NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

BPS-Connected Inverter-Based Resource Modeling

ESIG Webinar: Session 10

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RELIABILITY | RESILIENCE | SECURITY




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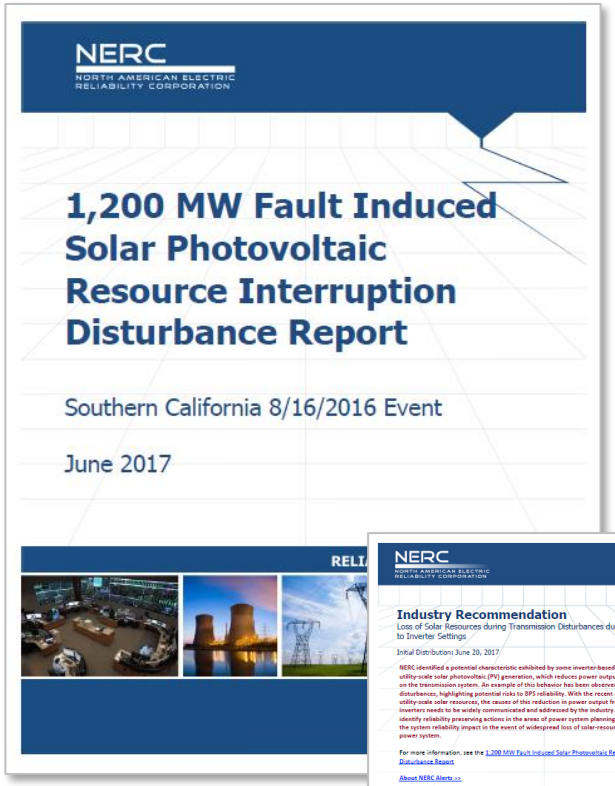
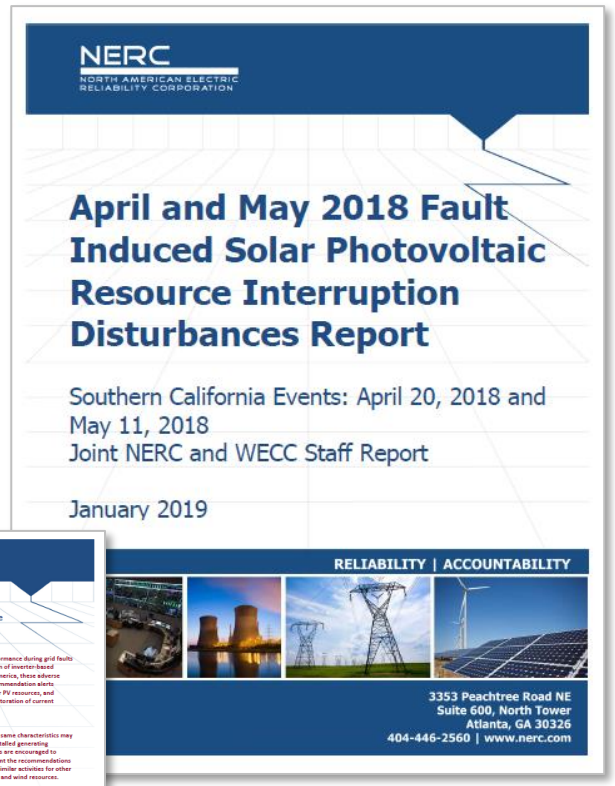
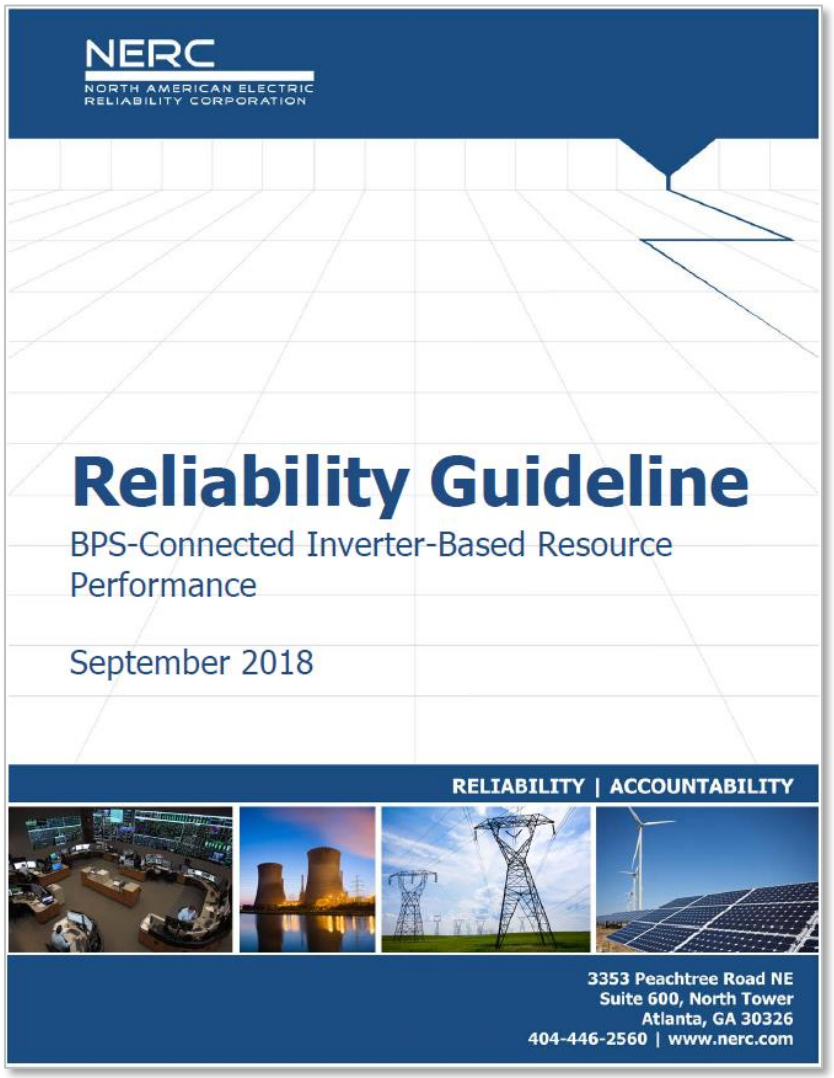
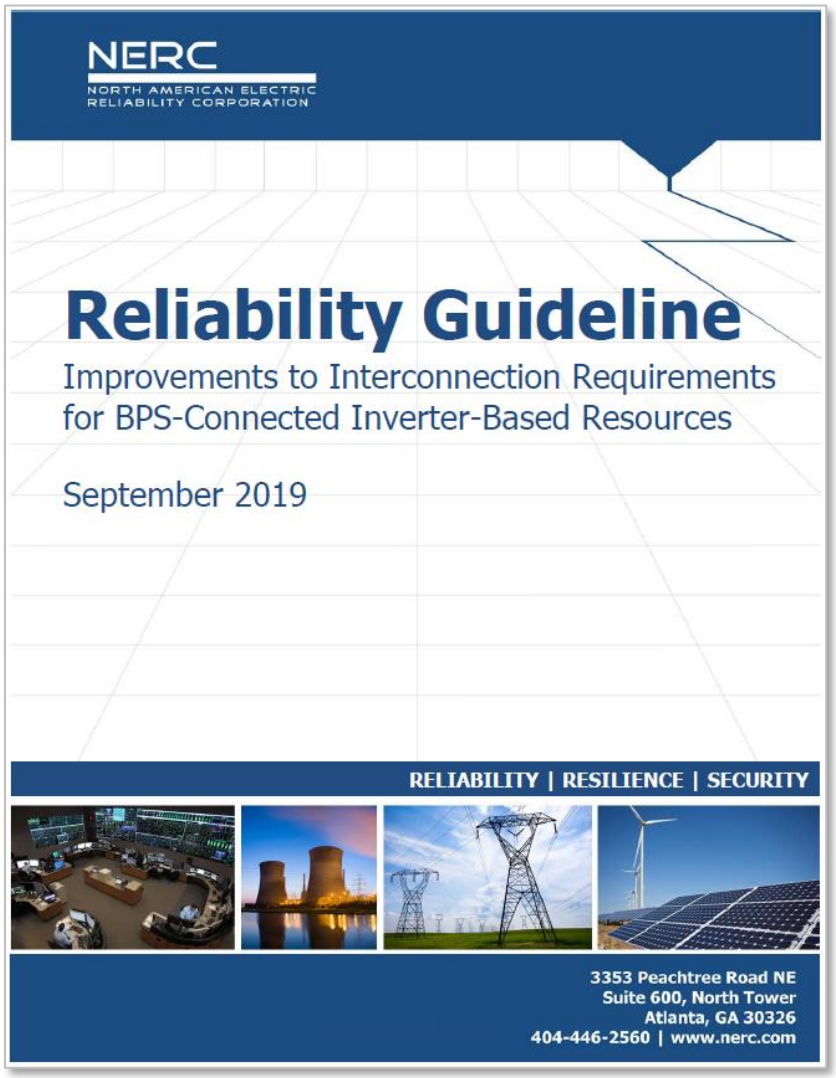
NERC Disturbance Reports of Solar PV Events





