U.S. House of Representatives
Committee on Energy and Commerce
Subcommittee on Energy and Air Quality

Executive Summary of Testimony of Audrey Zibelman, PJM Chief Operating Officer and Executive Vice President "Facilitating the Transition to a Smart Electric Grid" May 3, 2007

In her testimony, Ms. Zibelman outlines PJM's vision for the Smart Grid and includes recommendations for implementating a 21st Century Smart Grid. PJM is the Regional Transmission Organization responsible for ensuring the reliable and non-discriminatory operation of the high voltage electric power grid over a 13-state region including all or parts of New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, Tennessee, West Virginia, Kentucky, Ohio, Michigan, Indiana, Illinois and the District of Columbia.

In PJM's view, a "Smart Grid" encompasses three critical elements:

- **Transitioning the grid from a radial system to a true network so as to ensure connectivity all the way from fuel sources to end use customers;**
- **Converting from an electro-mechanical to a fully digital system to support information and automation-enabled assets; and**

- **Enabling two way communication within the grid community so that end-use customers can, if they choose, move from passive to active participation in the marketplace. Common protocols are needed to ensure communication of prices and system conditions to "smart" appliances in the home, as well as to renewable and other generating resources.**

Ms. Zibelman made the following recommendations to achieve the vision of a Smart Grid:

- **Development of regional technology plans similar to that called for in PJM's recently issued Strategic Report;**
- **A collaborative industry effort to develop common interoperability protocols, with the Congress ensuring federal agency support and coordination given the many agencies with jurisdiction over elements of the Smart Grid;**
- **Regulatory reform at the state and federal levels to remove barriers to the deployment and capitalization of new technologies to enable the development of the Smart Grid.**

Ms. Zibelman provided with her testimony the attached brochure which further details PJM's vision for the Smart Grid of the future.

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Testimony of Audrey Zibelman,
PJM Chief Operating Officer and Executive Vice President on
"Facilitating the Transition to a Smart Electric Grid"
May 3, 2007

I wish to thank Chairman Boucher and the Sub-Committee on Energy and Air Quality for inviting PJM Interconnection, L.L.C. ("PJM") to address you on this very important subject. We are encouraged that the Subcommittee recognizes the importance of gathering information on the need to transform our Nation's transmission infrastructure into the Smart Grid of the 21st Century as a key element of ensuring the country's energy independent future.

PJM is responsible for ensuring the reliable and non-discriminatory planning and operations of the transmission grid and the fair and efficient administration of the real-time wholesale electric market that serves 51 million people in an area that includes 13 States plus the District of Columbia. PJM operates the high voltage electric power grid in all or parts of New Jersey, Pennsylvania, Delaware, Maryland, the District of Columbia, Virginia, North Carolina, West Virginia, Kentucky, Ohio, Michigan, Indiana, Illinois and Tennessee. It is an area of the nation that, standing alone, represents approximately 19 percent of the nation's Gross Domestic Product. The power system under PJM's control is the largest in North America and one of the largest and most complex in the world. The PJM region incorporates 56,000 miles of transmission lines, 1,250 generating plants and 6,000 substations. PJM has 250 intertie points with adjacent systems in the Eastern Interconnection. This means that along with managing the

PJM system, our operators manage the seams between PJM and seven adjacent electric systems. To put this in perspective, the next most extensively interconnected power grid in the world is the transmission system that serves France, which has 41 interties. To maintain reliability of the system, PJM has identified approximately $10 billion in new transmission investments that will be required over the next 15-year planning period. When built, we believe this transmission will help reduce current congestion on the system at a value that will approximate $1 billion a year in savings.

The wholesale markets that PJM operates represent the largest competitive organized wholesale markets for electricity in the world. The PJM spot markets were started in 1997 and in the last 10 years grew from $450 million to $23 billion in annual revenues. Today, there are more than 450 members of PJM representing all segments of the industry as well as financial and trading institutions that add liquidity to the marketplace. The buyers and sellers into and from the PJM Markets also include many generators and load serving entities from adjacent regions, all of whom benefit from the transparency and robustness of the marketplace.

The installed generation capacity in the PJM region currently exceeds 165,000 MW while the peak demand for the PJM region reached a record 144,644 MW in August of 2006. This peak demand exceeded the peak achieved in 2005 by 10.627 MW. In short, in one year we saw an increase in peak load that is equal to the level of generation that is required to serve a large American city. Although we do not anticipate that sizeable an increase in peak demand each year, we do anticipate load growth in the region to remain in the range of 1.5 percent annually over the next 10 to 15 years. During this same period, we envision retirements of older, less efficient generating units, which necessitates further development of new more efficient generation. Indeed, the pattern of retirement of older generating plants affected by

environmental laws as well as the region's increasing demand for electricity has created new challenges. If we tried to meet this increased demand for electricity solely by building new generating plants, over the next 15 years this combination of factors could require as much as 55,000 MW of new generation investment, an amount equivalent to four large nuclear plants or coal plants being constructed every year.

