International Center for Enterprise Preparedness (InterCEP)

The Sky is Falling: Space Weather EMP's, Solar Flares & Grid Resilience

Web Forum

On January 12, 2016, Thomas Popik discussed various issues that can affect the reliability of the national electric power grid, such as space weather, and potential resilience solutions. Tom is the founder and chairman of the Foundation for Resilient Societies, a nonprofit organization dedicated to the protection of the North American critical infrastructure from natural and man-made disasters.

The forum began with a description of the electric power infrastructure in the United States. This critical infrastructure system is shown in Figure 1 below. The grid in the continental United States consists of three interconnected grids that extend to Canada. Vulnerabilities to the grid are considered critical since long-term power outages affect every other infrastructure system. Since grids are highly interdependent, resilience solutions often look for redundancies in faraway geographies. In the case of sites to back-up data, for example, 500 miles of separation may not be enough. To address this concern, services such as Microsoft Windows Azure allow users to select virtual locations and data backup on multiple locations and in different continents.

Figure 1. The U.S. National Power Grid

Long-term grid outages could potentially be caused by various factors, including:

- Coordinated terrorist physical attack on grid substations
- Coordinated cyber-attacks
- Solar storms & geomagnetic disturbances (GMD)
- Radio frequency weapons / international electromagnetic interference
- Nuclear electromagnetic pulses

In terms of potential long-term consequences, damage to extra-high-voltage-transformers is of particular concern. These transformers are difficult to replace since they are custom manufactured and they are difficult to transport. Even having spare parts for high-voltage transformers is very challenging. These characteristics make it difficult for utilities to have back-ups. Parts of Northern California were close to facing significant impacts as a result of a 2013 sniper attack on the Pacific Gas and Electric Company’s Metcalf Transmission Substation, which is located near San Jose, California.

Some moderate solar storms have affected transformers since they are not very resilient to long electromagnetic pulses. Transformers are also vulnerable to radio frequency weapons, which could be as small as a suit case or could be placed in the back of a van. Such weapons could disrupt the semiconductors in a substation. This kind of attack could result in permanent damage.

Another potential threat to electric power substations is the detonation of a nuclear weapon in the atmosphere. Such an explosion would produce a series of pulses. A part of the grid could act as an antenna under such a scenario and would conduct the induced energy and burn out semiconductors. This would represent a risk to high-voltage transformers. Repeaters for fiber optic lines would also be susceptible to pulses from such a weapon.

Potential technical and regulatory resilience solutions for the power grid can be summarized as follows for various threats:

**Technical Solutions:**

**Physical security**

- Backup control centers located on military bases
- Dispatch of backup fuel at first indication of wide-area outages
- Gunfire locators at critical grid substations and real-time reporting of detections to reliability coordinators
- Preservation of some coal-fired generation capacity

**Cybersecurity**

- Encryption of communications networks for bulk power system
- Prohibition on use of public internet for grid control
**Solar storms**
- Neutral ground blocking devices

**Radio frequency weapons**
- Radio frequency weapon detection devices
- Real-time reporting of incidents to reliability coordinators

**High altitude electromagnetic pulse**
- Ballistic missile defense
- Neutral ground blocking devices
- “E1” hardening for newly installed SCADA and other control systems

**Regulatory solutions:**
- Join the North American Electric Reliability Corporation as a “Large End-Use Electricity Customer”
  - Participate in Reliability Standards Development and Vote on Standards
  - “Demand Response” Customers: Become Involved in the NERC “GridEx” Exercises for Attack on North American Electric Grid
- Join the FBI Infragard Special Interest Group on EMP
  - www.infragard.org
- Join Your Regional Transmission Organization/Independent System Operator as an End-Use Customer
- Comment on Rulemaking Proposals for Electric Reliability Standards at the Federal Energy Regulatory Commission (FERC)
- Write or Call Your Elected Representatives

**General Discussion:**

Following the presentation of these ideas, the group engaged in a discussion about resilience and the power grid. Some of the main points are summarized below.

Would it be effective to have a data backup center in Florida if your central offices are in Boston? That may offer limited protection since the backup center would still be in the eastern interconnection. It may be better to locate such a center in a location such as Nevada, which is part of another grid. From a resilience perspective it is important to understand where you and your facilities are located in terms of interconnections.

Are there cross-cutting strategies for private corporations for improving resilience? Understanding how the electric grid is configured where you want to locate your backup data centers and understanding how the power generation is configured is very important and allows a company to gain a better
understanding for potential vulnerabilities to various threats. For example, in the northwest of the U.S. there is a lot of concentration of hydroelectric power. In other parts there is an overdependence on gas pipelines. This could be a problem if the compressed natural gas relies on power. These potential vulnerabilities underscore the need for companies to petition state public utility commissions for more resilient solutions.

How likely is it that we will see another Carrington-type event (a solar storm that took place in 1859)? The probability of this type of event is about 1% per year. This sounds like a low probability but the probability of such an event over a decade is significant.

Is the manufacturing capacity of transformers in countries that are friendly to the U.S.? A lot of this capacity is in countries such as the Republic of Korea and Germany that are friendly to the West. If EMP or solar storm impacted a large geographical area, there could be a transformer backlog.

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) can also be a resilience step. However, the vast majority of power runs over long-term transmission lines and we won’t be able to replace that with micro-grids in the short-term so it’s a good idea to have a diversity of systems out there.

**Additional Resources:**


