

**STATE OF NEW JERSEY  
BOARD OF PUBLIC UTILITIES**

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

**SUMMARY OF PRE-FILED DIRECT TESTIMONY  
OF KYLE G. KING ON BEHALF OF PUBLIC SERVICE ELECTRIC  
AND GAS COMPANY**

Mr. Kyle G. King, President of K&R Consulting, LLC, testifies on behalf of PSE&G in this proceeding. Mr. King has expertise in electric engineering and has been hired by Public Service Electric and Gas Company (“PSE&G”) to perform an analysis of the electric and magnetic fields (“EMF”), audible noise, and radio noise levels associated with the Susquehanna-Roseland Project (the “Project”) which is the subject of this proceeding.

Mr. King files direct testimony discussing the analysis he performed in connection with existing and proposed levels of EMF and audible noise. He sponsors a report on the electrical effects of the New Jersey Section of the Project. Specifically, Mr. King explains that he modeled the existing and proposed EMF levels associated with the Project using historical and proposed load flow data for the existing 230kV circuit and the proposed 500kV circuit. Using this data, Mr. King was able to model the expected

levels of EMF using predicted 2013 currents. Furthermore, Mr. King explains that he performed limited field measurements to confirm the modeling analysis.

Finally, Mr. King also testifies that electric field and audible noise levels at the edge of the 150-foot right-of-way will be below the standards set by the State of New Jersey at the completion of the Project.

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1                   **PRE-FILED DIRECT TESTIMONY OF KYLE G. KING**  
2                   **ON BEHALF OF PUBLIC SERVICE ELECTRIC AND GAS**  
3                   **COMPANY IN SUPPORT OF SUSQUEHANNA-ROSELAND**  
4                   **TRANSMISSION LINE PROJECT**  
5  
6

7   **I.       BACKGROUND**

8   **Q.       What is your full name and business address?**

9   **A.**My name is Kyle G. King, President of K&R Consulting, LLC with a business  
10           address of 64 Sherwood Drive, Lenox, MA 01240

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

12 **A.**I am the President of K&R Consulting, a company I founded in 2004. Prior to  
13           starting the engineering firm, I was the Director of the EPRI High Voltage  
14           Research and Test Center in Lenox, Massachusetts.

15 **Q.       Please briefly describe your educational and professional background.**

16 **A.**Prior to starting the engineering consulting firm, I was the Director of the EPRI  
17           High Voltage Research and Test Center in Lenox, Massachusetts. I have  
18           Bachelor and Masters Degrees in Electrical Engineering from Union College in

1 Schenectady, NY. I have been a Licensed Professional Engineer in New York for  
2 the past 16 years.

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

4 **A.** I am currently the President of K&R Consulting, LLC – a power engineering  
5 services and consulting company.

6 **Q. Please outline your scientific experience and research concerning electric  
7 and magnetic fields (“EMF”).**

8 **A.** Over the past 15 years, I have been the Project Manager for many EPRI programs  
9 including Transmission Line EMF Management. I have authored numerous EPRI  
10 handbooks and taught dozens of courses concerning transmission line design and  
11 magnetic field management. I also co-authored EPRI’s EMF series of handbooks.  
12 My curriculum vitae is attached as Exhibit KGK-1.

13 **Q. What has your role been with respect to the Susquehanna Roseland  
14 Transmission Project (the “Project”) that is the subject of this Petition?**

15 **A.** I have been consulting with PSE&G on transmission line reliability, electrical  
16 design, and electrical effects since March 2006. For this project I prepared an  
17 electrical engineering analysis of the existing Roseland to Bushkill 230kV  
18 transmission line and how it will be affected by the Project, which is a 500 kV  
19 transmission line running from Susquehanna, Pennsylvania to Roseland, New  
20 Jersey. My analysis included the effects of electric fields, magnetic fields,  
21 audible noise, and radio noise associated with the Project. Each of these  
22 parameters is compared to the levels along the existing 150-foot right-of-way (the  
23 “Right-of-Way”).

1 **Q. Are you sponsoring any exhibits attached to this application?**

2 A. Yes, attached as Exhibit KGK-1 is my curriculum vitae and attached as Exhibit  
3 KGK-2 is my report, “Electric Effects from the New Jersey Section of the  
4 Susquehanna – Roseland 500kV Transmission Line.”

