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Foreword

The Institute of Electrical and Electronics Engineers – United States of America (IEEE-USA) Energy Policy Committee and the Consortium for Electric Reliability Technology Solutions (CERTS) organized a one-day symposium on 24 May 2000 at the Hyatt Regency Hotel in Washington, D.C., with co-sponsorship by Electric Power Research Institute (EPRI) and the U.S. Department of Energy. The symposium examined the challenges that lie ahead for ensuring reliability as the U.S. electric power system undergoes the most fundamental transformation in its operation since its creation more than 100 years ago.

It explored the perspectives of market participants, systems operators, government, and academics on various aspects of reliability — including market operations, system management, industry oversight, and research and development. Held to promote a dialogue between industry stakeholders on issues related to reliability management, the symposium provided the factual backdrop to policymakers for the upcoming debates on reliability and the restructuring of the electric power industry.

Executive Summary

Today, many states are forging ahead with restructuring initiatives and laws, while Congress debates the issue of electric power reliability. As a result, a patchwork of regulations governing the operation of the electric grid system is developing. Increased reliance on market-based mechanisms is the hallmark of these approaches, yet the physical phenomena and technical issues involved in maintaining a reliable electric power system are understood by only a few people outside the electrical engineering profession. There is no experience on the use of market mechanisms for managing grid reliability and power systems operations, and market designs are being tested in real-time.

Markets today are placing great strains on physical, economic and institutional systems that have been developed to ensure reliability. The major outages and price spikes that occurred in the summer of 1999 in the mid-west, south and northeast were due at least in part to the new operating environment that is developing, and the increased stress on a system that has provided the most reliable electricity supply in the world. In examining the challenges of electric power supply reliability, we must consider that:

- ★ Electrification is the greatest engineering achievement of the 20th century. Reliable electricity is central to the health and well being of modern society. Its importance and value will also continue to grow to meet the needs of the digital economy in the 21st century.
- ★ Ensuring reliability is critical to the successful transition of the electricity industry to one in which competitive markets manage generation and consumption decisions.
- ★ Markets and reliability are inseparable. Markets are the first line of defense for ensuring reliable grid operations. Yet, just as market behavior guides grid operating decisions, the physical characteristics of the grid will also constrain market solutions.

- ☆ Information transparency is essential for well-functioning markets.
- ☆ The current lack of incentives for investment in transmission and absence of meaningful opportunities for loads to respond to market prices are serious shortcomings of today's markets.
- ☆ There are important, unanswered questions regarding the limits of efficient market operations in providing reliability-related services, and deeper questions regarding the extent to which reliability is a commodity, a product attribute, or a public good.
- ☆ Open processes and collaborative decision-making approaches are needed to improve reliability management.
- ☆ Voluntary approaches to reliability oversight are challenged by the competitive pressures faced by market participants in today's markets. Mandatory industry self-regulation of reliability, with federal oversight, is needed.
- ☆ The operation of the electricity grid must be unbundled to clearly separate market management functions from reliability management functions.
- ☆ Industry R&D needs are changing consistent with the need to support interconnection-wide trade of electricity through competitive markets. Experts also agree a lack of understanding exists about the interactions between reliability management and market operations.
- ☆ Trends in R&D spending are falling as future clients for reliability R&D remain in their formative stages, while traditional clients struggle to re-define their business interests.

Managing reliability through competitive markets requires research and technology development to understand functioning of the markets; develop the necessary tools and technologies to manage grid reliability based on market mechanisms rather than deterministic engineering principles; promote information transparency; and develop enabling technologies and systems to facilitate demand-side and customer participation in competitive markets.

Summary of the Keynote Address by Craven Crowell

Craven Crowell, chief executive officer of the Tennessee Valley Authority, and chair of the EPRI Board of Directors, opened the symposium by making the case for electricity research and development (R&D). He illustrated the leading role played by electricity in enabling the technological advances of the last 100 years — noting that electrification ranked as the greatest engineering achievement of the 20th century, according to the National Academy of Engineers, and drove a sharp increase in the quality of life. He also emphasized the global importance of “electrifying the future” to meet the new challenges of the 21st century. Challenges include population and economic growth in the developing world, demand growth, and the ever-growing importance of environmental stewardship.

But instead of a stepped-up commitment to electricity R&D for the 21st century, budgets are down. Crowell observed that U.S. pet food manufacturers spend a greater percentage of their revenue on R&D than do electric utilities. Particularly low is long-term funding — *patient money* — for the fundamental R&D needed to pursue potential scientific breakthroughs.

