Energy & Homeland Security
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GRID MODERNIZATION RESEARCH AT SANDIA: GRID ANALYTICS AND RESILIENCE

Sandia's advanced hardware and analytical solutions address emerging issues in our transmission and distribution systems to minimize the consequences one or more threats can have on the grid.

SANDIA'S GRID MODERNIZATION PROGRAM VISION

The U.S. electricity grid is central to the nation's infrastructure, security, and economy. Modernizing this complex system of interconnected networks and enhancing its resiliency ensures seamless, efficient availability of low-cost, reliable, and secure electricity. Sandia National Laboratories furthers this effort as a national research leader in cross-disciplinary fields including grid integration, cybersecurity, power electronics, microgrids, microsystems, materials science, energy storage, and transportation.

Sandia and our partners develop hardware and analytical solutions that address emerging issues in our evolving transmission and distribution systems. Tools such as advanced optimization, wide-area controls, and dynamic systems modeling are developed and coupled with commercial modeling packages to address reliability, grid services, and stability problems. Sandia also employs a suite of complex systems analytical toolsets to conduct cross-infrastructure analyses, including high performance computing.

THE RESILIENCE CHALLENGE

Because the complex network of electrical infrastructure that stretches across the United States is critical to our economic well-being and quality of life, grid owners and operators work hard to ensure the system is reliable and able to withstand the effects of common threats. However, strengthening grid resilience, or its ability to minimize the consequences of extreme weather or malicious physical or cyber-attacks, requires understanding the consequences of specific threats to the systems. For example, a grid operator wanting to increase system resilience may not have the tools needed to quantitatively assess the system baseline, nor to optimally select infrastructure improvements to maximize resilience given a budget.

SANDIA'S SOLUTION TO IMPROVING RESILIENCE

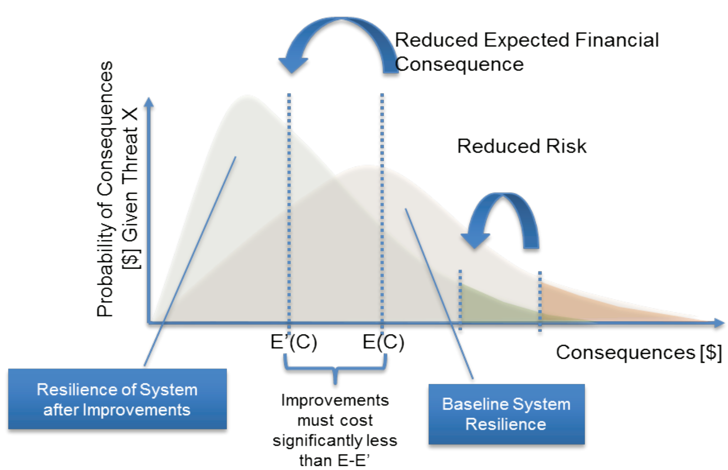
To help grid operators make effective, defensible decisions about protecting local and regional communities from catastrophes related to grid damage, Sandia has developed the Resilience Analysis Process (RAP), a comprehensive methodology for quantifying resilience and evaluating competing alternatives to improve resilience.

This multi-step method, which is based on Sandia's extensive experience with critical energy infrastructure security, calls for working closely with stakeholders to identify the most crucial potential threats and high-level consequences in their region. Sandia analysts then create a detailed system model and evaluate the model against the specified threats to determine system response and consequences. Finally, the analysts apply stochastic optimization algorithms to identify improvements to the system that minimize consequences and achieve the greatest system resiliency.

RESEARCH AREAS

Wide Area Damping Control

Sandia has developed a grid damping control strategy that employs real power injections at strategically located points in the grid based upon feedback from real-time Phasor Measurement Units (PMU). The primary objective of this work is to design and demonstrate a prototype control system for damping inter-area oscillations in large-scale interconnected power systems. A key element of the control strategy is a high-level supervisory controller that monitors the behavior of the power system, the PMU network, and the real-time control loop to ensure safe, secure, and reliable damping performance.



Geomagnetic Disturbances

Sandia has invested substantially in the development of analytic methods that can quantify resilience using risk based, probabilistic methods as it relates to geomagnetic disturbances (GMD). In the case of this work, the high consequence events take the form of voltage stability margin or specific critical load lost. The threat or threat vector would be one or more specific GMD scenarios. This framework, using an extended version of an AC optimal power flow, enables decision makers to optimally invest in resilience improvements, preventing voltage collapse and widespread blackout.

Solar and Wind Integration

PRESCIENT, a stochastic production cost modeling tool, automatically produces probabilistic forecasts from deterministic historical forecasts for load, solar, and/ or wind power production and their respective time-correlated actuals. Optimization problems for the grid are exceptionally difficult to solve stochastically, but PRESCIENT's solution method can take hundreds of scenarios and solve the system's commitment and dispatch problems in tens of minutes, showing the real value of variable generation. This tool uses commercially available solvers such as CPLEX and GUROBI or freely available ones such as GLPK and CBC.

PARTNERSHIPS

Sandia's grid modernization research relies on partnerships with a range of stakeholders, including other national laboratories, electric utilities, industry, federal and state agencies, universities, and international advanced grid consortia. These partnerships help the lab apply jointly developed tools and solutions, broaden technical capabilities, and gain insight into policy and regulatory issues.

IMPACT

By expanding our capabilities in grid resilience analytics and technologies, we are able to minimize the probability of major grid disruptions at the transmission and distribution levels. Benefits include improved system reliability, additional contingency in a stressed system condition, and economic benefits that include avoidance of costs from an oscillation-induced system breakup and reduced need for new transmission capacity. In addition, we are able to avoid outages from many other critical threats to the grid.

Phasor Measurement Units are used in Sandia's Control & Optimization of Networked Energy Technologies Lab to advance the grid's resiliency and reliability.

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