Response to NERC Request for Comments on Geomagnetic Disturbance Planning Application Guide

Comments Submitted by the Foundation for Resilient Societies
August 9, 2013

Background

NERC management of the Geomagnetic Disturbance Task Force (GMD Task Force) has requested "informal" comments on the "Draft Geomagnetic Disturbance Planning Application Guide" released via the NERC website on July 18, 2013 (hereafter the "Application Guide") with a comment deadline of August 9, 2013. According to the request for comment, the Application Guide will be used by utilities to perform GMD-related studies. The request for comment states, "At the conclusion of the comment period, task force leaders will review the comments and revise as necessary before providing to the Planning Committee for approval."

NERC Non-Compliance with Section 215

The Foundation for Resilient Societies objects to the NERC "informal" comment process which is not in compliance with Section 215 of the Federal Power Act. Section 215 requires that NERC, as designated Electric Reliability Organization (ERO), "provide for reasonable notice and opportunity for public comment, due process, openness, and balance of interests in developing reliability standards and otherwise exercising its duties." These ERO duties are not being presently met for the following reasons:

1. The Application Guide makes numerous references to a "design basis" event, i.e. the maximum expected threat level or solar storm severity—including maximum geoelectric field—that might be expected during a 1-in-100 year storm. For example, on page 14, line 27 the Application Guide states, "Carry out system impact studies assuming the maximum design-basis geoelectric field." However, the proposed design basis event is not posted in the revision of the Application Guide available on the NERC website as of August 9, 2013, the deadline for comments.[1] Instead, management of the GMD Task Force chose to partially disclose the design basis event in a PowerPoint presentation at the July 25-26, 2013 GMD Task Force meeting in Vancouver, British Columbia, with key elements of the proposed design basis event disclosed only verbally. As a result, the public has been deprived of key details of the design basis event and cannot adequately comment.

[1] A screenshot of the GMD Task Force web page on the NERC website is included as Appendix 1 of this comment. This screenshot shows the revision date of each document on the GMD Task Force page.

2. A critical element of any GMD planning study would be examination of power transformer vulnerability to damage from Geomagneticially Induced Currents (GIC). In fact, Chapter 4 of the Application Guide is titled "Equipment Impact Assessment" and has the subsection "Transformer Impact Screening Process." Chapter 4 recommends that electric utilities make use of the "NERC Transformer Modeling Guide" to assess impact of GIC on power transformers. Additionally, the "NERC Transformer Modeling Guide" is listed as Reference No. 3 at the end of the Application Guide. Despite its obvious importance, and despite being included as a key reference for the Application Guide, the "NERC Transformer Modeling Guide" is not posted on the GMD Task Force page of the NERC website as of August 9, 2013, the deadline for comments. Instead, management of the GMD Task Force chose to partially disclose elements of proposed transformer modeling in a PowerPoint presentation at the July 25-26, 2013 GMD Task Force meeting in Vancouver, with key elements of transformer modeling and testing in support of models disclosed only verbally. As a result, the public has been deprived of the right to review and comment on this key document and NERC has been denied benefits of independent assessment of its proposed modeling guidelines.

3. If previous NERC practice and expressed intent of NERC in the Request for Comment are followed, the Application Guide will be revised and sent to the Planning Committee for approval with no disclosure to the public of the final document and no opportunity to comment on substantive revisions or remaining defects in modeling guidelines. This would not be an "open" process as required by Section 215, but would instead be a secret process, with key decisions made in closed meetings out of public view. In fact, NERC and its Planning Committee previously used this same secret process in approving its interim report, "2012 Special Reliability Assessment: Effects of Geomagnetic Disturbances on the Bulk Power System."

Information Disclosed at Vancouver GMD Task Force Meeting

The proposed design basis event and expected impact on power transformers would be key elements of any electric utility studies of vulnerability to geomagnetic disturbance. We present below the limited information disclosed at the July 25-26, 2013 GMD Task Force meeting in Vancouver. This information may be indicative of future revision of the Application Guide before it is submitted to the NERC Planning Committee for approval.

The presentation titled "Team 3 Update, Application Guide" by Dr. Randy Horton of Southern Company disclosed several slides on the proposed design basis event and associated geoelectric field.

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GIC Application Guide

- We received several comments from the initial review
- These comments have been evaluated and implemented in the updated draft.
- A method for scaling the 1-in-100 year storm has been developed (proposed) and included in the application guide.
- Updated draft included in today's posted agenda package

Despite the above statement, "Updated draft included in today's posted agenda package," emails sent by GMD Task Force management on July 25 and July 26, 2013 did not include an updated draft of the Application Guide, nor was an updated draft posted on the GMD Task Force page of the NERC website.

