

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

BPS-Connected Inverter-Based Resource Modeling

ESIG Webinar: Session 10

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April 2020

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

Southern California 8/16/2016 Event

June 2017

900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

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

February 2018

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 cause 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: Acknowledgment Received by Midnight Eastern on June 27, 2017
Reportable Required by Midnight Eastern on August 31, 2017

FORUC: 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 30 of NERC's Rules of Procedure, NERC registered entities shall (1) acknowledge receipt of this advisory action by 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 injections by all inverter-based resources connected to the BPS.
(See Background section for more information.)

Although this NERC alert pertains specifically to RES solar PV resources, the same characteristics may exist for non-RES solar PV resources connected to the BPS regardless of installed generating capacity or interconnection voltage. Owners and operators of these 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: Acknowledgment Received by Midnight Eastern on May 8, 2018
Reportable Required by Midnight Eastern on July 31, 2018

FORUC: No Restrictions
[More on handling](#)

* These resources do not meet the Bulk Electric System definition, and are generally less than 75 MW and not connected to transmission level voltage.
** To the extent that Canadian jurisdictions have implemented laws or requirements that vary from Section 3(3) of the ROP, NERC requests entities in such jurisdictions voluntarily participate in response to this alert.

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Reliability Guideline

BPS-Connected Inverter-Based Resource
Performance

September 2018

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Reliability Guideline

Improvements to Interconnection Requirements
for BPS-Connected Inverter-Based Resources

