Critical Infrastructure: Electric Power Subcommittee*

Risk Mitigation in the Electric Power Sector: Serious Attention Needed

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Executive Summary

The Electric Power critical infrastructure is unique in that it supports all 17 other critical infrastructure and key resource sectors. Today's complex, digital world simply requires electric power for all or certain aspects of most business and consumer activities.

This white paper examines the risks associated with loss of electric power, by looking at three dimensions involving:

- Specialized equipment
- Human interaction among the specialists who restore power and communications
- Factors affecting the use of renewable energy from natural sources to provide power during Long-Term Outages (LTOs)

In order to provide a context for this analysis, the white paper on Critical Infrastructure – Electric Power looks at and updates three major recommendations in the Communications Dependency on Electric Power (CDEP) report (2009). This historical approach helps gauge the progress made in mitigating certain risks identified within the electric power sector and also raises awareness of the continuing risks.

Defining the Problem: Understanding Key Elements of Electrical Power Infrastructure

No Central View of US Power.

One of the first things to understand about the American power infrastructure is that, unlike the US telecommunications industry, the power grid emerged in the late 19th Century and early 20th Century using a highly competitive business model where each regional provider developed unique power generation and distribution systems. The United States high voltage transmission grid has over 80,000 miles of transmission lines at 345 kV and above.

*The views or opinions presented in this paper are solely those of the authors and do not necessarily represent those of the organizations.

There are three separate regional US power grids: East, West and Texas. Texas stands alone as a separate state and grid. Each grid has its own separate and unique design specifications.

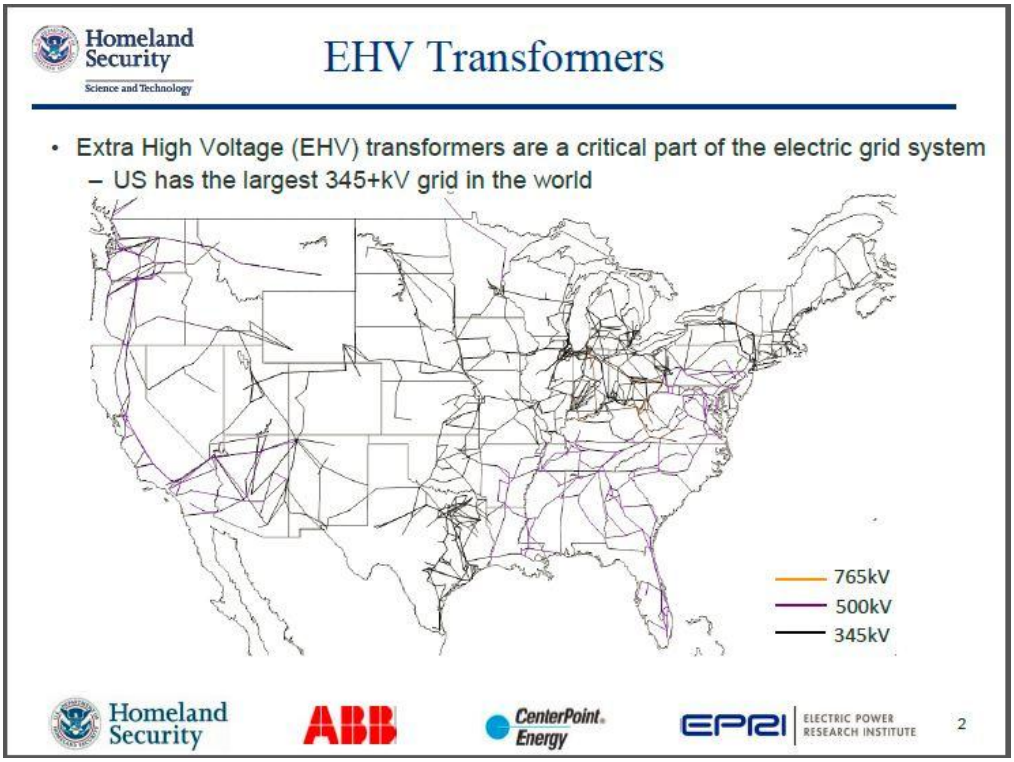

Figure 1: EHV Transformers

These power grid providers have always operationally or administratively worked as independent organizations. Each is run entirely separately, meaning that there can be no single integrated view or perspective across the United States of power grid vulnerability and exposure without individually polling each provider separately and compiling this information.

Electric Power is Unique among all the 18 Critical Infrastructure and Key Resource sectors.

