# TAG Meeting
# March 27, 2018

## Webinar

# TAG Meeting Agenda

1. Administrative Items – Rich Wodyka
2. 2018 Study Activities and Study Scope Update – Mark Byrd
3. Regional Studies Update – Bob Pierce
4. 2018 TAG Work Plan – Rich Wodyka
5. TAG Open Forum – Rich Wodyka

# 2018 Study Activities and Study Scope Update

**Mark Byrd**

**Duke Energy Progress**

# Studies for 2018

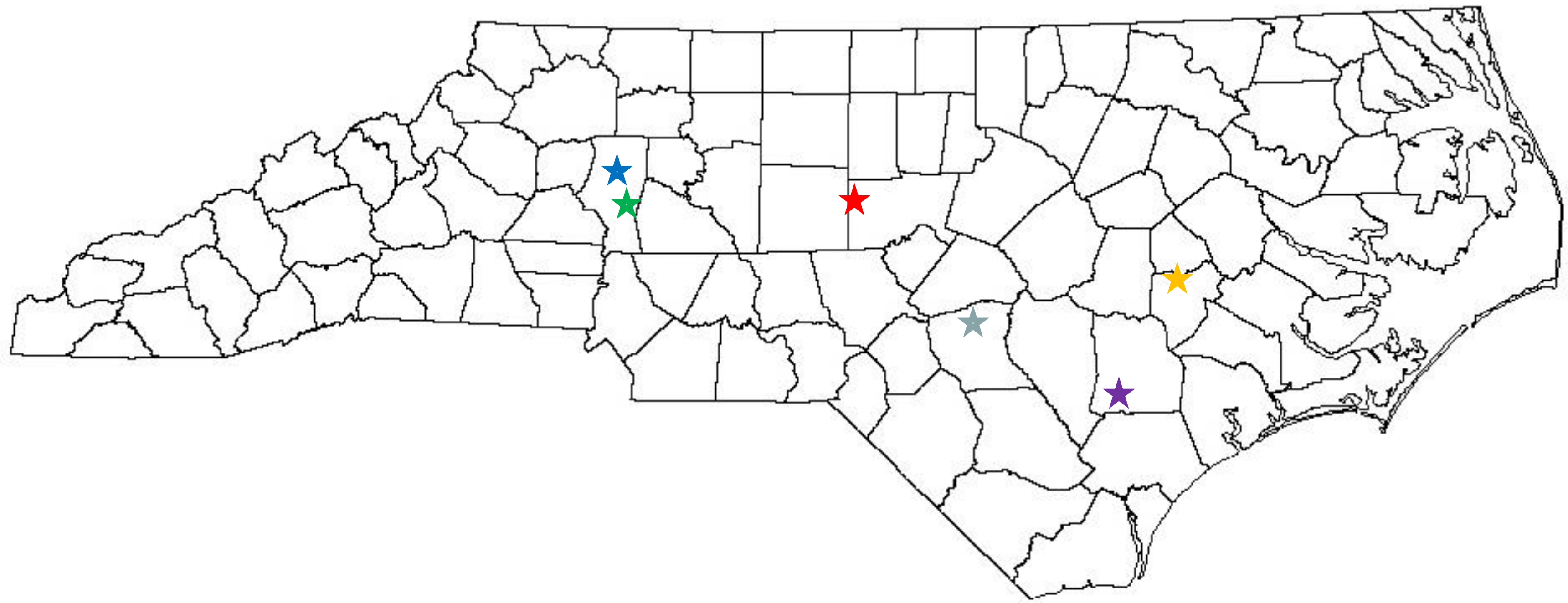
- **Annual Reliability Study**
  - **Assess DEC and DEP transmission systems' reliability and develop a single Collaborative Transmission Plan**
- **Local Economic Studies**
  - **Assess serving 300 MW hypothetical loads at 6 potential economic development sites that would have a choice of Electric Provider**
- **No Public Policy Studies submitted for 2018**

# 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

# 300 MW Hypothetical Industrial Sites

1. **Chatham-Siler City Advanced Manufacturing** – Chatham County – 1802 Acres
2. **GTP Parcel 1** – Lenoir County – 300 Acres
3. **Highway 70 East** – Iredell County – 204 Acres
4. **Peppercorn Plantation** – Iredell County – 342 Acres
5. **SouthPark Phase II Business & Industry** - Duplin County – 72 Acres
6. **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

Completed

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 Assumptions (Cont'd)

## DEP Western Area study assumptions:

- Two planned 1x1 combined cycle generating units at Asheville Plant
- Transmission upgrades associated with the installation of the planned generation are modeled

# Study Assumptions (Cont'd)

**DEP Western Area study assumptions:**

- **Imports:**
  - **Total of 36-386 MW firm interchange being imported:**
    - **0-200 MW from CPLE**
    - **0-150 MW from DEC**
    - **22 MW from SCPSA**
    - **14 MW from TVA**
- **Generation**
  - **Asheville 1 and 2 coal units shut down for all cases**
  - **Generation dispatch order:**
    - **Walters**
    - **Marshall**
    - **Asheville 230kV proposed generation**
    - **Asheville 115 kV proposed generation**
    - **Asheville CTs**

# Study Criteria Established

- NERC Reliability Standards
  - Current standards for base study screening
  - Current SERC Requirements
- 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

# 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 ?

# Regional Studies Reports

**Bob Pierce**
**Duke Energy Carolinas**

# SERC Long Term Study Group Update

# SERC Long Term Study Group

- Have begun work on 2018 series of LTSG cases

- RAWG study support

**Cases**

- 2017 series 2022 summer
- 2017 series 2022 winter
- 2017 series 2022 summer with CPP assumptions
- 2017 series 2022 winter with CPP assumptions

# SERTP

# SERTP

- 1st Quarter Meeting will be held on March 29th in Springfield MO
- Determine Economic Planning Studies to be performed for 2018
- Training session on GMD studies

**http://www.southeasternrtp.com/**

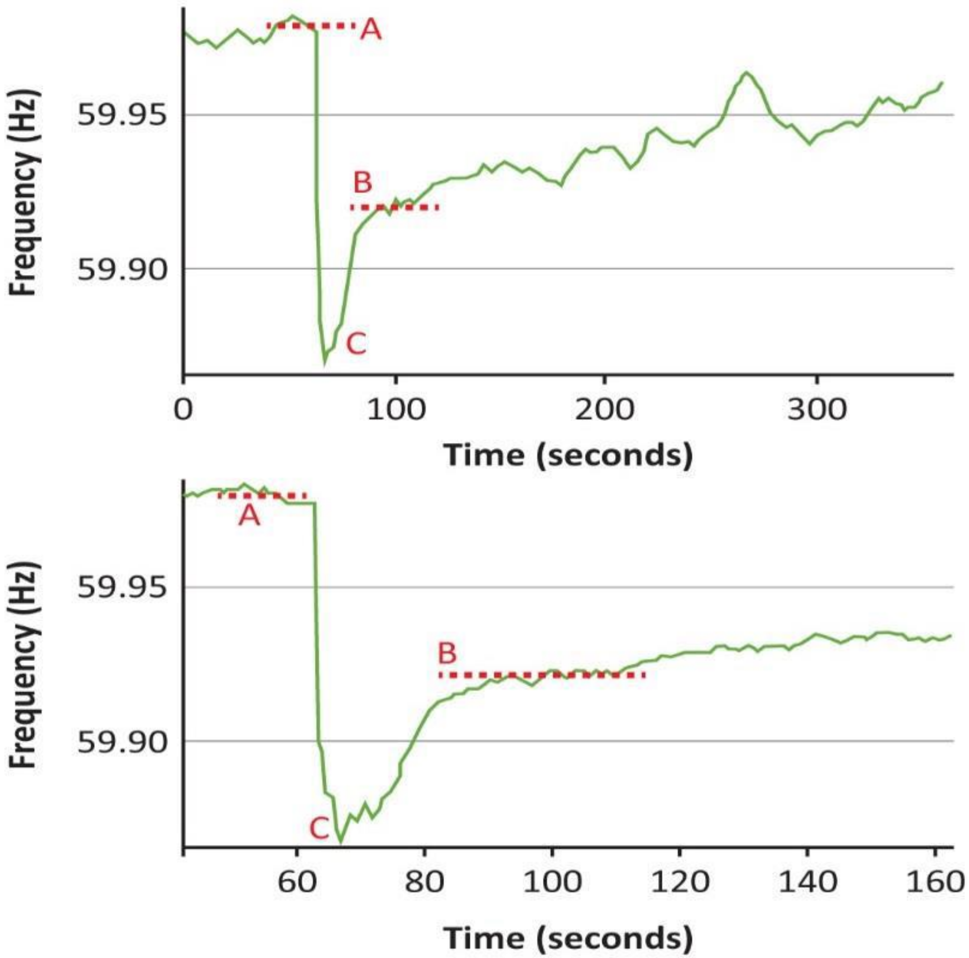
# NERC Canyon 2 Fire Report


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.
- A thorough analysis of the event and the operating characteristics of the related equipment is underway.




