TAG Meeting
July 13, 2017

Webinar
Presentations

TAG Meeting Agenda

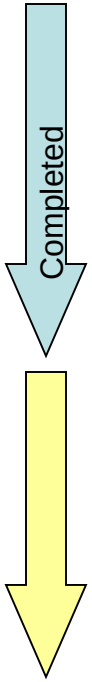
1. Administrative Items – Rich Wodyka
2. 2017 Study Activities Update – Orvane Piper
3. NCTPC 2016 Collaborative Transmission Plan Mid-year Update – Mark Byrd
4. Regional Studies Update – Bob Pierce
5. 2017 TAG Work Plan – Rich Wodyka
6. TAG Open Forum – Rich Wodyka

2017 Study Activities Update

Orvane Piper

Duke Energy Carolinas

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

Studies for 2017

- **Annual Reliability Study**
  - **Assess DEC and DEP transmission systems' reliability and develop a single Collaborative Transmission Plan**
- **Resource Supply Scenarios**
  - **Assess DEC and DEP interface with neighboring systems by modeling hypothetical transfers**

Annual Reliability Studies

- 2022 Summer: near term
- 2022/2023 Winter: near-term
- 2027/2028 Winter: long-term

Resource Supply Scenarios

Resource From	Sink	Test Level (MW)
PJM	DUK[1]	1,000
SOCO	DUK	1,000
SCEG	DUK	1,000
SCPSA	DUK	1,000
CPLE[2]	DUK	1,000
TVA	DUK	1,000

1 – DUK is the Balancing Authority Area for DEC
2 – CPLE is the eastern Balancing Authority Area for DEP

Resource Supply Scenarios

Resource From	Sink	Test Level (MW)
PJM	CPLE	1,000
SCEG	CPLE	1,000
SCPSA	CPLE	1,000
DUK	CPLE	1,000
SOCO[3]	CPLE	1,000

3 – This hypothetical transfer is intended to evaluate the impact of a 1000 MW Southern Co transaction through the DEC transmission system into CPLE.

Resource Supply Scenarios

Resource From	Sink	Test Level (MW)
PJM	DUK / CPLE	1,000 / 1,000
DUK / CPLE	PJM	1,000 / 1,000
CPLE	PJM	1,000
DUK	PJM	1,000
DUK	SOCO	1,000

Technical Analysis

- Conduct thermal screenings of the 2022S, 2022/23W and 2027/28W base cases
- Conduct thermal screenings for hypothetical transfers on 2027/28W 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 2016 Collaborative Transmission Plan Update

Mark Byrd

Duke Energy Progress

2017 Mid-Year Update to the 2016 Collaborative Transmission Plan

- **One DEP project was completed in early 2017**
- **Seven DEP project cost estimates increased and one DEC decreased (net change of + $68M)**
- **One DEC project was accelerated by 6 months**
- **Total Reliability Project Cost estimates changed from $214M to $282M**

Reliability Projects in 2016 Plan		
Reliability Project	**TO**	**Planned I/S Date**
Durham-RTP 230kV Line, Reconductor	DEP	June 2025
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	June 2018
Jacksonville-Grant's Creek 230 kV Line and Grant's Creek 230/115 kV Substation	DEP	June 2020

Reliability Projects in 2016 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**
Fort Bragg Woodruff St 230 kV Sub, Replace 150 MVA 230/115 kV transformer with two 300 MVA banks & reconductor Manchester 115 kV feeder	**DEP**	**Completed February 2017**
Sutton-Castle Hayne 115 kV North line Rebuild	**DEP**	**June 2019**

Reliability Projects in 2016 Plan (continued)		
Reliability Project	**TO**	**Planned I/S Date**
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 2019**
Cane River 230 kV Substation, Construct 150 MVAR SVC	**DEP**	**December 2019**
Reconductor Harley 100 kV	**DEC**	**December 2020**
Asheboro-Asheboro East 115 kV North Line Reconductor	**DEP**	**June 2019**

Questions ?