September 2019

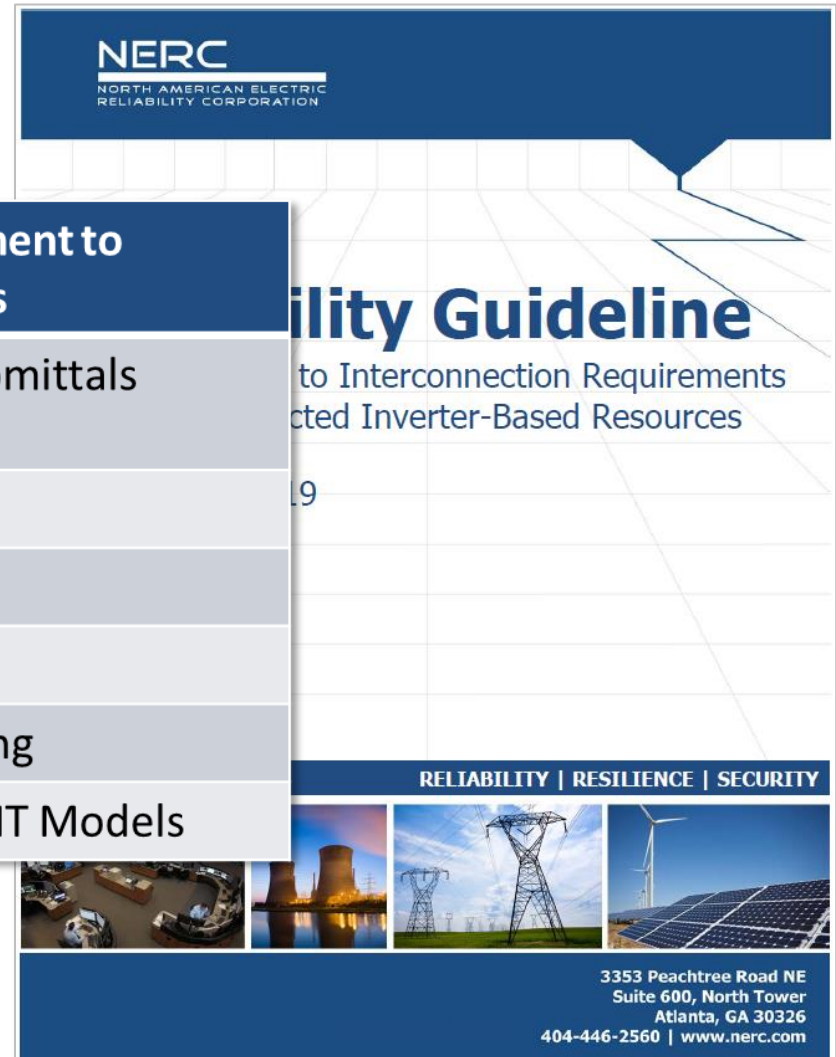
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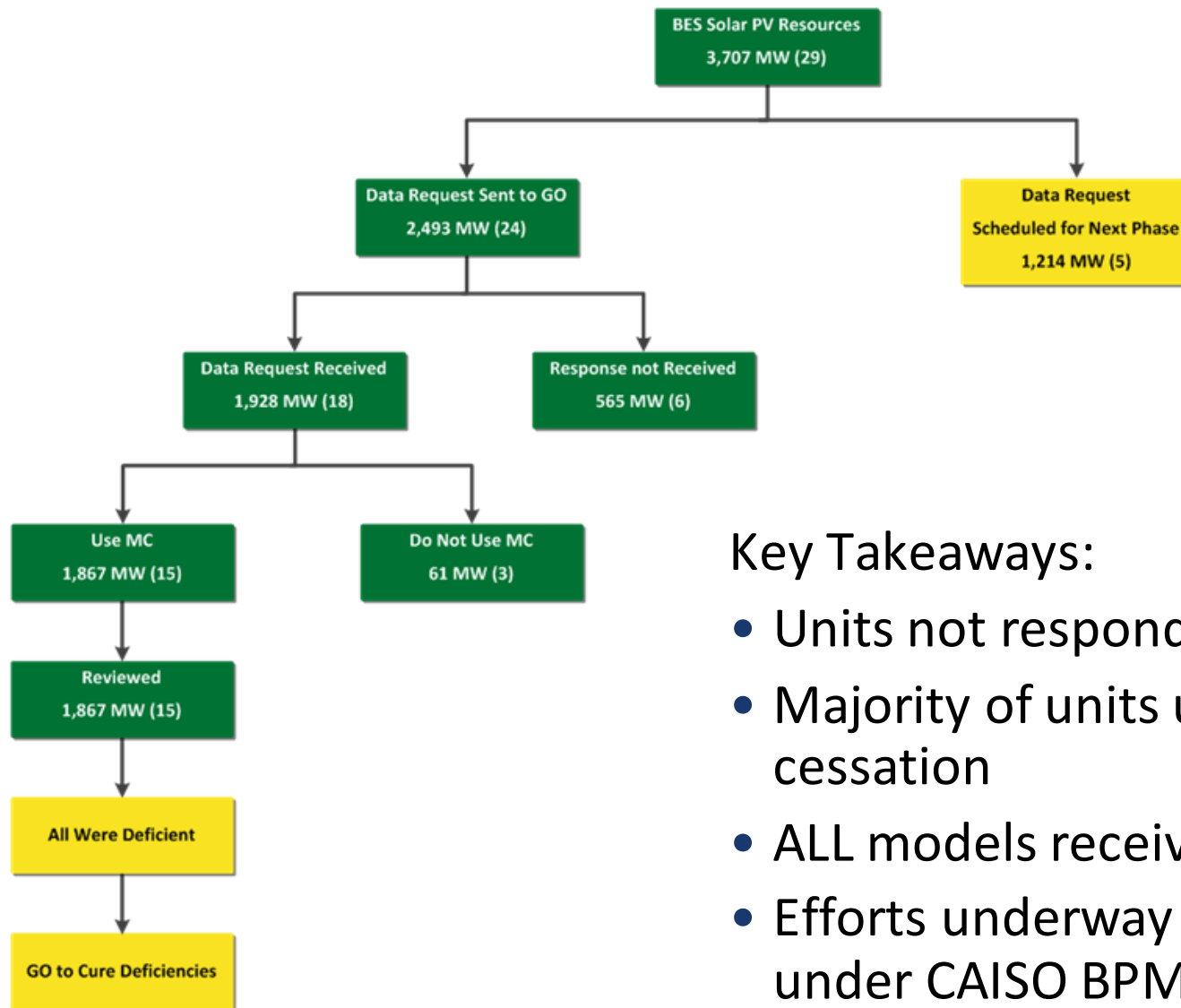
**Table 1.2: Recommended Improvement to
Interconnection Requirements**

- Timing and Quality of Modeling Data Submittals during Interconnection Process
- Steady-State Modeling
- Positive Sequence Dynamics Modeling
- Short-Circuit Modeling
- Electromagnetic Transient (EMT) Modeling
- Benchmarking Positive Sequence and EMT Models



- Topics:
 - Findings from NERC Alerts
 - Industry efforts updating dynamic models
 - WECC Solar Modeling Advisory Group
 - Challenges with MOD-026/-027
 - Growing need for EMT modeling
 - Needed improvements to interconnection process studies
 - IRPTF stability studies
- Currently undergoing approvals by NERC PC/OC (RSTC)





Key Takeaways:

- Units not responding
- Majority of units using momentary cessation
- ALL models received were DEFICIENT
- Efforts underway to updated models under CAISO BPM processes