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**

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# 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

| Table 1.2: Fault Event Information | | | | | | |
|---|---|---|---|---|---|---|
| Event No. | Date/Time | Fault Location | Fault Type | Clearing Time (cycles) | Lost Generation (MW) | Geographic Impact |
| 1 | 08/16/2016 11:45 | 500 kV line | Line to Line (AB) | 2.49 | 1,178 | Widespread |
| 2 | 08/16/2016 14:04 | 500 kV line | Line to Ground (AG) | 2.93 | 234 | Somewhat Localized |
| 3 | 08/16/2016 15:13 | 500 kV line | Line to Ground (AG) | 3.45 | 311 | Widespread |
| 4 | 08/16/2016 15:19 | 500 kV line | Line to Ground (AG) | 3.05 | 30 | Localized |
| 5 | 09/06/2016 13:17 | 220 kV line | Line to Ground (AG) | 2.5 | 490 | Localized |
| 6 | 09/12/2016 17:40 | 500 kV line | Line to Ground (BG) | 3.04 | 62 | Localized |
| 7 | 11/12/2016 10:00 | 500 kV CB | Line to Ground (CG) | 2.05 | 231 | Widespread |
| 8 | 02/06/2017 12:13 | 500 kV line | Line to Ground (BG) | 2.97 | 319 | Widespread |
| 9 | 02/06/2017 12:31 | 500 kV line | Line to Ground (BG) | 3.01 | 38 | Localized |
| 10 | 02/06/2017 13:03 | 500 kV line | Line to Ground (BG) | 3.00 | 543 | Widespread |
| 11 | 05/10/2017 10:13 | 500 kV line | unknown | unknown | 579 | Somewhat Localized |

## 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.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

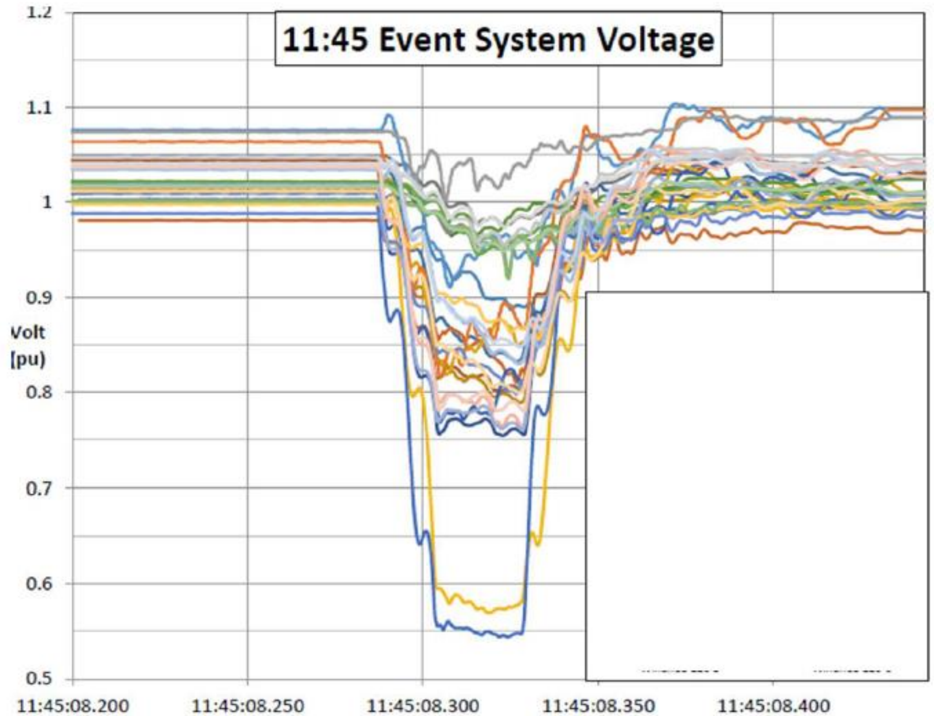
# Key Finding #1

- Isolated to one inverter manufacturer
- Manufacturer quickly devised solution following event
- Added time delay to inverter frequency tripping
  - Allows inverter to "ride through" transient/distorted waveform period without tripping.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Finding #2: Undervoltage Tripping

- 2nd largest block of inverter loss (~450 MW) was attributed to low voltage



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

## 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

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Alert responses

| Susceptible to Erroneous Frequency Calculations? | | | |
|---|---|---|---|
| | MW | Responses | Inverter units |
| Yes | 6,244 | 74 | 7,148 |
| No | 10,527 | 76 | 7,230 |
| **Total** | **16,771** | **150** | **14,378** |

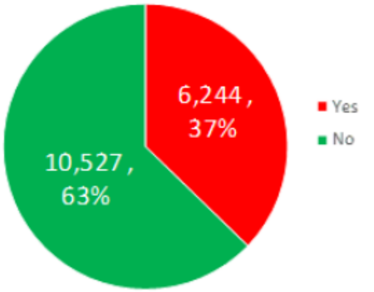



**Figure 2: MW susceptible to Erroneous Frequency Calculations**

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# 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** |

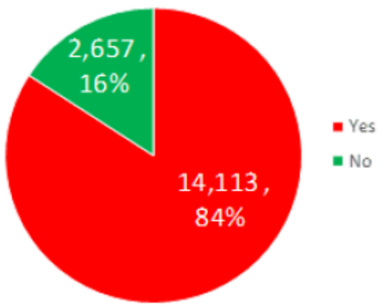



**Figure 4: MW cease output during abnormal voltages**

NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

# October 9, 2017
# Canyon 2 Fire Disturbance

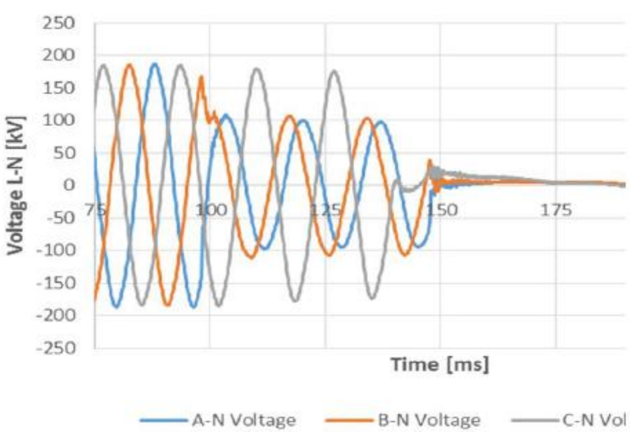
*Key Findings and Recommendations*

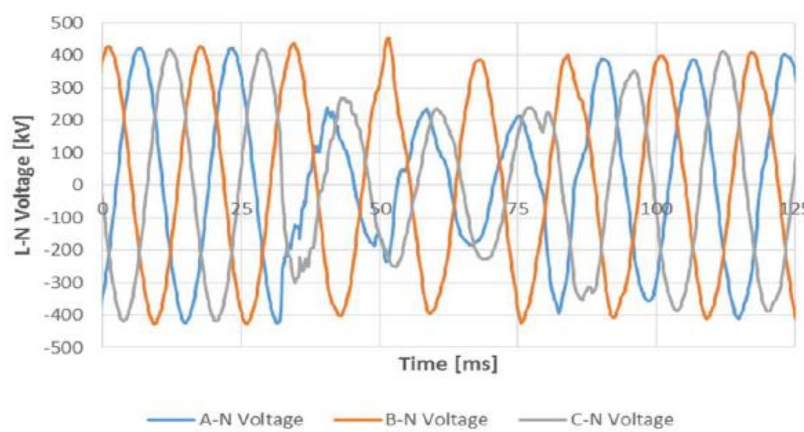

North Eastern PV (0 MW, -200 MW)
Northern PV (-75 MW, -340 MW)
Fire
Eastern PV (-607 MW, -397 MW)
Google earth