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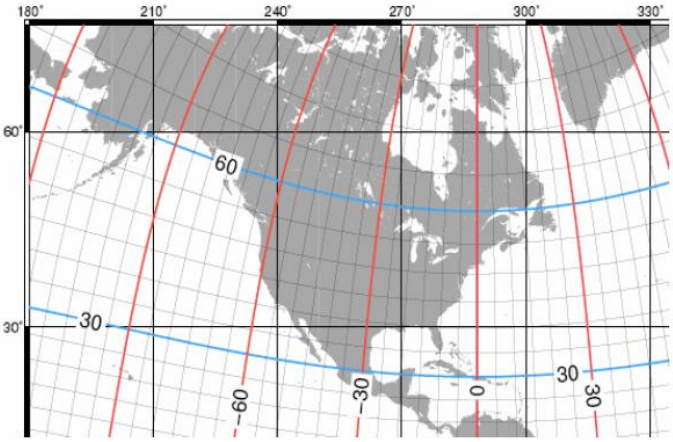
Storm Scaling

- Analysis by Pulkkinen indicates a 100-year peak geoelectric field of:
  - 5 V/km (high cond.)
  - 20 V/km (low cond.)
- Analysis also shows approximately two orders of magnitude drop from 65 deg to 40 deg of geomagnetic latitude



The above slide clearly states a maximum of 20 volts/kilometer for a peak geoelectric field in a 1-in-100 year storm.

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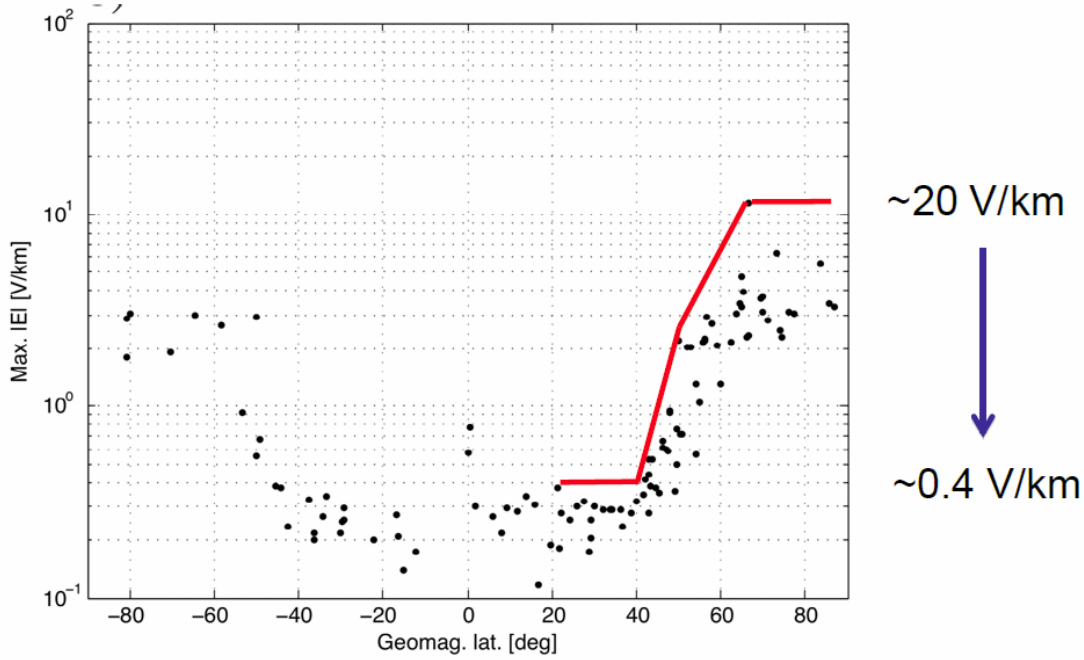
Storm Scaling

- Effect of geomagnetic latitude



5 RELIABILITY | ACCOUNTABILITY

During the presentation, Dr. Horton verbally disclosed that the above storm scaling data in the Pulkkinen analysis was taken over a thirty-year period not in the United States and Canada, but in Scandinavia. There were no severe solar storms during the thirty year observation period. NERC proposes to use this Scandinavian storm scaling data to underpin a design basis event with geoelectric field of approximately 5 volts/kilometer for latitudes within the United States.