Each of the 18 sectors has an important impact on the economic stability and safety of the US economy and its citizens but it has to be stated that the power grid is the single sector upon which all the other sectors are totally dependent. Commercial activity stops or is significantly impacted the moment there is any regional or local interruption of service. Emergency power supplies are typically sufficient for short term outages but would be highly inefficient in the face of more serious and extended disruptions. Loss of regional power typically has a cascading impact on American society that makes this sector entirely unique.

Lack of Interoperability.

With separate design standards and specifications for each grid provider there can be no meaningful discussion about interoperability between or among US power grid providers since this important sector often lacks common standards or even the means to create a common standard. The transmission transformers which are the heart of the each grid delivery system are typically custom built according to an electric power company's specifications for a particular site. Transmission transformers are 99.8% efficient in the system and location for which they are designed. For this reason any transformer moved to a new location or to another grid provider would be less efficient when used in another system. For example, if a neighboring utility needs a 345 kV/138 kV transformer to replace a non-functional one, the utility must decide if it is willing to pay an efficiency penalty to avert a significant long-term degradation to its system. While the one unit is down, other units are forced to operate at 120% over designed load, which situation reduces 30% of the good unit's effective life. The essential economics of the current US power grid often prevents cost-effective or realistic interoperability.

Massive Size Implication on Logistics.

It is equally important to understand that the transformer which is the backbone of the power grid is massive in size, creating a huge challenge when it needs to be replaced. Concerns about the size of transmission transformers factor greatly into the logistics of getting new and/or replacement transformers to the job site. In several instances, the rails used to deliver the original transformer several decades ago have been removed. Transport via highways is constrained by the height of overpasses and power lines across the road as well as the weight of the transformer. The massive size also affects which route the state(s) will authorize in transport permit(s), collectively resulting in a process that can take up to 10 weeks for delivery of a conventional transmission transformer, which can weigh as much as 400 tons.

Transformer Lifecycle (30-35 years).

Transmission transformers typically have a designed lifecycle of 30 to 35 years, but maintenance, repairs and updates throughout this period can extend operating lifecycles for an additional decade or two. According to a recent DOE Study, the number of EHV large power transformers (LPTs) in the United States is approximately 2,000, with the total number of LPTs estimated in the 10s of thousands.[1] The significant expansion of the electric power grid and interconnections via high voltage lines took place in the late 50s and 60s; thus, these key elements of the grid are now reaching the end of their natural life cycle and must be replaced to secure safe and reliable power infrastructure. This also adds to the grid providers' expensive capital costs needed to sustain the growing demand on existing power systems.

Limited Industrial Base.

The greatly diminished United States market was a factor in the considerable consolidation in the power equipment industry from the 1980s to 2010. Many of the surviving firms took advantage of lower labor costs offshore and the growing market for LPTs in emerging countries (e.g., China and India) to close down manufacturing facilities in the United States.

[1] "Large Power Transformers and the U.S. Electric Grid," Infrastructure Security and Energy Restoration, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy, June 2012, pp. 22-24.

This resulted in U.S. grid providers becoming dependent on off-shore sources. Until very recently U.S. electric power companies had to source new transmission transformers from South Korea, Austria, The Netherlands, Mexico, Germany and Japan. Because a large number of LPTs are now at or beyond their original life expectancy, the Department of Energy report cited the reduced LPT manufacturing capacity as a serious vulnerability in the U.S. industrial base.

18-24 Month Replacement Cycle.

The combination of unique design, challenging logistics and limited industrial base manufacturing has resulted in extended lead time for physical replacement of US transformers.

Limited Redundancy and Physical Design Protection.

The three regional power grids extend over vast areas of the United States. The power grid components: generation, transmission and distribution systems -- operate across great distances with key elements often in highly remote areas. These systems -- largely analog until the past decade -- were designed with limited redundancy or with little if any specific emphasis on secure locations.

Defining the Problem: Understanding the Vulnerabilities

Network Vulnerability.

The key management systems that have acted as the connective tissue of the power grid are called **SCADA** (**supervisory control and data acquisition**) systems. SCADA is a type of industrial control system (ICS) permitting remote monitoring of key elements. Until very recently the SCADA systems were proprietary private networks designed and hardened to protect from the inappropriate interference from outside unauthorized interaction. Most of the grid providers, however, have shifted from these unique network design specifications to a public Internet connection for cost-savings reasons without fully appreciating the increased inherent risk. There are documented cases of intervention with these systems, some malicious, some frivolous. In addition to cyber-hacker attacks linked to power outages in Florida in 2008 and Brazil in 2009, an outage as recent as February 2011 also suggests a similar cyber intrusion. It is reported that foreign governments have penetrated the computer networks of the US power grid and left behind “cyber time bombs” that can be set off remotely. Damage to electric grid components has become a common scenario of a terrorist cyber attack intended to disrupt our US economy.