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Two Fault Events

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



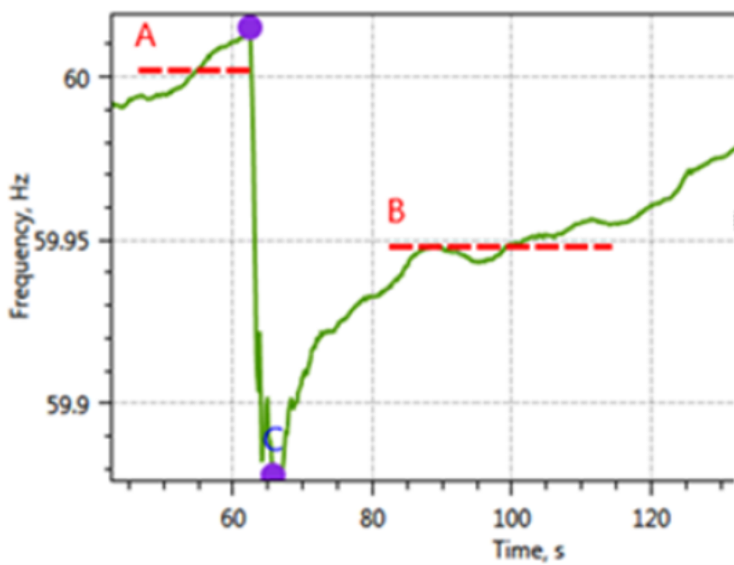

*Fault Event 1:*
*220 kV*
*L-L Fault*
*< 3 cycle clearing*

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

25 **RELIABILITY | ACCOUNTABILITY**

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Frequency Response from 500 kV Fault Event #2