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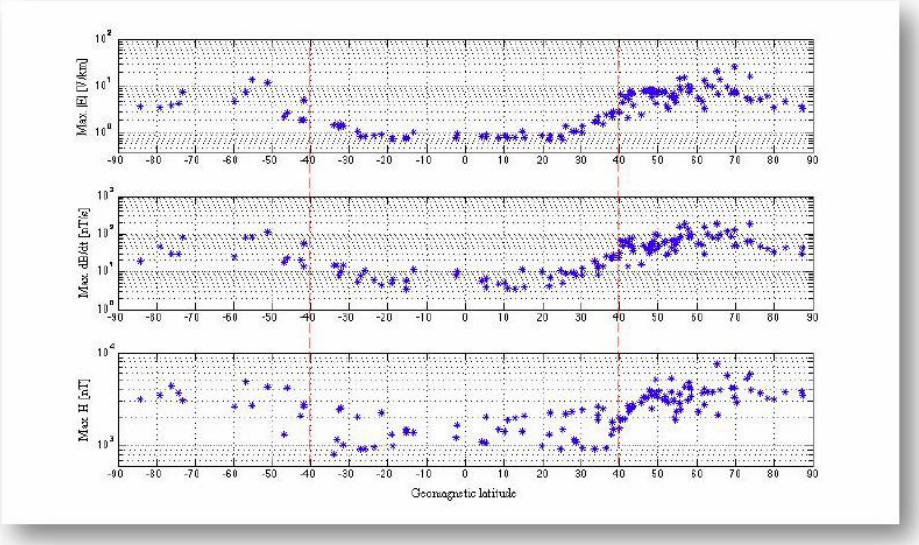
NASA/CUA

- We are getting 30-40 V/km max. fields (preliminary results)



54

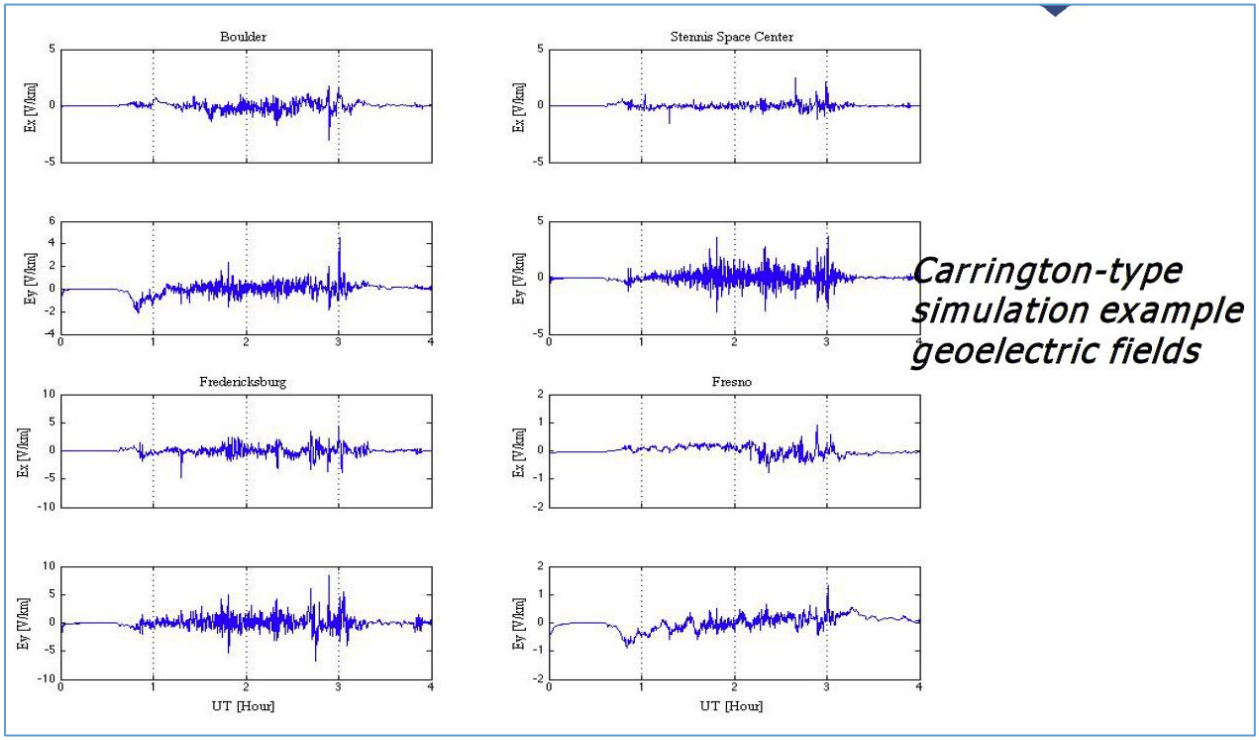
RELIABILITY | ACCOUNTABILITY

The storm scaling data developed by Dr. Pulkkinen and presented by Dr. Horton at the July 25-26, 2013 GMD Task Force meeting in Vancouver is in marked contrast to preliminary storm scaling data presented by Dr. Pulkkinen at the February 25-27, 2013 meeting of the GMD Task Force in Atlanta, as shown in the above slide.