5  
6 **II. ELECTRIC AND MAGNETIC FIELDS GENERALLY**

7 **Q. Please describe the purpose of your testimony.**

8 A. The purpose of this testimony is to describe and quantify the electrical effects of  
9 the Project. These include the levels of 60-hertz EMF, corona effects and noise  
10 produced by the line.

11 **Q. Briefly, what are electric and magnetic fields?**

12 A. Electric fields are a vector quantity with both a magnitude and a direction. The  
13 direction corresponds to the direction that a positive charge would move in the  
14 field. Sources of electric fields are electrical charges. Transmission lines,  
15 distribution lines, house wiring, and appliances generate electric fields in their  
16 vicinity because of electrical charge (voltage) on energized conductors. Electric  
17 fields are typically described in units of volts-per-meter (V/m) or kilovolts-per-  
18 meter (kV/m). On the power system in North America, the voltage and charge on  
19 the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times  
20 per second. This changing voltage results in electric fields near sources that are  
21 also time-varying at a frequency of 60 hertz.

22 The concentrated electric field at the surface of transmission line conductors may  
23 cause a phenomenon called corona. Corona results from the electrical breakdown

1 or ionization of air in very strong electric fields at the surface of the conductor,  
2 and can be a source of audible noise, radio noise, and ultraviolet light. Several  
3 factors, including conductor voltage, shape, and diameter, and surface  
4 irregularities such as scratches, nicks, dust, or water drops, can affect a  
5 conductor's electrical surface gradient and its corona performance. The  
6 conductor bundle design selected for the proposed transmission lines are of  
7 sufficient diameter and spacing to limit the localized electrical stress on the air at  
8 the conductor surface and minimize corona related effects.

9 Similar to electric fields, magnetic fields are a vector quantity characterized by  
10 both magnitude and direction. Electrical charges in motion (electrical currents)  
11 generate magnetic fields. In the case of transmission lines, distribution lines,  
12 house wiring, and appliances, the 60-Hz electric current flowing in the conductors  
13 generates a time-varying, 60-Hz magnetic field in the vicinity of these conductors.  
14 The strength of a magnetic field is measured in terms of magnetic lines of force  
15 per unit area, or magnetic flux density. The term "magnetic field," as used here, is  
16 synonymous with magnetic flux density and is expressed in units of milligauss  
17 (mG).

18 **Q. What are typical sources of electric and magnetic fields and what are the**  
19 **levels you might expect to find associated with those sources?**

20 **A.** Electric and magnetic fields are created by any device which produces, carries, or  
21 uses electrical energy. The National Institute of Environmental Health Sciences  
22 ("NIEHS") has estimated the average level of background magnetic fields range  
23 from 0.5 to 5.0 mG in most homes. Some typical median values (measured one

1 foot from the appliance) taken from the National Institute of Environmental  
2 Health Sciences “EMF Questions and Answers” June 2002 publication include:

3 Fluorescent Lights – 6 mG

4 Electric Pencil Sharpener – 70 mG

5 Hair Dryer – 1 mG

6 Electric Drill – 30 mG

7 Power Saw – 40 mG

8 Air Conditioner – 3 mG

9 Electric Range – 8 mG

10 Vacuum Cleaner – 60 mG

11 Portable Heater – 20 mG

12 Typical levels of magnetic field in New York City Metro-North Commuter  
13 Railroad cars range from 40 to 60 mG, and increase to 90 to 145 mG during  
14 acceleration. The earth has a static magnetic field of approximately 570 mG over  
15 its entire surface. The earth’s field at any position is constant in both magnitude  
16 and direction as opposed to the constantly changing power frequency magnetic  
17 fields discussed in this testimony.

18 Electric field levels are not easy to predict within homes because buildings, trees,  
19 and common objects all substantially shield (or reduce) electric field levels. A  
20 study of electric field levels near a range of common appliances ranged from 3 to  
21 70 V/m approximately one foot away from the appliance.

22

23

1 **III. EMF ASSOCIATED WITH THE PROJECT**

2 **Q. Can you explain how PSE&G designed the Project to reduce the levels of**  
3 **magnetic fields?**

4 **A.** As discussed in the testimony of PSE&G witness, Richard F. Crouch, the design  
5 of the Project has been optimized to limit the magnetic field levels produced at the  
6 edge of the right of way. When a single three-phase magnetic field source exists  
7 (a common overhead single circuit transmission or distribution line), the magnetic  
8 field created at ground level depends on the position of the wires in the air, the  
9 current in the wires, and the distance away from the wires. The magnetic field at  
10 any point in space has both a magnitude and direction. When there is more than  
11 one magnetic field source on a right of way, the wires may be arranged so the  
12 magnetic field produced by one circuit is partially cancelled by the magnetic field  
13 from the other circuit (See Exhibit RFC-5 to Richard F. Crouch's testimony). The  
14 resulting magnetic field from the two circuits is no longer directly proportional to  
15 the current in either of the circuits. Depending on the direction of power flow and  
16 positions of the wires, the magnetic field produced by two circuits may actually  
17 be lower than if only one circuit was present.

