

**UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

Reliability Standard for Transmission System)
Planned Performance for) **Docket No. RM15-11-000**
Geomagnetic Disturbance Events)

**REQUEST FOR REHEARING OF FERC ORDER No. 830,
RELIABILITY STANDARD FOR TRANSMISSION SYSTEM PLANNED PERFORMANCE
FOR GEOMAGNETIC DISTURBANCE EVENTS,
156 FERC ¶ 61,215, September 22, 2016
AND MOTION FOR REMAND**

Submitted to FERC on October 24, 2016¹

Pursuant to section 313(a) of the Federal Power Act (“FPA”), 16 U.S.C. § 825 (a), and Rule 713 of the Federal Energy Regulatory Commission’s (“FERC” or “Commission”) Rules of Practice and Procedure, 18 C.F.R. § 385.713, the Foundation for Resilient Societies (hereafter “Resilient Societies”) hereby respectfully submits this Request for Rehearing of the Final Rule issued in this docket and Motion for Remand, relating to FERC Order No. 830.

Introduction

Resilient Societies and other public stakeholders submitted rulemaking comments in FERC Docket RM15-11-000² for solar storm protection of the Bulk Power System. Resilient Societies appreciates the many years of FERC staff and Commissioner work on this technically complex rulemaking. Because of the large loss of life that could occur because of a severe solar storm, it is vital that the final rule be not only legally correct, but technically correct as well.

¹ The Request for Rehearing is timely filed, because the 30-day filing deadline falls on Saturday October 22, 2016. See *Cities of Batavia, et al. v. FERC*, 672 F.2d 64 at 72 (D.C. Circuit, 1982) (FERC regulations extend filing deadlines for weekend due dates and for legal holidays in the District of Columbia).

² See Comments of the Foundation for Resilient Societies” submitted to FERC on July 27, 2015 and August 10, 2015 under FERC Docket RM15-11-000, incorporated in their entirety by reference.

Multiple stakeholders representing the public interest participated in the Docket with well-reasoned technical comments. Some public stakeholders have spent the majority of their careers building the expertise displayed in their reasoned and technically-accurate docket comments. Commenters included John Kappenman, author of the Oak Ridge Laboratory report “Geomagnetic Storms and Their Impacts on the U.S. Power Grid;”³ Professor Charles T. Gaunt, a South African researcher with special expertise modeling impacts of solar storms on transformers and design margins for transformer protection; and Terry Volkmann, a consultant with deep expertise in electric grid planning and operations. In addition, Resilient Societies submitted a 91-page technical comment for the Docket, based on five years of work in NERC standard-setting and FERC rulemaking for geomagnetic disturbance (GMD) protection.

In its Order 830 the Commission significantly advanced long-term prospects for future “best practices” by recognizing and affirming that *“[t]he Commission did not suggest nor could it suggest, that compliance with a Reliability Standard would absolve registered entities from general legal liability, if any, arising from a disruption to the Bulk-Power System.”*⁴

We commend the Commission for its explanation of potential liability for imprudent practices that may technically fulfill mandated reliability standards: over an extended period of time the insurance and reinsurance industries can extend underwriting coverage and concurrently provide discounts for adoption by registered entities of voluntary “best practices” that reduce grid outage risks.

Despite this significant opportunity to strengthen “best practices” and reduce risks of long-lasting grid outages, the Commission should recognize that it may take many years or decades to achieve through “best practices” what existing reliability standards have not yet attained: a bulk power system that is not only reliable but also resilient, and capable of prompt recovery from prospective hazards including severe solar geomagnetic disturbances. It is therefore important that the Commission address all well-reasoned technical comments in the Docket.

³ John Kappenman. Geomagnetic Storms and Their Impacts on the U.S. Power Grid (Meta-R-319).” Metatech Corporation. January 2010. Prepared for Oak Ridge National Laboratory. Available from https://www.ferc.gov/industries/electric/indus-act/reliability/cybersecurity/ferc_meta-r-319.pdf.

⁴ Order No. 830, ¶ 122, at p. 76 (2016)(italics added)..

