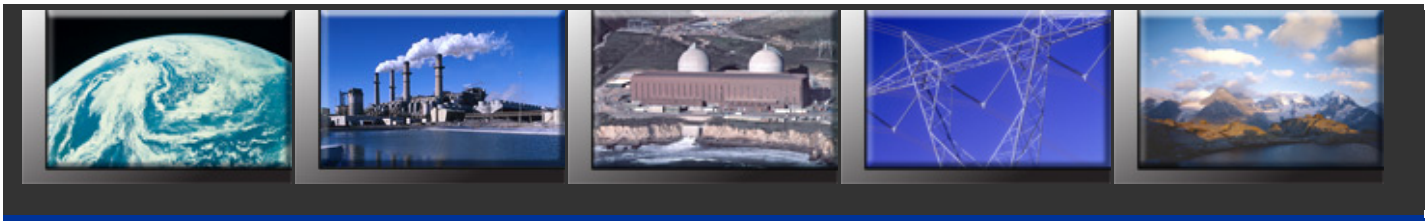
# GMD News and Observer

## *Your View into EPRI Research on Geomagnetic Disturbance Vulnerabilities, Impacts, and Mitigation*



**An EPRI Newsletter** **Issue 5, July 2013**

## EPRI EXECUTIVE UPDATE

Welcome to the fifth issue of our newsletter, *GMD News and Observer.* Published approximately quarterly, this newsletter provides progress reports and insights for the industry on the geomagnetic disturbance (GMD) area. This issue includes an update from NERC on its GMD Task Force work, a summary of a soon-to-be-published EPRI report on the impact of GICs on the North American Eastern and Western Interconnects, and noteworthy news, including the recent FERC final rulemaking on "Reliability Standards for Geomagnetic Disturbances."

Previous issues can be downloaded from epri.com (Issue 1: ID# 1025857; Issue 2: ID#1025858; Issue 3: ID#1025859; and Issue 4: ID#3002000847). In subsequent issues, we will discuss emerging research on GMDs and proposed mitigation plans by various industry leaders. We welcome your feedback.

Best regards,
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## NERC GMD RESEARCH

### NERC Update on Geomagnetic Disturbance Task Force Project

The NERC GMD Task Force is reaching the mid-point in its Phase 2 project and is on track to complete tasks in its 2013 work plan. The 2013 work plan includes tasks that support the industry's operators and planners in assessing and mitigating risks from geomagnetic disturbances. Ken Donahoo of Oncor chairs the task force. The task force is implementing the recommendations of the 2012 GMD report, with work now underway by four teams led by some of the industry's most experienced engineers and operators:

- Team 1: Planning Study and Assessment Design
  Chair: Russ Neal, P.E. (Southern California Edison)

- Team 2: Equipment Model Development and Validation
  Chair: Dr. Luis Marti (HydroOne)
- Team 3: GIC Model Development and Validation
  Chair: Dr. Randy Horton, P.E. (Southern Company)
- Team 4: System Operating Practices, Tools, and Training
  Chair: Frank Koza, P.E. (PJM)

Supported by contributions from EPRI and various equipment manufacturers, software companies, and government and private researchers, the task force is developing a number of open-source tools, models, and resources that will advance the capabilities utilities have for understanding risks from GMD events and developing strategies to address identified impacts.

Earlier this year, the task force produced Operating Procedure templates that incorporate best practices in monitoring and GMD effects mitigation from throughout the industry. These guides can provide a starting point for utilities to use in creating or updating entity-specific GMD Operating Procedures. The task force is also leading efforts to examine System Operator training materials and make recommendations for improvements that would increase the level of knowledge of System Operators.

Planners will soon have more open-source tools available to study GMD effects on their system. An application guide for calculating geomagnetically-induced currents (GIC) in the power system has been drafted and is in review. The guide will provide a theoretical basis for GIC calculations necessary for planning studies and vulnerability assessments. Additionally, initial open-source analytical models for transformer Var loss are being developed to support system power-flow studies. System planners will be able to draw upon guidance in the task force's initial Planning Study and Vulnerability Assessment guide, also undergoing task force review, to perform system studies and develop strategies to mitigate identified risks. A concerted effort is underway to provide broad opportunity for technical input as these efforts are steadily advanced for roll-out of first-iteration before the end of 2013.

