STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES

IN THE MATTER OF THE PETITION OF PUBLIC SERVICE ELECTRIC AND GAS COMPANY FOR A DETERMINATION PURSUANT TO THE PROVISIONS OF N.J.S.A. 40:55D-19	:	**BPU DOCKET**
(SUSQUEHANNA-ROSELAND)	:	

TO THE HONORABLE COMMISSIONERS OF THE NEW JERSEY BOARD OF PUBLIC UTILITIES:

SUMMARY OF PRE-FILED DIRECT TESTIMONY
OF RICHARD F. CROUCH
ON BEHALF OF PUBLIC SERVICE ELECTRIC AND GAS COMPANY

Mr. Richard F. Crouch, Senior Project Manager – Transmission Outside Plant Construction for Public Service Electric and Gas Company ("PSE&G"), testifies on behalf of PSE&G in this proceeding. Mr. Crouch has responsibility for the management of transmission line work associated with large utility projects, including the Susquehanna-Roseland Project (the "Project") which is the subject of this proceeding.

Mr. Crouch files direct testimony to support the design and engineering of the utility structures associated with the Project. Specifically, Mr. Crouch explains the three (3) options for the design of the transmission structures that PSE&G will be using for the Project and why these options were chosen. Furthermore, Mr. Crouch identifies the location within the existing right-of-way where each of the new structures will be constructed and explains why these locations were chosen.

Mr. Crouch also discusses the proposed height of the transmission facilities and explains that the National Electric Safety Code ("NESC") clearances, electrical field

requirements of the State of New Jersey and PJM Interconnection, L.L.C. ("PJM") safety practices are the driving factor in the height of the structures. Specifically, Mr. Crouch notes that the structures will be between 145 and 195 feet tall depending on the topography of the ground due to the vertical construction of the circuits. Currently, the existing single circuit 230kV facilities are in a horizontal configuration, while the proposed system upgrades will include be a double circuit with the 230kV circuit on one side and the 500kV circuit on the other side. This will require a construction of both circuits in a vertical alignment. Therefore, NESC clearances and PJM safety criteria require a minimum of 32 feet of clearance from the lowest conductor to the ground as well as 31 feet of clearance between the remaining conductors, which is the driving factor in the height of the structures.

Mr. Crouch further explains that undergrounding of the 500kV transmission circuit is not an option. Mr. Crouch explains that the reliability of underground 500kV AC (alternative current) circuits has not been established because of its limited use and application in the industry. Mr. Crouch further testifies that there are no 500kV AC underground circuits currently operating in transmission grids in the United States. Mr. Crouch testifies that 500kV DC (direct current) circuits have been accepted in the industry, but explains that the property necessary for converter stations, large environmental impacts and significant cost eliminate underground 500kV DC as an option.

Finally, Mr. Crouch explains the access and construction impacts associated with the Project. Specifically, Mr. Crouch discusses how and where PSE&G plans to access

the right-of-way to construct the facilities, how construction will be completed and how long the construction process will take.

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PRE-FILED DIRECT TESTIMONY OF RICHARD F. CROUCH ON BEHALF OF PUBLIC SERVICE ELECTRIC AND GAS COMPANY IN SUPPORT OF SUSQUEHANNA-ROSELAND TRANSMISSION LINE PROJECT

I. PROFESSIONAL BACKGROUND

Q. What is your full name and business address?

A. Richard F. Crouch, 4000 Hadley Road, South Plainfield, NJ 07080.

Q. By whom are you employed and for how long have you been employed?

A. I have been employed by Public Service Electric and Gas Company ("PSE&G") for the past 26 years.

Q. Please briefly describe your educational and professional background.

A. I have obtained a Bachelor of Science in Engineering Technology (Electrical) from the New Jersey Institute of Technology in 1992 and a Master of Science in Management Engineering from New Jersey Institute of Technology in 1994.

Q. What is your current title and nature of your present employment?

A. My title is currently Senior Project Manager – Transmission Outside Plant Construction.

I am responsible for the management of transmission line work associated with large complex utility projects including the Susquehanna -Roseland 500kV Transmission Project (the "Project"). I have responsibility for the overall execution of the design, engineering, and construction for these assigned projects within approved scope, budget, and schedule.

