PREPARED STATEMENT OF

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ACTION PLAN

FOR THE STATE OF MAINE

TO MITIGATE SOLAR STORMS AND

MAN-MADE ELECTROMAGNETIC PULSES

SUBMITTED TO THE COMMITTEE ON

ENERGY, UTILITIES, AND TECHNOLOGY

OF THE STATE LEGISLATURE

OF THE STATE OF MAINE

JANUARY 30, 2014

I wish to thank the Committee for its attention to solar storm and electromagnetic pulse (EMP) threats over the past year. Since I last testified before your Committee, much progress has been made and the Committee and individual Maine legislators can rightly take credit.

At the direction of the Legislature as expressed in LD131, the Maine PUC was directed to study and report on solar storm and EMP threats and also to propose mitigation measures. Solar storms and EMP are complex technical subjects—the task before the PUC was ambitious and demanding. The PUC diligently solicited, reviewed, and incorporated comments from both electric utilities and the public. Unfortunately, our review of the PUC report shows that the PUC did not address all of the requirements of LD131. Here are some of the things the PUC did not do, or did not do completely:

1. "develop options for low-cost, mid-cost, and high-cost measures"

2. "examine potential effects of Maine adopting state mitigation policies on regional transmission"

3. "develop a time frame for adoption of mitigation measures"

4. "Monitor federal mitigation efforts"

A detailed review of these gaps in the PUC report is attached in Appendix 1.

Based on events since I last appeared before the Committee, I am sorry to report that Maine cannot rely on the federal regulatory process to protect the economy of Maine and the lives of its citizens from long-term electric grid outage caused by solar storms, EMP, or other wide-area threats. The Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) process for setting electric grid reliability standards is fundamentally broken. NERC and its electric utility members effectively control the standard-setting process and FERC's legal authority to enforce stricter standards is minimal.

FERC Order 779 directed NERC to set two reliability standards for solar storm protection—one for "operating procedures" and another for hardware protection. The operating procedure standard was approved by the NERC ballot body last fall and sent to FERC for final rulemaking. This proposed NERC standard is fundamentally defective because it excludes generation facilities, despite official studies by the federal government that have shown generation facilities have particularly vulnerable Generator Step Up (GSU) transformers. Also, the NERC standard does not require any monitoring of Geomagnetically-Induced Currents and would therefore force "blind" operating procedures on grid operators. However, this toothless standard would provide implicit liability protection for electric utilities and this explains that great willingness of the NERC members to vote for it. While laypeople using only commonsense would rightly conclude that this operating procedure standard will not protect the public, FERC states in its January 14, 2014 Notice of Proposed Rulemaking, "Pursuant to FPA section 215(d)(2), we propose to approve Reliability Standard EOP-010-1 as just, reasonable, not unduly discriminatory or preferential, and in the public interest."

Last November, before the NERC operating procedure standard was sent to FERC, we wrote to the NERC Board of Trustees, reminding them of their fiduciary duty to not approve defective standards, and our request was ignored. Out letter to NERC is Appendix 2 of this statement.

Despite shortfalls at the Maine PUC and NERC, we hear that Maine's electric utilities have been moving forward on solar storm protection on their own initiative. I encourage the Committee to ask the representatives from Central Maine Power and ISO-New England about steps they have taken over the past year. Unfortunately, when lives of the citizens of Maine are fundamentally at risk, voluntary measures are not enough.

Next steps must extend beyond paper studies at the PUC and at individual utilities. Next steps should include grid monitoring equipment and plans to install protective equipment to block GIC currents from entering the Maine electric transmission system. Our proposed next steps are outlined in Appendix 3.

If members of the Energy, Utilities and Technology Committee have questions about issues in this Prepared Statement, I would be pleased to respond at the Committee Hearing on January 30th.

Moreover, if there are questions about the Foundation's March 2013 Report on Maine and ISO-New England, or our Recommendations to the Maine PUC on December 18th, 2013, earlier distributed to Committee members, I can respond to those issues.

Finally, I wish to commend the State of Maine, its citizens, its public utilities, its legislature and its Public Utilities Commission for initiating plans for electric grid protection at the state level.