Physical Attack.

Due to the remote locations of key elements of the grid it is not difficult to understand that a coordinated attack impacting critical elements of one grid or across several grids could to lead to a catastrophic failure to our US economy. It is important to understand the true nature of this vulnerability by exploring the simple math of a systemic failure below.

Two is all it takes.

The electric power industry has developed disaster prevention and recovery plans that factor in the loss of key grid components, such as generating facilities and transmission transformers, while continuing to provide electric power to customers. To promote reliability, the industry frequently uses an "N-1" standard (referring to the ability to operate without loss of service even after the failure of one key component in the grid). Over the years, the industry has achieved the capability in many locales to operate with the loss of two such key components ("N-2"); however, "N-2" capability does not exist throughout any one company's system or across the power grid regionally or nationally. Imagine a coordinated attack of key power grid sites on the scale of the 2005 attack in London of five Tube stations simultaneously. Current contingency plans incorporate the possible loss of one or two transmission transformers but not more than two. In light of the characteristics described above imagine a major service outage involving the loss of several transmission transformers with these extended lead times measured in years.

Methodology

AFCEA's Cybersecurity Committee formed the Critical Infrastructure – Electric Power Sector Subcommittee to examine existing risks within the U.S. electric power grid, to report on the status of efforts being made in industry and government to mitigate these risks, and to raise visibility on these efforts. To better gauge progress of these efforts, the Subcommittee decided to focus on certain key recommendations selected from an earlier comprehensive study and analyze what changes had occurred in recent years.

The National Communications System's (NCS) Committee of Principals (COP), consisting of senior representatives from 22 federal agencies having national security/emergency preparedness responsibilities, created the Communications Dependency on Electric Power (CDEP) Working Group in 2007. The COP tasked the CDEP Working Group with drafting a response to the recommendations made previously in the report of the Telecommunications and Electric Power Interdependency (TEPI) Task Force, an operating unit of the National Security Telecommunications Advisory Committee (NSTAC). NSTAC is a Presidential advisory committee consisting of the CEOs of nearly 30 communications companies.

AFCEA's Cybersecurity Committee formed the Critical Infrastructure – Electric Power Sector Subcommittee to examine and report on progress made since 2009 in three of the top 10 recommendations contained in the CDEP report. As explained hereafter, the Subcommittee decided to follow up on three specific recommendations:

- Recovery Transformer Program
- Cross-Sector Situational Analysis Tools
- Using Renewable Sources of Energy during LTOs

based on the considered view in 2009 that these three recommendations respectively held great promise for achieving significant mitigation of the risk of loss of electric power. The mitigation could occur in the following ways:

1. Reducing the long lead-time needed to replace damaged transmission transformers.
2. Increasing the availability of analytical tools to industry experts responsible for restoration of communications networks or electric power grids, which is often coordinated from state-level Emergency Operating Centers (EOCs).
3. Using reliable electric power from renewable energy sources that could function as isolated "islands" of power in the event of a Long-Term Outage of the electric power grid.

Electric power grids have three major components: generation plants, transmission transformers, and distribution transformers. *Generation* plants create electric power using various forms of energy, e.g., fossil fuels, hydroelectric, nuclear, etc. *Transmission* transformers increase or "step up" the generated voltage to much higher voltages needed for efficient delivery to distant locations. Typically, a small number of transmission transformers support a generation plant, which means that the loss of two or more of these large power transformers could lead to significant electric power outages over a large area. *Distribution* transformers reduce or "step down" high voltages to lower voltage levels used in homes and businesses in local neighborhoods. Although the ubiquitous *distribution* transformers are frequently damaged or knocked out of operation during weather events, they can easily be repaired or replaced within hours, days or a week, depending on how widespread the damage.

The first recommendation relates to alternative approaches to mitigating damage to the *transmission* component of the electric power grid. Although this component does not require the longest lead time to build or repair — the generating component clearly does -- these transmission components may be more vulnerable to weather-related events, e.g., solar storms, or man-made incidents than the generating facilities. Remember, the lead time for transmission transformers has been in recent history between 18 to 24 months.

The second recommendation deals with interactions, not only across two critical infrastructure sectors, but also between federal and state governments. It also leverages the several situational analysis tools developed for the communications and the electric power sectors and potentially offers state EOCs additional "lines of bearing" on an infrastructure issue.

The third recommendation offers a creative solution to responding to Long-Term Outages, taking advantage of renewable energy sources in ways perhaps not initially envisioned. As we shall see, consideration of this recommendation has evolved.

