

# **Electromagnetic Pulse and Geomagnetic Disturbance Grid Protections**

## **A Report from Maine, and an Update on Other Leading States by the Honorable Andrea M. Boland September 2016**

Maine has been a leader in advancing state electric transmission system protection policies since the legislature passed, almost unanimously, as emergency legislation, LD131.

**MAINE:** In 2013 enacted LD131, Sponsored by Representative Andrea Boland, “An Act to Secure the Safety of Electrical Power Transmission Lines,” directed the Maine Public Utilities Commission to investigate the major points of vulnerability of the Maine system, otherwise referred to here as “the grid,” options for protecting it against natural, but extreme, solar storms (geomagnetic disturbances (GMD), or geomagnetic storms) and manmade electromagnetic pulse (EMP) attack by terrorists or hostile nations. The studies were to include low-cost, medium-cost, and high-cost options, time frames for installation, and policy implications for adoption of them. The Maine Public Utilities Commission (PUC) was to include input from some of the independent experts that had testified on the bill. It required a report back to the Energy, Utilities, and Technology Committee of the legislature by January of 2014.

Emprimus, a research and development firm that licenses patented blocking equipment to protect major transformers against GMD, with enhancements against EMP, also contributed to the study, and did a complete one of their own. The PUC/Central Maine Power (CMP) study did not investigate EMP. The only tested and proven protective equipment identified by the studies was the Emprimus Neutral Ground Blocker (blocker). Monitoring devices, equipment replacements and upgrades, and spare transformers were also recommended by the studies.

Following release of the PUC study to the legislature, and in recognition that theirs was not complete, the PUC received permission to convene an Advisory Task Committee study team, sponsored by the PUC and with a research program managed by CMP. It comprised electric power companies, ISO New England, independent experts, involved legislators, and itself to continue the work of evaluating and beginning implementation of GMD mitigations and protections. It convened from 2014 into 2016. Reports were submitted to the PUC by CMP (December 2015) and by Emprimus (January 2016). Our last meeting was on February 26, 2016.

The study team project director, Justin Michlig, left CMP on May 6, 2016. The study team was not advised of that, nor have we been given any formal word on what that means for continuity of policy development and protective measures. We have not yet received the report of our last meeting, and have no word on any follow-up, wrap-up, or continuing regular team meetings.

We have made some significant progress in moving Maine forward – both in increasing awareness and examination of the issues of GMD and EMP vulnerabilities, and in improvements to the *Maine Power Reliability Program* (MPRP), originally a \$1.4 billion expansion of the

Maine electric grid, for which my 2013 LD 131 legislation had sought protections prior to construction. Augmentations to the MPRP in 2015 and 2016 include installation of GIC (geomagnetically induced current) monitors, synchrophasor unit (PMU) monitoring sites, additional reactive power system procurement, and system modeling by Ping Things, LLC. No neutral ground blocking devices have been procured by any Maine electric utility or approved by the PUC as cost-recoverable at this time.

At our September, 2015 meeting, ISO-New England (ISO-NE) reported that 8 transformers in Vermont were already monitoring GIC and feeding back to it.

An experimental synchrophasor unit (PMU) has been installed to detect abnormal electrical waves, and Ping Things, an independent analytics firm, is doing the analysis of the data so generated. We are told Maine's is the first instance in the U.S. of taking on this meaningful analytical step that transforms measurements into policy tools to mitigate solar storms. The PMU is configured to capture transformer performance during GIC flow and harmonics. It and a GIC monitor are installed at the same transformer; multiple events can be captured in this way. Fred Faxfog, of Emprimus, shared with Justin Michlig Idaho National Labs' results of harmonics testing on transformers. Installation of additional GIC monitors is under way. The results we have been presented on these efforts at monitoring and analysis have been very robust and exciting, offering a great deal of promise for policy and operational decision-making.

William Harris of the Foundation for Resilient Societies has stressed the importance of taking the coastal effect into account in CMP's continued modeling, as that is an important aspect of Maine's vulnerability to GMD.<sup>1</sup> I have stressed that we now have a National Space Weather Strategy Plan, and it calls for a "whole community" engagement in defending and preparing against such an event.