Summary of Unaddressed Comments

In Order 830 FERC did not address several important categories of technical comments submitted by public stakeholders and therefore did not examine relevant data and articulate a satisfactory explanation for its actions. These comments demonstrate the continuing vulnerability of critical grid equipment that, without hardware protection not now installed, could take years to replace after a severe solar geomagnetic disturbance.

These categories of unaddressed comments include:

- 1. Imprudent Design Factors for Scientific and Engineering Uncertainty.** Over a century of good engineering practice incorporates factors for scientific and engineering uncertainty, variously termed “design factors,” “overrating,” “overload factors,” “safety factors,” “factors of ignorance,” “reserves of strength,” and “conservatism” the Commission has failed to require prudent reliability design factors for critical grid equipment in Standard TPL-007-1. These design factors protect reliability and the public interest when physical phenomena are not well understood and there is uncertainty on the resilience of engineered structures. Unfortunately, FERC Order 830 did not address multiple stakeholder comments urging the use of prudent design factors for scientific and engineering uncertainty. In fact, in FERC Order 830, FERC permits the opposite—so called “spatial averaging” for peak geoelectric fields and downward scaling factors for “geomagnetic latitude” and “local earth conductivity.” This lack of prudent design factors for each separate physical phenomenon has a multiplicative effect, causing compounded error that can diverge from reality by a factor of one hundred times or more.
- 2. No Consideration of Vibration Impacts on Transformers.** GMD may cause transformer failure modes other than heating, including vibration and loss of insulation. FERC declined to address this technically complex but important topic in Order 830. The evidence in the Docket shows that transformers may fail due to vibration-caused damage, as happened during a solar storm at Seabrook Station on November 9-10, 1998 with a 12.2 day transformer outage.

- 3. No Collection and Disclosure of Data on Solar Storm Impacts.** In Order 830, FERC did require collection of data on storm intensity, including measures of both geomagnetically induced current (GIC) and changing magnetic flux. However, these are half measures at best—without data on the *impacts of solar storms*, research to correlate storm intensity with storm impacts will be precluded. By not addressing comments on the necessity of storm impact data for research, FERC will degrade scientific understanding—and also allow the impacts of solar storms on electric grids to remain hidden from public view.
- 4. Arbitrary and Capricious Exclusion of Relevant GIC Data.** In FERC Order 830, the Commission directed NERC to collect GIC monitoring and magnetometer data from registered entities for the period beginning May 2013 and make this data available. The period from May 2013 to the present is devoid of any significant solar storms and therefore any information made available for the NERC GMD research work plan will be of limited utility. The time period from the first day of May 2013 to the present has no legal or scientific significance.
- 5. Exemption of Networks Operating Between 100 kV and 200 kV.** The definition of the Bulk Power System generally includes networks operating at 100 kV and above. However, NERC Standard TPL-007-1 applies only to networks operating at 200 kV and above. In Order 830, the Commission did not address comments showing how this exclusion could discount reactive power resources operating at these voltages.
- 6. No Required-Public Disclosure of Mitigative Measures for Transformers.** Because of potentially large loss of life in a blackout following a severe solar storm, the public interest demands disclosure on whether prudent mitigative measures have been taken by utilities or, alternatively, evaded. Moreover, because FERC has granted cost recovery for mitigative measures, the public should have a right to know what they are paying for. However, FERC did not address the request of Resilient Societies to add a requirement that utilities annually disclose mitigative measures.

It is not in the public interest for FERC to ignore well-researched and well-reasoned comments. Public stakeholders can expend years of time in following dockets and submitting comments. In

early dockets for Critical Infrastructure Protection (CIP) standards, knowledgeable stakeholders from outside the electric utility industry refrained from submitting comments. Docket RM15-11-000 has been a notable exception to this previous pattern of unbalanced dockets for electric reliability.

