Workshop Report

U.S. Department of Energy Transmission Reliability Program
and the
Consortium for Electric Reliability Technology Solutions
(CERTS)

Workshop on Electric Transmission Reliability

September 17, 1999
Washington Hilton and Towers, Washington, DC

Background

The U.S. electric power system is in transition from one that has been centrally planned and controlled to one that will be increasingly dependent on competitive market forces to determine its expansion and operation. Restructuring and the transition to a competitive electric power market will be similar to recent experiences with the telecommunications and airline industries in some ways and different in other ways. On the one hand, many are hopeful that restructuring will unleash innovation and creative forces leading to lower costs and greater value for all. On the other hand, electricity is a unique commodity and reliable provision of electricity is in many ways a public good. As recent physical and market events demonstrate, reliability of the grid and integrity of the markets it supports are vital to the economic well-being of the nation. Seeking an appropriate balance between the self-interests of market participants and the national interest in an efficient and reliable power system is a fundamental challenge for restructuring of the electricity industry.

The mission of U.S. Department of Energy's Transmission Reliability Program is to develop technologies and conduct research on policy options that will maintain and improve reliability of the nation's electric power delivery system during the transition to competitive power markets. As part of this mission, the Program sponsored a Workshop on Transmission Reliability that gathered industry stakeholders and researchers to discuss federal R&D priorities necessary to ensure the reliability of the nation's electric power delivery system. Generating discussion for the Workshop was a series of six draft white papers on different aspects of reliability practices, technology, and policy.[1] The white papers were prepared for the Department of Energy by members of the Consortium for Electric Reliability Technology Solutions (CERTS).[2]

This report summarizes the presentations of the six draft white papers and the discussions that followed. The presentations were made by the lead authors for each paper and the discussions were initiated by discussants invited by DOE to comment on them. The white papers will be published separately following incorporation of comments from the electricity reliability community through forums such as this Workshop. When final, the white papers will form the basis for the development of a federal R&D roadmap for the Transmission Reliability Program. Copies of the author's presentations, written comments from lead discussants and other workshop participants, and the workshop attendee list are included in appendices to this report.

[1] The six white papers are: (1) *The Federal Role in Electric System Reliability RD&D During a Time of Industry Transition: An Application of Scenario Analysis,* (2) *Review of Recent Reliability Issues and System Events,* (3) *Review of the Structure of Bulk Power Markets,* (4) *Interconnection and Control for Reliable and Efficient Integration of Distributed Energy Resources,* (5) *Real Time Security Monitoring and Control of Power Systems,* and (6) *Accommodating Uncertainty in Planning and Operations.*

[2] The CERTS DOE research performers include: Lawrence Berkeley National Laboratory (LBNL); Edison Technology Solutions (ETS); Oak Ridge National Laboratory (ORNL); Pacific Northwest National Laboratory (PNNL); Sandia National Laboratories (SNL); and the Power Systems Engineering Research Center (PSERC), a National Science Foundation Industry/University Research Center.

Table of Contents

Introduction

The Workshop on Electric Transmission Reliability was held on Friday, September 17, 1999 at the Washington Hilton and Towers, Washington, DC. Nearly fifty attendees were present to share their views on the reliability of the nation's electricity system, and on appropriate federal research and development priorities.[3] For each of the six draft white papers, the author(s) first briefly presented the main points of their papers, which had been sent in advance to all registered participants. Discussion was then initiated by selected stakeholders who had been invited by DOE to comment on each paper. A moderated discussion session opened to the floor concluded each session.

Dan Adamson, Deputy Assistant Secretary for Power Technologies, Office of Energy Efficiency and Renewable Energy, opened the workshop by putting past reliability problems into perspective and stating the intent of the Transmission Reliability Program. "Insufficient investment in transmission, distribution, and generation is the perceived cause of energy reliability problems," Adamson said. "Power companies are postponing these necessary investments due to the uncertainty surrounding deregulation of the electric system."

The importance of power grid reliability was underscored by DOE Secretary Richardson's recent six-point national energy initiative developed in response to outages experienced during the summer of 1999. DOE plans to apply its $2.5 million budget for the Transmission Reliability Program in fiscal year 2000 with industry, to begin bridging investment gaps in reliability R&D and to help ensure the reliability of the nation's electric power system.

