Kenneth R. Foster & Associates

Electromagnetic Safety Consulting

February 8, 2010

Mr. Nicholas Ucci
Principal Policy Analyst, RI Public Utilities Commission
Coordinator, RI Energy Facility Siting Board
Rhode Island Public Utilities Commission
89 Jefferson Boulevard
Warwick, Rhode Island 02888

Re: Evaluation of Evidence Presented by National Grid Related to Potential Health Effects of Rhode Island Reliability Project

Dear Mr. Ucci:

Summary of Findings

The evidence and testimony presented by National Grid, in particular the testimony of Dr. Bailey, are consistent (in fact heavily rely on) reports of the World Health Organization (WHO) and other health agencies and are technically accurate descriptions of the scientific evidence as it stands at present. Despite some differences in emphasis, the conclusions of Dr. Bailey are consistent with statements of WHO and other major health agencies.

I conclude that the materials presented by National Grid and its consultants (a) shows that the project will result in only marginal changes in levels of public exposure to powerline fields, and (b) correctly describes the opinion of WHO that scientific evidence at present does not support the conclusion that exposures to powerline fields at levels below international guidelines can cause adverse health effects, despite raising some level of concern. I am aware of no recent advisories by WHO and other major health agencies that indicate a change in these agencies' longstanding recommendations on the issue.

Introduction

At your request, I examined materials that you sent me (listed in Appendix 1 below). The focus of my examination was whether the potential health effects from this project are different or contrary from that being reported by National Grid and its experts. The focus of my investigation was on potential health and biological effects from exposures to the public from electric and magnetic fields ("EMF") created by the proposed Rhode Island Reliability Project1, and whether the testimony and evidence provided to the Board by National Grid demonstrates that the potential bio/health effects in this project are different or contrary from that being reported by the Company and its experts.

Towards this end, I have closely read all written materials and hearing transcripts that you provided to me (which are listed in the Appendix). I did not re-do any of the calculations of field strength that were reported by National Grid or its consultants, or examine other issues such as compliance of the project with electrical and structural codes or environmental issues of a nonhealth nature. I note that the field calculations were performed by Exponent, Inc., which has extensive experience in such work.

The most relevant material to my evaluation was the testimony and report of William H. Bailey, Ph.D. of Exponent on behalf of National Grid on several dates from 2004-9 as well as the Environmental Report dated September 2008 (which summarizes Exponent's analysis). Also relevant were the brief testimony by Philip Cole in January 2005 (National Grid-23 Supplemental), and a statement by the RI Department of Health dated 9/15/09 (identified as EFSB-17 Advisory Opinion). I also read comments from the public in transcripts of various hearings about the issue; I did not review any expert testimony on health issues on behalf of opponents of the lines, and am not aware that any such testimony was presented.

1. In health discussions, the term EMF refers generically to electric and magnetic fields, without reference to any technology or frequency range. In the U.S. nearly all power systems operate at 60 Hz (cycles per second), which falls in what the health literature refers to as the extremely low frequency (ELF) range. Thus the fields referred to in this report are ELF EMF, in distinction to fields in other frequency ranges (e.g. radiofrequency fields).

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Exposure Assessment

National Grid maintains that the project will cause only modest changes (either modest increases or decreases) in levels of EMF outside of the right of way (ROW) of the lines.

In his testimony on 11/12/08, David J. Beron, manager for the project, testified

> If you look at Page 8-20 which is Table 8-2, A. [referring to National Grid-2] that table shows the calculated magnetic field levels for annual average load at the edges of right-of-way both pre-construction, immediately post-construction and then five years after construction… In some cases they're going down .. though in some cases they're going up marginally but no dramatic increases or decreases.

These opinions are supported by Exponent's calculations (which I did not independently confirm). For example, Table 8-2 of the environmental report (which is taken from Table 1 of Appendix B of the Exponent report of 5/19/09) compares pre- vs. post construction magnetic fields at the eastern and western edges of the ROW at 8 separate locations along the transmission corridor under average annual loading conditions. Of the 16 calculated field levels, 6 increase and 10 decrease after completion of the project.