- TPs and PCs reported...
 - Lack of inverter data prior to NERC Alert process (“trust the model”)
 - No means of verifying if dynamic model matches reality
 - Minimal updates provided by GOs through NERC Alert
 - Widespread model quality issues – models don’t match NERC Alert data
 - No/minimal “proposed” models of possible performance improvements
 - Minimal outreach to GOs to get better models
 - Some TPs/PCs stated outreach met with unwillingness from GO or no response
 - Some being very diligent (CAISO) but with long timelines (i.e., years)
 - Utilizing market rules or other requirements, not GIAs or NERC Standards
 - Minimal use of MOD-032-1 Requirement R3
 - Signed off on models provided – but with notable errors
 - For example, mismatch between model and NERC Alert data
 - Reliance on MOD-026/-027 to “verify” models

Standard MOD-026-1 — Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions

A. Introduction

- Title:** Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions
- Number:** MOD-026-1
- Purpose:** To verify that the generator excitation control system or plant volt/var control function model (including the power system stabilizer model and the impedance compensator model) and the model parameters used in dynamic simulations accurately represent the generator excitation control system or plant volt/var control function behavior when assessing Bulk Electric System (BES) reliability.

4. Applicability:

- Functional Entities:**
 - Generator Owner
 - Transmission Planner
- Facilities:**

For the
connected
"applicable"

Standard MOD-027-1 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions

A. Introduction

- Title:** Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
- Number:** MOD-027-1
- Purpose:** To verify that the turbine/governor and load control or active power/frequency control model and the model parameters, used in dynamic simulations that assess Bulk Electric System (BES) reliability, accurately represent generator unit real power response to system frequency variations.

4. Applicability:

- Functional entities:**
 - Generator Owner
 - Transmission Planner
- Facilities:**

For the purpose of the requirements contained herein, facilities that are directly connected to the Bulk Electric System (BES) will be collectively referred to as an "applicable unit" that meet the following:

- 4.2.1 Generation in the Eastern or Quebec Interconnections with the following characteristics:**
 - 4.2.1.1 Individual generating unit greater than 100 MVA (gross nameplate rating).**
 - 4.2.1.2 Individual generating plant consisting of multiple generating units that are directly connected to a common BES bus with total generation greater than 100 MVA (gross aggregate nameplate rating).**
- 4.2.2 Generation in the Western Interconnection with the following characteristics:**
 - 4.2.2.1 Individual generating unit greater than 75 MVA (gross nameplate rating).**
 - 4.2.2.2 Individual generating plant consisting of multiple generating units that are directly connected to a common BES bus with total generation greater than 75 MVA (gross aggregate nameplate rating).**
- 4.2.3 Generation in the ERCOT Interconnection with the following characteristics:**

¹ Turbine/governor and load control or active power/frequency control.

- Turbine/governor and load control applies to conventional synchronous generation.
- Active power/frequency control applies to inverter connected generation (often found at variable energy plants).



17.2 REGCAU1

Renewable Energy Generator/Converter Model

This model is located at system bus # _____ IBUS.
Machine identifier # _____ ID.
This model uses CONs starting with # _____ J.
and STATES starting with # _____ K.
and VARs starting with # _____ L.
and ICONs starting with # _____ M.

CONs	#	Value	Description
J			
J+1			
J+2			
J+3			
J+4			
J+5			
J+6			
J+7			
J+8			
J+9			

18.2 REECAU1

Generic Renewable Electrical Control Model

This model is located at system bus # _____ IBUS.
Machine identifier # _____ ID.
This model uses CONs starting with # _____ J.
and STATES starting with # _____ K.
and VARs starting with # _____ L.
and ICONs starting with # _____ M.

CONs	#	Value
J		
J+1		
J+2		
J+3		
J+4		
J+5		
J+6		
J+7		
J+8		
J+9		
J+10		

22.1 REPCAUI & REPCTAU1

Generic Renewable Plant Control Model

This model is located at system bus # _____ IBUS.
Machine identifier # _____ ID.
This model uses CONs starting with # _____ J.
and STATES starting with # _____ K.
and VARs starting with # _____ L.
and ICONs starting with # _____ M.

CONs	#	Value	Description
J			Tftr, Voltage or reactive power measurement filter time constant (s)
J+1			Kp, Reactive power PI control proportional gain (pu)
J+2			Ki, Reactive power PI control integral gain (pu)
J+3			Tft, Lead time constant (s)
J+4			Tfv, Lag time constant (s)
J+5			Vftr, Voltage below which State s2 is frozen (pu)
J+6			Rc, Line drop compensation resistance (pu)
J+7			Xc, Line drop compensation reactance (pu)
J+8			Kc, Reactive current compensation gain (pu)
J+9			emax, upper limit on deadband output (pu)
J+10			emin, lower limit on deadband output (pu)
J+11			dbd1, lower threshold for reactive power control deadband (<=0)
J+12			dbd2, upper threshold for reactive power control deadband (>=0)
J+13			Gmax, Upper limit on output of V/Q control (pu)
J+14			Gmin, Lower limit on output of V/Q control (pu)

