PART D

PREFILED TESTIMONY
OF
EDDIE S. DEHDASHTI, PH.D.
ON BEHALF OF THE STAFF OF THE STATE CORPORATION COMMISSION

APPLICATION OF
PATH ALLEGHENY VIRGINIA TRANSMISSION CORPORATION
CASE NO. PUE-2009-00043

Q1. PLEASE STATE YOUR NAME, POSITION AND BUSINESS ADDRESS.

A1. My name is Eddie S. Dehdashti. I am the President of Power Applications and Research Systems, Inc. (PARS), a California based consulting company that provides services in the areas of power transmission and wholesale electricity markets. My business address is 64 Dorado, San Francisco, California 94112.

Q2. WHO DO YOU REPRESENT IN THIS PROCEEDING?

A2. My testimony is provided on the behalf the Staff of the State Commission Corporation of Virginia.

Q3. PLEASE DESCRIBE YOUR EDUCATION AND PROFESSIONAL EXPERIENCE.

A3. I have a Ph.D. in Electrical Engineering from the University of Missouri, specializing in Power Systems. My Ph.D. thesis was in the area of short-term load forecasting for specific applications in electric power systems. I have over 27 years of experience in the electric power industry, working mostly with electric power utilities and Independent System Operators, and in providing consulting services. I spent 13 years at the Pacific Gas and Electric Company (PG&E), 11 of

which were with the Transmission Planning Department where I was responsible for bulk transmission planning. As the PG&E representative to the Western Electric Coordinating Council (WECC), I oversaw the development of transmission study base cases and transmission planning studies, as well as the development of advanced models and tools for analysis of the transmission system. In that regard, I have accumulated extensive experience in the analysis of power system emergencies, including cascading outages and blackouts. Furthermore, as an Industry Advisor to the Electric Power Research Institute, I worked on tools and methods for the analysis of reactive power and dynamic performance of electric power transmission systems, and oversaw the development of advanced analytical methodologies and software for such purposes.

As a consultant to the California Independent System Operator (CAISO), I developed analytical methodologies and software tools for the CAISO's Markets Operations Group, including tools for monitoring markets for abuse and the exercise of market power. During the California Energy Crisis of 2000 and 2001, I provided daily reports to CAISO senior management and the office of the Governor of California. In addition, as a consultant to the CAISO, I conducted studies in support of the now approved Sunrise Powerlink, a 500 kV transmission line that is intended to transport power from renewable resources located in the Salton Sea Area of the Imperial Valley near the Mexico border to the San Diego area. Further, I prepared the Transmission Planning provision of the CAISO's "straw man" protocol for the FERC Order 890 planning document, which is

intended to open the process of transmission planning. Outside of California, I have also provided services to ERCOT (Electric Reliability Council of Texas) and the Public Utility Commission of Texas.

I have provided consultation to major developers of wind and solar energy in California and have facilitated the location and interconnection of these resources to the California power grid. I have also provided consultation services in power system analysis to vendors and manufacturers including ABB, GE, Alstom, Areva, and Perot Systems. My international experience includes the analysis of transmission systems in Thailand, Indonesia, and Saudi Arabia, as well as consultation on electricity restructuring issues in Poland, Greece and Albania. Finally, I am a licensed Professional Electrical Engineer in the state of California, and a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE), the IEEE Power and Energy Society (PES), and the Chairman of the PES Subcommittee on Energy Trading. My resume is provided as Attachment 1.

Q4. PLEASE SUMMARIZE THE REQUEST/PROPOSAL OF PATH ALLEGHENY VIRGINIA TRANSMISSION CORPORATION (PATH-VA OR APPLICANT) IN THIS PROCEEDING.

A4. PATH-VA seeks Virginia State Corporation Commission (Commission) approval and issuance of a certificate of public convenience and necessity in order to construct, own, operate, and maintain the Virginia portions of the Potomac-Appalachian Transmission Highline (PATH) Project, a 276-mile, 765 kV

transmission line that has been approved and directed by PJM Interconnection, LLC (PJM). The PATH Project would link the Amos substation near St. Albans in Putnam County, West Virginia to the Kemptown substation located southeast of New Market, Maryland, with a midpoint interconnection at a new substation called Welton Spring near Old Fields in Hardy County, West Virginia. The transmission line is expected to provide 2,000 to 4,000 MW of additional power transfer capacity into PJM's Mid-Atlantic transmission grid and load area. Approximately 31 miles of the PATH Project would pass through the State of Virginia; however, the line would have no direct electrical interconnection within Virginia.

Q5. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A5. My testimony presents and explains the conclusions I have drawn from my investigation and evaluation of the Applicant's supporting studies and analyses presented to establish the electrical need for the PATH Project. Based on my transmission planning experience and professional judgment, it is my opinion that an adequate transmission reliability/needs justification has not been established for the PATH Project. I explain in my testimony that the electrical needs analysis falls short as a result of: 1) unrealistic, overly-stressed 2013 and 2014 base cases due to flawed data and modeling assumptions; 2) insufficient, missing and inconclusive studies; and 3) inadequate alternatives analysis. My testimony also identifies the missing data, models and analyses needed to justify projects such as

the PATH Project. I further explain that even if PJM's flawed load flow studies and contingency analyses were to be accepted as reasonable, the PATH solution, while resolving certain problems on the transmission system, creates almost the same number of new problems as those that are alleviated, and, thus, should not be built as proposed.

Q6. BRIEFLY SUMMARIZE THE APPLICANT'S ELECTRICAL NEEDS JUSTIFICATION.

A6. PATH-VA states that PJM, through its Regional Transmission Expansion Planning (RTEP) process, and more specifically based on analyses that incorporate PJM's 2009 Load Forecast and updated system topology, has determined that numerous violations of the North American Electric Reliability Corporation (NERC) transmission reliability standards are expected to occur beginning in June 2014 if the PATH Project is not constructed. The Applicant further clarifies that these violations, which occur under certain contingency scenarios, are based on load deliverability and generation deliverability studies prepared by PJM The Applicant concludes that, if not resolved by the PATH Project, one or more of these contingencies could result in transmission line overloads and voltage drops, or voltage collapse, leading to "brownouts" or "blackouts." PJM feels that the PATH Project is the most effective means to resolve the identified NERC reliability violations and that no feasible alternatives are available.

Q7. PLEASE SUMMARIZE THE SCOPE OF YOUR INVESTIGATION.

A7. My investigation has focused on evaluating the adequacy and reasonableness of the Applicant's and PJM's electrical needs analysis and justification. In performing my analysis, I have considered recent trends in the electric power industry that directly impact the transmission planning process. Specifically, I examined and analyzed the robustness of the Applicant's and PJM's analyses from several perspectives including:

- Input data and models;
- Base case creation, stress levels and study scenarios;
- Base case correlation with real time operations;
- Transmission planning criteria and assumptions;
- Analysis tools and study techniques;
- Expected frequency of the reliability problem;
- Completeness and conclusiveness of studies and results;
- Exploration of construction and non-construction alternatives;
- Renewable and non-renewable resource development impacts;
- Potential for the exercise of market power;
- Supporting studies including resource availability and economics; and
- Project documentation and reporting.

My analysis and conclusions are based entirely on the data, models, analyses and other information provided by PJM and the Applicant.

Q8. PLEASE DESCRIBE NEW TRENDS IN TRANSMISSION PLANNING AS THEY MIGHT RELATE TO THIS CASE.

A8. The art of transmission planning is currently in a state of evolution. The advent of wholesale electricity markets such as the one that PJM operates has complicated transmission planning. Transmission planning requires a combination of well-established engineering practices, studies of the reliability performance of the transmission project, and economic analyses of the impact of the transmission project on the underlying electricity market structures and operations.

Transmission projects that exert downward pressure on the wholesale price of electric energy and capacity by bringing new resources into the electricity markets (without creating opportunities for the exercise of market power) enhance the robustness of competitive wholesale energy markets. In addition, establishment of Renewable Portfolio Standards (in both mandatory and voluntary forms) now requires that transmission plans encourage the development and sustainability of renewable, as well as non-renewable, generating resources. Further, the increasing application of Demand Side Management, Energy Efficiency and Smart Grid technologies need to be considered within transmission planning, as these programs may substantially shift the timing and amount of traditional system loading trends, as well as increasing grid operational

flexibilities. I'll address these new trends in transmission planning in more detail as follows.

Wholesale Electricity Markets: A transmission plan now should be studied for its impacts on the prices of electric energy and capacity on the basis of its congestion impact on a system-wide, as well as local, area basis, and for potential market power impacts. As part of such an economic analysis, a transmission expansion plan should also be compared with market/operating mechanisms, such as out-of merit order dispatches and Reliability Must-Run designated resources.

Green Energy and Non-Renewable Resources: The ability to cost-effectively facilitate access to the new renewable resources is rapidly becoming one of the criteria for approval of a new transmission plan. A transmission project now has to demonstrate how it can create new transmission corridors and/or release capacity in the existing system for cost-effective interconnection of new renewable and non-renewable resources.

Demand Side Management and Energy Efficiency: The advent of inexpensive two-way communications via the internet and wireless technologies has provided consumers with an opportunity to reshape their load consumption patterns. Implementation of more energy efficient loads is another trend that is becoming widespread. The combination of these practices and technologies enables consumers to act as incremental negative loads (effectively, generators) and to actively participate in shaping the supply/demand picture on the power grid.

At a minimum, the forecasted load used in the transmission planning studies needs to consider these trends.

Smart Grid and Electric Transportation: The expected trends in the development of Smart Grid technologies will help change system demand curves and improve the efficiency of transmission asset utilization. In fact, widespread utilization of smart metering and the advent of plug-in electric and natural gas dual fuel transportation vehicles (which themselves can be viewed as components of a Smart Grid program) may increasingly shift the stress on the power grid from traditional on-peak periods to off-peak periods, resulting in grid stresses not historically experienced or contemplated. Therefore, transmission planning studies increasingly need to consider off-peak operating periods as well as on-peak operations.

Q9. PLEASE SUMMARIZE YOUR MAJOR CONCLUSIONS.

A9. While I believe that the electric transmission infrastructure in North America requires significant new investment and construction, proposals to construct new facilities, especially projects of the size and scope of the $1.8 billion PATH Project, should be supported by careful, in-depth and conclusive studies and analyses that are consistent with industry practices and standards. Based on my analysis, I conclude that the Applicant and PJM have not established a plausible case for a transmission reliability problem in the Mid-Atlantic Area that would

require construction of the PATH Project to rectify. The major flaws in the need case presented by the Applicant and PJM are:

Flaw #1: Data and modeling shortcomings

The PJM data and models used in the load flow and contingency analysis studies underestimate the electrical strengths of the existing transmission system and overestimate the burden imposed on the system to serve its load. The net result is unrealistic and overly-stressed 2013 and 2014 base case study scenarios that are not suitable for transmission planning studies.

Flaw #2: Insufficient, missing and inconclusive studies

The PJM transmission planning studies are rudimentary and, at best, are inconclusive. PJM has not conducted certain studies that I believe most transmission planning experts would generally consider essential when determining the need for a new transmission line of the size and scope of the PATH Project. For example, dynamic analysis is critical to understanding the reliability impacts associated with adding a major new transmission line. It verifies the ability of the transmission system to recover from the shocks of contingencies, including the outage of the new planned transmission line. A dynamic analysis has its own data, models, study scenarios and tools. Many electric utilities, ISOs and RTOs (including PJM) have a group of professionals within their planning departments who are dedicated to performing dynamic analysis. Further, PJM has not used modern tools that are available to the industry

in conducting transmission planning studies. Also missing are many support studies (such as economic and market analyses) that are essential for the complete analysis of a large project's impact.

Flaw #3: Non-exploration of alternatives

PJM claims that there are no suitable alternatives to the PATH Project, and that doing nothing is not an option. However, PJM has not demonstrated that it has conducted any reasonable analysis to explore the merits and workability of other construction and non-construction options to seek the Least Cost Best Fit solution to the claimed reliability problem.

