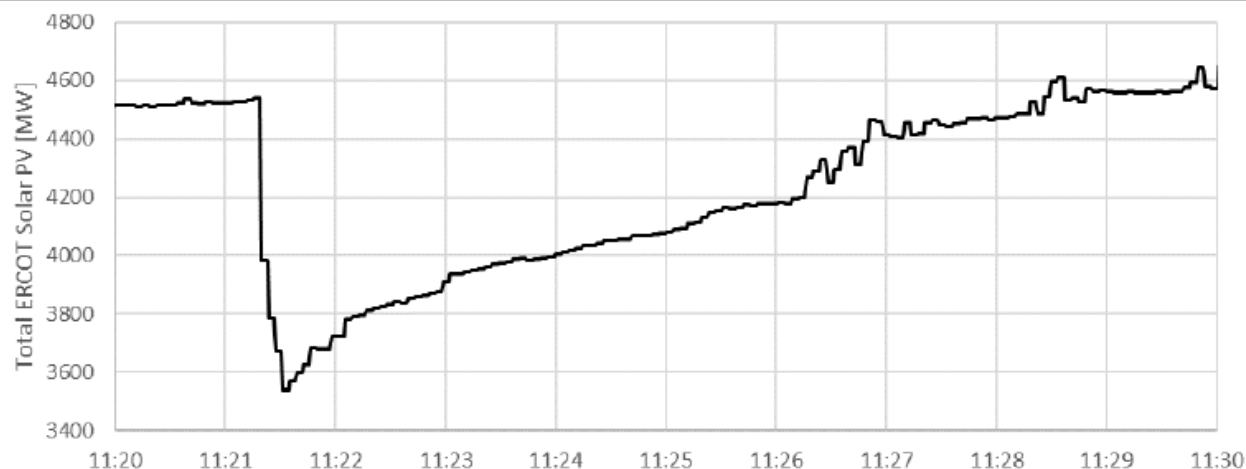
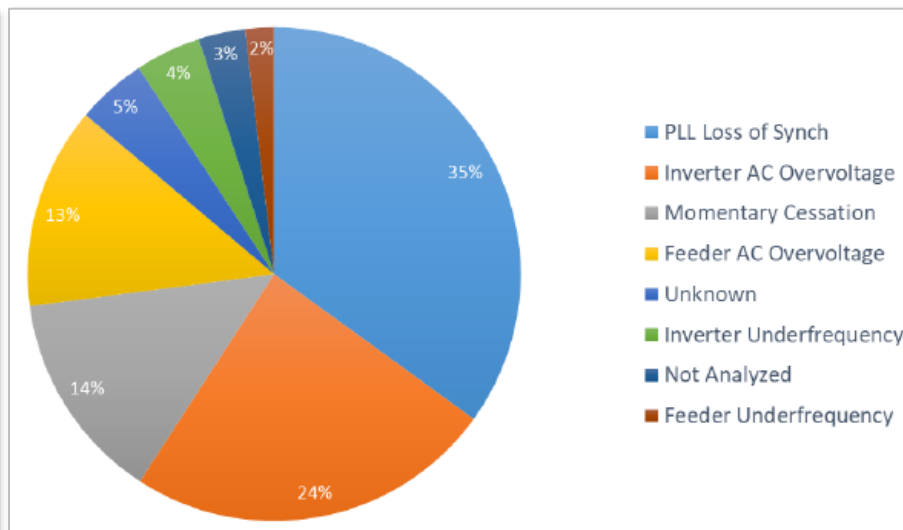
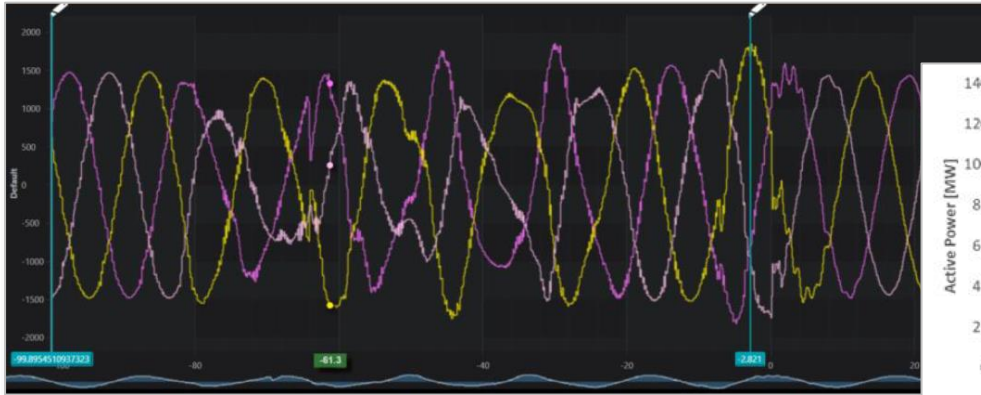


