TAG Meeting
June 19, 2018

Webinar

TAG Meeting Agenda

1. Administrative Items – Rich Wodyka
2. 2018 Study Activities Update – Orvane Piper
3. NCTPC 2017 Collaborative Transmission Plan Mid-year Update – Mark Byrd and Orvane Piper
4. Regional Studies Update – Bob Pierce
5. 2018 TAG Work Plan – Rich Wodyka
6. TAG Open Forum – Rich Wodyka

2018 Study Activities and Study Scope Update

Orvane Piper

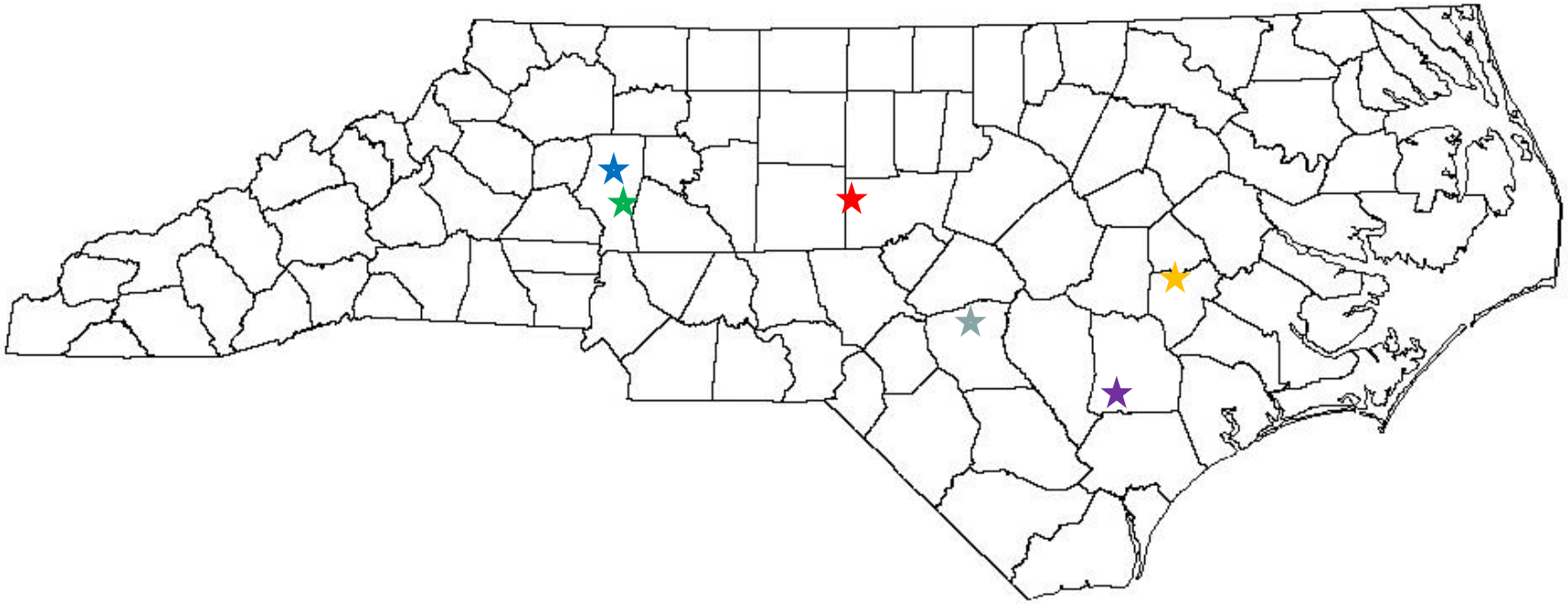
Duke Energy Carolinas

Studies for 2018

- **Annual Reliability Study**
  - **Assess DEC and DEP transmission systems' reliability and develop a single Collaborative Transmission Plan**
- **Local Economic Studies**
  - **Assess serving 300 MW hypothetical loads at 6 potential economic development sites that would have a choice of Electric Provider**

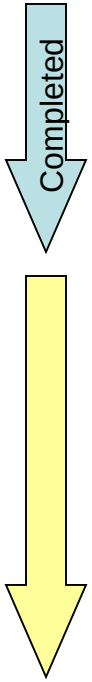
300 MW Hypothetical Industrial Sites

- **Chatham-Siler City Advanced Manufacturing**
  - Chatham County – 1802 Acres
- **GTP Parcel 1**
  - Lenoir County – 300 Acres
- **Highway 70 East**
  - Iredell County – 204 Acres
- **Peppercorn Plantation**
  - Iredell County – 342 Acres
- **SouthPark Phase II Business & Industry**
  - Duplin County – 72 Acres
- **US 401 North Site**
  - Cumberland County – 534 Acres



- Chatham-Siler City Advanced Manufacturing Site
- GTP Parcel 1
- Highway 70 East
- Peppercorn Plantation
- SouthPark Phase II – Duplin County Business & Industry
- US 401 North Site

Study Process Steps



1. Assumptions Selected
2. Study Criteria Established
3. Study Methodologies Selected
4. Models and Cases Developed
5. Technical Analysis Performed
6. Problems Identified and Solutions Developed
7. Collaborative Plan Projects Selected
8. Study Report Prepared

Study Assumptions Selected

- **Study Year's for reliability analyses:**
  - **Near-term: 2023 Summer, 2023/2024 Winter**
  - **Longer-term: 2028/2029 Winter**
- **LSEs provided:**
  - **Input for load forecasts and resource supply assumptions**
  - **Dispatch order for their resources**
- **Adjustments may be made based on additional coordination with neighboring transmission systems**

Study Criteria Established

- **NERC Reliability Standards**
  - **Current standards for base study screening**
- **Individual company criteria**

Study Methodologies Selected

- **Thermal Power Flow Analysis**
- **Each system (DEC and DEP) will be tested for impact of other system's contingencies**

Models and Cases Developed

- **Start with 2017 series MMWG cases**
- **Latest updates to detailed models for DEC and DEP systems will be included**
- **Planned transmission additions from updated 2017 Plan will be included in models**

Technical Analysis

- Conduct thermal screenings of the 2023S, 2023/24W and 2028/29W base cases
- Conduct thermal screenings for six sites with 300 MW hypothetical industrial loads on 2028/29W case

Problems Identified and Solutions Developed

- Identify limitations and develop potential alternative solutions for further testing and evaluation
- Estimate project costs and schedule

Collaborative Plan Projects Selected

- Compare all alternatives and select preferred solutions

Study Report Prepared

- Prepare draft report and distribute to TAG for review and comment

Questions ?