18 **Q. Did you model the existing and proposed electric and magnetic fields for**  
19 **PSE&G in connection with the Project?**

20 **A.** Yes, I modeled the existing and proposed line configurations to determine the  
21 expected levels of electric and magnetic fields in 2013, the first full year in which  
22 the Project will be in service. The results of my study are summarized in a  
23 separate report attached hereto as Exhibit KGK-2.

1 **Q. Can you explain exactly how you performed your study and the results of the**  
2 **study for the Project?**

3 **A.** To quantify electrical effects of the Project, I calculated the electric and magnetic  
4 fields, radio noise, and audible noise caused by corona from the transmission lines  
5 using the EPRI Transmission Line Workstation computer programs. Important  
6 input parameters to the computer program are voltage, current, and the number  
7 and geometric configuration of the wires. The transmission line conductors are  
8 assumed to be located above a flat ground plane. The computer model includes  
9 the affect of conductor sag between the tower attachment points. The validity of  
10 these computer models has been verified against field measurements and reported  
11 in many technical papers and reports over the past thirty years.

12 The study results confirmed the Project will meet all New Jersey regulations for  
13 electric fields and audible noise. For a more detailed review, please see my report  
14 attached hereto as Exhibit KGK-2.

15 **Q. What estimates of the power flows (load) on the transmission lines did you**  
16 **use to model magnetic field levels?**

17 **A.** The current carried on a power line or other conductor is the source of the  
18 magnetic field. PSE&G witness Esam Khadr provided expected current levels on  
19 lines based on historical load flows measured in 2005-2008, and forecasted future  
20 load flows in 2013 on both the 230kV circuit, and the 500kV circuit, which is part  
21 of the loading study (the “Loading Study”).

22 At the beginning of my analyses, we focused only on historical current levels.  
23 Later, the Loading Study that predicted current levels on all affected transmission

1 lines for each hour of each day in the year 2013 was completed. This load  
2 prediction provided data to determine what the median level of current (and  
3 associated magnetic field) will be for each line segment of the Project. The  
4 median current level is the level that will be exceeded 50% of the time. Half the  
5 time the currents will be higher than the median, and half the time currents will be  
6 lower than the median. My report and the analyses summarized in this testimony  
7 focus on the magnetic fields associated with operation in 2013 based upon  
8 estimates of load flows provided in the Loading Study.

9 **Q. Did you take any measurements of magnetic fields produced by the 230kV**  
10 **transmission line that is now operating along the proposed Project route?**  
11 **Did these measurements match your modeling of the magnetic field for the**  
12 **same load flows and other conditions?**

13 **A.** Yes, as part of my study I measured magnetic field levels near the existing 230kV  
14 Roseland-Bushkill Right-of-Way. The detailed results of the measurements are  
15 included in my report attached as Exhibit KGK-2. The measured magnetic fields  
16 closely matched the calculated values at each location where I took  
17 measurements.

18 **Q. Would you expect your measurements of the magnetic field to change if you**  
19 **performed field studies in the summer months?**

20 **A.** Magnetic field results are directly proportional to line loading for single circuit  
21 transmission lines. If during the summer the load flow conditions were not the  
22 same as on the day I made measurements of the magnetic fields, the magnetic  
23 field levels near the transmission line might be higher or lower. The purpose and

1 result of my magnetic field measurements was to confirm that the model set forth  
2 in my report is accurate

3 **Q, What will be the typical levels of the magnetic fields associated with the**  
4 **operation of the existing 230 kV line and the proposed 500kV/230 kV lines in**  
5 **the future?**

6 **A.** The magnetic field from the median current along the Right-of-Way from  
7 Bushkill to Montville ranges from 23 mG to 32 mG for the existing 230 kV line in  
8 2013. After the Project is completed, the expected magnetic field from the  
9 median current along the Right-of-Way from Bushkill to Montville will range  
10 from 29 mG to 57 mG on the 500 kV circuit side, and 12 mG to 20 mG on the  
11 230 kV circuit side in 2013.