Regional Studies Reports

Bob Pierce

Duke Energy Carolinas

SERC Long Term Study Group Update

SERC Long Term Study Group

- Firm Flow Task Force (complete)
- 2017 LTSG study beginning
- 2017 series model development
  - SERC LTSG complete
  - MMWG started

SERTP

SERTP

- 2nd quarter Stakeholder meeting – June 20th

- Perform Economic Transfer Studies
  - Santee Cooper Border to PJM Border – 300 MW
  - Southern Company to Santee Cooper Border – 500 MW
  - TVA to FRCC Border – 500 MW
  - TVA to PJM Border – 500 MW
  - TVA to Duke Energy Carolinas – 300 MW

http://www.southeasternrtp.com/

CTCA Study Results

- Posted on OASIS and NCTPC websites
- Per TPL-001-4
- Studied
  - 2018/19 Winter Peak
  - 2022 Summer Peak (VC Summer 2-3)
- Shared 20 Gen Down Cases

Reported results throughout the study area based on:

- Thermal loadings greater than 90%.
- Voltages less than individual company criteria.
- Potential reliability concerns that are located near control area borders or include significant EHV BES facilities

Concerns that are already being reported in each company's annual TPL assessment were not to be reported to avoid redundant reporting and sharing internal system projects that would not be of interest to neighboring companies.

Duke, Progress, SCE&G, and SCPSA each ran their own NERC TPL-001-4 P0-P7 assessments using their own internal planning processes.

SIMULTANEOUS FEASIBILITY ASSESSMENT

- With the addition or acceleration of the projects listed in the study results and reported in each company's 2016 annual TPL assessments, the study results indicated the Participants' current transmission expansion plans are simultaneously feasible for both 2018/19 Winter and 2022 Summer conditions

SUMMARY OF POTENTIAL RELIABILITY ISSUES

- Lyles-Columbia 115 kV SCE&G-SCPSA tie line was found to have potential thermal loading concerns. This issue was also found in SCPSA's internal transmission assessment as well as based on the TPL 001-4 standard in later cases. Both SCE&G and SCPSA have identified this potential tie line concern and are actively testing an Operating Procedure to implement in the near future. Potential project may be needed to address this issue.

LESSONS LEARNED AND FUTURE WORK

- Importance of sharing Generation Down cases from across the CTCA footprint for use by other participants when running their NERC TPL-001-4 P0-P7 assessments
- The assessment results provided the PFSG and PC an increased awareness of the impact of the availability of off-system generation on each company's transmission system reliability.
- Recognizable impacts in loading on participants' facilities were noted while studying neighbor's Generation Down cases, although none required initiation of additional corrective actions.

LESSONS LEARNED AND FUTURE WORK

- CTCA Powerflow Study Group to create framework for increased future coordination:
  1. Producing three coordinated peak base cases (Year 1 or 2, Year 5, and Year 6-10) including the latest available transmission planning models and planned projects
  2. The MMWG cases being created at the end of 2017 may be used for the external modeling.
  3. Coordination of interchange for the cases may be able to align with the timing of the SERC LTSG's Databank Update interchange coordination efforts.
  4. Producing all requested Generation Down/Alternate Dispatch (e.g. PV all on) scenario cases.
  5. Coordinating subsystem, monitor, and contingency files to enable accurate monitoring and analysis of neighboring control areas in support of NERC TPl-001-4 R3.4.1 coordination requirements.

