NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Update

NASPI
16 April 2019

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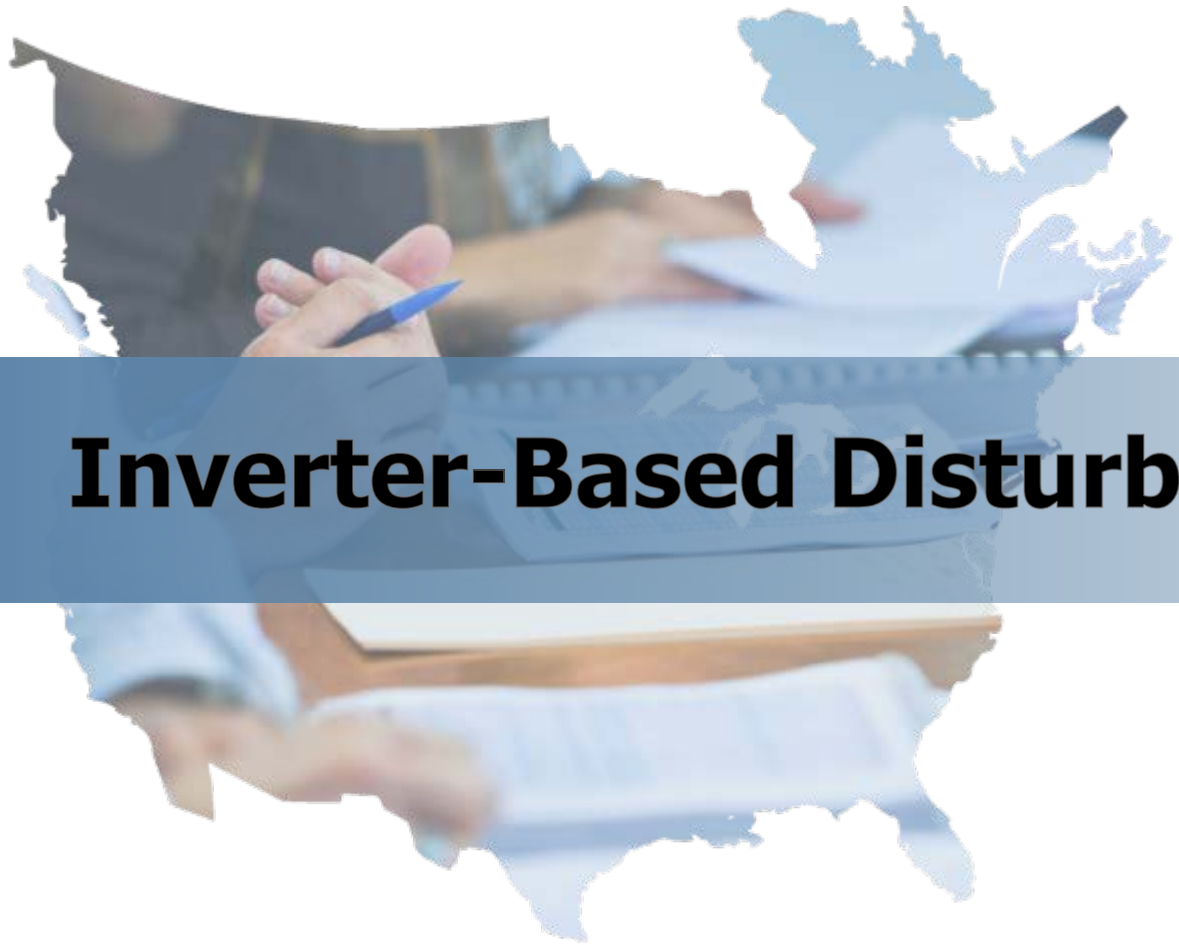

Inverter-Based Disturbances

August 16, 2016 Faults

Blue Cut fire caused

- Thirteen 500 kV line faults
- Two 287 kV line faults

11:45:06 PDT Fault

- 500 kV line-to-line fault
- Cleared normally in 2.5 cycles (41.7 milliseconds)
- PV resources impacted – 1,178 MW
  - 26 different solar developments
  - All utility scale – connected at 500kV or 230kV
  - 10 different inverter manufacturers
  - No PV site system protection relays/breakers operated
  - All action was by on-board inverter controls