Without intensive, long-term R&D, future electricity demand will go unmet: global predictions for 2050 call for 10 million megawatts to serve 10 billion people. Nor do challenges lie only overseas or further off in time — new technologies are needed now to ensure the continued reliable operation of the North American electricity grid. Grid capacity has been reached in some places, and with continuing demand growth, as well as increasing bulk power transactions and higher temperatures, conditions will only get worse. Because reliable electricity is so essential to the normal operations of society and the economy, electricity R&D must become a national — and global — priority.

EPRI has embarked on an effort to meet the challenge with the *Electricity Technology Roadmap*. Crowell considers the *Roadmap* to be the most strategic vision of the future he has seen, with clear markers to meet national and global goals and to realize the full promise of electricity for the 21st century. So far, some 150 organizations have contributed to the *Roadmap*.

Crowell closed by noting the important transformation worked by electrification on the Tennessee Valley in the 1930s. Electrifying the future will hold similar meaning to all people in the world in the 21st century. But today's technology is inadequate. For electricity to take us to the next level of technological evolution, patient money and increased stakeholder commitment are required.

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Summary of the Remarks of David Leiter

David Leiter, the principal deputy assistant secretary in the Office of Energy Efficiency and Renewable Energy at the Department of Energy (DOE), expressed the Department's concern about potential problems related to power reliability and quality. "This issue affects everyone," Leiter said, pointing out that U.S. companies lose an estimated \$26 billion per year in time and revenue as a result of power outages, and that the loss of power can be a matter of life and death. As such, the Secretary of the Department of Energy places a high priority on electric power reliability.

Although the Clinton-Gore Administration supports the national revolution towards consumer choice in electricity providers, the transition has led to uncertainties as utilities and other market players postpone decisions on adding new transmission lines and building new power plants, while more customers are added every day. Meanwhile, new technologies that could mitigate the congestion problems, face barriers that delay their introduction.

These factors have stretched some utilities to the limit, Leiter noted. As a result, the Secretary appointed a Power Outage Study Team, drawn from experts in the DOE, academia, and the electrical industry, which identified reliability issues, and recommended actions the Federal government could take to help avoid future outages. The Secretary also announced short-term plans for the Department to work more closely with federal, state, local, and utilities officials to reduce peak demand this summer.

However, Leiter said that it is critical that Congress enact comprehensive electricity restructuring legislation soon to provide long-term reliability solutions, noting that the federal government plays an important role in interstate power and transmission

markets. For example, he observed that, through the Bonneville Power Administration, the federal government owns more than 75 percent of the high voltage transmission in the Pacific Northwest. The Department has taken steps to ensure that federal power marketing administrations, including Bonneville, deliver power more efficiently by directing the Power Marketing Administrations to fully comply with the Federal Energy Regulatory Commission Order 2000, which promotes participation in Regional Transmission Organizations (RTO's).

In addition, Leiter noted, the Department is proposing increased funding for research and development. It is also implementing new programs, such as the Secretary's Energy Grid Reliability Initiative and the Distributed Energy Resources Task Force, to explore ways to promote reliability, efficiency and flexibility through such emerging technologies as wind, photovoltaics, fuel cells, microturbines, and natural gas turbines.

Finally, the Department is also addressing reliability on the demand side by looking for ways to increase the energy efficiency of building and industrial equipment. Specifically, for example, Leiter said that the DOE is accelerating the development of new efficiency standards for business and home air conditioners. Leiter concluded by reiterating the need for everyone — federal, state and local governments, consumers, utilities, and regulators — to “work together to meet the reliability challenges ahead.”

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Summary of Luncheon Address by Kurt Yeager

Kurt Yeager, president and chief executive officer of EPRI, focused attention on the electricity infrastructure needed for the new digital society. The core vision of the *Electricity Technology Roadmap* — to electrify the world — provides a reminder that electricity is the prime-mover of modern society through the innovations it makes possible.

To Yeager, the key characteristic of the marriage of electricity and innovation is its ability to amplify productivity. Productivity enhancement is critical because for world development to pace population increase, the rate of global productivity growth must exceed two percent per year. This truly means *electrifying the world* — bringing electricity to at least 100 million more people every year, for at least the next 50 years. It begins by harnessing the potential of electricity to transform productivity in the United States.