Based on this very limited number of calculations, it appears that the net effect of the project will be to modestly even out the exposure along either side of the ROW. There will be modest reductions in field levels along the west edge of the ROW (where fields presently are somewhat higher than along the eastern edge) and modest increases in levels along the eastern side. It is not clear how representative this will be for the entire length of the line, and in any event the changes in field levels are modest. I concur with Mr. Beron that there will be "no dramatic increases or decreases" in EMF exposure to the communities resulting from the project.

This is significant because, however one may feel about possible health risks of living near power lines, the project will not greatly change the levels of EMF to which the members of the surrounding communities will be exposed. Undoubtedly, some nearby residents' exposures to EMF from the line will be modestly increased, and for others will be modestly decreased. Variations of considerably greater magnitude undoubtedly occur on an hour to hour and day to day basis as a result of changes of loading of the lines as they exist at present, and the calculated field levels along the ROW, both before and after completion of the project, are generally similar and typical of levels found near many other transmission lines of similar voltage.

Exponent Report/ Bailey's Testimony

Much of Bailey's testimony of 6/29/09 was devoted to introducing and reviewing Exponent's environmental analysis, which is contained in the Environmental Report for the project (identified as National Grid-2).

I consider separately the analysis of the health issues in the Exponent Report (Appendix B of Vol. 1 of the Environmental Report, identified as National Grid-2) and Dr. Bailey's testimony. Both Dr. Bailey's oral testimony and the Exponent report touch on a number of topics; below I consider comments to the major issue at hand: whether there is a health risk to the community from fields produced by the proposed project.

Strictly speaking, discussion should perhaps be limited to the possible *additional* health risks, if any, from any *additional* EMF exposure associated with the project. In fact the testimony and written report address the general issue of whether power-frequency fields have any health effects at exposure levels below international exposure guidelines.

<u>Exponent Report (Appendix B of National Grid-2)</u>

This document consists of a long (43 pages, including 9 pages of references) scientific review of the EMF-health issue. Much of the document is tutorial in nature. It provides an introduction aimed at a nonspecialist audience of the nature of electric and magnetic fields, levels of EMF found in the environment and the "weight of evidence" approach taken by health agencies to evaluate data in drawing conclusions about possible health risks to humans. The Exponent report also provides a comprehensive but not exhaustive review of scientific evidence pertaining to several diseases as related to EMF exposure, and summarizes two major exposure limits for human exposure to powerline fields. Notably, both exposure limits (those of the International Commission on Nonionizing Radiation Protection (ICNIRP) and the International Committee on Electrical Safety (ICES)) far exceed any plausible exposure to the public from the project.

The Exponent review focuses on reviews and opinions by the World Health Organization (WHO), with lesser emphasis on (generally similar) conclusions of other national health agencies. For example, in its concluding section, the Exponent report quotes the 2007 WHO Environmental Health Criteria (ECH) report[2]

> "Acute biological effects have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines [which far exceed potential exposures to the public from the project in question] provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted."

The Exponent report concludes with a passage that is a shade stronger than the above-cited statement from the 2007 WHO EHC document:

Exponent:

> Given the amount and quality of research that has been conducted thus far, however, the opinion is strong that there is not a cause-and-effect link between EMF exposure and long-term, adverse health effects.

By comparison, the WHO EHC Report says:

> Scientific evidence suggesting that everyday, chronic low-intensity (above 0.3–0.4 μT) power-frequency magnetic field exposure poses a health risk is based on epidemiological studies demonstrating a consistent pattern of increased risk for childhood leukemia. [Because of uncertainties in the studies] the evidence is not strong enough to be considered causal, but sufficiently strong to remain a concern….A number of other diseases have been investigated for possible association with ELF magnetic field exposure…. The scientific evidence supporting a linkage between ELF magnetic fields and any of these diseases is much weaker than for childhood leukemia and in some cases (for example, for cardiovascular disease or breast cancer) the evidence is sufficient to give confidence that magnetic fields do not cause the disease.

