COMMONWEALTH OF VIRGINIA
STATE CORPORATION COMMISSION

APPLICATION OF

PATH ALLEGHENY VIRGINIA TRANSMISSION CORPORATION

CASE NO. PUE-2009-00043

For certificates of public convenience
and necessity to construct facilities:
765 kV Transmission Line through
Loudoun, Frederick, and Clarke Counties

DIRECT TESTIMONY

GEORGE LOEHR

On Behalf of the Sierra Club

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TESTIMONY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is George C. Loehr, and my business address is 4101 Killington Rd. NW, Albuquerque, NM 87114.

Q. BY WHOM ARE YOU EMPLOYED?

A. At present, I am self-employed.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND AND PROFESSIONAL EXPERIENCE.

A. I received a Bachelor of Electrical Engineering degree from Manhattan College in 1962, and immediately began my engineering career with the Consolidated Edison Company of New York, working in bulk power transmission planning. I also pursued graduate studies at New York University, from which I received a Master of Arts in English Literature in 1964. Also in 1964, Con Edison enrolled me in the General Electric

Power Systems Engineering Course (PSEC) in Schenectady, NY, which I completed in 1965. Following the 1965 Northeast Blackout, I was actively involved in a wide range of follow-up activities. For example, I was Chairman of the Computer Committee, Federal Power Commission System Studies Group, Interconnected System. My committee completed an accurate computer simulation of the event – the first such successful simulation of a widespread power failure in North America. I was later named Division Engineer of Con Edison's Transmission Planning Division.

I joined the New York Power Authority (NYPA) as Chief Planning Engineer in 1969. Up until that time, all of NYPA's system planning had been by consultants, and my first assignment was to recruit and train a planning staff. I was responsible for management of the planning staff and the conduct of all NYPA bulk power system generation and transmission planning activities, which included load flow, transient stability, and loss of load expectation studies. I also served on many New York Power Pool and Northeast Power Coordinating Council committees and task forces.

I was hired by the Northeast Power Coordinating Council (NPCC) in 1972. Again, my first assignment was to recruit and train a technical staff. My major responsibilities were to manage the NPCC staff, which worked in support of the eight NPCC expert task forces, and to advise NPCC's Joint Coordinating Committees and Executive Committee. I became very active in regional, national and North American Electric Reliability Council (NERC) activities, and served on numerous committees, subcommittees and task forces. I also served on a Federal Power Commission advisory committee following the

1977 New York City Blackout. I was named Executive Director of NPCC in 1989, and remained in that position until my (early) retirement in 1997.

Since retiring from the NPCC, I have done management consulting, appeared as an expert witness, and taught a variety of courses on power systems – especially courses and workshops for non-technical professionals. My clients have included organizations throughout the U.S., Canada, and China.

At present, I am an Unaffiliated Member of the Executive Committee of the New York State Reliability Council (NYSRC), and currently serve as its Chair; I formerly chaired the NYSRC's Reliability Compliance Monitoring Subcommittee. In addition, I serve as an Outside Director on the Board of Directors of the Georgia System Operations Corporation (GSOC), and as a member of its Audit Committee. I have served as Vice President and a member of the Board of Directors of the American Education Institute (AEI), and I was a charter member of Power Engineers Supporting Truth (PEST). I have given expert testimony in the states of Maine, Pennsylvania, New York, Vermont, Kentucky, New Mexico, Mississippi, and in Washington, DC. I have done TV interviews with BBC, CNN, WPIX and CBC, and have been a lecturer, keynote speaker, and/or chair at professional conferences in the U.S. and Canada. In addition, I've made audio tape lectures for various organizations, including the Institute of Electrical and Electronics Engineers (IEEE), Professional Development Options, Red Vector, and AEI. My articles have appeared widely in the trade press, including *Public Utilities Fortnightly*, *Electrical World*, *The Electricity Journal*, *Electricity Daily*, *Transmission &*

Distribution World, Energy Perspective, Restructuring Today, Energy Pulse, Natural Gas & Electricity, EnergyBiz, and the Belgian magazine, *Revue E tijdschrift*. I have been quoted in a number of U.S. newspapers, and interviewed on Michigan public radio. *The New York Times* published an op-ed piece of mine in 2006. I am co-editor of and a contributor to the IEEE book, *The Evolution of Electric Power Transmission Under Deregulation*.

In addition to my engineering career, I am a published author, have exhibited my art photographs at galleries in the New York metropolitan area, and have done stock photography for The Image Bank, a world-wide photo agency. My photos have appeared in numerous magazines, advertisements, business brochures, in several "coffee table" books, and as a book cover of a best seller. I recently published my own first novel, *Blackout*.

Q. PLEASE EXPLAIN THE MISSION OF THE NEW YORK STATE RELIABILITY COUNCIL (NYSRC).

A. The mission of the New York State Reliability Council is to promote and preserve the reliability of the New York State Power System in the New York Control Area. This mission includes developing, maintaining, and from time-to-time, updating the Reliability Rules which must be complied with by the New York Independent System Operator and all Market Participants. In fulfilling its mission, it works in close conjunction with the New York Independent System Operator. It carries out its mission in accordance with the New York State Reliability Council Agreement and the New York Independent System Operator/New York State Reliability Council Agreement.

Q. PLEASE EXPLAIN THE MISSION OF THE NORTHEAST POWER COORDINATING COUNCIL (NPCC).

A. The Northeast Power Coordinating Council (NPCC) was the first of the Regional Reliability Councils formed after the Northeast Blackout in 1965. Its role was (and is) to ensure the reliability of electric power systems in the northeastern United States and central and eastern Canada by developing, maintaining, and monitoring conformance with reliability criteria for planning and operations. It also provides a forum for the coordination of planning and operating procedures. NPCC's current membership encompasses New York State, the six New England states, and the Canadian provinces of Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. I might add that the main reason I left the New York Power Authority and joined NPCC was my keen interest in reliability and reliability criteria, and my wish to contribute toward making the bulk power system more reliable.

Q. PLEASE EXPLAIN THE ORGANIZATION KNOWN AS POWER ENGINEERS SUPPORTING TRUTH (PEST).

A. Following the August 14, 2003 blackout, several associates and myself, each with 40 years or more experience in electric power system planning and reliability, decided to form a group to bring out the truth about electric power system reliability. To this end, we established a not-for-profit organization, which we called Power Engineers Supporting Truth (PEST). As we stated in our *Principles*, which were issued in September 2003, our intent was "to identify the best ways to make the bulk power systems in the United States both more reliable and economic." We published several reports over the next few years, and made our reviews and recommendations available to the general public, as well as to interested industry groups, government officials, and the media.

Q. HAS THERE BEEN A COMMON THREAD TO YOUR TESTIMONY IN STATES SUCH AS MAINE, PENNSYLVANIA, NEW YORK, VERMONT, KENTUCKY, NEW MEXICO, AND MISSISSIPPI?

A. Yes. My expert testimony in the various states has focused on bulk power system reliability. So have my TV and radio interviews, my articles in the trade press, and my conversations with reporters and journalists.