The means are at hand with the digital revolution. This revolution is transforming the industrial economy, where value grows incrementally, into a network economy where value can grow exponentially. Electricity and real-time information are the life-blood of the network economy, and electric power reliability is critical. First, because any infrastructure or institution seen as sustaining *digital-divides* will come under pressure to change or risk being bypassed. Second, because perfect power is required. Today's infrastructure of large power plant and limited real-time connectivity must evolve to provide the precision and efficiency of the boundary-less microchip networks it serves. For the electricity business, market power is shifting from supplier to customer and transaction costs are relentlessly being driven down, pressuring grid owners and operators to keep pace.

A first step in meeting the challenge is provided by the EPRI-launched, *Power Delivery Reliability Initiative*, with more than 40 utilities and the support of the IEEE, NERC, and CERTS. But keeping the lights on represents only tomorrow's table stakes. The robust, adaptive infrastructure for the digital society will require new enabling technologies, from wider bandgap semiconductors and superconducting components to standards for distributed power and interactive metering. Renewed public/private collaboration will be critical to develop and deploy these technologies, starting with a commitment of an additional one billion dollars per year over, at least, the next five years.

Electrifying the world begins by transforming the U.S. electricity infrastructure into an arsenal of innovation. The stakes are high and failure intolerable. Yeager closed by calling on conference attendees to join with EPRI to help build the digital future.

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Session 1: Reliability and Markets

Moderator: ROBERT THOMAS — *Chair, Power Systems Engineering Research Center and Cornell University*

Panelists: PAUL BARBER — *Sr. Vice President, Citizens Power*; DOUGLAS HALE — *Sr. Economic Analyst, U.S. DOE Energy Information Agency*; RICHARD O'NEILL — *Director, Federal Energy Regulatory Commission*

In the new regime, markets will be substituted for many of the traditional planning and operations tools and techniques. The past fifty years have been devoted to improving the engineering efficiency of the interconnected power system. Restructuring is focused on improvements in the economic efficiency of the chain from supply to consumption. If the markets are to work properly, then they must be designed properly. Improperly designed markets can neither provide the adequacy and security functions of past systems, nor be economically efficient.

Moderator **Robert Thomas** opened the session with a discussion of spot prices in the summer of 1999. Price hikes can be good and bad. *Good* price hikes indicate the need to invest in new generation. *Bad* price hikes result when people take advantage of market rules or systems operating conditions. Bad hikes happened at the Pennsylvania-Jersey-Maryland (PJM) interconnection, and in California, in 1999. Thomas noted that simulations and studies at Cornell University of how people behave in spot markets — including spike behavior — suggest that there has been tacit collusion, and a tendency to take advantage of the market conditions in an unfair way. He concluded by stating that markets and systems planning and operation are inseparable — that markets have to be understood to assess system reliability. A key question is whether reliability can be sold as a market or whether it is an attribute of the system.

Paul Barber presented the viewpoint of a power marketer, and stated that markets and reliability can both exist, and said that, "Reliability is paramount to market." Markets or incentives that ruin reliability are inherently unstable and unsupportable markets. They do not work. Competitive markets will deliver all the reliability that the customer is willing to pay for, but we must have mechanisms in place that will enable competitive markets, according to Barber. This strategy means informed

consumers and informed customers. It is important to remember that all consumers are customers — but not all customers are consumers. Wholesalers should worry about their immediate customers and not the ultimate consumers. Retailers should worry about their immediate customers. And so on down the food chain. Consumers will react to high electricity rates if prices go up too much, but at present, prices are masked from consumers.

Barber discussed several options to bring consumers into the market loop, including smart appliances that react to prices and opportunities for large industrial and commercial customers (who consume about 30% of the load) to sell back the electricity they bought. A natural cap on the competitive market is liquidity, but liquidity itself is a very elusive term. The best definition is probably a market that has lots of willing buyers and sellers, who are not cramped by price caps. Because demand elasticity is very important, hubs where people can trade are needed, Barber said. But reliable and seamless delivery is required to make the hub trading market work. Rational transmission services are also necessary. At present, no secondary transmission market exists. Transmission needs to focus on what the load needs to serve the load; what the generator needs to take their product to market; and what the trader needs to move power from hub to hub.

