

# NERC

NORTH AMERICAN ELECTRIC  
RELIABILITY CORPORATION

# Industry Webinar

Project 2013-03 Geomagnetic Disturbance Mitigation

Frank Koza, PJM Interconnection

July 27, 2017

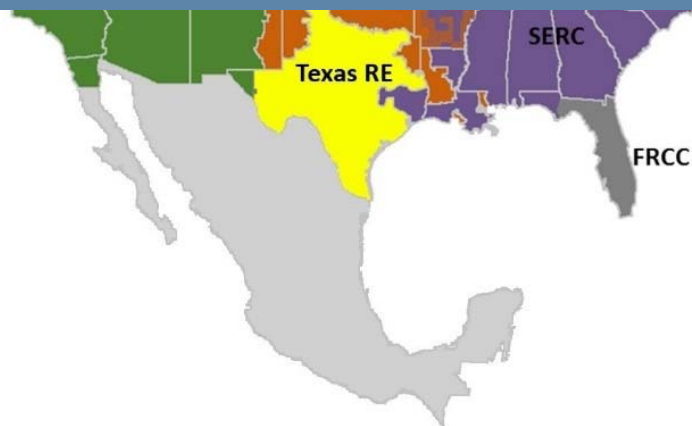
**RELIABILITY | ACCOUNTABILITY**



- Administrative Items
- Review of TPL-007-1
  - Benchmark GMD Event
- Directed Revisions
  - Supplemental Geomagnetic Disturbance (GMD) Event
  - Thermal Assessment
  - Corrective Action Plan
- New Requirements
- Supporting documents
- Next Steps
- Questions and Answers



# Administrative Items



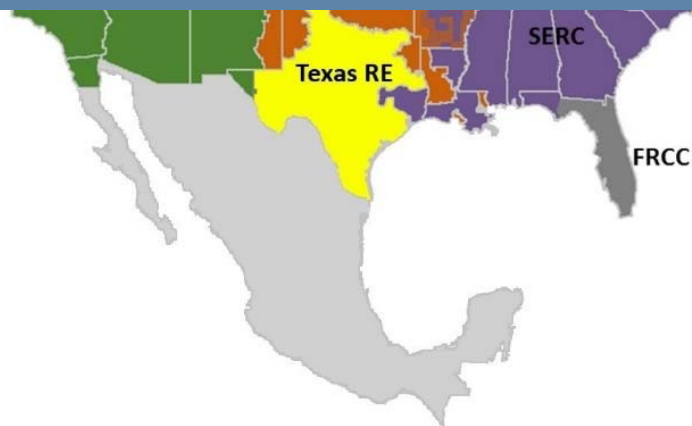
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- **Presentation Material**
  - Information used herein is used for presentation purposes and may not reflect the actual work of the official posted materials
- **For the official record**
  - This presentation is not a part of the official project record
  - Comments must be submitted during the formal posting

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Per-Anders Lof	National Grid
Jow Ortiz	NextEra Florida Power & Light
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# Review of TPL-007-1



- *...the Commission approves Reliability Standard TPL-007-1 as just, reasonable, not unduly discriminatory or preferential and in the public interest. While we recognize that scientific and operational research regarding GMD is ongoing, we believe that the potential threat to the bulk electric system warrants Commission action at this time, including efforts to conduct critical GMD research and update Reliability Standard TPL-007-1 as appropriate.*

U.S. Federal Energy Regulatory Commission (FERC)  
September 2016

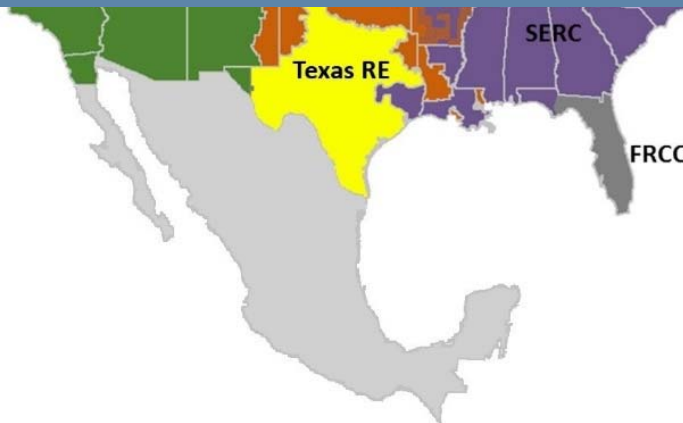


- TPL-007-1 addresses risks of voltage collapse and equipment damage in the Bulk Electric System (BES) caused by GMD events
- Applicable entities:
  - **Planning Coordinator (PC) and Transmission Planner (TP)**—perform ground induced current (GIC) calculation and network analysis (i.e., Vulnerability Assessments)
  - **Transmission Owner (TO)**—assess extra high voltage (EHV) transformers (Wye-grounded on high-side, 230kV and higher)
  - **Generator Owner (GO)**—assess EHV transformers (Wye-grounded on high-side, 230kV and higher)