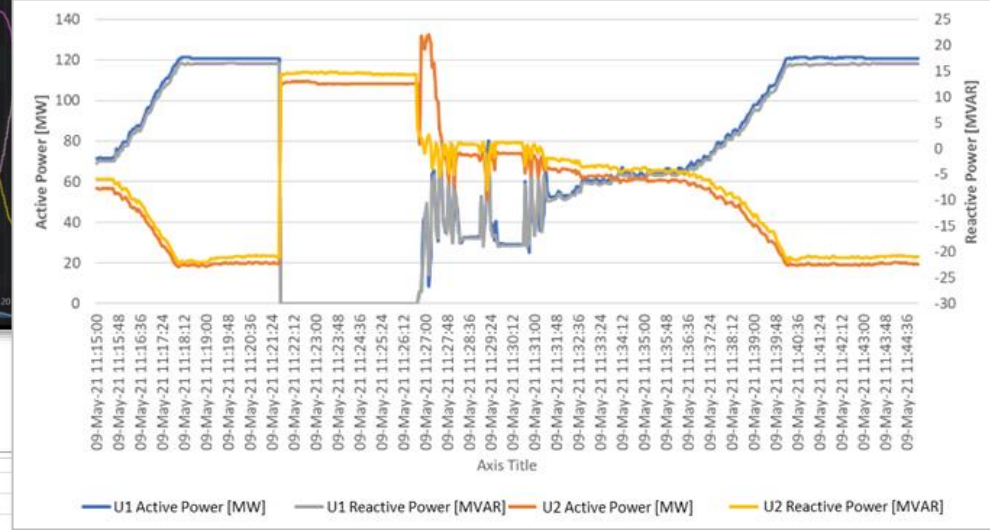
Table 1.1: Causes of Reduction	
Cause of Reduction	Reduction [MW]
PLL Loss of Synchronism	389
Inverter AC Overvoltage	269
Momentary Cessation	153
Feeder AC Overvoltage	147
Unknown	51
Inverter Underfrequency	48
Not Analyzed	34
Feeder Underfrequency	21



Sub-cycle AC overvoltage tripping



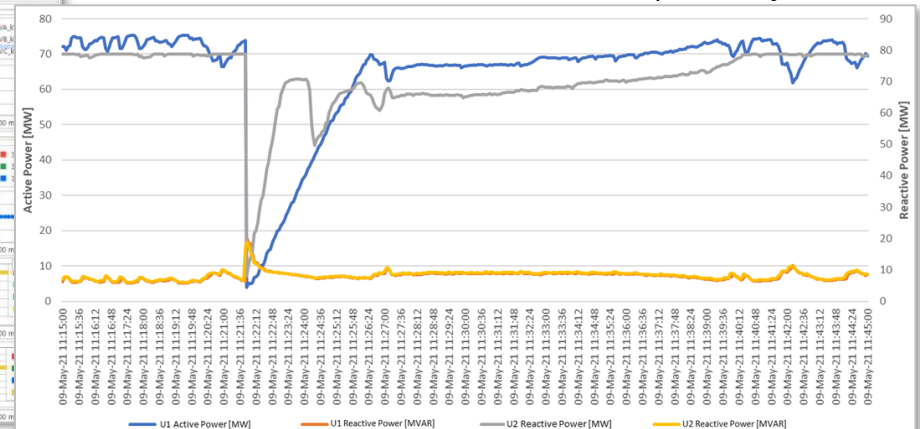
Abnormal response of plant PFR controls



Abnormal post-fault current injection leading to tripping



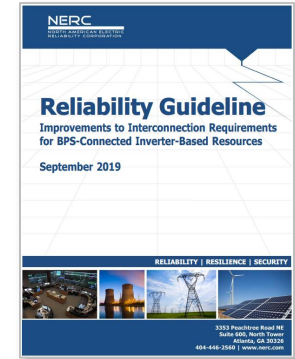
Plant controller interactions with inverter response to fault