Following Adamson's introduction, Transmission Reliability Program Manager Phil Overholt presented the Program's mission, strategy, history, and objectives. In addition to the direct benefits of maintaining and enhancing reliability of the nation's electricity system, Overholt noted indirect benefits, including economic benefits from better functioning competitive markets, as well as environmental gains from greater operating and system utilization efficiencies and the likely integration of cleaner generating resources. . The Transmission Reliability Program role is to assist industry by developing and facilitating the introduction of new reliability-enhancing technologies and strategies.

The six white papers commissioned of CERTS by DOE and this Workshop on Transmission Reliability are important first steps for the Program in developing a comprehensive federal program on reliability R&D in support of the transition to a more competitive electricity industry.

[3] See the attached attendee list in Appendix A. Inclement weather (Hurricane Floyd) prevented many additional registered participants from attending.

AGENDA

Workshop on Electric Transmission Reliability

Sponsored by the
U.S. Department of Energy
Transmission Reliability Program and
Consortium for Electric Reliability Technology Solutions
September 17, 1999
Washington Hilton and Towers
Washington, DC

7:30am – 8:30am **Registration**

8:30am – 9:00am **Introduction by the U.S. Department of Energy**

Dan Adamson
Deputy Assistant Secretary for Power Technologies
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Phil Overholt
Program Manager
Transmission and Distribution Reliability Program
U.S. Department of Energy

9:00am – 10:00am **Presentation and Discussion:**

The Federal Role in the Electric Reliability RD&D During a Time of Industry Transition: An Application of Scenario Analysis
Joseph Eto
Lawrence Berkeley National Laboratory

Lead Discussants

Susan Clark, Commissioner
Florida Public Service Commission

Thomas Schneider
TRS Energy

10:00am – 10:15am **Break**

10:15am – 11:15am **Presentation and Discussion:**

Review of Recent Reliability Issues and System Events
John Hauer
Pacific Northwest National Laboratory

Lead Discussants

Richard Sedano, Commissioner
Vermont Public Service Commission

Richard Wakefield
Chair, IEEE-USE Energy Policy Committee

11:15am – 11:35am **Distributed Power Program Presentation**

Joseph Galdo
Program Manager
Distributed Power Program
U.S. Department of Energy

11:35am – 12:30pm **Lunch**

12:30pm – 1:30pm **Presentation and Discussion:**

Organization of Bulk Power Markets
Brendan Kirby
Oak Ridge National Laboratory

John Kueck
Oak Ridge National laboratory

Lead Discussant

Dale Landgren
Wisconsin Electric Power Company

1:30pm – 2:30pm **Presentation and Discussion:**

Interconnection and Controls for Reliable, Large Scale Integration of Distributed Energy Resources
Carlos Martinez
Edison Technology Solutions

Lead Discussant

Henry Chao
ABB Power T&D Company

2:30pm – 2:45pm **Break**

2:45pm – 3:45pm **Presentation and Discussion:**

Real-Time Security Monitoring and Control of Power Systems
George Gross
University of Illinois at Urbana/Champaign

Lead Discussant

Douglas Bauer
National Research Council

3:45pm – 4:45pm **Presentation and Discussion:**

Accommodating Uncertainty in Planning and Operations
Mark Ivey
Sandia National Laboratories

Lead Discussant
Dejan Sobajic
EPRI

4:45pm – 5:30pm **Wrap-up**

Presentation of White Paper #1

The Federal Role in Electric System Reliability RD&D During a Time of Industry Transition: An Application of Scenario Analysis; by Joseph Eto, Lawrence Berkeley National Laboratory

Presentation

Joseph Eto provided an overview of the four scenarios developed in the white paper for the electric industry over the next 3-10 years. The scenarios are:

1. Industry in Transition
2. Large, Centralized Regional Transmission Organizations
3. Maximally Decentralized Independent System Operators
4. Distributed or Dispersed Energy Resources

Emphasizing that these scenarios are not predictions, but rather possible futures of the electric industry, Eto identified RD&D needs and appropriate federal roles for RD&D investments under each scenario. In a summary of his findings, Eto suggested that the focus for federal government investment in reliability RD&D during electric industry restructuring should include longer-term, strategic research (consistent with the traditional federal RD&D role); nearer-term research to fill emerging gaps in private investment; and un-biased research to facilitate the transition to a stable future industry structure with adequate incentives for privately-funded RD&D.