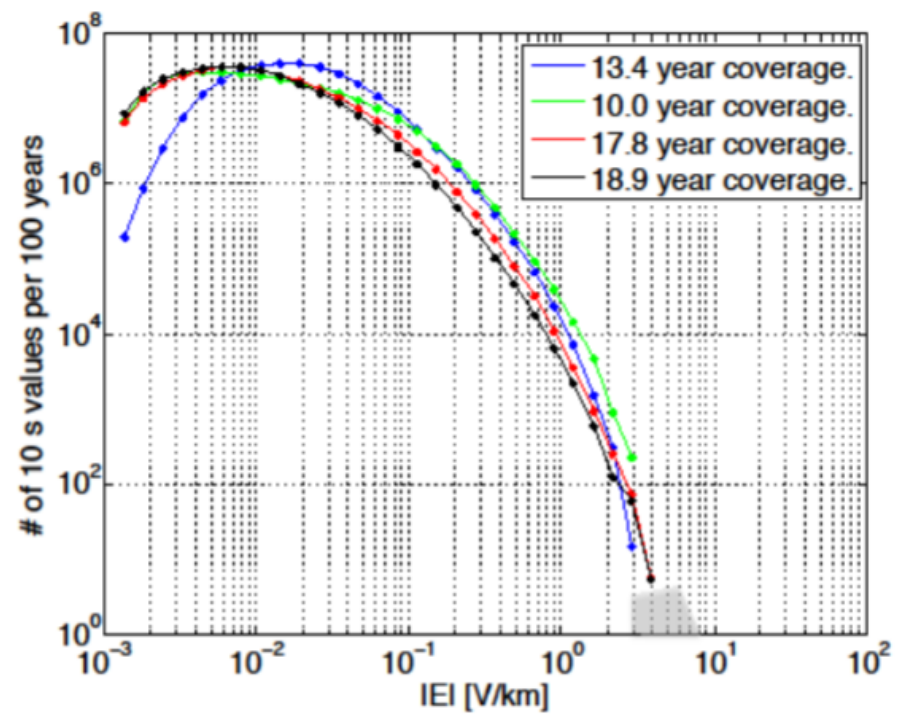
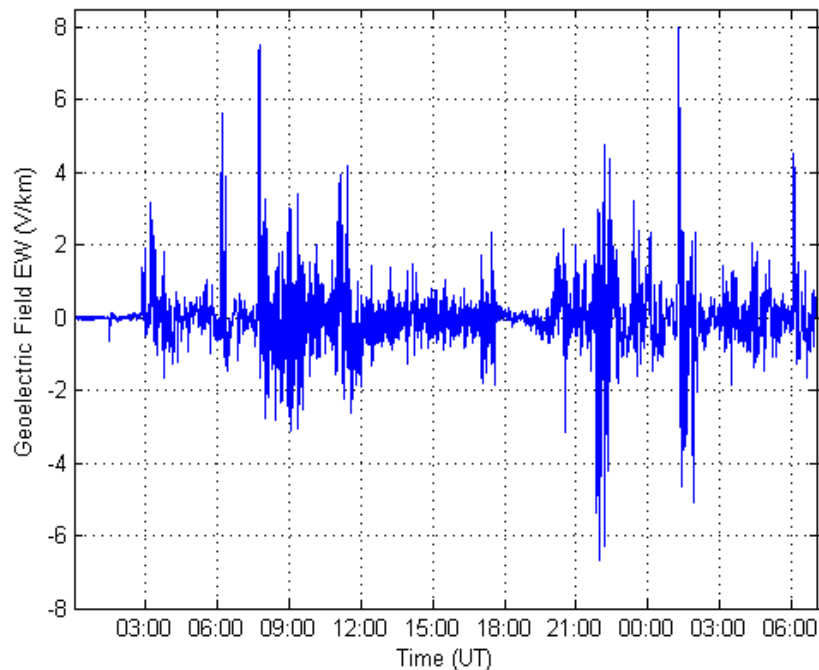
- Components of TPL-007-1
  - Benchmark GMD event
  - GMD Vulnerability Assessment
  - Transformer thermal assessment
  - Corrective Action Plan (CAP)
- Implementation phased-in over a five-year period
  - R1, July 1, 2017
  - R2, July 1, 2018
  - R3 and R4, January 1, 2022
  - R5, January 1, 2019
  - R6, January 1, 2021
  - R7, January 1, 2022



# Benchmark GMD Event

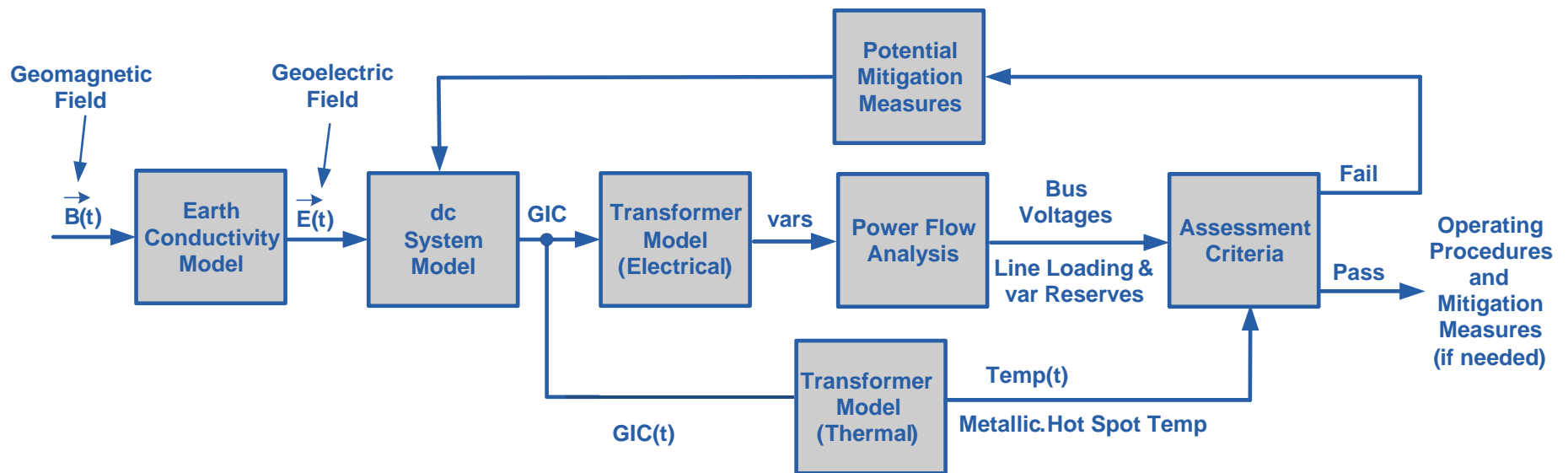


- Assessments are based on a severe 1-in-100 year GMD event
- Two components for analysis:
  - Amplitude of 8 V/km scaled to the **entity's** planning area
  - Waveform for assessing transformer hot-spot heating

