

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE APPLICATION BY NORTHERN STATES POWER
COMPANY, DOING BUSINESS AS XCEL ENERGY, AND OTTER TAIL POWER
COMPANY FOR A FACILITY PERMIT FOR A 765 KV TRANSMISSION FACILITY
AND ASSOCIATED FACILITIES IN GRANT, DEUEL, AND BROOKINGS COUNTIES,
SOUTH DAKOTA**

SD PUC DOCKET _____

**PRE-FILED DIRECT TESTIMONY OF DR. JEFFREY ELLENBOGEN
ON BEHALF OF NORTHERN STATES POWER COMPANY, DOING BUSINESS AS XCEL
ENERGY, AND OTTER TAIL POWER COMPANY**

September 4, 2026

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I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name and business address.

A. My name is Dr. Jeffrey Ellenbogen. My businesses are located in Baltimore, Maryland.

Q. By whom are you employed and in what capacity?

A. I am the President of Ellenbogen Scientific, LLC; the Medical Director of tele Neurology Clinics and Director of The Sound Sleep Project.

Q. Please briefly describe your educational background and professional experience.

A. I received a Bachelor of Arts from the University of Michigan, a Master of Medical Sciences degree from Harvard Medical School, and a Medical Doctor degree from Tufts University. After medical school, I went to the University of Pennsylvania where I completed an internship in internal medicine, residency in neurology, and fellowship in clinical electrophysiology. I then completed a two-year postdoctoral fellowship in Sleep, Circadian, and Respiratory Neurobiology at Harvard Medical School.

After completing my education, listed above, I joined the faculty at Harvard Medical School as an assistant professor of Neurology where I taught “The Neurobiology of Sleep” and conducted research in brain sciences of sleep, including noise-induced sleep disruption. At the same time, I was Director of the Division of Sleep Medicine, and was Staff Neurologist, both at the Massachusetts General Hospital (MGH), located in Boston, Massachusetts.

I then joined faculty as Assistant Professor at Johns Hopkins University, in Baltimore, Maryland, where I continued my research on noise and health, and I saw patients with sleep disorders or neurological conditions. I then joined the US Department of Defense as Vice Chair of Neurology at the Uniformed Services University (USU) and as medical doctor at Walter Reed National Military Medical Center (WRNMMC). My academic appointments at USU were Associate Professor of Neurology and of Military and Emergency Medicine. In 2019 and 2020, I deployed overseas as part of Operation Freedom’s Sentinel.

I am currently President of Ellenbogen Scientific, LLC. In this capacity, my focuses include sleep and brain health, in scientific, consulting and clinical care. Specifically, I am Medical Director of tele Neurology Clinics, where I provide medical care for patients with either sleep disorders, neurological conditions, or both; and I am Director of The Sound Sleep Project, where I continue my research, writing and scientific-related consulting at the interface of noise and human health. A comprehensive list of my training, experience, publications and education is included in my curriculum vitae (CV), which is attached as **Schedule 1** to this testimony.

Q. Please describe your clinical experience as a physician.

A. I am a licensed and practicing physician and have been for more than 20 years. My clinical work experience includes practice as a neurologist and sleep-medicine specialist at the following hospitals: MGH, Johns Hopkins Hospital, and WRNMMC. At WRNMMC, I also worked within the Otolaryngology Department (*i.e.*, ENT: ear, nose, and throat) caring for patients with hearing, vertigo, and balance problems; and at National Intrepid Center of Excellence (NICoE) caring for active-duty military with traumatic brain injury from combat, and the associated neurological or sleep-medicine problems. My current clinical work is in telemedicine as a neurologist and sleep-medicine specialist for tele Neurology Clinics.

Q. Do you have experience with acoustics?

A. Yes. First, the hearing mechanics are part of the nervous system, and disorders of hearing are included in neurology training and practice. I've specifically worked clinically with hearing programs, including in my work for the U.S. Department of Defense. My research program includes the interface of noise and sleep and health, for which I have published research. And I consulted for several years with Bose Corporation, working with acoustical engineers on consumer-based technology for sound and human health.