Discussion

Tom Schneider of TRS Energy illustrated that plotting different levels of regulation and technology development suggested different future scenarios, some similar to the four discussed by Eto [see illustration below]. In particular, Schneider reviewed a future known as Schweppe's World,[4] in which the electricity system works together through information exchange and not regulation. Alternatively, Schneider plotted the influence of political structures and environmental attitudes to suggest that the political sphere could drive a distributed generation future.

Opening his critique to the audience, Schneider questioned whether Eto's conclusion that private transmission and distribution investment might lessen the move to the distributed generation scenario. He also suggested that there could be a movement to re-regulate the electric industry in response to fall-out from deregulating.

Susan Clark, Florida Public Service Commissioner and Chair of NARUC's Electricity Committee, submitted written comments for discussion. She suggested that the four scenarios seemed to be a continuum, moving from 1 to either 2 or 3, then onto 4. All of the scenarios would be affected by NERC, the Transmission Reliability Program, and by competition pushing grid reliability to its limits. Clark specifically questioned whether for-profit RTOs would invest sufficiently to meet R&D needs—or if RTOs were non-profit, who would undertake and fund R&D. Additionally, she commented that states should have more active roles in RTO support. Clark challenged the assumption that renewable distributed generation would increase to reduce

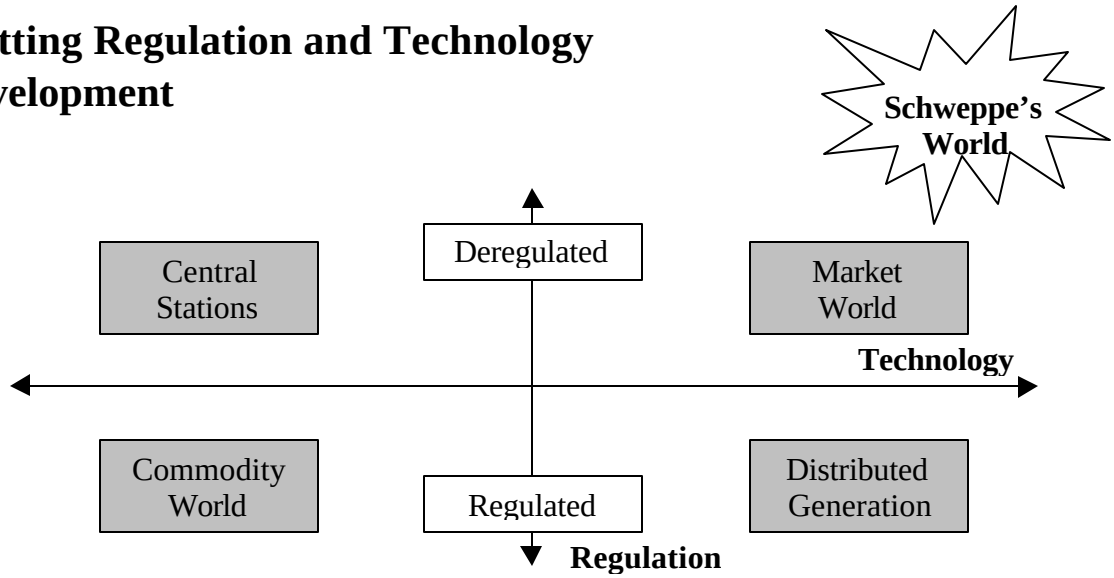
[4] Named for former MIT professor Fred Schweppe.

greenhouse gas emissions, and asked whether nuclear generation would instead be considered for this purpose (thus necessitating centralized generation). Once discussion opened to the audience, it was suggested that different areas of the country could exhibit different scenarios (e.g., decentralized generation in rural and RTOs/grid-connected power in urban areas). This would be driven by the profit motive, in the form of "economics of place."

