



Summary and Highlights:

FERC GMD Staff Technical Conference

Staff Technical Conference on Geomagnetic Disturbances to the Bulk power System

United States of America – **Federal Energy Regulatory Commission**

April 30, 2012

At the end of April, 2012, an important FERC Staff Technical Conference was held, taking testimony and holding discussions on the current status of GMD risks, and both existing and recommended mitigation steps and standards. The Conference achieved significant advances in building consensus on parallel efforts on standard setting, data gathering and mitigation actions.

Given the timeliness of the conference, EIS Council was asked to summarize and highlight some of the key comments and consensus that arose in the conference testimony and dialogue. This report provides a summary and highlights from the conference.

Background

On April 30, 2012, A FERC Staff Technical Conference was held, to “discuss issues related to the reliability of the Bulk-Power System as affected by geomagnetic disturbances,” and to “explore the risks and impacts from geomagnetically induced currents to transformers and other equipment on the Bulk-Power System, as well as options for addressing or mitigating the risks and impacts.”¹ Brief highlights of some of the key dialogue at the conference are provided below.²

¹ <http://www.ferc.gov/eventcalendar/Files/20120420162925-AD12-13-000a.pdf>

² This document was created without the aid of an official transcript, through use of the conference audio. As such, all quotations, though intended to be as accurate as possible and to capture the intent of the speaker, should be recognized to be paraphrases.

Highlights of testimony and panel discussion

Panel 1: Assessment of Geomagnetic Disturbance (GMD) Risks

*[Panelists were asked to address the North American Electric Reliability Corporation's (NERC) GMD Interim Report; other related assessments, e.g., Oak Ridge Study; and the differences between these reports and assessments.]*³

Highlights from introductory remarks from Joseph McClelland, Conference moderator, Director of FERC Office of Electric Reliability

“Recognizing that the decisions rendered on this issue may have far reaching effects on the industry, the government, and the citizens of the United States, this conference and the supplemental comments we receive are intended to generate a sufficient record in order that we can properly inform the Commission.”

Summary comments from FERC Commissioner Cheryl LaFleur

Putting the timeliness of calls for e-threat grid protection in a cost context, Commissioner LaFleur pointed out that “EEI has estimated that \$300B will be spent on transmission [upgrades/new equipment] between 2010 and 2030.” “I have read the testimony and I strongly believe there are a set of “no-regrets” actions that we can and must begin now, since they are called for by all the competing studies,” she said.

Scott Pugh – Interagency Programs Office, Science & Technology Directorate, U. S. Department of Homeland Security

Calling for an increase in hardware testing, Scott Pugh said: “A system for destructive testing of randomly selected transformers could tell us whether the U.S. transformer fleet needs to be protected. Without this information, we are essentially flying blind.”

Addressing the viability of procedural / operational GMD grid protection, he continued, “[20 minutes] is not much time to issue a warning and take preemptive [operational] actions to protect the grid.”

In conclusion, he said, “Many experts believe it would be prudent, on a prioritized basis, to install features to protect transformers and other critical grid components.”

Frank Koza – Executive Director, Support Operations, PJM Interconnection LLC

Frank Koza laid out a series of recommendations to address GMD risks. Calling for power companies to take responsibility to address GMD risks for their systems, he proposed: “Each asset owner must determine the overall health of its EHV transformers, and develop GIC protection measures for vulnerable transformers.” In addition, he said asset owners should: “Implement GIC withstand capability in any new transformers,” and also called on asset owners to “develop operating procedures and deploy monitoring equipment.”

Pointing to the need for additional modeling, he recommended that power companies “...include GMD impacts in power system analysis.” Why is this needed? “At the current level of knowledge,” he said, “no one can definitively say whether the above [procedural and transformer specification] steps will protect the transformers, nor do we know whether an immediately large scale investment would adequately address the risk, nor meet cost benefit requirements.”

³ FERC Conference Agenda, *op cit*.

John Kappenman, Storm Analysis Consultants

In his comments, John Kappenman pointed out that the fundamental conclusions about Power Grid vulnerability do not depend on any detailed model. Assessments of the overall grid risk, he explained, can be made by simply reviewing and extrapolating existing data. "Simple extrapolations from measured data leads to the conclusions," he explained.

Where are we in addressing this risk? "No standards exist for [GIC] rating for transformers," he pointed out. Furthermore, he said, "Even in transformers that are supposedly built to have GIC withstand, manufacturers are not able to physically test them to the withstand."