Summary of CDEP Recommendations

Continue the RecX Transformer Program.

Transmission transformers are typically designed for the unique characteristics of a particular installation to optimize operational performance. These transformers represent a particularly vulnerable component due to their relative scarcity and long-lead time for replacement (~ 18 to 24 months). The CDEP study reviewed two approaches to mitigating this vulnerability: (1) the Edison Electric Institute (EEI)-led "Spare Transformer Equipment Program" (STEP), which seeks to share pooled transmission transformers among regional participants, and (2) the Department of Homeland Security's Science and Technology Directorate and the Electric Power Research Institute (EPRI) focused on development of a rapid recovery transformer, now known as the "Recovery Transformer" or "RecX" program, which could be sent quickly from deployment sites and satisfy nearly all of the parametric needs of a particular damaged transformer. DHS decided to develop the RecX for the 345 kV/138 kV class of transformer, the most prevalent of the nine classes of extra high voltage transformers. This generic approach means that the RecX might potentially yield a sub-optimized solution (satisfying 98% to 99% of the parameters) while still having a cost nearly equal to the traditional, "tailor made" transformer. (See the CDEP report at pp. 27 and 37 [Section 3.3.4] and appendices at pp. 149-150.)

Use Situation Analysis Tools across Critical Infrastructure Sectors.

Communications networks operate nationally and have a top-down approach for most of their management; however, electric power companies operate more locally and address many management issues from the bottom-up. Notwithstanding this disparity, the CDEP report identified counterpart organizations and functions between these two sectors, as shown in the attached chart (Figure 2). The CDEP report also identified state Emergency Operations Centers (EOCs) as a location where both sectors' emergency leadership and data already are or could be co-located for cross-sector situation analysis. The CDEP report also reviewed several situation analysis tools used by one or the other sector, and recommended that these tools be shared across critical infrastructure sectors to accelerate coordination for restoration. (See the CDEP report at pp. 50-69 [especially Section 5.6, recommendation 6 on p. 69] and appendices at pp. 89-96.)

Use renewable sources of energy during LTOs.

Critical infrastructure sectors routinely employ diesel and natural gas generators as *back-up* sources when local electric power is lost. Because these *back-up* sources require refueling and access to potentially restricted areas, they become more cumbersome and less feasible solutions during LTOs, defined as 14 days or longer in duration. Idaho National Laboratories (INL) has envisioned another approach to restoration of electric power during LTOs -- linking high-priority users to *alternate or renewable* energy sources, e.g., geothermal, hydro, solar, and wind, to provide partial restoration as an interim or a future design solution. INL pioneered an initiative to provide locations of and data concerning renewable sources of electric power across the U.S. as possible sources of power during a LTO.

According to the Idaho National Labs representatives who participated in the CDEP effort, essentially no follow up has occurred since 2008. This is due partly to a growing awareness that stored energy, e.g., batteries, plays an essential role in regulating voltage needed for reliable usage of energy derived from renewable sources. Initially, attention focused on the sources/locations of renewable energy, and the feasibility of linking them via existing and extended power lines to an area or areas, e.g., in micro-grid fashion, where a LTO has occurred.

Findings

The Recovery Transformer (RecX) Program Has Evolved

The RecX program has made considerable progress since 2009. Although originally envisioned as a temporary solution to an electric utility's unanticipated need for a transmission transformer, DHS and EPRI subsequently upgraded the specifications and capability for Recovery Transformers to the point where a RecX could be installed and allowed to function for 30+ years.

DHS and its RecX partners worked with ABB to manufacture the prototype RecX, building the required three phases in modular fashion to facilitate transport, for a willing electric utility -- CenterPoint Energy in Houston. The successful demonstration of the deployment of the prototype RecX occurred in March 2012, when the dismantlement, transport from St. Louis to Houston, set-up and activation was completed in six days.

This RecX transformer is nearing one year of operation, which will provide useful data regarding efficiency, operating costs, maintenance, etc.

New Arrival: Spare Parts Effort (SPE)

A third initiative has come on the scene since 2009 that complements both the STEP and the RecX programs. The North American Electric Reliability Corporation (NERC) established the Spare Parts Effort (SPE) in 2010. The SPE consists of participation by Transmission Owners (TO), Generator Owners (GO), and manufacturers on a voluntary basis to develop and maintain a Spare Equipment Database (SED) to facilitate anonymous requests for assistance in obtaining replacements for major equipment items that typically require more than six months to replace. The SPE Working Group meets monthly to discuss issues and has reached out to a potential universe of over 1,000 members. This new initiative has a couple of advantages over the better-known STEP program. First, unlike the requirement of a Presidential declaration under STEP, the trigger for assistance under the SPE is voluntary interaction. Second, the SPE is available irrespective of the cause of the damage.