Q. WHAT IS THE SUBJECT OF THE COURSES AND WORKSHOPS YOU NOW TEACH?

A. Virtually all of my courses and workshops, my speeches and lectures, and my audio tapes primarily address two subjects: how the interconnected bulk power system (or "grid") works, and the importance of keeping it reliable.

Q. HAS MOST OF YOUR CAREER FOCUSED ON ENSURING THE RELIABILITY OF BULK POWER SYSTEMS?

A. I would say that "bulk power system reliability" is the one concept that best characterizes my 47 year career. It is even the main subject of my recently published novel, *Blackout*.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY HERE?

A. I was asked by the Sierra Club to complete an independent evaluation of the PATH application and determine if the applicants had proven a reliability need for the line. I reviewed the PATH application, the testimony and exhibits submitted with the application, and numerous discovery responses and documents from the various parties.

Q. COULD YOU SUMMARIZE YOUR VIEWS?

A. A reliability need for the proposed 765kV line has not been clearly demonstrated. My major reservation is with the assumptions that underlie the contingency studies – especially the conditions assumed for the base case load flows upon which the contingency studies were run. More specifically:

- The applicants and PJM do not have *carte blanche* from NERC. While PJM has been designated by NERC as a Planning Authority (a.k.a. Planning

Coordinator since 2007) and Transmission Planner, it is not authorized to make whatever assumptions it wants when conducting planning studies. In my opinion, the assumptions and base conditions of the applicant's and PJM's studies are not credible and reasonable. Therefore, neither are the conclusions.

- PATH would not improve reliability. Rather, by making eastern load centers all the way from northern New Jersey to northern Virginia more dependent on remote generation and transmission lines hundreds of miles in length, PATH would *exacerbate* reliability.

- PATH would effectively provide a subsidy to existing and future western generators – access to the lucrative eastern load centers without cost to themselves. Conversely, the western subsidies would place eastern generators at a significant disadvantage. This is a clear violation of FERC's "fair and non-discriminatory" principle.

- PATH would encourage remote rather than local generation by providing western generators with free transmission access to eastern load centers. Existing coal-fired generators would be ramped up, and new coal-fired generators would be encouraged to site in the west.

- PATH's approval now, before commitments need to be made for generators and other resources, would be a strong incentive to increase the output of existing coal-fired plants, and for developers to build western generation. It would be a disincentive for developers to site future generation and other resources in the East, where they're most needed.

• PJM planning studies represent future generators which have executed only a Facilities Study Agreement (FSA) if they add to a reliability problem, but require the next step, an Interconnection Services Agreement (ISA), if they contribute to a solution. This is a clear case of bias, and violates FERC's "fair and non-discriminatory" principle. More important, it does not make engineering sense.

• The applicants seem focused almost exclusively on AC EHV transmission. Non-transmission alternatives, and even other transmission alternatives like HVDC, have been ignored.

• PJM's one-at-a-time planning is a piecemeal approach to solving reliability problems. PJM, as the RTO, needs to step up to the plate and start planning its system on a coordinated, integrated basis.

• In my view, the Load Deliverability procedure used by PJM comes up with Capacity Emergency Transfer Objective (CETO) values that are unnecessarily high, and seems out of synch with what the rest of the industry is doing. There are better, more systematic and technically consistent ways to determine the import capabilities required by Load Deliverability Areas (LDAs) to maintain reliability.

- Without PATH, the capability of the Mid-Atlantic LDA to import power would still be in excess of 6,000MW. In other words, with a 6,000MW transfer into the Mid-Atlantic area, there would be no reliability violations. Not one.

- In my opinion, NERC violations have not been established since the base case assumptions are too conservative. So, too, are the CETO/Load Deliverability procedures.

- PJM's procedure for establishing CETO values is far more conservative than other eastern ISO/RTOs. It's ultra-conservative when compared to New York and New England.

- In general, the PJM process for assessing reliability and determining "need" seems to favor extreme solutions – solutions far more massive than necessary. This overkill approach violates an important engineering principle: "Don't use a pile driver to hammer tacks."

- All of PJM's load deliverability testing, which it relied on in determining the need for PATH, was based on a single dispatch. NERC standards call for multiple dispatch scenarios: according to a NERC interpretation of Standards

TPL-002 and -003, "a variety of possible dispatches should be included in planning analyses."

• While NERC Planning Standards call for the system to be stressed, the interpretation of "stress" must be reasonable. PJM and the applicants take the concept of "stress" to unreasonable extremes.

• PATH isn't really about reliability – it's about economics. While western generators would earn greater profits, eastern load centers would become more dependent on long EHV transmission lines; thus major East Coast cities like Philadelphia, Baltimore, Washington and Richmond would become more vulnerable to interruptions and blackouts, either from natural phenomena or from terrorist attacks.

• The alleged "voltage stability" problems have not been proven. We've been shown "knee-of-the-curve" results from steady state load flows, but no actual time-domain stability results. The alleged voltage violations are also based on the unnecessarily high CETO values. At more realistic CETOs, there would be no violations.

• Other than construction of the 765kV PATH line, solutions to the alleged steady state voltage violations have not been addressed. Apparently, neither power factor improvements by adding capacitors at the distribution and subtransmission level, nor shunt capacitors at 115/138kV substations, have been considered.

• Despite the fact that the latest "re-tool" analyses show different violations occurring on lower voltage facilities in a time-frame further out in the future, no alternatives to PATH as originally proposed have been examined.

• Conclusions regarding reliability violations beyond the 2014 study year were based on extrapolated results. In my opinion, this is not an acceptable way to assess the reliability of plan the bulk power transmission system.

• The PATH "solution" is not consistent with the alleged need to improve reliability. To improve reliability, PJM needs to promote the location of generation and other resources close to the load centers, rather than build a transmission line which will provide an incentive for the construction of generation, probably coal-fired, hundreds of miles away.

• The *real* reliability problem in PJM is the present high dependence of the eastern load centers on remote generation and multiple EHV transmission lines, each hundreds of miles long. *This* is the problem PJM should be addressing; instead, PJM is pursuing policies which will make the problem worse.

Q. PLEASE EXPLAIN THE HISTORY AND BASIC CONCEPTS INVOLVED IN BULK POWER SYSTEM PLANNING AND RELIABILITY

A. Among the more important considerations when dealing with large power systems are the reliability standards or criteria used for planning and operations. These have been an integral part of the electric power industry since the very first systems were developed in the late 19th Century, but they became increasingly important as power systems expanded and merged to form what we now know as synchronous interconnections, or simply "grids."

Early "central station" systems were relatively simple. A major disturbance or "contingency" could, at worst, shut down electric service in a small area – e.g., one square mile. But the introduction of high voltage alternating current technology permitted the use of long lines at higher voltage. This led to power systems which spanned progressively larger areas. Also, systems found it advantageous to share generating reserves, and minimize reliability risks from transmission problems, by interconnecting with each other.