Q. Please describe your experience with electric transmisssion projects.

A. Prior to my current assignment as Senior Project Manager, I was the Manager of Transmission Engineering for PSE&G from January 2002 to June 2008. During that period, I directed and led the engineering and design activities for all construction, operation and maintenance of PSE&G's overhead and underground outside plant transmission facilities. During this period, I worked on numerous projects involving both underground and overhead transmission assets ranging in scope from $100,000 to $65 million.

II. PROJECT OVERVIEW

Q. Briefly describe the Project from an engineering perspective.

A. PJM has identified multiple transmission circuits that will be overloaded in eastern Pennsylvania and New Jersey. PJM's Regional Transmission Expansion Planning Process ("RTEP") directed the construction of a system upgrade consisting of a new 500kV circuit beginning in PPL Electric Utilities' ("PPL Electric") Susquehanna Station in Berwick PA and running to PSE&G's Roseland Switching Station in the Roseland/East Hanover, New Jersey area. The new

500kV transmission circuit must tie to the existing Branchburg–Ramapo 5018 circuit, while maintaining existing 230kV circuits. PSE&G's portion of the Project involves the re-configuration and re-construction of an existing 230kV overhead single circuit. As part of the system upgrade, PSE&G will be deconstructing the existing lattice structures, which currently hold a 230kV circuit in a horizontal configuration. PSE&G will then be constructing a new double circuit structures. The new structures will support 230kV conductors on one side and 500kV conductors on the other, both in vertical configurations. PSE&G will connect the new 500kV transmission circuit into switching stations in Jefferson Township, where the existing Branchburg-Ramapo 500kV circuit would cross the Susquehanna-Roseland 500kV circuit, and at the termination point in East Hanover Township. PSE&G has designed the new structure and conductors to fit within the existing right of way limits while meeting all applicable regulations.

Q. What has your role been with respect to the Project?

A. I am responsible for the execution, design and engineering for the Project facilities located outside of the switching stations, including initial feasibility studies that were conducted by PSE&G. I am further responsible for hiring and directing consultants and in-house resources for the preparation of all plans, schedules, permit applications, detail design drawings and specifications. I am responible for interfacing, from an engineering and design perspective, with key project stakeholders including: customers (internal and external), property owners, other utilities, municipalities, governmental agencies and the public in

order to provide line design and engineering information and to resolve related issues and concerns.

Q. Please describe the purpose of your testimony.

A. The purpose of my testimony is to provide the Board with background information on the design, engineering and construction aspects of the Project for all facilities located outside of the switching stations, referred to as "outside plant" facilities.

Q. Are you sponoring any exhibits?

A. Yes, I am sponsoring the following exhibits:

Exhibit RFC-1: Photo renderings of existing and proposed structures

Exhibit RFC-2A, 2B, and 2C: Examples of the three proposed structure types

Exhibit RFC-3: Site Plan Drawings

Exhibit RFC-4: Preliminary Plans and Profiles of the Project

Exhibit RFC-5: Example of horizontal configuration, vertical configuration and phasing

Exhibit RFC-6: Typical access road material/construction.

Q. What is the existing voltage located on the right-of-way which is the subject of this Petition?

A. The existing overhead transmission circuit located on the existing Roseland-Bushkill Transmission Line Right-of-Way (the "Right-of-Way") is constructed and operated at 230kV or 230,000 Volts.

Q. When was the existing 230 kV line constructed?

A. Records indicate that the existing line was constructed over the course of several years from 1926 to 1931.

Q. What is the width of the Right-of-Way?

A. The existing Right-of-Way is 150 feet wide at its narrowest point. There are small sections of the Right-of-Way that exceed 150 feet.

Q. Have there been any upgrades to the existing line since completion in 1931?

A. Other than a few structural changes to facilitate service to substations at Kittatinny, Newton and Montville and possible repairs due to maintenance, no substantial work has been performed on the structures since their construction. However, the line segments were re-conductored in the 1970's.