NCTPC 2017 Collaborative Transmission Plan Update

Mark Byrd
Duke Energy Progress
Orvane Piper
Duke Energy Carolinas

2018 Mid-Year Update to the 2017 Collaborative Transmission Plan

- **One DEP project was completed in June 2018**
- **Two DEP and one DEC project cost estimates increased**
- **Two DEC projects were removed**
- **Two DEC projects and three DEP projects were accelerated.**
- **Two DEP projects were delayed.**
- **Total Reliability Project Cost estimates changed from $426M to $459M**

Reliability Projects in 2017 Plan		
Reliability Project	**TO**	**Planned I/S Date**
Durham-RTP 230kV Line, Reconductor	DEP	TBD
Brunswick #1 – Jacksonville 230 kV Line Loop-In to Folkstone 230 kV substation	DEP	June 2024
Raeford 230 kV substation, loop-in Richmond-Ft Bragg Woodruff St 230 kV Line and add 3rd bank	DEP	July 2018
Jacksonville-Grant's Creek 230 kV Line and Grant's Creek 230/115 kV Substation	DEP	June 2020

Reliability Projects in 2017 Plan (continued)		
Reliability Project	**TO**	**Planned I/S Date**
Newport-Harlowe 230 kV Line, Newport SS and Harlowe 230/115 kV Substation	**DEP**	**June 2020**
Sutton-Castle Hayne 115 kV North line Rebuild	**DEP**	**December 2019**
Asheville Plant, Replace 2-300 MVA 230/115 kV banks with 2-400 MVA banks, reconductor 115 kV ties to switchyard, upgrade breakers, and add 230 kV capacitor bank	**DEP**	**December 2018**

Reliability Projects in 2017 Plan (continued)		
Reliability Project	**TO**	**Planned I/S Date**
Cane River 230 kV Substation, Construct 150 MVAR SVC	DEP	June 2019
Reconductor Harley 100 kV	DEC	TBD
Asheboro-Asheboro East 115 kV North Line Reconductor	DEP	June 2019
Delco 230 kV Substation, Convert to Double Breaker	DEP	June 2019
Castle Hayne 230 kV Substation, Convert to Double Breaker	DEP	Completed June 2018

Reliability Projects in 2017 Plan (continued)		
Reliability Project	**TO**	**Planned I/S Date**
Rural Hall 100 kV, Install SVC	DEC	December 2019
Orchard Tie 230/100 kV Tie Station, Construct	DEC	December 2020
Reidsville 100 kV Lines (Dan River-Sadler), Reconductor	DEC	Removed
Wolf Creek 100 kV Lines (Dan River-Sadler), Reconductor	DEC	Removed

Questions ?

Regional Studies Reports

Bob Pierce

Duke Energy Carolinas

SERC Long Term Study Group Update

SERC Long Term Study Group

- Completed work on 2018 series of LTSG cases
- Building 2018 series MMWG cases

SERTP

SERTP

- 1st Quarter Meeting held on March 29th
- 2018 Economic Planning Studies

SERTP

Southern Company Balancing Authority Area to Santee Cooper Border – 1000 MW

- Year: 2021
- Load Level: Summer Peak
- Type of Transfer: Generation to Load
- Source: Generation within Southern Company Balancing Authority Area
- Sink: Uniform Load scale within Santee Cooper

SERTP

Santee Cooper Border to Duke Energy Carolinas & Progress – 1000 MW

- Year: 2021
- Load Level: Summer Peak
- Type of Transfer: Generation to Load
- Source: Generation within Santee Cooper
- Sink: Uniform Load scale within Duke Energy Carolinas (500 MW) and Duke Energy Progress (500 MW)

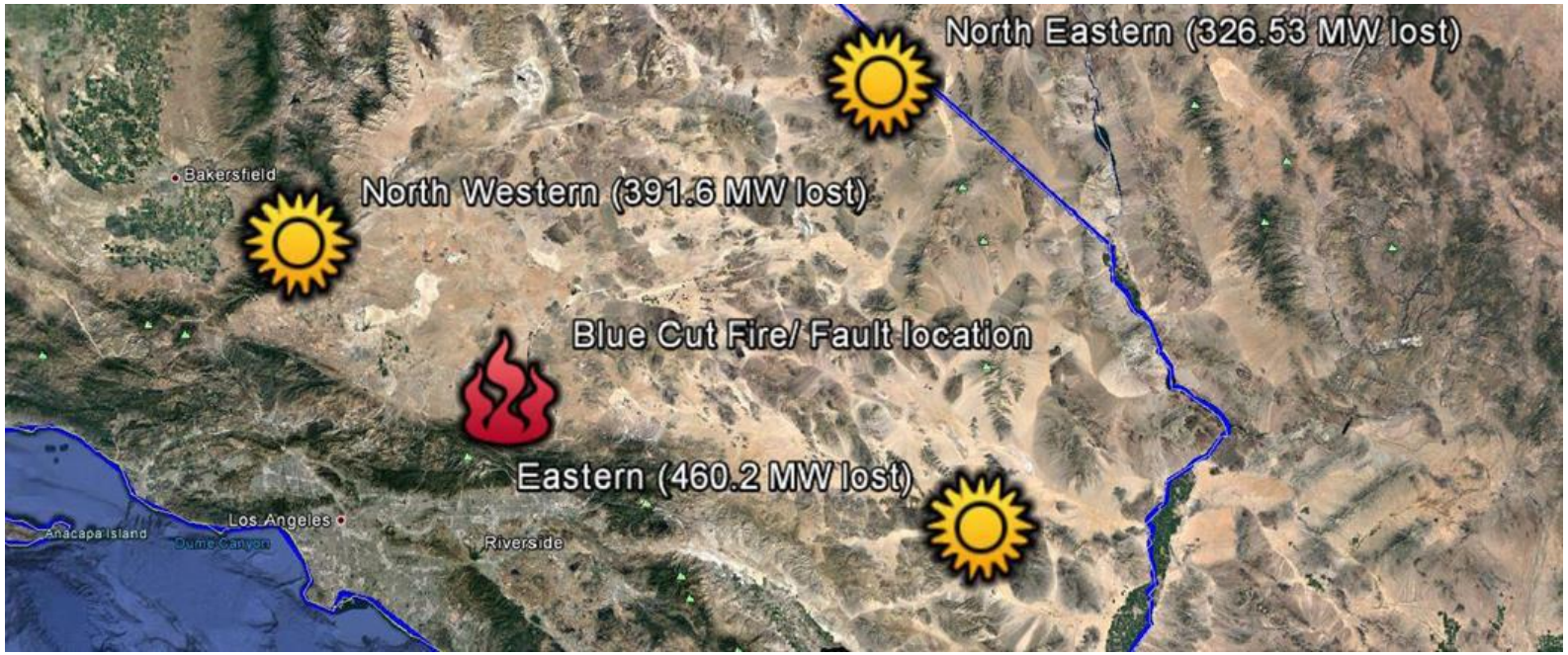
SERTP

Duke Energy Carolinas and Duke Energy Progress to Santee Cooper Border – 1000 MW

- Year: 2021
- Load Level: Summer Peak
- Type of Transfer: Generation to Load
- Source: Generation within Duke Energy Carolinas (500 MW) and Duke Energy Progress (500 MW)
- Sink: Uniform Load scale within Santee Cooper