Continue the Dialogue between Private Industry and Government.

The experts interviewed in connection with all three recommendations underscored the importance of maintaining the existing dialogue between companies and organizations in the private sector and government agencies at the federal, state and local levels. They agreed on this point even if there was not agreement on a common approach to mitigation or shared participation on respective approaches to mitigation.

Lack of Commonly Accepted Definitions of Risk and Vulnerability.

Although there seems to be almost universal agreement that the dialogue between private industry and government is important there does not seem to be a shared assessment of risk and therefore vulnerability. Therefore the sense of urgency that surrounds this dialogue can be vastly different. It is understood that private sector companies may feel uncomfortable about acknowledging vulnerability but this approach often prevents meaningful dialogue and more importantly appropriate investments in mitigation plans and strategies.

Need for Full Sense of Interdependency.

Probably the most disconcerting aspect of the lack of full disclosure and dialogue is the seemingly limited understanding of the full extent of the interdependency between the electrical power grid and a variety of other key infrastructure sectors. Hardly any sector is not fully dependent on the sustainability of the power grid, yet the existing discussion within the power sector of not being able to overcome the loss of two well-placed key components within a single company's system or more components over the wider grid does not appear to have been acknowledged or discussed beyond this one sector. A better understanding of this interdependency might lead to funding sources for the RecX transformers.

Public Awareness Essential to Support Future Investment.

The need for public awareness applies not only to the private sector electric power companies and companies in other sectors but also to federal agencies that work on these issues. The companies understandably need awareness among shareholders and within the financial community to generate and sustain the support for investment in physical plant. This is easier to accomplish for items normally found in the generation, transmission and distribution aspects of an energy company; however, it is considerably more difficult to achieve for those items deemed "experimental", "contingent" or "responsive to High Impact, Low Frequency (HILF) events, such as the emergency loss of two or more transmission transformers. For this reason, the private sector generally will not invest in activities which negatively impact the bottom line or for which a known, steady return on investment does not exist. Thus, it falls to the government to invest in activities measured not by ROI but rather in terms of the "common good" or "public welfare."

For federal agencies where the budget derives from Congress, the need for public awareness is considerably greater, not only due to the general lack of understanding and expertise concerning the electric power industry but also because the significantly broader range of "common good" or "public welfare" issues/interests compete for the federal budget dollars. Even when federal agencies do get involved, either on a government-only basis or in a joint effort with the private sector, e.g., the RecX transformer, there may come a time when the government needs to transition its involvement or share in the effort to the private sector.

Limited Impetus to Evaluate and Address Low Probability Events.

The issues surrounding High Impact, Low Frequency (HILF) (also known as low probability, high consequence) events were touched on earlier but may warrant amplification. The differing measures for the private sector (ROI) vs. the government ("common good") regarding making an investment may not adequately address the entire contours of this issue. There needs to be metrics that account for the overall consideration of risk, including costs associated with the consequences, that is, the third factor in the risk function (risk = threat x vulnerability x consequence). Years ago, General Motors stated this aspect succinctly in its "Mr. Good Wrench" ad campaign: ("You can pay me now or pay me later."). Is it easier to make an appointment to get the car's electrical system checked out at a convenient time or to try to arrange for a tow at a time, location and weather not of one's choosing? Some economists, in seeking to estimate the costs of cybersecurity, measure the difference between the cost of the initial investment vs. the cost of recovery, which can include damage to a company's reputation, customer's business, etc.

Integration with the State EOCs.

The Emergency Operations Centers in each of the 50 states seek a common operating picture, also known as "situational awareness", both before and during incidents. Their staffing levels vary by state and by critical infrastructure sector. These EOCs not only function as coordinating hubs during emergencies but they also interact with federal, adjoining states, and local government agencies as well as private sector within the state.

Trust building needed.

Several of those interviewed cited the absence of trust, between competing companies in the electric power sector and between industry and government, as a major hindrance in making progress.

RECOMMENDATIONS

Explore alternate power sources for critical telecom nodes.

If the common goal of our enemies is to disrupt the US economy it cannot be denied that targeting the power grid or the essential telecom networks fall within their cross-hairs. As this report goes to press the American newspapers are full of stories that suggest a series of pervasive attacks across US business. The enemy is not merely targeting the network; their intent is to seize intellectual property that resides on these networks. The disruption of the power grid -- which has far less redundancy and interoperability than the telecom sector -- could be the easiest way to impact our economy. This subcommittee therefore recommends that critical telecom nodes anticipate long-term outages and explore alternate power sources that are independent of or can operate independently of the grid, i.e., off-grid.