- BPS-connected solar PV resources continue to be interconnected in an unreliable manner
 - Abnormal performance during BPS fault events has resulted in widespread tripping, disconnection, and power reduction from these resources
- The positive sequence dynamic models used to study the interconnection of these resources are inadequate to identify these causes of tripping
- The EMT models that can capture these issues are either not being provided to the TP/PC or have modeling deficiencies
- Industry not adopting the strong recommendations in NERC reliability guidelines
 - Particularly related to improvements to interconnection requirements

- ERCOT models did not represent actual behavior of facilities involved in disturbance
- Existing positive sequence models will not capture the majority of tripping observed
- EMT models and simulations needed to identify ride-through issues during interconnection process
- Existing EMT models supplied to ERCOT likely have model quality issues
- Detailed model quality review needed for both positive sequence and EMT models to ensure they reflect as-built facility protection and controls

- #1: Industry Needs to Take Action – Adopt NERC Reliability Guidelines
- #2: Need improvements to FERC Generator Interconnection Procedures and Agreements
- #3: Need significant enhancements to NERC Reliability Standards



- Magnitude of reduction highlights importance of ensuring all BPS-connected inverter-based resources are operating in a manner that ensures reliable operation of the BPS
- **Time of Event:** 7,200 MW solar PV resources in ERCOT
 - Additional 790 MW in commissioning process
- **End of August:** 8,900 MW solar PV resources in the ERCOT
 - Additional 1,000 MW in commissioning process
- **Near Future:** 25,000 MW solar PV resources with signed interconnection agreements in ERCOT generation interconnection queue between now and 2023

Focus on Modeling and Studies: The Root of All Reliability Issues

"Why was this not identified prior to interconnection?"

Table 2.1: Solar PV Tripping and Modeling Capabilities and Practices

Cause of Tripping	Can Be Accurately Modeled in Positive Sequence Simulations?	Can Be Accurately Modeled in EMT Simulations?
Erroneous frequency calculation	No	Yes
Instantaneous* ac overvoltage	No	Yes
PLL loss of synchronism	No	Yes
Phase jump tripping	Yes	Yes
DC reverse current	No	Yes
DC low voltage	No	Yes
AC overcurrent	No	Yes
Instantaneous* ac overvoltage—feeder protection	No	Yes
Measured underfrequency—feeder protection	No	No**

* Sub-cycle

** Due to very limited protective relay models in EMT today



- There remains a need for accurate positive sequence studies ... but ...
- Majority of tripping across *all* events analyzed by NERC cannot be accurately simulated in positive sequence studies today
 - Most commonly performed during interconnection process
- Significant amount of models in planning cases are incorrectly parametrized
- Strong need for EMT studies moving forward