Maintaining the momentum throughout the current project is especially important with the issuance of FERC Order 779, which directs NERC to develop Reliability Standards to address the impacts of GMD. In the order, FERC directs a two-stage approach to standards development:

- Stage 1 Standard(s) require applicable entities to develop and implement Operating Procedures. Stage 1 Standard(s) must be filed by January 2014. An implementation period of six-months was recommended in the FERC Order.
- Stage 2 Standard(s) require applicable entities to conduct assessments of the potential impact of benchmark GMD events on their systems. If the assessments identify potential impacts, the Standard(s) will require the applicable entity to develop and implement a plan to mitigate the risk of instability, uncontrolled separation, or Cascading. Stage 2 Standards must be filed by January 21, 2015. A specific implementation period for Stage 2 was not addressed in Order 779.

Several references were made in the final rule to the work of the GMD Task Force. Specifically, guidance on the schedule for Standard development and the suggested implementation plans were modified from FERC's October Notice of Proposed Rulemaking based on industry feedback and a better fit with the GMD Task Force's current project. With the issuance of the final order, the task force took the lead in developing the Standards Authorization Request, which defines the scope of the standards development project and provides the technical justification needed to develop the Standards.

Looking ahead, NERC staff and the task force leadership are preparing for activities in 2014 that will help validate the results that are produced using the task force's tools and models, provide insights that will

enhance their usefulness in the hands of system planners, and expand upon models with additional data. This effort could take advantage of the studies that some entities have already done to assess their system vulnerability to GMD and the monitoring and mitigation strategies that they are employing. Comparing these study results and measured data with results produced by the task force's study tools will support validation and improvements which may be incorporated into updated guides, tools, and models. Additionally, several long-term activities to study thermal and magnetic behavior of transformers will produce additional results in 2014 that will enhance the initial models.

The GMD task force's current project continues to advance industry's leadership position in addressing the risks posed by geomagnetic disturbances from a solid technical foundation. The task force is uniquely focused on fulfilling industry's need for open-source tools that will enable system planners and operators to assess system impacts from geomagnetic disturbances and develop sound mitigation strategies. The collaboration between experienced engineers and operators from the utilities, EPRI, manufacturers, and a diverse group of public and private organizations is one of the strengths of the task force approach.

For more information, contact Mark Olson, Standards Developer, NERC, 404-446-9760, mark.olson@nerc.net.

**EPRI GMD RESEARCH**

## New Study Explores Impact of GICs on the North American Eastern and Western Interconnects

In the third quarter of 2013, EPRI will publish “Study of the Impact of Geomagnetically-Induced Currents on the North American Eastern and Western Interconnects” (EPRI report 3002000818). This report presents a methodology for the modeling and analysis of geomagnetic disturbances (GMDs) and geomagnetically-induced currents (GICs) on the power grid. The effects of GICs are integrated into the power flow in order to assess the impact on system voltage stability. Results of studies performed on EPRI benchmark models and large-scale power system models such as the Eastern and Western Interconnects are provided. The report also proposes a technique to perform sensitivity analysis of transformer GICs to electric fields and induced line voltages, to determine how much of a large power flow model is needed to accurately determine the GICs in transformers of interest. Finally, the impact of GICs on short-term voltage stability is discussed, which motivates the need to perform more detailed dynamic simulations in GIC studies. The highlights of this work are as follows:

The report first discusses the methodology behind the modeling of GMDs and the calculation of GICs in the system. The GIC-induced transformer half-cycle saturation can be modeled as an increased reactive power load. This effect is integrated into the power flow solution in order to provide an assessment of a possible voltage collapse in the system. The report shows the feasibility of incorporating GIC analysis in existing power flow modeling, and provides a detailed methodology.

The report next provides ac network parameters for the EPRI 18-bus GIC benchmark system; only the dc network data was benchmarked earlier. Some benchmark results for voltage collapse studies are shown. These studies show that for the given parameters, the test system is more susceptible to a voltage collapse for an east-west electric field than a north-south field.