Full Analyses of Four IBR-Related Events

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

Southern California 8/16/2016 Event

June 2017

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

900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

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

February 2018

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April and May 2018 Fault Induced Solar Photovoltaic Resource Interruption Disturbances Report

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

January 2019

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Industry Recommendation
Loss of Solar Resources during Transmission Disturbances due to Inverter Settings

Initial Distribution: June 20, 2017

NERC identified a potential characteristic exhibited by some inverter-based resources, particularly utility-scale solar photovoltaic (PV) generation, which reduces power output during fault conditions on the transmission system. An example of this behavior has been observed during recent BPS disturbances, highlighting potential risks to BPS reliability. With the recent and expected increases of utility-scale solar resources, the causes of this reduction in power output from utility-scale power inverters needs to be widely communicated and addressed by the industry. The industry should identify reliability preserving actions in the areas of power system planning and operations to reduce the system reliability impact in the event of widespread loss of solar-resources during faults on the power system.

For more information, see the 1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

About NERC Alerts >>

Status: Acknowledgement Required by Midnight Eastern on June 27, 2017
Reporting Required by Midnight Eastern on August 31, 2017

PUBLIC: No Restrictions
More on handling >>

Instructions: This recommendation provides specific actions NERC registered entities should consider taking to respond to a particular issue. Pursuant to Rule 810 of NERC's Rules of Procedure, NERC registered entities shall 1) acknowledge receipt of this advisory within the NERC Alert System, and 2) report to NERC on the status of their activities in relation to this recommendation as provided below. For U.S. entities, NERC will compile the responses and report the results to the Federal Energy Regulatory Commission.

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Industry Recommendation
Loss of Solar Resources during Transmission Disturbances due to Inverter Settings - II

Initial Distribution: May 1, 2018

NERC has identified adverse characteristics of inverter-based resource performance during grid faults that could present potential risks to reliability of the BPS. As the penetration of inverter-based resources (particularly solar PV resources) continues to increase in North America, these adverse characteristics need to be widely communicated. This Level 2 Industry Recommendation alerts industry to these adverse characteristics observed with BPS-connected solar PV resources, and provides recommended actions to address fault ride-through and timely restoration of current injection by all inverter-based resources connected to the BPS.
(See Background section for more information.)

Although this NERC Alert pertains specifically to BES solar PV resources, the same characteristics may exist for non-BES[1] solar PV resources connected to the BPS regardless of installed generating capacity or interconnection voltage. Owners and operators of those facilities are encouraged to consult their inverter manufacturers, review inverter settings, and implement the recommendations described herein. While this NERC alert focuses on solar PV, we encourage similar activities for other inverter-based resources such as, but not limited to, battery energy storage and wind resources.

For more information, see the October 9, 2017 Canyon 2 Fire Disturbance Report

About NERC Alerts >>

Status: Acknowledgement Required[2] by Midnight Eastern on May 8, 2018
Reporting Required by Midnight Eastern on July 31, 2018

PUBLIC: No Restrictions
More on handling >>

[1] These resources do not meet the Bulk Electric System definition, and are generally less than 75 MVA yet connected to transmission-level voltage.
[2] To the extent that Canadian jurisdictions have implemented laws or requirements that vary from Section 810 of the ROP, NERC requests entities in such jurisdictions voluntarily participate in response to this Alert.

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Blue Cut and Canyon 2 Disturbances

Blue Cut Fire Disturbance – August 16, 2016

- Line-to-Line 500 kV fault normally cleared in 2.5 cycles
- 1,200 MW loss back-calculated to ~2,500 MW from interconnection inertia
- Published disturbance report in June 2017

- Key Findings:
  - Use of momentary cessation
  - Frequency-related tripping

Canyon 2 Fire Disturbance – October 9, 2017

- Normally cleared 220 kV phase-to-phase fault followed by a normally cleared 500 kV phase-to-phase fault
- 900 MW loss back-calculated to ~1,500 MW from interconnection inertia
- Published disturbance report in February 2018

- Key Findings:
  - No frequency-related tripping but continued use of momentary cessation
  - Transient overvoltage-related tripping