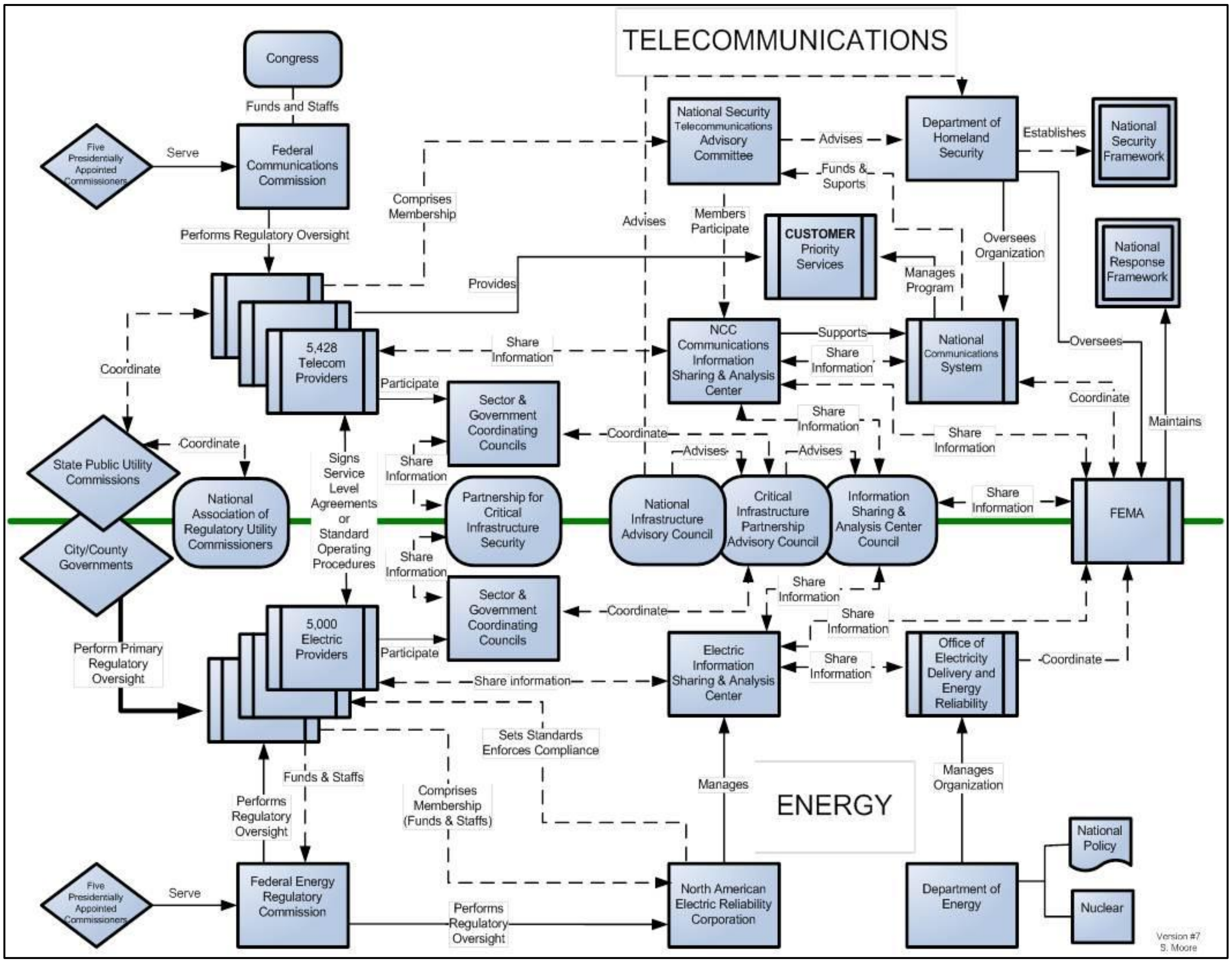

Figure 2: Telecommunications and Energy Interdependency

Need better forensics to detect network intrusion.

Jim Lewis of the Center for Strategic and International Studies (CSIS) presented an important White Paper in March of 2010, “The Electrical Grid as the Target for Cyber Attacks”. In that White Paper indicates that the cyber attacks on the grid have evolved into a model where the enemy is leaving behind “time bombs” across the US grids that can be triggered at a later date. We repeat and therefore support CSIS’s recommendation that calls for cyber forensics systems which are better able to understand what is occurring on these critical grids and networks.