The report then presents a methodology to perform GIC and integrated power flow studies on large-scale power flow models such as the Eastern and Western Interconnects. These analyses show that GICs tend to concentrate at network edges and discontinuities. GIC flow is also predominant in the higher voltage

networks. Voltage collapse analysis of these large-scale models shows the level of GICs and reactive power losses required to cause the system to experience a voltage collapse (which is defined here as the point of maximum reactive power loadability indicated by a non-convergent power flow solution).

The report proposes a sensitivity analysis technique that can determine what portion of a large interconnect would be important from the point of view of calculating GICs in certain transformers (i.e., the quasi-dc voltages induced in the transmission lines by GMDs). GMD-induced dc line voltages that influence the GICs in transformers of interest are determined. This analysis shows that only the nearby lines influence transformer GICs. Hence if non-uniform fields have to be used, the detailed field orientations on only those lines would be important.

The report also considers the shorter-term voltage stability aspects of GICs. Because the underlying GMDs can have rise times of less than one minute, there is a need to consider their impact on power system short-term voltage stability. The report shows that the assumed dynamic models for loads and network controls such as load tap changing transformers (LTCs) can significantly reduce the GICs needed to cause a voltage collapse. Therefore more detailed dynamic simulations are recommended for inclusion in GIC studies. Also, this is an area in need of additional study.

## EVENTS, NEWS, AND RESOURCES

### FERC Issues Order No. 779: "Reliability Standards for Geomagnetic Disturbances"

On May 16, 2013, FERC issued Order No. 779, "Reliability Standards for Geomagnetic Disturbances," which directs NERC to submit for approval reliability standards that address the impact of GMD on the "reliable operation of the Bulk Power System." Order No. 779 follows an October 12, 2012 Notice of Proposed Rulemaking ("NOPR"), and reflects comments on the NOPR received by the Commission. See the news article below for more information on this important development.

### Five New Sunburst GIC Measurement Nodes Added

Five new Sunburst Network GIC measurement nodes have been added in the last two months (one each in Ohio, California, and Tennessee, and two in Texas), and four more nodes will be installed in the next month. EPRI is currently working with the U.S. Department of Energy (DOE) and the U.S. Geological Survey (USGS) on variometer placement.

### Recent GIC Event

A GIC event was recorded June 29th, 2012. The GIC was greater than 10 amps at five measuring sites, with a peak of 24.2 amps (see Figure 1). Figure 2 shows sunspot activity for the last 13 years.

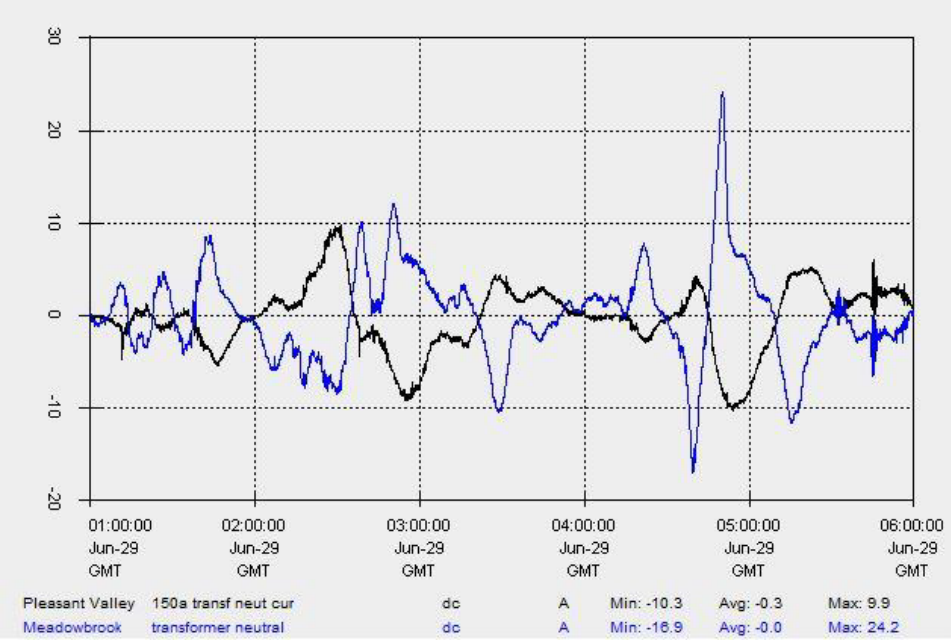


Figure 1. Solar activity on June 29, 2013.