http://www.southeasternrtp.com/

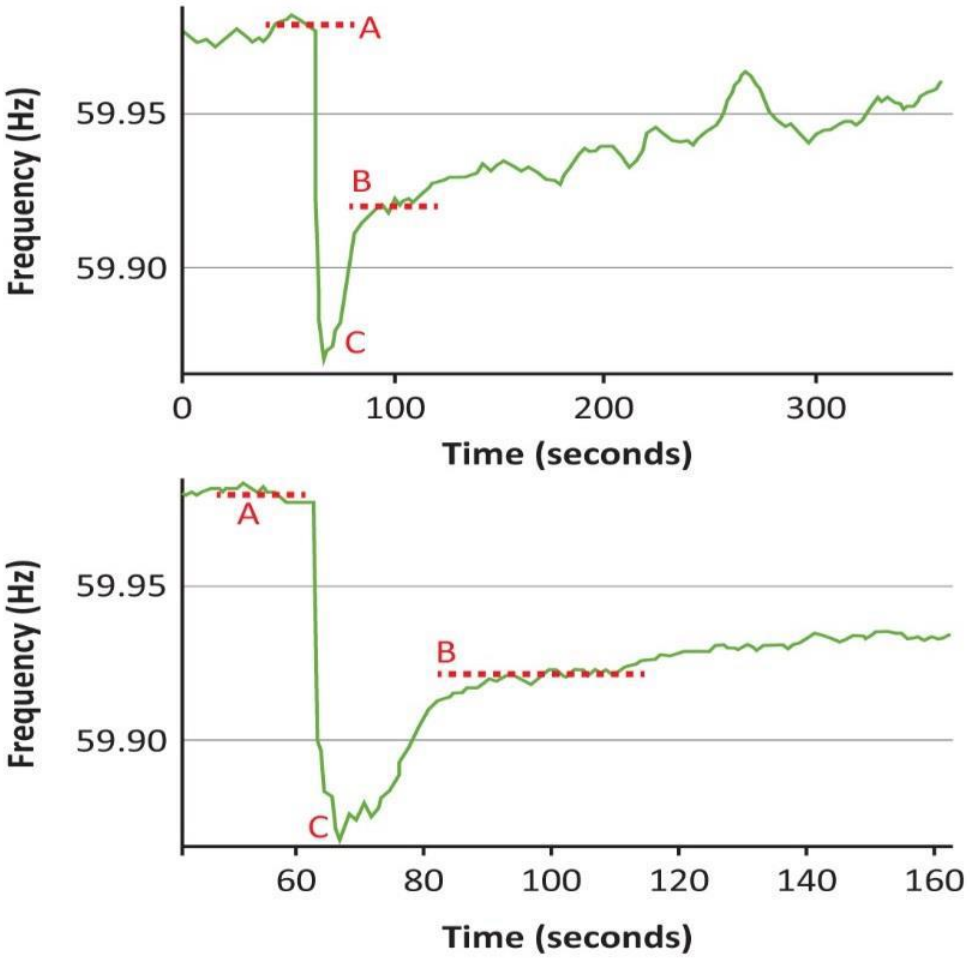
NERC Alert - IBR


North Eastern (326.53 MW lost)
Bakersfield
North Western (391.6 MW lost)
Blue Cut Fire/ Fault location
Eastern (460.2 MW lost)
Los Angeles
Anacapa Island
Riverside

SUMMARY

The tripping of the first 500 kV line was due to smoke from the fire creating a fault and the line clearing as designed. The second 500 kV line tripped as a result of a smoke induced fault, again by design, and cleared within three cycles. Before that fault cleared, the transient caused by the fault was experienced at the 26 nearby solar farms (thus the aggregate over 1,000 MWs of generation) and subsequently caused the inverters to quit injecting ac current (within two cycles).

- Many of the inverters stopped outputting power before the fault cleared, indicating that the faulted condition alone created the condition that caused the response as opposed to post-fault system response (transient stability).
- Many inverters calculated frequencies at the inverter terminals which are well outside of the values that would be expected for a normally cleared fault. Many inverters calculated a system frequency in the range of 57 Hz during the fault.



Event ID: WI_20160816_184506
UTC Time: 08/16/2016 18:45:06
Local Time: 08/16/2016 11:45:06
Time Zone: PDT
M4 Flag: Yes
BAL003 Flag: Yes
MW Loss: 0
Value A: 59.979
Value B: 59.92
Point C: 59.8669
Time of C: 4.7
Point C': -
Time of C': -
A-B [mHz]: 59
A-C [mHz]: 112
FRM_B [MW/0.1Hz]: 0
FRM_C [MW/0.1Hz]: 0

Western Interconnection Frequency during Fault

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Data Gathering

- 26 different solar developments
- All utility scale
- Majority connected at 500kV or 230kV
- 10 different inverter manufacturers
- Reported causes of “trips”
  - Under frequency
  - Under voltage
  - Over voltage
  - DC overcurrent
  - 1 loss of synchronism

Causes of the PV Resource Interruption

Based on information provided by the inverter manufacturers, solar development owners and operators, SCE, and the CAISO; it was determined:

- ~700 MW was attributed to a perceived, though incorrect, low system frequency condition that the inverters responded to by "tripping" (cease to energize and not return to service for a default duration of five minutes or later).

- ~450 MW was determined to be inverter momentary cessation due to system voltage reaching the low voltage ride-through setting of the inverters. Momentary cessation is when the inverter control ceases to inject current into the grid while the voltage is outside the continuous operating voltage range of the inverter.