Thomas S. Popik
Chairman, Foundation for Resilient Societies.

www.resilientsocieties.org

Appendix 1

"GAPS" IN MAINE PUC REPORT

What was done (in black) versus mandated tasks unfulfilled (in red)

H.P. 106 -L.D. 131 – MAINE RESOLVES 2013 CH. 45 AS ENACTED JUNE 10, 2013

Sec. 1 Examine vulnerabilities of Maine's electric transmission and distribution infrastructure to impacts of geomagnetic disturbance or electromagnetic pulse (EMP), including:

1. most vulnerable components of the State's transmission system;

2. potential mitigation measures

3. estimate costs of potential mitigation measures and develop options for low-cost, mid-cost, and high-cost measures;

(Maine PUC did not perform any cost studies or develop cost options; PUC merely quoted cost figures of docket commenters and proposed a cost-study in the future that would be effectively controlled by the Maine utilities.)

4. examine positive and negative effects of adopting a policy to incorporate mitigation measures into future construction and retrofitting.

5. examine potential effects of Maine adopting state mitigation policies on regional transmission

(Maine PUC did not make a written request to Federal Energy Regulatory Commission (FERC) for information or technical assistance, despite FERC's position as interstate regulator and an offer from FERC of such technical assistance.)

(Maine PUC did not perform any modeling or technical assessment of effects of neutral blocking devices in Maine on neither regional transmission nor engage commercial modeling firms to perform such studies. Instead, Maine PUC proposes future modeling performed by Maine utilities.)

6. develop a time frame for adoption of mitigation measures

(Maine PUC did not propose any time frame for mitigation measures such as Geomagnetically-Induced Current (GIC) monitors and neutral ground blocking devices. Maine PUC did not even propose a time frame for the proposed future cost study to be performed and effectively controlled by Maine utilities.)

7. develop recommendations for cost allocations among shareholders & ratepayers.

(Maine PUC did not make a written request for information to FERC on tariffs, despite writing in its report, "Recovery of transmission costs is within FERC's jurisdiction. Thus, issues regarding cost recovery for GMD or EMP mitigation measures, to the extent these mitigation measures involved the transmission system would be determined by FERC.")

Sec. 2. Monitor federal mitigation efforts

(PUC did not make prompt written requests for FERC to identify protective equipment that would meet standards for improved reliability within Maine and no adverse reliability impact in other states. PUC did not request FERC and ISO-NE guidance to design for cost-sharing eligibility.)

Appendix 2

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November 1, 2013

Frederick W. Gorbet, Chair
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Bruce A. Scherr
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Board of Trustees
North American Electric Reliability Corporation
3353 Peachtree Road, N.E. Suite 600, North Tower
Atlanta, GA 30326

Dear Trustees:

Scheduled for your November 7th Board of Trustees meeting is "Agenda Item 8a—Geomagnetic Disturbance Mitigation—EOP-010-1." We urge you to vote "no" on approval of this standard and to send the standard back to the NERC Standards Committee. The standard should be promptly redrafted to include Balancing Authorities, Generator Operators, and Transmission Operators having transformers with high side voltage at 100 kV and higher.

Standard EOP-010-1 was drafted in response to Order 779 of the Federal Energy Regulatory Commission (FERC) for a standard for operating procedures to protect the Bulk Power System against Geomagnetic Disturbance (GMD). The standard, as drafted, is technically inadequate, cost ineffective, and will not protect the American public for the following reasons:

1. While the FERC-approved Bulk Electric System definition includes transmission at voltages at 100kV and above, and while multiple GMD impacts on Static VAR Compensators and other equipment operating between 100kV and 200kV were reported by electric utilities during the March 1989 solar storm, Standard EOP-010-1 would exempt Transmission Operators with equipment operating between 100 kV and 200 kV. Transmission Operators operate Static Var Compensators, capacitors, and other equipment designed to provide reactive power and to stabilize transmission networks during GMD. Attached to this letter is a listing of March 13, 1989 storm impacts on critical equipment operating at less than 200 kV. These real-world and non-trivial GMD impacts during a moderate storm with geoelectric fields of only 2 volts/kilometer invalidate the Standard Drafting Team's summary determination that "The effect of GIC in networks less than 200 kV has negligible impact on the reliability of the interconnected transmission system." The pseudo-scientific study of the NERC Standard Drafting Team, "Network Applicability, Project 2013-03, EOP-010-1, Summary Determination" is an example of a report that is consistent with an apparent policy goal of NERC's membership, but which ignores available scientific evidence.