Q. Apart from the reliability need for the Project as explained in the testimony of PSE&G witness Khadr and PJM witnesses Herling and McGlynn, would construction of the Project have any engineering or operational benefits given the age of the existing line?

A. Yes. Since the existing structures are approximately 80 years old, there are inherent operational and maintenance benefits derived by their replacement. Operational issues such as lightning induced outage performance and relay protection would be enhanced. Maintenance benefits would be comparative to purchasing a new vehicle as opposed to maintaining an old one.

III. DESIGN OF TRANSMISSION STRUCTURES

Q. What is the height of the existing structures which carry the 230kV circuit?

A. The existing structures range in height from 72.5 feet to 187 feet tall. The 187 foot tall tower is located near the Newton 230kV sub-station in Andover, Township.

Q. What is the design of the existing structures?

A. The existing structures are steel lattice structures with horizontal construction of the circuit. A photo of the existing structures on this Right-of-Way is located in the photo renderings prepared by Truescape, which is attached to my testimony as Exhibit RFC-1.

Q. Can you describe the proposed structure design and the type of towers proposed for this Project?

A. Currently there are three (3) distinct tower design types: Lattice, Monopole and Three Pole tubular. An example of each is shown on the drawings attached hereto as Exhibit RFC-2.

Q. How are each of the different structures constructed?

A. Lattice structures are constructed by connecting (lacing/bolting) the individual steel members together piece by piece at the site or in sections, which can be shipped to the site and erected with the assistance of equipment such as a crane or helicopter. A monopole structure is manufactured and constructed in sections limited by length and weight for shipping and erection purposes. Monopoles require very large construction support equipment on site for erection. A multiple

pole tubular structure is constructed much like a monopole structure but may also be airlifted depending on weight of tubular section.

Q. What factors did PSE&G consider in its decision regarding structure design?

A. The design must respond to the natural conditions along the right-of-way. This includes the need to manage steep slopes, avoid wetlands, properly cross rivers, valleys, roads, and be able to withstand severe weather conditions. Furthermore, the design should take into consideration the location of construction access and maintenance roads. While attempting to locate new structures as near as possible to the existing locations, PSE&G has carefully reviewed the location of new structures in order to minimize the number of structures and avoid wetlands, steep topography, and difficult access requirements. Thus, the structure must be designed to reliably support the weight of the conductors and shield wires under all anticipated weather conditions. This also includes the stresses on the conductor and shield wires from the forces of wind and the additional weight when coated by winter ice.

Moreover, PSE&G's preferred right-of-way widths for 500kV transmission lines are 200 feet. Rights-of-way less than 200 feet in width result in additional design and maintenance restrictions, which may affect number of structures, type, spacing and height of the structures and the conductor size and number. Design will also be affected by the need to minimize the visual impact of the new structures, conductor, and the cleared right-of-way to blend in with the existing surroundings. Other environmental concerns (e.g., wetlands, stream floodplains, sensitive habitats) may also affect the location of the structures and access roads,

and could influence the number and height of the structures, and raise other design concerns.

Q. Please explain where the transmission structures will be located in the Right-of-Way.

A. Attached to my testimony as Exhibit RFC-3 are the Site Plan Drawings for the Project. The plans show the entire Right-of-Way from Roseland Switching Station in Roseland, New Jersey to the Delaware River. The Right-of-Way is outlined in red. The current tower locations are shown with a black dot and the proposed locations of new structures are shown with a blue dot. Also attached to my testimony as Exhibit RFC-4 is the Plan and Profiles showing the topography of the Right-of-Way and the height of each structure.

Q. What factors were considered in your decision regarding structure location?

A. Natural conditions such as steep land, avoidance of wetlands, river crossings, valleys and roads are taken into consideration in locating a structure. Other factors that influence structure location are proper clearance to ground, effects on foundation, property owner impacts and right of way alignment. Generally, PSE&G tried to locate towers within fifty (50) feet of existing tower, except when the transmission line makes a turn or angle, in which case the new structure must be located in the exact same location as the existing angle tower in order to maintain the facilities within the existing Right-of-Way.

IV. HEIGHT OF STRUCTURES

Q. What will the voltage of the new conductors be for this Project?

A. Since the Project will be replacing the existing structures and conductors, all of the conductors will be new for both the 230,000V and 500,000V lines.