Barber summarized by remarking that the role of competition is to better value, not to lower prices. Telephone bills are higher — but we are getting better value. For transmission, the need is to interact with many people to find out where the box is, so we can think *outside* of it. In doing so, it is important to think of transmission as a business, as opposed to a regulatory function or regulated function. Much more research needs to be conducted on how to make the transmission business truly competitive in nature. Barber stated that reliability is not a marketable commodity; rather, it is an attribute of the energy product — and cannot be bought or sold as a separate item.

Douglas Hale presented a view from the federal government, stating that reliability is measured by the “probability of the lost load.” Under the old structure, utilities could recover costs as long as they could convince the regulator, and reliability gained a lot of support, since no regulator wanted to be blamed for blackouts. The industry is now moving to markets, which means a focus on profits. Asset use is maximized; reserves are minimized. Great incentive exists to duck shared costs, and to push the fixed costs on to the next player — not good for reliability.

Not surprisingly, the early returns on outages are discouraging. The causes of outages in the summer of 1999 included lack of demand control, poor electrical and economic models and data, and trade mechanisms that neither worked very well nor very responsibly. Major maintenance issues and Not In My Backyard (NIMBY) syndrome are long-term problems. Moreover, the new markets move so quickly that old control and communications systems do not work. Hale does not find an inherent conflict between markets and reliability, because market solutions inherently require reliability. Even so, very serious design and incentives problems are cropping up in the long-term provision of systems assets; and a lot of new investment is required in transmission lines and information controls. At the same time, fixed end-user prices undermine the natural recovery process of the market to ensure reliability, which could result in capacity shortages.

Ultimately, reliability requires that electricity prices should either adjust or be flexible. Evidence exists to support that even a small demand in reduction can reduce price dramatically. However, flexible price markets must keep the poor and needy people in mind, especially those who have urgent medical needs. Hale called for greater efforts to establish real-time pricing experiments. He said regular field-testing and proper documentation should be taking place, so that the data can be shared with others. He also suggested additional support of metering technology to expand the benefit of spot pricing to small users. Hale also asked for expansion of software testing and development to calculate competitive prices in near real time.

Richard O'Neill spoke from the viewpoint of a federal regulator, and stated that reliability is a "public good." People do not want to pay for reliability. He said that there should be a real-time market for reliability. O'Neill emphasized the importance of preventing power markets design that favors large players. Further, he said small players in the markets should have the same ability to participate. If not, mergers, consolidations and collusive agreements among the large players will consolidate power. O'Neill said the aim should be to "keep the whole thing egalitarian;" to mitigate the inherent power of large players. At the same time, it is critical to rely on high-technology control systems to get additional transmission out of the existing capacity, because new lines are not going to be built. Distributed power is one alternative, and retail access is very important. O'Neill concluded that a real-time market, with some transmission rights, is possibly all that is needed.

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Session 2: Reliability Management

Moderator: VIKRAM BUDHRAJA – *Electric Power Group*

Panelists: RICK BOWEN – *Executive Vice President, Dynergy and WSCC Board Member*; PHIL HARRIS – *President and CEO, PJM*; DICK SCHULER – *Professor, Cornell University and NY ISO Board Member*; PAUL MCCOY – *Senior Vice President, TransElect*

The electric power industry is transitioning from a vertically integrated to a competitive electric market structure. Managing real-time operations and reliability in the competitive market is presenting operating challenges. The traditional methods of economic dispatch, central generation control, and control areas that were aligned with utility boundaries are no longer applicable. The panel focussed on the real world challenges and experiences of Independent Systems Operators, market participants and stakeholders in keeping the lights on without interfering with the operation of emerging competitive markets. In introducing the panel, **Vikram Budbraja** likened the process to remodeling one's home. He said: "Surprises always turn-up in the transition from one stable state to another." However, he also pointed out that, unlike home remodeling, these surprises are increasingly in the headlines of today's news — and on the minds of a general public concerned about the impacts of current restructuring processes electric reliability.

Rick Bowen opened the panel with the perspectives of an independent power producer. He cited an example in which 4,300 MW of transactions were curtailed, to provide only 400 MW of load relief, as a reason for concerns over the "sledgehammer" effect of current *transmission loading relief* (TLR) procedures. He described five market needs to improve this situation:

- 1) mandatory participation by all market participants in observing the new rules of the road, with clearly established lines of accountability for actions;
- 2) greater involvement by new market entrants (marketers and independent power producers) in contributing toward solutions;
- 3) push toward system-wide, rather than region-specific, outcomes;
- 4) accelerate introduction of modern technologies to facilitate more efficient markets (and avoid the need to continue to rely on inefficient and disruptive out-of-market fixes, such as TLR); and

- 5) find ways to support needed investments in transmission capacity.