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Key Findings and Recommendations

- NERC Alert/Recommendation to Industry was issued 6/20/2017
  - Work with inverter manufacturer to ensure no erroneous frequency tripping
  - If momentary cessation is used, restore output in no more than 5 seconds

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Alert responses

Inverter cease output during abnormal voltages?			
	MW	Responses	Inverter units
Yes	14,113	119	11,821
No	2,657	31	2,557
Total	**16,771**	**150**	**14,378**

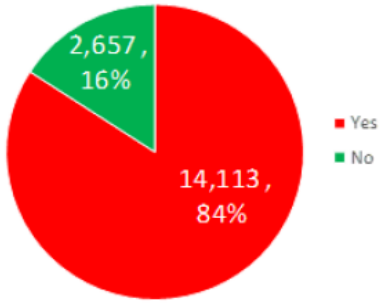

Figure 4: MW cease output during abnormal voltages

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October 9, 2017
Canyon 2 Fire Disturbance

Key Findings and Recommendations


North Eastern PV (0 MW, -200 MW)
Northern PV (-75 MW, -340 MW)
Fire
Eastern PV (-607 MW, -397 MW)
Google earth

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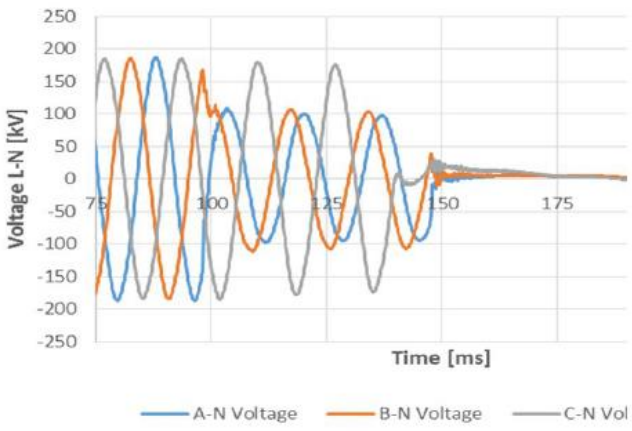
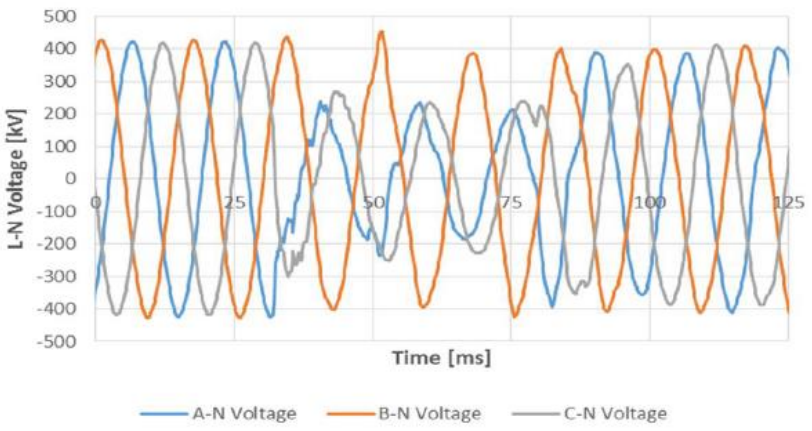
Two Fault Events

Smoke-induced L-L fault events caused by Canyon 2 Fire…
Both fault cleared normally…





Fault Event 1:
220 kV
L-L Fault
< 3 cycle clearing

Fault Event 2:
500 kV
L-L Fault
< 3 cycle clearing

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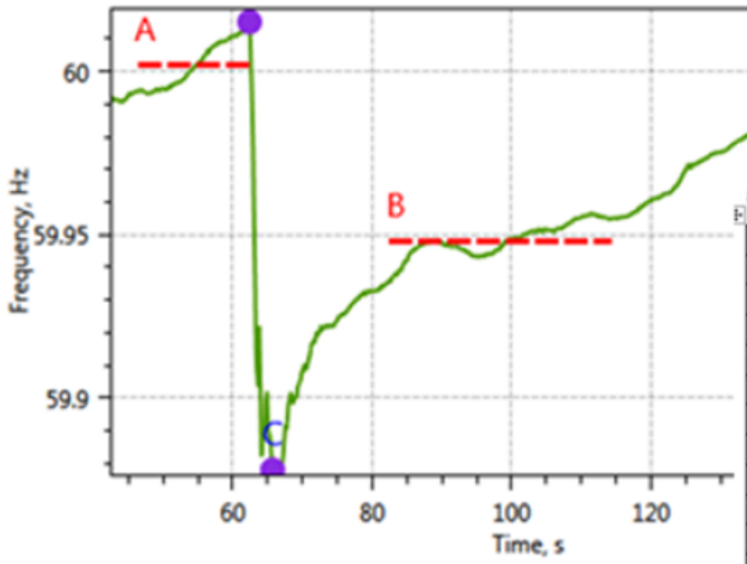
Frequency Response from 500 kV Fault Event #2



WI_20171009_191428

Event ID	WI_20171009_191428
Event Description	"Solar Generation 900MW loss"
UTC Time	10/09/2017 19:14:28
Local Time	10/09/2017 12:14:28
Time Zone	PDT
M4 Flag	Yes
BAL003 Flag	Yes
MW Loss	900
Value A	60.002
Value B	59.948
Point C	59.878
Time of C	3.3
Point C'	-
Time of C'	-
A-B [mHz]	54
A-C [mHz]	124
FRM_B [MW/0.1Hz]	1667
FRM_C [MW/0.1Hz]	726