NERC Reliability Standards Update

- PRC-024-2
- California PV Resource Interruption Report

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

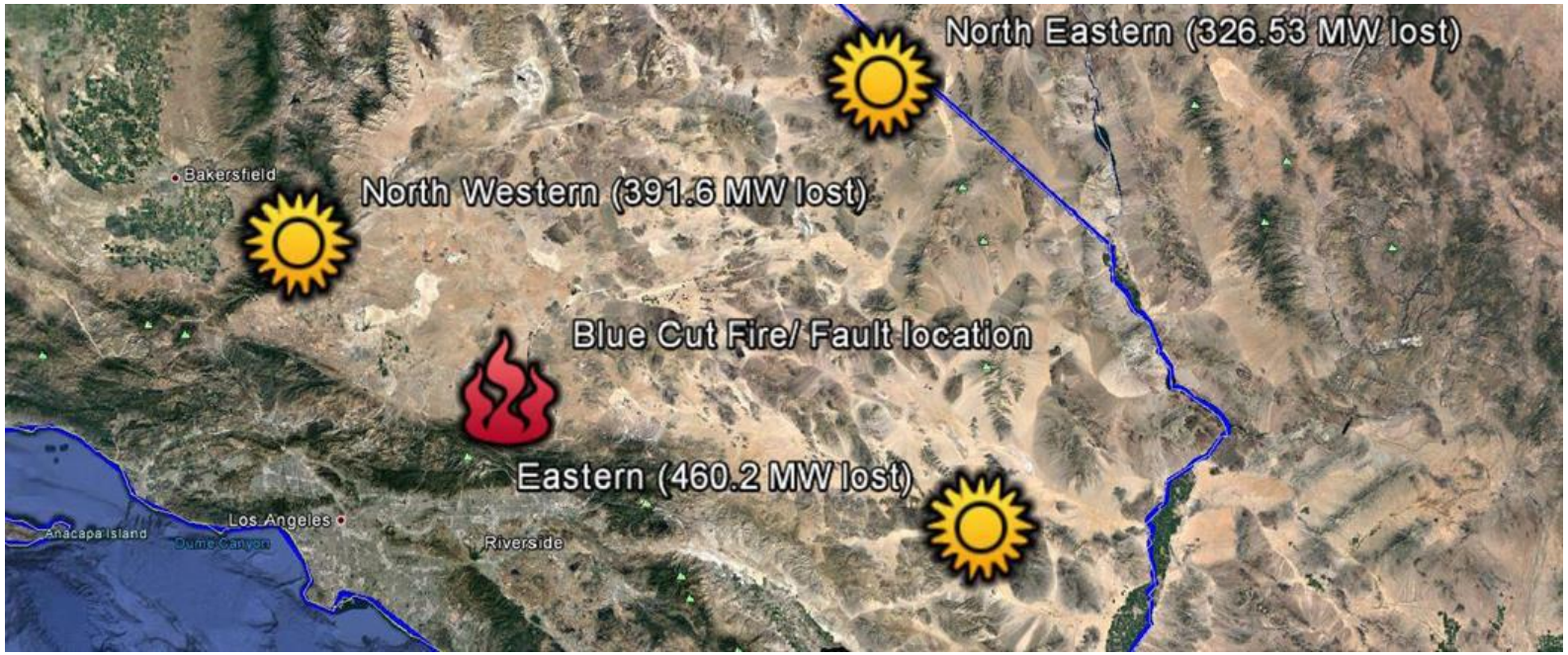
1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