The Exponent report draws heavily from WHO materials. Its conclusion ("opinion is strong that there is not a cause-and-effect link") is somewhat stronger than that in the WHO document ("evidence for a causal relationship is limited"). However, the practical difference in implications for public policy between these two opinions may be limited.

Bailey Testimony

On several occasions Dr. Bailey provided testimony on possible health effects of EMF from the proposed project (National Grid-22 , National Grid-23 Supplemental, 7/14/09 (Warwick)). His statements are generally in line with WHO positions on the issue. For example, in his testimony of 7/14/09 he states (p. 63 line 17):

> "the scientific agencies that have reviewed the research have determined there is a possibility of a risk, they have not reviewed or considered that evidence as establishing, in fact, any health risk."

And later (p. 68 line 7)

> "I agree that there is some lingering possibility of uncertainty has to do with the statistical association with childhood leukemia."

And on p. 96 line 11:

> "I should apologize for the inadequacy of science at this time to give a yes or no answer. What I can tell you is that after 30 years of intense research we have eliminated virtually all the uncertainties about exposures to these fields, and we have one area of uncertainty sort of still on the table and that is the statistical association with childhood leukemia."

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2. Environmental Health Criteria 238 (2007): Extremely Low Frequency (ELF) Fields WHO, Geneva, Switzerland, ISBN 978-92-4-157238-5. Available online at http://www.who.int/peh-emf/publications/elf_ehc/en/index.html. A summary is available online at http://www.who.int/mediacentre/factsheets/fs322/en/index.html

State of Connecticut Siting Council Supplemental Testimony of Drs. William H. Bailey and Philip Cole (January 24, 2005)

Drs. Bailey and Cole provided this testimony, introduced at a 7/14/09 R.I. hearing as an exhibit, in a Connecticut proceedings in 2005. It is a highly technical rebuttal to expert testimony by Drs. Bell and Rabinowitz, who argued that powerline fields do create health risks. This testimony is now 5 years old, and health agencies have had ample opportunity to consider the scientific arguments raised in this 2005 exchange of views.

Drs. Bailey and Cole in their 2005 testimony (p. 11 line 10) concluded:

> "the evidence is insufficient to demonstrate a causal relationship between [EMF exposure] and this disease [childhood leukemia]; neither has such a relationship been deemed to be totally impossible"

which echoes statements by WHO in its 2007 EHC report cited above.

Public Comments

At several public meetings (in particular, the meetings on 7/9/09 in Warwick) members of the public expressed their concern about potential health effects of fields from the powerlines. This was not expert testimony, and the scattered references in the record of these hearings to health reports are incompletely cited and difficult to evaluate. Nevertheless, this testimony demonstrates a high level of concern about potential health issues, at least among the members of the public who offered their views during the proceedings.

RI Department of Health Informational Advisory Opinion of 9/15/09

This brief statement concludes

> "The Exponent report appears to include an extensive (although not necessarily exhaustive) review of the relevant peer-reviewed literature regarding potential public health concerns relating to biological responses to power frequency electric and magnetic fields associated with the RI Reliability Project. The Exponent report also provides an appropriate summary of the recommendations contained in this peer-reviewed literature."

That concurs with my evaluation of the Exponent material as well.

General Comments about the Issue

The potential health effects of fields emitted by power lines have been controversial in the United States since the 1960s or even before. Until 1979, most of the controversy concerned with the siting of high voltage power lines, and the focus of discussion was generally on possible health hazards from the strong electric fields found directly beneath the lines within the ROW. After the publication of the Wertheimer-Leeper study in 1979[3], which alleged a link between neighborhood distribution lines and transformers and childhood leukemia, discussion shifted to possible hazards from exposure to the comparatively weak magnetic fields present in peoples' homes due to neighborhood distribution systems, household appliances and household wiring circuits, and then a bit later to possible effects of magnetic fields from high voltage transmission lines to residents living near the ROW.