However, when the Commission does not address public stakeholder comments relating to specific and important technical issues with even a single line of text in its orders, it provides a powerful disincentive for knowledgeable public stakeholders to continue their participation. Moreover, the U.S. Supreme Court has ruled that agencies such as FERC have a legal obligation under the Administrative Procedure Act to examine relevant data and explain the reasons for their actions—including addressing reasoned docket comments.⁵

When FERC ignores docket comments with a firm technical basis, it acts with great peril to the public interest. FERC may make rulings based on legal reasoning and a consensus of its Commissioners, but the physics of the electric grid does not operate according to *legal and political principles*—instead, the electric grid and its natural hazards are governed by *scientific principles*. The Sun will not respect FERC rulings that are scientifically ungrounded when it sends a catastrophic solar storm crashing into the electric grid.

Perhaps the Commission intends to implicitly correct the above technical errors through its current remands, including a NERC GMD research work plan to revise the Benchmark GMD Event. However, past experience has shown that FERC does not consistently hold industry to account in following each provision of its Orders and so the public can have little confidence that future NERC work plans will necessarily provide a remedy. For example, in Order 779, FERC directed NERC to conduct “Initial Actions” assessments of critical facilities most at risk from solar storms:

The Commission accepts the proposal in NERC’s May 21, 2012 post-Technical Conference comments and directs NERC to “identify facilities most at-risk from severe

⁵ See *Motor Vehicle Manufacturers Ass’n v. State Farm Mu. Auto Insurance Co.*, 463 U.S. 29, 43 (1983), available at <https://supreme.justia.com/cases/federal/us/463/29/case.html>. “While the scope of review under the ‘arbitrary and capricious’ standard is narrow, and a court is not to substitute its judgment for that of the agency, the agency nevertheless must examine the relevant data and articulate a satisfactory explanation for its action.”

geomagnetic disturbance” and “conduct wide-area geomagnetic disturbance vulnerability assessment” as well as give special attention to those Bulk-Power System facilities that provide service to critical and priority loads.

As of this late date, no such “Initial Actions” assessments by NERC have been filed in the Docket.

Statement of Issues and Specifications of Error

For the enumerated categories below, FERC did not address reasoned comments in Order 830.

1. Imprudent Factors for Scientific and Engineering Uncertainty

Page 7 of Terry Volkmann’s comments at the March 1, 2016 GMD Technical Conference reads:

1. Normal Engineering practices usually apply a factor of safety especially when human safety is a concern. In this case the Drafting Team has ignored the need for a factor of safety.
2. A typical safety factor used in by the electrical power industry typically varies from a multiplier in the range from 2 to 4. Therefore, a safety of factor in this range should be applied to the anticipated geo-electric field for an extreme geo-magnetic (GMD) impact.

Page 52 of Resilient Societies docket comments reads:

[S]afety factors are commonly used in a variety of engineered structures and products. For example, a safety factor of 2 is commonly used in built structures. Automobiles commonly have a safety factor of 3. However, the “Implicit Safety Margin” in Standard TPL-007-1 is only 1.4 (8 V/km over 5.77 V/km.)

Page 55 of Resilient Societies docket comments reads:

We urge the Commission to understand that fixing just one factor in Standard TPL-007-1, such as the 1-in-100 Year Reference Storm, will not fix all the other defective standards. Importantly, because the various component factors are multiplicative, the overall impact of hazard-reducing sub-models is to drastically reduce the prudence and the realism of the resulting Benchmark GMD Event design and benchmark standard.

Pages 40-41 of John Kappenman July 27, 2015 comments in Docket RM15-11-000 read:

The NERC Standard has devised a formulation of the Peak Geo-Electric field that has been described via the formula given in Figure 33. The NERC Standard Drafting team

has made numerous statements that this formulation provides a “Hundred Year” threat level and was noted by the SDT Team during the course of balloting of the standard. (“the SDT believes a 100-year scenario is an appropriate benchmark.”)

$$E_{\text{peak}} = 8 \times \alpha \times \beta \text{ (V/km)}$$

Figure 33 - NERC Standard Peak Geo-Electric Field Formula

As commenters to this standard have noted and as are also further elaborated on here, there are a number of fundamental problems with this formulation which can be summarized as follows:

- 8 Volts/km multiplier – which is the first constant in the above equation. Concern that Models do not Estimate this Constant Correctly due to Unsubstantiated Hot Spot Averaging or other unjustified techniques by the NERC SDT reducing a previously estimated 50 V/km peak geo- electric field by SDT Team members to 8 V/km – a greater than Factor of 6 de-rate that cannot and has not be substantiated.
- Alpha Factor - Factor Based on NERC Storm Intensity Profile, Threat Levels are Too Low and can be shown that a number of observations since 1972 greatly exceed the thresholds provided in this profile
- Beta Factor - Factor Based on Regional Ground Conductivity Estimates, Ground Models are Un-Validated & Can Be Readily Checked against Existing GIC Data.
- *Errors of Each Factor individually (the 8 V/km Constant, the Alpha and Beta) Being Too-Low Become Compounded, Greatly Increasing Overall Error.*

(Emphasis added.)

A diligent reading of the full order, as well as automated searches using the terms “factor” and “conservative” shows that FERC did not address the above comments.

2. No Consideration of Vibration Impacts on Transformers

Page 38 of Resilient Societies docket comments reads:

Altogether, vibrational impacts are important components of GMD hazards to high voltage transformers. The Commission should remand the NERC standard to include,

among other considerations, vibrational impacts and options for protective equipment against vibration.

Page 43 of John Kappenman July 27, 2015 comments in Docket RM15-11-000 reads:

An examination of these failure incidents also indicates that the failures are not just limited to thermal hot spots (which is the limited focus of the NERC Standard) but *can also occur due to transformer vibration related sources due to the GIC-caused transformer saturation.* (Emphasis added.)

A diligent reading of the full order, as well as automated searches using the terms “transformer” and “vibration” shows that FERC did not address comments on vibration impacts on transformers.⁶

3. No Collection and Disclosure of Data on Solar Storm Impacts

Page 18 of Resilient Societies docket comments reads:

We ask the Commission to remand the standard for collection of relevant data on grid impacts during GMD events and incorporation of these data into the standard-setting process.

Page 3 of Professor Gaunt’s July 25, 2015 comments on Docket RM15-11-00 reads:

Accordingly, the rules should be amended to: require the collection and analysis of key categories of data, including records of GICs in a representative sample of transformers, power system events related to GICs, transformer degradation and failure, and the costs to customers and society of unplanned interruptions of supply.

Pages 42-43 of John Kappenman July 27, 2015 comments in Docket RM15-11-000 read:

NERC has failed to gather any relevant data on transformer failures that could be attributed to Geomagnetic Storms and GIC exposure in those transformers. Further there has been relevant information made available to NERC and the public and there was no efforts to incorporate the same within the consideration of NERC design standards. In 2014, Storm Analysis Consultants felt it was necessary to publicly file a report to the US FERC on this topic of GIC and GSU Transformer Failures due to the lack of attention and actions on the part of NERC on this important topic. These GSU transformer failure events were reported in an IEEE Survey. There are also separate events of failures reported to the US Nuclear Regulatory Commission of transformer failure.

⁶⁶ Pages 45-45 of FERC Order 830 read, “Accordingly, we direct NERC to address the effects of harmonics, including tertiary winding harmonic heating and any other effects on transformers, as part of the GMD research work plan.” Harmonics are a distinct transformer effect other than “vibration”; both are caused by saturation.

A diligent reading of the full order, as well as an automated search using the terms “effects,” “impacts,” “failure” and “degradation,” shows FERC did not address these comments.

4. Arbitrary and Capricious Exclusion of Relevant Data

Page 49 of FERC Order reads:

As discussed in the next two sections of this final rule, the Commission directs a three-prong approach to further those efforts by directing NERC to: (1) develop, submit, and implement a GMD research work plan; (2) develop revisions to Reliability Standard TPL-007-1 to require responsible entities to collect GIC monitoring and magnetometer data; and (3) collect GIC monitoring and magnetometer data from registered entities for the period beginning May 2013, including both data existing as of the date of this order and new data going forward, and to make that information available.

The period from May 2013 to the present is devoid of any significant solar storms. However, significant solar storms did impact the North American electric grid in July 2000 and October 2003. GIC data on these storms was collected as part of the Electric Power Research Institute (EPRI) SUNBURST program. Moreover, Resilient Societies highlighted this industry GIC data in its docket comments. Footnote 21 on page 21 of Resilient Societies docket comments reads:

EPRI has operated its SUNBURST network of GIC monitors since 1991; see “Sunburst Network for Geomagnetic Currents” available at <http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000000001023278>.