Q10. PLEASE ELABORATE ON THESE FLAWS.

A10. I will begin with Flaw # 1.

FLAW #1: DATA AND MODELING SHORTCOMINGS

Q11. DESCRIBE THE DATA AND MODELING SHORTCOMINGS THAT YOU FOUND TO EXIST IN THE 2013 AND 2014 BASE CASES.

A11. The following assumptions that establish the stress level in the study base cases are excessively conservative and as such are unrealistic based on my professional judgment.

Shortcoming #1: Data and Modeling Flaws

The electrical characteristics of the loads in the system model greatly influence the stress level that is preset in a study's base case. Thus, the conclusions arising from

the subsequent contingency and other studies are greatly influenced because they originate from the base case.

The differing types of loads on the bulk power system create differing levels of stress in accordance with the electrical characteristics of the varying loads, particularly with respect to how these loads behave when voltage is lower than normal. The least amount of stress is created by resistive loads such as incandescent lighting. The most severe type of stress is created by motor loads.

PJM's load models assume that all loads consume constant "apparent power" and have a constant power factor, regardless of voltage. (Apparent power is the mathematical sum of real power and reactive power.) Thus, effectively, PJM models the entire system load as being composed solely of motor loads (see Attachment 2 (VAStaff-IX-5) and Attachment 3 (SierraVA-IV-51)). The reason that motor loads are the most demanding type of load is that when voltage to a motor decreases, both the real and reactive components of the motor's current increase with a concomitant decrease in voltage. The result is that the motor's apparent power (mathematical product of voltage times current) remains constant.

Actual aggregated system load does not behave in this manner because it is composed of more than just motor loads. With a diversity of loads, a transmission system stressed by low voltage benefits from the fact that the system load is diverse and will draw less power from the system than if the system served only motor loads. Accordingly, PJM's load model is more demanding and more conservative than is customary in transmission planning.

Contrary to PJM's claims, the transmission and distribution equipment found within its electric power delivery system (such as load tap changing transformers and line voltage regulators) does not have the capability to maintain constant normal operating voltages to all loads under all study conditions. Aggregate system load power normally drops, and power factors change, as voltages drop in the electric delivery system. As such, PJM's modeling assumption of constant power loads results in loads that draw unrealistically high real and reactive power from a stressed system and is not representative of actual conditions.

Accordingly, PJM's approach is overly conservative, resulting in a transmission expansion plan that contains new transmission circuits intended to support voltages that do not need supporting. Further, PJM has not performed any studies to substantiate the validity of this assumption concerning the characteristics of system load (see Attachment 4 (VAStaff-VII-25) and Attachment 5 (VAStaff-VII-26)). In contrast to its constant-power/constant-power-factor system load assumption, PJM's operations include the issuance of voltage reduction orders in the Mid-Atlantic Area to conserve energy during periods of stress,[1] which confirms that loads generally do respond to reduced voltage by reducing their power draw from the system.

[1] http://www.pjm.com/~/media/about-pjm/newsroom/2007-releases/20070808-pjm-orders-mid-atlantic-voltage-reductions-as-heat.ashx

Shortcoming #2: Generator Capability Curves

Reactive power management is an integral component of planning and operating an electric power system. The summation of generator reactive power capabilities and other reactive devices, such as synchronous condensers and Static VAR Compensators (SVC), constitute a reactive power "reserve bank" to be used to maintain the voltage (and thus, the reliability) of the transmission grid. This reserve bank greatly influences the results of voltage stability studies, as demonstrated by the P/V curve characteristics in terms of both collapse point and maximum power transfer capability of transmission circuits.

A P/V curve is a graphical plot of voltage versus power and shows the ability of a transmission system to maintain acceptable voltages (voltage stability) as the power transferred into an area, such as the Mid-Atlantic Area, is increased. Specifically, a P/V curve captures both the collapse point and the maximum power transfer capability. Collapse point pertains to the voltage that is associated with the maximum power transfer capability of the transmission system. If power is pushed beyond the maximum power transfer capability, voltage cannot be maintained and will collapse to an unacceptable level.

The minimum and maximum real and reactive power capabilities of a generator are interrelated and are reflected in the generator's power capability curve. A sample of generator Pmin (minimum real power), Pmax (maximum real power), Qmin (minimum reactive power), and Qmax (maximum reactive power) values for thirty-seven units was provided by the Applicant (see Attachment 6

(VAStaff-IX-4)). The data in Appendix A of discovery response VAStaff-IX-4 (included in the Staff's confidential work papers) show that the reactive power output range of each of the 37 generators was assumed to be static, rather than having the more realistic characteristic of varying in accordance with each generator's capability curve. This is apparent from the fact that only the values for Pmax, Pmin, Qmax and Qmin were provided in defining the real and reactive power limits of the generators.

The values of Pmax, Pmin, Qmax, and Qmin for the individual generators in the sample are shown in Attachments 7 and 8 of my testimony. As an example, generator No. 25 has a Pmax of 639 MW, and a Qmax of only 61 MVAR. However, based on my experience, I would expect to see Qmax around 330 MVAR as typical. Similarly, for generator No. 13, Pmin is 450 MW, and Qmin is 26 MVAR. Typically, I would expect to see 200 MVAR.

Attachment 9 of my testimony shows the aggregated Pmax, Pmin, Qmax, and Qmin for the 37 generating units in the sample. The aggregated Qmax and aggregated Qmin in this table show the reactive power reserve bank that I discussed earlier. Since the reactive power capabilities of the individual units are underestimated, the aggregated Qmin and Qmax values are also underestimated.

Based upon my analysis and professional judgment, the true reactive power limits of the sample that was provided by Allegheny Power are underestimated by 40% to 50%. Thus, I believe that the entire PJM system possesses more reactive power capability than has been modeled in the base cases. Understating the

reactive power capability available to a power grid can lead to the false conclusion of a reactive power deficiency and, hence, planning for unneeded transmission projects. PJM and Allegheny claim that they do not use generator capability curves since they do not possess them (see Attachments 10 and 11 (VAStaff-VII-24, VAStaff-IX-3)). PJM relies on the generator owners to provide their generator power capabilities, but that data is obtained from testing of the generators, not the manufacturer's capability curves. In my opinion, the industry experience for testing the reactive limits of generators has not been successful. Contrary to PJM's claims, generator capability curves are among the most basic information that is provided by the manufacturers and should be readily available to all generator owners, and should be shared with PJM.

Shortcoming #3: Omission of Future Resources

PJM only accounts for future generating resources if they have signed an Interconnection Services Agreement (ISA). Elsewhere in the country such as California, a resource that has a valid Interconnection Queue position and is in an advanced study stage is accounted for in the base case. Non-inclusion of resources with valid Queue positions can lead to under-estimating future system resources. In my professional judgment, if a developer has a Power Purchase Agreement (PPA) and/or it has completed an environmental impacts analysis, it should be included in the model of the transmission system without an ISA.

Q12. DR. DEHDASHTI, BASED ON YOUR PROFESSIONAL EXPERTISE, EXPERIENCE, AND THE ANALYSES YOU PERFORMED, DO THE 2013/2014 BASE CASES REPRESENT CREDIBLE SCENARIOS?

A12. No. The data and modeling flaws that I described above have produced base cases that do not reasonably represent any possible operating scenario; that is, they are unrealistic and do not provide valid starting points for transmission planning studies. I reached this conclusion based upon my examination of the base case result from three perspectives: Surge Impedance Loadings, phase angle separations, and grid operability.

SIL Loadings

Surge Impedance Loading (SIL) has a special meaning in power system analysis and operation. SIL is an electrical characteristic unique to every transmission circuit and corresponds to a specific amount of power entering the circuit; at this entering power level, the circuit is said to be at 1 SIL. Of particular importance is the fact that at 1 SIL the transmission circuit itself neither consumes nor supplies reactive power to the system. At any lower current level, the circuit is below 1 SIL and is a source of reactive power. On the other hand, at any higher current level, the circuit is above 1 SIL, and consumes reactive power. Further, above 1.5 SIL, the circuit's consumption of reactive power increases rapidly and nonlinearly.

It is uncommon during actual system operation to have more than a handful of transmission lines in a regional grid loaded beyond 1.5 SIL. As shown in

Attachment 12, the operational base cases for 2007, 2008 and 2009 have only 20, 21, and 22 circuits, respectively, with loadings above 1.5 SIL, the maximum of which is about 2 SIL. However, the base cases for 2013 and 2014 without PATH contain 850 to 895 transmission lines in the Mid-Atlantic area with loading levels above 1.5 SIL (see Attachment 13 (VAStaff-VII-27)). The maximum SIL is 24, a loading level significantly beyond what a transmission operator would allow in a steady state condition.

In my professional judgment, I consider a loading level above 1.5 SIL to be problematic since, above this level, the reactive power demand of most transmission lines increase rapidly. Attachment 14 charts the number of problematic SIL levels in the 2013 and 2014 base cases, both with and without the PATH Project. On average, in each base case, the SIL loading level for all lines is 3. At this loading level, the power grid has to supply approximately 5 MVAR of reactive power for every 1 MW of real power transferred by a line. This is a completely unrealistic condition. It is not conceivable that any power grid can operate with such an exorbitant need for reactive power.

Another indication of the base cases being unrealistic is found within the results of the power flows studies, where it is seen that while the addition of the PATH Project reduces some high SIL loading levels on some circuits, it creates additional excessive SIL loading levels on other circuits. Attachment 15 compares the number of problematic SIL levels that the PATH Project resolves versus the new problematic SIL levels that it creates for the 2013 and 2014 base cases. Thus,

we can see that the net impact of the PATH project in reducing high SILs is approximately zero.

While one expects a planning base case to be stressed, the levels of stress in the 2013 and 2014 base cases are wholly unreasonable. It is unrealistic to assume that in the Mid-Atlantic Load Deliverability Area between 2009 and 2013 over 800 additional transmission lines will develop loading levels above 1.5 SIL, with some as high as 24 SIL. Therefore, based on the SIL analysis alone, the stated reactive power deficiency identified in the base cases is not credible. PJM's analysis and identification of the PATH Project as a solution to the asserted reactive power deficiency is thus fundamentally flawed.

Phase Angle Separations

The voltages within an alternating current (AC) transmission grid are 60 Hertz (cycles per second) sinusoidal waveforms. The voltages at the two ends of a transmission circuit will differ in magnitude and phase shift, both of which are determined, in part, by the level of power flowing through the circuit. The difference (in electrical degrees) of those two voltages is called the phase angle separation of that circuit. The phase angle separation across a transmission line measures the amount of real power flowing through the line. I should note that the maximum phase angle for stable transfer of power is, in theory, 90 degrees. However, in practice, the stable limit of a transmission system is reached well below 60 degrees. Therefore, phase angle separations within the circuits of a grid make it easy to determine the amount of additional real power that the grid can

transfer due to a contingency or increased load without risking system stability. Phase angle separation was a key contributing factor in the Northeast Blackout of August 14, 2003. In fact, prior to that blackout, the phase angle between Cleveland and East Michigan had started to increase uncontrollably.

In transmission planning analyses, base case studies seldom produce any phase angle separations greater than 10 degrees. In PJM's 2013 and 2014 base cases, however, there are approximately 50 key transmission lines that have phase angle separations greater than 10 degrees. I consider any phase angle separation in excess of 10 degrees to be problematic. In my professional experience, phase angle separation across a contiguous transmission line above 10 degrees identifies that transmission line as a weak link in terms of its ability to stably transfer power during contingencies. Attachment 16 shows the number of problematic phase angle separations, with and without the PATH Project, for the 2013 and 2014 base cases. The largest phase angle separation is 43 degrees, which is excessive and unacceptable.