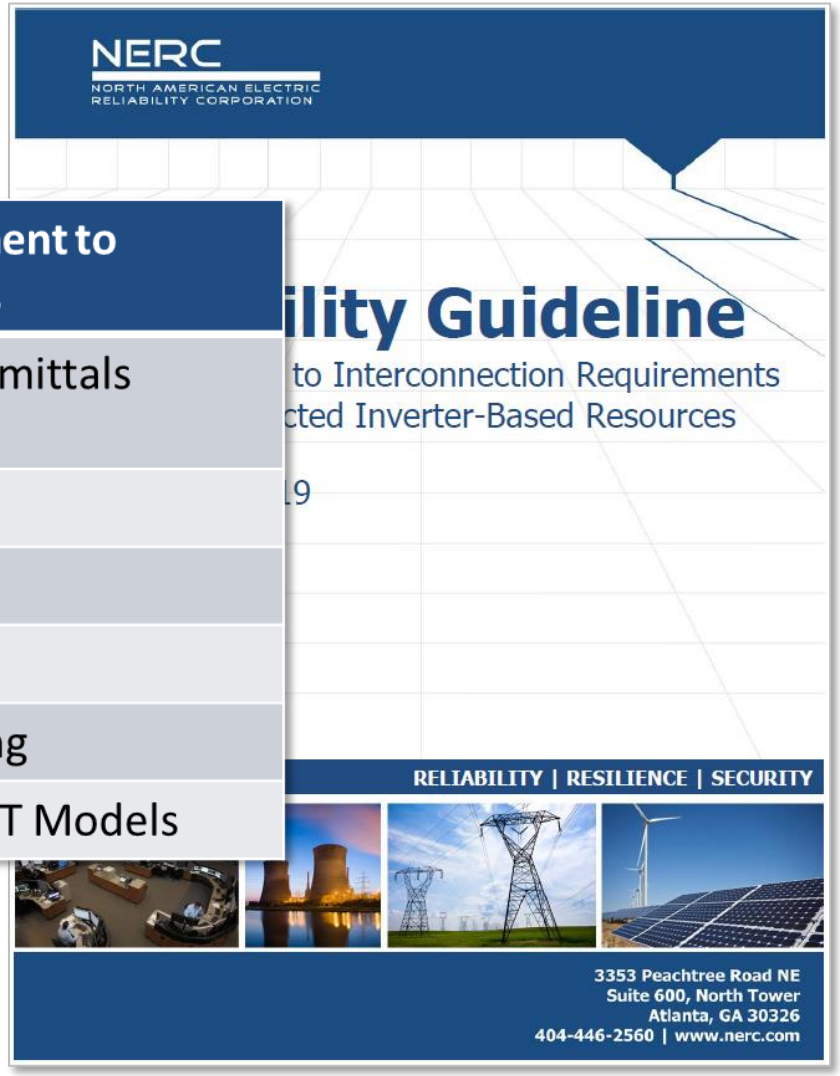
NERC Reliability Guidelines





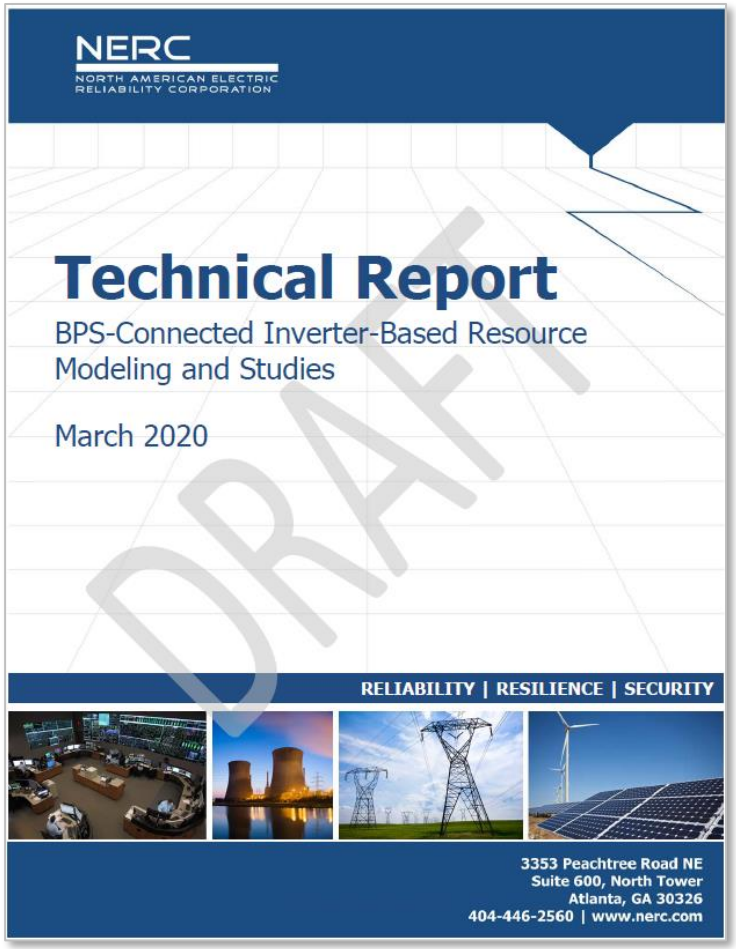
NERC Reliability Guidelines

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

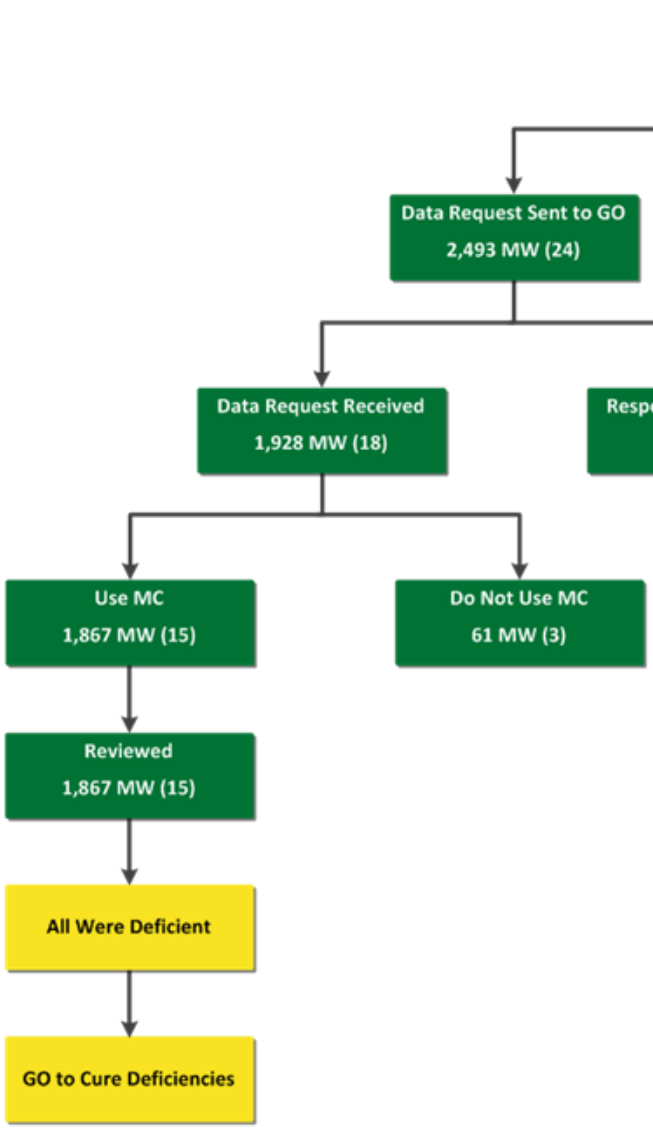


BPS-Connected Inverter-Based Resource Modeling and Studies

- 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)



Southern California Edison Modeling Updates (September 2019)



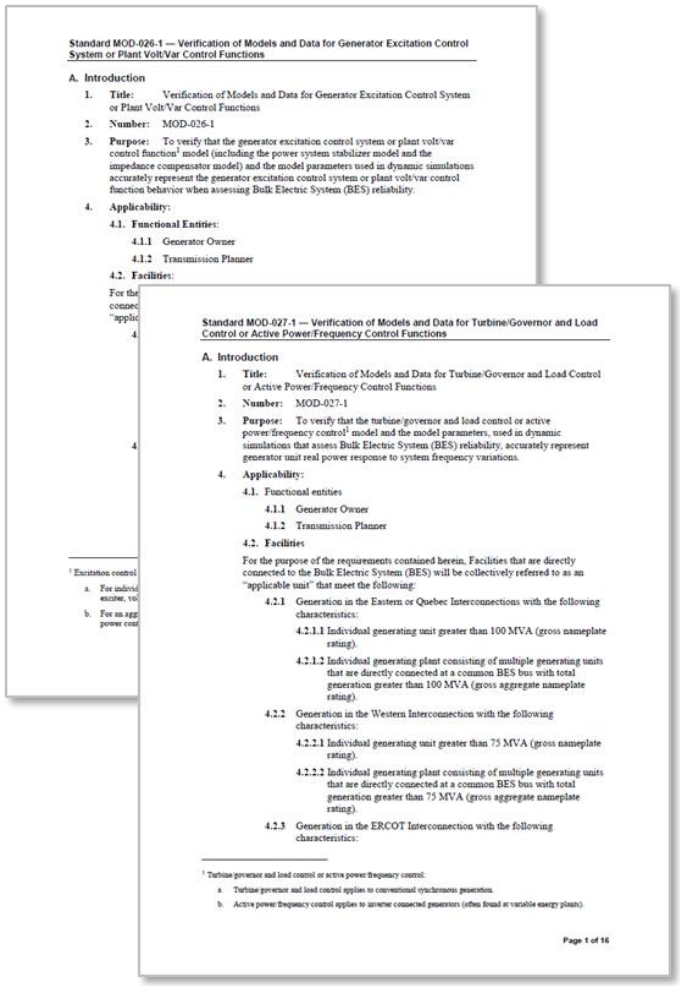
Key Takeaways:

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

NERC Alert Follow-Up

- 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

Challenges with MOD-026/-027



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

A. Introduction

1. **Title:** Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions
2. **Number:** MOD-026-1
3. **Purpose:** To verify that the generator excitation control system or plant volt/var control function[1] 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:**
   - 4.1. **Functional Entities:**
     - 4.1.1 Generator Owner
     - 4.1.2 Transmission Planner
   - 4.2. **Facilities:**

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

A. Introduction

1. **Title:** Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
2. **Number:** MOD-027-1
3. **Purpose:** To verify that the turbine/governor and load control or active power/frequency control[1] 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:**
   - 4.1. Functional entities
     - 4.1.1 Generator Owner
     - 4.1.2 Transmission Planner
   - 4.2. **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 at 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 at 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:
a. Turbine governor and load control applies to conventional synchronous generation.
b. Active power/frequency control applies to inverter connected generators (often found at variable energy plants).