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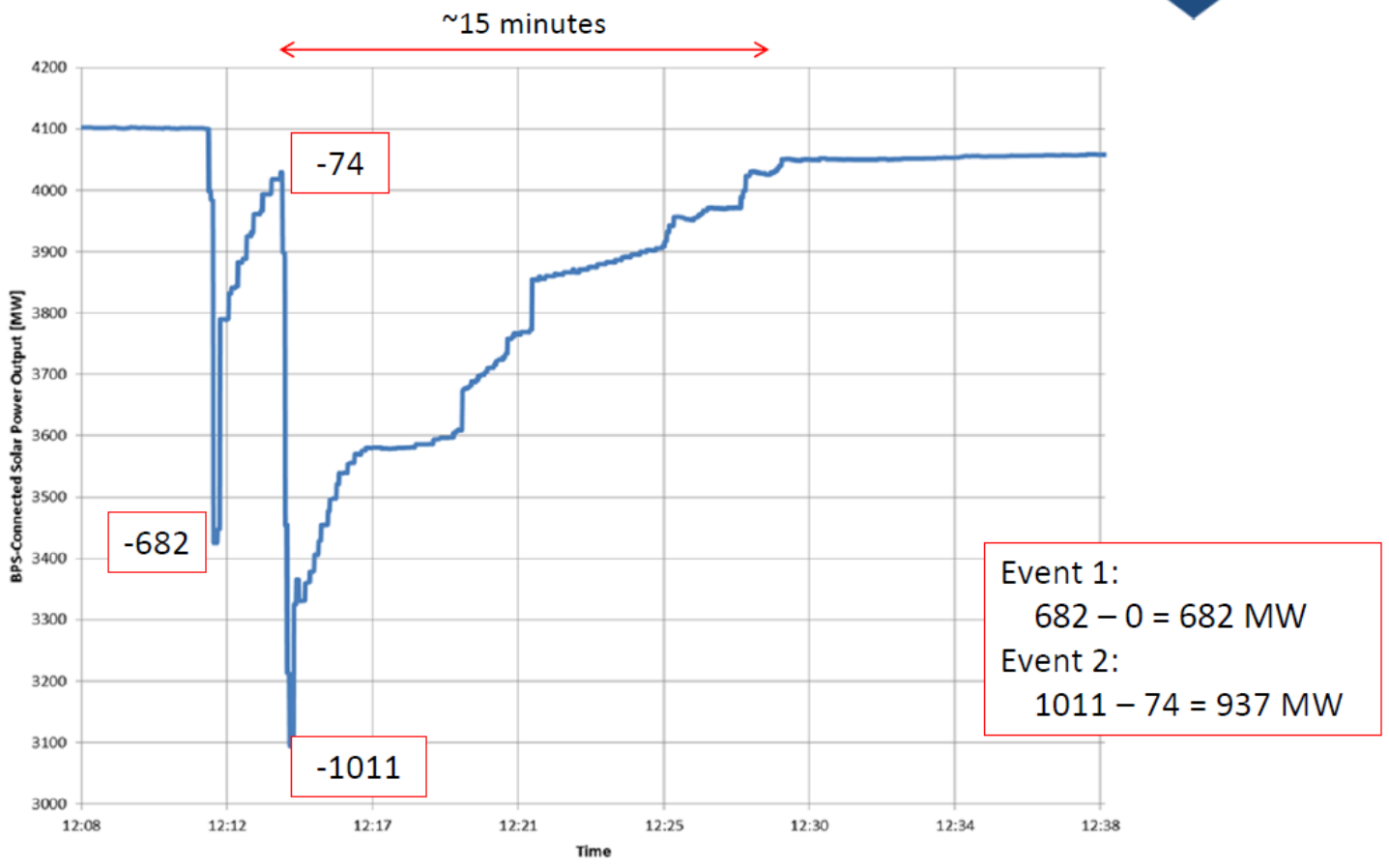
Aggregate SCE Solar PV Performance SCADA Data



Event 1:
682 – 0 = 682 MW
Event 2:
1011 – 74 = 937 MW

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Key Findings

1. No erroneous frequency tripping
2. Continued use of momentary cessation
3. Ramp rate interactions with return from momentary cessation
4. Interpretation of PRC-024-2 voltage ride-through curve
5. Instantaneous voltage tripping and measurement filtering
6. Phase lock loop synchronization issues
7. DC reverse current tripping
8. Transient interactions and ride-through considerations

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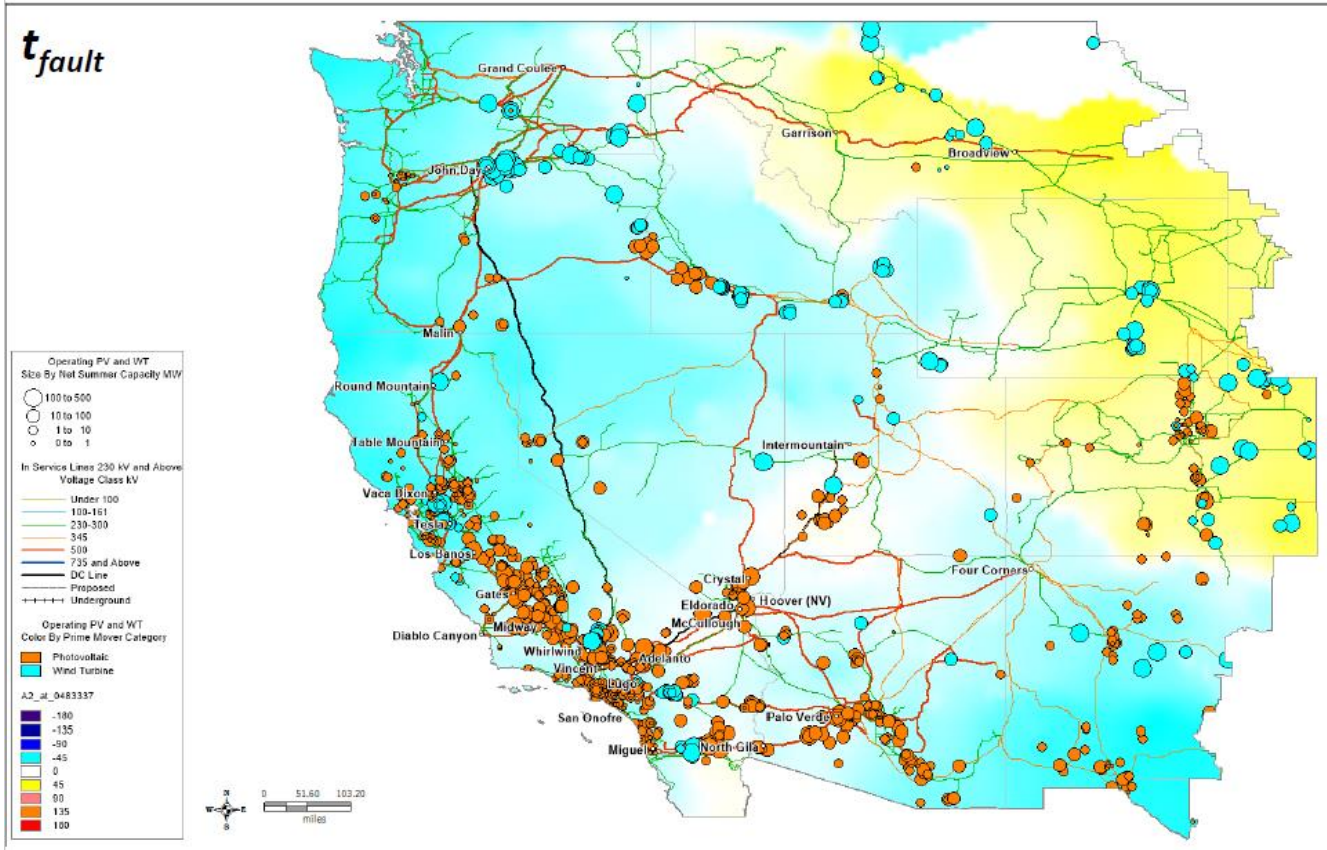
Clarification and Recommendation for Momentary Cessation