On this last point, Bowen pointed out that while prices are eliciting investments in new generation, adequate incentives for transmission (or conversely locating generation where it is needed) are lacking. Citing the situation in San Diego as an example, he expressed concern that soon a deliverability crisis will occur, unless meaningful incentives are created (and barriers are removed) for locating transmission and generation to serve load centers.

Phil Harris followed the introduction by sharing the views of one of the world's largest centrally dispatched electric systems, and one of the nation's first independent system operators. He began by emphasizing that the role of his organization is not to operate the system, but to direct its operation by others. In this sense, the Pennsylvania-Jersey-Maryland (PJM) interconnection is functioning primarily as an information provider. He also reminded the audience that the actions of PJM cannot be thought of in isolation from the operation of the entire Eastern Interconnection, of which PJM represents about 10%. Harris then discussed six central concepts or driving forces that must be recognized and embraced as the system evolves. He said that decision-making processes are being transformed from ones that were formerly internal and specific, to individual organizations, to processes that will be external and shared among many participants in the future. Harris emphasized that open processes are needed to facilitate these new decisions. Further, Harris said that people want choices, and that giving them choices will beget their desire for even greater choices in the future. He elaborated that real-time means the "present" time, from an individual's perspective. Harris pointed out that related to this last driving force — distances become zero in a digital economy of instantaneous communication. He added that open discussion of unexpected electric system behavior (e.g., near-misses) is essential; and that the risks of misusing information are far less than the risks of not sharing information. Harris predicted that 21st century decision-making will be done collaboratively, and that we must enhance mechanisms for these processes.

Dick Schuler shared the views of a board member for the newly created New York Independent Systems Operator (ISO). He began by reflecting on how topics from the last symposium had migrated from stranded costs to reliability management, and opined that we are all still engrossed in an experiment of the whole. Shuler observed that in New York, the procedures for reliability management have not changed in terms of the services required. What has changed is that market participants rely

on the prices offered, rather than the costs reported, to determine who will provide these services. In this regard, he said that reliability can be cast as a market power problem, when markets for reserves are thin. Shuler noted that recent perceptions of liquid reserve markets have led NY ISO to suspend these markets, and to engage market participants in working out a solution. He then offered that, in fact, prices are the greatest friend of reliability. However, currently customers have no opportunities to participate in these markets, and ISOs are faced with untenable situations in which prices can skyrocket when markets are thin.

Bringing customers into these markets, which is a must for the maturation of these markets, will begin to blur the distinction between transmission and distribution. More broadly, Shuler sees a need to confront the public goods aspects of reliability: While markets may allow customers the opportunity to better determine their personal willingness and ability to pay for reliability, the network properties of the grid dictate that, once determined locally, everyone will receive the same level of reliability. In closing, Schuler offered his perspective that a key measure of the success of current restructuring efforts should be the surprises encountered along the way. However, he also expressed confidence that lower reliability would not be one of these surprises.

Paul McCoy offered the insights of a new transmission-only business. He observed that today the threads of reliability management are becoming unraveled — because who is really in charge of reliability is changing. As a result, McCoy expects the situation to get worse before it gets better. Formerly, reliability was ensured by a comparatively small number of the nation's large utilities — the largest in each region. They managed reliability not just for the public good, but also because politically they were very visible. Managing reliability was facilitated by their ability to recover these costs more or less automatically.

Today, IPPs are increasing in market share and the influence and ability of the "old guard" to manage reliability is diminishing. Yet, new structures are not in place and the rate of change is uneven across the country. Indeed, in some parts of the country the transition will take longer than many would like or expect. McCoy offered several thoughts on the issues going forward: the cost of reliability management is significant; there are important unresolved questions regarding the minimum time-scale over which market mechanisms can work effectively in managing reliability; and there is room for dramatic improvements in reliability management, through application of advanced technology — especially in the areas of control, communications and data

management. In closing the session, Budhraj highlighted several recurring themes that would contribute to improved reliability as the transition continues to a competitive market:

- ★ R&D must develop tools, technologies and systems;
- ★ Information transparency is essential for well-functioning markets;
- ★ Open processes and collaborative decision-making approaches will be needed to make collective progress toward improvements in reliability management;
- ★ All market participants must work collectively to start fixing; and
- ★ Important unanswered questions remain regarding the limits of market operation in terms of time scale/scope (and on the deeper question of to what extent reliability is a commodity, a product attribute or a public good)