This issue, i.e. the possible health and biological effects of power frequency magnetic fields, became the subject of a massive amount of research, mostly conducted in the 1980s and 1990s, resulting in the publication of many hundreds of papers in the scientific literature. These studies vary widely in approach, quality, biological endpoints, and relevance to health.

This scientific literature has been reviewed repeatedly by health agencies around the world, a task that requires a massive investment in time by groups of experts with varying expertise to do properly. I regard the 2007 Environmental Health Criteria document by the World Health Organization (cited above) and the 2002 carcinogen risk evaluation by the International Agency for Research on Cancer (IARC, a part of WHO)[4] as being the most credible and exhaustive efforts along these lines in recent years. Other reviews have been performed by agencies in the U.S., Canada, The Netherlands, UK, and elsewhere, with conclusions similar to those in the WHO reports.

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3. Wertheimer N and Leeper E, Electrical wiring configurations and childhood cancer, American Journal of Epidemiology 109:273-284 (1979).

4. International Agency for Research on Cancer (IARC) Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 80, Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields , updated 2002.

While a variety of health claims can be found in the scientific literature, over time the discussion by health agencies has chiefly narrowed chiefly to one issue, the possible link between exposure to ELF magnetic fields, specifically power frequency fields, and childhood leukemia.

The 2002 IARC review classified ELF magnetic fields as a "possible human carcinogen" (category 2B). In the context of IARC's decision rules, a 2B classification indicates that the data support some level of suspicion but are insufficient to allow the agency to conclude that ELF magnetic fields actually do cause cancer in humans under real-world exposure levels. The classification (2B) is the lowest of several that IARC uses to indicate the weight of evidence that an agent or exposure causes cancer in humans. It was based on what IARC considered to be limited evidence of carcinogenicity based on the epidemiology data and less than sufficient evidence for carcinogenicity based on experiments with animals. This is an example of what Dr. Bailey calls a "weight of evidence" analysis – a formal, comprehensive evaluation of all available evidence, including epidemiological, animal, and laboratory data.

The 2007 EHC report by WHO updated the analysis of the cancer issue, and considered possible noncancer health risks. The EHC report reaffirmed the earlier IARC analysis, concluding that "the evidence for a causal relationship [between exposure to ELF magnetic fields and childhood cancer] is limited". The EHC also concluded that evidence for links to other diseases is still weaker than for childhood cancer. The analysis failed to identify any health risk at all at exposure levels that are below international exposure guidelines (all of which are far higher than anticipated exposure levels from the project).

It is important to note that childhood leukemia, while certainly tragic to the affected children and their families, is a rare disease. Moreover, best available estimates show that exposure to EMF in the environment from power systems would make only a small contribution to the total number of cases of childhood leukemia even if a causal link between field exposure and this disease indeed exists.

For example, Kheifets et al. calculated the "attributable fraction" of childhood leukemia due to EMF exposure[5]. This analysis, the most comprehensive and detailed presently available, concludes that, assuming that a causal link exists between EMF and childhood leukemia, somewhere between 2-4 % of leukemia cases in children below 14 across the U.S. might be attributable to ELF magnetic field exposures at levels greater than 0.3 μT. That would correspond to 54 or 121 additional childhood leukemia cases across the US per year (depending on how the exposure was calculated). Since Rhode Island has approximately 0.3% of the total US population, one might expect one additional case of childhood leukemia every few years that might be caused by EMF exposure *assuming that a cause and effect relation exists at all*. Any net *additional* disease burden from the modest *additional* exposure to ELF magnetic fields from the Rhode Island Reliability Project would be far too small to discern in state's health statistics.

As one might expect, the opinions of individual scientists about the issue vary widely. To some extent, this may be due to differences in the way that individual scientists weigh the small but persistent associations that have been reported in the numerous epidemiological studies on ELF magnetic field exposure and childhood leukemia, against the potential weaknesses that are inherent all such studies, the lack of supporting animal data, and the lack of any accepted biophysical mechanism by which ELF magnetic fields at ordinary exposure levels might produce any noticeable biological effect. Expert reviews conducted by WHO and other agencies are done by scientists with varying expertise and tend to reach middle-ground conclusions; indeed, various agency reviews of the issue are quite similar in their conclusions.