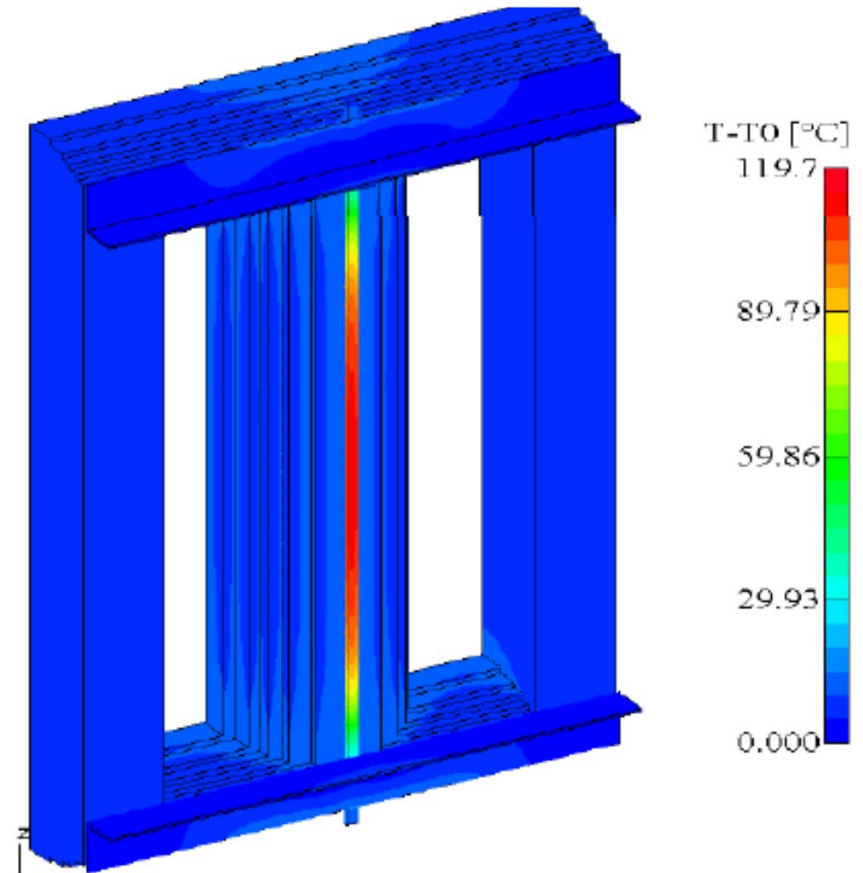


- $E_{peak} = 8 \left( \frac{V}{km} \right) \times \alpha \times \beta$
- Where,
  - $E_{peak}$  – Benchmark geoelectric field amplitude at System location in volts per kilometer
  - $\alpha$  – Factor adjustment for geomagnetic latitude
  - $\beta$  – Factor adjustment for regional Earth conductivity model
- 8 V/km is the peak geoelectric field amplitude at reference location (60° N geomagnetic latitude, resistive ground model)

- The objective of the GMD vulnerability assessment is to prevent instability, uncontrolled separation, or cascading failure of the System during a GMD event
- System performance is evaluated based on:
  - System steady-state voltage criteria established by the planning entity
  - Cascading and uncontrolled islanding shall not occur



- TOs and GOs conduct thermal impact assessment of EHV power transformers (Wye grounded on high side at 230 kV or higher)
- Techniques:
  - Manufacturer performance curves
  - Thermal response simulation
  - Thermal impact screening
- Assessment is not required for transformers <75 A per phase peak GIC for the Benchmark GMD event



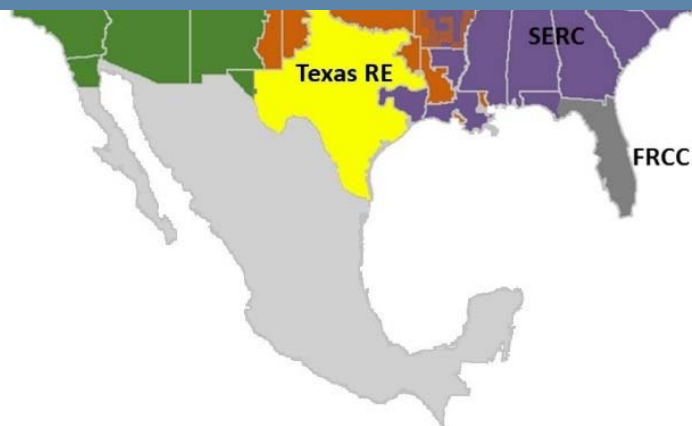
- *The Commission approves the reference peak geoelectric field amplitude figure proposed by NERC. In addition, the Commission... directs NERC to develop revisions to the benchmark GMD event definition so that the reference peak geoelectric field amplitude component is not based solely on spatially-averaged data.*

FERC Order No. 830 at P 44





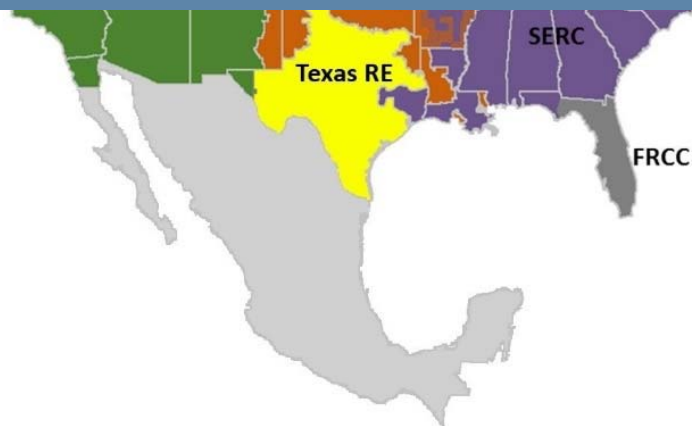
# Directed Revisions



- FERC Order No. 830 directed NERC to revise TPL-007-1 to address the following Commission concerns
  - Modify the benchmark GMD event definition used for GMD assessments
  - Require entities to collect GMD data for model validation purposes
  - Establish deadlines for CAPs and mitigating actions to address identified GMD impacts
- Revisions must be filed by May 2018