Q. What is the size, type and number of conductors planned for this Project?

A. Transmission lines transmit 3-phase electrical power. Each phase requires one or more conductors. A single-circuit transmission line structure must be capable of supporting three phases. A double-circuit structure must be capable of supporting six phases. "Shield wires" are one or two smaller steel cables or fiber optic cables that are suspended above the upper conductor. The shield wires are intended to intercept lightning strikes, which would electrically interfere with the power system if they were to strike the conductors directly. The shield wires may also have fiber optic communications capability for use in controlling the operation of the transmission and substation system. As mentioned previously, PSE&G will be installing both a 230kV circuit and a 500kV circuit on the proposed transmission structures. Both circuits will be utilizing 1590 kcmil 54/19 Aluminum Conductor Steel Reinforced "Falcon" conductor that is 1.545 inches in diameter, weighs 2.044 lb/ft and has a rated breaking strength of 54,500lbs. For the 230kV and 500kV conductors on the same structure, there will be two (2) conductors per electrical phase on the 230kV circuit and four (4) conductors per phase on the 500kV circuit, resulting in 18 conductors total.

Q. Will there be any other overhead wires on the structures in connection with this Project?

A. Yes. There will be two (2) overhead shield wires installed above the conductors for lightning and relay protection**.**

Q. Please describe the configuration of the conductors and why this configuration was selected.

A. The existing 230kV circuit's conductors are in a horizontal configuration, which allows all of the phase conductors to be at the same elevation. A double circuit structure will require the conductors to be placed in a vertical configuration, with the 230kV conductors on one side and the 500kV conductors on the other side of the structure. This double circuit vertical configuration is both economical and typical when there are two circuits co-located on the same structure in a right-of-way. In order to meet the State of New Jersey audible noise and electrical field levels, the 230kV circuit requires a two-conductor bundle per electrical phase and the 500kV circuit requires a four-conductor bundle per electrical phase.

Q. What is the height range of the proposed transmission structures that will be constructed for this Project?

A. Preliminary design of new structures range in height from 145 feet to 195 feet.

Q. What factors determined the height of the towers?

A. Major factors which determine structure height include mechanical loading, electrical insulation to ground and grounded objects, conductor galloping, electrical field effects, work practices and topography For instance, in the vertical configuration noted above, there are three sets of conductors for each

circuit, with the circuits designated as A, B and C, with A being the bundle of conductors on the top and C being the bundle of conductors on the bottom (depending on the configuration – PSE&G may also be optimizing the conductor phasing of the circuits, so the opposite circuit could be in a C, B, A configuration) as shown on Exhibit RFC-5. For the 500kV side of the structure, the NESC - Section 232 and PJM safety criteria require a minimum clearance to ground from the lowest conductor of 32 feet resulting in a typical conductor connection point at the structure of over 85 feet. Furthermore, the NESC, OSHA and PSE&G work practices require a clearance from conductor B to C and conductor A to B of approximately 33 feet. Accordingly, these clearances are the driving factor in determining the height of the structures.

Q. Was there any way to reduce the height of these structures?

A. Yes. The height of the structures could be reduced by increasing the number of structures to minimize the span length or by installing the 500kV circuit in its own, separate right of way.

Q. Does PSE&G have transmission structures at a similar height anywhere else in New Jersey?

A. Yes. PSE&G has over 1,000 transmission structures that range in height from 145 to 276 feet.

Q. Are there any transmission lines owned by PSE&G that consistently have towers exceeding 145 feet in height?

A. Seventy five (75) percent of PSE&G's Brunswick to Branchburg double circuit 230kV structure line is 145 feet in height or greater. This line runs from

PSE&G's Brunswick Station in North Brunswick, New Jersey to PSE&G's switching station in Branchburg, New Jersey, the span of which is approximately 17 miles long.

Q. Photo renderings of the proposed new transmission structures prepared by Truescape are attached as Exhibit RFC-1 to your testimony. Is this an accurate rendering of what the transmission structures will look like when completed?

A. I have inspected these locations and these photo renderings are an accurate representation of the Project when located in a specific location along or adjacent to the Right-of-Way.