However, given the extremely diverse and at times inconsistent scientific evidence on this topic, it is always possible to pick and choose data to support advocacy positions that are sharply different from the more balanced opinions of health agencies.

5. Kheifets L, Afifi AA, Shimkhada R, Public Health Impact of Extremely Low-Frequency Electromagnetic Fields, Environmental Health Perspectives 114: 1532-1537 (2006). Available online at http://ehp.niehs.nih.gov/members/2006/8977/8977.pdf. See also the Appendix of the EHO EHC report.

An example of this is BioInitiative Report[6] (BIR) which has become prominent in public debates about power lines and other electrical installations and is mentioned in the testimony. This is a review of the health literature by a self-selected group of individuals explicitly for advocacy purposes. An 11 member panel assembled by the Health Council of the Netherlands[7] concluded that the BIR "is not an objective and balanced reflection of the current state of scientific knowledge and does not provide any grounds for revising the current views as to the risks of exposure to electromagnetic fields."

Expert testimony along the lines of the BioInitiative Report would certainly have been very different from that provided by Dr. Bailey. Whereas the EHC states that there is "limited evidence" that ELF magnetic fields cause cancer, the BIR states: "There is little doubt that exposure to ELF [fields] causes childhood leukemia."

To fully argue out the scientific issues thus raised (as opposed to understanding the recommendations of WHO and other health agencies) would have required extensive and highly technical testimony from a variety of experts, which was not presented during the proceedings in question. Whether such an in-depth investigation of the underlying science would have been appropriate in the proceedings in question is a legal issue that is not addressed here.

The R.I. Department of Health is undoubtedly correct in its statement of 9/15/09 that it does not have "the technical expertise" to recommend any alternate limits for electric and magnetic field levels at the edge of the ROW of a powerline. Also, in my view, the Department is correct in its decision not to make such recommendations "in the absence of appropriate guidance from national and/or international standard setting organizations with technical competence in this area". I am aware of no recent health advisories by WHO or other major health agency that indicate a change in their assessments of the situation.

Conclusion

Dr. Bailey's testimony is consistent with views expressed by WHO and other major health agencies. The bottom line is that the evidence is not sufficient to conclude that exposure to powerline fields at levels below international limits (which far exceed any exposure to the public from the project) will produce any adverse health effects. However uncertainty remains about a possible link between exposure to EMF and childhood leukemia and in the views of the World Health Organization such a relationship cannot be deemed to be totally impossible.

Sincerely yours,

Kenneth R. Foster, Ph.D., P.E.

6. BioInitiative Report: A Rationale for a Biologically-Based Public Exposure Standard for Electromagnetic Fields (ELF and RF). See www.bioinitiative.org.

7. Health Council of the Netherlands. BioInitiative report. The Hague: Health Council of the Netherlands. publication no. 2008/17E, 2008. Available on the Internet at http://www.gezondheidsraad.nl/en/publications/bioinitiative-report-0

Appendix 1

Materials Examined. The last column to the right lists the documents that are most relevant to the issue of possible health effects from the electric and magnetic fields from the proposed transmission lines.