Angeles Forest and Palmdale Roost Disturbances

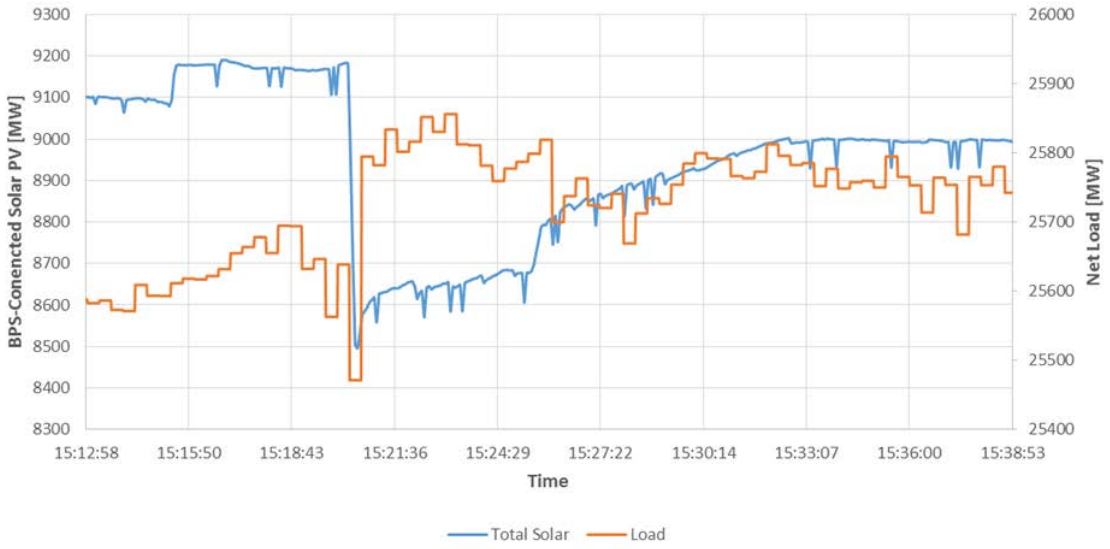
Angeles Forest Disturbance – 10 April 2018

- 500 kV "bolted" line-to-line fault – cleared in 2.6 cycles
  - Line is mixed 500 kV underground/overhead
- Lopsided RLC line parameters – unbalanced line shunt reactors used to compensate.
- Involved ~1,100 MW of BPS-connected PV
- 200 MW gas turbine loss/associated steam reduction
- Evidence of jump in CAISO Net Load – DER loss

Palmdale Roost Disturbance – 11 May 2018

- Fault on short 500 kV line – cleared in 3.6 cycles
- Involved ~900 MW of BPS-connected PV