DER Modeling in Transmission models

issues associated with probabilistic planning

TPL-001-5 Grid forming inverters

EMT simulation

Ev impacts

EV future

EMT

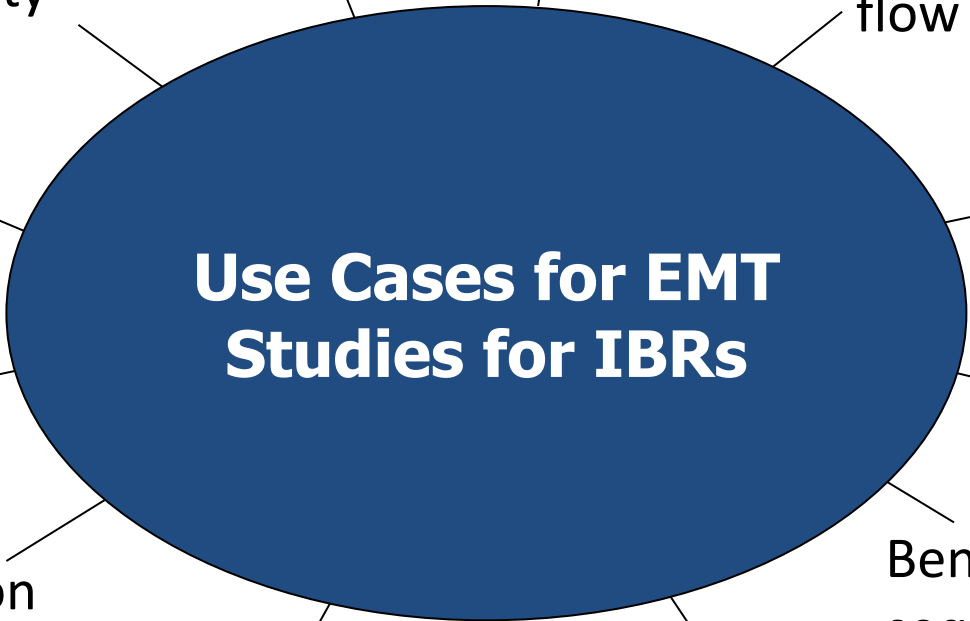
data exchange

T-D co-simulation

Short Circuit Duty

The need to perform EMT studies in the
planning of transmission system

chnages with TPL-001-5 Standardized models



Use Cases for EMT Studies for IBRs

Very high IBR penetrations
and islanded networks

Sub-synchronous
controls interactions

Unbalanced power
flow studies

High DER
penetrations

Power quality
studies

Benchmarking positive
sequence models

Controls interactions (plant-to-
plant and within the plant)

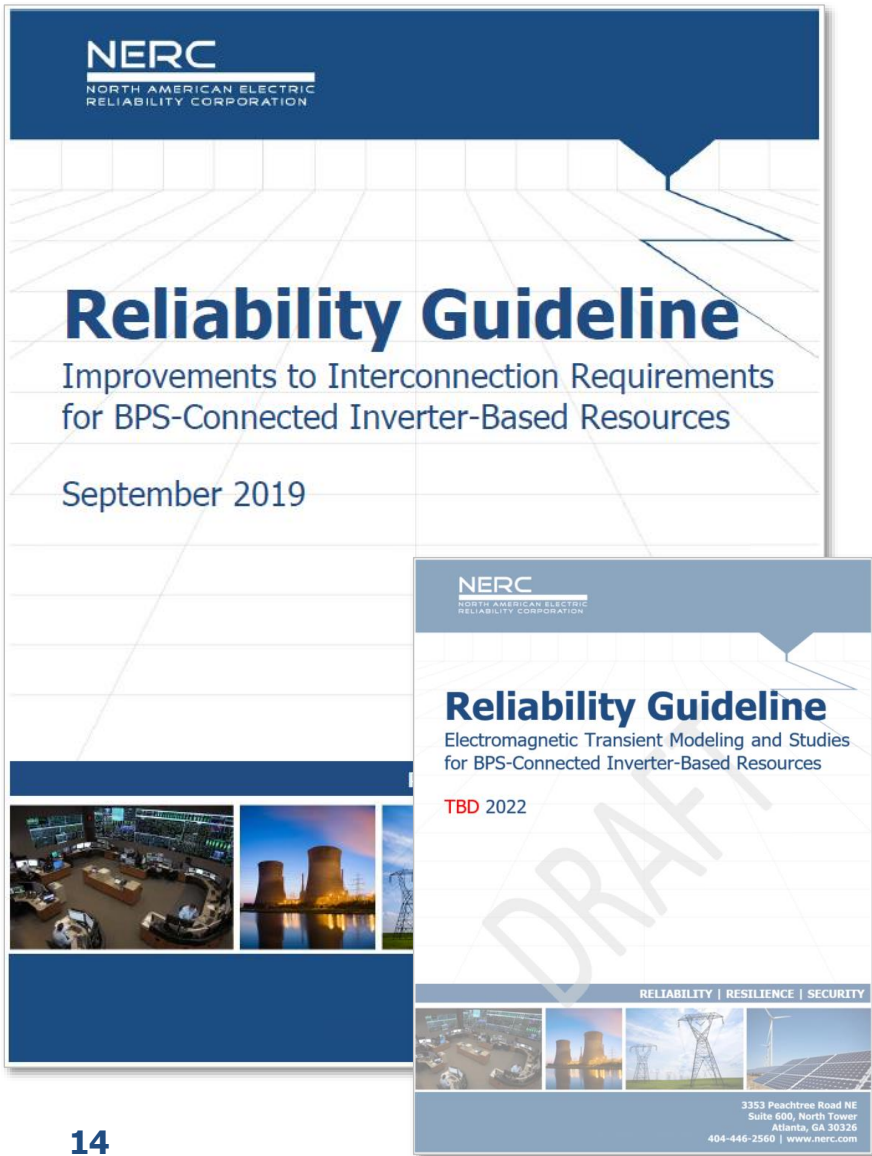
Ride-through capability and
performance analysis

