THE CONNECTICUT SITING COUNCIL
DOCKET NO. 272

Application of Northeast Utilities Service Company
for a Certificate of Environmental Compatibility
and Public Need for a new 345-kV Electric Transmission Line Facility
between Scovill Rock Switching Station in Middletown
and Norwalk Substation in Norwalk

Testimony Addressing Recent Questions Raised by the Connecticut Siting Council and Witnesses Re: EMF

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January 12, 2005

Q. What is the purpose of this testimony?

A. The purpose of this testimony is to respond to questions raised by the Siting Council, Dr. Bailey and Dr. Ginsberg, and to clarify the risks of childhood leukemia at EMF levels between 2 and 5 milliGauss (mG) so that the Siting Councilcan identify and establish safety buffer zones around power lines in the State of Connecticut.

Q. Have the three major meta–analyses, from Wartenberg [1], Greenland [2], and Ahlbom [3], identified a statistically significant increase in the risk of childhood leukemia associated with EMF levels over 2, 3, or 4mG?

A. Yes. Wartenberg [1] identified a statistically significant 34% increase in the risk of childhood leukemia for children exposed to 2mG or more. Greenland [2] identified a statistically significant 83% increase in the risk of childhood leukemia for children exposed to greater than 3mG. Ahlbom [3] identified a statistically significant 100% increase in the risk of childhood leukemia for children exposed to 4mG or more.

Q. Did the Greenland study create a mathematical model to demonstrate the measured EMF exposure levels at which leukemia risk increases?

A. Yes. Figure 1 in the Greenland study [2] shows an exposure-risk model based on the data from the grouped studies of EMF and childhood leukemia. The model shows, for the central estimate of risk, a "strictly increasing trend above 0.1 μT"(1mG). In other words, the model suggests that increased risk could begin well below 5mG.

Q. Does the mean EMF exposure level of 5.8mG for children in the greater than 3mG exposure group in the Greenland [2] study mean that most children in that group were exposed to an EMF level of 5.8mG or greater?

A. No. Most of the children described in Greenland [2] who were diagnosed with leukemia were actually exposed to EMF levels of less than 5mG. Of note, as stated above, the children in the study with exposure levels of greater than 3mG had a statistically significant 83% increase in the likelihood of developing leukemia. Importantly, 74% of exposed children who developed leukemia and had an exposure of at least 3mG had been exposed to EMF LESS than 5mG. Even more impressively, 86% of exposed children who developed leukemia and had an exposure of at least 2mG had EMF exposure estimates that were LESS than 5mG. In other words, the "average" value of 5.8mG for children in the greater than 3mG exposure group in the Greenland study is elevated since there are a very few children who develop leukemia who have very high exposures to EMF, but the vast majority of children with leukemia in this exposure group actually had measured exposures substantially less than 5.8 mG. In fact, most of them had exposures closer to 3mG [Note:94 cases of children with leukemia in the Greenland analysis had exposures between 2-3mG, 49 cases had exposures between 3-4 mG, 24 cases had exposures between 4-5mG, and only 26 cases had exposures >5mG]. Therefore, the estimate of 5.8mG markedly

overestimates the exposure of the "typical" child who developed leukemia in the studies analyzed by Greenland.

Q. Did any of these meta-analyses specifically examine whether there was a statistically significant increase in the risk of childhood leukemia for children exposed to increased EMF levels using an upper limit for exposure cutoff of 5mG?

A. No,although each of these studies examined childhood leukemia risk greater than a certain threshold, with 2mG to 4mG anchoring the lower end of the threshold, none of these studies also applied an upper boundary of 5mG on the EMF exposure level.

Q. While none of the most comprehensive studies examined this limited window of EMF exposure, did any of the smaller studies examine whether there was an elevated risk for childhood acute lymphocytic leukemia (ALL) within a limited window of EMF exposure below 5mG?

A. Yes. Linet et al.[4], one of the larger studies of EMF, found an increase in ALL risk for children exposed to EMF at levels of 3mG and above. The authors of this study also state that this risk "derived from a significant excess incidence of ALL at the intermediate level of 0.400-0.499μT [4-4.9mG]."

Q. Is it fair to conclude from the meta-analyses that there is no increased risk of leukemia to children exposed to EMF levels from power lines less than 5mG?