CMP has committed to installing series capacitors on two high voltage transmission systems, one a 1000 MV DC line from New Brunswick, Canada, to improve the smooth flow of power through the system. It has also committed to adding reactive power capacity where the Maine-Canada subsystem interacts with reduced stability with other ISO-NE systems, a service zone where voltage drops are a risk and where reactive power is needed, specifically at Coopers Mills, a major substation.

There have been many other suggestions for protecting the electric grid in Maine, relating to the lines, protection of SCADA systems, having spare transformers, and hardening of control centers. William Harris has submitted many robust suggestions, which he refers to as Ponderosa Resources, and which I append to this paper. They include economic modeling and incentives, along with human and equipment asset preparation. I also attach my Comparison of the CMP and Emprimus Recommendations for Maine, reflecting their respective modeling results, priorities and associated costs.

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<sup>1</sup> On September 22, 2016 the Federal Energy Regulatory Commission (FERC) instructed the North American Electric Reliability Corporation (NERC) to include modeling of coastal effects to assess protection requirements for electric transmission systems. See FERC Order No. 830, [Reliability Standard for Transmission System Planned Performance for Geomagnetic Disturbance Events](#), 156 FERC ¶ 61,215, at ¶¶ 78-79.

Chris Morin has replaced Justin Michlig as Electric System Planning Manager at CMP. He has been with CMP since 2008. I spoke with him on July 13, 2016. He said he is working to catch up on Michlig's notes, on what has already been done, and on what is planned for moving forward. He said there was a lot there to review. He told me there were no notes on the February meeting, and that Michlig left abruptly, giving only two weeks' notice. He added the following:

Analysis was completed by Michlig, and Terry Vogel, Area Dispatch Supervisor-ECC, was developing a final report. He was not sure of Vogel's time line, but understood his report would be complete within "a couple" of months.

Ping Things, a company that was brought in to do analytics on the data produced by the new monitoring equipment, is still involved with the project, but not as closely. CMP intends to finish up with them soon – which could be a move backwards.

CMP is trying to install more monitoring equipment to get better data, including better visual data, to understand the impacts of solar effects on the system. They are using GIC monitors, devices on the neutral to sense GMD, audible noise, and harmonics.

The Maine PUC is tied to both efforts – monitoring and assessing. They are exploring a test pilot for both GIC and audible noise.

Our Disappointment: CMP committed to continued modeling of neutral ground blocking options for Maine's large power transformers (operating at 345 kV). However, at the December 2015 meeting, when I asked Project Manager Justin Michlig if we couldn't get the blockers installed, especially since they were tested, proven, and available, and we had been offered a very low price deal for them, ISO-NE's Kevin Clark, in ISO-New England Operations, answered that, while some places will do things voluntarily, CMP will not install blockers unless they are made to. He had spoken what all their arguments around blockers had illustrated for a long time, but what was quite dramatic to hear said out loud, by him, in that venue. It almost took my breath away, as I knew how well supported the neutral blockers were by major independent experts, and how quickly they could be installed and working for us, a state considered one of the most vulnerable to geomagnetic storms. I had worked so long through the legislature to protect the people of Maine against the dangerous complacency of the electric companies, it jolted me. Then, at the end of our last meeting, February 26, 2016, I asked the same question again of Justin Michlig, and he answered: "We will not do any more unless we are mandated to." His use of the "mandate" word to me, an experienced legislator, was a blatant and cynical challenge, because legislators typically recoil from supporting anything that can be attacked as a "mandate." It is code for government overreach. He may have thought that would end the conversation, but it hasn't.