A discussion of federal R&D reliability needs followed. There was consensus that R&D should balance distribution and transmission. Deputy Assistant Secretary Adamson emphasized that reliability in general (i.e., "Are the lights still on?") is the focus of the Transmission Reliability Program. George Gross of PSERC stressed that R&D should capture the range of futures in the scenarios. Other participants suggested research on the cascading effects of reliability issues, as well as information overload and human ability to cope with increasing data complexity. Research into power quality, and the tolerance of high-tech electronic devices to changes in power levels, was also suggested.

Participants then compared infrastructure needs of the electric system with the deregulated phone and gas industries. Was there a similar danger of the infrastructure becoming overbuilt? If infrastructure cost and set-up prevented overbuilding transmission and distribution, would this mean competition only at the wholesale level?

Plotting Regulation and Technology Development



Key Comments

- The ultimate end-state is Schweppe's World, where information exchange and not regulation drives decision making.
- The political sphere is necessary to drive a distributed generation future.

- RTOs, whether non-profit or for-profit, are unlikely to invest sufficiently to meet R&D needs.
- An increase in renewables to reduce greenhouse gas emissions may not occur as assumed—the nuclear option (based on central power stations) must also be considered.
- Regional differences in scenarios are likely to occur, driven by differing "economics of place." Deregulation removed the obligation to serve, and added the opportunity to profit.

Presentation of White Paper #2

Review of Recent Reliability Issues and System Events; by John F. Hauer, Pacific Northwest National Laboratory.

Presentation

John Hauer reviewed recent "reliability events" in the North American power system and analyzed apparent technology needs and institutional implications. To provide a reliable electric power system during the transition throughout restructuring, we not only need to overcome the factors that caused these events, but also address a potential decline in reliability related to the transition to competitive electricity. Hauer suggests several ways that the electric industry can accomplish this, through expanded public/private/university partnerships, an enhanced information network, integrated modeling and decisionmaking tools, and research into outage recovery techniques.

Past reoccurring factors in North American outages include both technology failure and human error. In addition to these impediments, the electric power system will face new reliability challenges in a competitive market. Already, the pressures of competition are weakening the Reliability Coordination Council (RCC) as utilities gradually withdraw their support. Competition may result in the marketing of control services as commodities and in legal liability issues in wide area control. Competition could also answer the question, “How much do we pay to prevent the grid from breaking down vs. paying to fix it after it does?”

Discussion

Designated discussant Richard Wakefield, IEEE-USE Energy Policy Committee Chair, commented that the recurring factors of outages suggests investigation into 1) availability of timely system information (for real-time response and post-event analysis), 2) challenges of large-scale planning (tools, who is responsible, what are the incentives), and 3) meeting future human resource needs (through regional consortia and training partnerships between utilities and universities).

A detailed discussion of modeling followed. It was agreed that modeling is currently insufficient to meet present and future needs, although there was no consensus on the cause of insufficiency. Several participants remarked that models and conceptualization needed to account for non-linear responses to deal with situations such as system collapse. Part of the reason they currently do not could be industry resistance to change and focus on short-term interests (protecting equipment) vs. long-term needs (protecting the grid and providing power). Deputy Assistant Secretary Adamson stated DOE’s commitment to modeling and asked for guidance. Participants agreed that application of the models was as important as the models themselves—better models would be of no use unless modelers understood them and could apply the findings. It was suggested that future investments balance modeling, data collection for modeling, and training for modelers; R&D funding that is leveraged internationally for additional feedback; and model validation by utilities to ensure accuracy.

Key Comments

- Identification of data requirements may help in preventing reliability excursions—we need to determine how much and what type of data to acquire.
- Improved definition of appropriate power system models, training, and model validation is also needed.
- The reoccurring factors in power outages mentioned in the paper—and the ability of improved data collection, interpretation, and application to prevent future disturbances—suggest future topics for investigation.
- Future models and simulation tools need to account for system failure and provide information on how to rebuild.

Presentation on the Distributed Power Program

By Program Manager Joseph Galdo

Presentation

Distributed Power Program Manager Joe Galdo presented an overview of this new DOE initiative, which is being closely coordinated with the Transmission Reliability effort. The mission of the Distributed Power Program is to support the use of distributed generation, energy storage, and demand-side management in the power distribution system. Key research areas include strategic research, system integration, and institutional and regulatory barriers. A December 1998 workshop generated several recommendations for the Distributed Power Program, including the creation of a uniform national standard for interconnections, outreach to state regulators, modeling of codes and ordinances, and education of zoning, codes, and ordinance officials. These recommendations will shape future research and development activities.