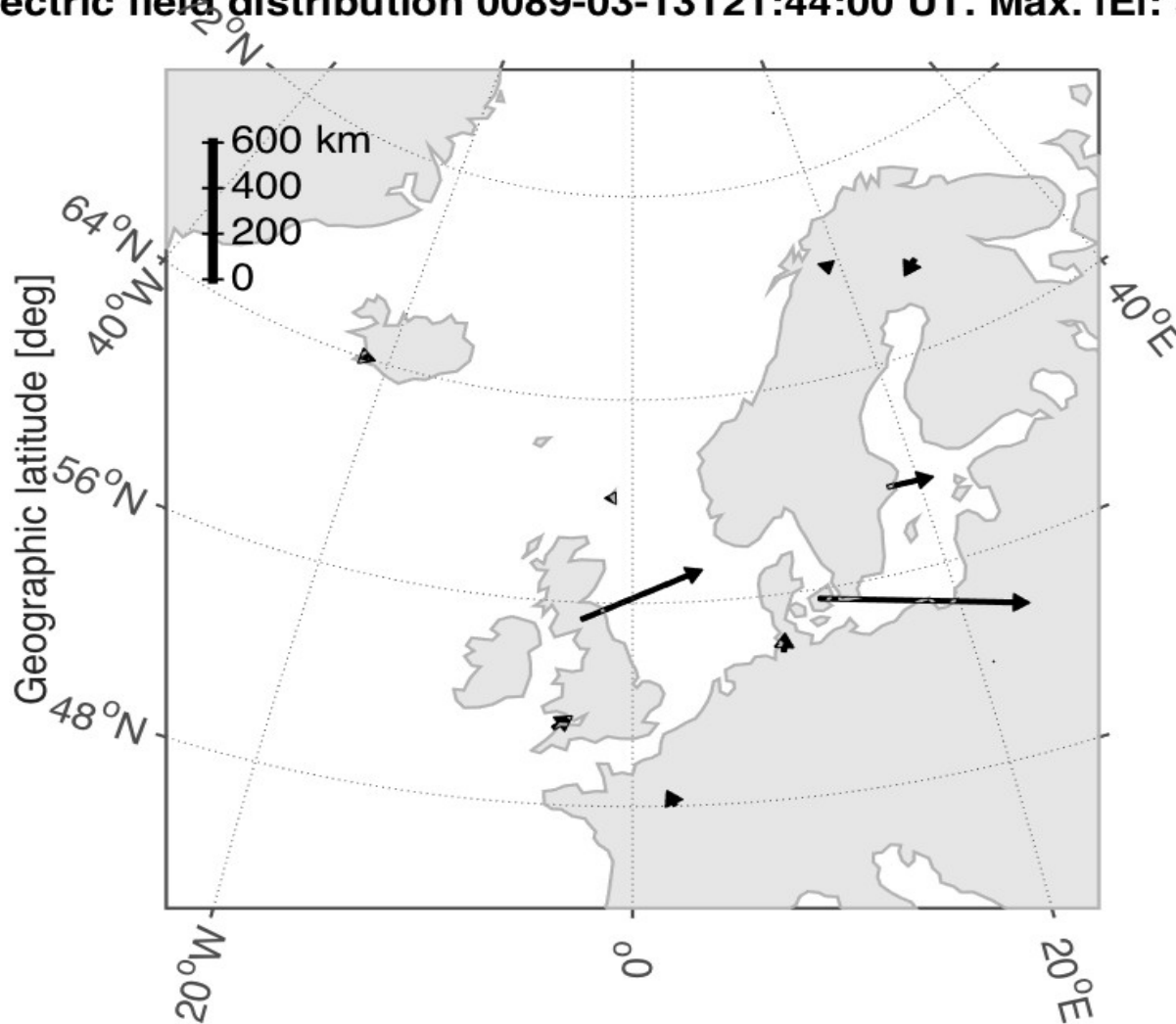
# Supplemental GMD Event



- Phenomenon
  - Electric field amplitudes are fairly well understood
  - Geographical extent is not well known
- Initial review of data from several significant events
  - Quebec, Canada, March 1989
  - Greenland, October 2003 (i.e., “Halloween”)
  - Svalbard, Norway, October 2003 (i.e., “Halloween”)
  - Alaska, United States, March 2015
- Observations
  - Waveform similarities—local intense peak (2-5 minutes in duration)
  - Longitudinal extent: ~300-500 km; Latitudinal extent; ~100 km
  - Amplitude increase: ~ factor of two