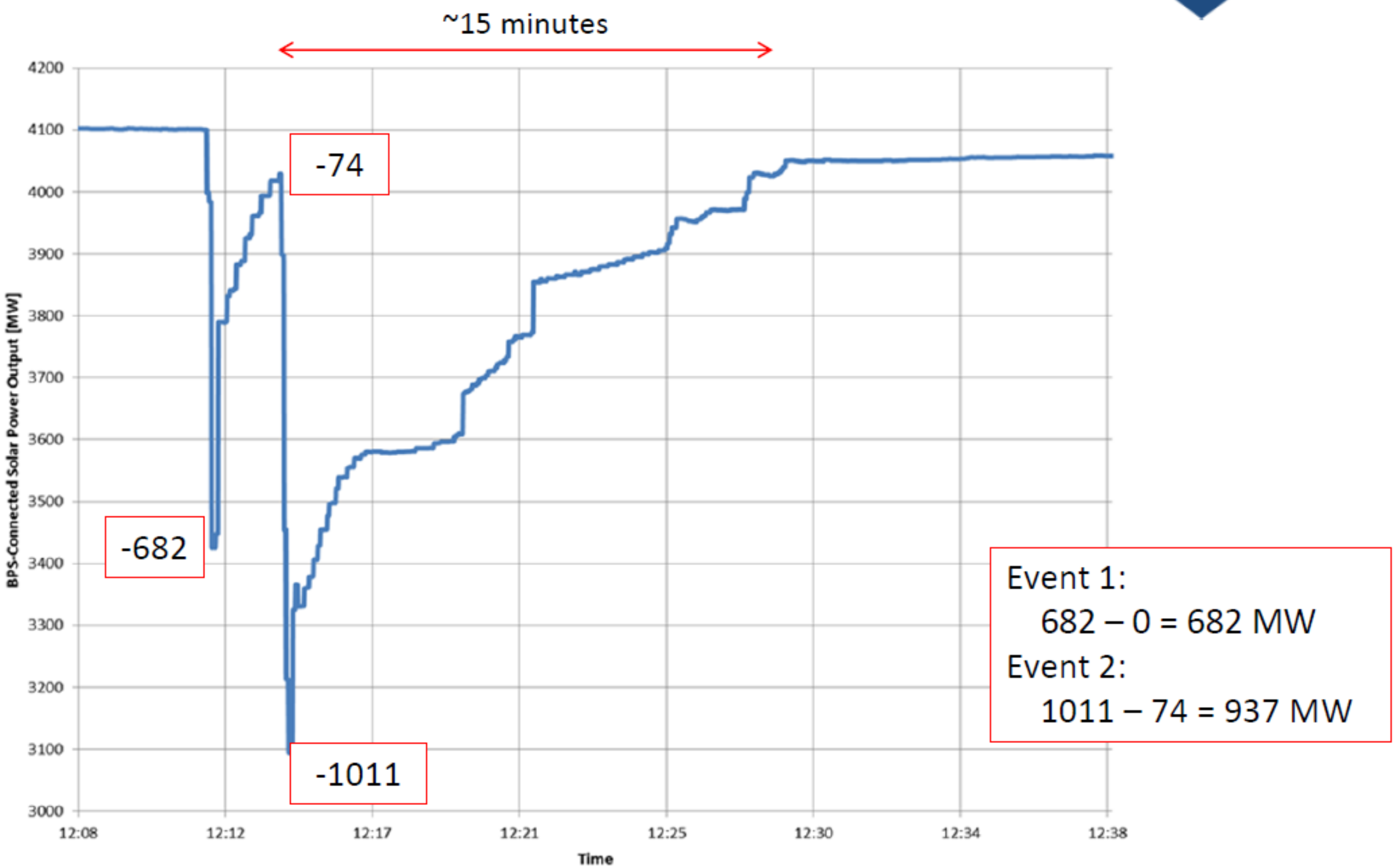



WI_20171009_191428

| | |
|---|---|
| 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 |

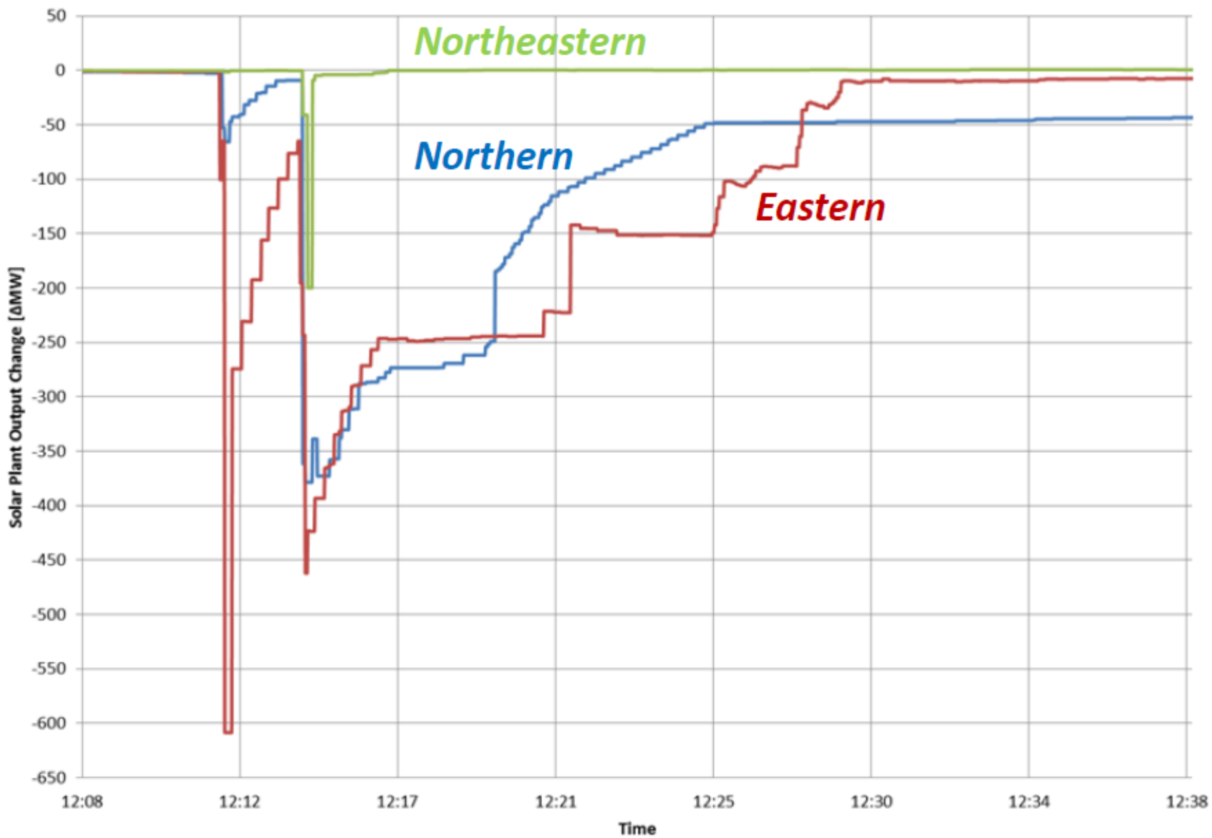
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Aggregate SCE Solar PV Performance SCADA Data



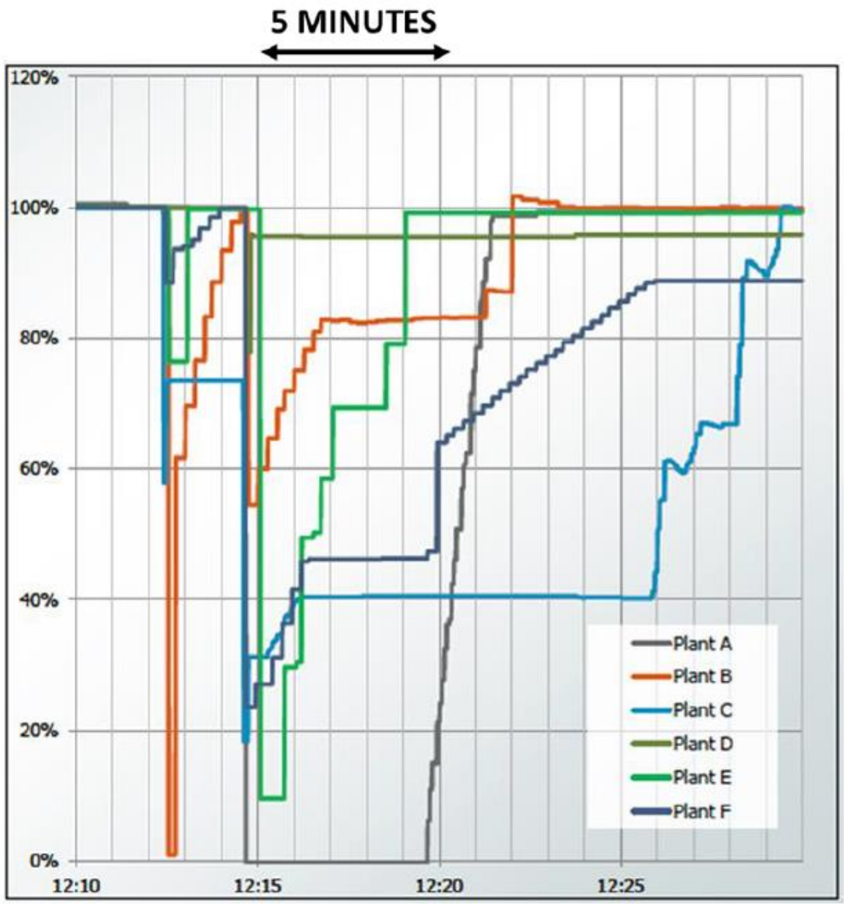
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Solar PV Outputs



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Solar PV Outputs



NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

# 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

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #1

*No erroneous frequency tripping*

- Alert recommended GOPs and GOs ensure inverter controls do not erroneously trip on instantaneous frequency measurements
- By October 9, 2017 event, 97% of inverter manufacturer's BPS-connected fleet had been updated
- Mitigating actions by inverter manufacturer and GOs appear to have worked

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #2

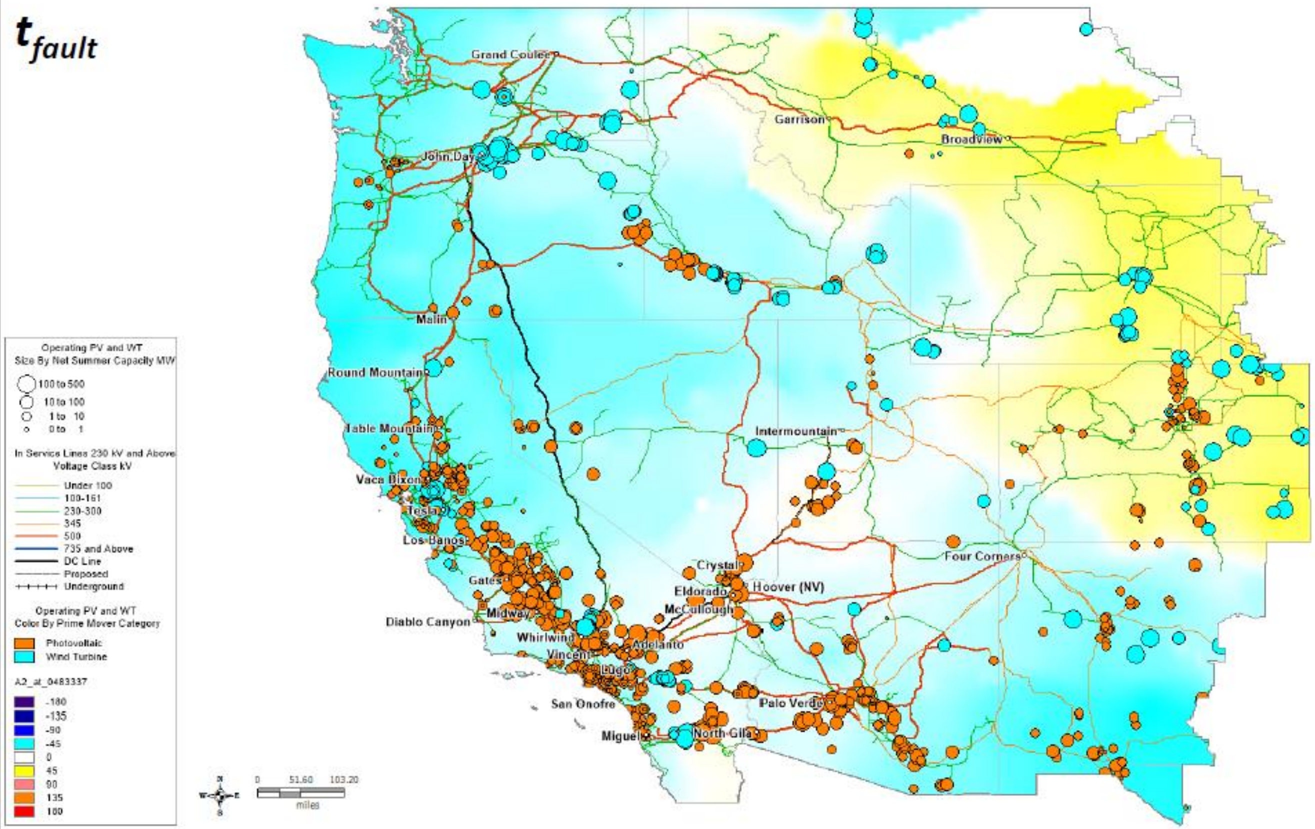
*Continued use of momentary cessation*

- Majority of existing inverters use momentary cessation
- Most use a low voltage threshold of ~0.9 pu
- Recovery of current following momentary cessation varies, relatively slow for grid dynamics
- Blue Cut Fire recommendation – interim solution
- NERC IRPTF studies – new recommendation
  - Stability studies show potential BPS wide-area stability issues