Discussion

Participants suggested that the Distributed Power Program investigate higher penetration of control systems, which would require more secure funding from the DOE. Other interconnection issues raised included the effects of both technical factors and business practices, and whether standards would protect utilities (equipment) or the grid (service).

Presentation of White Paper #3

Review of the Structure of Bulk Power Markets; by Brendan Kirby and John Kueck, Oak Ridge National Laboratory.

Presentation

Brendan Kirby and John Kueck together presented their analysis of several U.S. and international power markets, with a focus on energy prices, price controls, and reliability. The presentation reviewed California and the United Kingdom as examples of the two basic forms of energy markets—Power Exchange (PX) and bilateral contracts.[5] Based on these and other energy market analyses, Kirby and Kueck made several conclusions about the interactions between markets, reliability services, and reliability of the grid.

Examination of the power markets revealed an inseparable link between reliability and commerce. In addition, markets address inadequacy and insecurity (reliability) of the power system differently—adequacy can be individually contracted but security must be procured by the ISO. Although many reliability services can be provided through markets, there have been problems with competition levels, voltage control, and network stability. To address these and other early shortfalls of energy markets, Kirby and Kueck suggested additional research into the following market structure topics: standards, metrics, and ancillary service definitions; transmission enhancement market motivation; and market structure analysis and modeling.

Discussion

Lead discussant Dale Landgren, from Wisconsin Electric Power Company, noted that regional differences in energy markets exist, and that research into unique regional needs is needed. In the Midwest, for example, end-users are more concerned with reliability than price—and some areas are served by a single utility so ancillary services are not competitively available. More generally, it will be difficult for markets to justify transmission enhancements unless there are external incentives. Distributed generation may contribute to this problem, as the ISO will need to determine loads without knowledge of when customers will choose on- or off-grid power.

General discussion targeted the price of reliability in energy markets. One participant noted that Con-Ed is a utility that has implemented bilateral contracts with a set price for load interrupts. An infrastructure that can provide real-time pricing is essential to this operation. Others questioned how responsive customers would be to price fluctuations unless the changes were extremely large, and asked how responsiveness could increase. Kirby's answer was that price signals must match cost savings for the market in interruptible power to work.

Another suggestion was to build additional transmission with DC links to create smaller interconnects—which Kirby argued would alter market decisions. The danger of overcontracting and creating fictitious prices was also raised.

Kirby's observation that inadequate systems can be secure if operated well generated several opinions. Although the availability of storage and ancillary services can support system security,

[5] In a centralized market (such as the PX), a single pool operator coordinates hourly buying and selling of energy on behalf of all buyers and sellers. In a bilateral contract market, buyers and sellers make individual arrangements among themselves.

the market for these services cannot operate efficiently if the load provider is unaware that customers are buying these services. Performance of the ISO is then crucial for grid security. One participant suggested that an information infrastructure is needed to enhance capacity and respond to customers. Consequently, a for-profit TRANSCO may be more effective at ensuring grid security than a non-profit ISO. Kirby was hesitant to dismiss the role of the ISO, however, suggesting that power markets will respond to prices better with time.

Key Comments

- Significant regional differences in energy markets exist; analysis into unique regional markets is needed.
- Reliability pricing (the price that users are willing to pay for service disruptions) needs greater market study.
- A more scientific basis should be applied to the design of political structures that ensure reliability.

Presentation of White Paper #4

Interconnection and Controls for Reliable and Efficient Integration of Distributed Energy Resources (DER); by Carlos Martinez, Edison Technology Solutions.

Presentation

Carlos Martinez began his presentation by contrasting the traditional focus of research on individual DER technologies with areas identified in the white paper that require additional research in the future. In particular, integration, interconnection, control, and dispatch requirements should be emphasized instead of technology development; and national standards should be developed for DER integration. With seamless standards, based on R&D interconnection and control recommendations described in the white paper and the successful evolution toward and capture of economies of mass production, DER could penetrate the market sufficiently to provide 20 percent of the nation's electric energy needs in the next 10-20 years. As DER gains greater market penetration, it will advance from providing back-up generation to local micro-grids to fully integrated micro-grids.