Chris Morin sounded a bit more open when he updated me recently. I asked him about installing neutral ground blockers, and he said they might be doing a pilot using one of them on one

transformer. I mentioned that they had been tested and proven effective at Idaho National Labs. He said he had seen the claims, but CMP had not yet figured it out for itself. I told him about the successful installation at American Transmission Company in Wisconsin; he had not been aware of it. He said he'd be interested in researching it. We do not yet know what the final outcome will be on adopting blocking protection.<sup>2</sup>

### From Other States

**FLORIDA:** In 2014, State Rep. Michelle Rehwinkel Vasilinda introduced a resolution asking Congress to direct the Department of Homeland Security to request protection and recovery resources for the nation's grid, and sponsored an amendment to another bill, H.B. 7147, to require an emergency response plan for EMP and GMD: "to include defense against electromagnetic pulse attacks and geomagnetic storm events in [Florida's] preparedness planning"; to encourage municipal and private sector examination of infrastructure vulnerabilities; and "preparedness recommendations" to be issued to the public by the Florida Department of Agriculture and Consumer Services. Rep. Rehwinkel Vasilinda experienced high industry resistance to these efforts, and the bill failed.

In a parallel effort, and continuing on beyond the legislative effort, she was working, with the assistance of Dr. Peter Pry, designated to become the Staff Director of the Congressional EMP Commission, to encourage the Governor's use of an executive order to have GMD and EMP protections installed on their electric grid. Florida's legislature has had a lot of interest in this issue shown them by various agencies within the government there, but activity from the chief executive's office has slowed substantially.

In 2016, Rep. Rehwinkel Vasilinda introduced H.M. 1419, A House Memorial to urge the U.S. Congress to enact legislation supporting the reconstituted Commission on Electromagnetic Pulse, and Electromagnetic Pulse, Cyberattacks, and Geomagnetic Storms. It died in committee.

While many efforts in several states have not been fully successful, Rep. Rehwinkel Vasilinda is heartened that the electric power companies are finally acknowledging that GMD and EMP are real problems, and they are now engaged in considering them. She points that this is a true success, a big step forward from the days when they were denying they were issues. She believes that it should be good for them and their shareholders, alike. She especially notes the candor of Exelon and Southern Company in acknowledging the problem at a July 2016 international summit we attended in London.

She opines that, in recognition that supplying electric power is a for-profit business; protections will only be installed if it serves the profit motive. In considering the impetus for customers to save money and gain reliability by going to renewable sources such as solar, alternatives fuels or smaller generators, and conservation, the industry is probably becoming more engaged in response to competitive economic forces. She sees an opportunity for them to make a stronger

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<sup>2</sup> It is notable that these conversations with employees of Central Maine Power and ISO-New England preceded FERC's issuance of Order No. 830 on September 22, 2016. Paragraphs 24 and 92 of this recent FERC order signal that electric utilities that demonstrate reliability improvements for the bulk electric system will be eligible for cost recovery to protect critical grid equipment.

claim of dependability, if they are seen to be committed to EMP and GMD protections of their systems. Alternatively, they should want to avoid being assigned blame for not being prepared if an event occurs about which they were warned.<sup>3</sup>

Rep. Rehwinkel has decided to not run for re-election this year, but will support the efforts of others to provide informational meetings and drafting of legislative and executive language to bring protections to Florida, and her own continuing work to achieve EMP and GMD protections will target grass roots organizations and the general public. She looks to the Red Cross, girl scouts and boy scouts, churches, citizens, utilities, and non-utilities groups, and engaging The St. Bernard Society, a non-profit that helps people and businesses become more disaster resilient. Her focus will include both prevention and recovery, and schooling the press. I agree that an informed and outspoken public is a very strong motivator for action.

**ARIZONA, LOUISIANA, and KENTUCKY** have passed measures to study, develop, and/or institute preparedness for an EMP or solar event.

Kentucky, in 2013, enacted H.B. 167, sponsored by State Representative Tom Riner, which establishes the Kentucky Office of Homeland Security within the office of the Governor, with a “working group” purpose to identify risks and needs, and to assess the preparedness of Kentucky to respond to acts of war or terrorism, which includes EMP and GMD. Study would proceed via an “Interagency Working Group.” I have no evidence that the study has been completed.

Louisiana, in 2014, approved S.R. 169, sponsored by Senator Fred H. Mills, which requests that the Governor’s Office of Homeland Security and Emergency Preparedness study the “potential threats and consequences of an electromagnetic pulse (EMP).”