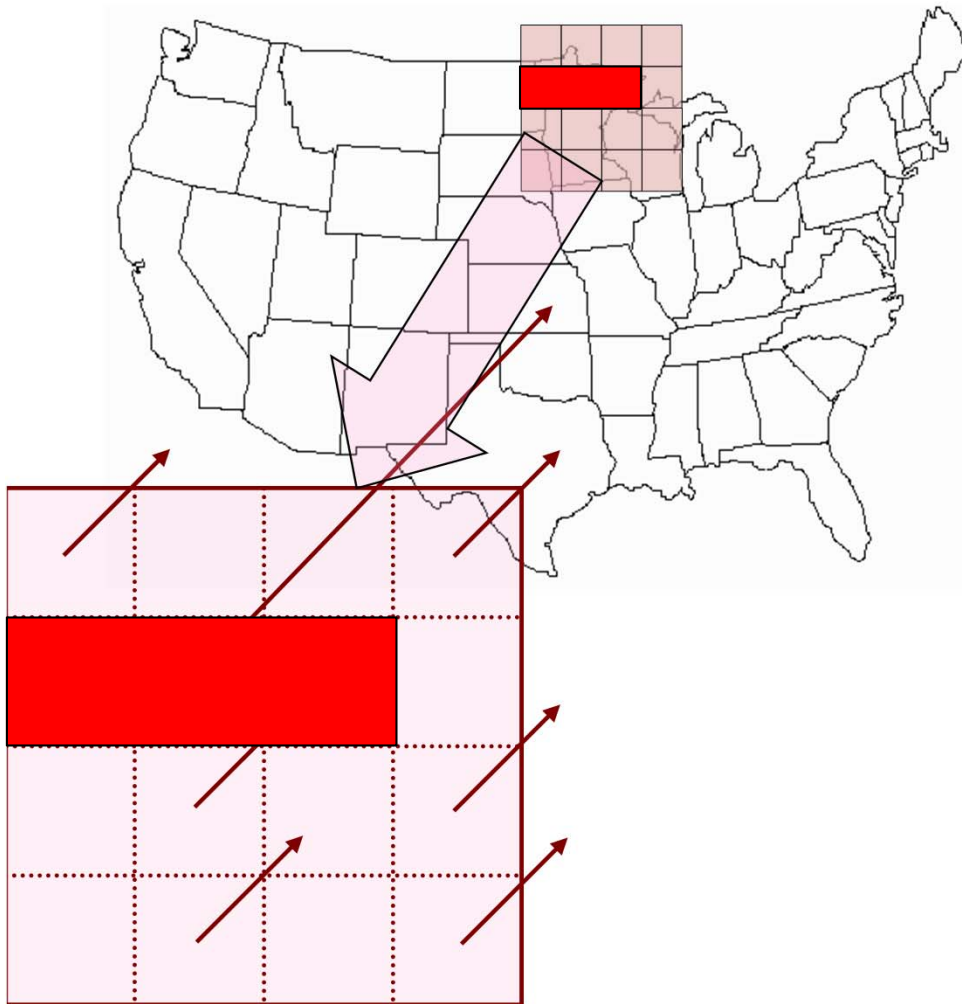
# Brorfelde (BFE), Denmark (March '89)

**Geoelectric field distribution 0089-03-13T21:44:00 UT. Max. IEI: 5.90 V/km.**



- $E_{peak} = 12 \left( \frac{V}{km} \right) \times \alpha \times \beta$ 
  - $E_{peak}$  is to be used in calculating GIC in the GIC system mode
  - 12 V/km is the supplemental regional geoelectric field peak amplitude in volts per kilometer
- Where,
  - $\alpha$  – Scaling factor to account for local geomagnetic latitude
  - $\beta$  – Scaling factor to account for the local Earth conductivity structure
- A CAP is not required
- Entities responsible for performing the supplemental GMD Vulnerability Assessment:
  - Planning Coordinator
  - Transmission Planner

# Simulation of the “Local Enhancement”



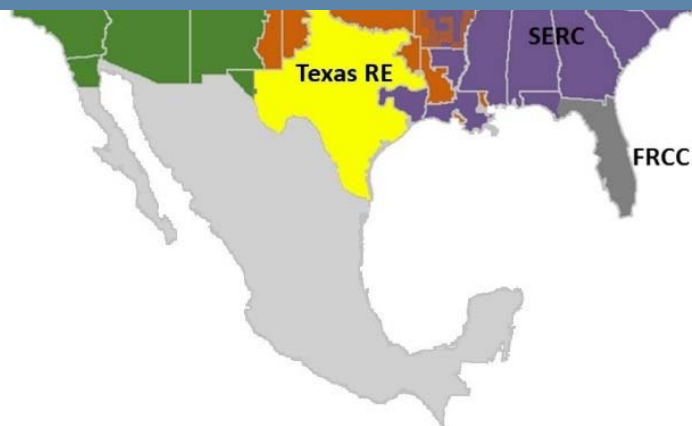
- For illustration purposes, a local enhancement on the order of 100 km (lat) by 300 km (long) would be applied at 12 V/km in a local area and the GICs calculated
- No CAP required, but the results are to be evaluated for possible mitigating steps

- Planning entity has the flexibility or “how” to perform:
  - Scaled 12 V/km applied to entire system,
  - Scaled 12 V/km applied to slices of the system (i.e., “moving box”), or
  - Other methods (e.g., scaled 12 V/km and scaled 8 V/km results compared and incremental Reactive Power consumption fed into the AC power flow)
- Current situation:
  - Power flow software vendors are working to integrate the ability to apply multiple geoelectric fields to the system topology





