Statement of Emily Heitman
VP and GM of Commercial Operations for Medium & Large Power Transformers in North America

ABB Inc.

on behalf of the

National Electrical Manufacturers Association (NEMA)

Discussion Draft Addressing Energy Reliability and Security

Subcommittee on Energy and Power
Committee on Energy and Commerce

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Statement Summary

- Large power transformers (LPTs) are essential components of the electric grid.
- The failure of a single LPT can cause a power disturbance. However, the concurrent failure of multiple LPTs could magnify the impact and lead to a highly significant outage.
- LPTs are susceptible to risks including extreme weather, criminal or terrorist attack, geomagnetic disturbances and electromagnetic pulse attack.
- LPTs cost millions of dollars and involve production lead times ranging from 12-24 months. Periodic material and component shortages can add to production delays.
- Once manufactured, the transportation and delivery of these large, ultra-heavy units pose challenges to their replacement.
- Industry and government have taken steps to both prevent and detect damage to critical infrastructure such as LPTs, and to aid recovery in the event that damage occurs.
- The National Electrical Manufacturers Association, the Edison Electric Institute, the North American Electric Reliability Corporation, the Federal Energy Regulatory Commission, the Department of Energy, and the Department of Homeland Security have all taken important steps to improve resiliency yet gaps remain.
- Manufacturers are developing new strategies. ABB is developing a five part approach: 1) Vulnerability assessment; 2) Design modifications to “harden” the transformer; 3) Remote monitoring and communication; 4) Ability to deploy rapid damage assessment and repair teams; and 5) Design and supply of replacement transformers that can be rapidly deployed.
- ABB and NEMA support studying the need for and design of a Strategic Transformer Reserve as proposed in the discussion draft and in H.R. 2244. We believe the creation of a Strategic Transformer Reserve would fill a gap in our nation’s capability to respond to the catastrophic loss of several LPTs.
- Improving the security and resiliency of our energy infrastructure requires ongoing cooperation between government and industry.

Introduction

Good morning Chairman Whitfield, Ranking Member Rush, and Members of the Subcommittee. My name is Emily Heitman and I am Vice President and General Manager of Commercial Operations for Medium and Large Power Transformers in North America for ABB.

I would like to thank you for inviting ABB, on behalf of the National Electrical Manufacturers Association (NEMA), to testify regarding the security and resiliency of America's energy infrastructure. The U.S. electric infrastructure fuels our economy. It is critical to our economic growth, global competitiveness, and quality of life. Virtually all industries are reliant upon electric power and dependent on the reliability and security of the grid.

ABB is a Fortune 500 producer of power and automation products and services for utilities, industry, government and transportation. With advanced global research and design and local manufacturing, we employ 147,000 people in over 100 countries including over 20,000 here in the United States. Our U.S. headquarters is located in Cary, North Carolina.

ABB engineers, manufactures, delivers and services the technologies that span our nation's energy infrastructure, so the topic of today's hearing is at the heart of ABB's daily collaboration with our customers.

We supply our utility customers with the technologies that make up the electric grid and our energy intensive industrial customers with a total power solution. We are the world's leading supplier of power grids.

With our motion, control, and process automation technologies, ABB enables our industrial customers—from oil and gas to food and beverage—to run their manufacturing lines and to optimize the productivity and energy use of their industrial processes.

ABB is a leading supplier of large power transformers (LPTs) across the globe, and as such our testimony focuses on the challenges and efforts underway to mitigate the risks associated with the loss of these critical elements of the grid. We enjoy a deep level of application, design and performance engineering expertise, and historically have been and continue to be on the leading edge of transformer technology and development.

My testimony today is offered on behalf of the National Electrical Manufacturers Association (NEMA) and the twelve members of the Power Transformer Committee of the NEMA Transformer Section.[1] NEMA represents nearly 400 electrical equipment and medical imaging technology manufacturers. NEMA's combined industries account for more than 400,000 American jobs and more than 7,000 facilities across the U.S. Domestic production exceeds $117 billion per year. The industry is at the forefront on electrical safety, reliability, resilience, efficiency, and energy security.

Large Power Transformer (LPT) Criticality

The United States transmission grid consists of approximately 390,000 miles of transmission lines, including more than 200,000 miles of high-voltage lines, connecting to more than 6,000 power plants[2].