To summarize, the industry challenges confronting the PJM community are reflective of those we are experiencing throughout the Nation. We are an electricity-dependent economy. The demand for electricity continues to rise reflecting a growing digital age economy. Yet, we have an aging infrastructure that will require significant new investment in all segments of the industry, from the fuel input to the customer meter. We also must actively consider how we can help achieve the energy independence that the country demands, while continuing to focus on maintaining fair and affordable electric prices and reducing our carbon footprint. We are in a period when we cannot afford to ignore the contributions of any segment of the industry to our energy policy objectives. In fact, based on PJM's perspectives as a grid operator and market administrator, we believe that the transformation of the bulk power transmission system to a Smart Grid of the 21st century should be considered part of the foundation of meeting America's energy policy and climate change objectives. I am attaching a brochure which was part of PJM's recently released Strategic Report. It is designed to explain the Smart Grid in understandable terms for the general public.

With this in mind, my remaining testimony will focus on four primary areas:

1. The PJM vision of the Smart Grid;
2. How Smart Grid implementation can increase reliable, secure and efficient system operations;

3. How a Smart Grid will enable true consumer participation in the electric marketplace as a means of gaining greater environmental benefit and affordable electric prices; and
4. The actions and public policy efforts we should focus on today to establish the right platforms for a 21st century electric power system.

1. The PJM Vision of the Smart Grid

There are many industry definitions and descriptions of the Smart Grid. For PJM, where we are required to keep the grid in balance 24 hours a day, 365 days a year, the Smart Grid is not a theoretical concept or a "gee, it would be nice" item. PJM's perspective derives from its dual focus on continuously looking for ways to improve secure, reliable and efficient grid operations, while assuring a robust competitive wholesale electric market that supports federal and state energy policies. PJM's vision of a Smart Grid encompasses the transformation of the interconnected electric system in three critical ways:

- ***Ensuring a Multi-Directional Grid***: The industry needs to transition from today's radial system linking generation to load to a true network with full connectivity and interoperability. The goal of this change will be to allow horizontal interconnectivity all the way through the energy value chain – from fuel management through to the end customer energy use. We have achieved much of this connectivity goal in telecommunications, yet are only beginning to work on this in the electricity sector;
- ***Moving to a Digital Grid***: We will need to convert from today's electro-mechanical grid to a digital system that supports information and automation-enabled grid assets. The objective of this conversion is to allow for more efficient, cost-effective and secure system operations;

- ***Moving to an Interactive Grid***: The grid of the future will require two-way communication between the system operator and the end-user. The objective of two-way communication is to convert end-users from passive to active participants in the marketplace.

Each of these elements will be a necessary component of implementing federal and state energy policies.

2. Developing a grid that promotes a more reliable, secure and cost effective electric transmission system

The interconnected electric system is often alternatively described as either a single complex engine comprised of generators, transmission and distribution systems and end-user devices or an ecosystem with many interdependent elements. In either case, there are four fundamental attributes of the interconnected system that help explain the value of a transformation to a Smart Grid. First, is the fact that the system is interconnected. As the nation learned again on August 14, 2003, an uncontrolled disturbance on one part of the system can cascade and impact large segments of the grid. A second attribute reflects that electricity is a speed of light product. Operators today must always operate the system in anticipation of what might happen next. Third, electricity is the only commodity that is consumed at the same time it is produced. At least at this time, large scale storage of electricity is not practical or economical. Fourth, the information environment required to operate and control the system is extraordinarily sophisticated. The information requirements of the grid continues to grow. Today, PJM employs an energy management system that processes about 88,000 bits of information every two to three seconds. This information need will grow in magnitude as we add more diverse demand side and generation resources on the system. The challenge for grid owners and

operators is to make certain that we maintain the sophistication to be able to instantaneously translate this data into the information operators will need to perform their jobs.

PJM's Smart Grid vision contemplates transitioning the system from one which is highly dependent on human interaction to a system that is highly monitored and provides human operators with the best of current and future computing technology. Advanced transmission technologies such as super conducting and other devices that are also considered part of the Smart Grid will further produce a system that is capable of moving energy more efficiently than the current system allows.

There are several direct benefits of this transformation. First, having a highly monitored transmission system will enable the grid itself to better optimize the performance of the system than can be accomplished today. Voltage and current can be monitored continuously and the system will be able to automatically adjust performance of the component parts. This will in turn allow operators the ability to manage the throughput on the system more accurately and efficiently. The societal benefits will include a more secure and efficient system from both an economic and environmental perspective. These objectives will be accomplished through the reduction of unaccounted-for energy, the reduction of transmission congestion since the grid assets will be operated at higher and more accurate limits, and the more efficient use of generation resources. In other words, to use our engine analogy, consumer demands will be met by a better running and operated machine.