Southern California 8/16/2016 Event

June 2017

RELIABILITY | ACCOUNTABILITY

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


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

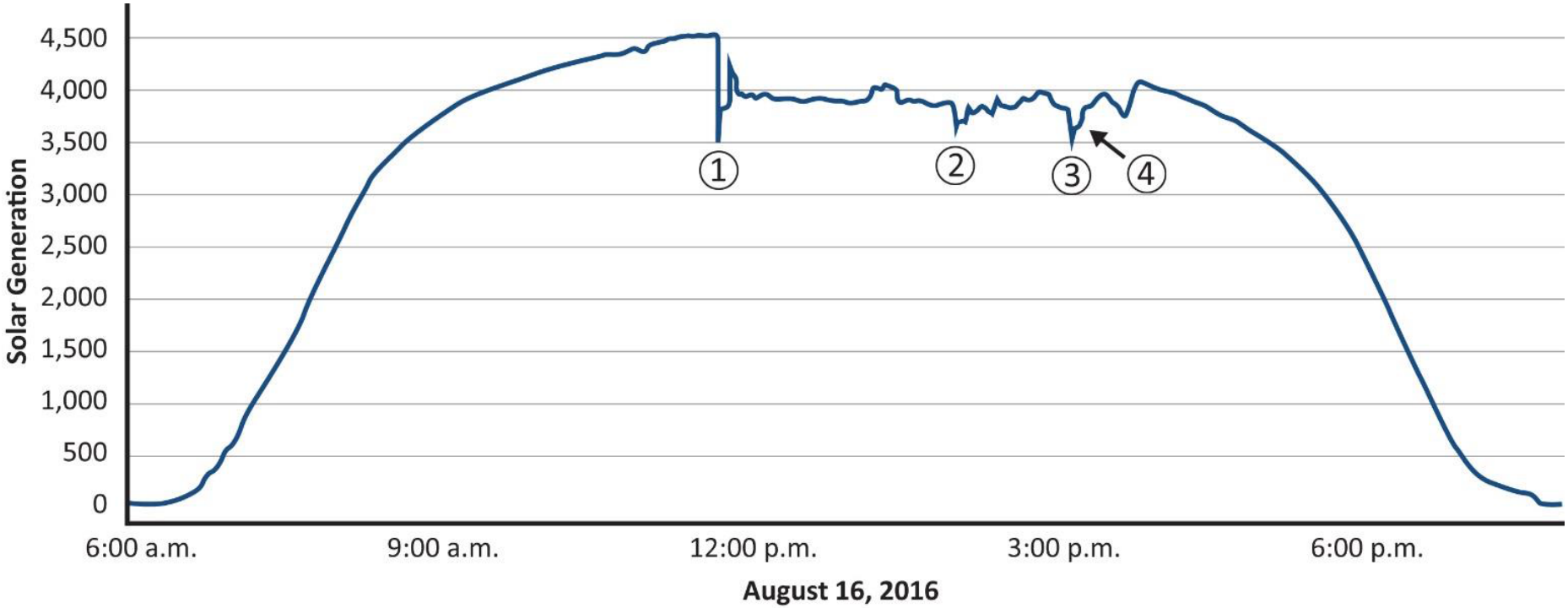
SUMMARY

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).

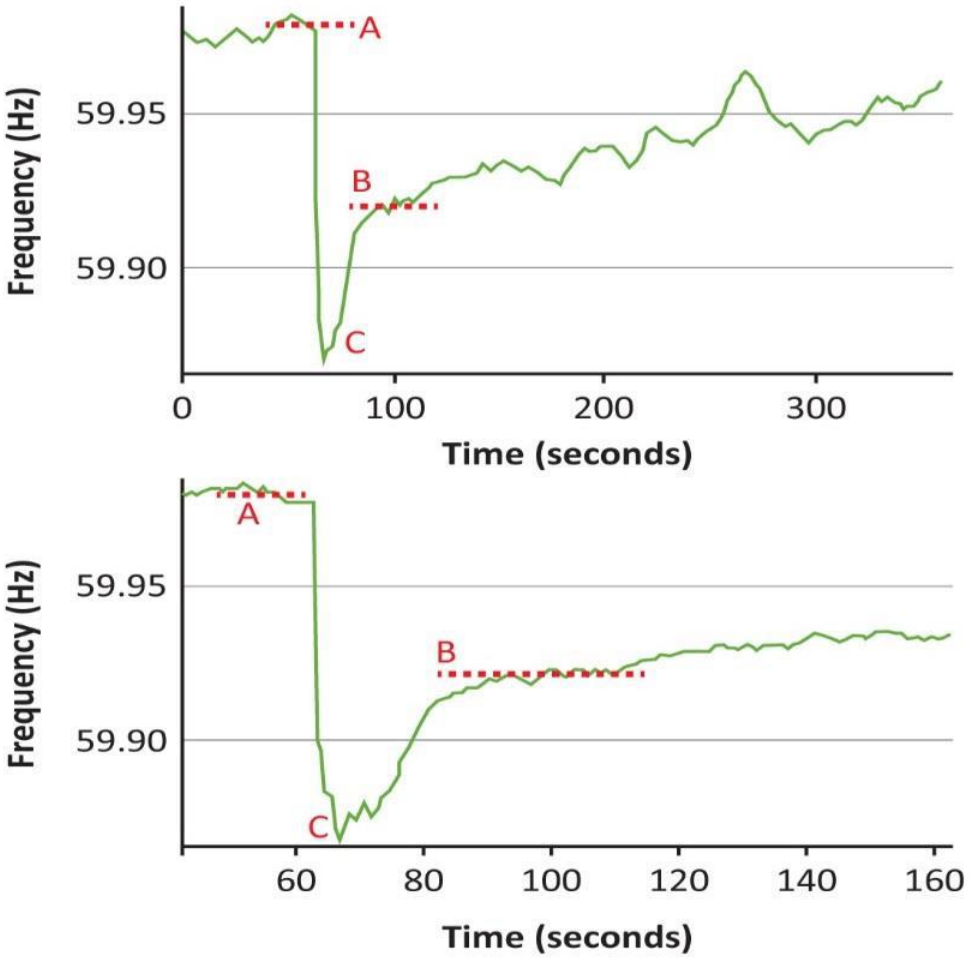
- Many of the inverters stopped outputting power before the fault cleared, indicating that the faulted condition alone created the condition that caused the response as opposed to post-fault system response (transient stability).
- Many inverters calculated frequencies at the inverter terminals which 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.