In both the 2013 and 2014 base cases the PATH Project eliminates some problematic phase angle separations, but creates many new ones. The results are shown graphically in Attachment 17. The large number of phase angle separations in the base cases, both with and without the PATH Project, is unrealistic. No power grid can operate stably under such conditions. In fact, if the 2013 and 2014 base cases (with and without the PATH Project) are studied for dynamic performance, they will most likely demonstrate severe dynamic problems. That is,

under such large phase angle separations, with or without a contingency, the PJM transmission system may experience cascading outages, possibly ending in a widespread blackout. This is further evidence that the base cases are poorly constructed and not reflective of actual operating conditions.

As shown graphically in Attachment 18, the 2007, 2008 and 2009 operating base cases have only 13, 11, and 11 instances where phase angle separations exceed 10 degrees, respectively, with the maximum angle being 25 degrees. In contrast, for 2013 and 2014, the number of phase angle separations exceeding 10 degrees (without PATH) is 52 and 53, respectively, and the largest is 43 degrees (again, see Attachment 16). Further, the PATH Project creates a new set of excessive phase angles, as shown again in Attachment 17. Therefore, it can be concluded that, the 2013 and 2014 base cases incorporate excessive power transfers and so do not represent realistically stressed study scenarios. PJM's claim that the PATH Project is the solution to reducing power transfer on heavily loaded transmission lines is invalid.

Load forecasting is being addressed by other Staff witnesses. However, my analysis indicates that the unreasonable SILs and phase angle separations of the base cases can only be the result of overly high load levels in the load forecast in combination with the above-described flaws in the load models.

Grid Operability

Transmission planning base cases associated with a recommendation for a transmission upgrade customarily depict a bulk power system subjected to a level

of stress. The key question is whether that stress is credible and whether the stresses assumed in the base case have any relevance to any recent actual operating base case. For a planning study to be valid, a base case that is going to be subjected to reliability criteria stressors such as PJM's CETO-CETL[2] test has to be, first and foremost, grid operable, meaning that the power grid should be able to actually operate under base case conditions. Then, that base case system is subjected to additional stresses (contingencies) to discover unacceptable conditions, such as excessive currents (thermal overloads) or unacceptably low voltages.

Based on my analysis of the load models, generation models, SIL data, and phase angle separation data provided by PJM, the 2013 and 2014 base cases are not grid operable. Therefore, planning studies based on these base cases do not have merit and are not credible.

Since the base cases are unrealistically stressed by exaggerated load levels and improper load models, among other things, the thermal violations associated with the NERC criteria identified are not credible. This is due to the fact that the reactive power component of electric current in the transmission lines contributes to thermal overloads just as much as the real power component of current. Once again, improper modeling of loads and underestimation of the generator reactive power capabilities create large reactive currents throughout the grid that consume a large portion of the thermal capability of the transmission lines. With proper

[2] CETO (Capacity Emergency Transmission Objective); CETL (Capacity Emergency Transmission Limit)

modeling and reactive power management, these thermal overloads should disappear.

Q13. DOES THIS COMPLETE YOUR TESTIMONY ON FLAW #1?

A13. Yes. Next I'll elaborate on to Flaw #2.

FLAW #2: INSUFFICIENT, MISSING, AND INCONCLUSIVE STUDIES

Q14. DR. DEHDASHTI, IN YOUR PROFESSIONAL JUDGMENT, BASED ON YOUR EXPERTISE AND EXPERIENCE, WHICH TRANSMISSION PLANNING STUDIES ARE MISSING FROM PJM'S ANALYSIS?

A14. The following transmission planning studies are missing from PJM's analysis:

Confirmation Studies

In voltage stability studies, while P/V curves were determined for the case of no PATH Project, P/V curves were not performed for the case with the PATH Project (see Attachments 19 and 20 (VAStaff-VII-23 and VAStaff-IX-6)). This means that the contribution of the PATH Project to satisfying the reactive power needs and the longevity of stated benefits have not been established.

Sensitivity Studies

The need studies for the PATH Project should be repeated for a varying series of incremental changes in any system parameters that have a significant impact on study outcomes and are subject to inherent estimation error. These parameters include: forecasted load levels, load models, generator reactive capabilities, and

load distribution factors. Conducting these sensitivity studies for each parameter (under full calculations) would reveal significant insight into the severity of the problems identified and the effectiveness of the PATH Project as a solution (see Attachment 21 (VAStaff-VII-7)). Due to the modeled high loading levels for the PJM system, the system's power transfer capability is very non-linear. This non-linearity leads to substantial error when extrapolating data as PJM has done. In general, and in particular in this case, extrapolation of data is not an acceptable substitute for conducting sensitivity studies.

Advanced Reactive Power Analysis Studies

PJM has only used rudimentary tools and analysis methods to study voltage stability and to assess the reactive power deficiency of its grid. Reactive power sources and solutions such as shunt capacitors, synchronous condensers, SVCs, and Flexible AC Transmission System (FACTS) devices have different attributes, applications and cost benefits. PJM has not done sufficient studies to determine the nature of the reactive power deficiency in its grid to ascertain the optimum type, location and capacity of reactive power sources needed to resolve its reactive power problems.

Dynamic Analysis Studies

Dynamic analysis is the study of the ability of the power grid to absorb the shock of contingencies such as the loss of a generator or transmission line. The transmission grid needs to have sufficient real and reactive power reserves so that if a contingency occurs, the grid can absorb the initial shock and then recover to a

stable state. Good utility practice requires that any proposal to add a major transmission line be preceded by a comprehensive dynamic analysis in order to ensure that the addition of the line does not itself lead to stability problems in the grid. PJM, in response to data requests (see Attachments 22 and 23 (VAStaff-VII-16, and SierraVA-IV-50)), indicated that it has not undertaken a complete dynamic performance analysis for the PATH Project. This is totally unacceptable and violates accepted power industry practices.

PJM's responses indicated that a limited stability analysis was performed for the Amos generators to assess the impacts of faults on these generators. Also, a generic stability study was performed by the Power Tech Labs of Vancouver, Canada. However, those studies are inadequate since they are generic, do not specifically study the PATH Project, and do not identify PATH's potential adverse impacts on the PJM system. PATH is intended to transfer up to 4000 MW, a significant amount of power. The PJM base cases indicate that the phase angle separation between Amos and Welton Spring is 28 degrees, and the phase angle separation from Welton Spring to Kemptown is 17 degrees, summing to a total phase angle separation of 45 degrees between Amos and Kemptown. This level of phase angle separation far exceeds 10 degrees and indicates that both sections of the PATH project can become weak links in terms of their ability to stably transfer power from West Virginia to Maryland. A complete dynamic analysis is necessary and should have been performed.

Load Duration Curves

As a measure of the severity of the identified potential reliability problems, actual load duration curves derived from past operating conditions can be used to assess how often a bulk power system may fail to fully serve its future loads. Load duration curves show the number of hours, as a function of load level, that a power grid supplied load. PJM has not performed any such studies. In fact, to my surprise, PJM claims that it does not maintain load duration curves (see Attachment 24 (VAStaff-VII-20)). For a proposed transmission project of such large magnitude, this analysis should be performed prior to the CETO/CETL analyses to establish the expected frequency of the stated transmission problems within the Mid-Atlantic Area.

Q15. WHAT SUPPORT STUDIES ARE MISSING FROM PJM'S ANALYSIS?

A15. The following support studies are missing from the PJM analysis:

Economic and Market Power Study

PJM has not conducted any meaningful economic studies to support the PATH Project. As noted earlier, economic analysis is an integral component of transmission planning study of any size and cost. This applies even under circumstances where the problem identified is reliability-based. In fact, the Applicant claims based on its study scenarios, that the PATH Project will reduce both real and reactive power losses by 331 MW and 4500 MVAR, respectively, when loaded to its full capacity (see Attachment 25 (VAStaff-VII-22)). This creates a plausible case for developing a full economic analysis for the PATH

Project. The economic study should address impacts on the PJM markets locally, and on a system wide basis, as well as market power issues. PJM should demonstrate that the PATH Project does not create or enhance market power conditions for the owners of the resources located in the Western PJM area. PJM rate payers should be protected from paying for a transmission line that could ultimately be used to increase wholesale and eventually retail prices to them.

Resource Availability at the Sending End of PATH

PJM has not demonstrated that up to 4000 MW of generation is available in West Virginia to load PATH to full capacity to maintain Mid-Atlantic area reliability when needed (see Attachment 26 (VAStaff-VII-9)). If such resources are not available in West Virginia, PATH will not load to its full capacity and will not be a sound investment. In fact, if such resources are not available, it may not be necessary to build PATH as a 765 kV transmission line, and a lower voltage such as 500 kV, with significantly less cost, may suffice if a suitable need case can be demonstrated. Generating resource availability is the key determinant in the selection of a transmission line's voltage, and PJM has not shown a match between resource availability and its choice of 765 kV as the line's voltage. In addition, the impact on other ISO/RTOs of loading the PATH Project to its full capacity is unknown and has not been studied.

Renewable Resources

PJM claims that the PATH Project releases transmission capacity for interconnection of renewables. However, no conclusive studies that identify how

PATH helps with the integration of renewable resources have been presented by PJM (see Attachments 27, 28, 29, and 30 (VAStaff-VII-11, SierraVA-IV-82, SierraVA-IV-83, and SierraVA-IV-74)).

Q16. DR. DEHDASHTI, IN YOUR PROFESSIONAL OPINION, ARE PJM'S TRANSMISSION PLANNING STUDIES CONCLUSIVE?

A16. No. The PJM studies constitute an incomplete analysis and do not substantiate the reliability problems identified by PJM in its attempt to justify the proposed PATH Project. PJM has used only simple power flow studies to create P/V curves, and has done so on an unrealistically loaded transmission system (using an unrealistic base case). While P/V curves can indicate reactive power deficiencies, they will not demonstrate definitive voltage collapses. Study of voltage collapse in a system requires the following analyses: steady state (load flow), modal, transient, post-transient, mid-term, and long-term time simulations. PJM's simplistic analysis does not support claims of incipient voltage instability, voltage collapse, uncontrollable cascading outages, and blackout problems in the Mid-Atlantic area.

Q17. DO YOU MEAN THAT PJM'S TRANSMISSION GRID HAS NO PROBLEMS?

A17. No. In fact, based on the results of PJM's RTEP studies and my own analyses of SIL, phase angle separation and grid operability, it appears, if load continues to grow, that the PJM power grid will require significant investment to relieve thermal overloads, as well as voltage and angular performance issues, at some as

yet unknown time in the future. Normally, when import of power into an area is increased through a newly added transmission line, losses go up. PJM claims the opposite. In fact they claim that the PATH Project actually reduces both real and reactive power losses. This may indicate that PJM's lower voltage transmission system may currently have major loading problems. However, the PATH Project has not been shown to be the solution to any such problems in the near term, or in the long term. The studies performed by PJM are based on non-credible scenarios and are inadequate and inconclusive. The studies do not support building the PATH Project.

Q18. IS PJM'S APPROACH TO TRANSMISSION PLANNING, IN THE CASE IT MAKES FOR THE PATH PROJECT, ACCEPTABLE?

A18. No. It is my professional judgment that PJM'S approach has the following shortcomings:

a) stress levels in the base cases are unrealistic;

b) frequency of the problems has not been explored;

c) only simplistic analyses using primitive tools have been performed;

d) studies are incomplete;

e) supporting studies are missing;

f) alternative non-construction solutions have not been fully explored;

g) the least cost, best fit solution has not been sought or found;

h) longevity and effectiveness of the proposed solution has not been established;

i) planning criteria are not applicable to the changing times; and

j) finally, it is critical to note that a single comprehensive report, which describes the data, models, assumptions, base cases, methodology, studies, results, analyses, discussions and conclusions, is not available.

Q19. DOES THIS COMPLETE YOUR TESTIMONY ON FLAW #2?

A19. Yes. Next I'll elaborate on Flaw #3.

FLAW #3: NON-EXPLORATION OF ALTERNATIVES

Q20. HAS PJM PROPERLY AND THOROUGHLY PERFORMED AN ALTERNATIVES ANALYSIS FOR THE PATH PROJECT?

A20. No. I discuss below the areas of deficiency in this regard.