Speaking of the NERC GMD Taskforce Report, he pointed out that the report, unfortunately, was written without the benefit of any U.S. transformer fleet data gathering. "We have a situation where the task force report was developed without sufficient information."

Dr. Ben McConnell – Research Scientist, Lecturer, University of Tennessee

Dr. McConnell, referring to his research, referred to GMD as one of the "Achilles heels of civilization." "GMD," he explained, "came out to be the most serious situation we considered." In fact, he pointed out, malicious EMP threats have the potential to be even greater risks than Space-weather-induced GMD. "Natural [GMD] events are less intense than HEMP," he said.

Dr. McConnell joined other panelists in calling for more data. "We need good measurements inside the transformers," he said. ["We can't hold the data to our vest because we think it is proprietary," he commented on this subject, later in the discussion]. "It is a chaotic system, and models aren't enough, and measuring top oil doesn't tell you anything." Nevertheless, he continued, data gathering is not sufficient to resolve the GMD risk. For example, he said, even "testing to failure will tell you about one and only one transformer."

Concluding, he spoke of the need for realistic, effective grid protection. "One of the best ways to protect the grid is in an islanding mode, but we are not in that configuration." His overall recommendation: "We need to not do research, we need to get something done." Why? "If a tenth of the transformers go down," he explained, "we'd be in a world of hurt."

John Houston – Division Senior Vice President, High Voltage Delivery & Compliance, CenterPoint Energy

In his comments, John Houston warned against the risk of complacency and making optimistic assumptions. "It is a debatable point whether our systems can be protected by a voltage collapse," he said. And even the most positive scenarios, he pointed out, would not justify complacency. "Voltage collapse, while better than widespread damage, is still not good for our industry."

Questions from the Moderator, Joseph McClelland (FERC)

Based on the developing dialogue, Joseph McClelland asked panelists to discuss the trend of GMD vulnerability of the power grid. "Are we [unintentionally] making the grid more vulnerable?" he asked. He also asked, in regard to the procedural or operational measures, "Where should the GIC monitors go and what level should we take action?"

Highlights of panelist responses to the moderator's questions:

Frank Koza (PJM Interconnection): Answering the question on the level at which action should be taken, he said: "PJM – takes action when we get 10 Amps of GIC at our monitoring station." "This came out of the 1989 event and the damage to the Salem transformer," he explained.

John Houston (CenterPoint Energy): “We’ve modernized since 1921 and it’s more vulnerable.” “We are adding more antenna, and you have to do something about that.”

Mark Lauby – Vice President and Director of Reliability Assessment and Performance Analysis, North American Electric Reliability Corporation

“The [NERC GMD Taskforce Interim] Report talks about the need for monitoring GIC flows, and for sharing that data.” Referring to an existing example of how grid hardware protection can be accomplished, he added: “Over 200 miles, we have series compensation, and that eliminates GIC.”

Joe McClelland (FERC -- Moderator)

Referring to a hoped-for positive, “best case” voltage collapse scenario, [i.e. timing and phenomenology of a severe GMD event such that the grid would fail in a best-case voltage collapse mode, minimizing permanent damage], “Voltage collapse to protect the grid isn’t an acceptable solution,” he said. Even if we were to depend on such a best case scenario, he explained, the resulting short term blackout would also be a serious problem. “We could buy a lot of mitigation for \$4 - \$10 Billion dollars, [the estimated cost of the 2003 North East blackout],” he said.

Highlights of concluding Panel 1 discussion:

Near the end of the Panel 1 discussion, most panelists included, in their final remarks, comments aimed at summing up the overall sense of the panel dialogue. Below are highlights of some of these concluding, summary assessments.

John Houston (CenterPoint Energy) called for a coordinated plan to protect the grid against GMD. “We need a coordinated plan, otherwise blocking GMD becomes a game of ‘whack-a-mole,’” he said. Investment – either in mitigation or recovery – is inevitable, he explained. “Asset owners are going to invest either in protection or in clean up afterwards.”

Mark Lauby (NERC), agreed that there may be a need for current blockers. “Some solutions may involve blocking GICs from coming onto the system,” he said.

Joe McClelland (FERC -- Moderator) pointed out there seemed to be a consensus among the panelists. “I’m hearing consensus that this will take a coordinated effort,” he said.

Mark Lauby (NERC), responding in turn to Joe McClelland, concurred with the need for coordinated effort, and also pointed called for a look, in response, at appropriate standards. “I agree,” he said, following Joe McClelland’s assessment of the need for coordinated effort. “And our report calls for a look at NERC standards.”