For DER to become reliably integrated into the utility grid, ETS recommended that DOE fund R&D in such areas as island and integrated operation and controls, wide area real-time data communication, development of standard interconnections and protocols, and field demonstrations of technologies and procedures.

Discussion

Henry Chao, ABB Power T&D Company, was the lead discussant for this presentation. He shared his experience in the industry and noted several problems with distributed generation, namely 1) economic and technical issues, such as quantifying the benefit of distributed generation to the customer and utility; 2) coordination of the distribution network; and 3) effects of system backflows in a looped system. Chao also noted that while some interconnection standards are needed, others might infringe upon utilities' different needs.

The topic of interconnection standards generated significant discussion. One participant remarked that while distributed generation manufacturers want a single standard, utilities want case-by-case, common ground standards. How applicable standards are to the real world, especially with the emergence of new market structures, is another issue. Standards can help reduce entry barriers to the distributed generation market. Formulating standards as systems constraints instead of specifications could make them more flexible, but would also create uncertainty among customers. It was suggested that standards could increase reliability and safety, and eventually help supply the grid through net metering of distribution generation. This would likely require a distributed generation database for load control.

In addition to funding general R&D, DOE could have a role in speeding the process of developing and implementing standards by working with utilities to resolve conflicting issues.

Key Comments

- An analysis of distribution generation needs to account for benefits to both customers and the utility.
- Voluntary standards will reduce barriers to distributed energy resources in the market, but changes to standard business practices, especially current incentives to utilities to discourage DER, will be required to remove the barriers.
- Cooperation among manufacturers, utilities, researchers, and other stakeholders is a must.
- Including demand-side load as a DER is a necessity.

Presentation of White Paper #5

Real-Time Security Monitoring and Control (RTSMC) of Power Systems; by George Gross (UIUC), Power Systems Engineering Research Center (PSERC).

Presentation

George Gross presented PSERC's examination of RTSMC in the restructured power industry and recommendations of research needs and strategies. He began by relating power system security to reliability, in that a secure system continues normal operation in the face of postulated contingencies. RTSMC needs to interact with all the "layers" of the power system, which include generation and physical delivery; markets; and communication, monitoring, and control. The complexity of these interactions means that data availability and management are key to maintaining a secure system—RTSMC must thus include both technologies to gather and disperse data effectively and strategies for operators to comprehend increasing data volumes (the data overwhelm problem). Analytical and software tools that can improve RTSMC include data visualization, voltage security and available transfer capability analysis, software engineering, model development and validation, training simulators, and complex systems applications.

PSERC's overall recommendations to improve RTSMC in the newly restructured power industry are to identify critical research needs; integrate advances in technology and processes in computers, controls, communications, and power electronics; resolve data overwhelm issues; formulate new control laws; and develop new enhanced analytical tools and software.

Discussion

Professor Garng Huang of Texas A&M began discussion by challenging the notion that more data is needed. He noted that industry believes they already have too much data. Dealing with large volumes of data (which are increasing) and overcoming the data overwhelm problem could be achieved by using incentives rather than requirements to collect data and ensure system security; by reapplying data to other uses; and by aggregating it for a more comprehensive analysis. One possible way to better link data acquisition and analysis to the market would be selling system security as a commodity.

Gross responded to the idea of selling security by asking how measurement and ownership of data would be controlled. Independent grid operators (IGOs) are in place to encourage the market, not maintain reliability. Other participants argued whether reliability could be bundled or not—if the free ridership problem (i.e., the few that require system reliability pay for it, but all users end up benefiting) could be solved and reliability could be priced. If reliability could be a commodity, the possibility of unreliable power could increase distributed generation. It was argued that system security could not be "commoditized" for the same reason an army or the fire department cannot be a market commodity. Currently there is a lack of positive incentives for reliability—utilities now see only disincentives for unreliable service. As a result, reliability is maintained at any cost (in the immediate), but there is no prevention of long-term failures. In some respects, vertically bundled utilities performed this task better.