This process took place through most of the 20th Century until, by the early 1960s, power systems in most of the U.S. and Canada had coalesced into four large synchronous interconnections or "grids." The largest of these, the Eastern Interconnection, stretches from the Canadian Maritimes to Florida, and from the Atlantic Ocean roughly to eastern Montana, Wyoming, Colorado and New Mexico. It encompasses all eastern, central and prairie provinces of Canada except Quebec and Newfoundland. The Western Interconnection runs from the Rockies to the Pacific Coast, and includes the Canadian provinces of Alberta and British Columbia, as well as a small portion of the northern Baja in Mexico. The ERCOT Interconnection comprises approximately 75% of the state of Texas. Finally, the Quebec Interconnection consists of that province in its entirety.

Power system planning begins with today's system – electric system planners do not have the option of throwing away last year's (or last decade's) thinking and starting over from scratch. So the power system as it exists is the starting point. Along with that, planners must begin with today's system demand levels, and predict or "forecast" how customer actions will affect electric demand in the future. In the present "deregulated" or "restructured" electric power industry, the ownership of generating resources in many states is separate from the ownership of the bulk power transmission system. Generation is also competitive – various companies vie with one another in an open market.

There are two aspects to effective reliability: "resource adequacy," having enough generation and other resources to meet the customers' electrical demand; and "transmission reliability," the ability of the transmission system to deliver the power and withstand sudden contingencies without overloads, low voltages, instability, or loss of customer load. To meet these twin goals, power systems must establish certain standards for both planning and operations.

Resource adequacy (generation, DSM, etc.) is determined on a probabilistic basis. In most North America systems, the generally applied standard is “one day in ten years.” This means that sufficient resources must be available to serve all firm customer demand on all but one day over a ten year period. Resource adequacy problems, or shortages in generating capacity and other resources, can lead to voltage reductions (or “brownouts”), public appeals, and rotating feeder outages. By their nature, they can usually be anticipated in advance, and actions taken ahead of time.

Transmission reliability is assessed on a deterministic basis. Transmission planning standards or criteria specify a variety of specific disturbances or “contingencies” – the bulk power system must be able to withstand any of these without adverse consequences. Failures of the transmission system can lead to overloads, cascading outages, instability, system separations – and total blackouts over widespread areas. They almost always occur without warning, and can rarely be anticipated; hence, preventive actions, other than scrupulous adherence to standards and criteria, generally are not possible.

Blackouts are usually caused by contingencies more severe than those specified in the applicable standards or criteria, by equipment failures, control system problems, human error, or some combination of these. They involve the break-up of the bulk power transmission system. Blackouts are not caused by shortages of generating capacity.

During the first half of the 20th Century, individual power systems each developed and applied their own planning criteria. By mid-century, however, with the dramatic growth of synchronous interconnections and the increasing use of the system to transmit power over long distances, the limitations of such an approach were becoming obvious. When the Northeast Blackout of 1965 occurred, it was plain to see that a more coordinated approach was necessary.

PJM, which had a much smaller footprint in 1965 than it has today, was already functioning with a uniform set of criteria. The systems involved in the 1965 blackout soon followed suit. Shortly after the blackout, they formed the Northeast Power Coordinating Council (NPCC). Other utilities across North America also formed their own regional reliability councils, which eventually encompassed most of the continent.

Each regional council established its own reliability criteria. Each also developed procedures for assessing conformance. Individual systems and power pools sometimes developed their own more detailed or more stringent criteria, but they were always responsible for adherence to the regional criteria as a minimum.

The regional reliability councils formed the National Electric Reliability Council (NERC) in 1968 to coordinate their activities nationally and develop overall reliability guidelines for their collective systems. NERC has evolved over the years. As additional Canadian systems became members, it became the North American Electric Reliability Council. But the most dramatic changes occurred in the wake of the August 14, 2003 Midwest/Middle Atlantic blackout. The Energy Policy Act of 2005 (EPAct) directed FERC to establish an Electric Reliability Organization (ERO). Its major role would be to develop and enforce mandatory reliability standards for planning and operations. After a period of study, FERC designated NERC as the ERO, and its name was changed to the North American Electric Reliability Council Inc.

Today, NERC develops reliability standards, which must be approved by FERC. The regional reliability councils may have their own criteria, but these must conform to NERC's. As provided by EPAct, compliance with NERC standards is mandatory. ISOs, RTOs and individual utilities, as well as all other market participants like generators and power marketers, are members of the regional reliability councils and must comply with both the regional criteria and NERC standards.

NERC planning standards require both short- and long-term studies. Any violations discovered in the short-term analyses must be addressed with appropriate solutions. On the other hand, the purpose of the long-term studies is to provide some indication of the nature and direction of future reliability problems, and to ensure that any recommended short-term solutions will be consistent with future needs.

Q. HOW ARE STANDARDS AND CRITERIA USED IN TRANSMISSION PLANNING?

A. The first step in evaluating the potential reliability need for new facilities is to investigate the existing transmission system for a chosen future year, with existing and planned generating resources added, along with any transmission additions already scheduled. First, power flow or “base load flow” cases are created, representing base conditions – generally, peak loads under various generation scenarios. Then, new load flow cases are run simulating a wide range of potential disturbances or contingencies. The results of these contingency load flows will indicate where and to what extent the existing system needs reinforcement. At this point, familiarity with the system and engineering judgment will usually suggest potential solutions to the violations, and typically several will be chosen for further scrutiny. The most successful enhancement will be chosen, consistent with a parallel cost-effectiveness analysis. Finally, non-transmission alternatives should also be identified and examined, and compared in terms of cost, reliability, and environmental impact with the preferred transmission solution.

One of the key questions is how severe the contingencies should be. Over the past fifty years, planning engineers have reached a consensus on what is commonly known as “worst single contingency” design – a.k.a. “n-1.” This means that the system must be able to survive the worst single event which could happen to the bulk power system. Typically, this is the loss of a large generating unit, or a three-phase fault on a major transmission line or autotransformer. But the devil, as is said, is in the details.

Current NERC standards allow the planning entity a degree of judgment. NERC’s TPL-002 and TPL-003, for example, require that the pre-disturbance system be *stressed*; however, the nature of the “stress” is not defined – despite several requests from transmission companies for a more definitive interpretation. It’s up to the planning entity to fill in the details.

Specifically, NERC states in its February 8, 2005 interpretation of Standards TPL-002 and -003 that “a variety of possible dispatches should be included in planning analyses.” NERC also specifies that the “selection of ‘critical system conditions’ and its associated generation dispatch falls within the purview of [the Planning Coordinator’s] ‘methodology.’” Finally, NERC directs that “a Planning Coordinator would formulate critical system conditions that may involve a range of critical generator unit outages as part of the possible generator dispatch scenarios.” One of the problems I have with the PJM approach is that only a single dispatch is used for all of the load deliverability analyses relied on in this proceeding.

Base conditions provide another example where the planning entity’s judgment is required. This would include assumptions regarding appropriate load level, the handling of proposed new generation, the potential retirement or older generating units, and the dispatch of the overall system. Dispatch scenarios, which can be viewed as the bridge between “adequacy” (sufficiency of resources) and “operating reliability” (transmission reliability), are of particular interest. Generally, the best approach is to examine several different dispatch scenarios – varying the components and applying the most serious contingencies in each example.

