Electric Power Network Surety

Critical Infrastructure Surety

Fact Sheet

Sandia is addressing many of the issues required to protect the surety—safety, security, and reliability—of the national electric power network. The specialized capabilities we bring to this national concern include the ability to create complex models and simulations of the grid, experience in using agent-based microsimulations and engineered collectives, and expertise in information surety.

Electric power in a changing environment

The electric power industry is restructuring, leading to competition in a formerly restricted and regulated environment. Benefits expected are lower electric rates and reduced cost to consumers. Restructuring will also allow new players and new technologies to enter the power generation arena, but some will have little experience in the field of bulk power. Existing utilities are feeling increased pressure to lower operating costs to maintain economic competitiveness.

In assessing the importance of the U.S. electric power grid to the national infrastructure, the President's Commission on Critical Infrastructure Protection found that it is key to the economy and security of the nation. At a recent workshop on the North American Power Grid, Sandia and 30 members of the power industry identified the following items as posing risks to the grid: the impact of restructuring and lack of sole responsibility for grid reliability; tendency for owners and operators to focus on a short-term, least-expensive approach to operations; cyber threats; use of new technologies; physical threats; and natural disasters. In turn, the national infrastructure as a whole is becoming increasingly complex and interconnected, making it and all its parts—including the grid—vulnerable in case of failure and/or sabotage.

Taken together, these factors raise questions about how reliable the grid of the future will be in the United States. Lacking are

- methods to evaluate probabilistically how the grid responds to perturbations
- methods to optimize grid designs and configurations to account for component reliability, parameter uncertainties, and cost/benefit trade-offs

Sandia is addressing many issues required to protect the surety of the national electric power network.

- models that easily handle dynamic system interactions likely to result from the integration of advanced switching technologies, distributed generation and storage technologies, and adaptive control concepts
- analytical tools, hardware, and secure control software for a decentralized grid
- models to treat possible changes in the frequency and duration of disruption of generation or transmission
- identification of critical nodes and consequences and their interdependencies.

Technical challenges for the new electric environment

Technology Roadmaps* have been developed for six U.S. infrastructures. For the electric power infrastructure, recommendations include devising accurate models and tools for the national grid; developing "intelligent telemetry" concepts, architecture, and behavior models; conducting research and development on robust, secure applications for electric power operations (including supervisory control and data acquisition systems and tools to detect and protect against malicious interference and disruptions); and developing a system to exchange important incident warnings. It is

* U.S. Infrastructure Assurance Strategic Roadmaps, August 1998, sponsored by the Department of Energy, the President's Commission on Infrastructure Protection, Sandia National Laboratories, and the U.S. Army Medical Research and Material Command.

clear that specific technical issues related to the surety of the electric power network require development of new tools and technologies. Challenges include

- assuring service to critical facilities, such as nuclear power plants, medical facilities, and communication centers, while restructuring occurs
- developing secure real-time control technologies to ensure information is accurate and used appropriately in this more dispersed, more complex electric network
- understanding accurately and fully the physical limitations and uncertainties of this multi-faceted and changing network
- understanding the impact of distributed generation and storage and interconnection issues associated with them.

Existing grid-modeling techniques relate to assessment of whether the grid is adequate to satisfy demand; however, tools for assessing its reliability are lacking. Moreover, advanced algorithms and computational capabilities are required when the issue of stability of the grid is coupled with adequacy and with the impact of dispersed power generation and storage.

Devising accurate models and other computer-based tools is essential to operational surety.

In addition to surety issues, the models of the emerging electric grid must take into account the complexity of the national infrastructure as well as provide insight into how restructuring should be implemented to assure continuous, uninterrupted service. Specifically, these computer models must include

- adequacy models for sequential and nonsequential reliability assessments and simulations to maintain continuous (and adequate) flow of electricity from generation to distribution
- security models for probabilistic security assessments to maintain the stability of the system following disturbances, such as multiple, simultaneous faults
- models to take into account complex issues involving interactions between the electric grid and other infrastructures, such as banking, oil and gas, and telecommunications
- cost/benefit analyses of protection options.

Coupled with advanced computing, the models can also guide decisions about policy and technology. In addition, they would ensure that policies can be formulated that help independent power producers or other parties succeed in this restructured environment.

Sandia's approach to the surety of the electric power network

Sandia has been working in partnership with the private sector to study and understand and then to provide information about the surety of the nation's electric power system. The following brief examples illustrate some of this work.

Sandia is currently using advanced modeling techniques to perform probabilistic characterization of voltage stability and probabilistic assessments of the impact of distributed power technologies. The results will answer questions related to the loss of offsite power at nuclear power plants and to the vulnerabilities of power systems.

To examine the interdependencies between the electric power grid and other infrastructures, Sandia is developing a national model of infrastructure systems by merging three powerful tools: the energy model ENERGY 2020, a commercial macroeconomic model by Regional Economic Models, Inc., and Sandia's own approach to understanding the behavior of complex systems using a Teraflop-scale supercomputer. The project will produce a tool that will allow government and industry to assess the impact of energy policy decisions on the nation's economy as well as on the safety, security, and reliability of the national infrastructure.

Sandia is focusing its current energy system supervisory control and data acquisition systems (SCADAs) research on techniques and hardware that allow generation and transmission operators and planners to operate the network closer to its maximum capacity while protecting against potential cyber threats. In addition, Sandia is researching control techniques for distributed systems, which allow for energy production or storage closer to the point of use and may improve the reliability of the grid. These distributed technologies include renewables (photovoltaics, concentrating solar power, wind, and geothermal), storage (batteries, flywheels, and superconducting magnetic energy storage), microturbines, and fuel cells.

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