Richard Waggel (FERC), emphasizing the need for standard-driven coordinated effort, pointed out that the most optimistic scenarios are, in any case, unlikely. “.. combining the possibility of the protection systems not operating and the breakers maybe not being able to interrupt, is it really conceivable to rely on a system collapse in that case?” he asked.

Scott Pugh (DHS) also concurred with the importance of a coordinated, standard-based plan, pointing out that such a plan should not depend solely on procedural / operational measures. “To think that NOAA could issue a warning at 3 A.M. on an average night and have everyone notice it, react to it perfectly ... that’s sort of

Supplemental summary material from Panel 1

An important, overall conclusion from all the Panel 1 dialogue related to the need for a collective, coordinated, power-grid-wide process to provide the required protection.

In this regards, panel members all concurred that grid protection cannot be done individually or in isolation. It must be done collectively - on an interconnection-wide basis.

The need for a national standard was also broadly discusses. The conclusion: all panelists agreed that a standard would be necessary to assure effective and consistent protection – and grid collapse, all panelists agreed, is not an acceptable manner in which to address GMD .

hard to imagine that going off perfectly, because we don't rehearse that very often. We ought to look at ways to protect the grid, not just rely on operators dealing with it."

Joe McClelland (FERC - Moderator), addressed concluding remarks to the balance of more analysis versus steps toward protection, pointing out that the existing agreement among the different models suggests we have a dependable basis now to go forward. "If our previous model and the open source EPRI model give the same results, we've validated that both work. The results are what matter," he said.

John Kappenman (Storm Analysis), added to this assessment, pointing out that there is specific data on transformer damage, consistent with model predictions. "Damage to the Salem transformer occurred within about a minute," he pointed out. "Heating high enough to melt the windings."

Dr. Ben McConnell (University of Tennessee), said, addressing some of his concluding remarks to the trend, or direction, of vulnerability over time, as older transformers are replaced by new, low loss transformers: "Very low loss steels in the [new] transformers have a very sharp knee... A little GIC and you are into super-saturation... The core will heat up extremely fast... The convective flow model is now completely blown away."

Frank Koza (PJM Interconnection), adding his own concluding remarks and, building on the panel's consensus on the need for a coordinated, standard-based plan, said: "Each asset owner must identify their key transformers and develop a protection strategy... it could be [GIC] blocking, it could be [vulnerable transformer] replacement..."

Panel II: Moving Forward on GMD

Panelists were asked to address two questions:

(1) What, if any, actions should the Commission, NERC, or industry undertake in response to the NERC report or other related assessments? This question included specific queries on the need for further studies, transformer data gathering, sparing and GMD specification, developing operating and training rules and reliability standards.

(2) What are the costs of potential mitigation options considered to date? This includes operational procedures, protection hardware or software and warning hardware or software.

William Murtagh – Program Coordinator, Space Weather Prediction Center, National Oceanic and Atmospheric Administration

Addressing the utility of the current “K Scale” standard for warning of the strength of an impending GMD event as guidance for power industry operating decisions, William Murtagh said “The K-scale is not very useful for GIC warning.”

Singh Matharu – Senior Engineer, Nuclear Regulatory Commission

Singh Matharu pointed out that nuclear power plant safety standards today depend on a highly reliable power grid. “NRC assumes high reliability of electric grid for safe operation of reactors and cooling of spent fuel,” he said.

In this regard, he continued, “After the 1989 [geomagnetic] storm, NRC issued an information notice titled ‘Failure of electrical power equipment due to geomagnetic disturbances’. The intent was to alert nuclear plant owners about possible failures of electrical equipment at their plants and the transmission system due to solar magnetic disturbances.”

Finally, he pointed out, there are two issues to be addressed by nuclear power plants – both reliable grid-based power, and vulnerability of nuclear power plant electrical hardware. “Availability of offsite power is [only] one variable,” he said, “because we do have transformers, connections and breakers, and we know there is a vulnerability there. As far as the plant transformers (GSUs).”

Michael Cousins, Head of Energy Resilience, UK Department of Energy and Climate Change)

“In the UK we expect a large space weather event to have moderate to severe impacts on the grid.” Addressing options for protection being considered, he said there are “two main methods: operational and hardening. Take hardening: the primary TSO has adopted design standards for transformers to make them better able to withstand GIC, and it has increased its spare holding of transformers. Consideration is being given to installation of series capacitors on certain transmission lines,” he said. In regard to new GIC current blocker prototypes now becoming available, “There has been a watchful eye on the development of neutral current blocking devices,” he said.