Large power transformers (LPTs) are essential components of the electric grid. They control the high-voltage flow of our nation's electricity. Transformers either increase the voltage of electricity from generation sources for long-distance transmission ("step-up") or decrease the voltage of electricity close to the customer for end use ("step-down").

According to the Department of Energy an LPT is defined as a transformer with maximum capacity of 100 megavolt-amperes (MVA) or more[3].

The failure of a single LPT can cause a power disturbance. However, the concurrent failure of multiple LPTs could magnify the impact and lead to a highly significant outage.

LPT Risks

LPTs are located throughout the country's electric substations, usually exposed to the elements, and are at-risk from extreme weather events. We have seen devastation in the wake of Hurricanes Katrina and Sandy and other extreme weather events.

[1] ABB, CG Power Systems USA Inc., Eaton, Emerson Electric Co., GE, Kentucky Association of Electric Cooperatives Inc., MGM Transformer Company, Schneider Electric, Siemens, SPX Transformer Solutions Inc., VanTran Industries Inc., and WEG Electric Corp.
[2] 2013 NERC Electricity Supply & Demand Database, http://www.nerc.com/pa/RAPA/ESD/Pages/default.aspx
[3] *Large Power Transformers and the U.S. Electric Grid*, U.S. Department of Energy, April 2014.

Recently, LPTs have received much attention for their vulnerability to criminal or terrorist attack, such as the 2013 rifle assault on a California transmission substation. Geomagnetic disturbances (GMD) caused by solar weather, and electromagnetic pulse (EMP) attack are also of concern.

Further, the U.S. LPT fleet is aging. While LPTs are designed for a 30-year life, the average age of units in the U.S. is between 38-40 years old, with approximately 70 percent of LPTs being 25 years or older. Units approaching 70 years of age are still found in some places and older units may be more vulnerable to disruption.

LPT Challenges – Production, Transportation, & Installation

Production

LPTs cost millions of dollars and involve production lead times ranging from 12-24 months. Periodic material and component shortages can add to production delays.

Specific components to LPTs include bushings; load tap changers; specialized, and mostly imported, electrical steel; uniquely formed copper (no two transformer designs use the same copper wire); and high voltage insulation. When it comes to bushings, most are produced out of porcelain for the external insulator. These are very large and porcelain is no longer manufactured in North America – the porcelain alone can have 26-40 week lead time. Periodic disruptions in the import of electrical steel have also adversely affected production schedules.

Very few LPTs have the same design. In fact, with 70% of the LPTs installed in the U.S. being greater than 25 years old, the designs are outdated for both manufacturing and current technology. Therefore, in a replacement situation, the existing designs cannot be used and as a result the manufacturer replacing the unit must generate a brand new electrical and mechanical design. This time requirement is a minimum of 3-4 months. The electrical design alone can be hundreds of hours, and the mechanical design can take between 1,000-2,000 hours.

Transportation

Once manufactured, the transportation and delivery of these large, ultra-heavy units pose challenges to their replacement. Depending on power requirements which dictate unit size, LPTs may weigh between 100 and 400 tons, or more. Their size and weight often require delivery by specialized train cars and trucks with exacting site access plans. These specialized train and cars and trucks have limited availability in North America. In addition, with many existing LPTs in place for 40+ years, the routes of access once available to them have since been de-rated or even removed, leaving some substations and LPTs virtually landlocked and inaccessible for replacement.

Installation

Installing a transformer is a major event. Since an LPT must be disassembled to ship and then reassembled on site, specialized knowledge, skills, and equipment are necessary to complete the final installation of an LPT. All units must be wired back to power and a control system. Therefore, the location of the electrical interconnect is critical in placing the new or replacement unit within the substation.

Matching electrical parameters from one transformer to the next is not enough. Physical parameters must also be met in order to fit the unit into its designated location. The layouts of substations are rarely alike. When setting a new transformer in place, there must be adequate room for the cooling configuration on the unit.

Finally, issues involving the structural integrity of the concrete pads supporting older transformers are also common. When pad replacement is required prior to installation of a new transformer unit, further time and complexity is added to the installation.