Q. Do you have any formal training or experience in electromagnetism?

A. Yes. I completed a fellowship in clinical electrophysiology at the University of Pennsylvania. The focus of this included applied concepts in electromagnetism, with

respect to human health. As a neurologist and sleep-medicine specialist, I routinely examine electromagnetic aspects of human physiology and health.

Q. In addition to neurology and sleep medicine, do you have specific experience with cancer?

A. Yes. I worked in two pediatric cancer research laboratories at Harvard Medical School. The first was under Dr. Judah Folkman of Boston Children's Hospital examining novel pathways for cancer development and treatment. The second was under Dr. Jane Weeks of the Dana-Farber Cancer Institute examining cases of cancer in children, principally pediatric leukemia. These were over a four-year period.

Q. Did your work with cancer lead to peer-reviewed scientific publications that you co-authored?

A. Yes. I published a paper on a model of cancer that examined circulating blood factors as a model for the diagnosis and treatment of cancer. This was published in the *Journal of Pediatric Surgery*.¹ And I co-authored a paper on the clinical factors impacting terminal cancer in children, most of them leukemia, published in the *New England Journal of Medicine*.²

Q. Do you have any teaching experience?

A. Yes. For several years I taught several courses, including a year-long neurobiology course at Harvard, entitled "The Sleeping Brain." In this course we examined the science of sleep. I received the Certificate of Distinction in Teaching from the students; and from the faculty I received the John Dowling Teaching Award in Neurobiology. I also taught numerous courses for the U.S. Department of Defense, including lectures in the classroom and field.

¹ Soutter AD, Ellenbogen J, Folkman J. Splenosis is regulated by a circulating factor. *Journal of Pediatric Surgery*. 1994;29:1076-9.

² Wolfe J, Grier HE, Klar N, Levin SB, Ellenbogen JM, Salem-Schatz S, Emanuel EJ, Weeks JC. Symptoms and suffering at the end of life in children with cancer. *New England Journal of Medicine*. 2000;342:326-33.

1 These focused primarily on aspects of neurologic care and sleep medicine that might be
2 encountered in combat operations.

3
4 **Q. Has your work led to national awards?**

5 A. Yes. I received the Wayne Henning Sleep Investigator Award from the American Academy
6 of Neurology.

7
8 **Q. What kinds of subject matter were covered in your master's degree program, and
9 what was its purpose?**

10 A. I completed a master's degree in medical science at Harvard Medical School. The purpose
11 was to provide medical doctors with formal education to critically assess and conduct
12 research in human health. Coursework included subjects of bio-statistics, research
13 methods, health technology, and public health.

14
15 **Q. For whom are you testifying?**

16 A. I was retained as an independent expert by and am testifying on behalf of Great River
17 Energy, Northern States Power Company, doing business as Xcel Energy, and Otter Tail
18 Power Company (collectively, Applicants), concerning their Application for a Facility
19 Permit for a 765 KV Transmission Facility and Associated Facilities in Grant, Deuel, and
20 Brookings Counties, South Dakota (Application) for the PowerOn Midwest-Big Stone
21 South to Brookings County to South Dakota/Minnesota Border Project (Project).

22
23 **Q. What is the purpose of your Direct Testimony in this proceeding?**

24 A. To provide information regarding health and safety relating to transmission line noise and
25 electric and magnetic fields.

26
27 **II. TESTIMONY OVERVIEW**

28
29 **Q. How is your Direct Testimony organized?**

30 A. My Direct Testimony is organized as follows:

- 31
- Section III: Noise

- Section IV: Magnetic Fields

Q. What schedules are attached to your Direct Testimony?

A. The following schedules are attached to my Direct Testimony:

- **Schedule 1**: Curriculum Vitae

III. NOISE

Q. What causes noise on transmission lines?

A. Corona discharge on transmission lines causes noise under certain conditions, principally atmospheric conditions of foul weather, such as snow, sleet, and freezing rain.