Reactive Power Solutions

PJM has used a "hit-or-miss" visual inspection procedure to identify locations for, and amounts of, shunt capacitors (see Mr. Glynn's testimony page 51 to 54; Attachments 31 and 32 (VAStaff-VII-15 and VAStaff-VII-17)). Discovery response VAStaff-VII-17 reports that advanced tools were not used, which obliges reliance on a "hit-and-miss" procedure. Solving voltage problems requires tracking series reactive power losses (reactive power consumed by transmission circuits themselves, transformers, and loads) and also requires careful analysis of interaction of the components that generate or consume reactive power. Proper placement of shunt capacitors on a heavily loaded system such as PJM requires

proper reactive power analysis via modal analysis. (A power flow analysis lacks the sophistication to provide detailed reactive power information.)

I recommend a modal analysis using an analytical tool such as VSTAB[3] to determine reactive power deficiencies in the grid and to determine optimum size and locations of reactive power sources. VSTAB was developed by the Powertech Labs of Vancouver, Canada, under a contract with the Electric Power Research Institute (EPRI) and has been shown by the industry to be a valuable tool in analyzing reactive power. VSTAB decomposes system reactive power deficiencies into the key contributors of the deficiencies which, given the local nature of reactive power deficiencies, would help PJM pinpoint the type, location and the amount of reactive power needs, as well as possible complementary operational solutions.

Operational Solutions

PJM's responses to interrogatory questions concerning possible operational solutions have been vague (see Attachment 33 (VAStaff-VII-18)). It may be possible, instead of investing nearly $2 billion in the PATH Project, that an operational solution, such as commitment of specific resources in the Mid-Atlantic area, could be developed to alleviate potential overloads and thereby mitigate the NERC violations. PJM's responses do not clearly demonstrate that PJM has conducted a thorough analysis to explore the merits of operational solutions.

Market Mechanism Solutions

[3] Voltage STABility computer program for static voltage stability analysis

PJM has not demonstrated that it has considered, or taken, any effective steps to explore cost-effective market mechanisms to solve its reliability problems in the Mid-Atlantic Area (see Attachments 34 and 35 (VAStaff-VII-10 and SierraVA-IV-65)).

Transmission Line Terminations and Midpoint

PJM claims that, electrically, Amos, Kemptown and Welton Spring are the best terminations and mid-point for the PATH Project. However, PJM has not, except for general discussions, presented any analysis to support this claim.

Voltage Selection

PJM has not demonstrated why a lower voltage (i.e., 500 kV) would not be more appropriate than 765 kV for the PATH line. No analysis has been provided.

Technology Selection

DC transmission lines are generally economic if the transmission distance is over 600 Miles. DC transmission lines are inherently flow controllable and, thus, offer system advantages over AC transmission lines which are not, generally, flow controllable. Given the very high cost of the PATH Project, despite its relatively short length, a 500 kV DC transmission line may be feasible and should be studied as an alternative. Currently, a vendor is conducting a DC feasibility study for PJM. However, the study has not been completed and analyzed (see Attachment 36 (VAStaff-VII-5)).

Q21. DOES THIS COMPLETE YOUR TESTIMONY ON FLAW # 3?

A21. Yes.

Q22. PLEASE STATE YOUR BOTTOM LINE CONCLUSIONS.

A22. Based on my experience, expertise, and analyses of relevant data, models and results readily available or provided through discovery, it is my professional judgment that the Applicant has not constructed a reasonable nor credible case to designate the PATH Project as the preferred solution to the Mid-Atlantic Area reliability problems. Further, the PATH Project has not been proven to be needed, even to resolve those problems that have been identified in the simplistic and inconclusive studies that have been presented by PJM.

Q23. UNDER WHAT CIRCUMSTANCES, COULD PATH BE BUILT?

A23. I have no doubt that the PJM transmission system will be facing performance problems in an as yet unknown time in the future. Based on the studies that I have reviewed, and based on my knowledge of the PJM system, it appears to me that the problems that need attention are spread out over the system and are driven by reactive power deficiency, excessive phase angle separations, and lack of thermal capacity of transmission circuits. These performance problems will eventually translate into higher prices for energy and capacity within the PJM system. In my opinion, these problems can only be resolved when they are addressed within the framework of a "Transmission Master Plan" consisting of an integrated and phased-in approach toward individual transmission projects that addresses all of PJM's transmission system performance problems. The PATH Project should be

considered only if it can be demonstrated to be an effective component of this Transmission Master Plan.

Q24. DOES THIS CONCLUDE YOUR TESTIMONY?

A24. Yes

RESUME OF EDDIE DEHDASHTI

SUMMARY

Over twenty-seven years of experience in system studies, analysis and research and development of new methods and techniques in power system design, planning with focus on deregulated electricity markets and energy trading. Experiences include electric utilities, Independent System Operators and engineering consulting lines of businesses.

EDUCATION

Ph.D., Electrical Engineering (Power Systems),
University of Missouri, Columbia, 1982.

M.Sc., Electrical Engineering (Power Systems),
University of Missouri, Columbia, 1979.

B.Sc., Electrical Engineering (Power Systems),
University of Missouri, Columbia, 1978.

EXPERIENCE

1997- Present; Power Applications and Research System, Inc. (PARS) - San Francisco, CA.
Founder and President of PARS, a consulting firm specializing in development of innovative technical solutions for the wholesale electricity markets as well as analysis of the power grid worldwide.

- Assisted wind and solar project developers in performing economics as well as selection and procurement of wind turbines and interconnection with the California Independent System Operator power grid.

- Developed White Paper and methodology for preservation of Long-Term Congestion Revenue Rights (CRRs) in the transmission planning process for the California Independent System Operator.

- Developed Open Transmission Planning Strawman Proposal for the California Independent System Operator mandated under FERC Order 890.

- Assisted California Independent System Operator on Justification the Sunrise 500 kV Transmission Project linking San Diego to renewable resources.

- Conducted readiness audit for participation under California's nodal electricity market (MRTU) for DOE's Western Area Power Administration (WAPA).

- Conducted testing and validation of ERCOT's market oversight software used by the Texas Public Utility Commission (PUCT).
- Designed market monitoring, shadow settlements and cost-causation software tools for participants of the City and County of San Francisco.
- Supported settlements analysis and development of market participation software and shadow settlements for the City and County of San Francisco.
- Developed recommendations on managing transitional issues of the wholesale electricity market at ERCOT in Texas in the area of application of Locational Marginal Pricing (LMP) methodology.
- Participant in an Electric Power Research Institute (EPRI) project and consultant to ABB to conduct research and define analytical tools to predict, prevent and control power system disturbances which can create cascading outages such as the Northeastern blackout of August 14, 2003.
- Reviewed and enhanced the "Grid Code" containing market rules and protocols for the Hellenic Transmission System Operator (TSO) for Greece.
- Designed structure, rules and protocols for the forward wholesale energy markets for the country of Albania in Eastern Europe.
- Developed recommendations for General Electric on designing a new breed of generators, which can better compete in the deregulated electricity markets.
- Evaluated Areva's "e-terrasettlements" software from design architecture and functionality perspectives for suitability of central wholesale markets as well as for the participants of the competitive electricity markets.
- Evaluated modeling adequacy of GridAmerica's "Flowgates" for transmission reservations purposes and participation under the Midwest ISO markets.
- Assessed Market Monitoring, gaming and requirements for adoption of the nodal (Locational Marginal Pricing) methodology for California.
- Conducted analysis and developed software tools which identified the quality of procured Ancillary Services at the California ISO.
- Analyzed and developed alternatives for settlement of the "Committed Period Penalty" for the California ISO.
- Analyzed the operational impacts of Metered Subsystems (MSS), identified settlements conflicts and modified the formulations of the No-Pay equations to resolve the conflicts in the California ISO settlements.

- Designed Market Indices, which identify and track gaming and exercise of market power, based on California ISO's settlements data.

- Designed and implemented a new anti-gaming market based load forecasting system to conduct Day-Ahead and Hour-Ahead markets, which considers operation of multiple subsystems and climatic zones. This system is currently used at the California ISO.

- Developed and implemented software that determines instructed and uninstructed deviations in the forward and real time markets at the California Independent System Operator (ISO).

- Developed and implemented market monitoring software that reflects the cost liquidity, volatility, gaming and effectiveness of various market rules for the California ISO.

- Developed and implemented software that detects price spikes in Ancillary Services bid supply curves for the California ISO.

- Developed software that assists the California ISO market operators in procurement of Ancillary Services decisions (HADAT).

- Developed software that identifies the bidding strategy of the California ISO market participants.

- Developed financial reporting routines for the California ISO Energy Imbalance and the Ancillary services markets.

- Developed scheduling agreement for energy traders and Electricity Service Providers (ESP) in California.

1993-1997; Pacific Gas and Electric Company (PG&E), Research and Development Dept.
Program Manager and Supervisor Power Transmission- Supervision and development of analytical tools and methodologies for systems planning, operation, control and maintenance technologies for PG&E's Electric Transmission Business Unit, managing a budget of five Million.

- Participated in the WEPEX (Western Power Exchange) electric industry restructuring process in California to assess technological requirements.

- Proposed, developed, recommended and implemented a process to evaluate economic justification of projects linking research and business needs.

- Proposed, developed and implemented a new process in developing research portfolios for five departments in Electric Transmission Business Unit.

- Assessed the Pros and Cons of nodal (Locational Marginal Pricing) versus Zonal modeling and network model requirements for adoption in California's restructuring process.

- Recommended and implemented techniques to improve hourly load forecasting accuracy of PG&E's Power Management System.

- Performed analytical studies to determine the impact of Dynamic Scheduling as an ancillary service on the PG&E's transmission system.

1984-1993; Pacific Gas and Electric Company, Transmission Planning Department Lead Electrical Engineer

- Led studies related to the dynamic performance of PG&E and WECC (Western Electric Coordinating Council).

- Project Manager for the Bulk System Reactive Support Project, resulting in 60 million capital investment for reactive power facilities of PG&E.

- Participant in PG&E's Committee to develop strategy on Transmission Access and Retail markets.

- WECC Northern California Area Coordinator.

- PG&E representative for the WECC System Review Work Group.

- PG&E representative for the WECC Modeling Work Group.

- Developed computer simulation dynamic models for power plants within the PG&E control area.

- Designed and developed several state-of-the-art transmission system analysis software to determine reliable power transfer limits.

- Performed voltage stability analysis of the PG&E transmission system to identify susceptibility to voltage collapse.

1982-84; LEMCO Engineers, Inc., St. Louis, Missouri
Project engineer in system planning studies, automated distribution systems analyses, software development and electromagnetic interference analyses.

- Conducted system planning studies for Mah-Moe to Bangkok 500 kV transmission line in Thailand.

- Analyzed power distribution among 5000 Indonesian Islands.

- Analyzed network type distribution system for Pakistan.

- Participated in development of a trouble call based outage management system for Consolidated Edison of New York

1978-82; University of Missouri, Columbia
Teaching Assistant, responsible for teaching power systems and rotating machinery courses.

INDUSTRY ADVISOR

Served as an industry advisor representing the electric utility industry to the following Electric Power Research Institute (EPRI) projects:

- EPRI RP-2707-1 SVC Controllability Improvements.
- EPRI RP-1999-8 Voltage Instability & Security and Assessment.
- EPRI RP-3040-1 Voltage Instability and Security Assessment and On-Line Control.
- EPRI RP-3023 GTO Based Static Compensation
- EPRI RP-3717-01 Phase Angle Measurement for Real-Time WSCC Monitoring and Control.

SELECTED PUBLICATIONS

- "Forecasting of Hourly Load by Pattern Recognition - A Deterministic Approach." IEEE Transactions on Power Apparatus and Systems, September 1982, Vol. 101, PP. 3290-3294.

- "Dynamic Voltage Control by Remote Voltage Regulation for Pumped Storage Plants." IEEE Transaction on Power Systems August 1988, Vol. 3, PP. 1188-1192.