The presence of monitoring devices will also increase the asset management capabilities of owners. By deploying a Smart Grid, owners will not be required to send employees in the field to identify potential problems on the system. Rather, they will have better information about the state of the system and be able to better target employees' repair and restoral efforts.

This will in turn allow owners and operators improved capability to assure the reliability of the system at lower costs.

A Smart Grid also provides operators a better and more rapid opportunity to anticipate disturbances on the system. Today, operators have limited control over the entirety of the grid (which includes the distribution system as well as the high voltage transmission grid) and still make many emergency decisions over the telephone. The grid of the future will have pervasive control systems and rely on secure computers to help identify the best step to take if there is a potential disturbance created by a failed generator or transformer or line outage on the system. System operators will also be able to rely on secure and distributed computing capabilities to develop sophisticated decision support analyses so that they can select the best solution to either optimize the system or to reduce the risk of system failure. We call this a fast look-ahead simulation. The benefits are to provide greater predictability and security. This again allows operators to optimize the operations and secure the system at a much greater level of granularity and certainty.

The third advantage of a Smart Grid becomes readily apparent when there is in fact a significant disturbance. One critical goal of the Smart Grid is known as "islanding" or grid-sectionalization. This occurs when there is a disturbance. In these circumstances, pre-identified solutions will cause the affected part of the grid to "island" itself into defined self-sustaining regions. This avoids the type of cascading failures we witnessed in 2003 and also, when there is a failure, allows for much quicker and easier restoration. In turn, our economy and society as a whole realizes the direct benefit of a reduction in the risk and costs of widespread blackouts.

3. The Smart Grid will help reduce electric prices and produce environmental benefit by promoting a customer-centric electric energy marketplace

One of the primary lessons that PJM has learned repeatedly over the last ten years is that the information ubiquity provided by organized markets is the single most important factor differentiating well-functioning markets. With accurate and timely market information about the value of their generating asset to the marketplace, owners of generation operate their generating assets more efficiently which, in turn, makes electricity available at lower costs to consumers. With timely and accurate pricing information, the grid works better. PJM operators are able to find ways to optimize the system continuously by dispatching the lowest priced generator among a broad diversity of resources. Information availability and markets also allows greater diversity of resources and innovation. Wind generators and other forms of interruptible resources can compete more efficiently in the marketplace by participating on their own terms – not terms dictated by traditional utility operations. Finally, and most importantly, we have also learned in the last several years, that with real time information ubiquity provided by markets, end-use customers have the opportunity to participate in the electricity market and as a result save money and contribute to a cleaner environment.

As I mentioned, one of the chief attributes that contributes to the complexity of the electric power system is that electricity is not able to be stored in large quantities. To keep the lights on, the operator must keep the system in balance – which on a real-time basis means continuously increasing or decreasing the output of generators to meet the electric demands of customers and the economy as a whole. In a competitive market, we accomplish this objective by selecting the generators based on their price – and in the absence of reliability requirements – the generator payment is based on the lowest incremental price offered for that time period.

Until the last several years, competition in the electric industry has largely been characterized by the ability of customers to choose among generators at the wholesale level and, in certain states, suppliers at the retail level. However, several years ago, PJM and its members changed the characteristic of the wholesale market by starting to match every source of revenues provided to generators that sell their energy and capacity into the market to a similar revenue source for load customers who are willing to sell their demand into the market.

As I stated, as a reliability operator, PJM's responsibility is to make certain that generation and load are in balance. As an independent market administrator, we are indifferent whether that next megawatt of change occurs because we are increasing generation or decreasing load. When operating the grid in real time, PJM is also indifferent to the next megawatt of supply or demand that is produced or saved due to the operations of a central station power plant, a wind generator, a roof-top solar device, a stand-by combined cycle turbine at a manufacturing plant, a restaurant dimming its lighting or a family turning down the air conditioner. For the market and the system, that next megawatt has the same value. For customers however, there is a clear difference – since the price of electricity varies depending on the level of load on the system, reducing load by controlling demand allows us to run less expensive generation which ultimately saves customers money.