CAISO BPS-Connected Solar and Net Load



When PMUs are just not fast enough

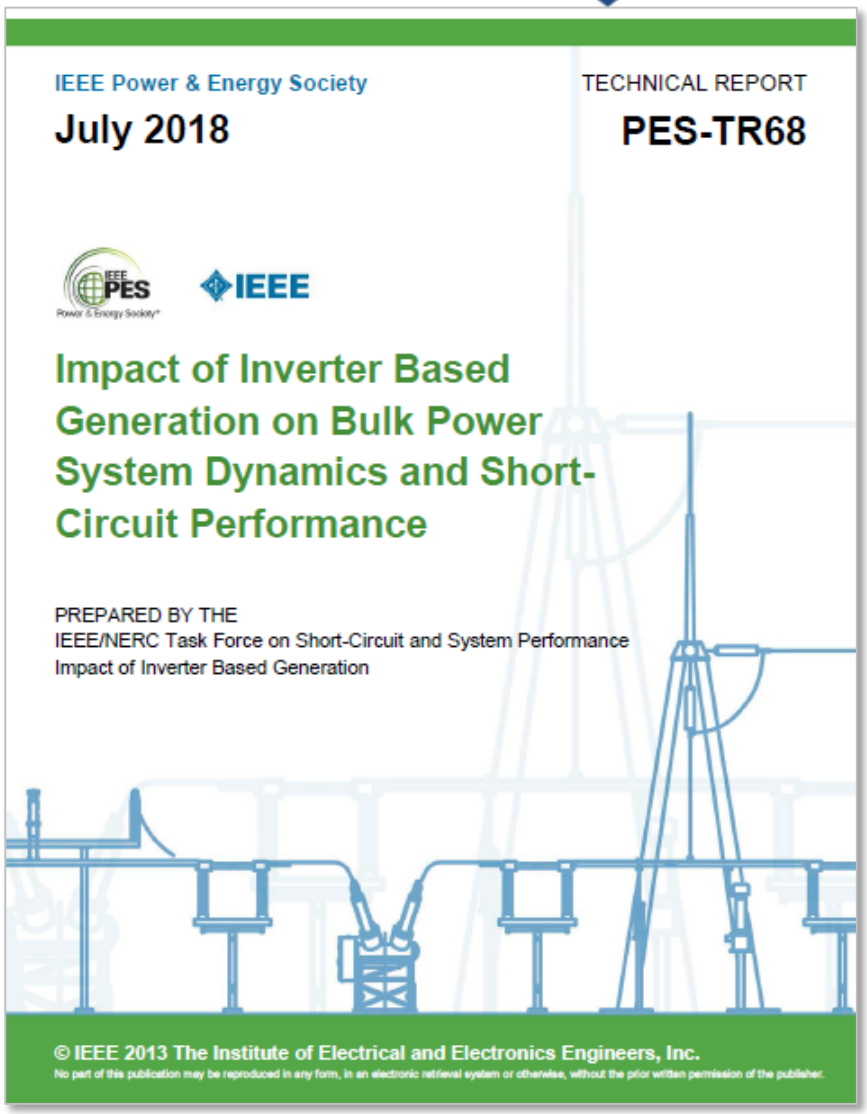
What we quickly learned from inverter-based event analysis:

- SCADA data with samples every 4 seconds are virtually useless
- Momentary cessation on inverters and return can occur in 10-20 milliseconds – many have time delays on return that can be seen by SCADA
  - Back-calculation of actual momentary loss from known system inertia is much larger than SCADA can see, but leaves a much higher rate-of-change-of-frequency (RoCoF) – makes event detection easier
  - Blue Cut fire SCADA value = 1,178 MW Back-calculated = ~2,500 MW
- PMUs at 30 samples per second deliver data at ~33 milliseconds
- PMUs will still miss most if not all of the momentary cessation impact
- Point-on-Wave data is needed

Joint NERC-IEEE Paper on Impacts

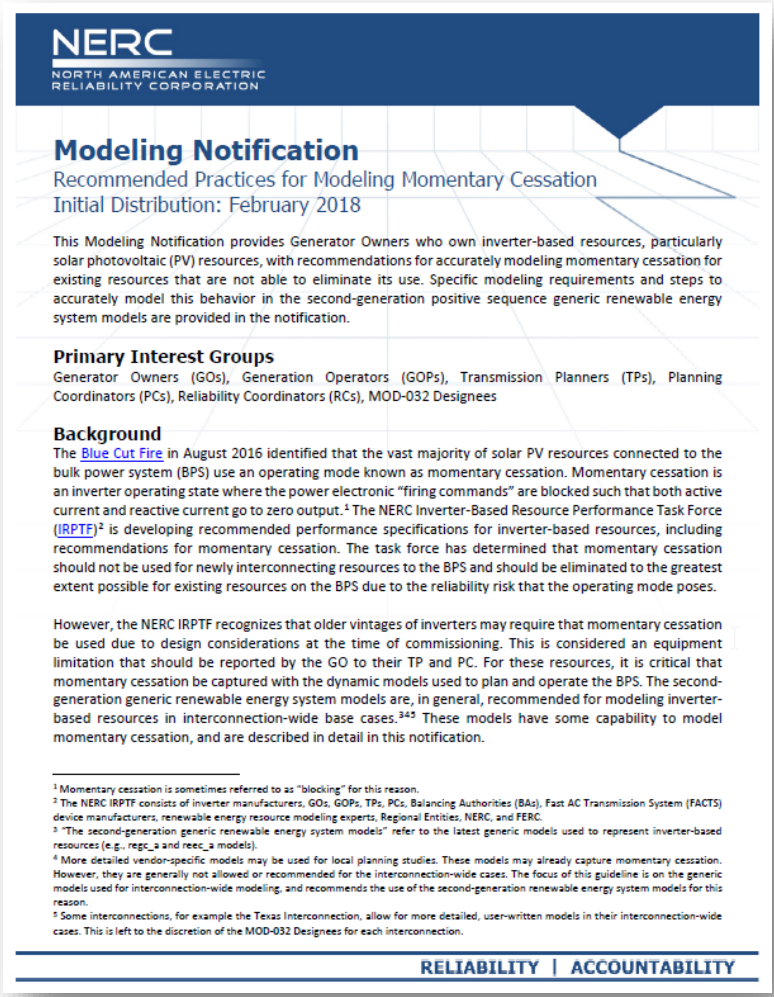
- How do we deal with lower short circuit current?
- What are the dynamics issues?