Page 1 of 16

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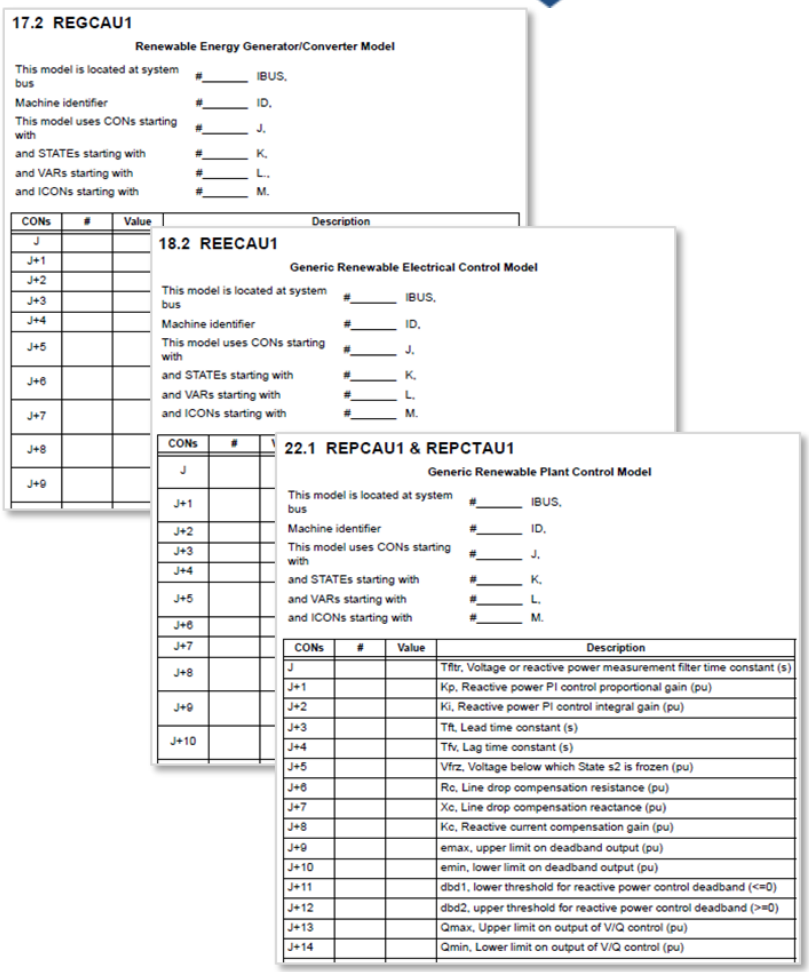


17.2 REGCAU1

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

22.1 REPCAU1 & 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			Tfltr, 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			Vfrz, 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			Qmax, Upper limit on output of V/Q control (pu)
J+14			Qmin, Lower limit on output of V/Q control (pu)