Arizona, in 2014, enacted S.B. 1476, sponsored by Senator David Farnsworth, Senator Nany Barto, and others, “A measure to require the Arizona Department of Emergency and Military Affairs, Division of Emergency Management to develop recommendations for the public to mitigate electromagnetic pulse and geomagnetic disturbances.” I have no evidence that such recommendations have yet been made.

**TEXAS:** In 2015, Texas State Senator Bob Hall introduced S.B. 1398, on “Electromagnetic Threat Preparedness,” that directed the Public Utilities Commission of Texas to assess threats to the grid, including electromagnetic pulse preparedness, geomagnetic disturbances, terrorist and cybersecurity threats, and to improve the resiliency of critical infrastructure in Texas. It was to:

- (1) “implement a program to develop technical expertise in protections of their electric grid against electromagnetic, geomagnetic, and cyber-attack . . . (2) identify and develop technical resources . . . (3) implement a program to educate owners and operators . . . (4) determine critical infrastructure and vital utility facilities that are at

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<sup>3</sup> In FERC Order No. 830, the Commission indicated that the Commission “has never stated . . .that compliance with Commission-approved Reliability Standards absolves [NERC] registered entities from legal liability generally, to the extent legal liability exists, should a disruption occur on the Bulk-Power System due to a GMD event.” See FERC Order 830, ¶ 121 (2016).

risk. . . (5) evaluate critical emergency planning and response technologies related to electromagnetic, geomagnetic, and cyber-attack threats; . . .(6) evaluate technologies available to improve resiliency. . . (7) evaluate capabilities of critical infrastructure and vital utility facilities to recover. . . (8) develop a comprehensive plan to protect the critical, infrastructure and vital utility facilities of this state against electromagnetic, geomagnetic, terrorist, and cyber-attack threats.”

The legislation would allow the governor to instruct an agency to implement the plan, and the governor would develop a cost recovery mechanism for the utilities for related costs.

I found this legislation noteworthy particularly because it sought to include the cyber threat with EMP and GMD, and it called for evaluating capabilities to recover. I think that including cyber was too ambitious, but evaluating recovery capability would have been helpful in goal-setting and planning, although possibly a somewhat burdensome addition to the main purpose of instituting protections.

Other Texas bills were authored in 2015, but this one was seen to be the most viable. It was heard in the State Senate, but not the House of Representatives due to delays on the calendar. Senator Hall is bringing it back in 2017, and consulting with outside experts, including the Foundation for Resilient Societies, on a modified version.

At the same time, Senator Hall has been vigorously working to raise public, industry, and government awareness of the issue, and building a strong network of interested contacts to better assure its passage. He ran a two-day summit earlier this year that produced fifteen hours of expert testimony, which can be accessed on his senate website.

Additional help has come from the Infragard chapter in Houston, which has provided its own form of complimentary public education, it being a non-profit public interest group that addresses all types of critical infrastructure issues.

Senator Hall’s office is feeling that this kind of preparation will result in a very powerful presentation of their EMP bill this coming session.

**VIRGINIA:** In 2015, enacted S.B. 1238, sponsored by State Senator Bryce Reeves, a bill entitled “Geomagnetic Disturbances & Electromagnetic Pulses; Joint Commission to Study Preventing Damages that requires the Joint Commission on Technology and Science to study Virginia’s exposure and develop a strategy for protection.” It directs the Virginia Department of Emergency Management to plan for and respond to disasters resulting from electromagnetic pulses and geomagnetic disturbances.

Senator Reeves has regularly spoken about how amenable the electric companies in Virginia are to securing their electric grid against EMP and GMD, in great part because they are very mindful of the many military installations nearby that are dependent on the civilian grid. They understand and do not oppose installing protection on the grid, so he had little trouble getting his legislation passed.

**COLORADO:** In 2015, State Representative Joann Ginal introduced H.B. 15-1363 to the Colorado State legislature. It was designed much like Maine's, in that it called for examination by the Colorado Public Utilities Commission of their grid's GMD and EMP vulnerabilities, and recommendations for mitigating vulnerability of existing electric generation, transmission, and distribution facilities, but added, "and other vital infrastructure." It also added examination of, "the potential effect these requirements may have on the electric grid outside of the state," and a funding requirement: "Cash funds are required from gifts, grants, and donations by up to \$66,000 in FY 2015-16 in an account within the Fixed Utility Fund (FUF). Any contributions collected in a lesser amount by September 1, 2015, will be remitted, and the study abandoned."