2. Geomagnetically-Induced Current (GIC) monitors are commercially available and can be installed for as little as $10,000 each, which is far less than the cost of a technical study to see if a GIC monitor might be required.[1] Nonetheless, Standard EOP-010-1 has no requirement for GIC monitoring or the mandatory sharing of GIC data with Reliability Coordinators and would therefore require Reliability Coordinators to force "blind" operating procedures on Balancing Authorities, Transmission Operators, and Generator Operators, increasing blackout risks to the public and imposing costs on ratepayers due to "off-cost dispatch" of bulk power transmissions.
3. While Generator Step Up (GSU) transformers are a major GMD vulnerability according to a study by the Oak Ridge National Laboratory, "Geomagnetic Storms and Their Impacts on the U.S. Power Grid," Generator Operators are exempted from specific responsibility in Standard EOP-010-1. In notable contrast, NERC's own GMD Task Force recognized the vulnerability of GSU transformers and developed a "Geomagnetic Disturbance Operating Procedure Template—Generator Operators" which was formally approved by the Planning Committee in February 2013 and also endorsed by the Operating Committee. The Standard Drafting Team exempts Generators Operators from Standard EOP-010-1 because Generator Operators have no current requirement for GIC monitoring devices and absent GIC data, "the GOP would not have the technical basis for taking steps on its own and would instead take steps based on the RC or TOP's Operating Plans, Processes, or Procedures." This convenient rationale is proposed in the NERC document "Functional Entity Applicability, Project 2013-03, EOP-010-1, Summary Determination" and ignores that the lack of required GIC monitoring is completely the result of a defectively drafted standard; see Item 2 above. In essence, the Standard Drafting Team proposes that Generator Operators pay up to $250,000 for a technical study to see if their equipment might be vulnerable to GIC rather than install a GIC monitor for $10,000 and find out for sure. The Standard Drafting Team also believes that the real-time responsibilities of Generator Operators under fast-moving GMD conditions are already covered in the NERC Functional Model. In fact, the deficiencies in the NERC Functional Model during GMD conditions are a primary rationale for FERC Order 779.
4. While Balancing Authorities are responsible for scheduling reactive power, spinning reserves, demand response, and other real-time mitigative steps during GMD, these entities are exempted from specific responsibility in Standard EOP-010-1. The Standard Drafting Team believes that the real-time responsibilities of Balancing Authorities under fast-moving GMD conditions are already covered in the NERC Functional Model. In fact, the deficiencies in the NERC Functional Model during GMD conditions are a primary rationale for FERC Order 779.

[1] For example, Bonneville Power Administration paid $253,000 for modeling of GIC in their network.

5. The "Requirements and Measures" in Standard EOP-010-1 are so non-specific that utilities could easily develop paper plans to satisfy the requirements of the standard, but these plans could be ineffective during severe or even moderate solar storms.[2]

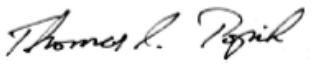
For further background on these deficiencies in the standard, please see our comments filed and available in the official record for Standard EOP-010-1 on the NERC web page for "Project 2013-03 Geomagnetic Disturbance Mitigation."

Any reasonable person would likely conclude that Standard EOP-010-1, as currently drafted, is not compliant with the requirements of FERC Order 779. Moreover, the proposed exemption of networks with high side voltage between 100 kV and 200 kV is not compliant with the requirements of FERC Order 773, which established a "bright line threshold" of 100 kV for the Bulk Electric System.

Oak Ridge National Laboratory estimates that a severe solar storm would interrupt power to as many as 130 million Americans. Accordingly, a reliability standard to prevent a blackout from GMD should deserve the highest level of attention and thoughtful consideration from NERC and its independent trustees. However, past meetings of the NERC Board of Trustees have had only perfunctory discussion about GMD risks to the American public—an example being the trustee meeting that approved the now-discredited NERC report, "2012 Special Reliability Assessment: Effects of Geomagnetic Disturbances on The Bulk Power System." Instead, the independent trustees have had a practice of quickly and mechanistically moving through numerous agenda items, voting to "approve" on each item.

As independent trustees of NERC, it is your fiduciary duty to have a substantive and public discussion of the merits and shortfalls of Standard EOP-010-1 at your November 7th meeting. Again, we urge you to vote "no" on EOP-010-1, Agenda Item 8a, because this defective standard would not protect the American public from long-term and widespread electric grid outages caused by solar storms.