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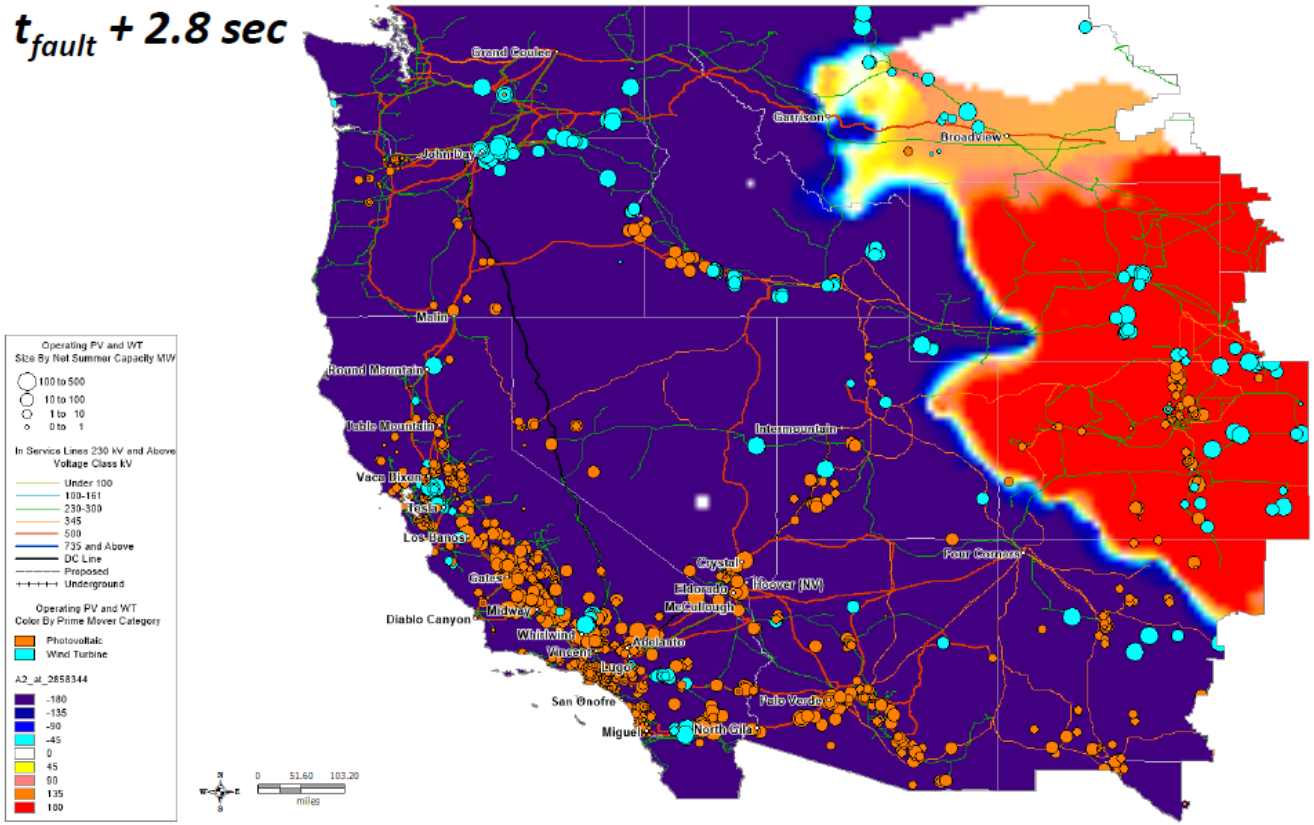
Clarification and Recommendation for Momentary Cessation

t_{fault} + 2.8 sec



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Momentary Cessation Recommendation Moving Forward

- Generator Owners should coordinate with their inverter manufacturer(s) to **eliminate momentary cessation (MC) to the greatest extent possible**.
- For inverters where MC cannot be eliminated (e.g., use another form of ride-through mode), MC settings should be changed by:
  - Reducing the MC low voltage threshold to the lowest value possible.
  - Reducing the recovery delay to the smallest value possible (e.g., on the order of 1-3 electrical cycles).
  - Increasing the active power ramp rate to at least 100% per second (e.g., return to pre-disturbance active current injection within 1 second).
  - Setting reactive current priority upon recovery (if applicable) should eliminate the use of MC on all inverters that are capable of continuous current injection during abnormal voltages.

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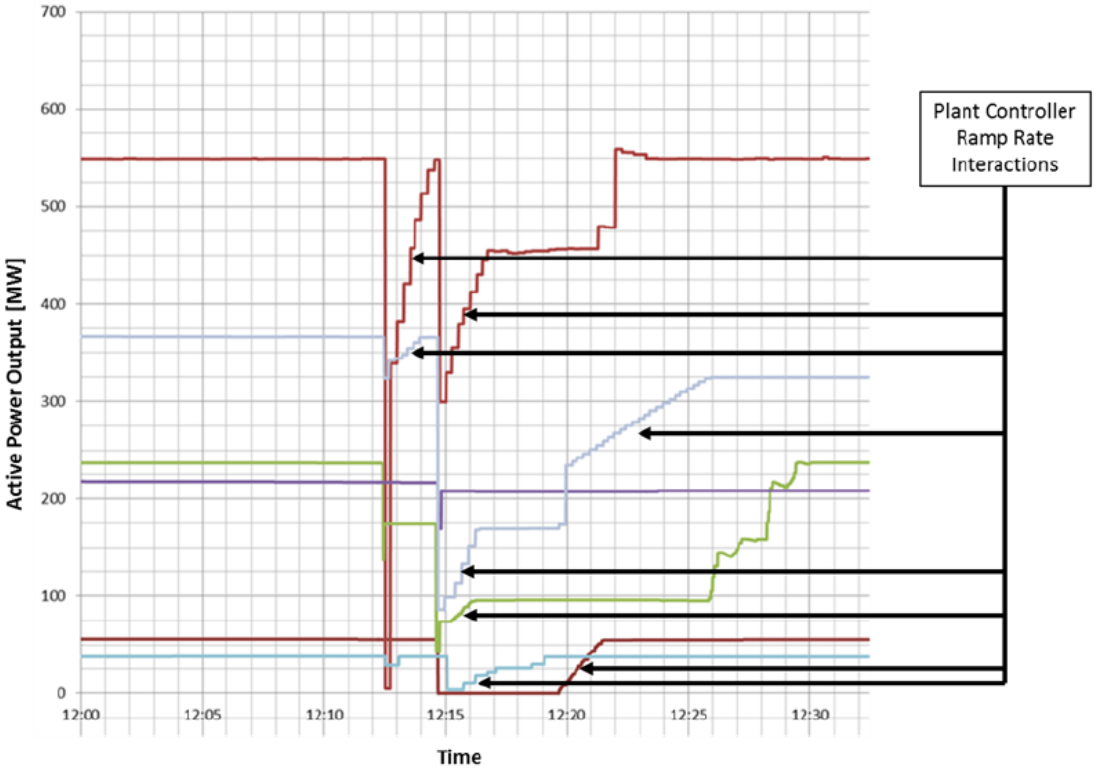
Key Findings #3