The benefit, of course, is a more efficient economic marketplace, both in terms of the economy and the environment. For example, during the week of extreme peak conditions last August, PJM calculated that it paid demand providers approximately $5 million to participate in reducing demand in the wholesale market. As a consequence, reducing that demand reduced the incremental price of electricity by approximately $650 million. On the assumption that during this period, PJM would have been dispatching coal or oil plants, the savings could also be seen

as a reduction of 1,367 tons of coal or 15,855 barrels of oil. Similarly, a study prepared by the Brattle Group for PJM and a coalition of Mid-Atlantic State Commissions showed that a modest reduction in electricity usage by 3% through demand response could save consumers, on an extremely conservative basis, up to $182 million annually. I would note that this calculation only involved a portion of the PJM region. However, for demand response to work most effectively, we must have the ability to know with certainty that the load on the system is reducing in response to the price, similar to what now occurs when generating units produce more or less electricity.

For PJM then the issue is a truly a no-brainer. We have an opportunity and, I would suggest from a societal standpoint, an obligation to continue to promote demand response as a critical component of our electric market. The future as we would like to see it requires transforming wholesale competition, which today is almost exclusively among generators of power, to a new form of competition where customers are empowered, through interactive technology, to be able to select how much electricity they want to purchase, at what price, from what vendor and at what time. In other words, a truly customer-focused market that enables new technologies such as advanced metering, plug-in cars and distributed generation and storage, will result in innovative new ways of providing electric service at a net benefit to the economy and the environment.

To achieve this vision, we will need certain key elements in place. First, and most important, customers, whether directly or through an automatic metering device, need to receive timely price information so that they know the value of reducing or altering usage and can respond accordingly. Second, as the system operator, PJM has to have accurate information that the load is responding to price – otherwise we cannot guarantee reliability. Depending on the

size of the customer load, this information can be provided directly or through the local utility. Third, since we are now talking about numerous devices on the system working in concert (a true network), we will need to make sure that these devices are interoperable. The PJM energy management system, the brains of our network, must be able to use the same communication protocol whether that information is coming from a large central station generator or an individual "smart" appliance in the home. Fourth, PJM and third parties will need to develop the computing capability to optimize this system. Today, PJM processes approximately 88,000 bits of information every two to three seconds. In the future, as we operate the system as a complex network of centralized and dispersed generators – in essence, an intelligent grid with active consumer participation – the information needs and the ability of computers to process that information will increase significantly.

4. The actions and pubic policy efforts that will support Smart Grid development

PJM has identified several actions that we believe should be taken today to support development of the Smart Grid. There is no one government or business organization that can make the Smart Grid happen all at once. Rather, from our perspective there are activities that have to be taken at the federal and state levels and among all segments of the industry for the transformation to occur. With that said, however, we believe that there are some first steps that Congress can and should support:

- **Development of a regional technology plan** – Today PJM and its members and stakeholders develop long-term regional transmission plans that are designed to identify the transmission infrastructure required to assure reliability and economic efficiency. We believe that for the Smart Grid to develop we should work with our asset owners to develop a living technology plan to ensure that we have a coordinated, deliberate and realistic plan to make this transformation. In our view, this collaboration is essential to

make sure that, in the end, the installations that are being made throughout the system will work together to achieve our common goals.

- **Promotion of horizontal network systems, including standard communication protocol and service oriented architecture** – Industry and policy makers must support the development of a web-based communications network that uses service oriented architecture to enable the Smart Grid network. In other words, industry and government must insist on the goal of interoperability to ensure that all devices on the system are able to communicate. This is the same sort of common information protocol that enabled the Internet. We believe that Congress can help "jump-start" this effort through encouraging the industry to develop uniform interoperability protocols, the equivalent of open network architecture that guided the development of today's telecommunications network. Today, there are a plethora of agencies with jurisdiction over some part of the Smart Grid – ranging from state PUCs, to the Departments of Energy and Homeland Security to the Federal Energy Regulatory Commission. We believe that a coordinated effort among these agencies can help to reinforce industry efforts at developing common protocols.
- **Regulatory reform at multiple levels** – We need to look at the current methods in place to regulate retail and wholesale utilities and identify any and all impediments to Smart Grid implementation. For example, industry and regulators must examine whether the timing and mechanisms currently used to recover capital assets are impediments to investment in new infrastructure and technology. We believe it is incumbent on regulators to examine methods for regulating retail utilities which might inadvertently be serving as impediments to advancing energy efficiency and demand response. If utilities are only economically rewarded for increasing throughput and making new investment in

traditional generation, transmission and distribution plant, it will be difficult for them to embrace a regime where the goal is less throughput and increased consumption efficiencies.

In closing, we are on the precipice of requiring billions of dollars of investment in the electric industry, including billions of dollars in transmission infrastructure. This investment is necessary to ensure the continuing reliability of our electric infrastructure and hence, the well being of our nation's economy. The challenge and opportunity before us must be to ensure that investments in technology and infrastructure are transformational and will allow us to secure a reliable, economically efficient and environmentally-responsible industry future.

Thank you.