Many planning entities today use a so-called “90/10” load forecast, as opposed to a “50/50” forecast, as one of many ways to satisfy the NERC “critical system conditions” requirement. This means that there is a 10% probability that the actual load will exceed the forecast demand, and a 90% probability that the actual peak demand will be lower.

In conducting planning studies, the critical contingencies as defined by the NERC standards are applied to the modeled system for each chosen scenario. Some of these contingencies will involve the sudden loss of a single element (n-1) – this could be a generating unit, critical transmission line, transformer, or any other power system component. Others contingencies will cause simultaneous loss of two related elements – such as both circuits of a double-circuit transmission line. Since the loss of both elements is caused by a single event, these are also referred to as n-1 contingencies. A few will involve the loss of two unrelated elements (n-1-1), with manual system adjustments between the two contingencies (usually within 10 minutes). Regardless of the contingency applied, the system must suffer no overloads, low voltages, cascading outages, instability, system separation or loss of firm customer load before adjustment.

Q. ARE THE RELIABILITY STANDARDS MANDATED BY NERC?

A. For some time, NERC has developed reliability standards for planning and operations. As a result of the Energy Policy Act of 2005 (EPAct), these are now mandatory under federal law. The NERC planning standards define the contingencies which the power system must be able to survive without significant adverse consequences – overloads, low voltages, instability, system separations, or blackouts. However, the NERC standards do *not* define the configuration of the system to which these contingencies are applied, other than to say that the system must be stressed – assumed base conditions must "cover critical system conditions and study years as deemed appropriate by the responsible entity." [NERC Standards TPL-002-0 and TPL-

003-0.]   But the nature of the "critical system conditions" must be credible and reasonable.

NERC has designated various entities, including PJM, as Planning Authorities (Planning Coordinators) and Transmission Planners, as described in the NERC Functional Model. These are responsible for deciding how their systems will be configured – stressed – for application of the NERC contingencies. As NERC has stated, "The selection of a credible generation dispatch for the modeling of critical system conditions is within the discretion of the Planning Authority." [March 13, 2008 NERC Planning Committee interpretation of TPL-002-0 and TPL-003-0.] The language here (e.g. use of the word "credible") clearly indicates that the assumptions must have a basis in reality.

NERC does not scrutinize the manner in which the PJM or any planning entity's system is represented. Neither does FERC. NERC and FERC are not the drivers – the applicants and PJM are the drivers. And they must answer for the base system assumptions they have made.

In my opinion as an expert, the manner in which PJM and the applicants configured the PJM system prior to the application of contingencies went considerably beyond what I consider reasonable. If the base assumptions are not credible, then the contingency analyses based on them are not credible – even though the applied contingencies are those specified in the NERC standards. A house built on sand will not stand. The PATH studies are built on sand; they're based on assumptions, how the PJM system is represented, which are neither credible nor reasonable. Therefore, neither are the conclusions.

Q. BUT NERC HAS DESIGNATED PJM AS A PLANNING AUTHORITY AND TRANSMISSION PLANNER. DOESN'T THAT GIVE PJM AUTHORITY TO MAKE THESE DECISIONS?

A. Not completely – the assumptions must be credible and reasonable. NERC's designation of PJM and other entities as Planning Authorities and Transmission Planners does not give them *carte blanche* to make whatever assumptions they want when conducting reliability assessments and planning studies. NERC neither supports nor condemns PJM's decisions about base conditions – the PJM Load and Generation Deliverability procedure, for example. NERC doesn't endorse *any* planning entity's specific approach. Therefore, the applicants cannot hide behind PJM's designation as a Planning Authority and Transmission Planner to support the need for PATH.

Q. DO YOU BELIEVE THE PATH VIOLATIONS ARE REASONABLE?

A. No. The alleged violations are based on the applicants' initial assumptions, and in my view those are *not* reasonable. Why I believe that the procedures used in the PATH studies are not reasonable is covered in the remainder of my testimony. But the major objection I have is with what I consider an overly conservative process for determining the Capacity Emergency Transfer Objective (CETO), leading to an import target for the

LDA which is unnecessarily high. When the load flows are run to determine if there are any NERC violations, they use this import value; since it's unnecessarily high, finding "violations" is practically guaranteed. With a more reasonable import value, neither thermal nor voltage violations will be found.

Overall, PJM's and applicants' procedures are overly conservative. They pile conservative assumptions on top of conservative assumptions – beyond what, in my opinion, is reasonable.   In brief, they push the "conservative" envelope too far.

Q. PLEASE COMMENT ON THE USE OF "CAPACITY EMERGENCY TRANSFER OBJECTIVE" BY PJM AND THE APPLICANTS.

A. For any defined Load Deliverability Area (LDA), PJM does a Loss of Load Expectation (LOLE) study to determine the import capability necessary to maintain a "one day in 25 years" LOLE. This is then called the Capacity Emergency Transfer Objective (CETO) for that LDA. The CETO value is based, among other things, on the load forecast. A mean or median schedule is developed for the LDA, using the same probabilistic statistics as in the LOLE, to accommodate an import equal to the CETO. Next, load flow cases are run at that value, simulating the various requirements of NERC Planning Standards TPL-001, -002, and -003. If the existing transmission system results in "violations" for any of these (A, B, and C), the planners conclude that a transmission reinforcement is required. PJM maintains that they're only permitted to consider transmission reinforcements.

In theory, the Capacity Emergency Transfer Objective (CETO) is the amount of import capability which the LDA geo-electric area would require to allow it to satisfy a chosen loss of load expectation, given its load characteristics and the amount of generation it contains.

Mr. McGlynn discusses the Mid-Atlantic LDA at some length in his testimony. He cites the Mid-Atlantic LDA's CETO used in PJM's April 2009 modeling as 8,190MW [McGlynn, page 28.]. In my opinion, the 8,000MW+ value he comes up with as the CETO is breathtakingly (and unnecessarily) high. That's an awful lot of power to transfer into eastern PJM from the West. It's a very large value to expect to export to *any* single area – something like one MW for every eight MWs of peak load. One has to ask if this is really a reliable way to supply a high percentage of the electric requirements of a metropolitan area that stretches from northern New Jersey to northern Virginia. That entire megalopolis would be subject to interruption by many and diverse causes, natural and human, intentional as well as unintentional. The present import capability of the Mid-Atlantic LDA is in excess of 6,000MW – a pretty high number itself. (Exhibit PFM3 lists the most restrictive contingency at a Mid-Atlantic LDA import of 6,240MW.) In other words, without PATH, it would still be possible to send more than of 6,000MW into eastern PJM. According to the PATH response to SierraVA-IV-61, there is 67,635MW of generating capacity in the Mid-Atlantic LDA as of October 2009 – *right now*. Given this amount of *existing* generating capacity, not even counting whatever additional capacity will be added over the next five years, why isn't a 6,000MW CETO enough? PJM should place greater emphasis on incenting new generation to locate within the Mid-Atlantic LDA, which would provide greater reliability to the eastern load centers.

In responding to the VAStaff-V-5 request for updated data on the Mid-Atlantic LDA, PJM cited a lower peak load forecast for 2014, an 827MW increase in installed capacity, and a lower CETO value – 7,720MW. This CETO reduction of 470MW further reduces any alleged "need" for the PATH line.