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Session 3: Reliability Oversight

Moderator: ROBERT WOODWARD – *Consultant, Power Systems Consulting, Inc.*
Panelists: DENNIS EYRE – *Executive Director, WSCC*; MICHEIL GENT – *President, NERC*; JOHN POPE, *Director, Southern Company Services*; STANLEY SZWED – *Vice President, FirstEnergy Corp.*

Reliability oversight involves developing performance standards and parameters for measuring reliability. As there are but four synchronous grids in North America, some degree of uniformity in standards and parameters seems desirable. However, the diverse structure of the industry challenges uniform oversight. **Robert Woodward** opened the session with a series of questions: Who is minding the store in this transitory restructuring period? Ultimately, who will be responsible for oversight and customer interests? Does oversight include the means to take mitigating action, or does it simply provide an alert mechanism? What is the maximum/minimum system (Independent Systems Operator/Regional Transmission Organization/Region) size for effective measurement and compliance monitoring of reliability standards? Where do regulators and

legislators stand on this matter? Woodward pointed to the importance of differentiating reliability for the distribution system; the source of 90% of all outages, typically local; for capacity shortages, where the solution resides mainly in the unregulated marketplace; and for the transmission system, where outages are likely to be regional, and where the most serious concern is the risk of cascading transmission failure.

Dennis Eyre, executive director of Western Systems Coordinating Council (WSCC), presented a regional viewpoint on reliability oversight. Eyre agrees that reliability is a critical element of industry restructuring, but believes the more pressing issue will be what happens during the restructuring transition itself. Once the transition is complete, Eyre believes a very reliable system will emerge because the public will accept nothing less. Eyre contended that the voluntary North American Electric Reliability Council (NERC) approach will no longer work in the new competitive era. Without existing legislation, WSCC decided to launch its own, member approved Reliability Management System (RMS) plan in 1998, which called for them to sign contracts to comply with certain requirements or else face sanctions. After the RMS was approved by FERC and the Department of Energy, the mandatory program was activated on 1 September 1999, with voluntary participation from 21 of WSCC's 30 control areas.

At present, the RMS program addresses reliability criteria, transmission path limits, load flow monitoring, reserve requirements, and use of generator power stabilizers. A four-tiered system is used, with monetary penalties as well as letters of reprimand at the highest levels. WSCC completed two trial periods, which together demonstrate how making the criteria more visible will improve compliance. Some remaining challenges Eyre recognizes include ensuring compliance within the industry standards, maintaining high visibility in continuing compliance, and passing legislation mandating reliability — necessary for legally enforcing uniform reliability standards with sanctions for a “level playing field.”

The threat over the next two years, will be from decreased reliability due to the tremendous pressures being put on the operations of systems from reduced reserve levels, potential capacity shortages and the rapid pace of change. Proper incentives are needed to have new generation built and to have adequate transmission capability to accommodate that new generation to serve all required load areas.

Michehl Gent, president of NERC, spoke about the challenges ahead in ensuring electric supply reliability. The challenge to NERC — surely one of the great collaborations of all time — is how to adapt to all the changes taking place in the power industry. There is no interest in having a government agency dictating reliability standards to the

industry; the industry is determined to be in charge of reliability. The best way to accomplish this goal is to enact legislation (pending) to allow creation of the self-regulating reliability organization NAERO (North American Electric Reliability Organization). NERC claimed that such an organization is needed today because of the egregious behavior that took place in the industry in 1999.

NAERO's aim is to become the certified Self-Regulating Reliability Organization (SRRO) for the North American power industry. This SRRO will, in turn, assure the government that interconnections will be operated fairly and with acceptable reliability via set reliability standards. Compliance will be backed up by the regulatory agencies, with the actual implementation of the standards by delegated Regional Reliability Organizations (RROs), which will also solicit input from stakeholders and the general public. NAERO's design is based on the securities industry model, specifically the NASDAQ's NASD Regulation Program. At present, NAERO does not have the power to levy fines — but in a program of simulated enforcement, if a company is caught out of compliance, the amount of a potential fine will be made known. However, money is not the object in this program. The objective is to compel compliance, and NAERO legislation is needed now.

