Electric Distribution System Resilience

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Presented at the 2nd National Symposium on Resilient Critical Infrastructure
Philadelphia, PA
August 18-20, 2015

A strong case can be made for enhancing resilience at various levels — asset, community, regional, national — in terms of the social benefits that would accrue from such actions. However, enhancing resilience can be costly in terms of both time and resources. At the community and regional levels, government budgets are severely strained in the current economic environment. Thus, local and regional governments must understand the benefits of investing in assessing and enhancing the regional resilience of their critical infrastructure.

Recognizing that more than 85 percent of critical infrastructure is privately owned and operated, it is important to be able to convince owners and operators that investing in both the assessment of and, where necessary, the enhancement of critical infrastructure resilience is in their best interest. There is growing awareness in the business community that enhanced resilience is part of a well-designed strategy to improve a business's ability to withstand various impacts (i.e., natural and man-made disasters, supplier outages, industrial accidents, or economic) and thus increase a business's competitive position.
For example, resilience of the electric grid has gained an increasing amount of attention over the past 7 years since the Energy Independence and Security Act of 2007. The Obama administration expanded these efforts through the American Recovery and Reinvestment Act (ARRA) of 2009. The ARRA allocated $4.5 billion to the U.S. Department of Energy (DOE) to be used for investment in electric delivery and energy reliability in support of grid modernization. In June 2011, the Office of the President, National Science and Technology Council, released a policy framework focused on cost-effective investments, encouraging innovation, and educating and enabling consumers to make smart decisions to the secure the grid from attacks. The recent *Quadrennial Energy Review*, published in April 2015, reinforces the need to increase the resilience, reliability, safety, and security of energy infrastructures. The second chapter of this report specifically highlights the need to improve assessment tools and frameworks for measuring the effects of best practices for response and recovery.

To assess system resilience, it is necessary to identify each of the components within the system to provide a holistic picture; such identification allows for a more comprehensive understanding of how the components are interconnected to achieve successful delivery of the product to the end user (e.g., electric power to the customer). Defining the characteristics of the system allows analysts to capture and analyze system-specific information. For example, the quantification of resilience in electric power distribution systems includes many physical factors that characterize overall distribution system reliability. Among the commonly considered factors are system voltage, feeder length, exposure to natural elements (i.e., overhead or underground conductor routing), sectionalizing capability, redundancy, conductor type/age and number of customers on each feeder.

Traditionally, there have been standard, accepted metrics for electric reliability (i.e., System Average Interruption Frequency Index, Customer Average Interruption Duration Index, and System Average Interruption Duration Index). However, many factors in addition to reliability must be considered to indicate the resilience of the electric grid. Additional resilience data that should be captured include planning, training, and exercising of plans focused on responding to disruptions to normal operations; relationships with local emergency responders; and the ability of the facilities that depend on the electricity distribution system to perform their core mission. Further, the information that allows characterization of electric distribution system resilience may vary depending of the types of hazard or threat considered. In particular, the assessment must consider that electric distribution systems extend over large geographic areas with variable characteristics. The challenge, therefore, is to capture enough information to identify the common resilience characteristics of these systems and take into account their specificities to allow comparison among systems that operate in similar environments.

Assessing the resilience of electric distribution system operations is complex and requires analysts to consider the specificities of the distribution system and its operational environment. Principles of Value-Focused Thinking and decision analysis can be used to define the elements contributing to the resilience of the electric grid and how they can be aggregated for calculating a system resilience performance indicator. High quality data are required to calculate an index that captures the performance of a system in terms of resilience. It is important to define a process to ensure the consistency of the data collected. With the appropriate training, private-entity owners and operators can populate a questionnaire. An interactive display can provide owners and operators with relevant information about their infrastructure-specific resilience. To ensure the uniformity and reproducibility of the data collected, the survey tool must be combined with specific explanation for each question and a quality assurance process.

This presentation will describe an approach being developed for DOE to measure electric distribution system resilience to extreme weather events to improve owners' and operators' understanding of where their systems are in terms of resilient infrastructure and where improvements should be considered.

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The work presented in this article was partially supported by Argonne National Laboratory under U.S. Department of Energy contract number DE-AC02-06CH11357. The submitted manuscript has been created by UChicago Argonne, LLC, Operator of Argonne. Argonne, a U.S. Department of Energy Office of Science laboratory, is operated under Contract No. DE-AC02-06CH11357. The U.S. Government retains for itself, and others acting on its behalf, a paid-up nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the government.