At the February 2013 GMD Task Force meeting, the maximum postulated geoelectric field was 30-40 volts/kilometer. At the July GMD Task Force meeting, the maximum postulated geoelectric field was 20 volts/kilometer.[2]

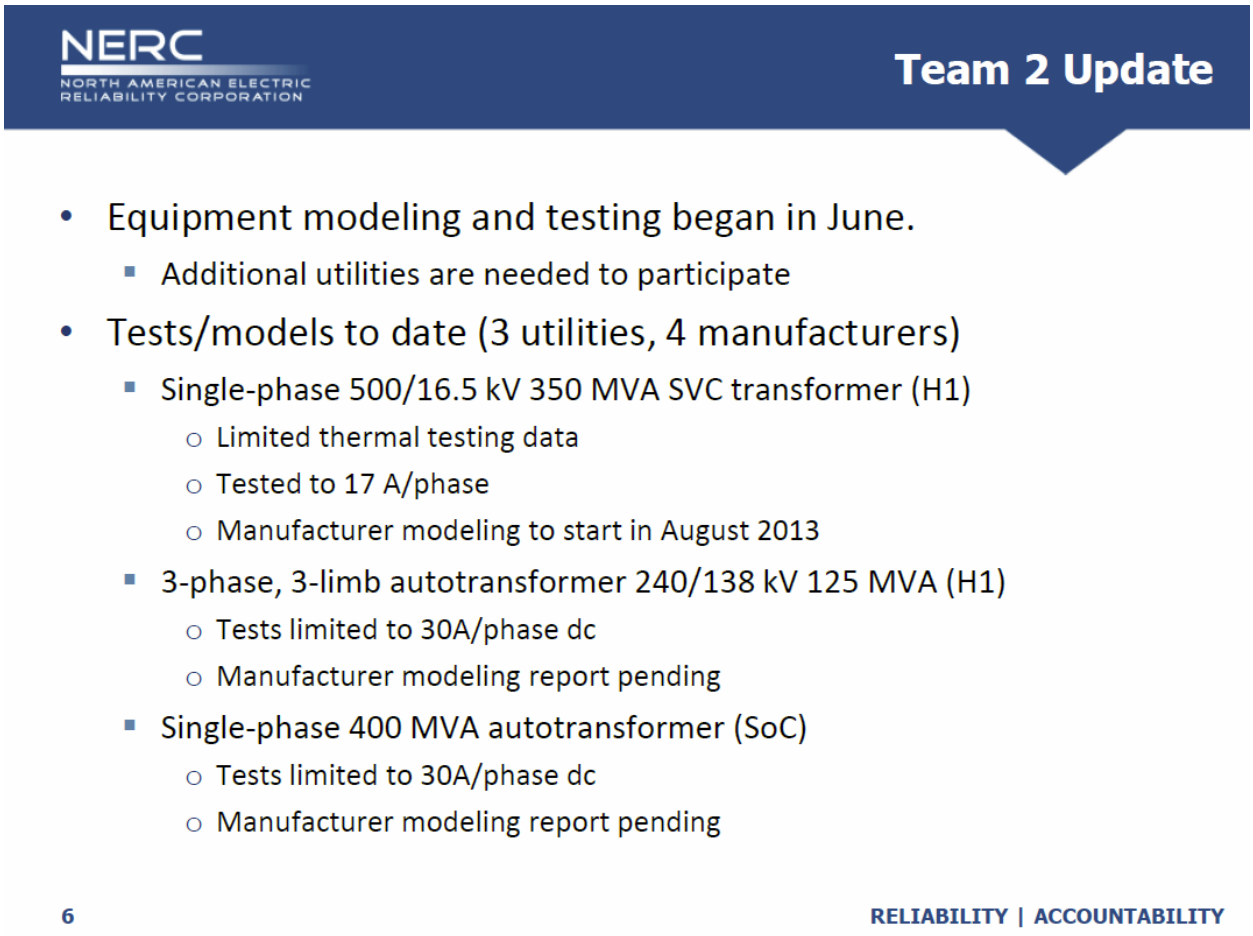
[2] Dr. Pulkkinen stated at the February 2013 GMD Task Force meeting that the maximum postulated geoelectric field of 30-40 volts/kilometer was "preliminary" and subject to future change. Nonetheless, his downward revision in maximum geoelectric field is a good example of the substantial uncertainty in modeling geoelectric fields. Moreover, a reduction in the maximum postulated geoelectric field from 40 volts/kilometer to 20 volts/kilometer, if not consistent with geomagnetic risks in the United States, could result in reliance on ineffective operating procedures when only hardware protection would protect public safety.