V. UNDERGROUDING OF TRANSMISSION LINE

Q. Did PSE&G consider placing the 500kV facilities underground?

A. Yes. I reviewed several underground options for the Project.

Q. In your expert opinion, would undergrounding these facilities be a reasonable alternative for this Project? Why or why not?

A. The purpose of constructing these new facilities is to strengthen the reliability of the electric transmission grid and to relieve 23 overloaded circuits in Eastern Pennsylvania and New Jersey. In my opinion, undergrounding the 500kV is neither feasible nor reasonable because it does not provide for the appropriate levels of reliability necessary for a reliability project. The following is a list of reasons why 500kV Alternating Current ("AC") undergrounding is not a reliable alternative:

1. **Limited experience.** There is no U.S. experience with 500kV AC cable installed underground, and worldwide experience is limited to cable installed in utility tunnels, on bridges, or underwater.

2. **Lengthy repairs.** When there are problems, it could take longer than a month to repair an underground line. Prolonged outages of this duration could jeopardize the reliability of the grid. Overhead repairs can be completed in as little as a few hours or a couple of days.

3. **Less capacity.** Underground cables carry far less power than overhead lines – as many as five or six might be needed to have the same transfer capacity.

4. **Environmental Impacts.** Underground cables require extensive excavation that would negatively impact streams, wetlands and other sensitive areas, especially in the rugged terrain associated with the Right-of-Way. The amount of excavated material would greatly exceed that removed by digging foundations for towers.

Q. Has PSE&G considered undergrounding the 500kV circuit with Direct Current ("DC")?

A. Yes. In my opinion, however, DC underground transmission lines have similar issues with reliability, including the following:

1. **Environmental impact.** To lay an underground line, the utility would need to excavate trenches, boring through every rocky outcrop and beneath every stream, wetland and roadway in its path. Permanent access is necessary for maintenance or repairs.

2. **Lengthy Repairs**. This is the same issue as 500kV AC, discussed above.

3. **Less power-transfer capacity.** The DC lines would require multiple two-conductor circuits to be buried to carry the same amount of power as the overhead line.

4. **Costly conversion equipment.** Large, multi-story AC/DC conversion stations covering acres are necessary at the line ends and at any point along the line where it would connect to other utility substations. This would require PSE&G to acquire large parcels of property from numerous property owners along the route.

5. **Size constraints.** Due to the diameter of the cable and shipping limitations, the cable can only be installed in lengths of 1,500 to 2,000

feet, requiring frequent placement of large underground vaults to facilitate splicing.

6. **Costs.** The cost to construct this line overhead for the New Jersey Portion is approximately $750 million dollars compared to approximately six (6) to ten (10) times as much to construct this line underground.

VI. ACCESS AND CONSTRUCTION

Q. As Senior Project Manager – Transmission Outside Plant Construction, are you responsible for designing and implementing a construction plan?

A. Yes.

Q. Briefly describe the construction process and sequence for this Project.

A. The sequence for construction of this Project is as follows:

- Soil borings are taken.
- Construction access roads to the right-of-way and switching stations are prepared.
- PSE&G will perform temporary relocation work for existing circuits if necessary – this work may be dependent upon PSE&G's ability to obtain outages on the existing 230kV circuits.
- PSE&G will begin to construct concrete tower foundations.
- PSE&G will erect new towers, either by crane or helicopter (outage dependent).
- Once the structures have been constructed, PSE&G will install the new hardware, insulators and string new conductor for existing 230kV circuit (this particular step is outage dependent).

- Once the new conductors are strung, PSE&G will energize new 230kV circuit and remove temporary construction if necessary.
- PSE&G will deconstruct old towers (outage dependent).
- PSE&G will install new hardware, insulators and string conductors for new 500kV circuit.
- Perform testing and system checkout.
- Energize system.
- Remove temporary access roads – perform site restoration.

Q. Who will be performing the construction, PSE&G or a contractor?

A. PSE&G will be contracting out all of the construction. However, PSE&G will at all times remain responsible for the oversight of the construction.