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Clarification and Recommendation for Momentary Cessation

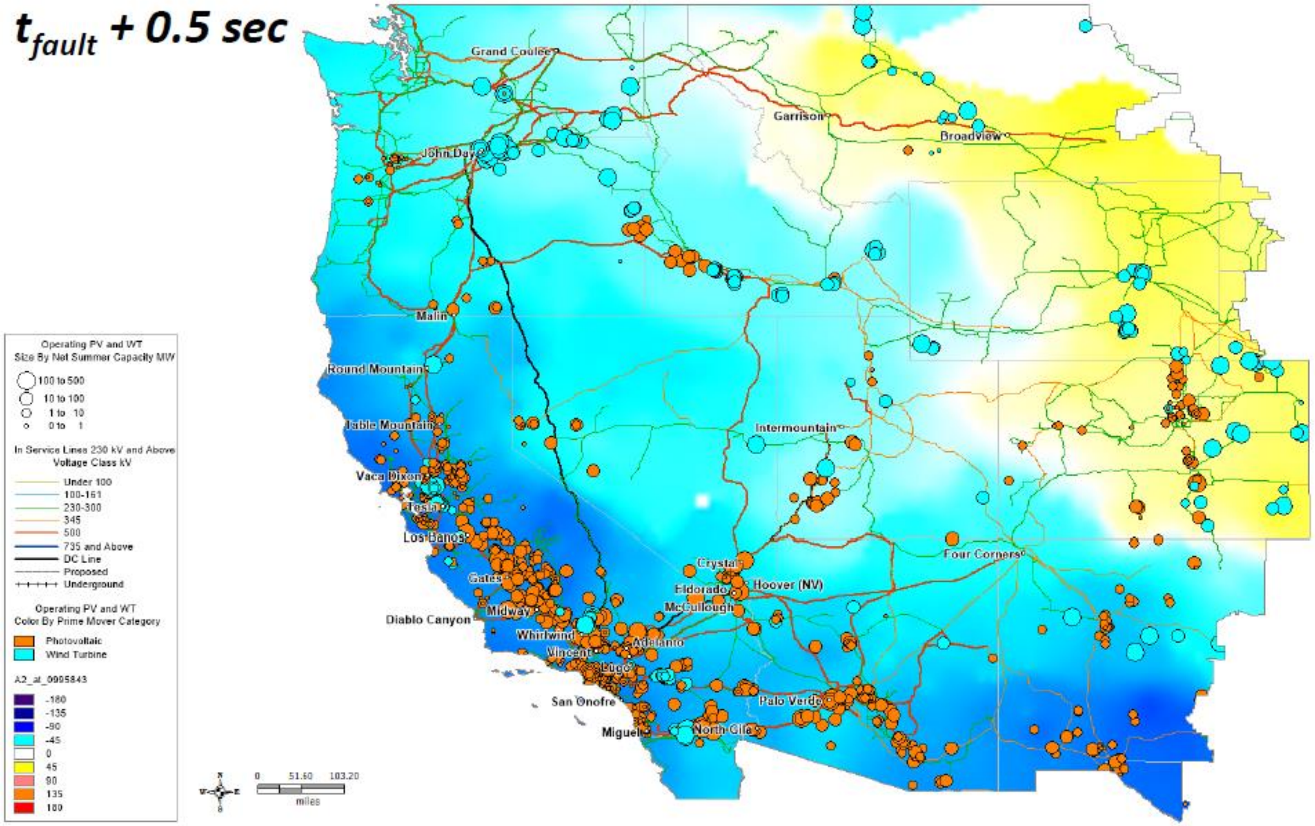
$t_{fault}$



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Clarification and Recommendation for Momentary Cessation