Develop systemic analytical models to define and understand risk.

Interviews with experts and organizations revealed that there is as yet no comprehensive analytical model that identifies, defines and normalizes the risks in this particular space. Individual utility companies have models of varying quality for their own systems; however, what exists at the regional and larger geographic areas needs further work in order to be comparably useful.

Part of the pervasive inertia is attributed to flawed probabilistic analysis: organizations and agencies are using Bayesian analysis, which calculates probabilities for events based on prior outcomes; transmission transformer outages due to terrorist attacks have not yet occurred and only one incident has been linked to solar storms (which triggered an N-1 event). If such outages were analyzed as part of a stochastic chain of events, the likely occurrence of outages might be greater.

There is plenty of academic work and literature to show ***how*** such analysis could be done. However, this has not been done because of conscious avoidance (by industry) and the concern that enumeration of risks, probabilities, vulnerabilities and consequences (even for low probability, high consequence events, also known as High Impact, Low Frequency (HILF)) may lead to potential legal liability. Instead of disincentives of which there are many, an incentive structure is needed which would provide an upside. Moreover, utilities themselves need to contribute to a more thorough risk analysis which might lead to a significantly different mitigation strategy in response to a Long-Term Outage.

Finally, on a more comprehensive level, the risks associated with transmission transformers have not been quantified and rank ordered among other events in the overarching risk portfolio, e.g., air traffic control system failure, pipeline transmission system failure, etc. Such overall ranking could affect how government and industry would decide the priority ordering of issues to address. An academic institution could coordinate the research on behalf of a consortium comprising DHS/CIP, DHS/S&T, DOE, EPRI, EEI, and private sector companies in the communications and electric power as well as other sectors.

Move towards common standards to allow future modularization and interoperability.

The most essential element of the grid vulnerability involves the extended delays inherent in the replacement of key grid elements such as the transmission transformer. As discussed elsewhere in this paper, the DHS Recovery Transformer Program (RecX) constitutes the first serious effort to create a modular design and create common design standards across the industry to positively impact the intervals for new equipment delivery. The subcommittee’s interviews suggest a resistance to this standard module approach (which is already common in the telecom sector). Our recommendation is that the power grid providers move more aggressively in this direction to protect this basic infrastructure element.

Continue to invest in LPT mitigation/recovery programs.

The three mitigation/recovery initiatives discussed in this paper represent different approaches and levels/stages of maturity. The STEP effort was chronologically the first program. Based on information provided by the EEI, the STEP effort has matured and appears to have achieved a high participation level by electric power companies across the nation. The equipment available for sharing under this initiative is already owned by the consortium members.

The RecX program, begun by the Department of Homeland Security and EPRI in 2006, continues to evolve. There is no publicly available information regarding the number of RecX transformers or pre-deployment sites envisioned for this initiative. The first RecX was built and installed at an electric utility only in 2012. This installation will provide operational data; however, because it was delivered and installed as a result of prior planning rather than in response to an emergency, these circumstances cannot provide completely comparable information. A reliable funding mechanism needs to be identified for RecX transformers, e.g., possibly large electric power customers in other sectors, e.g., in the communications, commercial facilities and transportation sectors, might be willing to consider forming coalitions or consortiums to fund an appropriate number of RecX transformers. Further, because DHS appears ready to transition from its role as the co-sponsor with EPRI time is of the essence.

NERC's Spare Parts Effort, the newest entrant in this area, has advantages over the STEP effort previously described. The equipment available for this initiative is likewise already owned by participating electric power companies. One significant drawback is that the take-up or registration lags among the more than 1,100 companies eligible for this effort. With the benefit of added visibility, the SPE should attract additional registered participants which are needed to make this program truly viable.

With respect to all of these initiatives, however, there appear to be many questions needing further analysis and investment. There should be a shared situation awareness and improved cooperation among these complementary initiatives—something currently lacking. For example, the best practices shared among current STEP participants ought to be shared more widely. As another example, the electric power sector should invest in improved algorithms or protocols for determining prioritization of equipment transfers under each program separately and on an integrated basis, i.e., considering the needs, capabilities of all three programs—answering the question who gets what when two or more companies request assistance.

OVERALL CONCLUSIONS AND NEXT STEPS

Mitigate Risk Due to Loss of Large Power Transformers.

The STEP and the RecX programs coexist, but seemingly n'er the twain shall meet. Representatives from each program stay in touch with one another, but at present they respectfully see no need or potential for merger or synergies. These programs, along with the SPE, should cooperate and complement each other. The apparent disinterest or separation needs to change.