PJM's "one day in 25 years" standard – used to come up with the CETO number – is also questionable. This is a conservative assumption, PJM admits – part of the need to "stress" the system. To my knowledge, no other RTO or ISO uses a value this high. Why shouldn't PJM use "one day in 10 years," like everyone else? By comparison, one day in 25 years is a higher standard than that used by either ISO New England or the New York ISO, each of which is only about half the size of the Mid-Atlantic LDA. And this is on top of a 90/10 load representation, which would be expected to occur only once every ten years. PJM seems to pile one conservative assumption on top of another.

In fact, I would question whether a criterion of "one day in 10 years" for all of PJM is itself overly conservative, given the large size of the expanded PJM system. The New England and New York ISOs each use an adequacy criterion of one day in 10 years, yet each is approximately one-fourth the size (in MWs) of the PJM system. Standardized to the PJM peak load, New England and New York at one day in 10 years would be equivalent to *four* days in 10 years. New York and New England include metropolitan areas at least as critical as PJM's; why should PJM use a much more conservative reliability criterion? In my opinion, it would not be unreasonable for PJM to use a less conservative criterion, more in keeping with its peak load relative to other ISO/RTOs like the New York ISO and ISO New England. For example, just by changing from a criterion of one day in 25 years to one day in 10 years for the Mid-Atlantic LDA, and putting it on the same loss of load expectation basis as New York and New England, PJM could lower the CETO for the Mid-Atlantic LDA by approximately 3,000MW.

There are other, and in my opinion better, ways to do this kind of analysis. For example, when it studies the LOLE of the entire PJM system to calculate the required installed reserve margin, PJM uses a multi-area probabilistic program. It does not model separate areas within PJM, however. PJM could use the same program to model all the LDAs along with the existing transmission transfer capabilities between them, and still target an overall LOLE criterion. A need to increase any of the inter-area transfer capabilities would be evident from such an analysis. Thus PJM could unify the process, and also meet the desired objective vis-à-vis the overall PJM system.

In fact, PJM's process for addressing reliability "need" is far more conservative than necessary. In an earlier case (the proposed Prexy facilities in southwestern Pennsylvania), this overly conservative approach led to a recommendation for a major new 500kV transmission line, which was approved by PJM. In my opinion, such a high voltage facility was clearly unnecessary, and I testified to this during the proceedings. After the state hearings were mostly concluded, the PUC ordered a voluntary collaborative effort. This led to a much simpler, less expensive, and less environmentally intrusive solution involving modifications to the local 138kV system and the addition of shunt capacitors.

The proposed Prexy Facilities were to consist of a new 500kV substation in Washington County called “Prexy”, a new 500kV transmission line (36 miles long) in Washington and Greene counties, and three new 138kV lines (running 15 miles) to connect the proposed new substation to the existing transmission system. After the collaborative process, the approved fix reinforced the electric grid without any new 500 kV lines, substations, or 138 kV lines. Instead, it involved installing one new monopole on an existing utility right of way (to allow the connection of two existing lines), adding equipment (capacitors) at five existing substations, and replacing the conductors on 2.5 miles of existing 138 kV lines. The estimated cost for the agreed-upon fix is $11.6 million, instead of $213 million for the proposed Prexy Facilities. And the solution solved the same reliability issues that were “driving the need” for the previously proposed "Prexy Facilities."

PJM’s approval of the need for Prexy facilities, and PATH in this proceeding, violated an engineering principle which a former professor of mine used to insist on: “Don’t use a pile driver to hammer tacks.”

Q. WOULDN'T THERE BE VIOLATIONS OF THE MANDATORY NERC STANDARDS IF PATH IS NOT BUILT?

A. Not at all. Whether or not violations will occur ultimately depends on the value selected for the CETO. This applies to voltage as well as line loading violations. There would be *no* violations of NERC Standards if realistic CETO values were used. The only reason that "violations" were identified in PJM's studies is that PJM was trying to cram too much power from outside (essentially western PJM) into the eastern LDAs by using unnecessarily high CETO values. It's sort of like a mouse trying to swallow a lion. For the Mid-Atlantic LDA, without PATH, a 6,000MW CETO would result in zero violations. Zero. And the Mid-Atlantic area would still be capable of importing over 6,000MW.

As I see it, based on my more than 47 years of experience in transmission planning and reliability assessment, eastern PJM is *already* too dependent on western generation – this is the *real* reliability problem, and a major reliability risk.

In my opinion, PJM faces a reliability problem – a *serious* reliability problem – which will worsen if PATH is built. It's the overdependence of the eastern PJM load centers on generating units hundreds of miles to the west. The megalopolis from northern New Jersey to northern Virginia is over-dependent on long transmission lines, any one of which could be taken out of service by natural or human agents. This is a *major* problem that needs to be addressed. And it's a *national security problem* as well. PJM should, in my opinion, develop a program to address this problem as soon as possible – but instead PJM is pursuing policies that will only make the problem worse.

Q. WOULDN'T PATH, IN AND OF ITSELF, INCREASE RELIABILITY ANYWAY?

A. No. Rather than *increase* reliability, PATH would actually make it *worse*. Eastern load centers from Boston to northern Virginia comprise what urban planners sometimes call a linear city or megalopolis. It's essentially one continuous metropolitan area. Within this linear city, the area from northern New Jersey and Philadelphia to Washington and northern Virginia is part of PJM. If PATH is approved, generating companies will be given a powerful incentive to site new generators in the Allegheny coal fields, hundreds of miles to the west, rather than in or close to the eastern load centers. Even existing coal-fired generators will have the opportunity to ramp up their outputs. This will make the eastern megalopolis even more dependent on remote generation resources than it already is. Cities like Newark, Philadelphia, Wilmington, Baltimore, Washington and Richmond will depend for their electric supply on generators hundreds of miles away. I've been in electric power transmission planning and reliability for more than 47 years, but you don't have to be an engineer to understand that this is a less reliable situation than if the resources were located nearby. It's like running an extension cord down the block to plug your toaster into a neighbor's outlet rather than using an outlet in your own kitchen. The long transmission lines are vulnerable to all sorts of interruptions – including terrorist attack – so this is a national security issue as well as a reliability concern.

More transmission does not equal a higher level of reliability. Consider two hypothetical transmission systems: one a system with a lot of transmission lines, but planned and operated to *less* stringent reliability standards; the other a system with very little transmission, but planned and operated to *more* stringent reliability standards. The first system would be less reliable than the second system, because it uses less stringent reliability standards. <u>Reliability is not a function of the amount of wire in the air</u>.

Now consider what happens when transmission is added. The apparent electrical impedance across the grid is reduced, in effect making it electrically tighter. Thus a given contingency could have a more widespread effect. By increasing the amount of west-to-east transmission in PJM, the proposed PATH line would make the Eastern Interconnection subject to larger blackouts.