- IEEE Special Publication, "Voltage Instability of Power System: Concepts, Analytical Tools, Industry Practice", IEEE publication No. 90TH0358-2-PWR, December 1990.

- "Voltage Instability and Voltage Collapse in Electric Power Utility Grids", Publication No. SS-F-203, 6th Tavanir International Power Conference, November 1991, PP. 65-75.

- "Dynamic Security Assessment and Voltage Stability", EPRI Report TR-102444, August 1993.

- "Assessment of Applications and Benefits of Phasor Measurement Technology in Power Systems", EPRI Report TR-107903, April 1997.

- "Assessment of Applications and Benefits of Phasor Measurement Technology in Power Systems," Proceedings of the EPRI Wide Area Measurements Systems (WAMS) J. Paserba, C. Amicarella, R. Adapa, E. Dehdashti, Workshop, Lakewood, Colorado, 1997.

- "Understanding the California Energy Markets and Customer Choice", 29th Energy Information Dissemination Conference, Oklahoma City, Oklahoma, April 1998.

- "Distributed Autonomous Real-time System for Power System Operations - A conceptual Overview" by K. Moslehi, R. Kumar, E. Dehdashti, Peter Hirsh, Warren Wu, presented at the IEEE PES meeting October 2004. Scheduled for publication.

- "Unbundling in the deregulated Scandinavian and California Electricity Markets" by Helle Groenli and Eddie Dehdashti, presented at the Power Delivery Europe Conference, October 1998, London UK.

- "Restructuring and Suitable Market Structures for Developing Countries" IEEE Power and Energy magazine, September/October 2004 issue, PP. 16-23.

- "Monitoring and Surveillance of Wholesale Electricity Markets-Roles, Responsibilities and Challenges", presented and published at the IEEE/PES summer 2005 meeting, June 2005 San Francisco, California.

- "Transmission Fast Simulations and Modeling (T-FSM)- Functional Requirement', co-author, EPRI Report 10111666, March 2005.

HONORS

Dean's Honor List, Grant-in-Aid Scholarship, PG&E's Performance Recognition Award, 1986 Winner of President George Maneatis Incentive Program. Winner of "Ideas in Action" Program for suggestion leading to over one million in savings.

PROFESSIONAL LICENSE AND REGISTRATION

State of California, Electrical Engineering, 1985.

PROFESSIONAL ASSOCIATIONS

Senior Member, IEEE Power Engineering Society, Chairman of the IEEE PES Task Force on Energy Trading, Chairman of the San Francisco chapter of IEEE Power Engineering Society Continuing Education Committee, 1985-1986 and San Francisco State University part-time faculty member.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Ninth **Date received:** October 1, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: October 12, 2009

VAStaff-IX-5:

Has PJM or any of its members done any study that shows which (or, all) load tap changing transformers within PJM have sufficient range to emulate a constant MVA behavior? If so, provide a copy of the study and specification for the LTCs.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions and objects specifically to the breadth of the request to include information on studies that may have been performed by members of PJM , PATH-VA responds as follows:

PJM has not conducted any such study. To PJM's knowledge, bulk power system transformer tap positions are changed manually.

Response of PATH Allegheny Virginia Transmission Corporation
to Sierra Club Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received**: September 29, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: October 8, 2009

SierraVA-IV-51:

With respect to Mr. Herling's testimony at 42, what are the load power factors at all buses in the area(s) where reliability violations are alleged?

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

See Attachment SierraVA-IV-51-A.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received:** September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-25:

Describe PJM justification for using "Constant Power" and "Constant Power Factor" for modeling all loads.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Consistent with PJM Operations, PJM Planning performs all its steady state power flow work with constant real and reactive power loads, as submitted by the PJM Transmission Owners. Normal practice – consistent with PSS/E's Application Guide - in steady state power flow work is to assume that distribution system tap changers and voltage regulators have brought customer voltages to nominal values and, hence, that load at the buses represented in the power flow case may be treated as a constant real and reactive power demand.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-26:

Describe PJM justification and practices for load power factor correction and modeling.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

The minimum load power factor requirement of 0.97 lagging is defined in Attachment D of PJM Manual-14B available at the following link:

http://www.pjm.com/documents/~/media/documents/manuals/m14b.ashx

CONFIDENTIAL INFORMATION

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Ninth **Date received:** October 1, 2009

Response prepared by or under the direction of: Lawrence Hozempa

Responsible case witness for this response: Lawrence Hozempa

Response date: October 12, 2009

VAStaff-IX-4:

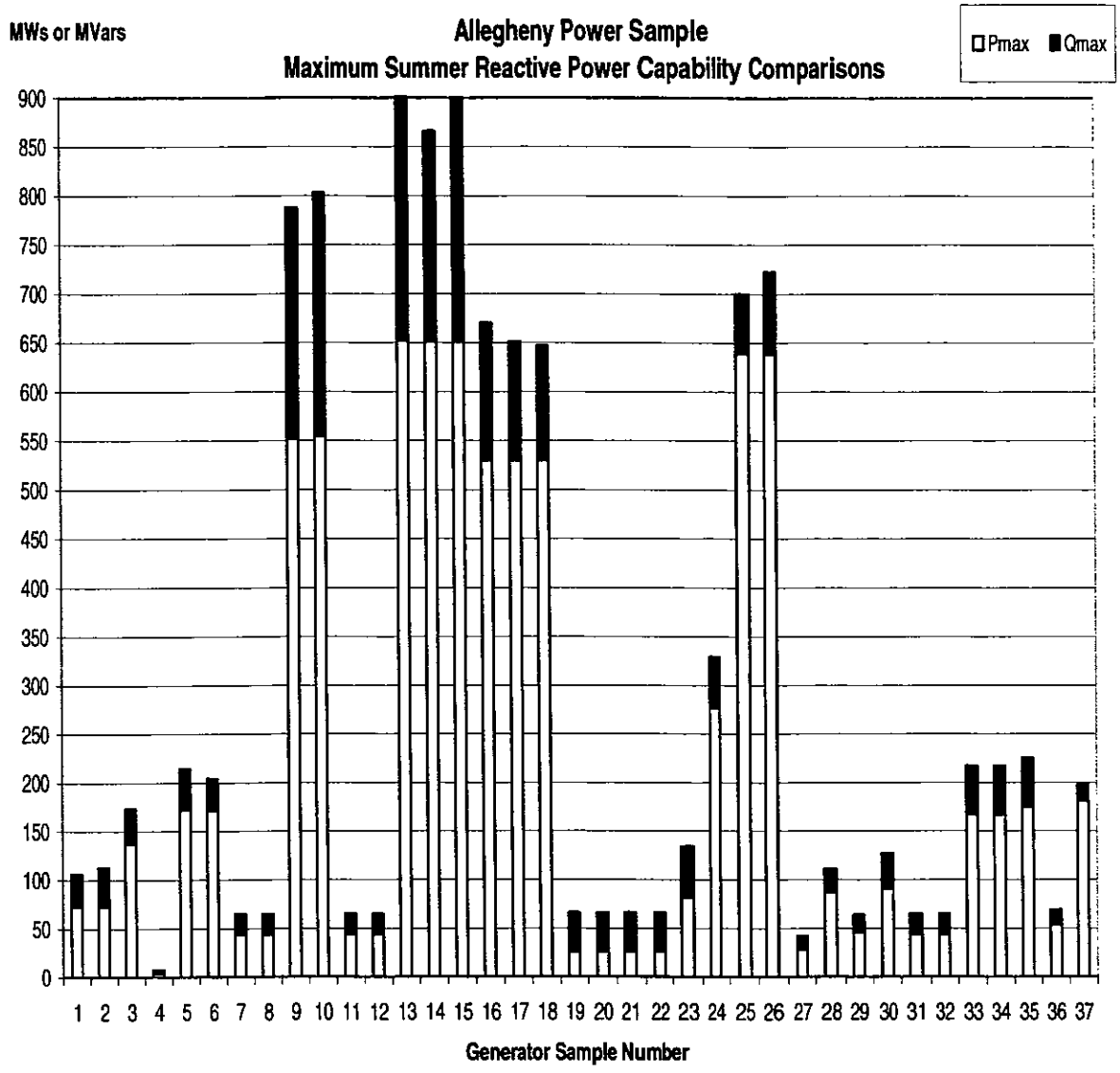
For the generators in 3, can you please provide detailed information in Microsoft Excel format database including the following details:

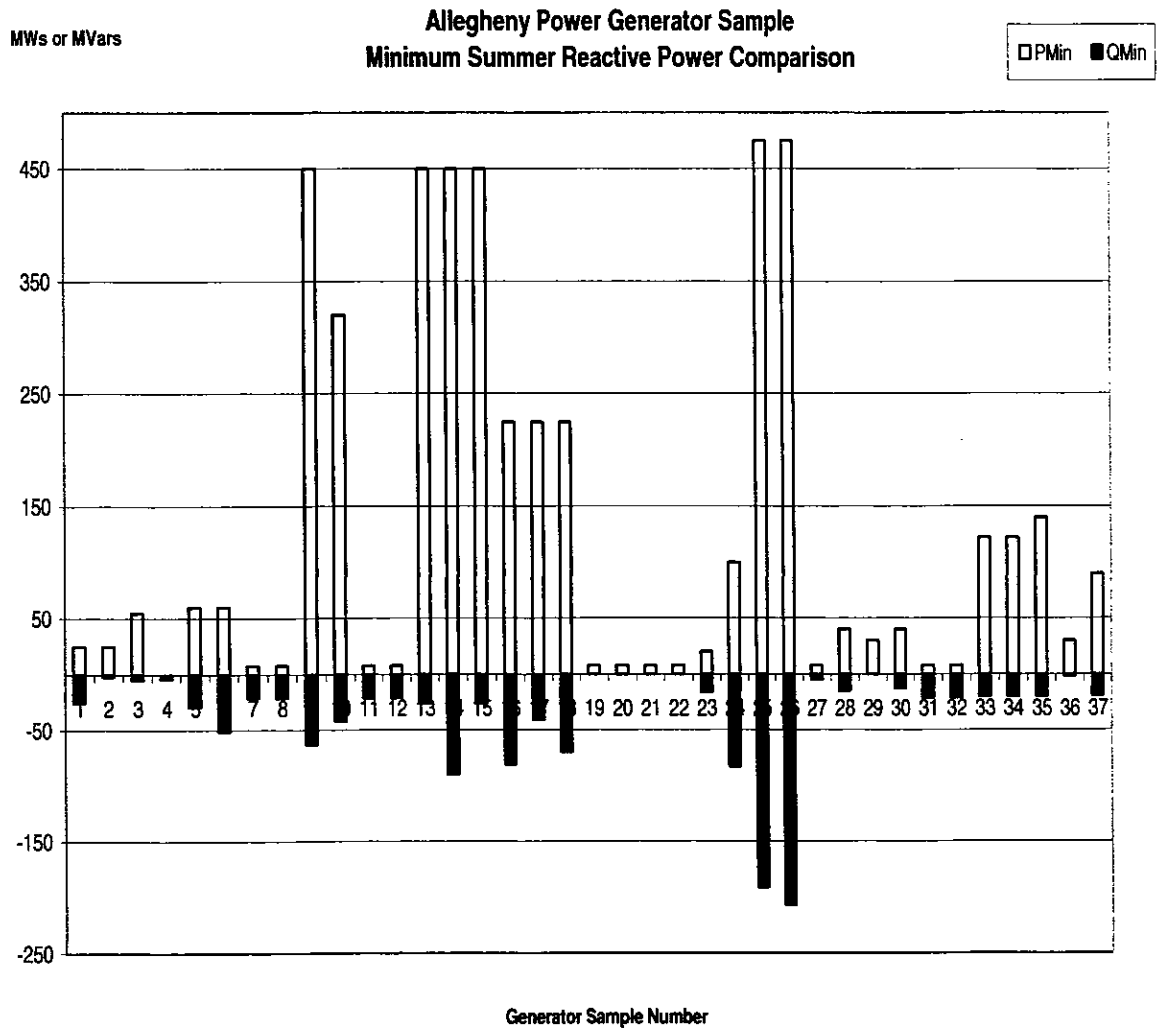
Name, Owner, area, Type- Hydro, thermal, Terminal Voltage, Pmin, Pmax, Q min, Q Max, Voltage Setpoint, *etc.*

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Notwithstanding there was no data in the response to VAStaff-IX-03, the following information is being supplied by Allegheny Power. Attachment VAStaff-IX-04-A contains the information requested for a sampling of generators in the Allegheny Power Transmission Zone. The attached information is collected by Allegheny Power from generators within the Allegheny Power Transmission Zone as part of the annual process of developing the MMWG cases and is covered by NERC Standard MOD-010-0. Note the attached information was collected to develop the 2009 Series cases and may not match the data in the power flow cases from previous years.