Ramp rate interactions with return from momentary cessation



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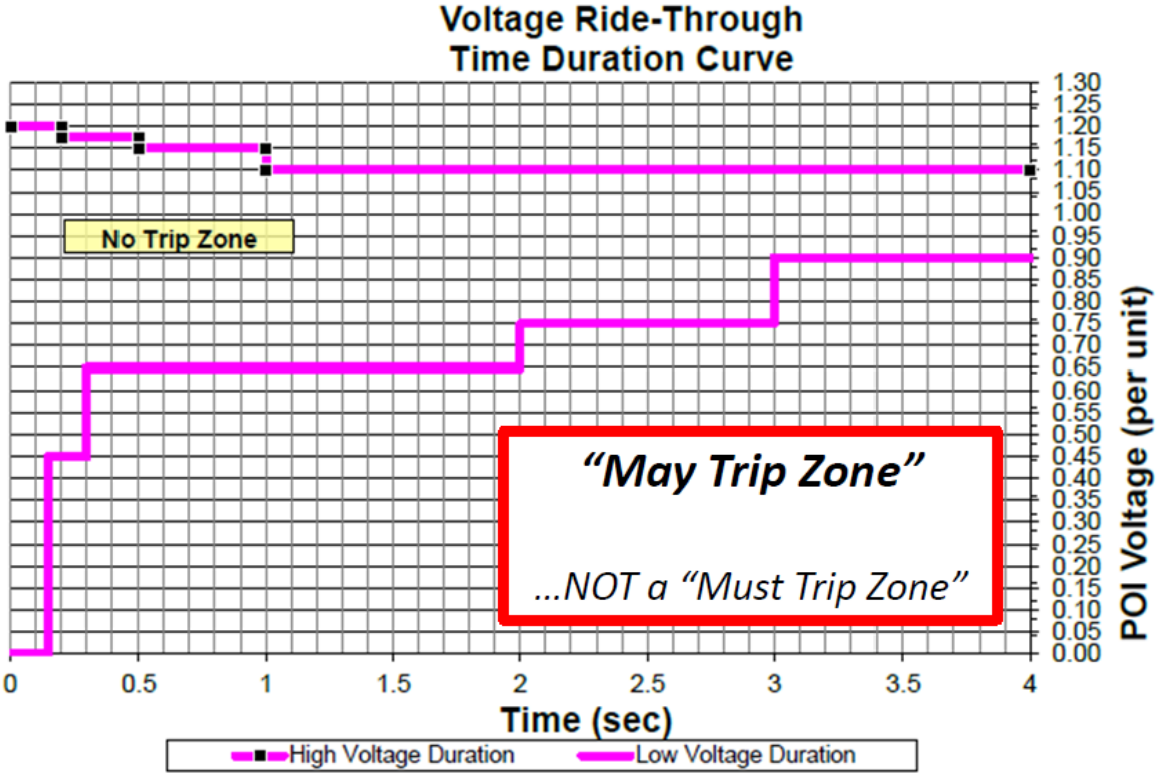
Key Findings #4 Clarification 1

Interpretation of PRC-024-2 voltage ride-through curve



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Loss of Solar Resources during Transmission Disturbances due to Inverter Settings – II

Informational Webinar on Level 2 NERC Alert

Ryan Quint, Senior Manager, Advanced Analytics and Modeling
Rich Bauer, Associate Director, RRM-Event Analysis

May 11, 2018

RELIABILITY | ACCOUNTABILITY

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Clarification for Non-BES Resources connected to the BPS

- 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.

1 These resources do not meet the Bulk Electric System definition, and are generally less than 75 MVA yet connected to transmission-level voltage.