Q. Were you provided with modeling data for the corona noise that the Project might create?

A. Yes. The Applicants provided me with modeled sound levels for both the 765 kilovolt (kV) line and 345 kV line facilities. For the 765 kV line, modeling showed a 45 A-weighted decibels (dBA) L50 at the edge of the 250-foot right-of-way. For the 345 kV line, the modeled sound level showed that sound would not exceed 41 dBA L50 for the 345 kV line at the edge of the 345 kV line right-of-way. These levels would decrease as a person moves farther away from the lines.

Q. As a neurologist with experience in noise-related health issues, including hearing loss and tinnitus, would you expect transmission line corona noise at the levels modeled at the edge of right-of-way to cause hearing damage or tinnitus?

A. No. This level is substantially below established occupational and public-health thresholds associated with noise-induced hearing loss, tinnitus, or other recognized adverse auditory health effects. For context, regulatory concern for hearing damage does not begin until continuous exposures exceed approximately 85 dBA over an 8-hour period. A 50 dBA sound is therefore far below levels known to cause auditory injury. Fifty dBA is a level of quiet conversation. It is not a risk to human hearing.

1 **Q. As a sleep expert, would you expect sleep disruption from transmission line corona**
 2 **noise at the levels modeled at the edge of right-of-way?**

3 A. No. I would not expect noise from the transmission line to disrupt sleep. While there is no
 4 research study directly addressing this question, we can draw from known principles of
 5 acoustics and sleep physiology. I expect corona noise would not disturb sleep for several
 6 reasons:

- 7 • Under many operating conditions, corona noise would be minimal, if present at all,
 8 and thus likely inaudible.
- 9 • Foul weather, such as wind, rain, sleet, and snow, might result in corona noise.
 10 However, at the same time, the ambient (background) noise would also be elevated
 11 due to the weather conditions. Elevated ambient noise would often mask corona noise
 12 from perception.
- 13 • The noise level relevant for sleep is not the noise level outside the house, it is the
 14 noise level inside the bedroom. A typical household reduces external noise by
 15 approximately 15 dBA with windows fully open; 20 dBA with partial opening; and
 16 25 dBA with full closure.³ So if a maximum corona noise at edge of 250-foot right-
 17 of-way would not exceed 50 dBA in foul weather outside, then the bedroom would
 18 likely experience at least 15 dBA reduction – and more likely 25 dBA reduction –
 19 making the corona noise in the bedroom whisper quiet, likely inaudible, and thus not
 20 a risk for sleep disruption.
- 21 • To summarize: corona noise from transmission lines is not constant. When it does
 22 occur, it occurs in the context of foul weather, which often masks the noise. And even
 23 if maximum predicted noise levels at edge of right-of-way occur in the absence of
 24 masking sounds, corona noise would not be expected to disrupt sleep because the
 25 levels reaching inside a home would still be low.

³ Locher B et al. Int J Environ Res Public Health. 2018;15(1):149: <https://www.mdpi.com/1660-4601/15/1/149>.