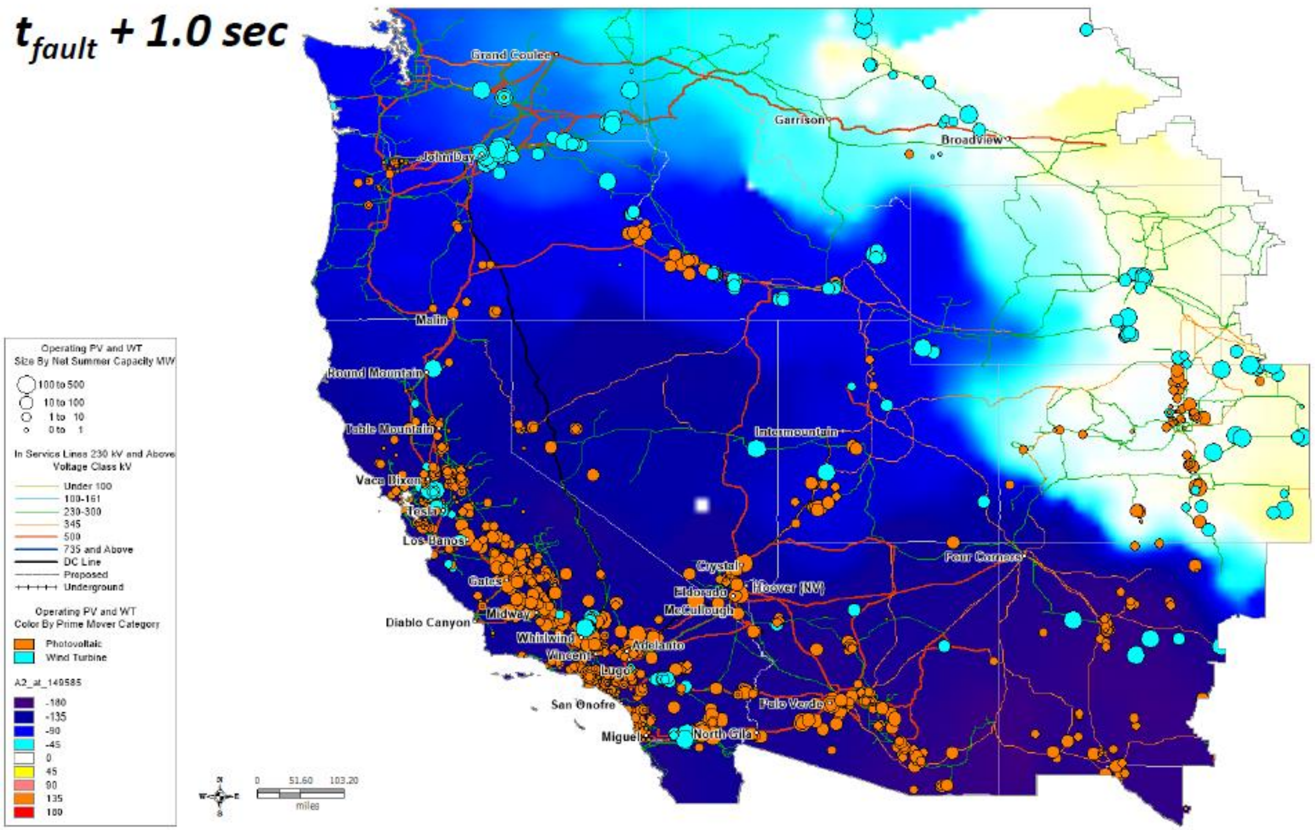
$t_{fault}$ + 0.5 sec



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

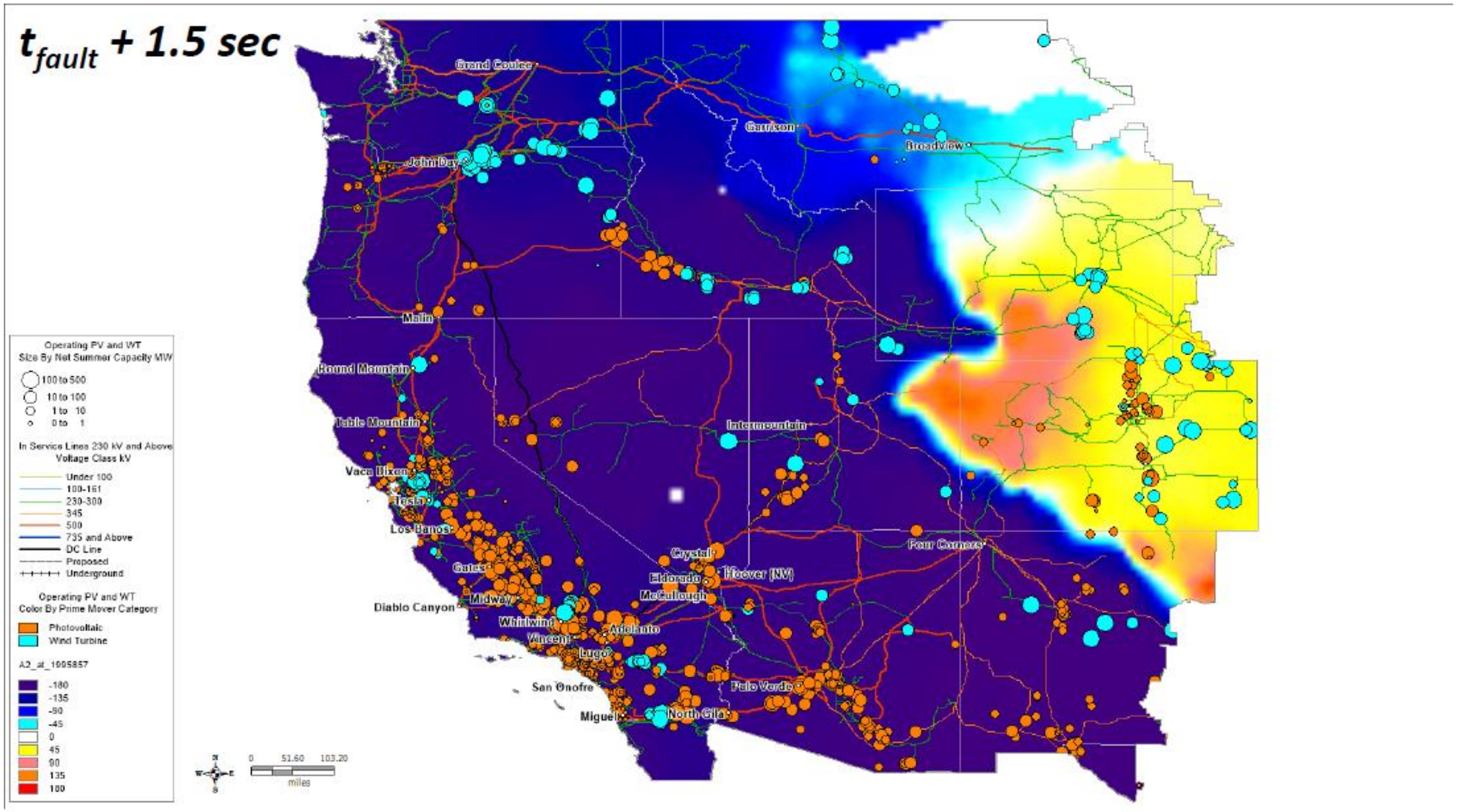
# Clarification and Recommendation for Momentary Cessation

***$t_{fault}$ + 1.0 sec***



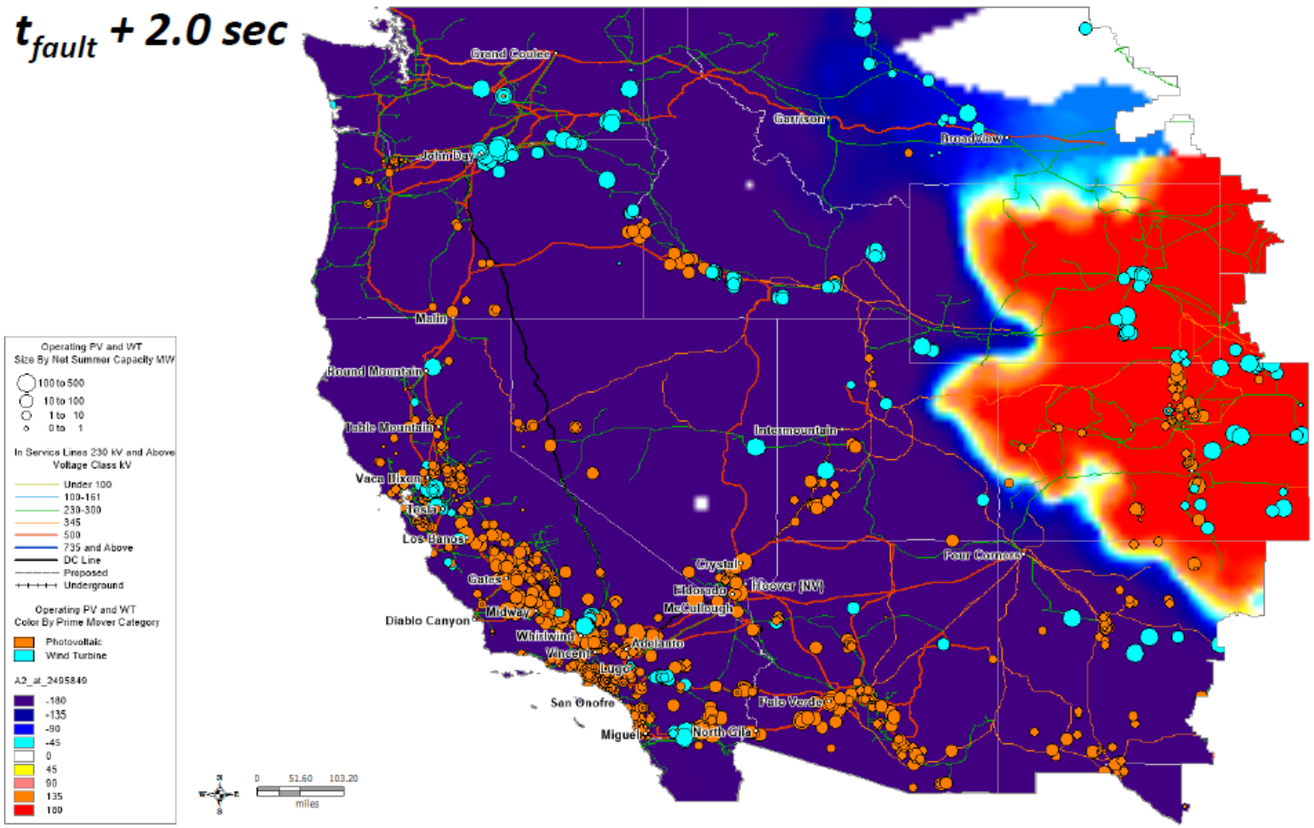
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Clarification and Recommendation for Momentary Cessation