This can be visualized in a more technical light. The key factor in the stability of a system is the electrical angle between generators. Building transmission lines reduces the equivalent electrical impedance between generators – the units become electrically closer, and the angle is decreased, which tends to make the system more stable. However, stability will be improved *only if no additional power is scheduled across the system*. If the power flow is increased, then the angle is increased, and the units will be electrically further apart, making the system less stable. My own experience after doing this kind of analysis since the early 1960s is that, even if the impedance is decreased and the power flow increased such that the electrical angles are the same, the system will still be more vulnerable to extreme emergency contingencies – those that are more severe than the criteria used in planning and operations, and which are either the major cause or an important contributing cause of nearly all bulk power system blackouts.

When systems build more transmission only to accommodate higher levels of transfer, they push the system harder. The likelihood of instability is increased; the system is more likely to suffer a blackout if an unforeseen contingency occurs, and the blackout is likely to be larger and more damaging. In my opinion, PJM has not proven a reliability problem that requires the construction of PATH, or that PATH will make the overall system more reliable. However, instead of building the PATH line, reliability could be *improved* by promoting additional generating capacity and other resources in the East, close to the load centers. Lower west-to-east transfers across the PJM system would significantly reduce the angle between generators, making the northeast quadrant of the Eastern interconnection less susceptible to instability and blackouts.

Q. DO YOU THINK THAT PJM PLACES TOO MUCH EMPHASIS ON EXTRA HIGH VOLTAGE (EHV) TRANSMISSION LINES?

A. Very definitely. PJM seems to see EHV AC transmission not as the *best* solution to reliability problems, but as the *only* solution. Under the current PJM cost allocation rules, all transmission facilities at 500kV and higher are "socialized" – i.e. their costs are charged to all the Load Serving Entities (LSEs) in PJM essentially in proportion to their electric loads. This means that all customers throughout the PJM area will pay the construction costs for PATH. Because of this "socialization," PATH will provide existing and future western generators, including coal-fired generators, with free access to the eastern load centers. In effect, western generators will be subsidized at the expense of the ratepayers. It's also a case of discrimination against generators and other resource providers in the East.

In other words, western generators will be given market access to eastern load centers without having to pay the cost of providing that access. Customers throughout PJM will bear the full cost of the new transmission. Western generators, both existing and future, will be able to compete with eastern resources without paying for the transmission that makes it possible. This will skew the economics of electric generation supply by subsidizing some generators at the expense of others – and ultimately at the expense of ratepayers. This is not the "fair and non-discriminatory" market that FERC envisaged in promoting "deregulation."

Q. IT HAS BEEN SAID THAT TRANSMISSION PROJECTS MUST BE APPROVED EARLY ON, SINCE THEIR LEAD TIMES ARE NOW LONGER THAN LEAD TIMES FOR GENERATORS.

A. That's true, but early approval of transmission has another, unanticipated consequence. Transmission lead times are now longer than the lead times for generators. That means that transmission projects will generally be approved before generators or other resource providers need to make their commitments. In other words, generating companies can wait until a major transmission line is approved or disapproved before deciding whether to build new generating units in the East or West. If a new line is not planned, or a proposed line isn't approved, developers could site new units in the East, where long EHV lines would not be required to reach load centers. On the other hand, if a line *is* approved, developers are likely to build in the West, where it would be less expensive, since they will be provided transmission access to the eastern load centers at no cost to themselves.

Such transmission approvals would foreclose other options, including generators sited in the East, load management systems, and greater reliance on Reliability Pricing Model (RPM) solutions in general.

In summary, PATH would provide a strong disincentive to anyone considering locating generation or other resources in eastern PJM, and a correspondingly strong incentive to build coal-fired generation in western PJM. The seeming obsession with transmission solutions will not only provide an effective subsidy to existing generators in the West, but it will act as a magnet for siting future generators there, as opposed to locating in the East, where they are really needed.

Q. ARE THERE ANY OTHER EXAMPLES OF DISCRIMINATION IN THE ASSUMPTIONS UNDERLYING THE PATH STUDIES?

A. Yes. To me, an egregious example of PJM's discrimination is how the representation of planned, future generators is handled. In its planning studies, PJM represents only those generators which have executed a Facilities Study Agreement (FSA). To be represented in the studies, generators which would contribute toward the solution of a reliability problem must also have executed an Interconnection Services Agreement (ISA), the next step after the FSA. However, generators which exacerbate a reliability problem are represented even if they have *not* received an ISA. This is patently discriminatory, and in my view is a direct violation of FERC's "fair and non-discriminatory" principle. In defense of this procedure, Mr. McGlynn testifies that more than 75% of all proposed generators eventually drop out, but adds that "5% of requests drop out after an FSA is executed." [McGlynn, page 13, line 2] Mr. McGlynn testifies that only 5% of requests drop out between the execution of an FSA and an ISA. *By McGlynn's own admission*, there's very little difference between the number of generators that complete FSAs and those that complete ISAs – a mere 5%.

In my opinion, no distinction should be made. Any generator which has an executed FSA should be represented, regardless of whether it exacerbates or solves reliability problems. To intentionally discriminate against the very generators which could solve reliability problems is both foolish and potentially costly. It goes against one of the most important principles of FERC and deregulation – that all generators must be treated in a manner that is both fair and non-discriminatory. Finally, again in my opinion, it represents very poor engineering. Good engineering is premised on even-handedness – PJM's biased handling of future generators, based on whether each would contribute to a problem or its solution, tilts the science toward a presumably desired conclusion which might not be proven by a fair and non-discriminatory approach. This constitutes a bias towards transmission and in favor of western coal-fired generators and against eastern generators and other resources; it is not even-handed at all. Political and economic motives should not be permitted to interfere in the engineering. As I say in my courses, "When the Laws of Physics and the Laws of Economics collide, Physics wins."

Q. DID THE APPLICANTS CONSIDER SUFFICIENT ALTERNATIVES TO PATH?

A. The testimony of the applicants' witnesses indicates that the only alternatives seriously considered during the 2007 RTEP were other AC EHV transmission lines. No alternatives involving non-transmission resources (generation, additional DSM, etc.) in the East, close to the load centers, were examined, even though they might offer distinct advantages in terms of cost, reliability, and environmental impact. Little recognition seems to have been paid to PJM's Reliability Pricing Model (RPM) process – despite the fact that one of its stated purposes is to provide incentives for generators to locate near the eastern load centers. PJM argues that it is not permitted to *order* anything other than transmission – but it certainly could develop policies that would *encourage* non-transmission solutions. Eastern resources seem to rate second-class status as compared to AC EHV transmission. No attention was even paid to transmission alternatives other than alternating current (AC) 500 and 765kV. High Voltage Direct Current (HVDC) alternatives were totally ignored in 2007 – despite HVDC's obvious advantages, and its utilization for other projects in PJM (e.g. Neptune and MAPP). PJM's planning process seems to be wearing blinders – any alleged reliability problems will be addressed by the "same old same old" EHV transmission solutions.

Somewhat belatedly, a “PATH HVDC Conceptual Study” has been initiated. Since this was not mentioned in any of the witnesses’ testimony, we can safely conclude that HVDC was not considered as an alternative while the PATH studies were being conducted, and not evaluated at the time the decision was made to recommend PATH as a 765kV, AC project.