IV. MAGNETIC FIELDS

Q. Do transmission lines produce magnetic fields?

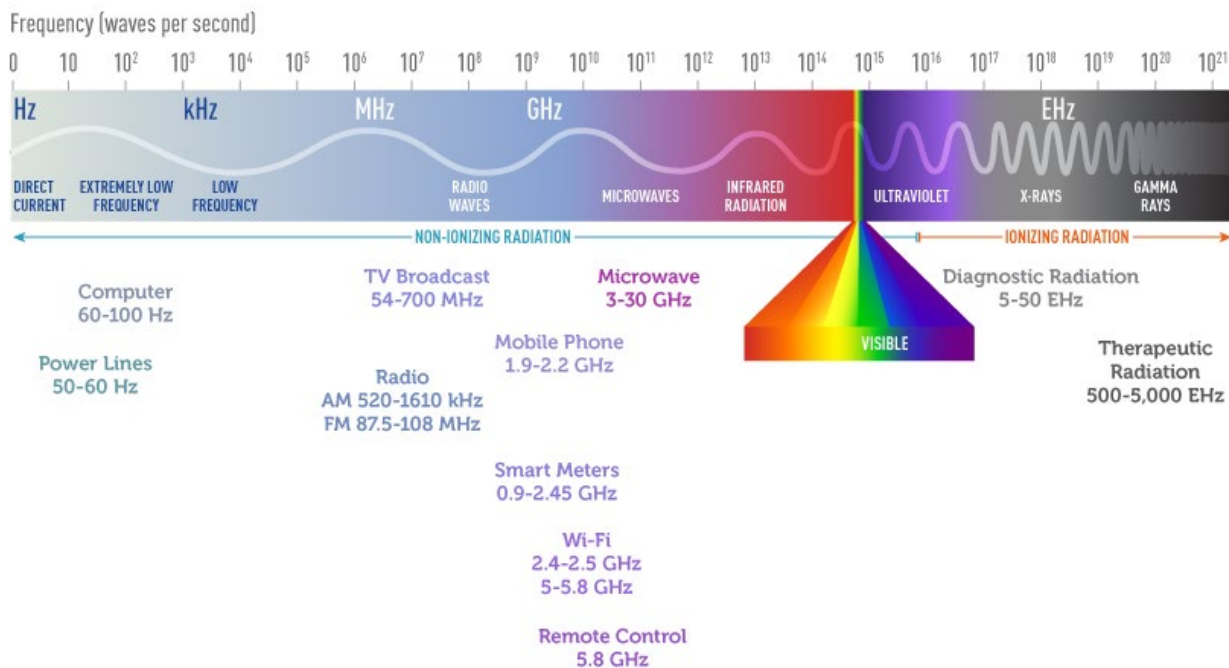
A. Yes. Transmission lines carry alternating electric current. The flow of current through a conductor produces a magnetic field in the surrounding area. The strength of these fields decreases with distance from the line.

Q. Are all magnetic fields the same?

A. No. Magnetic fields span a broad spectrum. Figure 1 is a chart from the National Cancer Institute (NCI) showing the spectrum by frequency. The magnetic fields produced by transmission lines are among the slowest cycling magnetic signals, oscillating at 60 cycles per second. By contrast, visible light oscillates at trillions of cycles per second. Ultraviolet light, x-rays, and gamma rays operate at even higher frequencies.

Figure 1

ELECTROMAGNETIC SPECTRUM



Q. Are magnetic fields from transmission lines the same as ultraviolet light, x-rays, and gamma rays?

A. No. Ultraviolet light, x-rays, and gamma rays operate at extraordinarily high frequencies and, at these frequencies, carry enough energy to break chemical bonds, including those in DNA. This process is known as ionization, and fields capable of causing it are classified as ionizing radiation. The 60 hertz (Hz) magnetic fields produced by transmission lines do not carry anywhere near enough energy to cause ionization and are classified as non-ionizing. This is an important distinction, because the health concerns associated with ionizing radiation, such as direct DNA damage, do not apply to the magnetic fields produced by transmission lines.⁴

Q. Do magnetic fields from transmission lines cause cancer?

A. No. There is a large body of scientific research, and it does not support a conclusion that magnetic fields from transmission lines cause cancer.

Q. Aren't there studies that have found a correlation between transmission lines and cancer?

A. Yes. Nearly five decades ago, there was speculation that magnetic fields from power lines might cause childhood leukemia, a form of cancer of the blood. In the subsequent years, there were poorly conducted correlational studies that continued to raise concern. As a result, in 2002, the International Agency for Research on Cancer (IARC) classified extremely low frequency magnetic fields (ELF-MF) as "possibly carcinogenic" (Group 2B). This is IARC's lowest level of positive classification. IARC acknowledged only "limited evidence" and that findings might reasonably be due to chance, bias, or confounding.

⁴ [Electromagnetic Fields and Cancer - https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet.](https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet)

Q. Has the evidence strengthened or weakened since the 2002 IARC classification?

A. It has weakened. In the decades since, the weight of scientific evidence has moved further away from any association between low-level magnetic field exposure and cancer, including childhood leukemia. No causal mechanism has been identified, and the major health authorities that have reviewed the evidence, including the World Health Organization (WHO), the NCI and the National Institute of Environmental Health Sciences (NIEHS), have not concluded that these fields cause cancer.