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

## Clarification and Recommendation for Momentary Cessation



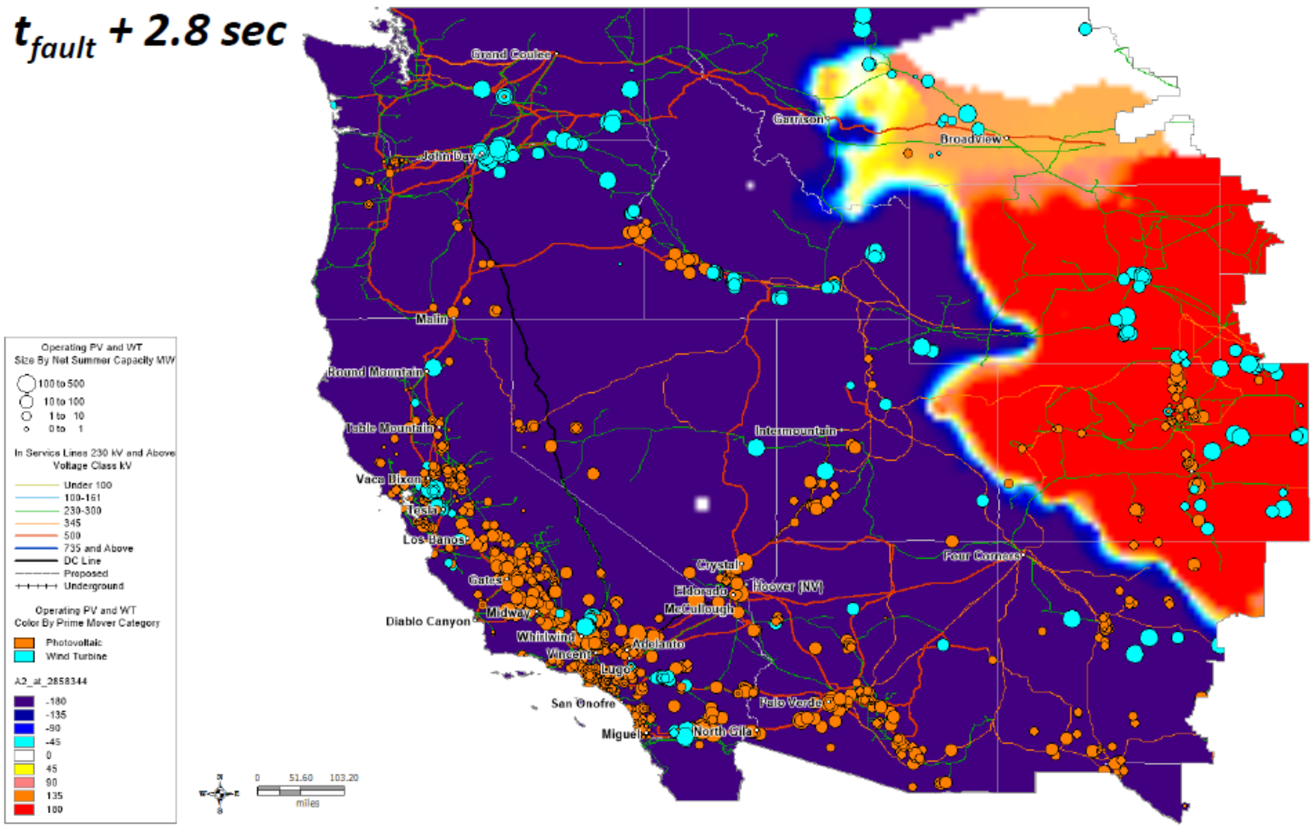



RELIABILITY | ACCOUNTABILITY

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Clarification and Recommendation for Momentary Cessation

$t_{fault}$ + 2.8 sec



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

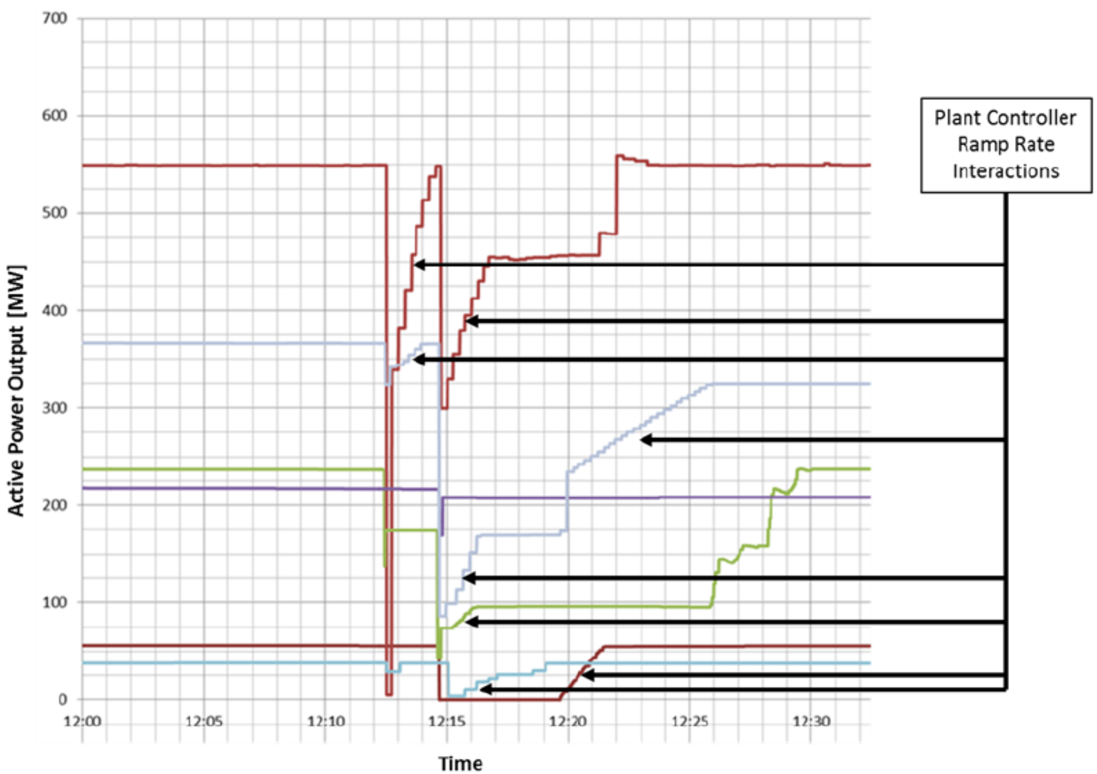
# Momentary Cessation Recommendation Moving Forward

- 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.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #3

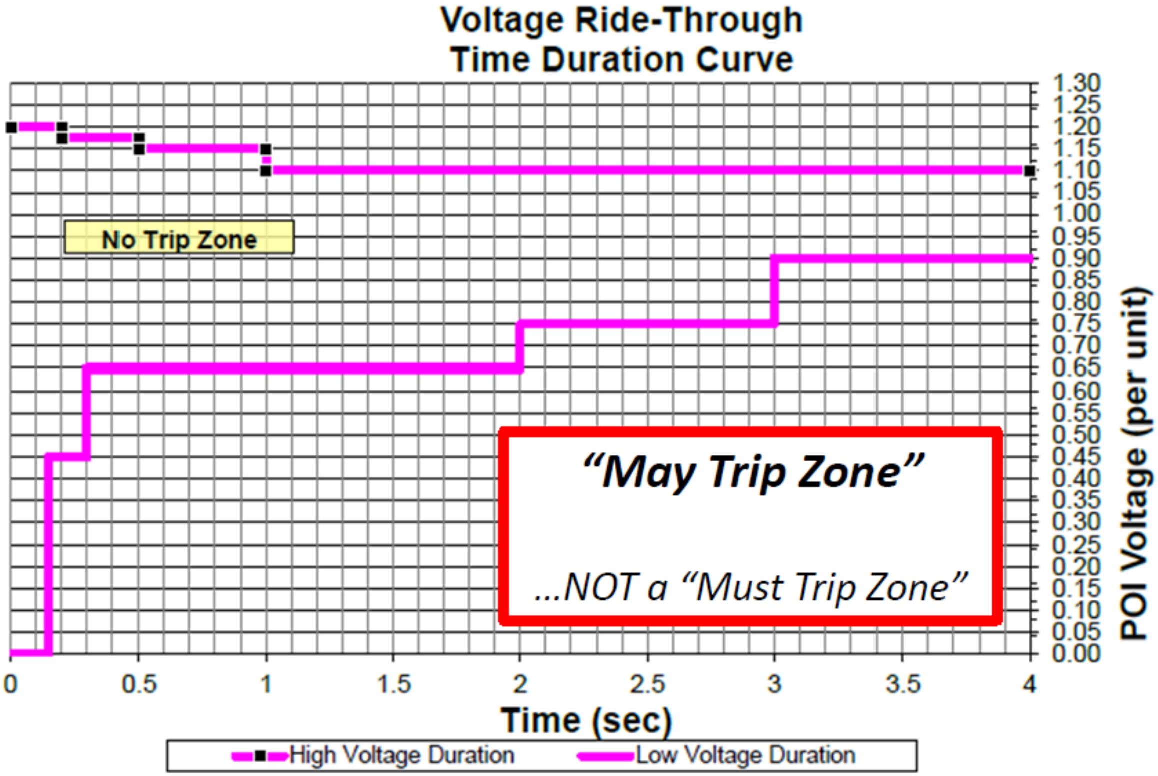
*Ramp rate interactions with return from momentary cessation*