On May 16, 2013, between the February and July 2013 GMD Task Force meetings, the Federal Energy Regulatory Commission (FERC) issued Order 779 mandating protection of the Bulk Power System from geomagnetic disturbance.[3] At the May 20-21, 2013 Electric Infrastructure Security Summit at the U.S. Capitol, Gerry Cauley, CEO of NERC, stated the importance of determining an appropriate GMD threat level, because beyond a certain threshold, electric utility mitigation expenses could increase substantially.



The July 2013 Horton presentation at the GMD Task Force meeting disclosed the above slide, which postulates a maximum geoelectric field of approximately 5 volts per kilometer for a "Carrington type" event at observatories within the United States. The simulation and resulting data plots were developed at University of Michigan by undisclosed researchers using an undisclosed methodology.

[3] Reliability Standards for Geomagnetic Disturbances, FERC Order No. 779, 143 FERC ¶ 61,147, *Rehearing denied,* 144 FERC ¶ 61,113 (Aug. 8, 2013).



The above slide titled, "Team 2 Update," presented by Luis Marti of Hydro One at the July 2013 GMD Task Force meeting, disclosed information about currently ongoing NERC plans to model and test power transformers. One could reasonably expect that these test results would be a key component of the modeling assumptions in the undisclosed "NERC Transformer Modeling Guide."

The NERC transformer tests specified above were, or would be, limited to 17-30 amps of injected direct current. Notably, GIC observed at power transformers during past solar storms has been regularly in excess of 30 amps; while electric utilities and the SUNBURST data sharing consortium at EPRI have generally refused to release GIC data to the public, a graph disclosed by EPRI to the NERC GMD/EMP High Impact Low Frequency Report Working Group on March 21, 2010 shows 20 observations over 30 amps and 6 observations over 100 amps from 1990 to 2010. During a severe solar storm, GIC would be expected to be over 1,000 amps, according to Metatech Report R-319 sponsored by the Federal Energy Regulatory Commission.

During his presentation, Mr. Marti stated that technical limitations preclude transformer tests at above 30 amps injected direct current. Mr. Marti also revealed that all of the above specified transformer tests were, or would be, under "no-load" conditions. In contrast, during an actual solar storm, power transformers would be under load.[4]

Preliminary Technical Comments

While we cannot fully comment on the Application Guide because of incomplete and inadequate disclosure, based on the partial information in the draft Application Guide and the information conveyed at the July 2013 GMD Task Force meeting in Vancouver, we make these preliminary technical comments:

1. Measured geoelectric fields that have actually been observed in the United States during moderate storms are significantly higher than the proposed NERC design basis event. For example, AT&T measured a geoelectric field of 8 volts/kilometer on August 4, 1972 between Iowa and Illinois when recorded dB/dt was approximately 800 nanoTesla/minute. During a severe solar storm, such as the 1921 Railroad Storm analyzed in the U.S. Government sponsored Metatech R-319 report, dB/dt of 4,800 nanoTesla/minute could be reasonably expected in this region, which would imply a geoelectric field of approximately 50 volts/kilometer for a design basis event—ten times larger than the proposed NERC design basis event of approximately 5 volts/kilometer within the United States.

2. Electric utilities have generally refused to release GIC data, but the limited data released can be utilized to provide reasonable estimates of GIC levels and by extension geoelectric field intensity during a severe solar storm. For example, the observed GIC of approximately 60 amps during the November 6, 2001 storm at Hurley Ave in New York caused by a 180 nanoTelsa/minute disturbance would imply a geoelectric field of approximately 1.5 volts/kilometer in that region. During a severe solar storm of 4,800 nanoTesla/minute, simple extrapolation would imply a geoelectric field of approximately 40 volts/kilometer and GIC of 1,600 amps.

3. The proposed NERC design basis event uses measured geomagnetic fields from Scandinavia adjusted to Quebec, Canada grounding conditions, with observed data over a 30 year period. There were no severe solar storms during the 30 year period of observed

[4] On one hand, electric utilities and transformer manufacturers claim that power transformers can withstand dozens or even hundreds of amps of GIC. On the other hand, electric utilities refuse to realistically test power transformers operating under load in the commercial electric grid by injecting direct current over 30 amps. If electric utilities and transformer manufacturers are so confident in the withstand capability of transformers to GIC, why do they refuse to engage in realistic testing using load from commercial customers? Could it be that injecting even moderate levels of simulated GIC into power transformers risks transformer failure and cascading blackout for utility customers?

data. The soil geology of the United States is different from Scandinavia and Canada. The USGS survey of the United States soil geology is still not complete nor has it been validated using published GIC data and so any model for the United States would have substantial uncertainty.