Table 1.1: Solar Photovoltaic Generation Loss						
Event No.	Date/Time	Fault Location	Fault Type	Clearing Time (cycles)	Lost Generation (MW)	Geographic Impact
1	8/16/2016 11:45	500 kV line	Line to Line (AB)	2.49	1,178	Widespread
2	8/16/2016 14:04	500 kV line	Line to Ground (AG)	2.93	234	Somewhat Localized
3	8/16/2016 15:13	500 kV line	Line to Ground (AG)	3.45	311	Widespread
4	8/16/2016 15:19	500 kV line	Line to Ground (AG)	3.05	30	Localized

Event No. 1 was particularly impactful because of the widespread loss of 1,178 MW of PV generation. Approximately 66 percent of the generation lost in that event recovered within about five minutes. Three PV plants had a sustained loss of 400 MW that did not return until the following day, reportedly due to curtailment orders from the BA.



Utility-Scale Solar PV Output in SCE Footprint on August 16, 2016



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

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.

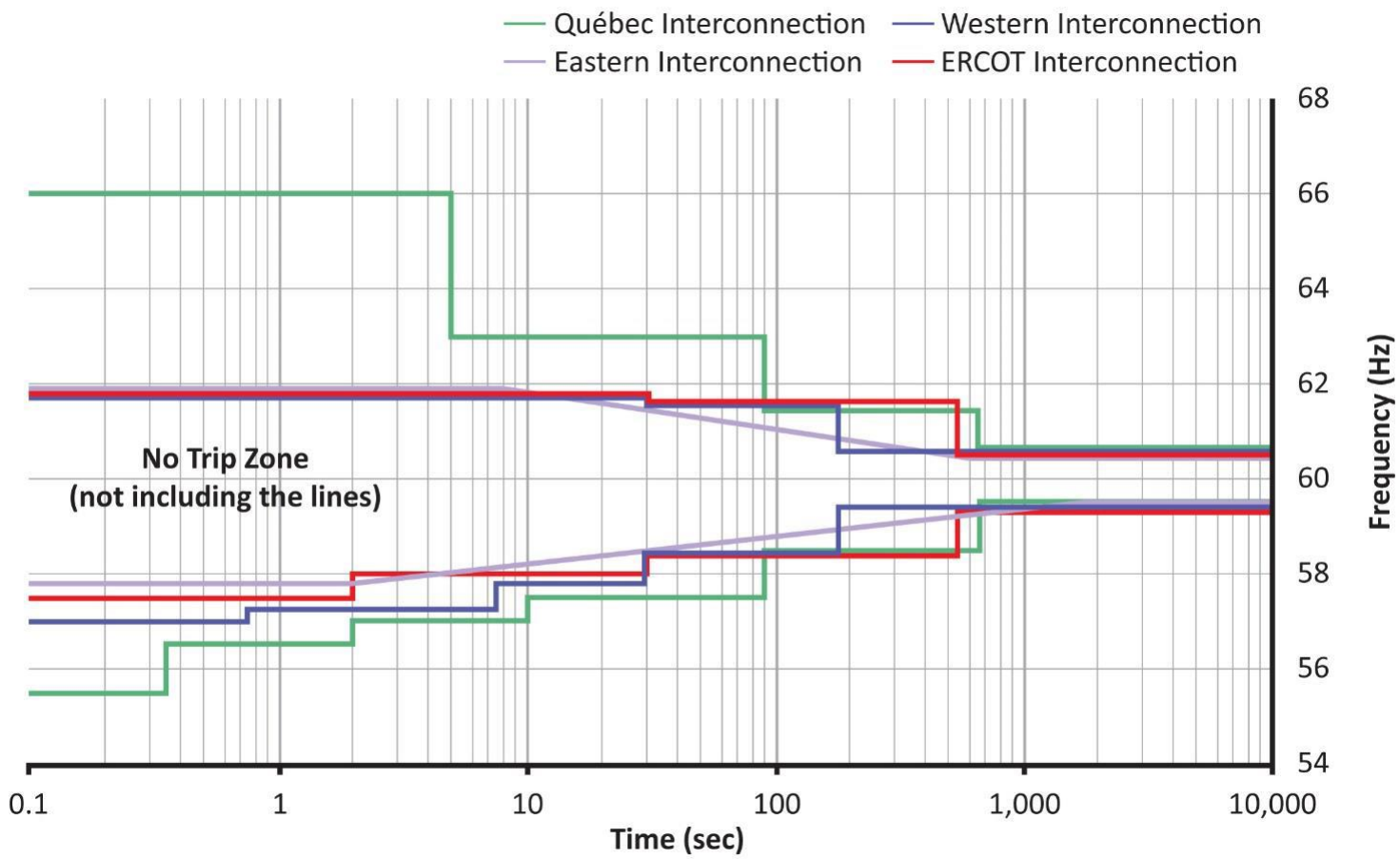
- ~100 MW that tripped by inverter dc overcurrent protection after starting the momentary cessation operation. The exact cause of these inverters tripping has not been determined and is still under investigation by the manufacturers.

Of the two types of interruption, tripping and momentary cessation, tripping is the most impactful as it removes the resource from the interconnection for approximately five minutes. If momentary cessation is restored quickly, the frequency decline is less severe than an equivalent MW amount of tripping.