Gross's answer to whether we already have too much data was that much of this data is irrelevant to the challenges of RTSMC. For example, we do not have sufficient data on integration of distributed resources with the grid. Other participants commented that data volume

will increase with improved data collection tools, but that smaller time-scale data is still needed. Effective data management and utilization could be improved by ensuring public access and regional data movement. Another observation was that current controls are only applicable to a steady-state system and do not function in crises. Improved information access, in the form of data visualization and greater availability, could be a possible solution. Incentives, either as rewards or liability, could also encourage the right amount of security.

Key Comments

- Overcoming the data overwhelm problem is key—this will enable a link from data acquisition and analysis to system security.
- System security could be commoditized—would this be desirable?
- Currently there is a lack of positive incentives for reliability—only disincentives for unreliable service exist. There needs to be an analysis of what positive incentives would be most successful in achieving the right amount of security at reasonable cost.

Presentation of White Paper #6

Accommodating Uncertainty in Planning and Operations; by Mark Ivey, Sandia National Laboratories.

Presentation

Mark Ivey's presentation reviewed uncertainties currently not captured by regulated utilities' planning processes, and outlined uncertainties likely to emerge in restructuring. He then identified technologies and strategies to accommodate and manage uncertainty. As the industry undergoes deregulation towards a competitive market, there will be new entrants in energy production and trade, increases in regional and intra-regional power transactions, increasingly sensitive customer loads, and many new types and numbers of generation sources. These changes in the industry will likely exacerbate existing sources of uncertainty in generation availability, transmission capacity, load, and distribution.

According to Ivey, existing deterministic methods and tools are not adequate to accommodate these higher levels of uncertainty tantamount with emerging competitive markets. Probabilistic methods and tools are needed to cope with the increasing complexity and higher volume of information flow. In addition to making use of probabilistic tools, Ivey advocates the recommendations made by the Secretary of Energy's Advisory Board (SEAB), as well as expanding measurement and evaluation of system and component health and performance to identify and address causes of system reliability events.

Discussion

Dejan Sobajic of the Electric Power Research Institute (EPRI) was the lead discussant for this topic. Sobajic, speaking of behalf of EPRI members, remarked that accommodating uncertainty is on both the short and long-term agenda. EPRI members recognize that both engineering and new research will be needed to deal with higher levels of uncertainty, and that data visualization will also be important. Sobajic cautioned, however, that maintenance models can be either reliability-centered or profit-centered; it is important to understand the underlying assumptions before applying model predictions to planning and operations.

General discussion focused on developing planning tools and implementing planning decisions. The usefulness of planning tools—who would use them—was questioned. It was asked whether the need for uncertainty planning was real, since market forces will replace the planning functions that are a hold-over from a command-and-control, regulated industry. Many utilities have eliminated planning departments to cut costs since the "obligation to serve" under regulation is now gone. However, the industry is still constrained by political pressures—the penalty for not serving is high. Will planning tools be able to integrate such policy and subjective constraints? If not, their relevance is in question. Similarly, realistic models and scenarios will need to be created that represent distributed generation and other situations—can probability realistically account for all the possibilities and define a secure system? One concern was whether there would be sufficient data on the system's health condition to forecast the probability of failure. In response, Ivey referred to the petroleum industry's ability to resolve system health through competition by encouraging preventative maintenance over repair after failure.

Participants agreed with Ivey's assessment that competitive markets are producing new sources of uncertainty. For example, the linkage between transmission capability and new generation is now uncertain—how will the system accommodate it? While market decisions will likely resolve this issue for new entrants in generation, the decommissioning of nuclear plants (and other as yet unidentified factors) could affect capacity as well. One participant criticized the white paper for missing a discussion of markets, which will be necessary to analyze data for generation planning and other decisions. Several others reinforced the idea that planning would be provided by the market.

Key Comments

- Maintenance models can be reliability-centered or profit-centered. The underlying assumptions for each are key for planning and operations.
- Industry is replacing planning tools and models with reactions to market forces. Study of the operation of markets with data for generation planning, etc. is a necessary element in planning and operations analysis.
- Competitive markets *are* introducing new uncertainties, such as the linkage between transmission capability and new generation.