- Several Working Groups and Task Teams of IEEE PSRC are working on the System Protection issues
- Other IEEE Committees are



Modeling Notification: Momentary Cessation

- Existing models largely DO NOT accurately represent installed resource performance
  - Identified issue that must be addressed for models in planning and operations studies
  - Developed notification to help industry in modeling efforts
  - Guidance provided as part of second NERC Alert



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Modeling Notification
Recommended Practices for Modeling Momentary Cessation
Initial Distribution: February 2018

This Modeling Notification provides Generator Owners who own inverter-based resources, particularly solar photovoltaic (PV) resources, with recommendations for accurately modeling momentary cessation for existing resources that are not able to eliminate its use. Specific modeling requirements and steps to accurately model this behavior in the second-generation positive sequence generic renewable energy system models are provided in the notification.

Primary Interest Groups
Generator Owners (GOs), Generation Operators (GOPs), Transmission Planners (TPs), Planning Coordinators (PCs), Reliability Coordinators (RCs), MOD-032 Designees

Background
The Blue Cut Fire in August 2016 identified that the vast majority of solar PV resources connected to the bulk power system (BPS) use an operating mode known as momentary cessation. Momentary cessation is an inverter operating state where the power electronic "firing commands" are blocked such that both active current and reactive current go to zero output.[1] The NERC Inverter-Based Resource Performance Task Force (IRPTF)[2] is developing recommended performance specifications for inverter-based resources, including recommendations for momentary cessation. The task force has determined that momentary cessation should not be used for newly interconnecting resources to the BPS and should be eliminated to the greatest extent possible for existing resources on the BPS due to the reliability risk that the operating mode poses.

However, the NERC IRPTF recognizes that older vintages of inverters may require that momentary cessation be used due to design considerations at the time of commissioning. This is considered an equipment limitation that should be reported by the GO to their TP and PC. For these resources, it is critical that momentary cessation be captured with the dynamic models used to plan and operate the BPS. The second-generation generic renewable energy system models are, in general, recommended for modeling inverter-based resources in interconnection-wide base cases.[3][4][5] These models have some capability to model momentary cessation, and are described in detail in this notification.

[1] Momentary cessation is sometimes referred to as "blocking" for this reason.
[2] The NERC IRPTF consists of inverter manufacturers, GOs, GOPs, TPs, PCs, Balancing Authorities (BAs), Fast AC Transmission System (FACTS) device manufacturers, renewable energy resource modeling experts, Regional Entities, NERC, and FERC.
[3] "The second-generation generic renewable energy system models" refer to the latest generic models used to represent inverter-based resources (e.g., regc_a and reec_a models).
[4] More detailed vendor-specific models may be used for local planning studies. These models may already capture momentary cessation. However, they are generally not allowed or recommended for the interconnection-wide cases. The focus of this guideline is on the generic models used for interconnection-wide modeling, and recommends the use of the second-generation renewable energy system models for this reason.
[5] Some interconnections, for example the Texas Interconnection, allow for more detailed, user-written models in their interconnection-wide cases. This is left to the discretion of the MOD-032 Designees for each interconnection.