In addition, PJM’s 2009 “re-tool” cases came up with different limiting elements than those relied on for the “need” assessment. These were generally on lower voltage facilities, and occurred further out in time. These differences alone should have suggested that other alternatives need to be explored. But they did not. In brief, the need for PATH was based on problems that no longer exist.

Q. WOULD YOU COMMENT ON PJM’S ONE-AT-A-TIME TRANSMISSION PLANNING?

A. I would describe PJM’s approach to solving its alleged reliability problems as a piecemeal one. In recent years, we’ve witnessed a succession of proposals to build EHV transmission projects in PJM, each designed to solve a list of alleged reliability violations. It seems that no attempt is made to address the problems on an overall, integrated basis. Once a project is approved, it becomes cast in concrete. We’re told it will take care of everything. Until the next one, that is. There never seems to be an attempt to look at what combination of solutions could solve *all* reliability problems/violations with a single overall solution or a set of integrated solutions. Nor does there appear to be any attempt to examine whether a new proposal, perhaps with some modifications, might obviate the need for one already approved.

It seems to me common sense that planning on a piecemeal basis will inevitably result in more facilities being built than would really be necessary to meet the requirements of NERC and other reliability standards. Perhaps a simple, hypothetical example will make this more understandable.

Let's assume that a planning entity follows a "piecemeal" approach. It studies its system, identifies certain reliability violations, and determines that a particular new facility would solve them. Let's assume it gains approval for that facility, and adds that facility to its base assumptions. It then begins another reliability study, and discovers another set of violations. A second facility is planned to fix these violations – it's also approved, and added to the base. A third study is conducted, and a third set of violations appears – and a third facility is identified and added to the base system. And so on through, let's say, seven studies and seven facilities. Is it not common sense that, had the planners looked at the *entire* system, and identified *all* reliability violations, they would almost certainly have been able to develop an "integrated," multi-facility solution which included *fewer* required elements than the earlier, piecemeal approach? A piecemeal approach is neither the best nor most efficient way to plan a system – more facilities will invariably be found to be "needed" than truly would be. That's because the second (or third or fourth) facility may prove to be an efficacious solution to the problems which drove the need for the first (or second or third). The net result will be an overbuilt system, with all the attendant economic, social and environmental consequences.

This bias or tendency toward “piecemeal,” one-at-a-time transmission planning is a grave weakness of the current RTEP process in PJM.

Further, the piecemeal, cast-in-concrete approach forecloses other options. Each new facility goes into all the models, and is assumed in place for all the capacity auctions. Even the possibility of delay or cancellation is ignored. If *uncertainty* is viewed as an important factor for the representation of new generating units, it should also be included for proposed transmission additions.

There’s another problem here. Once PJM, acting as the RTO, has identified one or more violations, it goes to the appropriate transmission owners (TOs) in whose systems the violations occur and in effect orders them to develop a solution. This kind of Balkanization does not serve the interests of overall reliability with minimum expenditure for new facilities. It’s essentially a corollary to piecemeal, one-at-a-time planning. It seems to me that PJM should be more involved in developing overall solutions – and taking a second look at prior solutions, too.

Q. WOULD ADDING TRANSMISSION CAPACITY INTO THE EASTERN LOAD CENTERS MAKE THEM MORE RELIABLE?

A. No. Not if the added transmission results in the load centers being more dependent on remote generation. The more Philadelphia, Baltimore, Washington and Richmond must depend on long distance transmission, the more vulnerable they will be. And lower reliability is an inescapable consequence of greater vulnerability.

A further note. PJM seems to want to build a transmission system capable of delivering every MW from any generator anywhere on the system to any load point in PJM – regardless of reliability need or system conditions at the time. But that's not necessary for a reliable, or even an economically optimum system. On a reliability basis, comparable plans or options would include sufficient transmission capability to maintain an appropriate Loss of Load Expectation overall.

PJM could use Loss of Load Expectation techniques to compare generating capacity and other resources sited close to the load vs. less expensive generation more remote from the load, including the constraints of the intervening transmission system. Economic analyses would consider combinations of greater or lesser percentages of remote and local generation. However, the cost of necessary new transmission, plus incremental system losses, should be included. These costs would, of course, be much higher for remote generation, which would tend to offset any economic advantage it might otherwise have. Yet neither the applicants nor PJM has conducted any such analysis.

Q. IS PATH, IN YOUR OPINION, REALLY ABOUT RELIABILITY?

A. No. PATH is more about economics than reliability. When added to the present import capability in excess of 6,000MW, there is more than enough generating capacity within the constrained Mid-Atlantic LDA to supply all the load all the time. Thus there is no reliability need to increase the import capability by about 2,000MW – from 6,240MW to 8,190MW. This would involve operating more expensive, local generation more frequently; however, reliability would be enhanced, since the Mid-Atlantic LDA would be less dependent on generating capacity hundreds of miles away. Such an approach is called "transmission constrained dispatch," or the use of "out of merit" generation, and is consistent with how the system is actually operated. It's commonly used by most power systems in North America in both planning and operations. It would reduce the chance of widespread interruption, whether from human error, equipment failure, *force majeure*, or terrorist attack. Any increase in generation costs would be offset by savings in transmission construction, at least in part. Finally, and perhaps most important, this case is supposed to be about *reliability*, not *economics*.

In my opinion, PATH isn't just about economics *in general* – it's about *coal-fired* economics. This is clearly illustrated by a presentation made by Mr. Karl Pfirrmann at a FERC Technical conference on May 13, 2005. At the time, he served as President, PJM Interconnection, L.L.C., Western Region. In his Executive Summary, Mr. Pfirrmann describes "the potential for new transmission resources in the region to enhance opportunities for coal based generation to reach eastern markets." The proposal is called Project Mountaineer, and includes "potentially 550 to 900 miles of new backbone 500 or 765 kV transmission at an approximate cost of $3.3 to $3.9 billion." In his written comments, Pfirrmann describes this as a “new initiative … to utilize our regional transmission planning process to explore ways to further develop an efficient *transmission ‘super-highway’ to bring low cost coal resources to market*.” [Emphasis added.] Mr. Pfirrmann also hails “dramatic increases in the amount of power flowing from this region into ‘classic’ PJM, including from coal-based generation,” and offers an exhibit illustrating a 35-40% increase since PJM’s expansion to the west.

We can gain some perspective on this by considering PATH’s predecessor. An EHV line from Amos to eastern PJM was proposed before any “violations” had been indicated. This was in connection with Project Mountaineer, as discussed above. As suggested by Mr. Pfirrmann, Project Mountaineer’s original goal was to provide access to eastern markets for an additional 5,000MW of western generation. The TrAIL and PATH projects, taken together, are remarkably consistent with such an intent. Some might ask, if PATH is approved, what will be next?