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Large BES Solar Resources

Unofficial - Illustration Purposes Only

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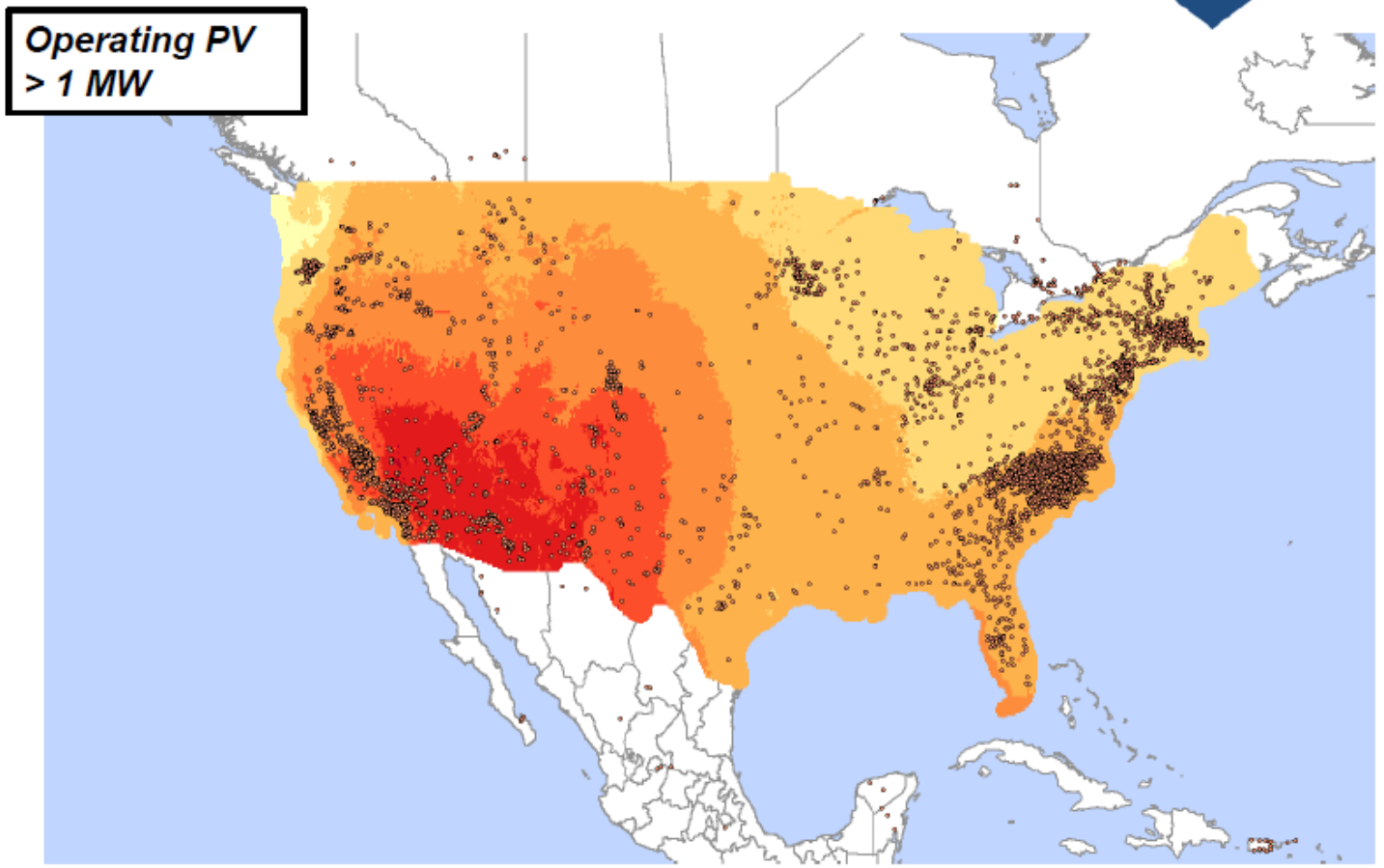
BPS-Connected Solar Resources



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RELIABILITY | ACCOUNTABILITY

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Relevant Materials

- Disturbance Report: https://www.nerc.com/pa/rrm/ea/October%209%202017%20Canyon%202%20Fire%20Disturbance%20Report/900%20MW%20Solar%20Photovoltaic%20Resource%20Interruption%20Disturbance%20Report.pdf
- NERC Alerts Page: https://www.nerc.com/pa/rrm/bpsa/Pages/Alerts.aspx
- Level 2 NERC Alert – Loss of Solar Resources II: https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_Loss_of_Solar_Resources_during_Transmission_Disturbance-II_2018.pdf
- Data Submission Worksheet: https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/Data_Submission_Worksheet-IId.xlsx

Questions ?

2018 TAG Work Plan

Rich Wodyka

Administrator

2018 NCTPC Overview Schedule

Reliability Planning Process

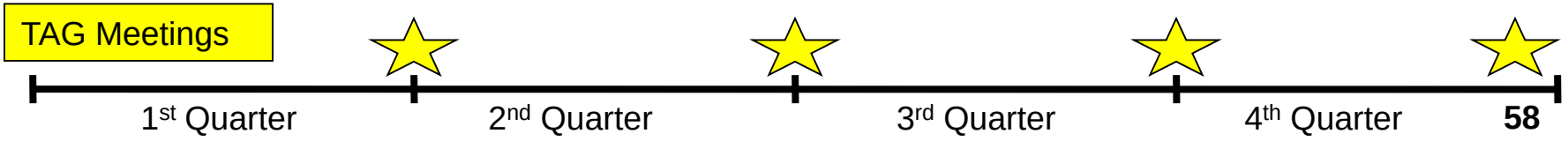
- Evaluate current reliability problems and transmission upgrade plans
- Perform analysis, identify problems, and develop solutions
- Review Reliability Study Results

Local Economic Planning Process

- Propose and select Local Economic Studies and Public Policy Study scenarios
- Perform analysis, identify problems, and develop solutions
- Review Local Economic Study and Public Policy Results

Coordinated Plan Development

- Combine Reliability and Local Economic Study and Public Policy Results
- OSC publishes DRAFT Plan
- TAG review and comment



January - February – March

- **2018 Study – Finalize Study Scope of Work**
  - ✓ **Receive request from OSC to provide input on proposed Local Economic Study scenarios and interfaces for study**
    - *TAG provide input to the OSC on proposed Local Economic Study scenarios and interfaces for study – No TAG requests received*
  - ✓ **Receive request from OSC to provide input in identifying any public policies that are driving the need for local transmission**
    - *TAG provide input to the OSC in identifying any public policies that are driving the need for local transmission for study - No TAG requests received*
  - ✓ **Receive final 2018 Reliability Study Scope for comment**
    - *TAG review and provide comments to the OSC on the final 2018 Study Scope*

January - February – March

First Quarter TAG Meeting – March 27th

- **2018 Study Update**
  - ✓ **Receive a report on the Local Economic Study scope and any public policy scenarios that are driving the need for local transmission for study**
  - ✓ **Receive a progress report on the Reliability Planning study activities and the final draft of the 2018 Study Scope**

April - May – June

Second Quarter TAG Meeting – June 19th

- **2018 Study Update**
  - ✓ **Receive a progress report on study activities**
  - ✓ **Receive a mid-year update on the status of the upgrades in the 2017 Collaborative Transmission Plan**

July - August – September

Third Quarter TAG Meeting – September 25th

➢ 2018 Study Update

- **Receive a progress report on the study activities and preliminary results**
- **TAG is requested to provide feedback to the OSC on the technical analysis performed, the problems identified as well as proposing alternative solutions to the problems identified**

October - November - December

Fourth Quarter TAG Meeting – TBD

- **2018 Selection of Solutions**
  - **TAG will receive feedback from the OSC on any alternative solutions that were proposed by TAG members**
- **2018 Study Update**
  - **Receive and discuss final draft of the 2018 Collaborative Transmission Plan Report**
  - **Discuss potential study scope for 2019 studies**

Questions ?

TAG
Open Forum Discussion

Comments or Questions ?