



Preventing Long-Term Outages Due to Loss of Key Transformers

— Technical Presentation —
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1. Abstract

The loss of a key transmission or step-up transformer, whether due to a natural or man-made event, can cause a loss of significant power to the grid. Depending on the circumstances, this loss of power could cause other cascading effects resulting in long-term outages. Several programs have been put into place to mitigate this risk. In this tutorial, we will present two of these programs:

- 1) In 2006, federal energy regulators approved the Spare Transformer Equipment Program (STEP), an electric industry program that strengthens the sector's ability to restore the nation's transmission system more quickly in the event of a terrorist attack. STEP represents a coordinated approach toward increasing the electric power industry's inventory of spare transformers and streamlining the process of transferring those transformers to affected utilities in the event of a transmission outage caused by a terrorist attack.

Under the program, each participating electric utility is required to maintain and, if necessary, acquire a specific number of transformers. STEP requires each participating utility to sell its spare transformers to any other participating utility that suffers a "triggering event," defined as an act of terrorism that destroys or disables one or more substations and results in a declared state of emergency by the President of the United States.

Any investor-owned, government-owned, or rural electric cooperative utility in the United States or Canada may participate in the program. Currently 56 utilities are members.

- 2) Extra high voltage (EHV) transformers are critical components of our nation's backbone transmission grid. Approximately 90% of consumed power flows through the transmission grid and through such a transformer. These EHV transformers are typically very large, challenging to transport, and often have lengthy procurement times of one year or greater. The transformers are also subject to a number of vulnerabilities, such as natural disasters or human-initiated physical attacks.

To address this risk to the grid, EPRI's Infrastructure Security Initiative project looked to determine the feasibility of rapid deployment of large power transformers that would be needed to replace transformers that are severely damaged. Once the concept was determined to be feasible, the Department of Homeland Security's S&T Resilient Systems Division led an effort to develop, design, build and deploy a prototype Recovery Transformer (RecX), a spare transformer designed to be rapidly deployed in the event of a transformer failure. The RecX was successfully demonstrated in 2012 with a pilot deployment that transported, installed and energized the prototype transformers in less than six days, as compared to two months or more using conventional methods of disassembly, movement and reassembly and testing a typical large power transformer.

2. Learning Objectives

This presentation plans to:

- Explain how the grid is susceptible to prolonged outages by the loss of key transformers.
- Describe how the STEP program established a pool of transformers, maintained by participants in the program, which can be made available for purchase should a transformer suffer a “triggering event”. Further the definition of “triggering event” and the rules for participation will be described.
- Describe what a Recovery Transformer is as defined by the Department of Homeland Security. To further explain how this transformer was designed and deployed as demonstrated by the pilot demonstration.

3. Learning Outcomes

As a result of attending this session, participants will gain an understanding of the following:

- Susceptibility of the US grid to prolonged outages due to the loss of key transmission transformers.
- How transformers can be specified to accommodate a multitude of system specific criteria to establish a national spare transformer pool.
- How weight and transportation restrictions can be overcome to rapidly deploy a Recovery Transformer.

4. Presenters' Biographies

Kenneth Hall is Program Manager for the Spare Transformer Equipment Program (STEP), where he is responsible for managing all aspects of STEP. Prior to working for STEP, he was employed at the Edison Electric Institute (EEI), where he was the Director, Security and T&D Operations. Prior to EEI, he worked for Carolina Power and Light Company. He received a Bachelor of Science Degree in Electrical Engineering from North Carolina State University.

Craig L. Stiegemeier is Senior Director of Technology for ABB Inc.'s transformer service (TRES – Transformer Remanufacturing and Engineering Services) North American group. He is responsible for developing effective processes supporting condition evaluation and assessment tools, life extension solutions and training programs for utility and industrial users of power transformers. He has worked with EPRI, DHS and other agencies and customers on the development of recovery transformers to support grid reliability. Craig's areas of expertise include transformer design, application, engineering, production and maintenance; components design and application; computer analysis and network systems; dielectric insulation system performance; fleet assessment and condition evaluation of power transformers, including transformer diagnostics. He has been a member of the Power & Energy Society of the IEEE since 1977 and is actively involved in the work of the IEEE/PES Transformers Committee. He received his BS & MS degrees in Electrical Engineering with a focus on utility power systems and high-voltage insulation performance from the University of Illinois (Urbana/Champaign) in 1979 and 1981 and did graduate work in the MBA programs at Ball State University and the University of Pittsburgh.