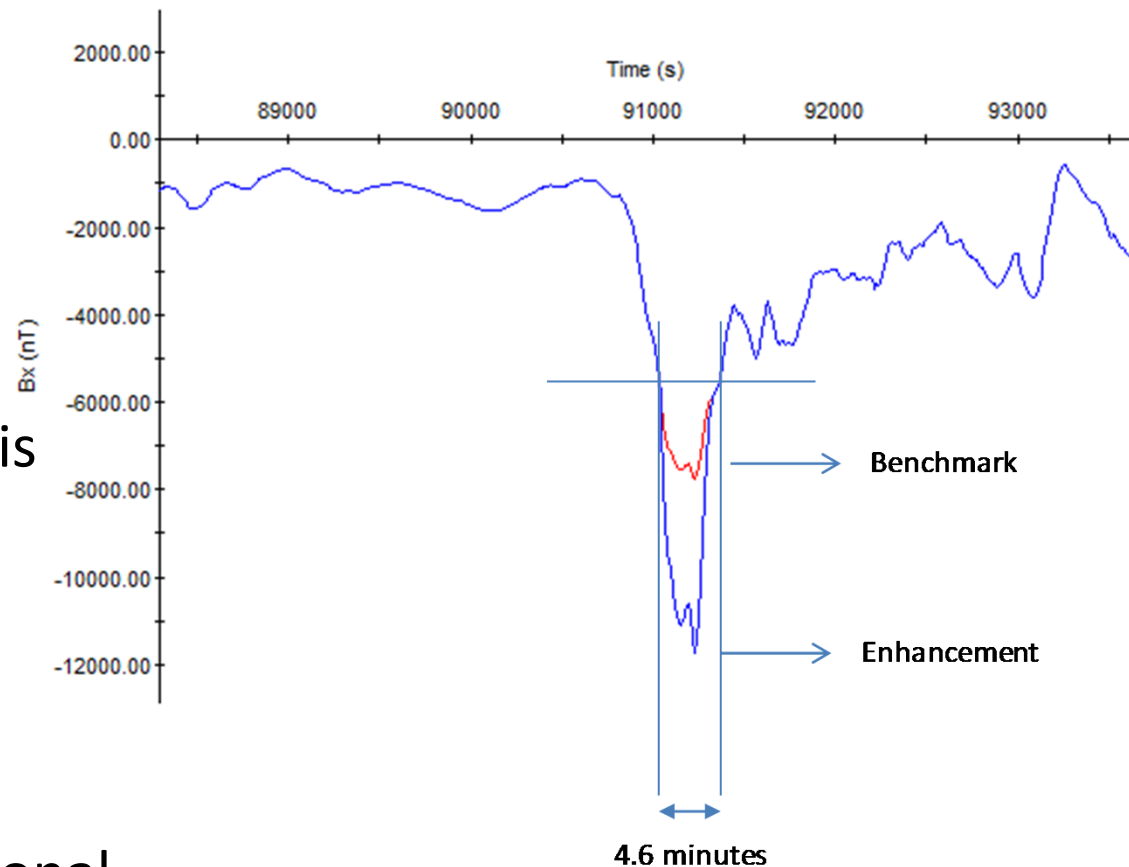
# Thermal Assessment



- *...the Commission directs NERC to revise Requirement R6 to require registered entities to apply spatially averaged and non-spatially averaged peak geoelectric field values, or some equally efficient and effective alternative, when conducting thermal impact assessments.*

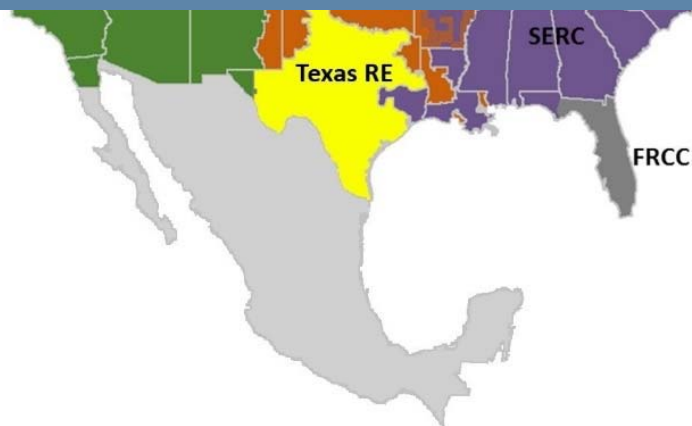
FERC Order No. 830 at P 65

- Scaled 12 V/km used to calculate GIC(t)
- **Thermal screening criterion** would be:
  - 85 amperes
- If times series analysis is required, then:
  - Local enhancement synthetically inserted into the benchmark wave shape
- Results are informational
  - Left to the asset owner to address
  - **No** CAP is required





# Corrective Action Plan



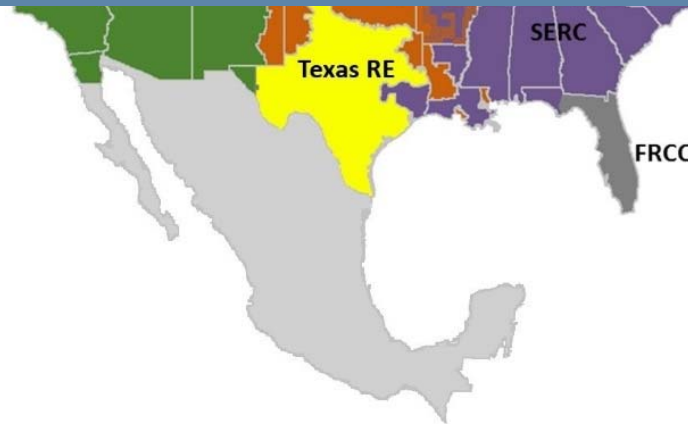
- TPL-007 requires a CAP when the GMD Vulnerability Assessment indicate system performance requirements are not met
- Options include:
  - Hardening the system
  - Installing monitors
  - Operating procedures
- FERC Order No. 830 directed to establish deadlines (P 101)
  - One year for development of CAP
  - Two years for implementing operating procedure mitigation
  - Four years for implementing hardware mitigation
- Regional Entity reporting required if:
  - CAP deadline cannot be met, and
  - Provide annual updates until CAP is complete

- *The Commission ... adopts the NOPR proposal in relevant part and directs NERC to develop revisions to Reliability Standard TPL-007-1 to require responsible entities to collect GIC monitoring and magnetometer data as necessary to enable model validation and situational awareness, including from any devices that must be added to meet this need. The NERC standard drafting team should address the criteria for collecting GIC monitoring and magnetometer data... and provide registered entities with sufficient guidance in terms of defining the data that must be collected....*

FERC Order No. 830 at P 88



# New Requirements



- **R8.** Each responsible entity, as determined in Requirement R1, shall complete a supplemental GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon at least once every 60 calendar months. This supplemental GMD Vulnerability Assessment shall use a study or studies based on models identified in Requirement R2, document assumptions, and document summarized results of the steady state analysis.
  - **8.1.** The study or studies shall include the following conditions:
    - **8.1.1.** System On-Peak Load for at least one year within the Near-Term Transmission Planning Horizon; and
    - **8.1.2.** System Off-Peak Load for at least one year within the Near-Term Transmission Planning Horizon.