Sincerely,



Thomas S. Popik
Chairman, Foundation for Resilient Societies

Attachment: March 13, 1989 Geomagnetic Disturbance Chronology of Reported North American Power Grid Events

cc:
Jon Wellinghoff, Chairman, FERC
David Morenoff, Acting General Counsel, FERC

[2] For an example of GMD operating procedures that would probably meet the requirements of Standard EOP-010-1, but would nonetheless be inadequate, see our study of ISO-New England operating procedures, "Solar Storm Risks for Maine and the New England Electric Grid and Potential Protective Measures" available at: http://resilientsocieties.org/images/Interim_Foundation_Report_on_Maine_Solar_Storm_Risks_March_19_2013.pdf.

March 13, 1989 Geomagnetic Disturbance

Chronology of Reported North American Power Grid Events

Adapted from Pages A2-2 to A2-8 of "Geomagnetic Storms and Their Impacts on the U.S. Power Grid"
Oak Ridge National Laboratory, January 2010

Event		Time (EST)		Area or		Base	
No.	Date	From	To	System	Event	kV	Comments
29	3/13/1989	245		Minn. Power	Capacitor	115	Lost capacitor bank at Nashwauk. Neut overcurrent relay
44	3/13/1989	608		Cent. Hud.	Capacitor	69	Pulvers Corners capacitor trip
47	3/13/1989	615		APS	Capacitor	138	7 Capacitors tripped
54	3/13/1989	618		Va. Pwr.	Capacitor	115	Virginia Beach
57	3/13/1989	619		Cent. Hud.	Capacitor	115	Hurley Ave. capacitor trip
94	3/13/1989	1645	2000	WPL	Voltage	138	Various voltage problems. Regulators hunting
100	3/13/1989	1655		Atl. Elec.	Voltage	69	
108	3/13/1989	1658		BPA	Capacitor	115	Tripped by neutral time ground at 4 substations
175	3/13/1989	2017		NEPOOL	Capacitor	115	Orringion capacitors (1, 2, &3) opened and would not close
183	3/13/1989	2020	2030	Atl. Elec.	Voltage	138	
192	3/13/1989	2032		PJM		69	Nazareth Capacitors tripped

Appendix 3

Proposed Next Steps for Maine Solar Storm and EMP Protection

REQUIRE GIC MONITORING AT ALL HIGH VOLTAGE MAINE PUC-JURISDICTIONAL TRANSFORMERS AND OTHER CRITICAL EQUIPMENT

Monitoring impacts of geomagnetic storms in Maine is an essential first step to identification of critical equipment that would benefit from hardware protection. The same geomagnetic monitoring is also essential to develop and validate models of solar storm effects upon the Maine electric grid.

Flows of geomagnetic induced currents (GICs) during solar storms should be monitored at all MPUC-jurisdictional 345 kV transformers in the State of Maine. We estimate the need to install GIC monitors at 15 to 20 installations, including updated GIC monitors at static VAR compensator facilities. The equipment sets cost $10,000, perhaps 25% more if additional sensor probes for dissolved gases and transformer "hot spot" temperatures are also monitored.

In addition to mandated GIC monitoring, the Maine PUC should request voluntary participation in a state program for geomagnetic disturbance monitoring statewide. Some wind power installations have voluntarily installed GIC monitors.

Experience in the American Transmission Co. transmission network operating in Wisconsin indicates that vendor design and installation costs, including the GIC monitors and SCADA systems for reporting to control centers may cost about $50,000 per installation.[1] For 20 GIC monitoring installations statewide, the total cost would be about $1 million dollars.

During moderate level geomagnetic storms, the first commercially operating neutral ground blocking system, manufactured by Emprimus, will be tested by varying the resistance at which it would block geomagnetic induced currents in Wisconsin. Between the GIC monitoring and the first neutral ground blocking equipment, American Transmission Co. can improve modeling of where to locate protective equipment.

If Maine follows American Transmission Co. in Wisconsin with the nation's second deployed network of GIC monitors, Maine will soon be ready to host voluntary installation of neutral ground blocking equipment by participating Maine electric utilities. It is likely that removing GIC flows into the Maine transmission system will lower overall electric costs due to improved transmission throughput, reduced costs of reactive power, and reduced outages or losses of key transformers.