MWs or MVars
Allegheny Power Sample
Maximum Summer Reactive Power Capability Comparisons
Pmax
Qmax
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Generator Sample Number


MWs or MVars
Allegheny Power Generator Sample
Minimum Summer Reactive Power Comparison
PMin
QMin
450
350
250
150
50
-50
-150
-250
1 2 3 4 7 8 11 12 19 20 21 22 27 28 29 30 31 32 33 34 35 36 37
Generator Sample Number

Generator Real and Reactive Power Comparisons
Aggregate Summer Pmax and Pmin for the Allegheny Sample:

Pmax	Pmin	Qmax	Qmin
8,282 MWs	4,792 MWs	2570.4 MVARs	-1291.4 MVARs

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-24:

Describe generator capability curve modeling practices at PJM and whether it has been used for the study of the PATH Project - provide one or two examples of developing Qmin and Qmax.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

NERC requires generator owners to submit to Transmission Owners, for both Summer and Winter, the maximum (Qmax) and minimum (Qmin) rated net unit reactive output in MVAR at the corresponding net seasonal unit output in MW (Pmax) of the generator. The NERC ERAG MMWG develops cases based on this submitted data. The 2014 power load flow model used in PJM's RTEP process out of which the need for the PATH line originated, came from the 2008 Series 2014 Summer Peak ERAG MMWG case.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Ninth **Date received:** October 1, 2009

Response prepared by or under the direction of: Lawrence Hozempa; Paul McGlynn

Responsible case witness for this response: Lawrence Hozempa; Paul McGlynn

Response date: October 12, 2009

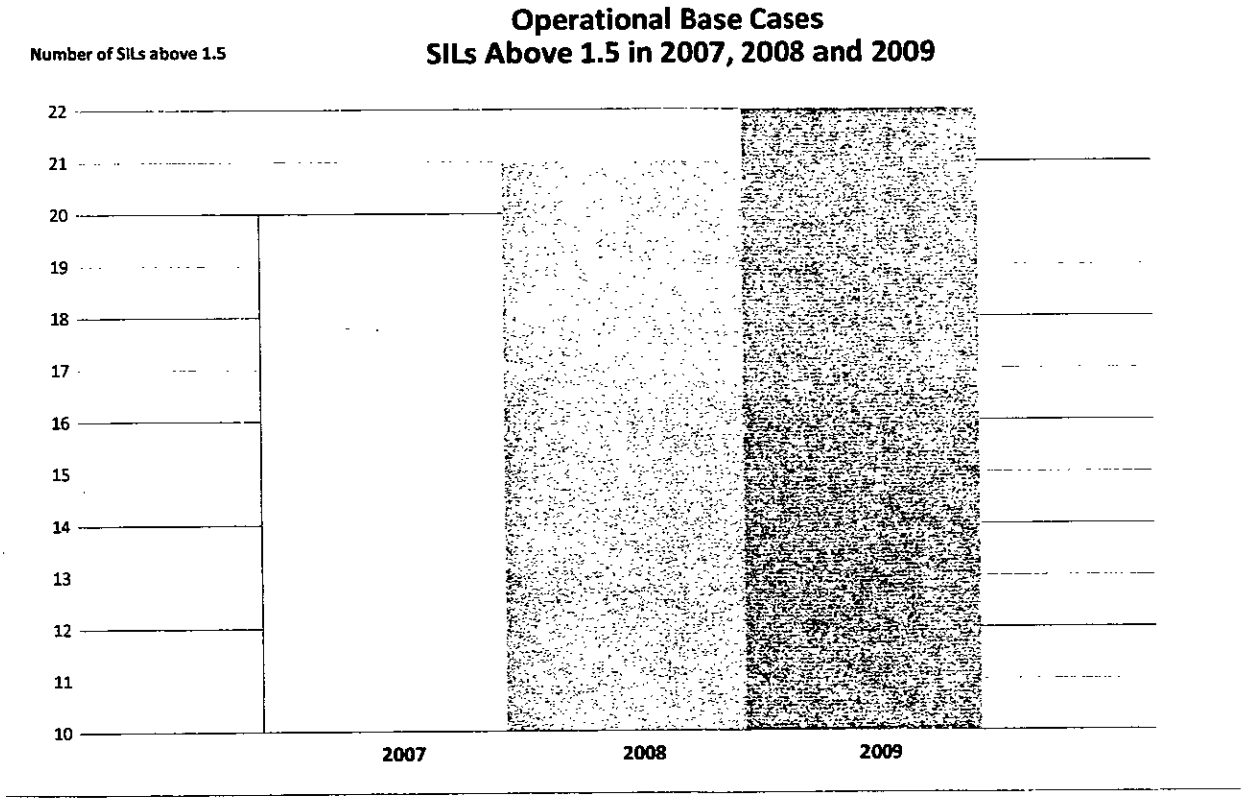
VAStaff-IX-3:

Response to VAStaff-VII-24 - Can you please provide a dozen or so generator capability curves anywhere within PJM? Samples from Allegheny Power will be just fine.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Neither PJM nor Allegheny Power has record of generator capability curves.


Operational Base Cases
SILs Above 1.5 in 2007, 2008 and 2009
Number of SILs above 1.5
22
21
20
19
18
17
16
15
14
13
12
11
10
2007
2008
2009

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn; Lawrence Hozempa

Responsible case witness for this response: Paul McGlynn; Lawrence Hozempa

Response date: September 21, 2009

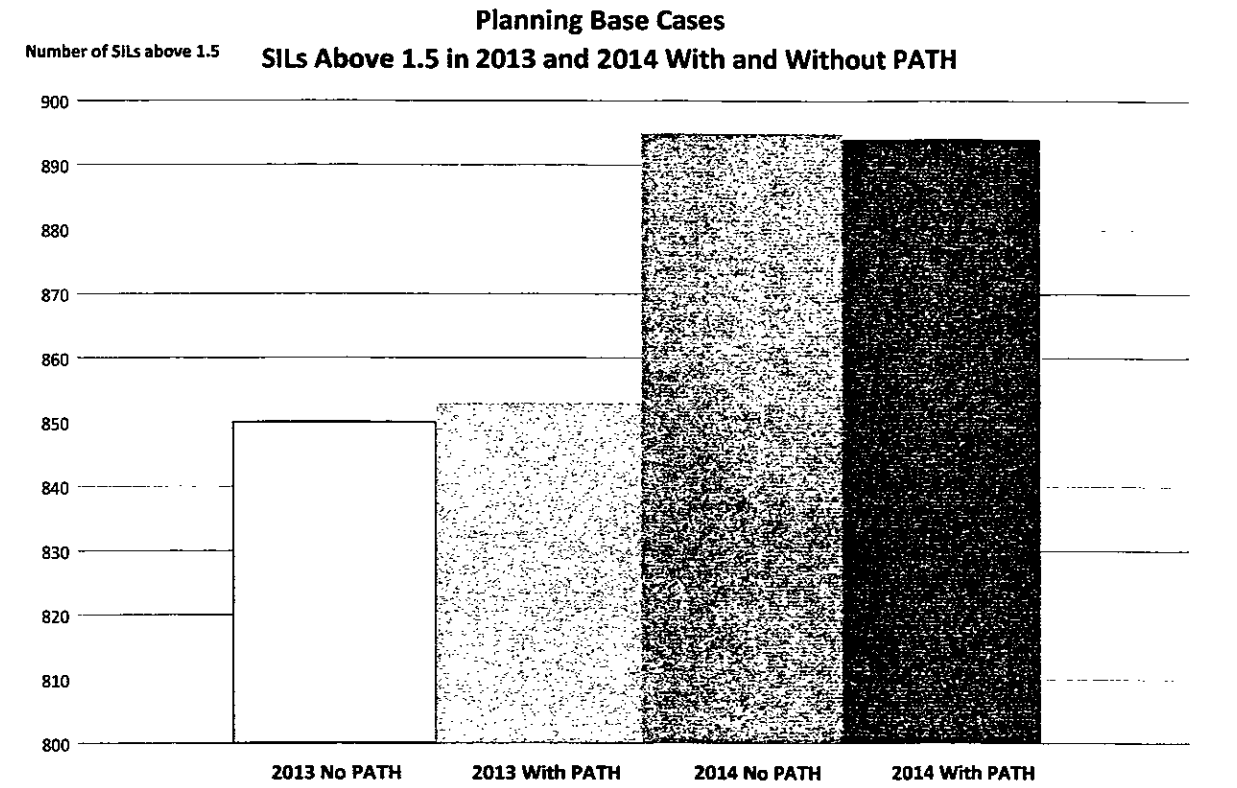
VAStaff-VII-27:

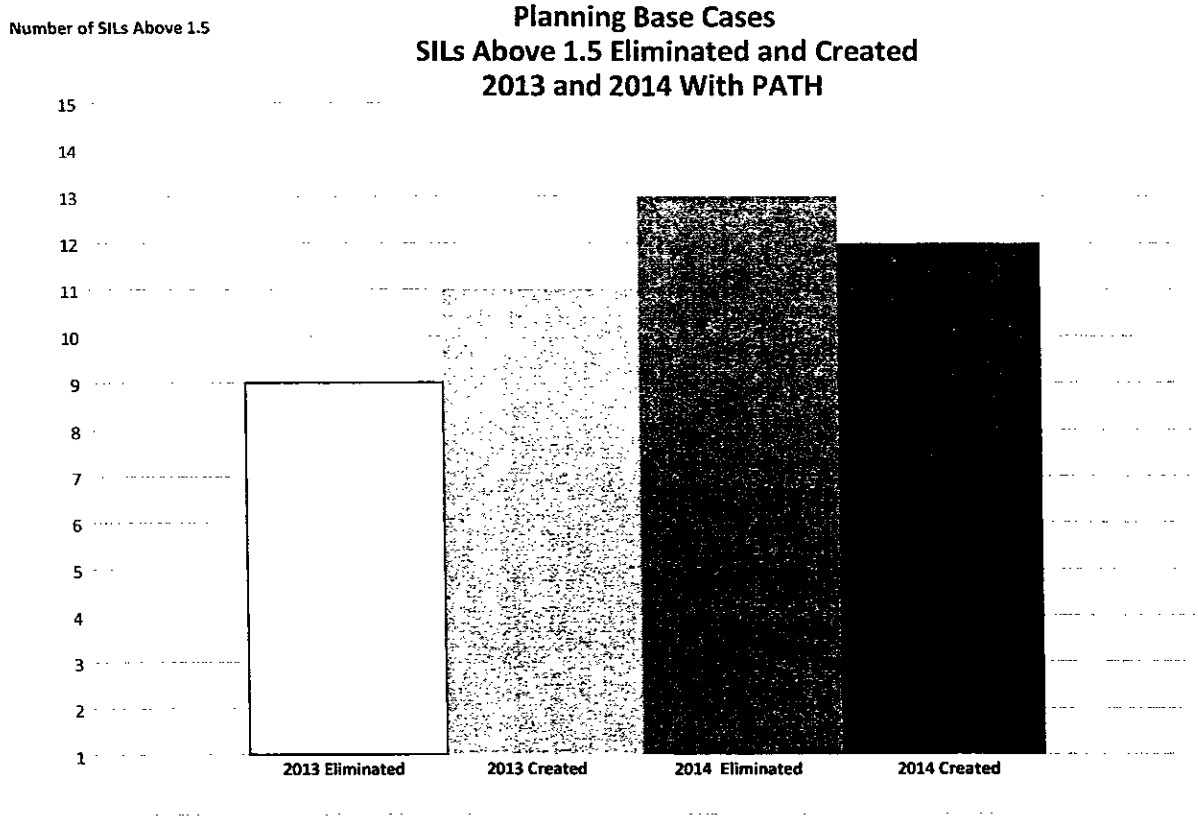
Provide a list of all transmission and sub-transmission lines loaded above 1.5 SIL before and after PATH within the Mid-Atlantic Area.