Document/Exhibit	**Title**	**Read**	**Principal Focus of Examination**
National Grid-2	Environmental Report Vol. I (September, 2008) In particular Exponent, Inc. Electric and Magnetic Field Research Update: Rhode Island Reliability Project, August 8, 2008 (Appendix B to Environmental Report – Volume 1).	X	X
National Grid-3	Environmental Report Vol. II (Figures) (September, 2008)	X	X
National Grid-16	Pre-filed Testimony of National Grid (June 29, 2009)	X	
National Grid-16A	Testimony of David J. Beron and attachment (6/29/09)	X	
National Grid-16B	Testimony of David M. Campilii (6/29/09)	X	
National Grid-16C	Testimony of Susan Moberg (6/29/09)	X	
National Grid-16D	Testimony of EDR Witnesses (Mr. Hecklau, Ms. Gagliano, and Mr. Manizer) and attachments (6/29/09)	X	
National Grid-16E	Testimony of William H. Bailey and attachments (6/29/09)	X	X
National Grid-22	Supplemental Testimony III of Dr. William H. Bailey Concerning Magnetic Field Exposure Policy before the State CT Siting Council (10/12/04)	X	X
National Grid-23 Supplemental	State of Connecticut Siting Council Supplemental Testimony of Drs. William H. Bailey and Philip Cole (January 24, 2005)	X	X
National Grid-24	48-hour Magnetic Field Exposure (from Exponent)	X	X
EFSB-17 Advisory Opinion	RI Department of Health Informational Advisory Opinion issued 9/15/09	X	X
National Grid-25	RI Reliability Project Magnetic Field at Average Annual Loading	X	
	Exponent , Inc. Rhode Island Reliability Project: Electric and Magnetic Field Modeling (report dated 5/19/09 with Addendum, 5/26/09).		
	Transcripts of hearings in re: National Grid Reliability Project, Docket SB2008-2: 11/12/08 (Warwick) 6/2/09 (Warwick) 6/16/09 (N. Smithfield) 6/24/09 (Smithfield) 6/25/09 (Johnston) 7/7/09 (Cranston) 7/8/09-7/9/09 (two hearings, Warwick and West Warwick) 7/14/09 (Warwick) 10/19/09 (Warwick)	X	Transcripts 11/12/08 (testimony by Beron on EMF exposure levels) 7/14/09 (Bailey) 7/8/09 (testimony by citizens in Warwick)

Appendix 2
SUMMARY RESUME

NAME Kenneth R. Foster

DATE/PLACE OF BIRTH July 21, 1945
Baltimore, Maryland

NATIONALITY United States Citizen

EDUCATION 1967 B.S.(Honors) Physics
Michigan State University
1971 Ph.D. (Physics)
Indiana University
Professional Engineer in the State of Pennsylvania
(Certificate Number: PE-030018-E).

EMPLOYMENT
Lieutenant, Medical Service Corps, USNR 1971-6
Department of Bioengineering
University of Pennsylvania 1976-present
Postdoctoral Fellow (1976-7)
Assistant Professor (1977-83)
Associate Professor (1983-present)
Professor (1999-)
Consultant, World Health Organization EMF Project, Geneva, Switzerland 2000 (sabbatical leave from the University of Pennsylvania)

HONORS/DISTINCTIONS
Indiana University Physics Department Award for Excellence in Teaching, 1970.
Defense Nuclear Agency Certificate of Achievement, 1976.
Fellow, Institute of Electrical and Electronics Engineers, 1988.
Fellow, American Institute of Medical and Biological Engineering, 1991

PROFESSIONAL SERVICE
AdCom, IEEE Engineering in Medicine and Biology Society, 1984-6, 1988-
Associate Editor, IEEE Transactions on Biomedical Engineering, 1985-1989
Program Chair, 1987 IEEE EMBS Annual Meeting (1200 papers presented)
Conference Chair, 13th Annual Northeast Bioengineering Conference, 1987
Chair, IEEE Committee on Man and Radiation 1997-9
Chair, IEEE EMBS Ethics and Professional Responsibility Committee, 1989-1993
President, IEEE Society on Social Implications of Technology 1996-8
President, Philadelphia Society for Risk Analysis 1996-7
President, IEEE Society on Social Implications of Technology, 1996-8
Member, IEEE/ANSI C95.1 (sets exposure standards for RF energy) 1998-
Member, National Council on Radiation Protection and Measurements 2000 - 2004

RESEARCH EXPERIENCE AND DIRECTION
Since receipt of the Ph.D. in 1971, Dr. Foster has been engaged in studies on the interaction of nonionizing radiation and biological systems, with more than 100 papers in peer-reviewed journals on topics including biophysical mechanisms of interaction, electrical properties of biological materials, and medical applications. In addition he has written widely about the public controversy surrounding these issues. He is coauthor or coeditor of two books on risk assessment and the law.