4. The NERC Application Guide does not propose safety factors, or other safety allowances for modeling uncertainty. Prudent engineering practice would utilize safety factors of at least two, and as much as four, for events with catastrophic consequences. If a safety factor of four were to be applied to a design basis event based on real world measurements—not unproven models—then the solar storm design basis event should have a geoelectric field of 200 volts/kilometer for locations within the United States.

5. The proposed NERC design basis event with geoelectric field of only 5 volts/kilometer within the United States could be used to claim that power transformers would be unlikely to fail during even severe solar storms. But real world experience shows that transformers do fail during solar storms with relatively small geoelectric fields. For example, a Generator Step Up (GSU) transformer failed at the Salem nuclear plant during the March 1989 solar storm that caused the Hydro-Quebec blackout. This GSU transformer failure occurred shortly after a geoelectric field of 1.7 volts/kilometer at the nearby Fredericksburg Observatory, according to an analysis by the United States Geological Service (USGS).[5] Other GSU transformer failures during even smaller solar storms include failures at the Seabrook plant on November 8-11, 1998; the Braidwood 1 plant on April 5, 1994; and the Maine Yankee plant on April 28, 1991.

6. The proposed NERC design basis event does not account for sudden commencement solar storms at low latitudes, despite these conditions having been observed in the real world and producing surprisingly large GIC levels at low latitude locations. For published work on this topic, see "Storm sudden commencement events and the associated geomagnetically induced current risks to ground-based systems at low-latitude and mid-latitude locations," John Kappenman, SPACE WEATHER, VOL. 1, NO. 3, 1016, 2003.

7. The proposed NERC design basis event relies on the scientifically unsound and outdated assumption that geoelectric field varies with a power curve of the *geographic latitude*. In fact, the geoelectric field varies with the *magnetic latitude*, which can be significantly different than the geographic latitude. In fact, soil geology is a significant determinate of geoelectric field, and differing soil geology is not accounted for in the proposed NERC design basis event. In fact, proximity to water bodies is a significant determinate of geoelectric field, and water proximity is not accounted for in the proposed NERC design

[5] A presentation slide from the February 2013 GMD Task Force meeting showing the USGS analysis of geoelectric field from the March 1989 solar storm is included as Appendix 2.

basis event. In fact, there are multiple peer-reviewed and published studies showing that low latitudes can have significantly higher geoelectric fields during severe solar storms than higher latitudes.

8. The proposed NERC design basis event is inconsistent with other published models, such as the model in the U.S. Government-sponsored Metatech R-319 study. The Metatech R-319 study physically modeled the United States bulk power grid and established benchmarking and validation of the grid for a number of storms where GIC data was publicly available. To date no such NERC physical model has been demonstrated nor have any efforts been undertaken to validate a model to verify accuracy of proposed storm levels and associated geoelectric fields; and to submit these data to independent and public review before propounding a model upon which to propose reliability standards.

9. Within the United States and Canada, high capacity High Voltage Direct Current (HVDC) ties run from north to south for hundreds of miles. Examples include the 2,000 MW Phase II tie running from Quebec to Sandy Pond, Massachusetts and the 3,000 MW Pacific Intertie running from Celilo, Oregon to Sylmar, California. Power generated at high latitudes and then exported to lower latitudes could be interrupted by a solar storm. In fact, had the Phase II tie been in operation at the time of the Hydro-Quebec storm of March 1989, up to 2,000 MW of power import would have been interrupted. In fact, the Phase II tie has already been tripped by a small solar storm. It is fallacious to assume a low-latitude terminus of a HVDC tie would not be affected by a more severe solar storm at higher latitude. The Application Guide should specifically prescribe modeling for north-south HVDC ties, and utilize geoelectric fields calibrated to northern latitudes to gauge risk of power disruption at more southerly terminals of HVDC ties.

10. The Application Guide proposes complicated, iterative, and subjective procedures for electric utilities to establish a geoelectric field "threshold" at which negative equipment and system impacts might occur. (The term "threshold" is per the specific language of the Application Guide.) There is no sound scientific basis for pretending that a "threshold" geoelectric field can be determined with precision. Moreover, there is no sound scientific basis for pretending that impacts of GIC can be modeled with precision. By progressively altering modeling assumptions until the estimated geoelectric field is below the "threshold," electric utilities might erroneously conclude no GMD protection is necessary and thereby transfer substantial uncompensated risk to utility customers and to the general public with catastrophic consequences for public safety and the economy. The impact study procedures proposed in the Application Guide are susceptible to gaming and are therefore unsuitable for inclusion in a standard-based regulatory process. In fact, the Application Guide reads as an instruction manual for electric utilities to game equipment and system impact studies; page 14 of the Application Guide in the subsection titled "Integration of Equipment Impact and System Impact Studies" (lines 35-37) reads, "If

equipment considerations require mitigating measures, reduce the magnitude of the geoelectric field to the point where there are no equipment issues."