[1] Informal Communication from David Wojtczak, Substation Services Team Leader & GMD project leader, American Transmission Co. LLC (ATC) to William R. Harris, January 28, 2014. ATC has 23 GIC monitors installed and plans to have the first neutral ground blocking system operational within a U.S. electric utility commencing in 2Q 2014.

Since the Maine Power Reliability Program will cost about $4.1 billion dollars, the cost of GIC monitoring statewide should be considered a *de minimus* cost, an essential down payment towards a more reliable electric grid for the State of Maine.

MODELING GEOMAGNETIC CURRENT FLOWS AND CRITICAL EQUIPMENT PERFORMANCE THROUGHOUT THE STATE OF MAINE

A critical challenge will be to utilize the GIC monitoring network to improve the modeling of how geomagnetic storms propagate through a regional electric transmission system. Experience within the American Transmission Co. system in Wisconsin indicates that a generic PowerWorld model of GIC flows, while beneficial as a baseline to understand a regional grid, is not a reliable predictor of GIC flows at particular sites within a high voltage electric grid. To improve the accuracy of geomagnetic current flows and rates of change, it is essential to improve site-specific understanding and regional models of soil conditions and ground resistivity.[2]

We recommend that the Maine PUC reach out, beyond the State of Maine, so as to contract with one or more of the nation's expert firms with geomagnetic storm modeling capabilities. Acquiring the GIC data set from monitors installed throughout the State is just a first step. Concurrently, it is necessary to adapt existing models of geomagnetic induced current flows and rates of change. Unlike Wisconsin, the modeling effort for the State of Maine will require analysis of both coastal and end-of-line geomagnetic effects. Moreover, high saline content in the ocean and river basins may be essential components of modeling solar storm effects within the Maine electric grid.

We do <u>not</u> recommend a risk analysis, such as the Maine PUC suggests as a next step. First, the risks of solar storms are increasingly well understood. The risks of operating without protective equipment are unacceptable, given the consequences of extensive electric blackouts or long duration blackouts. Commercially available, third party validated monitoring equipment and neutral ground blocking devices have been demonstrated to protect high voltage transformers, and to reduce damage from thermal and vibrational impacts of solar geomagnetic weather. Keeping geomagnetic induced currents out of transformers also protects generator turbines and other equipment at risk of thermal or vibrational damage.

REGULATORY RESEARCH

We recommend that the State of Maine sponsor one or more Workshops in the State or Maine, and another Workshop in Washington, D.C. aimed at developing prudent pathways to cost-recoveries for protective grid equipment to mitigate geomagnetic disturbances.

One issue requiring attention involves the acquisition of Bangor Hydro by a subsidiary of an Emera holding company. As of January 2014, subsidiaries of Emera, including both Bangor Hydro and Central Maine Power have interlocking financial ownerships. Will the direct connection of Bangor Hydro, or the "wheeling" of hydropower from Canada through Bangor Hydro, then to electric purchasers in other New England states enable a higher share of grid

[2] Personal communication, David Wojtczak, American Transmission Co. to William R. Harris, January 28, 2014.

protective equipment to qualify for cost-sharing by the five other New England states? Already, 92 percent of Central Maine Power's transmission reliability upgrades for years 2010-2015 are eligible for cost recoveries from ratepayers in other New England states.

Similarly, might the Federal Energy Regulatory Commission (FERC) authorize designated classes of "safe harbor" equipment investments? If for example, GIC monitoring equipment and neutral ground blocking equipment are to be included in a "safe harbor" class of protective equipment, then the purchase and operation of these equipments might be eligible for cost recoveries from others within the bulk power system – so long as the investor entity can demonstrate improved reliability for other states and not just for the State of Maine.

Finally, the State of Maine would benefit from FERC and Department of Defense and other federal guidance as Maine prepares options for protections against man-made EMP devices. What federal standards will be applied to investments in the protection of SCADA control devices, telecommunications equipment, battery chargers and backup batteries, or control room hardening? Might there be matching funds from the federal government? These are also key elements of standard setting and cost recovery procedures; understanding cost recovery options will enable the State of Maine to proceed without undue costs to Maine ratepayers.

INSTALLATION OF NEUTRAL GROUND BLOCKING DEVICES

Neutral ground blocking devices that would protect Maine from solar storms are commercially available. At approximately $300,000 per device, all of Maine's extra high voltage transformers could be protected for less than $5 million. The citizens of Maine have waited long enough for solar storm protection. Plans for installation of these protective devices should begin immediately.