- **8.2** The study or studies shall be conducted based on the supplemental GMD event described in Attachment 1 to determine whether the System meets the performance requirements for the steady state planning supplemental GMD event contained in Table 1.
- **8.3.** If the analysis concludes there is Cascading caused by the supplemental GMD event described in Attachment 1, an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences and adverse impacts of the event(s) shall be conducted.

- **8.4.** The supplemental GMD Vulnerability Assessment shall be provided: (i) to the responsible entity's Reliability Coordinator, adjacent Planning Coordinators, adjacent Transmission Planners within 90 calendar days of completion, and (ii) to any functional entity that submits a written request and has a reliability-related need within 90 calendar days of receipt of such request or within 90 calendar days of completion of the supplemental GMD Vulnerability Assessment, whichever is later.
  - **8.4.1.** If a recipient of the supplemental GMD Vulnerability Assessment provides documented comments on the results, the responsible entity shall provide a documented response to that recipient within 90 calendar days of receipt of those comments.

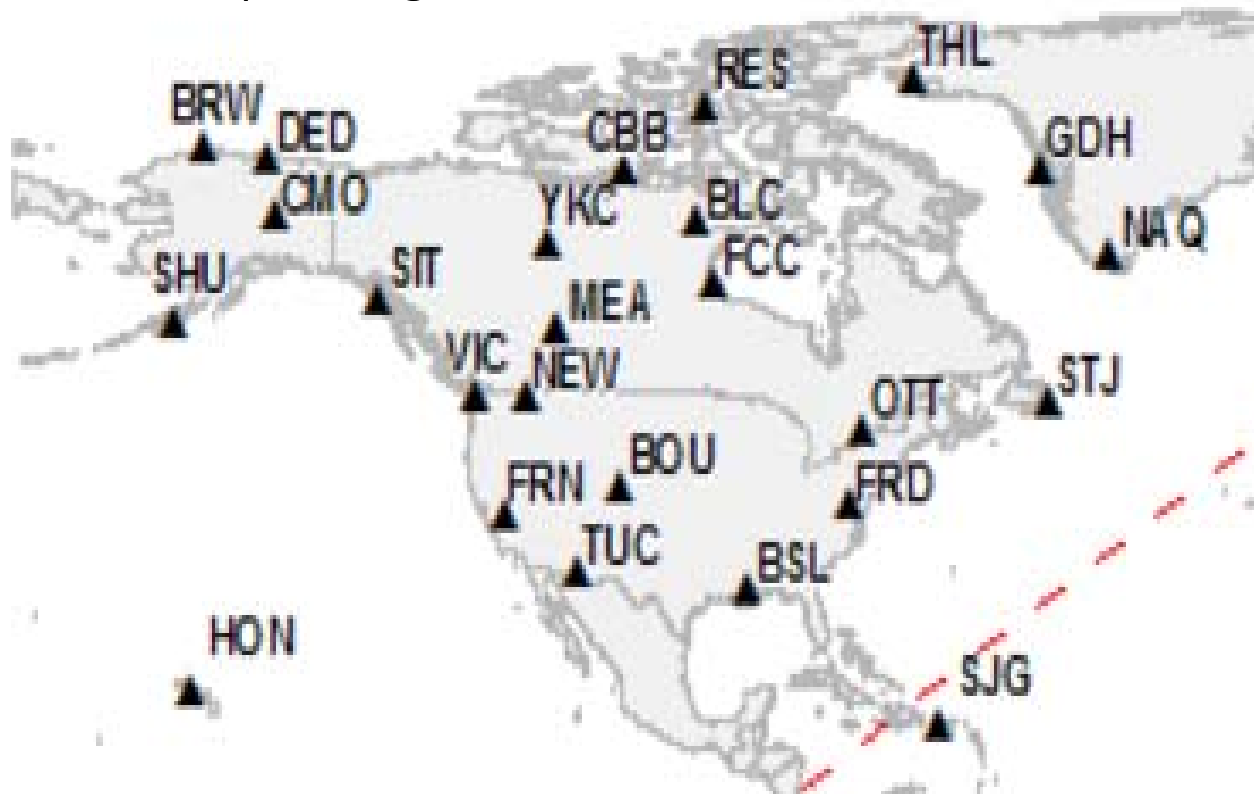
- **R9.** Each responsible entity, as determined in Requirement R1, shall provide GIC flow information to be used for the supplemental thermal impact assessment of transformers specified in Requirement R10 to each Transmission Owner and Generator Owner that owns an applicable Bulk Electric System (BES) power transformer in the planning area. The GIC flow information shall include:

- **9.1.** The maximum effective GIC value for the worst case geoelectric field orientation for the supplemental GMD event described in Attachment 1. This value shall be provided to the Transmission Owner or Generator Owner that owns each applicable BES power transformer in the planning area.
- **9.2.** The effective GIC time series,  $GIC(t)$ , calculated using the supplemental GMD event described in Attachment 1 in response to a written request from the Transmission Owner or Generator Owner that owns an applicable BES power transformer in the planning area.  $GIC(t)$  shall be provided within 90 calendar days of receipt of the written request and after determination of the maximum effective GIC value in Part 9.1

- **R10.** Each Transmission Owner and Generator Owner shall conduct a supplemental thermal impact assessment for its solely and jointly owned applicable BES power transformers where the maximum effective GIC value provided in Requirement R9, Part 9.1, is 85 A per phase or greater. The supplemental thermal impact assessment shall:
  - **10.1.** Be based on the effective GIC flow information provided in Requirement R9;
  - **10.2.** Document assumptions used in the analysis;
  - **10.3.** Describe suggested actions and supporting analysis to mitigate the impact of GICs, if any; and
  - **10.4.** Be performed and provided to the responsible entities, as determined in Requirement R1, within 24 calendar months of receiving GIC flow information specified in Requirement R9, Part 9.1.