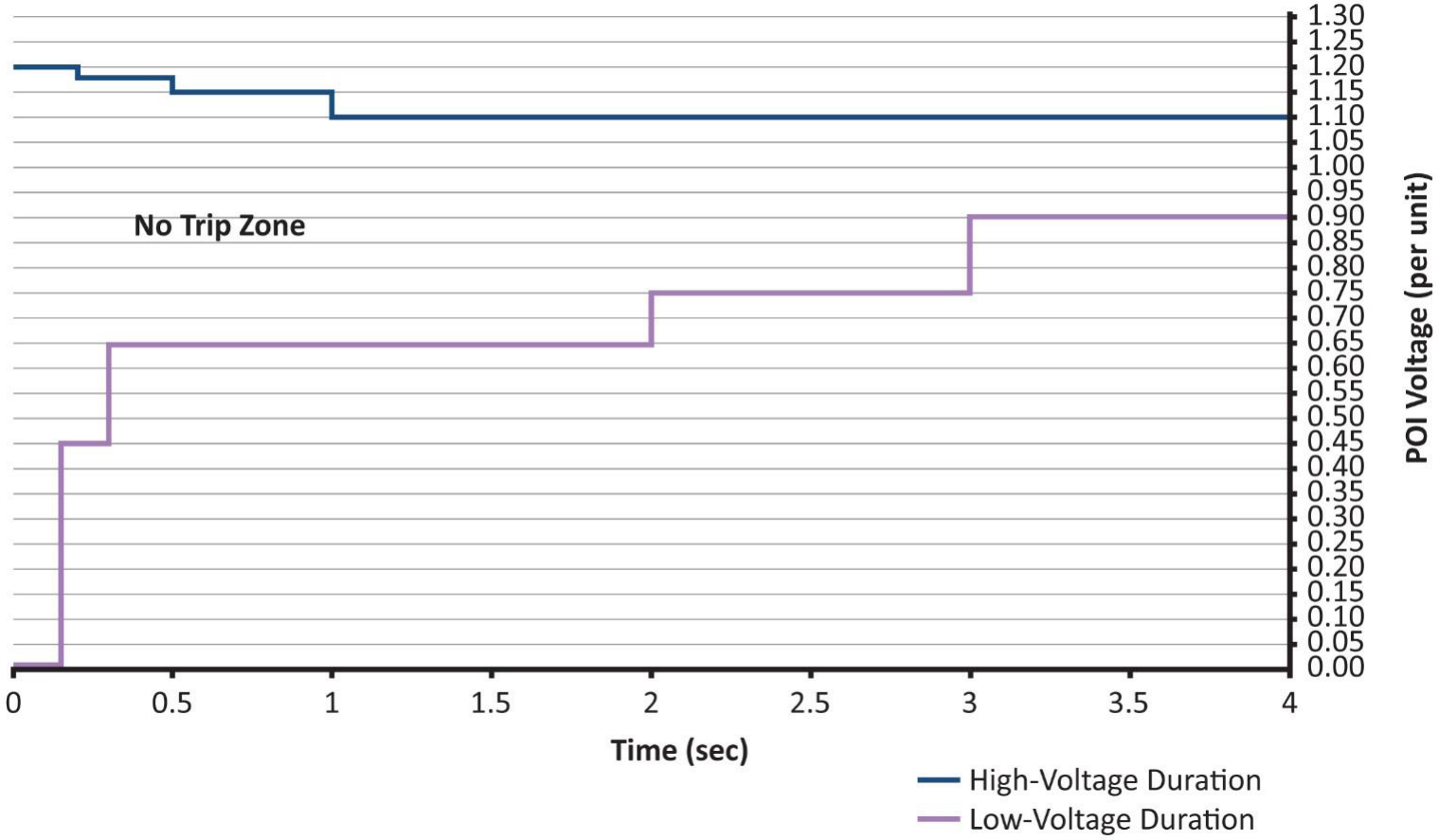
Contributing Factors

Two predominant industry standards relate to inverter operation:

- NERC Reliability Standard PRC-024-2
- IEEE Standard 1547



PRC-024-2 Frequency Ride-Through Curves



PRC-024-2 Voltage Ride-Through Curves

Inverter-based resources do not typically use traditional protective relaying, and they operate very differently than conventional synchronous rotating ac machines.

At a high level, inverters have the following three operating modes:

- **Continuous Operation**: An operating mode where they are actively injecting current into the grid
- **Momentary Cessation:** A mode where they have momentarily ceased injecting active current into the grid but remain electrically connected. This mode is triggered by abnormal system voltages (< 0.9 or > 1.1 per unit)
- **Trip mode (Cease to Energize):** A mode where the inverters have ceased injecting current and will delay returning to service (typically a five-minute delay). They may also mechanically disconnect the inverter from the grid

PRC-024-2 specifies a no-trip area for voltage and frequency excursions.

Solar development owners and inverter manufacturers have articulated that they do not treat the no-trip area as a “no momentary cessation” area and may use momentary cessation within the no-trip area.

In addition, the use of “instantaneous trip” in **Table 2.1** in the PRC-024-2 standard have led solar development owners and inverter manufacturers to believe that outside of the no-trip area is a required must-trip area.