Potential protection
system operation

Short-circuit
current analysis

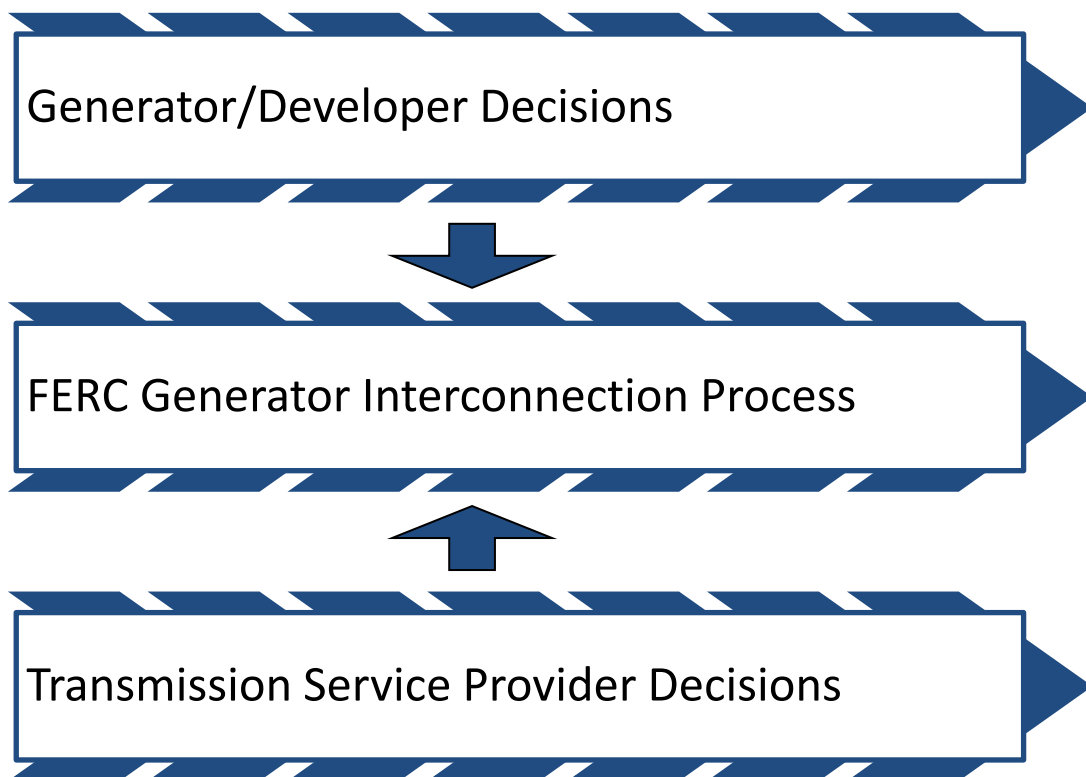
Low short circuit
strength networks

Controls instability



- Future grid conditions will demand the increased use of EMT modeling and studies
- Industry lacking in expertise, tools, processes, and experience to perform EMT studies at scale
- Innovation needed to move the needle for skillset development and tools adoption
- Step 1: Establish EMT modeling requirements
- Step 1a: Establish EMT model quality checks