Rep. Ginal had made extensive efforts to engage all stakeholders in her preparations for submitting this bill, and for addressing their possible concerns. She presented it to the House Committee: Transportation and Energy, with some very distinguished independent experts testifying on its behalf. Her bill met with what appeared to be a predetermined decision to turn it down. Those testifying against the bill had little of import to say, but that did not seem to matter. It was startlingly clear that there was no interest in giving the bill serious consideration. Committee members seemed to want to please the local electric cooperatives, rather than benefit them with important research support. It occurred to me that the local cooperatives had been lobbied by the big power companies and trustingly bought their story. Based upon what I have been told, the reception of the proposed legislation by the House Committee members appears to have been imprudent and lacking in intellectual curiosity on behalf of their constituents.

From that experience forward, it became clear to me that the electric power companies, apparently on a nationwide basis, were intent on fighting against protections of American citizens, against their customers, against the horror of what their careless stewardship of the power grid could deliver.

**NORTH CAROLINA:** North Carolina has been doing planning exercises, both in their Emergency Management Center sector and in their Energy Policy Council. Lieutenant Governor Dan Forest chairs the Energy Policy Council, whose mission is to develop short- and long-term energy policy for the State.

The Energy Policy Council is the State's chief energy policy making body. Many opinions and orientations are represented at these meetings; they agreed to focus on the following infrastructure sectors that would be impacted by an EMP or GMD: water and waste water; fuel; communications; electricity; transportation.

The emergency preparedness people used a scenario of an EMP attack on Washington, D.C that resulted in North Carolina's getting impacted in a serious but not profoundly debilitating way. From that, they created a draft of a phased plan to recover, which is not yet available for public review.

I recently spoke with General Counsel and Policy Director in the Lt. Governor's office, Steven Walker, and he updated me on their activities. They have convened meetings that include members of emergency management, government, and the industry to consider the issues, and a

table top exercise to consider how they would respond to an EMP or GMD event that had just hit. They are also working with EPRI, an electric utility industry research group, and looking to them for help in not miss anything important. Duke Energy Company is doing a cost/benefit analysis. The state geologist is researching what would be needed for grounding rods to go down into bedrock, for grounding out appropriately. They are looking at questions around the “load” and load balancing, and what effects different options will have on it. For example, hot water heaters and heating and cooling units have particularly big draws on energy.

North Carolina is making distributed energy part of the conversation, and looking at costs for micro-grids. They are facing the need to harden radio communications.

I also spoke with Stephen Volandt, a fellow Infragard member, military veteran, and North Carolina businessman who participates in the North Carolina efforts. He is working on putting together a “resilient communities” plan that would develop a way to think of merging EMP, GMD and cyber into a single protection and recovery plan. He is bringing his professional experience in business mergers and acquisition to bear on what he terms this “enterprise transformation.” It incorporates inventory and resources, laws, goal development, situational awareness (e.g. understanding what losses will be occurring), and a budget to execute the plan. He finds that water would be the first priority, and nuclear generator melt-downs the next, because water goes bad faster than a nuclear generator melts down. He emphasizes the need for state governors to be well informed on the plans and their key components in order to be able to make sensible decisions as the chief executive with ultimate responsibility to respond quickly when a grid-down situation occurs.

I find the activities in North Carolina to be charged with vision, energy, and potential, especially as they can benefit from the ancillary work of Stephen Volandt. However, too much reliance on an industry research group such as EPRI threatens to introduce cracks into the foundation upon which it intends to proceed. Independent, expert, and otherwise appropriate input is also needed for a sound understanding of the complex material and political challenges that can emerge from a self-regulating, self-interested industry’s providing the exclusive, or even predominant source for information upon which North Carolina would develop its own credible goals, standards, and action plans.

