BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

In the Matter of the Transmission Permit for the Big Stone South to Ellendale Project

EL13-028

DIRECT TESTIMONY OF JON LEMAN

BACKGROUND OF WITNESS

Q. Please state your name, employer, and business address.

A. My name is Jon Leman. I work for POWER Engineers, Inc. ("POWER"). My business address is 1300 16th Ave, Suite 200, Clarkston, WA 99403.

Q. What is your current position with POWER?

A. Senior Project Engineer and Area Lead - electrical system studies.

Q. What are your duties and responsibilities in that position?

A. Electrical design and analysis of AC and DC power delivery systems, including transmission lines. As part of that work, I coordinate and prepare engineering studies regarding conductor (line) insulation, corona effects, electrical and magnetic field, effects, conductor and shield wire selection, transient studies, power system planning, protective relaying, and arc flash. I also supervise other electrical engineers in POWER's Clarkston, WA office.

Q. How long have you worked for POWER?

A. Since June of 2005.

Q. How long in your current position?

A. Approximately two and one-half years.

Q. Can you describe your work experience before your current position.

A. Prior to my current position I worked as a junior engineer, mid level engineer, and project engineer in POWER's SCADA and Analytical Services (electrical studies) business unit. Prior to POWER I worked for the United States Navy as an electrical engineering instructor.

Q. What is your education?

A. I received a Bachelor of Science in electrical engineering from the University of Idaho in 2001. In 2010, I received a Master of Science degree in electrical engineering from the University of Idaho.

Q. Are you a licensed engineer?

A. Yes, I am a licensed electrical engineer in the State of Idaho.

Q. Do you have any prior experience working on electrical transmission lines?

A. Yes, most of my career at POWER has involved electrical analysis of transmission lines and I have been involved in many projects prior to this one. Much of my experience is with 345 kV transmission lines though I have also worked with many other projects ranging from 35 kV sub-transmission through 500 kV transmission projects.

Q. What is exhibit 15?

A. This is my a copy of my curriculum vitae.

Q. Is it true and accurate?

A. Yes.

Q. What is the purpose of your testimony?

A. I am going to testify about the electrical engineering issues arising out of the construction and operation of the transmission line.

ROLE IN THE PROJECT

Q. What is your role in the Big Stone South to Ellendale Project ("Project")?

A. I have performed electrical design activities and have assisted in addressing some of the purported electrical engineering concerns arising out of the construction of the Project, including concerns about electrical fields, magnetic fields, and stray voltage associated with the project.

Q. Have you reviewed any studies or research as part of your work on the Project?

A. Yes. In performing my work, I reviewed the following:

1. *National Electrical Safety Code (NESC),* Institute of Electrical and Electronics Engineers (IEEE), 2012

2. *IEEE Std. C95.6, Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3kHz,* Institute of Electrical and Electronics Engineers (IEEE), 2002

3. *ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz),* International Commission on Non-Ionizing Radiation Protection, 1998

4. *Field and Wave Electromagnetics, 2nd ed.*, D. K. Cheng, 1992

5. *EPRI Transmission Line Reference Book, 200 kV and Above 3rd ed.*, 2005

6. *Corona Performance of High Voltage Transmission Lines*, P. S. Maruvada, 2000

7. *Electric and Magnetic Fields Associated with the Use of Electric Power – Questions and Answers*, National Institute of Environmental Health Services (NIEHS), 2002

Q. Are these studies or research the type of information an electrical engineer would commonly rely on in performing electrical engineering services?

A. Yes, they are.

Q. Has POWER performed any engineering studies relating to your work on the Project?

A. Yes, POWER performed a conductor optimization study. In the conductor optimization study, POWER analyzed the options for selecting conductors (lines) for the Project. In analyzing the conductor options, POWER modeled the electric and magnetic fields (EMF) and corona effects associated with the Project. POWER also performed studies to confirm whether

the Project's design will comply with National Electric Safety Code (NESC), which requires that any induced currents due to electric fields do not exceed a specified level.

Q. What was your role regarding these two studies?

A. I supervised the creation of the two studies by POWER. I have reviewed both studies.

Q. Are these studies the type of information an electrical engineer would commonly rely on in performing electrical engineering services?