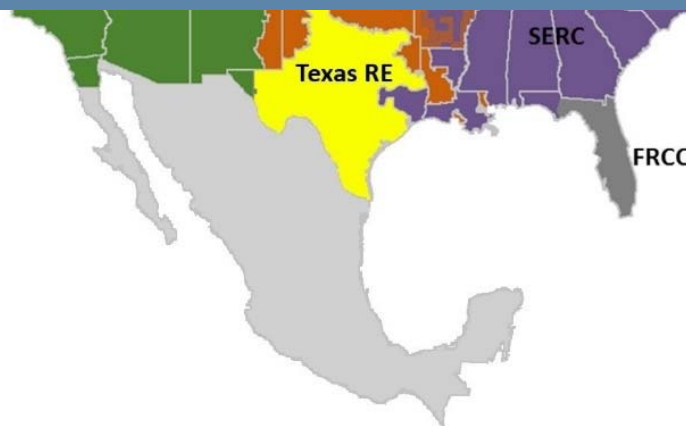
- GIC Monitors
  - **R11.** Each responsible entity, as determined in Requirement R1, shall implement a process to obtain GIC monitor data from at least one GIC monitor located in the Planning Coordinator's planning area or other part of the system included in the Planning Coordinator's GIC System model.

- Magnetometers
  - **R12.** Each responsible entity, as determined in Requirement R1, shall implement a process to obtain geomagnetic field data for its Planning Coordinator's planning.





# Supporting Documents



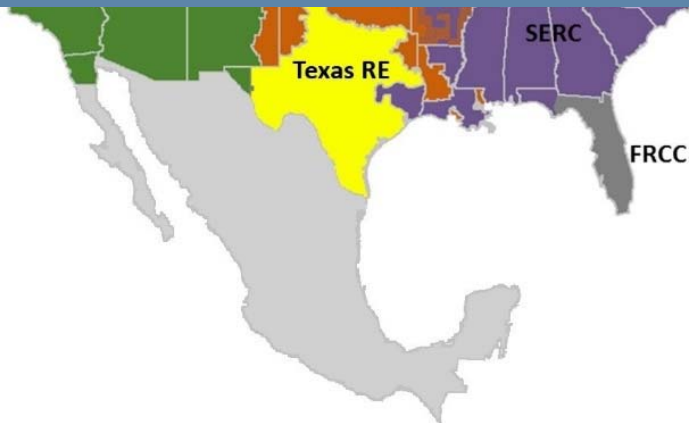


Req.	If TPL-007-2 becomes effective before January 1, 2021	If TPL-007-2 becomes effective on or after January 1, 2021
R1	Effective July 1, 2017	Effective July 1, 2017
R2	To be effective July 1, 2018	To be effective July 1, 2018
R3-R4	42 months after effective date	42 months after effective date
R5	To be effective January 1, 2019	To be effective January 1, 2019
R6	30 months after effective date	To be effective January 1, 2021
R7	54 months after effective date	24 months after the effective date
R8	42 months after effective date	72 months after the effective date
R9	6 months after effective date	36 months after the effective date
R10	30 months after effective date	60 months after the effective date
R11-R12	24 months after effective date	24 months after effective date

- VRF/VSL Justification
- Consideration of Directives
- White papers
  - Supplemental GMD Event White Paper
  - Thermal Screening Criterion White Paper
  - Transformer Thermal Impact Assessment White Paper
- Reliability Standard Audit Worksheet (RSAW)



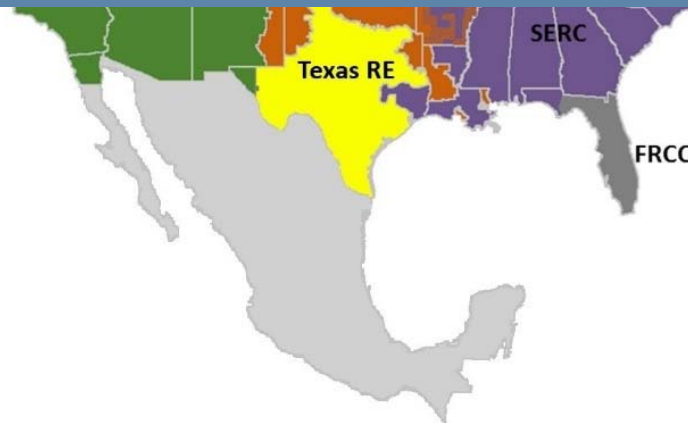
## Next Steps



- Comment period
  - [Project 2013-03 page](#)
  - 45-Days – June 28 to August 11, 2017
  - Initial Ballot – August 2-11, 2017
- Respond to Comments
  - August 29-31, 2017
  - PJM Interconnection – Audubon, PA
- Point of contact
  - Scott Barfield-McGinnis, Senior Standard Developer
  - [Scott.Barfield@nerc.net](mailto:Scott.Barfield@nerc.net) or call 404-446-9689
- Webinar posting
  - 48-72 hours
  - Standards Bulletin



# Questions and Answers



- Informal discussion
  - Via the Q&A feature
  - Chat only goes to the host, not panelists
  - Respond to stakeholder questions
- Other
  - Some questions may require future team consideration
  - Please reference slide number, standard section, etc., if applicable
  - Team will address as many questions as possible
  - Webinar and chat comments are not a part of the official project record
  - Q&A recording will be posted within 48-72 hours



**Webinar has ended – Thank you**