NOTE: The above states are those with which I am the most familiar, and with which I’ve worked personally, but other state legislatures have also worked to secure their electric grids. Please refer to the work done by William R. Harris of the Foundation for Resilient Societies, Highlights of State Resiliency Legislation regarding Electromagnetic Pulse or Geomagnetic Disturbances (2013 – 2016) for a fuller list of those efforts, appended to this paper.

## **Summary of Experiences in the States and Ideas for Moving Forward**

### **A Compendium of Conclusions**

1. The extreme vulnerability of the electric power grid is no longer a hidden subject, so we can expect electric power companies to increasingly accept and engage in meaningful discourse about it. We should celebrate that progress in the fight for protections, while continuing to battle them for higher ground in the protection wars.
2. The states are increasingly recognizing the regulatory role they have to play in protecting their own people, and modeling various approaches to accomplish that.
3. Legislators can create laws to require protections be installed, but must anticipate very robust opposition from the electric utilities, most of whom cling to the faulty, low reliability standards and models of the North American Electric Reliability Corporation (NERC), their lobbyist and buffer against liability. They need to be reminded that NERC has often been caught in promoting falsehoods.
4. In our work, we must be aware that the Federal Energy Regulatory Commission (FERC) is unlikely to be helpful as it currently operates. Strong advocates are working very hard to stand them up, however.
5. Legislators should be aware of their state's electric utility contracts, which seem to universally hold the electric companies harmless in a catastrophic event – thus diluting the motivation to raise their protective standards to respond to threats. In my experience in Maine, I found that the threat of removing that provision stimulated vivid argument from industry.
6. The profit motive and cost considerations should be recognized as likely keys to achieving robust mitigations and protections. Cost recovery should be allowed for any approved mitigations and protections.
7. The emergency management population is likely to be good partners in promoting grid protections against EMP and GMD. They will be left the leading burden.
8. Governors may initiate protections and mitigations by executive order, and should be well versed in plans and have adequate situational awareness to be able to respond in the event of a crisis.
9. There is great value in engaging the public in advocating for protecting the grid and planning for preparation and recovery. The National Space Weather Strategy and Action Plan publications provide good tools for forming a foundation of study.
10. Know that the general public includes lots of individuals who are aware of EMP and GMD, and often think they are somewhat alone in their interest in them. For them, and even for others who know little about EMP and GMD, it is often not a great leap to accept that either threat is believable.

11. Our network is growing. Knowledge is expanding. We owe enormous gratitude to the scientists, legal, business, engineering, and policy experts that have been blazing the trail for us.

**IN GENERAL:** There are more things happening in the world of grid protections against EMP and GMD than I can describe here, and that are done willingly by some electric power companies, businesses, military and other nations. For security and other reasons, they are often wanting to be quiet about it. Competitors, bad actors, and careless talk can cause problems for them.

# **PONDEROSA RESOURCES**

## **TO PROTECT AND RECOVER CRITICAL INFRASTRUCTURES**

*enduring, flexible, and recovery-enhancing,*



Criteria to identify “best buy” resiliency assets  
Dupont Summit Workshop, Washington, D.C.

December 3, 2015

Bill Harris, Secretary, Foundation for Resilient Societies

## PONDEROSA RESOURCES SOME CRITERIA

- ▶ Design for “all hazard” operability, if cost-effective
  - FLEX warehouses for emergency diesel generators (EDGs): harden EDGs, not just warehouses for EMP, so EDGs can endure at nuclear power plant sites
  - Inventory “older style” equipment that is less vulnerable to cyber or electromagnetic pulse (EMP) attack, such as emergency diesel generators with manual start options.
- Pre-deploy reserve assets where needed
  - E.g. Four units of single-phase transformers with fourth unit as cold spare prepositioned on concrete pad; avert time delays and risks of transport infeasibility
  - On-site backup power extending self-sufficiency windows after Loss Of Offsite Power (LOOP) enables reallocation of emergency assets to protect other critical sectors
- Identify force-multiplier assets
  - MARS communications: connecting centers that are force multipliers
  - Civil equivalents for emergency communications
  - Volunteer and non-governmental (NGO) entities with self-recruiting network development
  - Law enforcement entities deputizing volunteers to contain and co-opt civil unrest
- Economic modeling of system resiliency
  - E.g. Black Start “cranking paths”: all-hazard hardening as a “best buy”
  - Pre-investments in supply chain resilience
  - Providing market incentives for resiliency investments, including cost recovery for reliability enhancements. E.g. cost-recovery for large power transformer hardening.