A. Yes, they are.

ISSUES WITH ELECTRICAL AND MAGNENTIC FIELDS (EMF)

Q. Do high voltage transmission lines like the 345kV transmission line as part of the Project create an electrical field?

A. Yes, high voltage transmission lines, like power lines of all voltages, create both electric fields and magnetic fields, which are collectively referred to as EMF.

Q. What did the conductor optimization study indicate regarding the effects of the EMF?

A. The design of the Project results in EMF levels that are lower than the levels recommended by the Institute of Electrical and Electronic Engineers (IEEE), who issue standards and guidelines for the industry. The EMF levels are also below the recommendation of International Commission on Non-Ionizing Radiation Protection (ICNIRP), who have done studies on the effects of EMF and published guidelines for exposure limits. Also, the Project's design meets the safety requirements imposed by the NESC.

Q. Are there any potential issues arising from the electrical fields created by the transmission line for the project?

A. Yes, like all high voltage transmission lines, there are some potential effects due to the electric field interactions between the high voltage transmission line of the Project and metallic objects near the transmission line. Depending on the design of the transmission line, the electrical field can cause stray voltage in metallic objects. Also, electric fields from high voltage transmission lines ionize the air around the conductor resulting in corona. Corona can cause audible noise (AN), radio interference (RI), and television interference (TVI). The conversion of television transmission to digital eliminated most problems with TVI.

Q. What has POWER done to address those issues?

A. POWER has designed the line to meet National Electrical Safety Code (NESC) clearance requirements. These clearance requirements prevent electric fields from being strong enough at ground level to cause a harmful shock if a person touches a large metallic object. An example of such an object would be the chassis of a semi tractor-trailer or farm equipment parked within the influence of the transmission line electric field. The larger the metal surface area of the object and the closer to the transmission line, the greater the risk of the electrical field creating a shock. By designing to NESC requirements, the risk associated with electric fields is mitigated. Additionally, the conductor size, conductor bundles, phase spacing, and other line geometry are designed to minimize corona audible noise and radio interference effects. Ultimately, the conductor optimization study indicates that the EMF and corona effects of the transmission line meet NESC requirements, industry guidelines, and design specifications.

Q. Are there any safety issues to people from the electrical field created by the Project?

A. No, both the conductor optimization study and the NESC clearance study establish that the electric field created by the transmission line does not pose a safety hazard.

Q. Are there any safety concerns for livestock or wildlife?

A. No. Livestock and terrestrial wildlife will not experience electrical fields any higher than humans, and the compliance of the transmission line with the NESC design clearances means no electric field safety hazard to animals on the ground.

Q. When constructed and energized, will the transmission line create a magnetic field?

A. Yes, it will create a magnetic field when current flows in the conductors.

Q. Do these magnetic fields create any issues?

A. Yes, magnetic fields from current on high voltage transmission lines can induce voltages in parallel facilities (*e.g.*, fences, railroads, pipelines). In poorly designed systems, this can lead to corrosion, shock, or service interruption on the parallel facility. The Project's design and routing avoid these problems.

Q. What has POWER done to address those issues?

A. POWER designed the line according to NESC clearances which help reduce the effect of induced voltages due to magnetic fields. Also, the transmission line does not parallel any railroads or pipeline facilities. For locations with equipment such as fencing, mitigation options are well known in industry and will be dealt with on a case by case basis via grounding, filters, etc.

Q. Does the Project pose any safety issues to people based as a result of the magnetic fields?

A. No, because there are no parallel railroad and pipeline facilities, and because the Project will employ industry standard mitigation methods for fencing and other equipment.

Q. Do magnetic fields created by the Project pose any safety risk for livestock or wildlife?

A. No. The safety risk to livestock and terrestrial wildlife of a magnetic field is the same as humans.

STRAY VOLTAGE ISSUES

Q. What is stray voltage?

A. Stray voltage is an accidental difference in electrical potential between two objects during normal operation of an energy delivery system. In other words, it is a situation in which voltage (or electrical current) is present where not intended.