Source: PTI

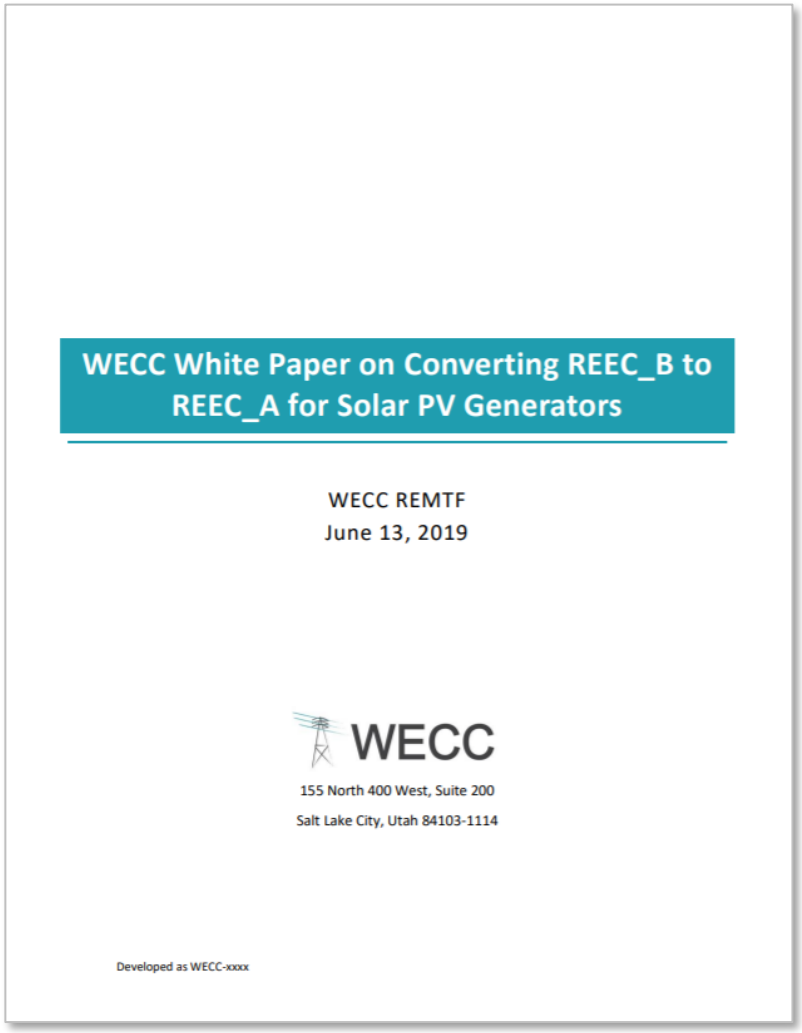
MOD-026-1 and MOD-027-1 ***Verified Dynamic Models***

Pro Forma GIAs

- 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

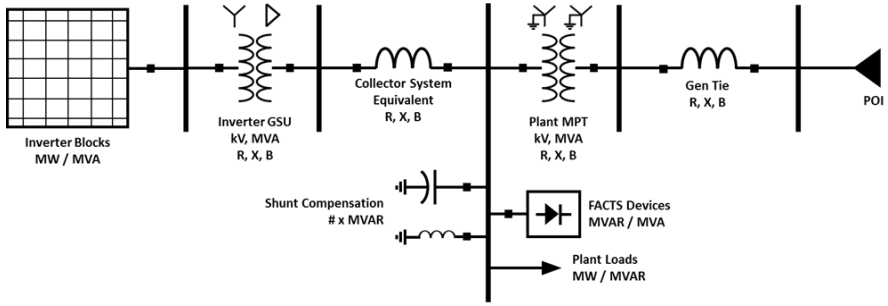
Conversion from REEC_B to REEC_A

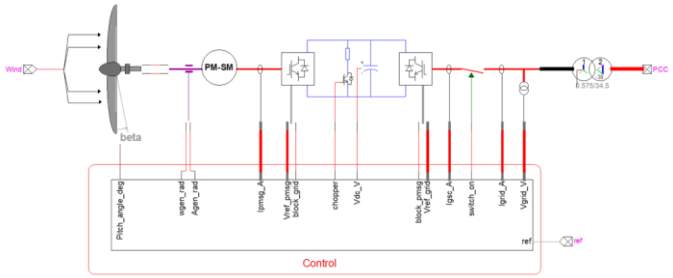
- REEC_B deemed unacceptable –
  - Cannot represent momentary cessation
  - Missing voltage-dependent current logic and other large disturbance functionality
- In WECC base case for solar PV…
  - REEC_B = 218
  - REEC_A = 56
- Work to do to get models updated
- Who has the responsibility to update these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

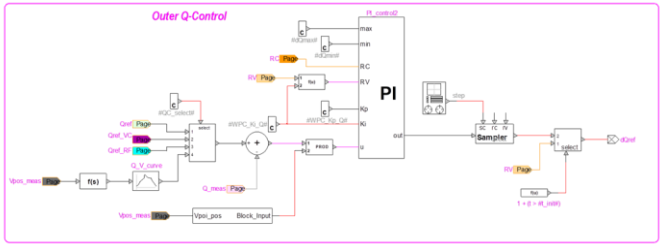


Growing Need for EMT Modeling

- 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







Handling High Penetration IBR Conditions in Planning Studies

- 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

Get Engaged with NERC Activities

- 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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