Q. WHAT IS YOUR VIEW OF THE VOLTAGE STABILITY PROBLEMS CITED BY MR. McGLYNN?

A. PJM has not proven that the alleged “voltage instability” is a legitimate problem. Mr. McGlynn goes to considerable length to establish voltage instability, but his only evidence – so-called “knee-of-the-curve” analyses – is incomplete. No transient stability results have been shown. “Knee-of-the-curve” analysis is useful as a screening tool, but voltage instability can only be proven by rotor-angle stability analysis in which the dynamic response of the overall system to a sudden disturbance is simulated in the time domain. Neither the applicants nor PJM have presented any such stability results. And all of the cited violations occur at CETO values that I consider to be unnecessarily high. Mr. McGlynn's testimony confirms that there are no voltage issues until transfers into the Mid-Atlantic LDA are well above 6,000MW.

Q. WHAT ABOUT STEADY STATE VOLTAGES, BOTH ABSOLUTE VOLTAGES AND VOLTAGE DROP?

A. Whatever voltage problems may exist might be solved by power factor correction. Low voltage problems, whether on an absolute or a voltage drop basis, are generally an indication that reactive (MVAR) loads are too high relative to active (MW) loads. This is reflected by low power factors – i.e. the ratio of MW to MVA. Reactive (MVAR) load is a natural part of power system load, and comes from various apparatus on customers' premises. It can be reduced by the installation of shunt capacitors or static VAR compensators (SVCs), which supply reactive power. Failure to adequately compensate for reactive load means higher MVAR loads as seen from 115kV and 138kV substations, hence lower power factors. Basically, what happens is that the high reactive loads have to be supplied from remote generators and the EHV system, essentially dragging MVARs through all the impedances of the various transmission lines and transformers. This results in larger voltage drops. [A close approximation of voltage drop can be determined by multiplying the per-unit inductive reactance of a line or transformer times the per-unit MVAR flow through it.] Further, the higher power flows through all the lines and transformers will result in higher reactive (MVAR) I^2X losses, and the consequent need to pull even more reactive power off the EHV system, which leads to larger voltage drops, etc. This phenomenon will only get worse as load grows. The best place to correct power factor is to place shunt capacitors on the subtransmission and distribution system – as close to the load as possible.

Many of the Mid-Atlantic buses listed in PATH's response to SierraVA-IV-51 have power factors below 95% – despite the fact that PJM Manual 14B, Appendix D: "PJM Reliability Planning Criteria" calls for a minimum power factors of 97%.

Power factor correction is in essence a reduction in reactive (MVAR) load, generally by adding shunt capacitors on the distribution and/or subtransmission systems. If this is impractical for some reason, shunt capacitors can be added at 115 and 138kV substation. If for any reason even *that* is impractical, the applicants themselves have suggested the solution – shunt capacitor or SVC additions at higher voltage stations.

Power factor correction (reactive compensation) is an ongoing process – it has to be continued year after year as system load grows. It's part of the continuing obligation of providing good utility service. The applicants do not seem to have examined if the voltage problems could be fixed by improving power factors. Nor have they examined the possibility of adding switchable shunt capacitors to some of the 115/138kV substations. We have been told that a "high level" investigation was made which considered adding shunt capacitors at 500kV and 230kV substations without PATH, and this was deemed to be too expensive. But applicants' witnesses in other states have testified that more than 1700MVAR of shunt capacitance will be required at both terminals of the proposed PATH line! (See Dr. Hyde Merrill's testimony.) In any case, no description of the nature of this "high level" investigation was provided. Without a presentation of the results of power factor and lower voltage substation studies, and an explanation of the reactive additions needed by PATH itself, the alleged voltage problems cannot be proven.

Q. PLEASE DESCRIBE SOME OF YOUR OVERALL IMPRESSIONS OF THIS CASE.

A. PJM and the applicants demonstrate a distinctly "one track mind" in their planning. Alternatives involving means other than an AC EHV transmission line have not been explored – this is true despite the fact that the problems discovered in the 2009 analyses depict dramatically different limiting facilities than those uncovered in 2008. In fact, the 2009 "re-tool" cases came up with a very different set of problems, were less severe, and occurred further out in the future. To most planning engineers, this would suggest that other possible solutions should be examined, but no such attempt has been made. This is especially true if the conclusions are the result of extrapolation. The original PATH proposal remains unchanged, and alternatives remain unexamined.

There's a built-in bias against any other approach; e.g. the way representation of new generators is handled strongly discourages serious consideration of non-transmission alternatives. Even in the area of transmission itself, no alternatives other than 500 and 765kV AC have been examined. A strong case can be made that no additional transmission is needed. But even if additional transmission *is* needed, why hasn't PJM considered building PATH as, for example, an HVDC line? Or why hasn't the conversion of an existing AC line (such as the Mt. Storm-Doubs 500kV line, as suggested by Mr. Merrill) been considered?

As pointed out by my colleague, Dr. Hyde Merrill, all conclusions beyond the study year of 2014 were based on extrapolation from 2014 results. It's almost inconceivable to me that the need for a major transmission facility, costing in the neighborhood of $2 billion, would be based on extrapolated results. Extrapolation is also inconsistent with NERC's requirements for long-term studies. As I indicated earlier, the purpose of long-term studies is to provide some indication of the nature and direction of future reliability problems, and to ensure that any recommended short-term solutions will be consistent with future needs. Extrapolation does not, in my view, satisfy that requirement.
AEP and its partners seem to have refused to "think outside the box." Perhaps PATH's emphasis on AC EHV transmission, and the effective subsidization of western generation, reflects the potential profits that could be made from transmission usage charges, as well as AEP's ownership of major significant western generating resources. A major facility like the PATH line should not be approved based on extrapolation.

To summarize:

- In my opinion, there's a major problem with PJM's present RTEP/CETO process of assessing reliability. The assumptions are too conservative, and lead to requirements beyond what would be needed for good reliability.

- PATH would discriminate against eastern generation and other potential resources, and promote western generation, by providing the latter with free access to eastern load centers – all at the expense of the rate-payers.

- Whereas the rest of the industry utilizes a loss of load expectation of one day in 10 years, PJM uses one day in 25 years to determine the import capability required by each Load Deliverability Area (LDA) – which can be quite large. The Mid-Atlantic LDA, for example, has a peak load in excess of 60,000MW. This makes it equal in size to the combined neighboring New York and New England ISOs. Assumptions more in line with the industry, rationalized to a reliability standard equivalent to that used by New York and New England, would result in a CETO which would be lower than the point at which the first reliability violations occur. In other words, there would be no NERC violations.

- Without this overly conservative approach, CETO values would be lower and there would be no NERC violations. Hence there is no demonstrated need for PATH.

- Reasonable alternatives, both non-transmission and even transmission, were not considered despite their potential advantages in terms of cost, reliability, and environmental impact. The applicants did not consider any reasonable alternatives based on the currently identified (April 2009) issues.

• By increasing the dependence of the eastern load centers on remote generators and transmission lines hundreds of miles long, PATH would actually lower reliability. This is the *real* reliability problem in PJM. Further, the increased reliance on very long transmission lines is a national security issue.

Q.   DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

CERTIFICATE OF SERVICE

I, Emily Greenlee, hereby certify, under penalty of perjury, that a true and correct copy of the foregoing Direct Testimony of George Loehr on Behalf of the Sierra Club was served to the following by electronic mail or U.S. mail, first class, postage prepaid on this 23rd day of October, 2009:

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