Q. How will PSE&G oversee construction?

A. PSE&G may use a combination of in-house expertise coupled with third party external resources to manage and oversee the construction of the Project. Large projects of these types require the use of external resources due to their size, scope and duration. PSE&G has experience using these types of third party firms for large construction projects as do many other utilities that undertake these types of projects.

Q. Do you anticipate that construction of the new towers will be within the existing 150-foot Right-of-Way on which PSE&G currently has legal rights?

A. Yes. As explained by Robert Gibbs, Manager of Corporate Properties**,** PSE&G will not be acquiring additional property for the siting of the new transmission

structures. However, existing easements may not include the necessary property rights and, therefore, PSE&G may need to acquire easement modifications.

Q. How do you anticipate access for construction will be completed?

A. Construction access needs along the route are being identified as part of the detailed design effort and PSE&G plans to access the Right-of-Way for construction along these designated routes. However, current maintenance and operations access is not capable of supporting construction activities and will need to be developed and installed. Where there is no current access, PSE&G will need to locate access points across neighboring properties and negotiate with property owners for the right to access these properties.

Q. What will be the driving factor in determining the type of access needed?

A. Structure type will be a driving factor in determining the type of access roads required, and in some cases where access will be limited due to topography, specialized construction techniques will need to be employed**.** For example, in significant steep areas where vehicular access may be difficult or impossible or in environmentally sensitive areas, PSE&G may employ the use of helicopters to fly in sections of the transmission structure and then construct the structures in place.

Q. Are the proposed access roads shown on the Site Plans, which are attached to your testimony as Exhibit RFC-3?

A. Yes, these are the access roads PSE&G plans to use for construction of the Project. However, as stated above, further design efforts are necessary to confirm these locations and further negotiations are necessary with adjacent property owners.

Q. What material will PSE&G use to construct the access roads?

A. Access road material is dependent upon site specific conditions and requirements. However, typical construction access road material consists of gravel/crushed aggregate, geo-tech meshing, matting and filter cloth, as shown on the drawing attached hereto as Exhibit RFC-6.

Q. Where do you anticipate construction lay down areas will be located?

A. Construction lay down not adjacent to or part of the structure lay down area will be determined as part of the detailed design effort. However, it is currently anticipated that approximately 3 to 4 construction lay down yards will be required along the Project route.

Q. What factors determined the proposed location of the access roads?

A. The factors PSE&G considered in determining access road locations are: proximity to structures, locations, environmental impacts, topography, structure type, adjacent access, and property rights.

Q. Do you anticipate any clearing of the Right-of-Way will be necessary for construction?

A. The only clearing anticipated on the Right of Way is in areas where current maintenance has yet to be performed or where vegetation has re-grown and needs to be removed.

Q. After completion of construction, will PSE&G restore the Right-of-Way and any access roads?

A. Yes. PSE&G will remove any access roads that are not needed to safely maintain or operate the transmission facilities or where specific agreements have been

made with property owners. PSE&G will then restore the Right-of-Way and any access road locations to a condition as good or better than what existed prior to commencing construction.

Q. How long will it take to complete construction of the entire Project in New Jersey?

A. From commencement of construction, it is currently expected to take approximately 2-1/2 years to complete construction of the Project.

Q. What is the timetable to complete construction and have the facilities in service?

A. The current schedule calls for completion of engineering, design, site investigations, property rights negotiations, and permitting in 2009, allowing for construction to begin late in 2009 or early 2010. Construction would conclude in the Spring of 2012 and, after testing and commissioning is complete, the Project would be placed in service in June 2012.

Q. Will property owners be notified when construction begins? How?

A. Yes. Any property owner within 200-foot proximity of the Right-of-Way will receive a registered letter prior to construction. Furthermore, PSE&G will establish a website for property owners to access and find out what construction activities are taking place in their immediate vicinity. This site will also have a contact number so that property owners can contact someone immediately with a question or a concern.

Q. Do you have any safety concerns regarding the construction of the Project?

A. No, I do not. However, as always, PSE&G's primary concern is protecting the health and welfare of citizens along the Right-of-Way. This includes following all safety standards in the design of the Project and in all construction activities.

Q. Does this conclude your testimony?

A. Yes.