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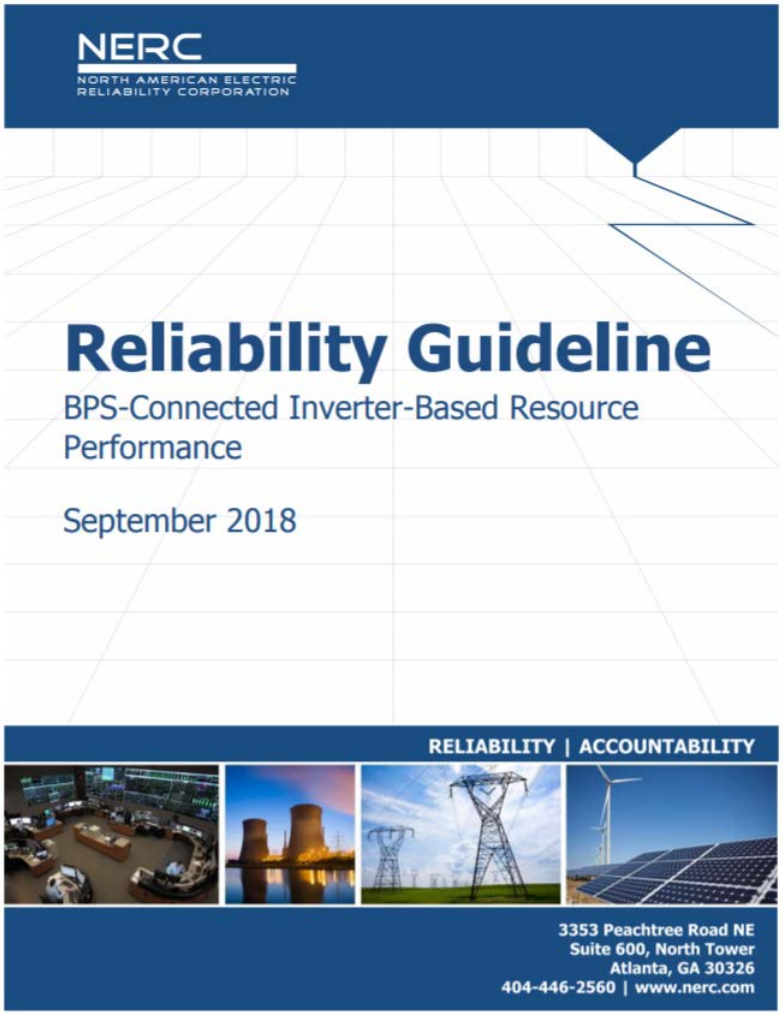
Inverter-Based Resource Reliability Guideline

- BPS-connected inverter-based resource performance
- Guideline based on findings and recommendations of NERC disturbance reports
- Intended as cornerstone document for industry moving forward
- Approved by NERC Operating Committee

  https://www.nerc.com/comm/Pages/Reliability-and-Security-Guidelines.aspx
- Basis for IEEE P2800 Inverter-Based Resources – Connected above Distribution



NERC's Multi-Pronged Approach

- Disturbance analyses and reports
  - Blue Cut Fire, Canyon 2 Fire, Angeles Forest/Palmdale Disturbances
- Level 2 NERC Alerts
  - Identifying extent of condition, and recommending mitigating actions
- Modeling and simulations – Impacts of BPS-connected IBRs
- Outreach to BPS-connected non-BES resources (e.g., < 75 MVA)
- IRPTF Reliability Guideline – for BPS Connected IBR
- NERC System Planning Impacts of Distributed Energy Resources (DER) Working Group (SPIDERWG)
- Clarifications to NERC Standard PRC-024 – Generator Frequency and Voltage Protective Relay Settings
- Industry education – webinars and workshops

NERC's Multi-Pronged Approach

- IEEE 1547-2018 Standard applies to inverters connected to distribution systems
- IEEE P2800 Inerter Based Resource Performance Standard – for inverters connected above distribution voltage (including transmission voltages)
- IEEE DER Managements System Guideline (P2030.11)
- Regulator education workshops – IEEE Standards are not enforceable unless:
  - Adopted by regulators
  - Included in interconnection agreements (SGIA and LGIA)
- New Interconnection Agreement White Paper being prepared
- Potential modifications needed to NERC Standard PRC-002 – Disturbance Monitoring and Reporting Requirements

Questions