Finally, he added, procedural approaches also play a role. “Last month we exercised our rotor disconnection procedures.”

Overall, he suggested, the power industry may be at the beginning of a new phase of protection. “The UK sees this as a long term, continual improvement type of process,” he said in his final remarks.

Gerry Cauley – President and CEO, North American Electric Reliability Corporation

Early in his remarks, Gerry Cauley provided a clarification of the conclusions of the NERC GMD Taskforce Report. The report, he explained, points out both a risk for voltage collapse and for power grid hardware damage. “The NERC task force report points out two key risks, one for system disturbance and voltage collapse, and the other for potential equipment damage.” The report did not claim grid hardware damage

would be avoided by voltage collapse, he explained. “I think there were some things said earlier in the first panel, about NERC’s theory that voltage collapse will save the day. I don’t recall seeing that. I don’t think that was intended to be the implication of the NERC study.”

Hardware damage and voltage collapse are two separate risks, he said. “I think what we’re saying is that there are dueling concerns. The magnitude of a voltage collapse can be significant, as we saw in hydro Quebec, we also know there is evidence of equipment damage, but we need to put each in perspective in terms of what the information tells us, and the magnitudes of each of those two risks, supported by data and historical information.”

Characterizing the report as just a starting point, he said, “The intent of the report was to put 20 recommendations on the table. I view it as a starting point and a roadmap. It is not the end of the road.” He also agreed that more data is needed. “One thing we heard this morning that I agree with is the need for more data. I would be an advocate of data devices that could monitor the current themselves at key locations, as well as the performance and response of system equipment to those events.” He concluded with praise for the power industry’s seriousness in addressing the GMD threat, and for the progress being made through the dialogue taking place “today” at the FERC technical conference, “I’m encouraged by the industry’s response and the seriousness with which they’re taking the issue, and I think this discussion today will help progress for the future.”

Michael Heyeck, Senior Vice President of Transmission, American Electric Power Company

Michael Heyeck focused on what AEP is already doing, and urged others to act. “What is it that we can do right now, and what are we doing right now? We are sparing transformers.” [...] “We have drop-in control houses, and we’re using a Faraday cage approach and shielding the wires to try to deal with the high altitude EMP. We have no results; we just have intuition, based on what we’ve seen to date.” [...] “There are things we can do: First, let’s find out what sparing we can do today. Second, what is the age of these transformers and what types?” [...] “We could do all those things, probably within a few months, it’s not hard to do, then identify which are risky and which are not.”

He also called for a new, systematic process to record GIC data. “Those are things we can do this year,” he said, “but I can’t overemphasize, we’ve got to get the monitors in – we have the monitors in but we’re collecting it [the GIC data] anecdotally. There is no synchronous way of collecting this data until all of us get together, probably under the auspices of a NERC, to have an RTO collect this data, to at least capture what we know today, while we’re inventorying transformers and the age of transformers.”

Dr. Peter Pry, Executive Director, Task Force on National and Homeland Security

Peter Pry began by highlighting the large body of scientific studies performed over the last ten years. “Reports by the Congressional EMP Commission, the National Academy of Sciences, the Department of Energy and NERC itself, FERC and, most recently, the Defence Committee of the British Parliament, all independently arrived at the scientific consensus that a great Geomagnetic Storm could cause widespread damage to Power Grid transformers, resulting in a protracted blackout lasting months or years, with catastrophic consequences for society.

Steven T. Naumann – Vice President, Wholesale Market Design, Exelon Corporation

Steven Naumann echoed the broad concurrence that more data is needed. “Companies are installing GIC monitors, and it’s important that you get this real world information.”

Following the initial testimony of Panel 2 participants, FERC Commissioner Cheryl LaFleur summarized the consensus she derived from the discussion, and proposed two additional questions: addressing what specific, parallel actions can be taken in the near term, and the need for standards to drive the protection process.

Commissioner Cheryl LaFleur (FERC): “A number of you have outlined really potential next steps,” she said, “along the whole spectrum that Mr. Cousins put forth, of modeling and monitoring, mitigation, both hardening of the existing system and new standards, and operating practices.” [...] “And I’m interested in any of the panelists giving any indications of how quickly we could put some timeframes around these things, and proceed in parallel as has been suggested. We may or may not have time this solar cycle – we may have a long time or a short time.” [...] “And I’m interested in any teeth we can put around what you propose.”

Continuing, Commissioner LaFleur suggested that national standards are needed.