Homeland Security Science and Technology

Comparison: Conventional Auto vs. RecX

Activity	Conventional Duration*	RecX Duration*
Acquisition	12-24 months	-
Permitting	Up to 10 weeks	1 week
Transportation	4-8 weeks	1-3 days
Assembly (varies by manufacturer)	2-3 weeks	24 hours
Vacuum	36 hours	8 hours
Oil Fill	24 hours	5 hours
Circulate Oil	48 hours	24 hours
Sit Time	48 hours	
Test & Check-out	2-3 days	20 hours
Primary Connections	2 days	4 hours
Transportation →Primary Connections	**7 – 13 weeks**	**4 – 7 days**

* Source: Centerpoint Energy

Homeland Security ABB CenterPoint. Energy EPRI ELECTRIC POWER RESEARCH INSTITUTE 15

Figure 3: RecX Duration

<u>**Generate Support from Other Infrastructure Sectors for RecX Program.**</u>

DHS has envisioned the manufacture of several RecX transformers which would be pre-positioned around the country for quicker response to emergencies. DHS is currently conducting an extensive outreach effort to raise awareness and seek industry interest for this effort, even if the program were to transition from DHS to the private sector due to reduction or elimination of federal funding for the RecX transformer program in the near future.

DHS and its RecX associates should continue working on the RecX. When the results of the first year of operation of the RecX installed at CenterPoint Energy are available, they should be analyzed and the result shared across the industry and across other sectors, and particularly with large electric power customers.

Make Improvements to Spare Transformer Equipment Program (STEP).

The EEI has helped the electric power industry address the issue of emergency replacement of transmission transformers through the Spare Transformer Equipment Program (STEP), a program akin to the industry's long-standing "mutual assistance" arrangements. Pursuant to STEP, electric utility companies form consortiums and agree to share transmission transformers which are specifically identified as their "required obligation" under a binding "pooling" arrangement. Transformers have been identified for all nine voltage classes. A Presidential finding or declaration is necessary to "trigger" this arrangement and the program is limited to responding to terrorist attacks. As of 2012, more than 50 utilities participate, providing almost coast-to-coast coverage. The average time for response, transport and installation under the STEP effort ranges between 11 to 13 weeks.

Even though the RecX approach achieves significantly better time for "recovery" or replacement, proponents of the STEP approach believe that the greater operating efficiencies (> 99% efficiency) thereafter are worth the wait.

The STEP program could consider where improvements might be made. For example, if the statutory scope were expanded to make STEP available in instances beyond terrorist attacks, this might yield greater usefulness throughout the industry. Also, EEI, as the sponsor of the STEP program, might reach out to the SPE and see if it could lend assistance in encouraging companies to register for the SPE.

Increase the Visibility and Take-up for Spare Parts Effort (SPE).

The SPE represents an important addition to the risk mitigation effort. It has much greater applicability than the STEP program and uses already-purchased equipment. However, it lacks registered participants in part due to lack of visibility and recognition. Both the electric power industry and associated organizations should actively work to help remedy this.

Re-visit Use of Situation Awareness Tools across Sectors at State EOCs.

The Department of Homeland Security established the Telecommunication Energy Working Group (TEWG), a four-part group to follow up on CDEP recommendations. This group included participants from DHS, the Department of Energy (DOE), and one representative each from the communications and the electric power sectors. This group initially held monthly meetings beginning in 2009 which later shifted to quarterly meetings. However, DHS disestablished the TEWG in spring 2011, stating in effect that highlighting the need for this capability was equivalent to resolving this particular recommendation in the CDEP report.

This need not and should not be the final word on this recommendation. The situational awareness tools continue to evolve and help their intended users diagnose and treat outages within their respective industry sectors. By sharing these tools and trained analysts across sectors, ideally at state EOCs, the time to restore operation in these critical sectors should diminish. The DHS and industry sector representatives should contact state EOCs and offer this assistance, perhaps demonstrating its usefulness in the context of a disaster recovery exercise.

Re-Focus Attention re Using Renewable Energy Sources in LTOs.

More recently, the focus on renewable energy sources has shifted to advanced techniques for bulk storage, including new-design batteries, compressed air, etc. Improved storage mechanisms also hold forth the promise of more efficient management of the overall electric grid, allowing the supply-demand balance to be adjusted on a more granular, real-time basis.

Ultimately, once improved energy storage mechanisms are developed to provide voltage regulation, renewables could be used to power off-grid islands which could support high-priority users.

The downside to these new approaches to more efficient grid management is that SCADA systems are used, which increases the exposure to cyber attacks.