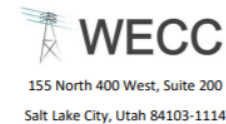
Source: PTI

- IRPTF and industry discussions seeking root cause analysis – interconnection study process and models
 - “Inaccurate models up front = inaccurate models throughout”
- LGIP Interconnection Request
 - Appendix 1
 - Section 6.1: Interconnection Customer must provide “technical data called for in Appendix 1, Attachment A.”
 - LGIP, Attachment A to Appendix 1:
 - Defines the technical data required for an Interconnection Request.
 - Synchronous: fairly comprehensive, provides reasonable amount of information to inform and verify dynamic models provided.
 - Wind: information unrelated to modeling
 - Solar: blank
 - Battery: blank

- REEC_B deemed unacceptable –
 - Cannot represent momentary cessation
 - Missing voltage-dependent current logic and other large disturbance functionality
- In WECC base case for solar PV...
 - REEC_B = 218
 - REEC_A = 56
- Work to do to get models updated
- Who has the responsibility to update these models?

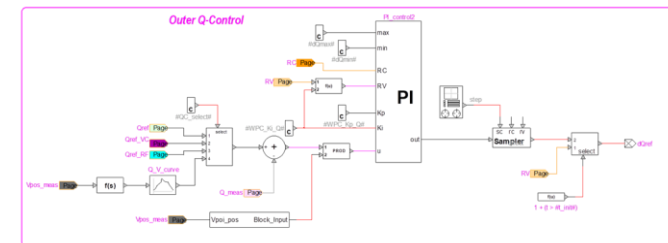
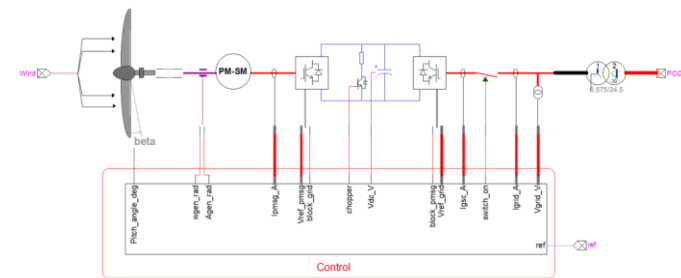
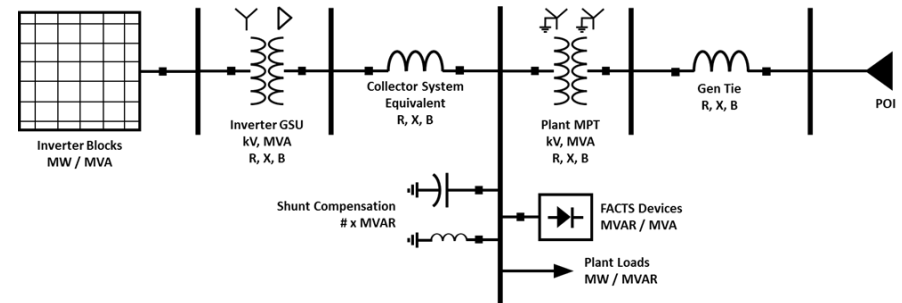
WECC White Paper on Converting REEC_B to REEC_A for Solar PV Generators

WECC REMTF
June 13, 2019



Developed as WECC-xxxx

- Increasing levels of IBRs
- More detailed studies =
More detailed models
 - Interconnection process
- New challenges
 - Low short circuit strength
 - Controller interactions
 - Controls stability
 - “Grid forming” (?)
- Need for advancement
 - Lack of industry expertise
 - Lack of wide-area study capability



- Dispatch assumptions
 - BPS-connected inverter-based generation
 - Distributed energy resources
 - Area interchanges
 - Synchronous generation assumptions
 - Contingency reserves, frequency responsive reserves, synchronous inertia
- Energy storage
 - BPS-connected energy storage dispatch assumptions
 - Distributed energy storage reflected in net loading conditions
- Drastically more variable system;
- Increasingly complex planning assumptions

- Reliability Guidelines ([here](#))
- NERC Inverter-Based Resource Performance Task Force ([here](#))
- NERC Power Plant Modeling and Verification Task Force ([here](#))
- Guideline: Recommended Performance for BPS-Connected IBR ([here](#))
- Guideline: Improvements to Interconnection Requirements ([here](#))
- Blue Cut Fire Disturbance Report ([here](#))
- Canyon 2 Fire Disturbance Report ([here](#))
- Palmdale Roost and Angeles Forest Disturbance Report ([here](#))
- NERC Alert: Loss of Solar Resources I ([here](#))
- NERC Alert: Loss of Solar Resources II ([here](#))
- Summary of ERO Activities for IBR ([here](#))
- IEEE P2800 ([here](#))



Questions and Answers

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