## PONDEROSA RESOURCES SOME CANDIDATES

- Augment on-site and off-site large power transformer spares
- Nuclear power plant FLEX program—hardening for EMP; cyber protection, including supply chain, for SCADA and controls
- On-site backup power for indefinite protection of nuclear facilities and spent fuel
- Geomagnetic Disturbance (GMD) blocking devices for transformers so generation and transmission can “operate through” solar storms
- Redesign of nuclear facilities with multiple power plants for mutual backup & ability to “operate through” hazards, and “black start” fossil fuel thermal plants
- Design and incentivize microgrids to “black start” grid generation facilities
- Harness “early adopter” renewable transmission systems to offset voltage or frequency deficits. E.g. PJM Interconnection standards
- Designing self-healing, self-recovering systems. E.g. INCOSE initiatives
- ▶ Voluntary organization outreach programs that train for resilience and recovery
- ▶ Law enforcement civil outreach infrastructure development: a force multiplier
- ▶ National Guard “surge” capabilities for cyber and other emergencies
- ▶ Military assistance to civil authorities
- ▶ Encourage augmented household stocks of emergency supplies: food and water
- ▶ Pre-position diesel fuel, and fuel trucks, including low pressure nozzles for electric grid, telecom, and other retail customers
- ▶ Establish emergency credit and loan guarantee programs to sustain supply chains without electronic payment system operability
- ▶ Exercise supply chain interoperability & identify key resilience investments
- ▶ Educate on benefits of “shelter in place” options to reduce transportation congestion
- ▶ Education on resiliency benefits and opportunities in all school systems

## **Comparison of CMP and EMPRIMUS Recommendations for Maine GMD and EMP Grid Protection\***

	<b><u>Vulnerability</u></b>	<b><u>Fix</u></b>	<b><u>Cost</u></b>	<b><u>Time Frame</u></b>
<b>CMP</b>	Inadequate monitoring	Add 16 GMD monitors	\$576,000	None given
	Electromechanical relays can trip from harmonics	Replace with microprocessor type to filter harmonics: for capacitor control	\$1M for 4 relays	None given
	All Electromechanical relays	Replace with microprocessor type: for all substations	\$20.25M for 81 relays	None given
	Capacitor recovery time	Install Independent Pole Operating (IPO) breakers at 9 locations	\$21 million	None given
	Excessive transformer heating due to higher GIC flows	Install GIC transformer blocking devices	\$400,000 each: 7 for \$2.8M (20V/km, their 100 Yr. Storm) 9 for \$3.6M (29V/km, their 500 Yr. Storm)	None given
Note: No simulations done for EMP E-1 and E-2. "As this topic develops, substations, control centers and other power system components should be tested for their vulnerabilities."				
<b>Emprimus</b>	System vulnerable, even without voltage collapse.	Install neutral blocking at 12 Substations (18 transformers.)	\$400,000 per blocking unit; 18 transformers: \$7.2M	None given
	High GIC's danger to Transformers & Generators	Neutral blockers relieve CMP from reliance on procedures which are shown by Emprimus modeling to be ineffective	Saves approx. \$8.6M per year (net savings \$1.4M first year, \$8.6 succeeding years)	None given
	Harmonics and. EMP E3.	Install 30 neutral blocking devices total to add this protection.	\$12M (\$4.8M additional)	None given
	Other EMP	Install EMP/IEMI detectors and protective cabinets at key substations	None given None given	None given None given

Note: Loss to revenue of utilities and customers, public health and safety, and damaged transformers and customer equipment offset costs.

*Rep. Andrea Boland, updated 3-2-15*

\*My extract of their reports, as I understand them. See CMP and Emprimus full reports.