11. The assessment procedures proposed in the Application Guide are biased toward paper studies and operating procedures that would not require hardware protection against GMD. Moreover, these operating procedures would not exclude GICs from entering high voltage transmission networks and placing other critical grid infrastructure at risk. Alternatively, if electric utilities were to install neutral ground blocking devices that would block all geomagnetically induced currents—rather than relying upon uncertain protection against the GIC magnitude induced by a postulated but unsubstantiated "threshold" geoelectric field—a wide range of threats could be protected against and inherent uncertainty in impact studies would no longer be a concern. Neutral ground blocking devices would protect against solar storms larger than a "Carrington-type" event and even protect against the approximately 40 volt/kilometer geoelectric field produced by a nuclear EMP attack.

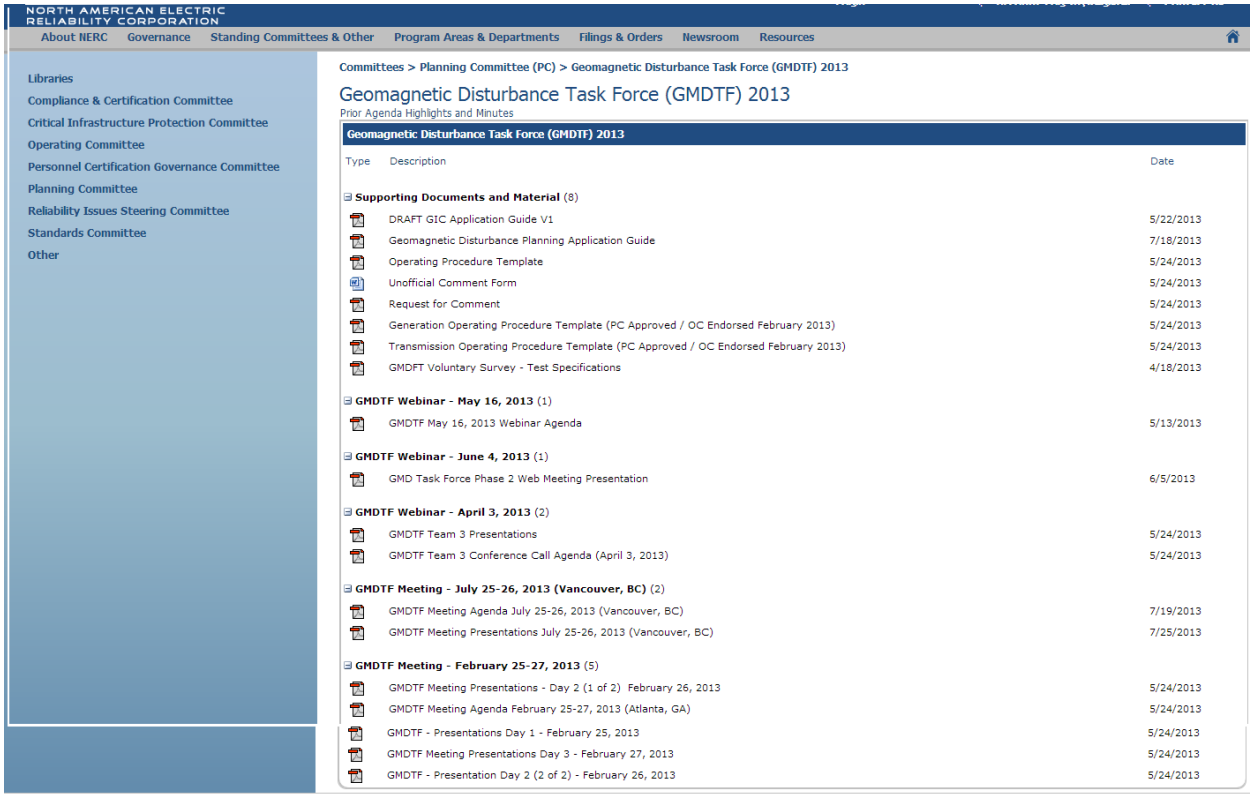
Conclusion

The rosy scenario proposed in the NERC Application Guide and its proposed design basis event does not take into account the enormous economic, legal, safety, and strategic consequences of potentially erroneous technical assumptions. If NERC is incorrect in its modeling guidelines—and the weight of both real world observations and published technical studies indicate that NERC is not only wrong, but grievously wrong—then the deaths of millions of Americans could result. With this potential outcome, the NERC Application Guide and reference documents should be revised substantially, or at least subjected to the most strenuous independent scientific review. However, due to ongoing NERC non-compliance with Section 215 of the Federal Power Act, this external review by the public has to date been effectively prevented.