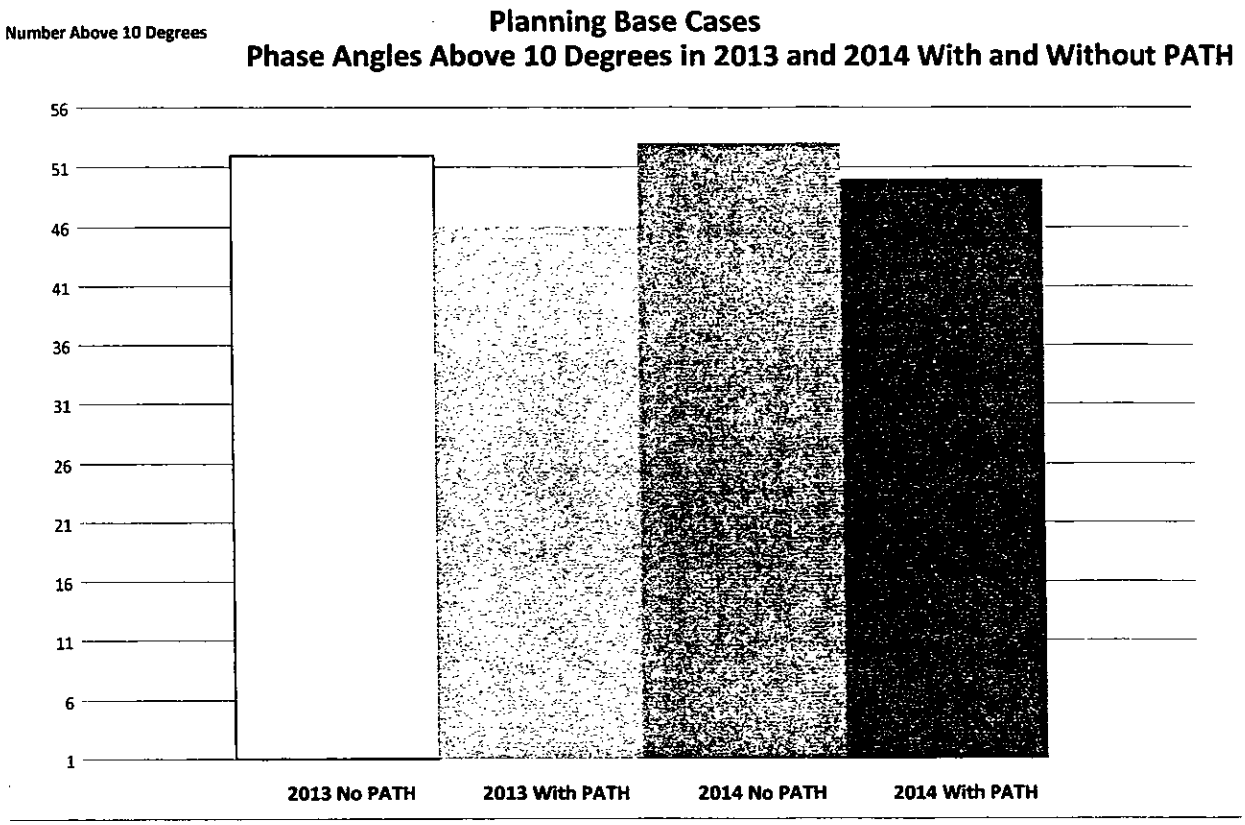
RESPONSE:

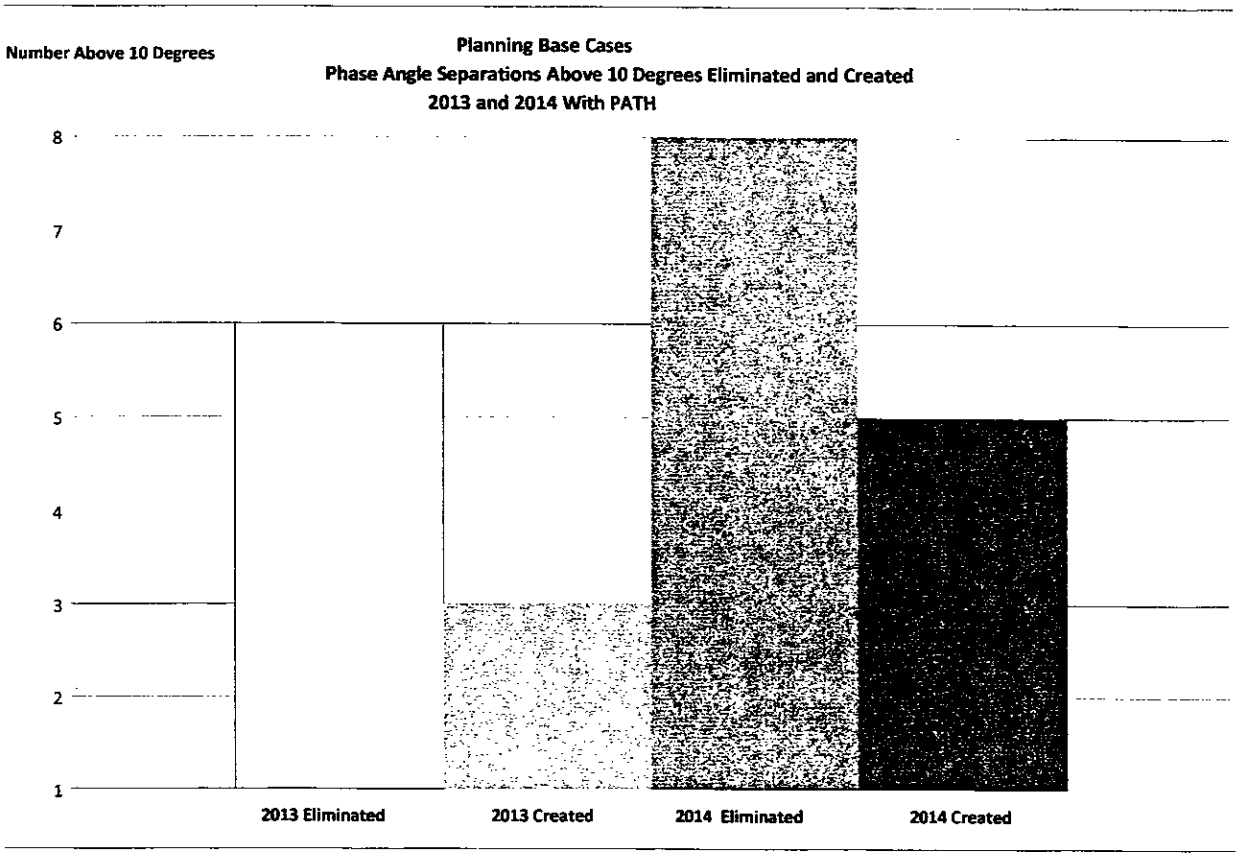
Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

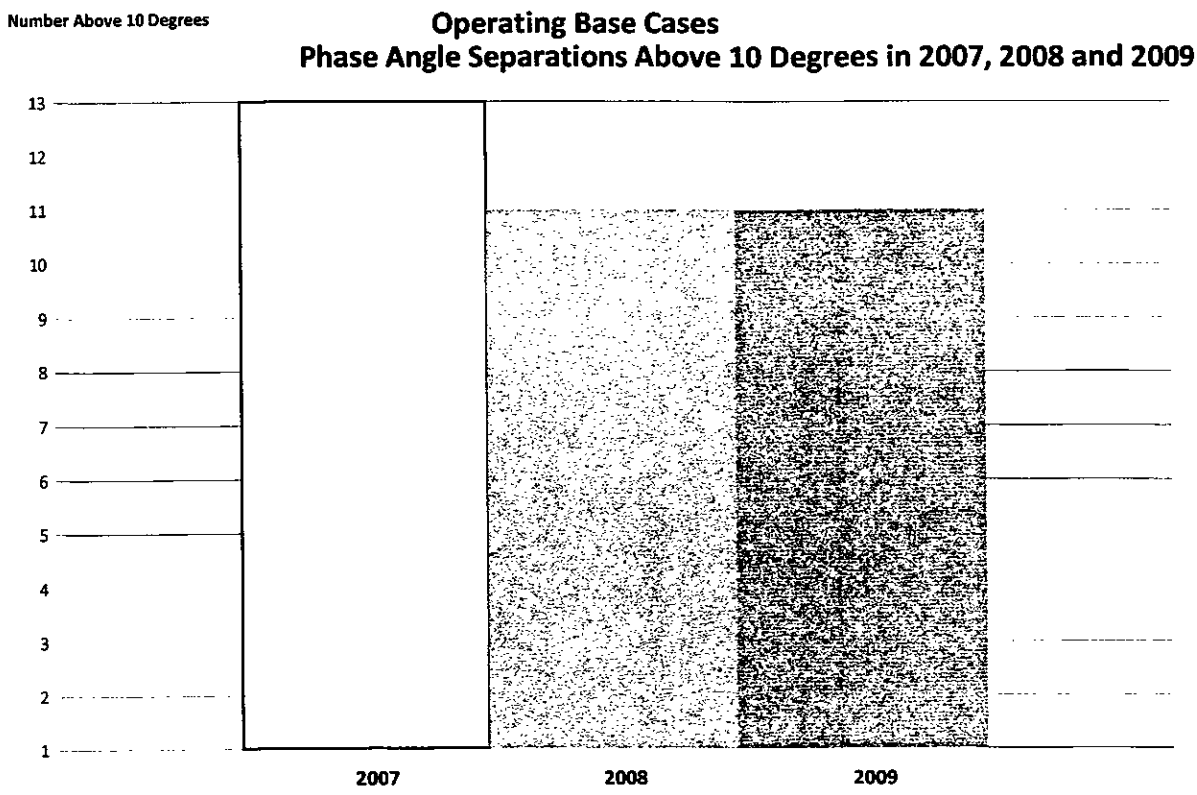
A list of all transmission and sub-transmission lines loaded above 1.5 SIL before and after PATH within the Mid-Atlantic Area has been provided in attachments VAStaff-VII-27-A and VAStaff-VII-27-B. VAStaff-VII-27-A is for the 2013 Mid-Atlantic Load Deliverability case before and after PATH, and VAStaff-VII-27-B is for the 2014 Mid-Atlantic Load Deliverability case before and after PATH.