John Pope, director of bulk power operations for Southern Company Services, spoke on reliability in transition. Recently, NERC's Control Area Criteria Task Force was established to authorize a number of new control areas, particularly in the Southeast, but the NERC guidelines for approving new control areas were minimal. Consequently, a new group was formed with the initial charge to develop a control area certification process and to determine the function and responsibilities for ensuring operating security. This group began by researching the market advantages of being a control area, identifying two: inadvertent interchange and parking and hubbing. Identifying such advantages was important because of the power NERC granted to control areas, which have traditionally been the operating entities for balancing load and generation. To ensure fair competition, operating policies had to be unbundled and reformulated to remove market advantage. Specifications are needed for the basic operating functions (balancing authority, security authority, transmission service provider, etc.) and the entities that provide those functions. The blueprint for this unbundling is the NERC Reliability Model (see NERC website at www.nerc.org), which is currently being introduced to the industry.

Clear delineation of reliability responsibilities is critical because of the great need for security analysis in today's stressed transmission environment. At present, it is not

known, in real time, how "close to the edge" operation is; it has never been known how close to a cascading outage we have been, hence the usage of a safety margin. The security coordination tools and techniques now in use by different utilities have significant inconsistencies, which does not bode well for the promotion of reliability management. For the promotion of reliability, the focus should be on building the best security tool sets, and on having them readily available throughout North America, regardless of operating companies. In this field, promising studies are now being conducted on risk-based reliability indices, and results should be available soon. Meaningful presentation of security data to operators remains an issue.

Stan Szwed, vice president of transmission for First Energy Corp., addressed reliability oversight and cooperation among inter-regional transmission organizations. Transmission, as the link between load and generation, is a vital business and a very important part of the restructuring process. For customers to exercise choice in this new era, it is absolutely necessary that the transmission infrastructure is strengthened by sufficient new investments. FERC Order #2000 provides for the voluntary development of transmission structures (RTOs) on a broader, larger scale to facilitate reliable operation and commerce. As transmission restructuring progresses along RTO lines, there are three critical ingredients to developing reliability and its oversight in transmission:

- 1) standards and rules for coordinated operations and planning;
- 2) infrastructure investments for the future; and
- 3) development of the independent transmission company or Transco business structure, with the sole function of moving power from generator to load.

As part of this process, First Energy is involved with the Alliance RTO, which also includes American Electric Power, Consumers Energy, Detroit Edison, and Virginia Power. Alliance RTO is seeking regulatory authority to operate as a single entity following the rules of NERC, NAERO, and reliability councils. Benefits and efficiencies from this RTO result from consolidating certain control functions, making transactions easier, and promoting better reliability on a regional scale. The Alliance RTO is proposing an inter-RTO cooperative framework to handle "seams." This framework would provide a planning process spanning the various RTOs to determine the right structures and investments to reinforce the system, and to provide additional reliability for transactions to take place. At the same time, the coordination of transfer capabilities, capacity benefit margins, and reserve margins among RTOs must be coordinated, and

postings provided for the user. Appropriate FERC policy is needed to provide proper incentives and investment possibilities to induce infrastructure investments that relieve congestion, add generation where most needed, and implement a Transco-based business structure.

In summation, clearly, the industry is evolving. By definition, evolution has no end, but it can change speeds. Competition has swept in without clear responsibility for maintenance of reliability. Our panelists have set forth their current plans (among others in the industry) to accommodate reliability in this competitive generation marketplace, but reliability oversight is playing catch-up. In the meantime, traditional utilities and maturing market entrants through voluntary coordination are "minding the store." Before, reliability took precedence over economy; change accommodated reliability. Now, the nation waits for the marketplace to resolve capacity shortages — which have resulted in recent brownouts — and transmission owners to make a case for incentives for transmission expansion to deliver energy to a growing population. As this evolution continues, should we not pace change to assure all critical aspects move in unison?

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Session 4: Reliability Research and Development

Moderator: THOMAS SCHNEIDER, *Vice Chair, IEEE-USA Energy Policy Committee*

Panelists: BRUCE RENZ, *Vice President, Energy Delivery Support, American Electric Power Corporation*; ROBERT DIXON, *Acting Deputy Assistant Secretary, Office of Power Technologies, U.S. Department of Energy*; MARIJA ILIC, *Program Director, National Science Foundation and Senior Research Scientist, Massachusetts Institute of Technology*

Concern over electricity reliability is not new. Reliability was a central topic at the IEEE-USA symposium held in Washington, D.C. in 1997, because the costs from a decline in reliability could easily outweigh any savings resulting from competition. Speakers at today's symposium report that electricity reliability has indeed suffered under competition. At the same time, industry collaboration for reliability research and development (R&D) has declined, even as R&D becomes exceedingly important for understanding and adapting to a competitive electricity marketplace.