Under the proposed NERC design basis event, the magnitude of geoelectric field during a severe solar storm would be much smaller than both previous real-world observations and alternative models would suggest. Moreover, under the still undisclosed NERC Transformer Modeling Guide, the withstand capability of power transformers to GIC could be much higher than observed transformer failures during solar storms would indicate. Unrealistically low assumptions for geoelectric field combined with unrealistically high assumptions of GIC withstand for power transformers could easily result in studies concluding that electric utilities need take no GMD mitigation measures other than operating procedures. In this way, the explicit mandate of FERC under Order 779 for hardware-based GMD protection could be defied and defeated. Consequently, this prospective use of scientifically-invalid NERC modeling guidelines would foreseeably result in indefinite postponement of hardware protection, negation of ratepayer benefits of excluding GICs from the bulk power system, and preclusion of effective protection against both natural and man-made threats to the electric grid.

Appendix 1

NERC GMD Task Force Web Page as of August 8, 2013



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Committees > Planning Committee (PC) > Geomagnetic Disturbance Task Force (GMDTF) 2013

Geomagnetic Disturbance Task Force (GMDTF) 2013

Prior Agenda Highlights and Minutes

Geomagnetic Disturbance Task Force (GMDTF) 2013

Type	Description	Date
Supporting Documents and Material (8)		
	DRAFT GIC Application Guide V1	5/22/2013
	Geomagnetic Disturbance Planning Application Guide	7/18/2013
	Operating Procedure Template	5/24/2013
	Unofficial Comment Form	5/24/2013
	Request for Comment	5/24/2013
	Generation Operating Procedure Template (PC Approved / OC Endorsed February 2013)	5/24/2013
	Transmission Operating Procedure Template (PC Approved / OC Endorsed February 2013)	5/24/2013
	GMDFT Voluntary Survey - Test Specifications	4/18/2013
GMDTF Webinar - May 16, 2013 (1)		
	GMDTF May 16, 2013 Webinar Agenda	5/13/2013
GMDTF Webinar - June 4, 2013 (1)		
	GMD Task Force Phase 2 Web Meeting Presentation	6/5/2013
GMDTF Webinar - April 3, 2013 (2)		
	GMDTF Team 3 Presentations	5/24/2013
	GMDTF Team 3 Conference Call Agenda (April 3, 2013)	5/24/2013
GMDTF Meeting - July 25-26, 2013 (Vancouver, BC) (2)		
	GMDTF Meeting Agenda July 25-26, 2013 (Vancouver, BC)	7/19/2013
	GMDTF Meeting Presentations July 25-26, 2013 (Vancouver, BC)	7/25/2013
GMDTF Meeting - February 25-27, 2013 (5)		
	GMDTF Meeting Presentations - Day 2 (1 of 2) February 26, 2013	5/24/2013
	GMDTF Meeting Agenda February 25-27, 2013 (Atlanta, GA)	5/24/2013
	GMDTF - Presentations Day 1 - February 25, 2013	5/24/2013
	GMDTF Meeting Presentations Day 3 - February 27, 2013	5/24/2013
	GMDTF - Presentation Day 2 (2 of 2) - February 26, 2013	5/24/2013

Appendix 2

United States Geological Service Analysis Showing 1.7 Volts/Kilometer Geoelectric Field Shortly Before Failure of Generator Step Up Transformer at Salem, New Jersey Nuclear Plant

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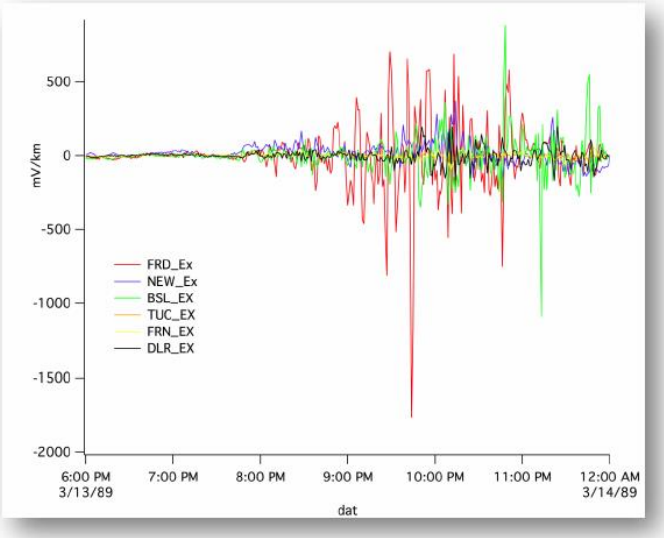
USGS

- Application of the derived 1D ground models for computing the geoelectric field for USGS stations (individual events and statistics).



1989 Storm Electric Field x-component