Planning Base Cases
SILs Above 1.5 in 2013 and 2014 With and Without PATH
Number of SILs above 1.5
900
890
880
870
860
850
840
830
820
810
800
2013 No PATH
2013 With PATH
2014 No PATH
2014 With PATH


Planning Base Cases
SILs Above 1.5 Eliminated and Created
2013 and 2014 With PATH
Number of SILs Above 1.5
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2013 Eliminated
2013 Created
2014 Eliminated
2014 Created


Number Above 10 Degrees
Planning Base Cases
Phase Angles Above 10 Degrees in 2013 and 2014 With and Without PATH
56
51
46
41
36
31
26
21
16
11
6
1
2013 No PATH
2013 With PATH
2014 No PATH
2014 With PATH


Number Above 10 Degrees
Planning Base Cases
Phase Angle Separations Above 10 Degrees Eliminated and Created
2013 and 2014 With PATH
8
7
6
5
4
3
2
1
2013 Eliminated
2013 Created
2014 Eliminated
2014 Created


Number Above 10 Degrees
Operating Base Cases
Phase Angle Separations Above 10 Degrees in 2007, 2008 and 2009
13
12
11
10
9
8
7
6
5
4
3
2
1
2007
2008
2009

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-23:

Provide PV Curves, with and without PATH for all locations where voltage criteria violated, and the reasons for choosing those locations.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PV curves for the system without PATH were provided in Exhibit PFM-4. Those locations were chosen because they were representative of the wide range of voltage violations identified. Applicant does not have PV curves with PATH in service for all locations. To create these PV curves would constitute original work. Further, there is no need to develop PV curves with PATH in service because PATH resolves all the reliability criteria violations identified.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Ninth **Date received:** October 1, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: October 12, 2009

VAStaff-IX-6:

Response to VAStaff-VII-23- Mr. McGlynn's testimony page 49 claims that PATH resolves NERC's voltage violation until 2021. Can you please describe how this conclusion was possible to make without doing a P/V curve with PATH in service.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Mr. McGlynn's testimony cited in this question refers to earlier analysis in which all the violations were thermal overloads and the reference to the resolution of "violations" referred only to thermal violations. No P/V analysis has been performed for the later years of the planning horizon.

Response of PATH Allegheny Virginia Transmission Corporation
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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-7:

Provide descriptions of any sensitivity studies with PATH considering changes in the load, among others, for the Mid-Atlantic area and PJM as a whole.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

The 2008 and 2009 RTEP analyses included retooling studies confirming the need for PATH. Each of these retools addressed the impacts of all changes to the system, including load, generation, long term firm transmission service requests, demand response and transmission topology. PJM did not analyze the impact of each individual change. In addition, the August 22, 2007 TEAC meeting presentation included a generation sensitivity analysis for three 500 kV lines. This presentation can be accessed at: http://www.pjm.com/committees-and-groups/committees/~/media/committees-groups/committees/pc/20070822-teac-reliability-interconnection-analysis-update.ashx

Response of PATH Allegheny Virginia Transmission Corporation
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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received:** September 14, 2009

Response prepared by or under the direction of: Paul McGlynn; Takis Laios

Responsible case witness for this response: Paul McGlynn; Takis Laios

Response date: September 25, 2009

VAStaff-VII-16:

Provide a detailed description of any dynamic analysis performed with and without PATH.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

A dynamic analysis was performed to assess any adverse impact of reclosing operations of the PATH 765 kV circuits on the turbine-generator shafts of Amos Units 1 & 3. The analysis was based on the "IEEE Screening Guide for Planned Steady-State Switching Operations to Minimize Harmful Effects on Steam Turbine-Generators." The Screening Guide recommends delta P values of 50% or lower at the generator terminals due to line reclosing operations in the vicinity. The analysis involved the calculation of delta P values at the terminals of Amos Units 1 & 3 for reclosing operations on the Amos-Bedington 765 kV line under various operating conditions representing normal and contingency conditions. The results indicated no potential adverse impact on these generating units since the delta P remained below 50%. It should be noted that the study was not repeated for the new PATH configuration (Amos-Welton Spring-Kemptown), since the results and conclusion of this analysis also remain valid for the new configuration.

Response of PATH Allegheny Virginia Transmission Corporation
to Sierra Club Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received:** September 29, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: October 8, 2009

SierraVA-IV-50:

With respect to Mr. Herling's testimony at 39:12, please provide angle-vs-time swing curves for all transient stability cases used to determine the "severe voltage instability problems identified in PJM's most recent analysis."

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Transient stability analysis techniques were not used to determine the severe voltage instability problems. Power flow analysis techniques were used.

Response of PATH Allegheny Virginia Transmission Corporation
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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 25, 2009

VAStaff-VII-20:

Provide legible load duration curves, by membership, and for total PJM, for 2006, 2007 and 2008.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM does not maintain load duration curves. Load duration information for the total PJM system can be accessed in the 2008 State of the Market Report at the Monitoring Analytics, Inc. website at: http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2008.shtml
Page 45 of Section 2 contains load duration curves for 2004-2008. Page 445 of Appendices, Part 1 contains frequency distribution information.

Response of PATH Allegheny Virginia Transmission Corporation
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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 22, 2009

VAStaff-VII-22:

Provide a detailed description of loss reductions attributable to PATH broken out into real and reactive losses, and listed according to PJM membership and total PJM.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Loss reductions attributable to PATH are included in attachment VAStaff-VII-22-A.

Response of PATH Allegheny Virginia Transmission Corporation
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Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 22, 2009

VAStaff-VII-9:

Provide a detailed description of resource availability assessment for 3300 MWs at or near the Amos substation (the sending end of PATH). Provide resource availability assessments for all other sending ends appearing in the viable alternatives.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

First, some clarification, from a system physics perspective either end of a transmission line can be a "sending end." Notwithstanding, PJM did not quantify the resource availability at or near the Amos substation The PATH transmission project resolves identified reliability criteria violations. In doing so, the PATH Project will enhance the ability of all generating resources in PJM, in aggregate, to be delivered to the aggregate customer load on the PJM system. The PATH project is neither intended to deliver any one specific generating resource or class of generating resources, nor is it designed to promote the future development of any class of new generation. New generation projects "at or near Amos substation" can be found in PJM's generation interconnection queue, accessible from PJM's web site via the following URL link: http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx

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Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: September 21, 2009

VAStaff-VII-11:

Describe PATH'S potential impact to renewable resource development in the PJM, and potentially, MISO, footprints. At a minimum, identify the additional renewable resource capacity that can be integrated, based on known generation interconnection requests in the PJM, and potentially the MISO. generation queues, if PATH is added.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM did not analyze the impact to renewable resource development due to PATH. See the response to VAStaff-VII-9 which notes that PJM plans the electrical system to be able to deliver the aggregate of all PJM generation to the aggregate PJM customer load. The addition of a backbone transmission facility such as PATH will increase the capability of the electric system to deliver the aggregate of generation, including proposed generation projects. The PATH project was not planned-for nor is being constructed for the interconnection of any specific generators or class of generation.

Response of PATH Allegheny Virginia Transmission Corporation
to Sierra Club Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received**: September 29, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: October 8, 2009

SierraVA-IV-82:

With respect to Mr. Herling's testimony at 56:14, stating that new renewable energy such as solar and wind is located in remote areas far from population centers, provide the studies that PJM has completed and/or commissioned to evaluate the potential for solar and wind energy to meet load demand in PJM.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM has not conducted such studies. See the response to SierraVA-IV-83.

Response of PATH Allegheny Virginia Transmission Corporation
to Sierra Club Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received**: September 29, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: October 8, 2009

SierraVA-IV-83:

With respect to Mr. Herling's testimony at 57:10-14, stating that the PATH project supports the Obama Administration's goals to increase the percentage of energy provided by renewable energy to 20% by 2024, provide the basis for this statement, including planned or current adjustments to PJM tariffs that would provide preferential treatment for renewable resources and/or tariffs that would preclude access by existing generation resources.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

The PATH Project is not designed to serve any generator or class of generators. A new backbone transmission project will provide additional transmission capacity for all generating units, both new and existing, including renewable resources which are planned largely in the western portion of PJM or to the west of PJM. See the response to SierraVA-IV-73.

Response of PATH Allegheny Virginia Transmission Corporation
to Sierra Club Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received**: September 29, 2009

Response prepared by or under the direction of: Lawrence Hozempa

Responsible case witness for this response: Lawrence Hozempa

Response date: October 8, 2009

SierraVA-IV-74:

With respect to Mr. Hozempa's testimony at 21:9-12, stating that the proposed PATH transmission line will "permit increased transfer of energy generated by renewable resources," provide the names, locations, expected capacity and expected energy for renewable resources that would transmit their output using the proposed PATH transmission line.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

The PATH line is not designed to deliver the output of any generator or class of generators. See the response to SierraVA-IV-73. Renewable generation that is in the queue is located largely to the west and the PATH line will facilitate delivery of these resources to load.

Response of PATH Allegheny Virginia Transmission Corporation
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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-15:

Provide detailed information on the reactive power studies, including the locations and distribution of the 2000 MVAR of shunt capacitors used in the power flow analysis.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

Response: A high-level voltage analysis was performed to estimate the approximate amount of reactive support required to resolve the reliability criteria violations in 2014. This high-level analysis was sufficient to confirm PATH as the preferable solution over additional amounts of reactive compensation. As noted in Mr. McGlynn's testimony at pages 51-54, the addition of reactive compensation would be ineffective at resolving the thermal violations and make the system more susceptible to sudden voltage collapse. The reactive study determined that approximately 2,000 MVAR of static capacitors would be required to resolve the voltage problems that occur in 2014 without PATH. These reactive upgrades were placed at the following substations. Note that PJM did not pursue whether it would be feasible to locate capacitors at these locations.

500 MVAR at Jacks Mountain 500 kV
500 MVAR at Doubs 500 kV
500 MVAR at Meadowbrook 500 kV
500 MVAR at Brighton 230 kV
50 MVAR at Dale 230 kV

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Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-17:

Describe, in detail any voltage stability analysis performed that used analytical tools other than load flows and PVIQV curves.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM did not perform any voltage stability analysis that used analytical tools other than load flows and PV/QV curves.

Response of PATH Allegheny Virginia Transmission Corporation
to Staff of Virginia State Corporation Commission Discovery Request
Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received**: September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-18:

Provide detailed information on operational remediation studies, if any, to deal with the reliability issues that are solved by PATH.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

The PATH project was justified to resolve NERC Reliability Criteria violations. In the PJM analysis confirming the need for PATH, redispatch of generation on the PJM system was not sufficient to resolve the reliability criteria violations. PJM has an obligation to resolve these violations through the addition of transmission facilities such as PATH. In actual power system operations, operator actions such as off-cost operation and the implementation of emergency procedures, up to and including the interruption of firm customer load, could be used. Such actions are noted in Manual M3, accessible at:
http://www.pjm.com/documents/~/media/documents/manuals/m03.ashx

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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received:** September 14, 2009

Response prepared by or under the direction of: Steve Herling

Responsible case witness for this response: Steve Herling

Response date: September 21, 2009

VAStaff-VII-10:

Provide the economic analysis of the PATH, including total average annual LDA zonal LMP price (total of spot energy, congestion, and line losses) variations by area/utility with and without PATH, out of merit order calls, payments to load by area/utility with and without PATH, payments to generators by unit and area/utility with and without PATH, FTR or Congestion Revenue Rights (CRR) payments by area/utility with and without PATH, and market power analysis by area/utility with and without PATH.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM's "economic analysis" is limited to the market efficiency elements of PJM's regional transmission expansion planning process analyses, the results of which were presented at the March 30, 2007 TEAC meeting and which can be accessed at: http://www.pjm.com/committees-and-groups/committees/teac/teac-archive.aspx

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Discovery request submitted by: Sierra Club

Discovery request set number: Fourth **Date received:** September 29, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: October 8, 2009

SierraVA-IV-65:

How many hours in a typical year would the PJM system have to be operated out-of-merit to prevent any violations of NERC or other planning standards or criteria in the absence of the PATH line?

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

PJM has not analyzed this scenario. See the response to SierraVA-IV-64.

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Virginia State Corporation Commission
Case No. PUE-2009-00043

Discovery request submitted by: Staff of Virginia State Corporation Commission

Discovery request set number: Seventh **Date received:** September 14, 2009

Response prepared by or under the direction of: Paul McGlynn

Responsible case witness for this response: Paul McGlynn

Response date: September 21, 2009

VAStaff-VII-5:

Provide a description of the HVDC alternative assessment.

RESPONSE:

Subject to and without waiving any objections to this discovery request, including separately submitted objections to this set of discovery requests and objections to definitions and instructions, PATH-VA responds as follows:

See the attachment to the response to Ghiorzi-I-75 for the scope of work for an HVDC feasibility study to be conducted by Black & Veatch. When the report is finalized it will be posted on PJM's website.