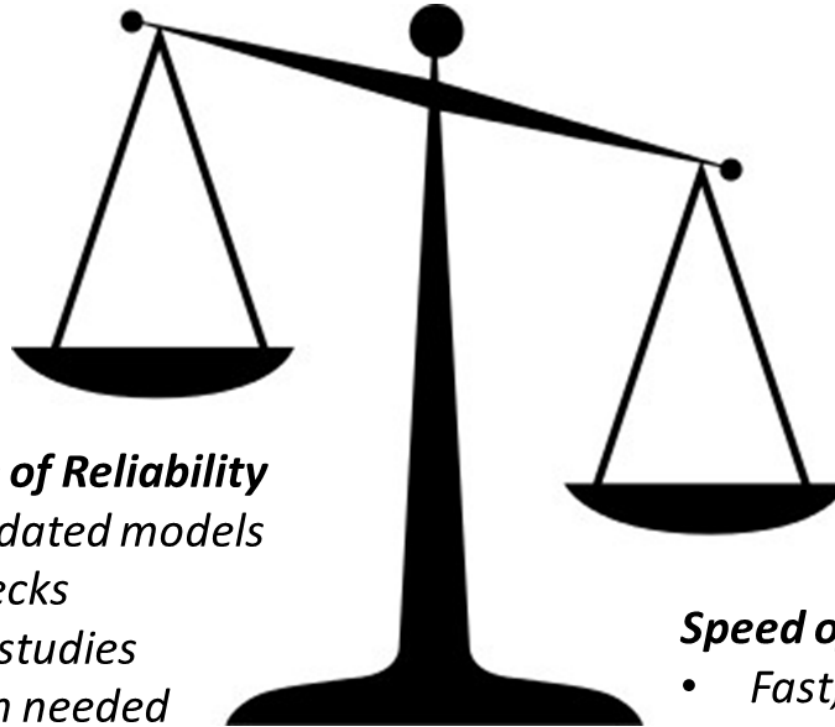
- Transmission entities taking models at face value with no analysis of model quality
 - Unintentionally incorrect models (parameterization) used and never questioned
 - Intentionally incorrect models used to get through interconnection process easily
 - EMT models using generic representations
 - Transmission entities lack resources, time, and/or expertise to analyze vast number of models for interconnection requests
- Interconnection studies not picking up reliability issues
 - Positive sequence studies mostly, will not identify ride-through problems
 - Detailed EMT studies without accurate models of protection
 - Inappropriate use of EMT models, or overestimation of model quality
 - Studies disabling protection and modifying controls without OEM involvement
- Systemic modeling errors during interconnection and in planning studies
 - Defaults models used in interconnection studies, never get updated or restudied during interconnection process
 - Generator owners making changes to equipment without seeking prior approval (models not getting updated)
- Little to no performance validation to compare expected performance (based on model) with actual performance (based on events) – this is NOT “model validation”



- Complex process
- Inconsistent modeling and study requirements
- Lack of clarity at time of request
- Changes in equipment and settings throughout process
- Short timeline to run detailed studies, if needed
- Lack of transparency and “sign-offs” on critical decisions
- Lack of mutual agreement and understanding about equipment settings/models
- Process improvements needed
 - Difficult for both generation and transmission sides

"Why was this not identified during interconnection studies?"

Under Conditions of High Penetrations of Inverter-Based Resources...



Adequate Assurance of Reliability

- *Accurate and validated models*
- *Model quality checks*
- *Detailed stability studies*
- *EMT studies when needed*

Speed of Interconnection

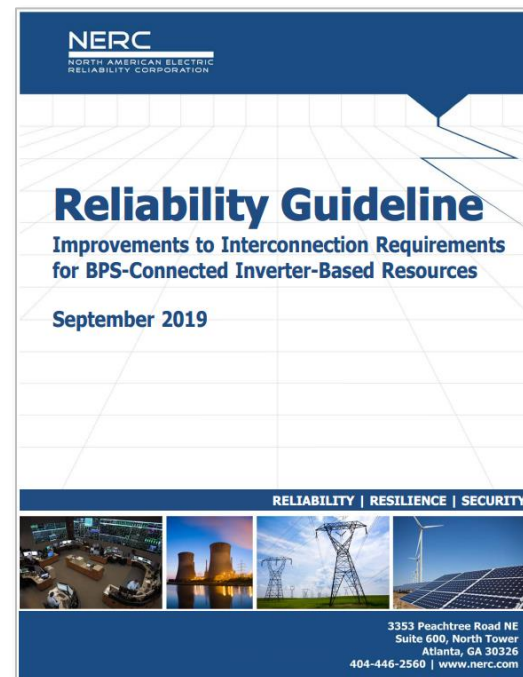
- *Fast, effective, streamlined*
- *Minimal re-work*
- *Clear modeling requirements*
- *Quick studies*

ERO Recommendations

"Why this matters to everyone...and what we can take away from this."