A typical order cycle (barring possible delays cited earlier)

Utility specifications	1 month
Request for quote	1 month
Design	3 months
Material procurement	3 months
Manufacture	2 months
Ship	1 month
Commission	1 month
Total	**12 months**

LPT Hardening and Resiliency – Collaboration Between Industry & Government

Industry and government have taken steps to both prevent and detect damage to critical infrastructure such as LPTs (hardening), and to aid recovery in the event that damage occurs (resiliency). The National Electrical Manufacturers Association (NEMA) has brought together transformer manufacturers to develop joint industry recommendations for how to reduce the time it takes to replace compromised transformers, including submitting recommendations for the Quadrennial Energy Review, participating in industry information-sharing forums, and developing standards to make these critical transformers more resilient to physical attack, natural disasters, and geomagnetically induced currents.

To respond to the request for input on the Quadrennial Energy Review, NEMA convened a working group of transformer manufacturers to develop recommendations for how to best respond in the wake of a transformer failure. NEMA suggested studying the need for a regional reserve program for critical grid equipment, including LPTs. This recommendation was included in the QER as well as in proposed legislation being considered by this Committee.

In March, the U.S. Department of Energy and Natural Resources Canada convened a full-day discussion about the impacts of geomagnetically induced currents on large power transformers. Many NEMA members participated and spoke at length about the efforts they are taking to harden their equipment so that they can withstand these low-probability, high-impact events should they occur.

NEMA members are also actively involved in industry efforts to develop standards and best practices for hardening transformers, including an effort at the Institute of Electrical and Electronics Engineers (IEEE) to study the impacts of geomagnetically induced currents that, if large enough, could lead to voltage instability and potentially even blackouts.

Manufacturers are producing hardened LPTs and critical components such as dry bushings as well as fully enclosed substations. Anti-ballistic protection is also an option.

On the resiliency side, smart grid technologies can mitigate the impact of a disabled LPT on its surrounding grid. It is important to note that there has been a significant investment in large power transformer production capacity in the U.S. in recent years to help satisfy domestic demand.

The Edison Electric Institute (EEI) runs the Spare Transformer Equipment Program (STEP), a voluntary program whereby participating utilities are bound by contract to share their spare transformers with any other participating utility that suffers a "Triggering Event." A Triggering Event is defined as an act of terrorism that destroys or disables one or more substations and results in the declared state of emergency by the President of the United States.

Due to the diversity of voltages and impedances on the U.S. electric grid, the program’s usefulness relies on the match between the spares available and the system that experiences a failure.

The North American Electric Reliability Corporation’s (NERC) Spare Equipment Database is a voluntary and confidential information sharing resource to connect those with an immediate technology need (due to a high-impact, low-frequency event) with potential suppliers of spare equipment.

We support and applaud both programs as important additions to grid resilience.

In November 2014, Federal Energy Regulatory Commission (FERC) through Order 802 approved a physical security reliability standard (CIP-014-1) for critical transmission assets which requires owners and operators to identify their critical assets, evaluate physical security threats to and vulnerabilities of these assets, and develop and implement security plans. In June 2014, FERC through Order 797 approved a reliability standard (EOP-010-1) governing how owners and operators respond to geomagnetic disturbances. Both orders further add to grid security.

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate has also added its resources to improving grid security. Working with the Department of Energy, DHS supported the development of a prototype recovery transformer which is lighter, smaller, easier to transport, quicker to install, and compatible with a greater variety of electric systems than a conventional LPT. I will address this in greater detail later in my testimony.

The steps that have been taken by these many stakeholders are valuable, but without a comprehensive strategy, we are concerned that gaps remain. That concern is reflected in recent US Department of Energy (DOE) research and reports including the April 2014 update to its Large Power Transformers and the U.S. Electric Grid report. Further, the recently released Quadrennial Energy Review recommends the creation of a large power transformer reserve program.

LPT Technology and Service Advancements

At ABB we are addressing our utility customers' concerns about the vulnerability of LPT. ABB is in the final stages of developing solutions for our customers to significantly increase transformer resilience and enhance the reliability of the electric power supply. These solutions consider both existing transformers and the design and supply of new transformers.

ABB's approach to increased transformer reliability is five-fold:

- Vulnerability assessment
- Design modifications to "harden" the transformer
- Remote monitoring and communication
- Ability to deploy rapid damage assessment and repair teams
- Design and supply of replacement transformers that can be rapidly deployed

ABB's approach is to provide a menu of products and services that contribute to enhance transformer reliability.