Q. If the evidence has weakened, why does the IARC still classify ELF magnetic fields as possibly carcinogenic?

A. The IARC has not specified what threshold of new evidence would trigger a re-evaluation of ELF magnetic fields. In 2024, despite decades of accumulated null results, the IARC declined to revisit its 2002 classification. The agency acknowledged that evidence had "weakened," but concluded that re-evaluation was "unwarranted" for 2025–2029.

As to what level of data would be required to remove ELF magnetic fields from the IARC's Group 2B list, a clue comes from coffee, which carried the same "possibly carcinogenic" Group 2B label from the IARC for 25 years, until review of "more than 1,000 studies" prompted its removal in 2016.⁵

Q. Have the National Institutes of Health conducted their own assessment concerning the potential for transmission lines to cause cancer?

A. Yes. The NCI notes that "there is no known mechanism" by which these fields could cause cancer.⁶ In 1999, the NIEHS, concluded that the scientific evidence for a health risk was "weak."⁷

⁵ Loomis D, Guyton KZ, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, et al.; International Agency for Research on Cancer Monograph Working Group (2016). Carcinogenicity of drinking coffee, mate, and very hot beverages. *Lancet Oncol*, 17(7):877–8. doi:10.1016/S1470-2045(16)30239-X PMID:27318851.

⁶ NCI EMF Fact Sheet (reviewed October 2022, accessed July 2026): <https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>.

⁷ National Institute of Environmental Health Sciences. *NIEHS report on health effects from exposure to power-line frequency electric and magnetic fields*. EMF Research and Public Information Dissemination (EMF RAPID) Program. NIH Publication No. 99-4493. 1999.

Q. Has the WHO provided guidance or opinion concerning the potential for EMF of transmission lines to cause health effects?

A. Yes. Since 2007 the WHO maintains the following position: "... EMF limits below the limits recommended in the ICNIRP international guidelines do not appear to have any known consequence on health."⁸

Q. What is ICNIRP, and what are their guidelines?

A. "ICNIRP" stands for the International Commission on Non-Ionizing Radiation Protection. ICNIRP establishes guidelines for exposure to non-ionizing sources of magnetic fields, including those from transmission lines. Most of the European Union adopted ICNIRP's 1998 guidance for public exposure limits of 830 milli gauss (mG). In 2010, ICNIRP revised their guidelines by increasing acceptable exposure to 2,000 mG.⁹ For context, this Project is expected to produce less than 76 mG at the edge of the 765 kV 250-foot right-of-way. In other words, the reasonable public safety limit according to ICNIRP is many times higher than that which might exist near (or even in) the 250-foot right-of-way.

Q. Is there evidence examining the potential for magnetic fields from transmission lines to cause interference with implanted electrical devices, including implanted cardiac devices?

A. Yes. Tiikkaja et al. published two companion studies in 2013. In the first, volunteers with implanted pacemakers and defibrillators were exposed in a laboratory to magnetic fields far exceeding anything produced by a transmission line. All devices operating in bipolar configuration, showed no interference at any level tested. Bipolar configuration has been the clinical standard for cardiac pacemakers and defibrillators since the mid-1990s. In a companion experiment, Tiikkaja et al. confirmed these findings in the field, showing no interference in volunteers walking directly beneath a 400 kV transmission line.

⁸ World Health Organization. Radiation protection norms and standards. World Health Organization <https://www.who.int/teams/environment-climate-change-and-health/radiation-and-health/protection-norms>. Accessed January 25, 2026.

⁹ International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Physics. 2010;99(6):818-836.

V. CONCLUSION

Q. Please summarize your opinions discussed in this testimony.

A. With respect to this proposed transmission line and possible health impacts on the public: corona noise will not cause health effects, including hearing problems, tinnitus, or sleep disruption; and magnetic fields will not cause adverse health outcomes, including childhood cancer, or any other form of cancer, or interference from implanted medical devices.

Q. Does this conclude your Direct Testimony?

Yes.

Dated this 4th day of September, 2026.

/s/ Dr. Jeffrey Ellenbogen

Dr. Jeffrey Ellenbogen