Bruce Renz, speaking from a utility viewpoint, noted the general agreement expressed by earlier speakers on industry reliability issues and challenges. Warning signs abound: the gap between transmission need and capacity is widening, bulk power transactions are increasing exponentially, and climate variations appear to be getting more extreme. As a result, power outages have grown in frequency and size (at a cost of some million dollars per minute), and litigation is increasingly common and costly. These trends are consistent with the underlying factors at work in the U.S. power industry — an increasingly challenging business environment facing shrinking investment.

Critical R&D needs to meet the industry's widespread challenges, from maintenance and diagnostics, to controls and protection, to fundamental understanding of power markets. Where promising technologies do exist, such as reliability-centered maintenance and Flexible AC Transmission Systems (FACTS), development is needed to reduce cost. The \$5 million recently invested by utilities in EPRI's "Power Delivery Reliability Initiative," is helpful, but is only a small step in the right direction; much greater commitment is required. Mr. Renz summarized the current situation as precarious because systems-wide failures could untrack the restructuring progress made to date, with no indication of how to move forward or return to the past.

Robert Dixon, of the U.S. Department of Energy (DOE), described the DOE's research initiatives launched in response to electricity reliability concerns. Near-term, the Power Outage Study Team (POST) focused on assessing the 1999 summer outages. This effort yielded a series of public workshops, a comprehensive report, and 12 recommendations for specific actions to improve grid reliability. POST's results are available at www.policy.energy.gov. For the mid-term, the ongoing Energy Grid Reliability Initiative (EGRI) faces the challenge of developing technologies and systems to maintain and enhance the reliability and security of the nation's complex energy delivery infrastructure. Elements of EGRI's program address electric power systems — including transmission reliability under competition, storage, and distributed power — as well as natural gas systems and the security of energy infrastructures. This initiative will see a \$22.5 million budget increase in 2001. Details can be found at www.osti.gov/portfolio. Looking long term, the DOE organized a Distributed Energy Resources (DER) task force in March 2000. The task force will focus on all of DOE's DER programs to better promote the benefits of these technologies, including increased electric reliability, greater customer choice, reduced outage costs, and more jobs. The goal of this effort is to work with industry to develop a suite of DER technologies that will achieve 20 percent of new U.S. electric capacity additions by 2010.

Marija Ilic represented the viewpoint of an academic researcher. Ilic described key aspects of work underway at MIT to develop fundamental understanding of and new software for transmission competition. Software tools depend strongly on the market structures and standards that are implemented (e.g., bilateral markets vs. spot markets), and many key decisions are pending. For reliability, present concepts consider adequacy and security independently, which is not necessarily the case in today's competitive industry environment, where value-based concepts — such as thinking of reliability as a tradable commodity — may be needed to develop proper incentives. Furthermore, without the development and recognition of power market-side rules, rights and responsibilities analogous to traditional supply-side command, control, and communications concepts, the fundamental changes needed to ensure reliability under competition will come slowly. In the meantime, Ilic and her students are developing various prototype software systems, including on-line implementation for improved grid efficiency; near real-time control that shifts emphasis from correction to prevention (as is already applied at Electricité de France; smart components for both rate-of-return (ROR) and performance-based-rate (PBR) transmission markets; and an intelligent transmission congestion management system for reliability. These examples represent but a few of the software pieces needed to solve the competitive marketplace puzzle for the grid. Considerable academic research will also be needed to develop a complete understanding of the complex issues the industry faces.

Moderator **Tom Schneider** closed the session by noting that despite documented concerns about electricity reliability and a professed lack of understanding about reliability in competitive markets by industry experts and academics, R&D support has declined dramatically with the onset of competition. EPRI funding has dwindled from approximately \$600 million in 1996 to approximately \$300 million in 2000; increases in reliability programs at the DOE and other organizations total only a few tens of millions of dollars. By contrast, over the same period, California spent \$300 million establishing its Independent System Operator (ISO) and Power Exchange (PX). Mr. Schneider considers the existing system of funding "broken," and suggested that a self-organized industry tax for collective "public good" R&D may be necessary to give the power delivery system the ability to function reliably under competition.

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