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #4 Clarification 1

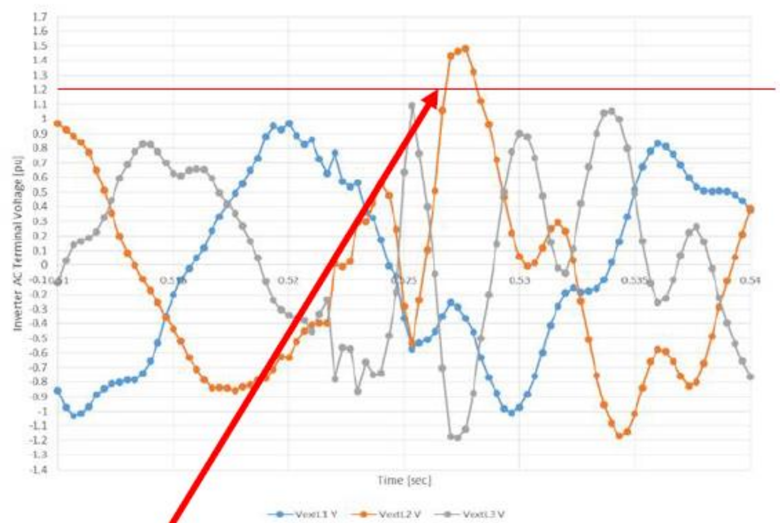
*Interpretation of PRC-024-2 voltage ride-through curve*



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #5

*Instantaneous voltage tripping and measurement filtering*



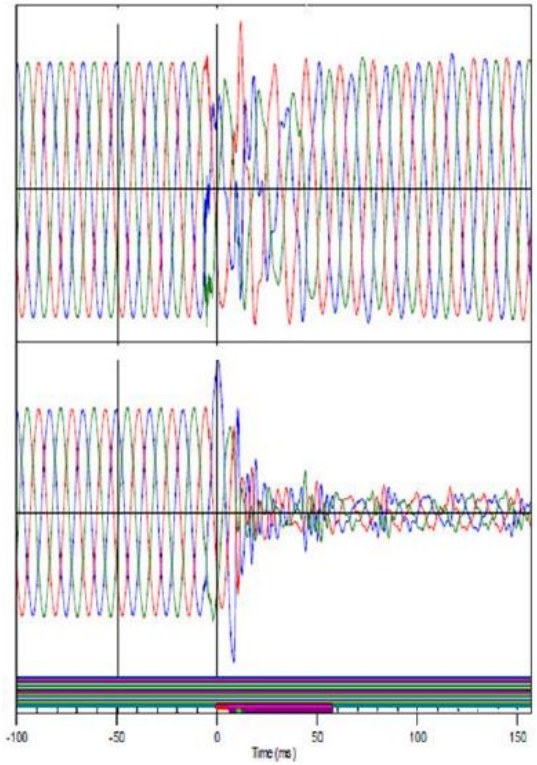

| Inst. Voltage [pu nominal peak] | Samples | Time [sec] | Cycles |
|---|---|---|---|
| > 1.1 | 5 | 0.00167 | 0.1 |
| > 1.2 | 4 | 0.00133 | 0.08 |
| > 1.3 | 4 | 0.00133 | 0.08 |
| > 1.4 | 3 | 0.00100 | 0.06 |

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

# Key Findings #8

*Transient interactions and ride-through considerations*

- Interactions between momentary cessation, in-plant shunt capacitors, transient voltages, harmonics, etc., that are not sufficient understood
- Requires detailed electromagnetic transient (EMT) studies needed



# TPL-001-5 Update

# TPL-001-5 Revision

**R1.** Each Transmission Planner and Planning Coordinator shall maintain System models within its respective area for performing the studies needed to complete its Planning Assessment. The models shall use data consistent with that provided in accordance with the MOD-032 standard, supplemented by other sources as needed, including items represented in the Corrective Action Plan, and shall represent projected System conditions. This establishes Category P0 as the normal System condition in Table 1. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

**1.1.** System models shall represent:

**1.1.1.** Existing Facilities.

**1.1.2.** Known outage(s) of generation or Transmission Facility(ies) scheduled in the Near-Term Transmission Planning Horizon selected for analyses pursuant to Requirement R2, Parts 2.1.3 and 2.4.3 only. Known outage(s) shall be selected according to an established procedure or technical rationale that, at a minimum:

**1.1.2.1.** Includes known outage(s) that are expected to result in Non-Consequential Load Loss for P1 events in Table 1 when concurrent with the selected known outage(s); and

**1.1.2.2.** Does not exclude known outage(s) solely based upon the outage duration.

# TPL-001-5 Revision

**2.1.** For the Planning Assessment, the Near-Term Transmission Planning Horizon portion of the steady state analysis shall be assessed annually and be supported by current annual studies or qualified past studies as indicated in Requirement R2, Part 2.6. Qualifying studies need to include the following conditions:

**2.1.1.** System peak Load for either Year One or year two, and for year five.

**2.1.2.** System Off-Peak Load for one of the five years.

**2.1.3.** P1 events in Table 1 expected to produce more severe System impacts on its portion of the BES, with known outages modeled as in Requirement R1, Part 1.1.2, under those System peak or Off-Peak conditions when known outages are scheduled.

# TPL-001-5 Revision

| Category | Initial Condition | Event [1] | Fault Type [2] | BES Level [3] | Interruption of Firm Transmission Service Allowed [4] | Non-Consequential Load Loss Allowed |
|---|---|---|---|---|---|---|
| **P8**<br>Multiple Contingency *(Fault plus non-redundant component of a Protection System failure to operate)* | Normal System | Delayed Fault Clearing due to the failure of a non-redundant component of a Protection System[13] protecting the Faulted element to operate as designed, for one of the following:<br>1. Generator<br>2. Transmission Circuit<br>3. Transformer [5]<br>4. Shunt Device [6]<br>5. Bus Section | 3Ø | EHV, HV | Yes | Yes |

Currently considered an Extreme Event that does not require Corrective Action Plan

- Delayed clearing due to failure of a non-redundant component of a Protection System is a concern

- Definition of "non-redundant component of a Protection System" is a major issue.

- Footnote 13

# Footnote 13

13. For purposes of this standard, non-redundant components of a Protection System to consider are as follows:

   a. A single protective relay which responds to electrical quantities, without an alternative (which may or may not respond to electrical quantities) that provides comparable Normal Clearing times~~, e.g. sudden pressure relaying~~;

   b. A single communications system, necessary for correct operation of a communication-aided protection scheme required for Normal Clearing, which is not monitored or not reported at a Control Center;

   c. A single station dc supply associated with protective functions required for Normal Clearing, and that single station dc supply is not monitored or not reported at a Control Center for both low voltage and open circuit;

   d. A single control circuitry (including auxiliary relays and lockout relays) associated with protective functions through and including the trip coil(s) of the circuit breakers or other interrupting devices required for Normal Clearing.

Meeting the standard's requirements associated with this footnote is likely to require relay, breaker and battery monitoring or battery bank modifications.

# *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

TAG Meetings

1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter

# 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***
  - ✓ **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***
  - **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 2018 Study Scope**

# April - May – June

***<u>Second Quarter TAG Meeting – June 19th</u>***

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

# July - August – September

***Third Quarter TAG Meeting – TBD***

## ➢ 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

***<u>Fourth Quarter TAG Meeting – TBD</u>***

## ➢ 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 ?