FERC did not address our docket comments on relevant GIC data available through the SUNBURST program.

5. Exemption of Networks Operating Between 100 kV and 200 kV

Page 52 of Resilient Societies docket comments reads:

The arbitrary exemption of networks operating between 100 kV and 200 kV, without any specific study by owners and operators, is technically unreasonable, discriminatory, preferential, and inconsistent with real-world scientific evidence. Critical equipment can operate between these voltages, as the examples for SVCs, STATCOMs, and HVDC links show. Modeling within the BPA system shows that 115 kV networks are vulnerable to GMD. The Commission should remand to eliminate the exemption for networks operating between 100 kV and 200 kV.

A diligent reading of the full order, as well as an automated search using the terms “200 kV” and “100 kV,” shows that FERC did not address this comment.

6. No Required-Public Disclosure of Mitigative Measures for Transformers

Also on page 55 Resilient Societies docket comments reads:

We further urge the Commission to add a requirement that utilities annually disclose the number of extra high voltage transformers in their fleet, the number undergoing thermal assessment, the number of transformers determined to need mitigative measures, and the number and categories of mitigative measures among hardware protection, spare units, isolation from service, or other mitigative strategy. If the disclosed number of transformers needing thermal assessment and/or the number of transformers with installed hardware protection or other mitigative measures is trivial, then the Commission will know that the intent of FERC Order 779 for hardware protection is being evaded.

A diligent reading of the full order, as well as an automated search using the terms “disclose” and “disclosure” shows that FERC did not address this comment.

7. Unperformed “Initial Actions” Assessments

Page 38 of Resilient Societies docket comments reads:

In FERC Order 779, the Commission ordered “Initial Actions” assessments to be performed by NERC, at NERC’s own suggestion. These assessments are to be completed by the effective date of the standard. To the best of our knowledge, none of these assessments has been initiated at this late date. We encourage the Commission to remind NERC of its obligations under FERC Order 779 (p. 36).

A diligent reading of the full order, as well as an automated search using the term “Initial Action,” shows that FERC did not address this comment.

Risk Reduction Methodologies for Electric Reliability Rulemakings

Where the harms of electric grid failure are great, as with cascading power outages with long duration, a reliability standard should set a high level of reliability, taking into account uncertainty of physical phenomena and resilience of the grid to these phenomena. Greater uncertainty correlates with reduced reliability.

One approach for risk reduction in reliability standard setting would be to utilize probabilistic risk assessment (PRA). PRA is the approach used by the Nuclear Regulatory Commission in its rulemakings. However, because NERC did not collect and share data on GIC, transformer and generator failures, and other solar storm impacts, and also because the primary data sources for the NERC standard-setting are derived from Finland, Sweden and the Baltic states, PRA cannot be applied to the rulemaking in Docket RM15-11-000.

Without well-developed risk and failure data, it is important therefore to alternatively use prudential “design factors,” “overrating,” “overload factors,” “safety factors,” “factors of ignorance,” “reserves of strength,” and/or “conservatism” in the Benchmark GMD Event and other aspects of Standard TPL-007-1 upon which the lives of millions of electric consumers depend. The use of these prudential factors is a well-established engineering practice.

One set of examples comes from an American Society of Civil Engineers text on electrical transmission line design, “Guidelines for Electrical Transmission Line Loading”⁷:

1.2.1.1 Return Period Adjustments. It is possible to adjust the relative probability of failure of two designs by changing the return period of the design load. The higher the return period of the design load, the more reliable the design. If the nominal or characteristic design strength of two components is consistently defined [for example, if both components have a 5% lower exclusion limit (LEL) characteristic strength], then the relative probability of failure of the two components is approximately inversely proportional to the design load return period (Peyrot and Dagher 1984). *Hence, doubling the return period of the design load reduces the relative probability of failure by approximately a factor of 2.*

⁷ Task Committee on Structural Loadings of the Committee on Electrical Transmission Structures of the Structural Engineering Institute of the American Society of Civil Engineers, “Guidelines for Electrical Transmission Line Loading, Third Edition,” American Society of Civil Engineers. 2010.

