

Grid Reliability Management Tools

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INTRODUCTION

The U.S. electric power system is in the midst of a fundamental transition from being centrally planned and controlled to being dependent on competitive market forces for its expansion and operation. Unique features of electric power, including the need to match supply and demand in real time, the interconnectedness of the networks over which power flows, and the immediate propagation of disturbances throughout the system have always posed unique challenges for reliability. Today, these challenges are even greater and there is no prior experience to draw upon for guidance in relying on markets to manage the complexities of the electric power system. At the same time, the Nation's demands for electricity and reliable electric service are increasing. As the events of recent years demonstrate, the reliability of the grid and the integrity of the markets it supports are integral to the Nation's well-being.

Rapid restructuring is raising concerns over the reliability of the Nation's electricity grid. The transition of the electric power industry to a competitive market structure has created substantial new operating and planning challenges for reliability. Today, operators are faced with:

- Large volumes of transactions
- Larger areas to control
- New players
- Changing operational responsibilities
- Movement of power over long distances in response to market signals
- Reliance on markets to match customer's loads and manage reliability as opposed to direct control over generation and load
- Evolving operational rules and market structures
- Shrinking and changing definitions for reserve margins
- Unpredictable system behavior
- Managing systems with operational tools that were designed for a centrally planned and controlled electric grid.

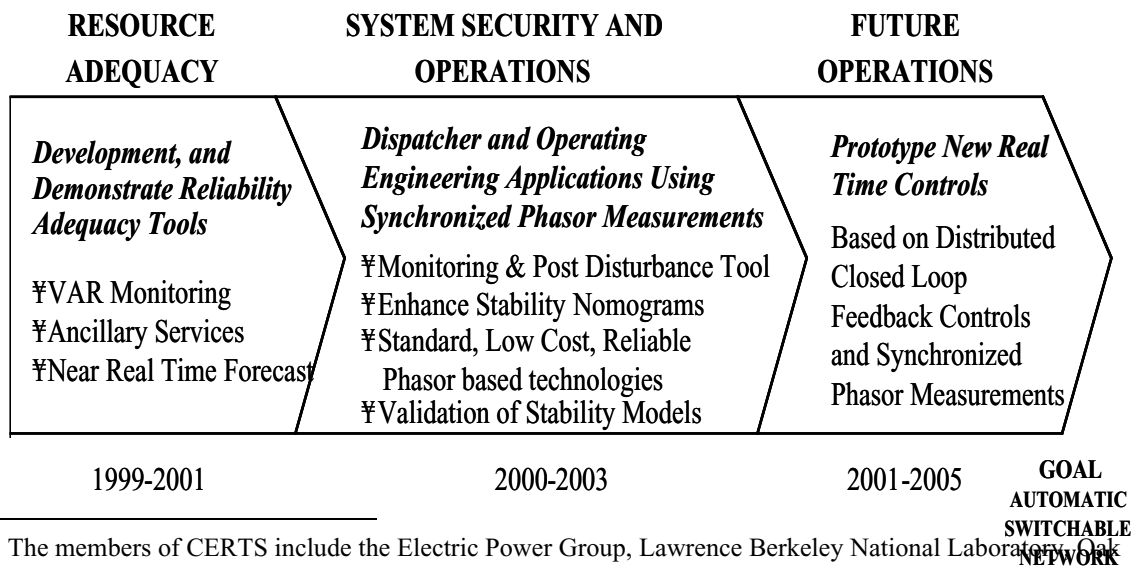
Evidence of reliability challenges comes from increasing incidence of transmission congestion, price spikes, voltage degradation, and managed and unmanaged outages are all indicators of stress on the system. Traditional grid operations and reliability management strategies and tools did not envision today's high-pressure environment in which there are increased demands on existing corridors to support greater trade. In particular they did not envision reliance on a competitive market for the buying and selling of electricity and reliability-related (or ancillary) services. Operators are being

constantly challenged to manage these increasingly unpredictable power flows with an aging and increasingly inflexible transmission infrastructure. The tools and technologies available for this task - developed originally to support centrally-planned, vertically-integrated operations — are currently inadequate for managing reliability in competitive, region-wide electricity markets.

As the transition moves forward (and at times backward), there is a widening gap between the industry's need for new tools, technologies, and systems to manage reliability in a competitive electricity market and the industry's ability to identify, develop, and implement them in a timely manner. This presentation describes selected recent efforts and current plans by the Consortium for Electric Reliability Technology Solutions (CERTS) to address these needs.¹ The CERTS program is conducting a multi-year program of research in 4 areas: Grid of the Future, Real-Time Grid Reliability Management, Reliability and Markets, and Reliability-Enhancing Distributed Energy Resource Integration.

In 1999, for the first phase of its work in the area of Real-Time Grid Reliability Management, CERTS created prototypes for operational software tools to help dispatchers maintain and enhance electric system reliability (see Figure 1). The Department of Energy's Transmission Reliability program funded the initial development of the prototypes. The California Energy Commission's Public-Interest Energy Research Program is currently funding demonstrations of the prototypes at the California Independent System Operator (ISO). CERTS is also in discussions with utilities and ISO's in other regions of the country, as well as the North American Electric Reliability Council for additional demonstrations and extensions of these prototypes.