Q. Can transmission lines cause stray voltage?

A. As indicated in Section 23.4.4 of the Application, transmission lines alone typically do not cause stray voltage. Instead, stray voltage typically comes from distribution lines rather than transmission lines. Additionally, in some circumstances, the EMF from transmission lines can induce stray voltage on large metallic objects very close to the line. Stray voltage due to insulation deterioration is possible but less likely.

Q. What has POWER done to address stray voltage for the transmission line?

A The design clearance of the transmission line consistent with NESC guidelines prevents the inducement of excessive voltages from EMF on large metal objects near the transmission line. Regarding the insulators, the project will perform regular maintenance of the transmission line as described in Section 22.4 of the Application.

Q. Have engineering studies been performed regarding the issue of stray voltage?

A. Yes, these are the same engineering studies that I testified about regarding electrical fields.

Q. What do those studies indicate?

A. They indicate that the transmission line's clearance design is sufficient to limit induced currents caused by stray voltage to levels that comply with NESC requirements.

Q. What affect does stray voltage have in locating a transmission line in comparison to a railroad track?

A. If a transmission line runs parallel to a railroad track, there is a risk of stray voltage. As a result, if a project has the potential to be near a railroad track, studies are done to identify stray voltage and electromagnetic issues. If issues are identified the line is either routed farther from the track or mitigation is implemented to eliminate or reduce the effects. This is not an issue with the Project, however, because no known railroads are near the preferred route for the Project.

Q. Do you have an opinion regarding whether the construction or operation of the transmission line will result in stray voltage that will affect farming operations, vehicle usage, or location of metal buildings?

A. Yes, I have an opinion.

Q. What is your opinion?

A. The Project will not cause stray voltage that will affect farming operations, vehicle usage, or location of metal buildings. Although large metallic objects (such as large vehicles or metal buildings) can experience electrostatic induced voltages due to electric fields from power lines, the clearance of the Project is designed to meet NESC requirements for large farm combines and semi tractor-trailers. Vehicles up to these sizes should not have any issues with stray voltage. Metallic buildings that are very close to the transmission line may require grounding to eliminate electric field effects. There are no metallic buildings in the right-of-way.

If there are any metallic buildings outside the right-of-way that are close enough and large enough to create stray voltage issues, the Project will work with the landowner to address the issue during the construction process by using industry standard mitigation techniques.

GLOBALY POSITIONING SYSTEM (GPS) ISSUES

Q. Do you foresee any issues with the transmission line negatively affecting GPS for farming?

A. As indicated in interrogatory answer no. 12 of Gerald Pesall's First Set of Discovery Requests to Applicants, which is Exhibit 4 attached to Henry Ford's direct testimony, isolated cases of interference are possible but unlikely. Electric field corona from high voltage power lines can produce radio frequency emissions, but these radio frequency emissions are generally at a lower frequency than the frequencies used for satellite GPS systems. Individual transmission structures near GPS based farm equipment may block or reflect GPS signals like a building would, but the presence of multiple GPS satellites usually prevents this from being a significant issue.

Q. What is the effect of transmission line on ground based GPS?

A. Isolated cases of corona based interference from transmission lines are possible, but unlikely. Interference effects tend to be very location specific and also depend on the location and type of antennas, weather conditions, presence of other radio frequency noise sources, etc. Ground based GPS can also be impacted by transmission structures, but the effects are similar to trees, buildings or other obstructions that can block line-of-site communications between GPS base stations and roving equipment. As with any other line-of-site obstruction this issue can be overcome by relocating the base station or using repeater stations.

Q. Based on your experience, education, training, research, and work on the project, do you have an opinion regarding whether the construction, operating, or maintaining of the South Dakota facility, from an electrical engineering perspective, will cause any significant problems (*i.e.*, electrical fields, magnetic fields, stray voltage) for landowners, their families, and other inhabitants where the line is anticipated to be constructed?

A. Yes, I have an opinion.

Q. What is that opinion?

A. From an electrical engineering perspective, the construction and operation of the transmission line will not create significant problems.

Q. Does this complete your direct testimony?

A. Yes.