Recommendation:

- Comprehensively adopt the recommendations in this NERC reliability guideline
- Act (quickly) to significantly strengthen your interconnection requirements related to inverter-based resources
 - Clarity and consistency needed
 - Shore up gaps in unreliable performance
 - Then VERIFY that performance with models – transparent analysis

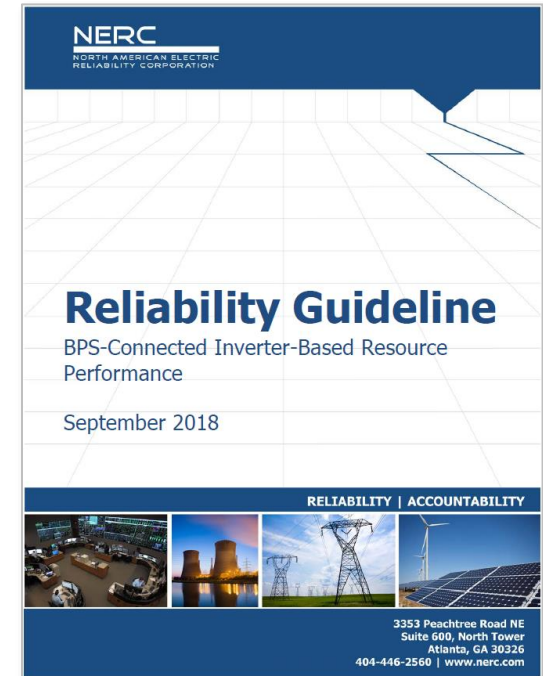


Risk Assessment Questions:

- Have you *comprehensively* adopted the reliability guideline? If not, why?
- Have performance requirements been established to mitigate the known risks described in the NERC disturbance reports (at a minimum)?
- What challenges are you facing in improving interconnection requirements?

Recommendation:

- Adopt this NERC reliability guideline – mitigate known reliability issues
- Strengthen contractual agreements with OEMs and vendors – incorporate language to address known risks
- Ask questions to transmission entities when lacking clarity
- Help ensure models represent as-built equipment
- Improve monitoring and analysis of plant performance

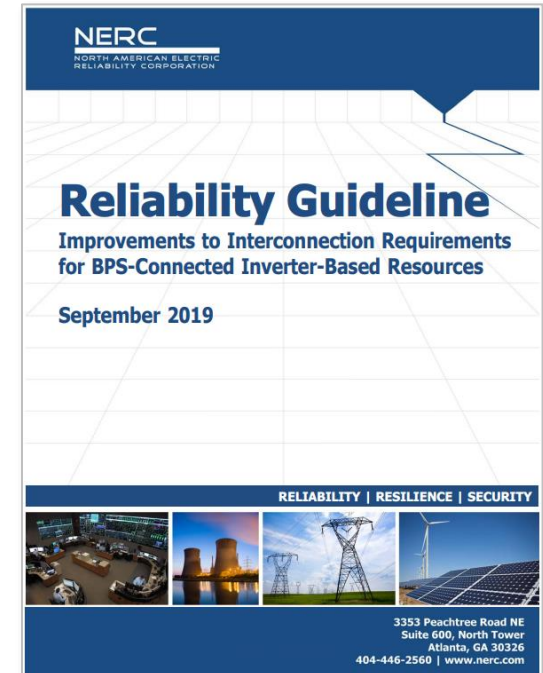


Risk Assessment Questions:

- Are you analyzing and reporting performance (tripping) during faults?
- Have you *comprehensively* adopted the guideline recommendations? Have you addressed performance issues from the reports and guidelines?
- Have you improved modeling practices to help address systemic modeling gaps?

Recommendation:

- Comprehensively adopt recommendations in this NERC reliability guideline
 - Improve modeling and data collection processes
 - Establish EMT modeling requirements
 - Establish strong ***model quality check requirements***
- Conduct model quality checks on all plant models provided
- Proactively correct deficient models
- Identify plants performing differently than models – seek corrective action



Risk Assessment Questions:

- Have you established and implemented model quality checks?
- Are you certain that the models match as-built equipment (or planned equipment)?
- Have you *comprehensively* adopted the guideline recommendations?
- Is plant performance validation being conducted after major disturbances?



Questions and Answers

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*Feel free to reach out to us if interested in
participating in the NERC IRPWG!*