The IEEE 1547 standard recommends certain operating characteristics for distribution connected resources. In the past, one of the main concerns for distribution connected generation was islanding. This emphasis on anti-islanding led to a large amount of the operating criteria in the currently approved 154714 to be contrary to the ride-through requirements of the BES. While existing IEEE 1547 and PRC-024-2 cover distinctly different jurisdictions, the requirements are inherently in conflict with each other. The philosophy for distribution connected generation has changed in the recent past to put more emphasis on ride through and smart inverter type technology. These revised philosophies are now in line with the intent of NERC PRC-024-2 with regards to ride-through capability and voltage support. If the revised IEEE 1547 goes into effect without major changes, the ride-through requirements of IEEE 1547 will be in alignment with PRC-024-2.

NERC Solar Resource Performance Joint Task Force

Questions ?

2017 TAG Work Plan

Rich Wodyka
Administrator

2017 NCTPC Overview Schedule

Reliability Planning Process

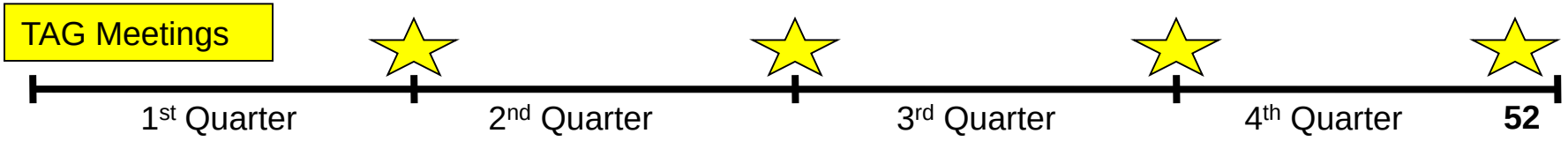
- Evaluate current reliability problems and transmission upgrade plans
- Perform analysis, identify problems, and develop solutions
- Review Reliability Study Results

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



2017 TAG Work Plan

January - February - March

- **2017 Study – Finalize Study Scope of Work**
  - **Receive final 2017 Reliability Study Scope for comment**
    - ***Review and provide comments to the OSC on the final 2017 Study Scope – Provide Comments by March 31st***
  - ✓ **Receive request from OSC to provide input on proposed Local Economic Study scenarios and interfaces for study**
    - ***Provide input to the OSC on proposed Local Economic Study scenarios and interfaces for study – No Requests***
  - ✓ **Receive request from OSC to provide input in identifying any public policies that are driving the need for local transmission**
    - ***Provide input to the OSC in identifying any public policies that are driving the need for local transmission for study – No Requests***

January - February - March

First Quarter TAG Meeting – March 17th

- **2017 Study Update**
  - ✓ **Receive a progress report on the Reliability Planning study activities and 2017 Study Scope**
    - ***Provide comments on the final 2017 Study Scope to Rich Wodyka at rawodyka@aol.com by March 31st.***
  - ✓ **Receive a report on the Local Economic Study scope and any public policy scenarios that are driving the need for local transmission for study- No Requests**

April - May - June

Second Quarter TAG Meeting – delayed until July 13th

- **2017 Study Update**
  - ✓ **Receive a progress report on study activities**
  - ✓ **Receive update status of the upgrades in the 2016 Collaborative Plan**

July - August - September

- **2017 Study Update**
  - **Receive a progress report on the study activities and preliminary results**
  - **TAG will be requested to provide input to the OSC and PWG on the technical analysis performed, the problems identified as well as proposing alternative solutions to the problems identified**
- **2017 Selection of Solutions**
  - **TAG will receive feedback from the OSC on any alternative solutions that were proposed by TAG members**

July - August - September

Third Quarter TAG Meeting – September 19th Tentative

- **2017 Study Update**
  - **Receive a progress report on the study activities and preliminary results**

October - November - December

- **2017 Study Update**
  - **Receive and comment on final draft of the 2017 Collaborative Transmission Plan Report**
  - **Discuss potential study scope for 2018 studies**

October - November - December

Fourth Quarter TAG Meeting – December 13th Tentative

- **2017 Study Update**
  - **Receive presentation on the final draft report of 2017 Collaborative Transmission Plan**
  - **Discuss potential study scope for 2018 studies**

Questions ?

TAG
Open Forum Discussion

Comments or Questions ?