Table 1-1. Load Factors, γ_w , to Adjust Relative Reliability from 50-Year RP Extreme Wind Load Design

Relative Reliability Factor (RRF)	Load Return Period, RP (years)	Probability that the Load Is Exceeded in 50 Years = $1 - (1 - 1/RP)^{50}$	Wind Load Factor, γ_w
0.5	25	0.87	0.85
1	50	0.64	1.00
2	100	0.39	1.15
4	200	0.22	1.30
8	400	0.12	1.45

1.4.2 Relative Reliability of Components and Failure Containment There is a natural and well-founded desire to exercise some control over the sequence of failure of the different line components. An event that cannot be avoided or a weather-related load exceeding the RPN load can, if not controlled (by using, for example, anti-cascading measures), lead to unnecessary and excessive damage. For many reasons, it is not possible to precisely delineate the desired sequence of failure of the many different components, among the first being the large scatter of use factors (ratios of design load effect to the factored strength) of many of the components.

Furthermore, although the conductors and the ground wires can be selected with small steps in strength and can be installed to even finer gradations, the insulators and hardware that are in series with the wires are manufactured in standard strength ratings (i.e., at 15,000, 25,000, 36,000, and 50,000 lbs). Many components of the wire system are typically designed to a lower percentage of their nominal strength than are other components of the line. The extra reserve of strength should ensure that, even with normal deterioration with aging, they should remain more reliable than the major components of the support system. *This “extra reserve of strength” is especially important under extreme loading events because a component failure in the wire system puts critical demands on the failure containment capabilities of the support system.*

(Emphasis added.)

Another example comes from the IEEE C2: National Electrical Safety Code, CFR 1755.503(d)(1)⁸:

253. Overload Factors for Structures, Crossarms, Guys, Foundations, and Anchors

Loads due to the combined ice and wind loads in Rule 250B and the extreme wind loading condition in Rule 250C shall be multiplied by the overload factors in Table 253-1

⁸ Secretariat, Institute of Electrical and Electronics Engineers, Inc., et al., “National Electrical Safety Code,” 1997 Edition.

or the alternate overload factors in Table 253-2. Table 253-1 shall be used with Table 261-1A. Table 253-2 shall be used with Table 261-1B. For wood and reinforced (not prestressed) concrete, two methods for determining the capacity are included herein. Either method meets the basic requirements for safety.

Table 253-1
Overload Factors for Structures¹, Crossarms,
Guys, Foundations, and Anchors to Be Used
with the Strength Factors of Table 261-1A

Overload Factors		
	Grade B	Grade C
Rule 250B Loads Vertical Loads ³	1.50	1.50
Transverse Loads Wind Wire Tension	2.50 1.65 ²	2.20 ⁴ 1.30 ⁵
Longitudinal Loads At Crossings In general At deadends Elsewhere In general At deadends	1.10 1.65 ² 1.00 1.65 ²	no requirement 1.30 ⁵ no requirement 1.30 ⁵
Rule 250C Loads	1.00	1.00

Note the required wind overload factors in the National Electrical Safety Code are in excess of a factor of two.

Yet a third example comes from the design factors used for steel pipe in natural gas pipelines, “CFR §192.111 Design factor (F) for steel pipe.”⁹ The required design factors range from 0.40 to 0.72, which equate to multipliers of 1.4 to 2.5 for hazard levels. Design factors for natural gas

⁹ The text of CFR §192.111 is available at <https://www.gpo.gov/fdsys/pkg/CFR-2015-title49-vol3/xml/CFR-2015-title49-vol3-sec192-111.xml>.

pipelines received special attention in the aftermath of the San Bruno pipeline explosion, which amply demonstrated the danger of insufficient margins for technical error.¹⁰

§192.111 Design factor (*F*) for steel pipe.

