Grid Security: Protecting Against EMPs and GMDs

Edison Electric INSTITUTE

Why It Matters

Protecting the nation's energy grid and ensuring a reliable and affordable supply of energy are top priorities for America's electric companies. The energy grid's complex, interconnected technologies may be impacted by bursts of electromagnetic energy such as naturally occurring geomagnetic disturbances (GMDs) or malicious, man-made electromagnetic pulses (EMPs). To address these hazards, the electric power industry continues to enhance the resilience of the energy grid and to accelerate recovery from potential incidents.

Understanding EMPs

There are two categories of intentional man-made EMPs. First, an EMP event can be caused by nuclear weapons detonated to create electromagnetic interference. A high-altitude EMP (HEMP) is caused by the detonation of a nuclear weapon in the atmosphere or in space. This is a low-likelihood, high-consequence event that would amount to an act of war or terrorism.

The second type of EMP, sometimes called a briefcase EMP, is related to the use of a smaller directed energy weapon that would target a single facility or piece of equipment, presenting a more localized threat.

EMPs have three primary characteristics—E1, E2, and E3—each of which can cause a different physical effect on the bulk-power (or electric transmission) system.

- **E1 EMP** is an initial high-magnitude pulse over a large geographic area. E1 EMP has a rise-time of approximately 2.5 nanoseconds—that's 2.5 billionths of a second. Potential impacts on the energy grid from E1 include disruption or damage to electronics such as digital relays, communications, and industrial control systems.
- **E2 EMP** is an intermediate pulse with characteristics similar to those caused by nearby lightning strikes, with no expected impacts to the electric transmission system.
- **E3 EMP** is a very low-frequency, late pulse lasting around two minutes. E3 EMP is *similar* to a severe GMD caused by solar flares. Potential impacts from E3 include voltage collapse (e.g., regional blackout) and transformer damage.

Understanding GMDs

GMDs are caused by solar storms that eject electrically charged particles from the sun. When these particles interact with the Earth's magnetic field, especially in certain geographic regions, they can cause potentially disruptive phenomena.

There are important differences between man-made EMPs and naturally occurring GMDs. Though a GMD wave is similar to an E3 EMP, there are key distinctions. For example, the intensity of an E3 EMP can be orders of magnitude more severe, and an E3 EMP is much shorter in duration than GMD events (which can last for several days). Each type of threat must be addressed independently, and appropriate mitigation and protection strategies must be implemented for each.

The similarity between an E3 EMP and a GMD solar flare wave has led some to conflate EMP and GMD, which overlooks critical distinctions and can have unintended consequences, including potentially undermining or conflicting with mitigation measures and protective standards already in place.

Policy Priorities

- Leverage the ESCC and government partnerships.
- Maintain the NERC-FERC standards drafting process.
- Support federal research and development on grid security technologies and expedite technology transfer to the private sector.
- Continue to promote the electric power industry's efforts to protect the energy grid, and support the associated cost recovery of its investments.
- Support the collaborative efforts of electric companies and state and federal agencies to address threats to the energy grid.

Research and Response

To engineer and test mitigation options that address the EMP threat and to avoid unintentional consequences, the electric power industry has made significant efforts to better understand the impacts of an EMP. In 2016, the Electric Power Research Institute (EPRI) launched a research project to provide a scientific basis for investments to mitigate EMP threats to the bulk power (or electric transmission) system.

EPRI's latest report, studying the potential combined effects of E1, E2, and E3 on overhead transmission lines, substations, and switchyards, was released on April 30, 2019. This new report shows that initial E1 and late E3 pulses could trigger a regional service interruption, but would not trigger a nationwide energy grid failure. EPRI concluded that "recovery times are expected to be similar to those resulting from large-scale power interruptions caused by other extreme events provided that mitigations specific to the initial pulse are deployed." Importantly, EPRI also concluded that "possible damage to large power transformers was found to be minimal," with only 3 to 21 large power transformers at potential risk from E3 within a target area.

Multiple electric companies are working together with EPRI to pilot and to field study mitigation options for the initial pulse (E1) on their systems. This is necessary to identify any potential unintended consequences of any solutions on other components on the energy grid. Electric companies want to ensure that new mitigation strategies do not undermine or conflict with mitigation and protective measures that already are in place. EPRI also will be launching a new project to evaluate EMP impacts to generation facilities. As solutions are identified, tested, and piloted, priorities are being determined, as not every asset can be protected from every threat at all times.

The industry remains focused on mitigation strategies for all EMP threats. EPRI's findings, and the pilot projects that are getting underway, are helping companies to evaluate their systems and to identify and prioritize the most critical components that need protection.