“Much of this just sounds to me like it cries out for national standards,” she said. “Just as we have seismic standards and other things [...] we have numerous reliability standards on tree trimming, on relays or so forth that respect different situations or different geography, but still set some sort of national baseline that has to be met. I’m interested in people’s thinking about which of these things lend themselves to standards so we can get started on that also.”

Gerry Cauley (NERC): Echoing concurrence that a GMD Standard is needed and achievable, Gerry Cauley commented, “Ideally what I would like a standard to do at some point, which I think will be achievable, is to set some kind of performance expectations some kind of planning and design criteria to which we would expect the system to perform.”

In addition, he said, “If we had a detailed roadmap with some anticipated timelines I think it would give the commission a sense of accountability. [...] Set up a roadmap with timelines based around some of these activities and manage to that..”

Gerry Cauley also indicated there could be some near term priorities for some of the most vulnerable hardware. “We know enough about what kinds of transformers would be the most vulnerable and [we could] ask those companies about accelerated replacement or more monitoring.”

In his final remarks, Gerry Cauley indicated he does not oppose GIC blocking devices, but does believe it will be important to study the performance of these devices before they are used. “I’m not opposed to blockers and capacitors and I think they are reasonable solutions but in my 30 years in the industry we never do anything without studying it first.”

Peter Pry (Task Force on National and Homeland Security), responding to Commissioner LaFleur’s questions, commented that, while additional study is needed, there is adequate information to put a standard in place and begin working on mitigation.

“We certainly don’t know everything we need to know about geomagnetic storms and the threat,” he said. “We know enough so that we can set standards now, and as we do more research, improve those standards in the future. Doing more analysis and modeling shouldn’t become an excuse for doing nothing,” he said. The reasons little mitigation has been done, he explained, are organizational, not technical. “The primary problem has not been technological, but it has been political and institutional. Who has the authority – nobody seems to have the authority.

With all the studies already completed, he continued, we have enough information to set standards and begin taking actions. “Our knowledge is never going to be perfect about the threat from geomagnetic storms,” he said. “We can invest a lot more time and money studying them, and it will not result in a dramatic, great increase in our knowledge.” [...] We’ve been collecting data for about 70 years, and the sun is 4.5 billion years old.”

William Murtagh (NOAA), addressed his final remarks to the inability to push even approximate GMD predictions past the 20-60 minute lead offered by the ACE satellite readings, and therefore the difficulty of using procedural / operational measures for grid protection. “We just don’t know the direction of the magnetic field [prior to hitting the ACE satellite],” He said.

Steven T. Naumann (Exelon): In his concluding remarks, Steven Naumann explained there are serious limits to the availability of spare transformers. “The STEP program does not include generator step up transformers,” he pointed out. In addition, he continued, “It is my understanding that there are not spares for

300 transformers at one time. That's an awful lot of transformers." "STEP was postulated by the industry for a [local] terrorist attack, not for the simultaneous loss of 300 transformers."

Singh Matharu (NRC). From a Nuclear Regulatory Commission perspective, Singh Matharu made it clear that a severe Geomagnetic Storm could have a serious impact on nuclear power plants. "If a [storm big enough to cause] grid collapse was predicted ahead of time, all nuclear power plants would shut down." [...] "The policy is, if you do not have adequate offsite power sources, you will shut the plant down."

Cheryl LaFleur (FERC), pointed out in her concluding remarks that there is broad agreement that companies that act must be able to recover their costs. "I just wanted to acknowledge the cost point." [...] "Obviously any time you're looking at a fleet of resources, some are close to end of life and you're not going to do anything to them, some others are maybe worth retrofitting, others an operational solution. There's always a cost analysis, as well as Steve [Naumann]'s point on cost recovery. I don't think that's been the big issue that's held us up, but I do think – message received."

Supplemental summary material from Panel 2

There was general agreement that, for the most critical transformers, blockers or series capacitors should be added to assure they remain in-service – given that there is adequate study / testing to avoid creating inadvertent problems. This would mean, in an interconnection-wide initiative, that these critical elements would be protected first, with the rest of the system adapting as required, to ensure those assets are protected..

There was also no disagreement to the moderator's summary comment, that not only the most vulnerable, but also the most critical, equipment – such as transformers that serve the nuclear plants, critical military facilities – should be protected.

Finally, nuclear power plants were discussed as important, critical assets requiring GMD protection, including Startup Auxiliary Transformers. In the event of an intermediate duration wide area blackout, Singh Matharu made it clear that it would be essential that power be restored within no more than a two week period.