(a) Except as otherwise provided in paragraphs (b), (c), and (d) of this section, the design factor to be used in the design formula in §192.105 is determined in accordance with the following table:

Class location	Design factor (<i>F</i>)
1	0.72
2	0.60
3	0.50
4	0.40

Request for Rehearing

For each of the issues stated and errors specified, Resilient Societies respectfully requests that FERC schedule a rehearing on FERC Order No. 830 and NERC Reliability Standard TPL-007-1.

Motions for Remand

As remedy for not addressing the reasoned comments of public stakeholders, Resilient Societies requests that FERC remand to NERC modifications of Standard TPL-007-1 to include:

1. In order to ensure reliability, establishment of separate design factors for each condition of scientific and engineering uncertainty:
 - a. A design factor for uncertainty of reference peak geoelectric field amplitude.
 - b. A design factor for uncertainty of geomagnetic latitude scaling.
 - c. A design factor for uncertainty of local earth conductivity, including a specific supplemental design factor for each U.S. coastal state that has not received 3-D magnetotelluric surveying of its “coastal zone” geoelectric hazards.
 - d. Design factors for uncertainty of GMD impacts on power transformers, one for each type of impact: overheating, vibration, harmonics, etc.

¹⁰ See presentation of Chris Foley, Vice President, RCP Inc., “MAOP San Bruno Aftermath.” August 23, 2011. Available at <http://www.westernregionalgas.org/2011ppt/MAOP%20Issues%202011.pdf>.

- e. Design factors for uncertainty of GMD impacts on other electric grid equipment, one for each type of equipment: transformer relays, high voltage direct current links, static Var compensators, etc.
2. Consideration of vibration impacts on transformers.
3. Collection and disclosure of data on solar storm impacts.
4. Collection and disclosure of all relevant GIC data in possession of the EPRI SUNBURST program and electric utilities, including data collected before May 2013.
5. Inclusion of networks operating between 100 kV and 200 kV.
6. Public disclosure of mitigative measures for transformers.
7. FERC to require a response from NERC in the Docket on the status of “Initial Actions” in Order 779.

Resilient Societies Seeks These Remedies as an Adversely Affected and Aggrieved Party

Resilient Societies seeks these remedies as an Adversely Affected and Aggrieved Party suffering Injuries in Fact.

The Foundation for Resilient Societies, Inc. is a recognized Section 501(c)(3) non-profit research and education organization based in Nashua, New Hampshire. Our principal investigators perform research and maintain databases in three states, all of which depend upon load serving entities that obtain the substantial majority of their electric supplies from the Bulk Electric System subject to FERC reliability standards. We communicate by telecommunication systems and data storage systems that depend upon reliable electricity.

All three of the principal investigators of Resilient Societies and the majority of its board members are residents of “coastal states” that border the Atlantic Ocean. FERC has approved GMD reliability standards for hardware protection that provide no prudential design factors for critical equipment in coastal states or coastal regions.

Both of the signatories of this Request for Rehearing and Motion to Remand depend upon electric generation by a NERC registered entity, NextEra Energy and its subsidiary NextEra Nuclear, which in fact supplies about 40 percent of the annual net electric load for the State of New Hampshire, the location of our headquarters. Moreover, Seabrook Station No. 1, a Generator Operator subject to FERC-approved reliability standards, provides electric service to National Grid, a load serving entity for Massachusetts and a Transmission Operator for New England.

Due to the pendency of FERC Electric Reliability Standard TPL-007-1, filed by NERC with FERC in January 2015, NextEnergy Nuclear determined to install a newly designed Generator Step Up transformer without any neutral ground current blocking device, for installation at a salt marsh, in Seabrook, NH. The prior Generator Step Up (GSU) transformer experienced adverse vibrations and melting of the low voltage windings of the on November 9-10, 1998. Resilient Societies reported the November 1998 transformer damage to the GMD Task Force of NERC, on January 19, 2012 but they excluded both vibration and coastal effects in their Benchmark GMD Event and associated modeling. The substitute GSU transformer installed at Seabrook Station in October 2015 will comply with NERC Reliability standard TPL-007-1 in spite of defective hazard modeling, including failure to include prudential design factors, exclusion of vibration impacts already observed at Seabrook Station, and avoided modeling of “coastal zone” effects.