Figure 1. CERTS Real-Time Grid Reliability Management Research Roadmap



¹ The members of CERTS include the Electric Power Group, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Power Systems Engineering Research Center (PSERC), and Sandia National Laboratories. PSERC is a National Science Foundation Industry/University Cooperative Research Center. Southern California Edison is a research provider to CERTS.

RELIABILITY ADEQUACY TOOLS

The CERTS program on reliability adequacy is designed to assist system operators with real-time grid reliability management. The old engineering based modeling and analysis of system performance is no longer adequate — markets determine system loading not engineering and least cost dispatch principles. New tools are needed to reliably and efficiently match customer demands with suppliers of different services within competitive markets in addition to identify critical resources deficiencies that could endanger system reliability. The CERTS program is identifying, prototyping, demonstrating, and disseminating software necessary to:

- Measure key system parameters
- Monitor and graphically visualize system performance - how far the system is from pre-established safety margins
- Track, identify, and archive abnormal operating patterns
- Predict, in near-real time, system response through simulations and what if analysis

Key parameters presented in this manner provide operators with a rapid and intuitive real-time assessment of the health of the system and its vulnerabilities, and facilitate appropriate corrective actions.

The first two tools are called reliability adequacy tools. In today's deregulated environment there is a special need for tools that empower operators to quickly assess the adequacy of supply and demand in a market environment, and respond to potential threats to system reliability with appropriate preventive actions. The ability to measure, track, forecast (in near-real time), and implement protocols for near real-time management of ancillary services including spinning reserves and voltage supply, and risk analysis for load and equipment performance uncertainties is critical. Tools that mine existing SCADA and synchronized phasor data, analyze it, and present it to operators both geographically and dynamically will allow them to manage operating margins more effectively and reliably within their jurisdictions.

The CERTS VAR Management adequacy tool provides security coordinators and system operators with immediate access to critical information on wide-area system voltages and, more importantly, reactive reserve margins at critical grid locations through the use of sensitivity calculations and visual geographically-oriented displays. Maintaining adequate voltages and reactive reserves, which vary according to local conditions, is essential for maintaining system reliability during and immediately after a significant disturbance on the grid. Currently, system operators receive this information in the form of tabular displays or from single line-diagrams that suppress the geographic relationship among voltage at various points within the system. Tools such as these could have been instrumental in alerting operators of dangerously low reactive reserve margins at critical stations and possibly prevented the widespread of the 1996 outages on the West Coast.

The CERTS Ancillary Services Performance and Tracking adequacy tool was developed specifically to address the needs of operators who manage ancillary service markets in a restructured electricity industry. The tool presents performance, tracking and predictive information visually on generator s provision of ancillary services and their impact on system control performance in a graphical format that allows operators to assess actual generator performance and then use this information to predict up-coming ancillary service requirements. The tool was also designed to facilitate operator s need to comply with new reliability performance requirements of the North American Electric Reliability Council.

The two reliability adequacy tools represent the first of several prototypes being developed by CERTS as part of its Real Time Grid Reliability Management research program. Starting in late 2000, CERTS has begun developing and prototyping workstations that turn synchronized phasor data collected by advanced system monitoring technologies into operational decision-making information for both dispatchers and engineering support personnel.

The workstations will incorporate currently under-utilized phasor measurement data from the DOE/EPRI/BPA/WAPA-sponsored monitoring system developed in the mid-1990s. Graphically-oriented visualization displays based on available phasor measurements will provide dispatchers with detailed information on the state of the grid that they can use to augment current knowledge of system conditions and detect the precursors to system collapse. Identifying and making information available to dispatchers on these precursors from historic events is the first step toward developing effective operational procedures that can anticipate problems and respond appropriately to future disturbances.

The intermediate objective of these new tools and visualization approaches is to use time-synchronized, precisely-measured, real-time phasor measurement and other advanced measurement technologies on the actual wide-area state of the electric system in order to update previously-established operating procedures and confirm engineering off-line studies to ensure continued grid reliability. Specifically, CERTS aims to develop prototype schemes that will complement (and ultimately replace) deterministic methods of predicting operational stability limitations, and that improve or replace current deterministic remedial action schemes. The ultimate objective of this research area is to use the experience gained and tools developed in the first two phases to develop and prototype new real-time controls conducive to the deployment of an automatic switchable network in the future.

SUMMARY

To summarize, CERTS is engaged in a multi-year program of public interest R&D to develop and prototype software tools that will enhance system reliability during the transition to competitive markets. The core philosophy embedded in the design of these tools is the recognition that in the future reliability will be provided through market operations, not the decisions of central planners. Embracing this philosophy calls for

tools that:

1. Recognize that the game has moved from modeling machine and engineering analysis to simulating markets to understand the impacts on reliability (and vice versa);
2. Provide real-time data and support information transparency toward enhancing the ability of operators and market participants to quickly grasp, analyze, and act effectively on information;
3. Allow operators, in particular, to measure, monitor, assess, and predict both system performance as well as the performance of market participants;
4. Allow rapid incorporation of the latest sensing, data communication, computing, visualization, and algorithmic techniques and technologies.

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