12 The magnetic field from the median current along the Right-of-Way from  
13 Montville to Roseland will be approximately 7 mG for the existing 230 kV line in  
14 2013. After the Project is completed, the expected magnetic field from the  
15 median current along the Right-of-Way from Montville to Roseland will be  
16 approximately 38 mG to 42 mG on the 500 kV circuit side, and 19 mG to 21 mG  
17 on the 230 kV circuit side in 2013.

18 All the magnetic field calculations are based currents provided by PSE&G  
19 witness Esam Khadr in the "Loading Study". Additional magnetic field details  
20 are provided in my report attached hereto as Exhibit KGK-2.

21

22

1 **Q. On the hottest day of the summer will the magnetic fields be higher than the**  
2 **typical levels?**

3 **A.** Yes. The typical median levels described above and in the “EMF Report” are  
4 expected to be exceeded 50% of the time. To describe the upper expected limit  
5 for magnetic field levels we used the maximum continuous circuit current of 3000  
6 amperes for 500 kV and 200 amperes for 230 kV. The current in each circuit is  
7 limited by substation equipment. Any continuous operation above these currents  
8 will damage the equipment. For those maximum currents, the magnetic field  
9 levels will be 115 mG on the 500 kV side and 58 mG on the 230 kV side of the  
10 right of way.

11

12 **IV. STATE STANDARDS FOR EMF AND AUDIBLE NOISE**

13 **Q. Does the State of New Jersey have electric field requirements?**

14 **A.** Yes, the State of New Jersey has a limit of 3 kV/m for electric fields at the edge  
15 of the ROW. This limit was established by the New Jersey Department of  
16 Environmental Protection on June 4, 1981.

17 **Q. Upon completion, will the Project meet the State of New Jersey’s electric**  
18 **field requirements?**

19 **A.** Yes, the proposed project will meet the State of New Jersey’s electric field  
20 requirements at the edge of the right of way. The Project will produce  
21 approximately 1.6 kV/m on the 500 kV circuit side and 0.5 kV/m on the 230 kV  
22 circuit side of the right of way. For comparison, the existing 230 kV circuit’s  
23 electric field level is approximately 0.8 kV/m.

1 **Q. Does the State of New Jersey have any magnetic field requirements?**

2 **A.** The State of New Jersey does not have a limit for magnetic fields from  
3 transmission lines.

4 **Q. Are you aware of any states that currently have magnetic field**  
5 **requirements? What are those levels?**

6 **A.** Yes, two states have established limits on the magnetic field levels at the edge of  
7 the right-of-way. The Florida Department of Environmental Regulation  
8 established transmission line edge of right-of-way magnetic field limits of 150  
9 milligauss for 230 kV transmission lines and 200 milligauss for 500 kV  
10 transmission lines. The New York State Public Service Commission established  
11 transmission line edge of right of way magnetic field limits of 200 milligauss for  
12 all transmission voltages.

13 Both Florida and New York specify the loading conditions to be modeled to  
14 determine the maximum edge of right of way magnetic field level. In Florida, the  
15 summer normal continuous rating of the conductor is used. In New York, the  
16 winter normal continuous rating of the conductor is used.

17 **Q. Does New Jersey have limits on audible noise that would apply to nearby**  
18 **residences?**

19 **A.** Yes, New Jersey has published limits for Audible Noise. The New Jersey  
20 Administrative Code Section 7:29-1.2 (a) (2) (i) establishes a limit of 50 dBA for  
21 “continuous airborne sound” between the hours of 10:00 P.M. and 7:00 A.M.

22

23

1 **Q. Are the audible noise levels expected by the Project below these levels?**

2 **A.** Yes. In order to meet the sound level requirement, the project will be using two  
3 conductor bundles for the 230 kV phases and four conductor bundles for the 500  
4 kV phases. The larger number of sub-conductors for each phase, limits the  
5 localized electric field stress on the air at the conductor surface. The larger  
6 number of conductors for each phase position were selected only to meet the  
7 noise level requirements. The bundle designs limit corona and noise levels to  
8 approximately 36 to 40 dBA at the edge of the right of way. The project noise  
9 levels are well below the New Jersey 50 dBA limit and are comparable to the  
10 existing circuit design on 38.5 dBA at the edge of the right of way.

11 **Q. Does this conclude your testimony?**

12 **A.** Yes