Figure 3. Photographic illustration of some of the damage sustained by the transformer bushing links

Figure from paper “Generator step-up transformer, low voltage bushing overheating event” describing November 1998 damage to transformer at Seabrook Station after solar storm¹¹

The new Siemens GSU transformer at Seabrook manufactured in Linz, Austria is designed to withstand higher thermal stresses through use of synthetic oils and better cooling system design. However, without a neutral current blocker or comparable equipment, in a severe solar geomagnetic storm Seabrook Station, and other 345 kV transformer locations managed by an affiliated New Hampshire transmission company, are all at risk of permanent damage or explosion. The geomagnetically induced currents that could have been blocked at the GSU transformer will now flow to other 345 kV transformers. Lack of protection at the GSU transformer will expose connected transformers to vibration and thermal damage hazards. As John Kappenman reported to Oak Ridge National Laboratory in Metatech Report R-319 (2010), multiple high voltage (345 kV) transformers in the State of New Hampshire are at risk of total loss in a severe geomagnetic disturbance event. Installation of a neutral current blocker would not only protect the single GSU transformer at Seabrook Station, but associated 345 kV transformers that serve Transmission Operators and Load Serving Entities in Maine, New Hampshire, and Massachusetts.

¹¹ Richard Bjornson, Seabrook Nuclear Power Station, "Generator step-up transformer. low voltage bushing overheating event." n.d.. See also William R. Harris, "[Seabrook Station Unit 1: Damage to Generator Step-Up Transformer Identified 10 November 1998 Immediately Following Geomagnetic Storm Shocks of November 7-9, 1998](#)", Research Paper of the Foundation for Resilient Societies, Submitted to the Geomagnetic Disturbance Task Force of NERC, January 19, 2012. NRC ADAMS Doc. ML12122A106, filed April 26, 2012.

Absent hardware protection for transformers in this coastal region of New Hampshire, it is foreseeable that a severe solar storm would result in what the Nuclear Regulatory Commission (NRC) terms “extended loss of AC power” or ELAC. An ELAC event requires shutdown of NRC-licensed power plants, which causes these power plants with radioactive material and spent fuel pools requiring regular water makeup to depend upon on-site electric power for preservation of public health and public safety. Resilient Societies has petitioned the NRC to augment on-site power backup capabilities (PRM-50-96, accepted for rulemaking by the NRC in December 2012). But those on-site dependencies risk loss of life and property if outside power is not restored in good time, because power cannot be restored quickly enough due to long wait times associated with replacement transformers and generators, including back-order processing, delivery, and installation.

In the event of long-term outage of outside power for Seabrook Station, New Hampshire, due to the unscientific and imprudent modeling enabled by FERC-approved Reliability Standard TPL-007-1 and the installation of a new GSU Transformer at Seabrook Station with no hardware protection, there will be injury in fact to communities within the ten mile evacuation zone of Seabrook Station. William R. Harris, both an officer and a principal investigator for Resilient Societies, resides in the ten mile evacuation radius for Seabrook Station, and every two years volunteers in support of biennial graded evacuation planning drills for communities within the ten mile evacuation radius of Seabrook Station. Radioactive releases, due to an inability to restore the Bulk Electric System, would cause injury in fact, including the long-term uninhabitability of regional residential communities. Already, property values surrounding residential areas of New Hampshire and Massachusetts may be diminished by imprudent under-protection of electric reliability and nuclear safety of Seabrook Station.

Therefore, Resilient Societies asserts that its organization and its officers and directors are in fact aggrieved parties; that we are adversely affected by FERC-approved Standard TPL-007-1; and that we suffer injury in fact without FERC addressing upon rehearing the remedies that we seek.

Finally, we have exhausted our administrative remedies, via the NERC GMD Task Force; and via the Level 1 and the only Level 2 Appeal in NERC's history, reviewed without relief by a Committee of the NERC Board of Trustees.

Conclusion

Without rehearing, reconsideration, and remand, FERC Order 830 will leave the Bulk Power System and the American public vulnerable to long-term blackout and other electric reliability shortfalls from severe solar storm hazards for an indefinite period of time. This outcome would be unjust and not in the public interest.

Respectfully submitted by:



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