Appendix A: Presentations of the Six White Papers

Presentation on White Paper #1
The Federal Role in Electric System Reliability RD&D During a Time of Industry Transition: An Application of Scenario Analysis (Joseph Eto, LBNL)

Presentation on White Paper #2
Review of Recent Reliability Issues and System Events (John Hauer, PNNL)

Presentation on White Paper #3
Review of the Structure of Bulk Power Markets (Brendan Kirby, John Kueck; ORNL)

Presentation on White Paper #4
Interconnection and Controls for Reliable and Efficient Integration of Distributed Energy Resources (DER) (Carlos Martinez, Edison Technology Solutions)

Presentation on White Paper #5
*Real-Time Security Monitoring and Control of Power Systems (*George Gross, UIUC; PSERC)

Presentation on White Paper #6
Accommodating Uncertainty in Planning and Operations (Mark Ivey, SNL)

Appendix B: Workshop Attendance List*

Daniel Adamson
Deputy Assistant Secretary, Office of Power Technologies
U.S. Department of Energy

Abbas Akhil
Sandia National Laboratories

Douglas Bauer
Executive Director
Commission on Engineering and Technical Systems
National Research Council

Anjan Bose
School of Electrical Engineering & Computer Science
Washington State University/PSERC

Jeff Brown
Enron Corporation

Paul Carrier
General Engineer
U.S. Department of Energy

Henry Chao
ABB Power T&D Company, Inc.

Kevin Coates
Director, Public Affairs
American Superconductor

Jeff Dagle
Senior Res. Engineer
Pacific Northwest National Laboratory

James Daley
Physicist
Office of Geothermal Technologies
U.S. Department of Energy

Richard DeBlasio
Principal Engineer
National Renewable Energy Laboratory

* Inclement weather (Hurricane Floyd) prevented many additional registered participants from attending.

Joseph Eto
Lawrence Berkeley National Laboratory

Joseph Galdo
Program Analyst
Office of the Deputy Assistant Secretary for Power Technologies
U.S. Department of Energy

Huang Garng
Texas A&M University
Department of Electrical Engineering

George Gross
Professor, Electrical and Computer Engineering
University of Illinois at Urbana-Champaign/PSERC

Imre Gyuk
Program Manager
Energy Storage Program
U.S. Department of Energy

John Hauer
Senior Staff Scientist, Energy Technology Department
Pacific Northwest National Laboratory

Dale Henderson
Los Alamos National Laboratory

John Holt
Manager, Fuels and Transportation
National Rural Electric Coorperative Association

John Howe
Vice President, Electric Industry Affairs
American Superconductor

Jonathan Hurwitch
Senior Vice President
Sentech, Inc.

Joseph Ianucci
Principal
Distributed Utility Associates

Marija Ilic
MIT/NSF

Mark Ivey
Sandia National Laboratories

Brendan Kirby
Oak Ridge National Laboratory

Dale Landgren
Assistant Vice President
Wisconsin Electric Power

Robert Lasseter
Professor, Electrical and Computer Engineering
University of Madison-Wisconsin/PSERC

Chen-Ching Liu
Professor
University of Washington
Electrical Engineering Department

John Makens
Energy Information Administration
U.S. Department of Energy

Carlos A. Martinez
Manager
Edison Technology Solutions

A.P. Sakis Meliopoulos
Professor
Georgia Institute of Technology
School of Electrical and Computer Engineering

Chris Namovicz
Sentech, Inc.

Shmuel Oren
Professor, Industrial Engineering and Operations Research
University of California at Berkeley/PSERC

Philip Overholt
Program Manager, Transmission and Distribution Reliability
Office of Power Technologies
U.S. Department of Energy

Orman Paananen
Sandia National Laboratories

Diane Pirkey
Energy Technology Specialist
Office of the Deputy Assistant Secretary
U.S. Department of Energy

James Rannels
Director, Office of Photovoltaic and Wind Technologies
U.S. Department of Energy

Fred Roach
Los Alamos National Laboratory

Thomas Schneider
Vice Chair
IEEE Energy Policy Committee

Dejan Sobajic
Director, Power Delivery Department
Electric Power Research Institute (EPRI)

Margie Tatro
Sandia National Laboratories

Robert Thomas
School of Electrical Engineering
Cornell University/PSERC

Jim VanCoevering
Manager, Power Systems Program
Energy Division
Oak Ridge National Laboratory

Richard Wakefield
Chair, IEEE - USA
Energy Policy Committee