The Electric Power Industry's Security Strategy

The electric power industry takes a risk-based defense-in-depth approach to protecting critical energy grid assets from all threats, including EMP. This includes close coordination between industry and government partners at all levels; rigorous, mandatory, and enforce-able reliability standards; and efforts to prepare for, prevent, respond to, and recover from a wide variety of hazards. The industry prioritizes protecting the energy grid's most critical components against the most likely threats; building in system resiliency; and developing contingency plans for response and recovery should any type of man-made or natural phenomena impact operations.

The electric power industry has managed GMDs for decades through mandatory and enforceable standards to help protect the energy grid from the impacts of GMDs, developed by the North American Electric Reliability Corporation (NERC) under the oversight of the Federal Energy

Regulatory Commission (FERC). Electric companies also have operating processes and procedures to manage GMD risks. Furthermore, GMDs only impact entities with long lines that can carry current—specifically the electricity and telecommunications sectors—whereas an EMP could impact all critical infrastructure within the detonation impact zone.

As the owners and operators of the critical infrastructure on which our society relies, electric companies have an important role to play. Whether planning for a kinetic attack (e.g., firearms, explosive devices, theft, vandalism), a directed energy weapon or HEMP attack, solar storms, or severe weather, the electric power industry will continue to employ a defense-in-depth approach to grid security and resilience. Developed over many decades, this risk management program focuses on preparation, prevention, response, and recovery to deal with a wide variety of hazards.

Industry and Government Initiatives and Collaboration

Addressing dynamic threats to the energy grid requires vigilance and a coordinated approach that leverages government and industry expertise and resources. Policymakers and the electric power industry share the goal of developing capable, cost-effective mitigation to all threats.

To better understand and address the EMP threat, the industry works across the sector and with the ESCC; EPRI; NERC; federal agencies, including the Department of Energy (DOE), the Department of Defense (DOD), the Department of Homeland Security (DHS), the FBI, and FERC; and state and local law enforcement agencies.

Through the Electricity Subsector Coordinating Council (ESCC), the electric power industry continues to strengthen its government partnerships, coordinate with other critical infrastructure sectors, engage and educate external stakeholders and the public, and support the investments needed to make the energy grid stronger, more reliable, and more resilient in the face of any threat. These efforts include spare equipment programs, mutual assistance programs, exercises, the transformer transportation emergency support guide, supplemental operating strategies, additional research and development, and coordinating across sectors and with government on identifying roles, responsibilities, and interdependencies.

The detonation of a nuclear weapon causing an EMP would amount to an act of war or terrorism, and the federal government has primary responsibility for preventing such an attack as a matter of national security. The role of government in preventing, preparing for, and responding to such a scenario was acknowledged in the Executive Order on Coordinating National Resilience to Electromagnetic Pulses dated March 26, 2019. The responsibility for protecting the United States from war should fall on the nation's defense intelligence and military services, not on individual critical infrastructure providers.

With input from the electric power industry, DOE developed the Electromagnetic Pulse Resilience Action Plan that identified five goals: (1) improve and share understanding of EMP threats, effects, and impacts; (2) identify priority infrastructure; (3) test and promote mitigation and protection approaches; (4) enhance response and recovery capabilities to an EMP attack; and (5) share best practices across government and industry, nationally and internationally. DOE's plan was released in January 2017 and is complementary to EPRI's research project.

The impact from a high-altitude nuclear explosion over the continental United States would affect more than just the energy grid. Nearly all other critical infrastructures that utilize microprocessors are vulnerable. Any activity that relies upon devices containing integrated circuitry, such as industrial control systems, hospital equipment, and transportation and telecommunications systems, could be affected by an EMP attack. For any one sector's efforts to truly be fruitful, the interdependencies between critical infrastructures must be considered in national mitigation and recovery scenarios—cross-industry coordination is critical.

Conclusion

Protecting the nation's energy grid and ensuring a reliable and affordable supply of electricity are top priorities for the electric power industry. The industry recognizes that it cannot protect all assets from all threats and, instead, must manage risk via our defense-in-depth approach. Owners and operators of the nation's critical energy infrastructure take their obligation to protect this infrastructure seriously, and they should be included in any efforts commissioned to study these issues.

About EEI

The **Edison Electric Institute** (EEI) is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for about 220 million Americans, and operate in all 50 states and the District of Columbia. As a whole, the electric power industry supports more than 7 million jobs in communities across the United States. In addition to our U.S. members, EEI has more than 65 international electric companies with operations in more than 90 countries, as International Members, and hundreds of industry suppliers and related organizations as Associate Members.

Organized in 1933, EEI provides public policy leadership, strategic business intelligence, and essential conferences and forums.

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