Vulnerability assessment

With the world's largest installed base, ABB has a comprehensive experience and technical understanding of transformer design. This includes understanding the vulnerability of transformers to various threats, both manmade and natural. We offer assessments of transformer health and vulnerabilities to enable remediation before disaster strikes.

Design modifications to "harden" the transformer

Traditional transformers are designed to optimize power flow on the grid while maintaining optimal reliability. ABB has developed and continues to develop unique design and manufacturing techniques that make the transformer less susceptible to physical damage.

Remote monitoring and communication

Advances made in both sensing diagnostics and communication provide a new automated system that trends normal operating parameters, detects sudden changes, and communicates automatically to remote devices. The use of intelligent devices to monitor and report anomalies on transformer critical characteristics through secure networks has the promise of identifying problems and minimizing transformer damage, significantly speeding up the recovery process.

Ability to deploy rapid repair teams

ABB in North America offers rapid transformer repair. With years of experience supporting customers through natural disasters such as hurricanes, tornadoes, floods and earthquakes, we maintain regional offices with teams who work closely with our customers to develop in advance individualized response and implementation (contingency) plans. A recent notable example in this regard was the support of utilities during Hurricane Sandy. In the case of terrorist activities, ABB would work with the local authorities and would be interested in training our personnel to be certified as first responders to reduce the delay in the assessment and repair effort.

Design and supply of replacement transformers that can rapidly be deployed

The key to quickly restoring service is efficient logistics to deploy and energize a replacement transformer. Unless a damaged LPT is reparable or a matching unit is available on or near-site, the replacement transformer must be small enough to be quickly transported by truck on typical

Interstate highways instead of rail, and must be universal enough to provide near plug-and-play interoperability.

The Rapid Recovery transformer we designed and built in partnership with the U.S. Department of Homeland Security, the Electric Power Research Institite and CenterPoint is a case in point. Our modular single phase transformer has engineered designs and materials to improve interoperability with the majority of LPTs on the North American grid, and a reduced size and weight that permit rapid deployment and energization.

As part of the DHS rapid recovery transformers demonstration program, three single-phase transformers and the modular components to support them were shipped from our St. Louis factory to Houston, TX and installed and energized in just over 5 days. Because key transformer interfaces were engineered to maximize interoperability, the recovery transformer can provide temporary replacement for many traditional, custom-designed transformers, allowing restoration of power much more quickly.

Note that because the recovery transformer's plug and play design supports interoperability over the custom design needed to optimize transformer efficiency, these units are generally considered interim power solutions pending the availability of a permanent, customized replacement unit.

We believe the rapid recovery design concept is an important advance in our ability to restore power to the grid. These replacement transformers can also be designed with the hardening technology which is currently under development.

Strategic Transformer Reserve

H.R. 2244, authored by Congresswoman Renee Ellmers (R-NC) and Congressman Jerry McNerney (D-CA), as well as the Energy and Commerce Committee's discussion draft addressing reliability and security, direct the Department of Energy to produce a plan to create a Strategic Transformer Reserve.

ABB and NEMA support this legislation as we believe the creation of a Strategic Transformer Reserve would fill a gap in our nation's capability to respond to the catastrophic loss of several LPTs.

It is important to recognize that even the new generally interoperable and rapidly deployable transformer only reduces the time it takes to transport and energize an LPT. The manufacture of those units still takes months. Should an event occur that requires a replacement transformer, if a replacement unit is not already built, utilities would still face a long delay.

Having appropriate reserves of LPTs, located at strategic points around the country, would fill this challenging gap and complement existing industry programs.

Given the complexities of the electric system--its sheer size, the large number of owners and operators, uneven technical specifications, varying business models, a multitude of regulatory bodies--precisely how such a strategic transformer reserve should be designed and operated is a topic that warrants detailed analysis and close consideration. H.R. 2244 and the committee draft direct DOE to undertake the needed review. They offer an appropriate and measured response to the greatest vulnerability to our nation's electric grid and we urge their adoption.

Conclusion

ABB and NEMA would like to once again thank the Committee for inviting us to testify on this important topic. Improving the security and resiliency of our energy infrastructure requires ongoing cooperation between government and industry. The LPT issue is one further example of the need to continue our work together. ABB and NEMA are committed to fully engaging in that process and look forward to helping this committee, government regulators, and our utility meet the challenges ahead.

I look forward to answering your questions.