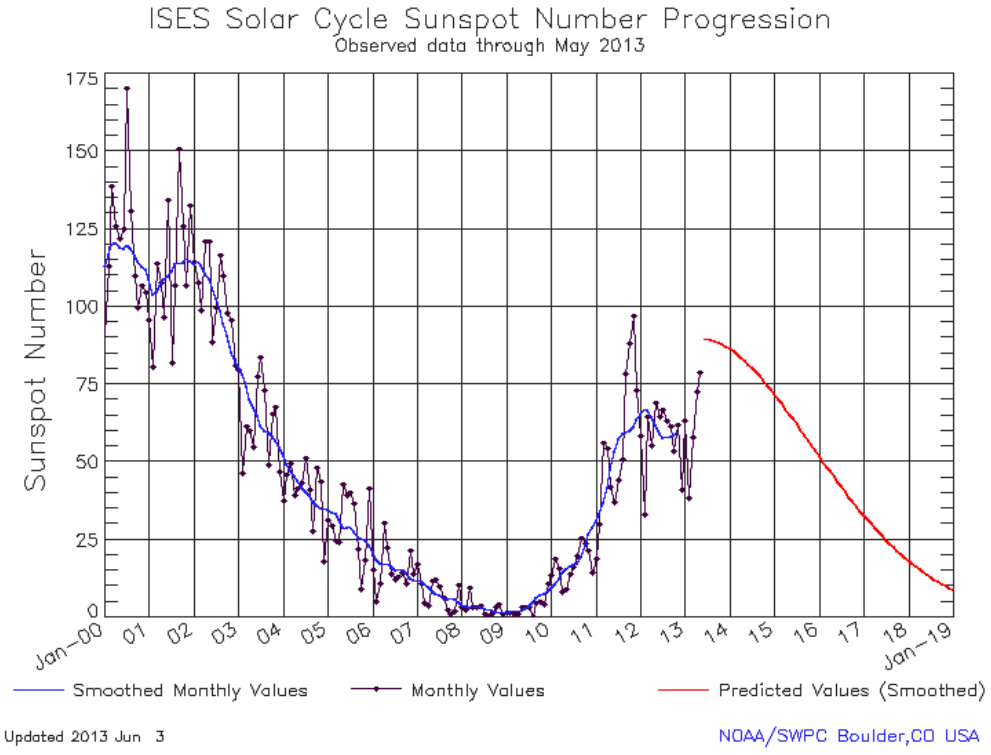


Figure 2. Sunspot Activity from 2000-Present and Projected Activity

## Congress Introduces Bill on GMD and EMP

On June 18, House Speaker Newt Gingrich introduced the Secure High-voltage Infrastructure for Electricity from Lethal Damage Act (SHIELD Act), a bill that would amend the Federal Power Act to protect the bulk-power system and electric infrastructure against natural (GMD) and manmade electromagnetic pulse ("EMP") threats and vulnerabilities. Sponsored by Representative Trent Franks (AZ), the bill would push the federal government to install grid-saving devices, surge protectors that could save the transformers and power system from EMPs.

The SHIELD Act, which would amend section 215 of the Federal Power Act, encourages cooperation between industry and government in the development, promulgation, and implementation of standards and processes that are necessary to address the current shortcomings and vulnerabilities of the electric grid from a major EMP event. For more information, see http://thomas.loc.gov/cgi-bin/query/z?c112:H.R.668.IH:and http://washingtonexaminer.com/article/2532038#.UcIBke3QKVQ.email.

## Opportunities for Participation

To find out about opportunities to participate in EPRI's research on GMDs, please contact EPRI Senior Technical Executive Rich Lordan, rilordan@epri.com, (650) 855-2435.

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