A. No. Similar to the Connecticut Department of Public Health testimony [5], we agree that the three major meta-analyses did not seek to examine whether there is an identifiable health risk in a limited EMF exposure window with an upper limit of 5mG. Indeed, for these reasons, we believe that it is important to examine the available data in order to identify whether there is an increased risk of leukemia in children exposed to EMF levels from power lines less than 5mG.

Q. Do you feel that the data from the above cited meta-analysis supports setting a safety buffer zone at exposures of approximately 5mG in order to protect children from the risk of leukemia?

A. No. As stated above, there is evidence that the typical child with leukemia in the exposure groups above 2-3mG actually has EMF exposure substantially below 5mG. For this reason, it might be expected that exposure levels below 5mG would also be associated with an increase in the incidence of childhood leukemia.

Q. You mention that in most of the studies included in the meta-analyses such as that by Greenland [2], the "typical" exposures of children with leukemia in the higher exposure groups is closer to 3mG. Do the meta-analyses present original data in a form that would shed light on the risk to children of EMF exposures in a limited window between 2 and 5mG?

A. Yes. For example, Greenland et al [2] present raw data from all the studies they analyzed that show the number of children with and without cancer who had exposures in this range.

Q. Have you examined these data?

A. Yes. Based upon our view, and the view expressed by the Connecticut Department of Public Health, that no one has sought to tease out whether there is an increased risk in a limited window of EMF exposure below 5mG [6], and the question posed by Chairman Katz [7] we have examined the data published by Greenland [2] in order to determine whether there is a statistically significant increase in the risk of leukemia for children exposed to EMF levels less than 5mG. We recognize that there may be potential limitations to examining a subset of the subjects, even though this is a very large subset representing approximately 87% of all children exposed to EMF levels more than 2mG, but since this specific topic has been a subject of previous testimony and the Siting Council has expressed interest in whether there may be an increased risk of leukemia in children with exposure to EMF within this exposure range, we feel it is important to directly examine such data.

Q. What methods did you use to examine these data?

A. Our examinations are based on the data employed by, and are intended to mimic the methods used by, Greenland et al. [2]. Relying upon the data tables presented in Greenland [2], we performed an initial examination necessary to supplement the results reported in Table 4 in order to provide estimates for the odds ratios associated with exposure categories not reported in the table. In this form of examination, we used the Mantel-Haenszel method to examine the effect of EMF exposure across the different studies included in the meta-analysis with the assumption of a fixed effect which has been described as an "appropriate method for analyzing data for a meta-analysis" [8]. Importantly, this form of examination is the same form of statistical analysis used by Greenland et al. [2]. We examined odds ratios according to established, validated, and published techniques [9]. Additionally, in an effort to further validate this subsequent examination, we applied the same statistical techniques to Greenland et al.'s [2] own analysis and were able to reproduce the odds ratios presented in Greenland's published meta-analysis (Greenland [2], Table 4) and also reproduced probability values (ie., to determine whether something is statistically significant) similar to those published by Ahlbom [3].

Q. Did you use data from peer-reviewed scientific articles published by experts in the field?

A. Yes. We used the data presented in Table 3 of Greenland et al. [2], because the data provided in this publication were sufficiently segregated in their presentation to

permit an examination of the risk in the largest EMF window with the upper boundary of 5mG.

Q. Is there an identifiable statistically significant increase in the risk of childhood leukemia in children who are exposed to more than 2mG but less than 5mG of EMF from power lines?

A. Yes. With an extension of the work from Greenland [2], statistical examination of the data showed that there is an identifiable, statistically significant, increase in the risk of childhood leukemia in children who are exposed to more than 2mG but less than 5mG of EMF from power lines.

Q. Can one estimate the increase in the risk for childhood leukemia, and the likelihood that this increased risk is due to chance and not a true association, for children exposed to less than 5mG of EMF?

A. Yes. An estimate of the quantitative increase in risk and the specific level of statistical significance, based on our examination, are described in the table below:

EMF Exposure	Odds Ratio	95% Confidence Intervals	P Value
2 – 5mG	1.30	1.03 – 1.64	0.013
3 – 5mG	1.81	1.25 – 2.62	0.001

Q. Did this examination of the data in Greenland [2] show an increase in risk for leukemia in children exposed to EMF levels between 2 and 5mG?

A. Yes. This examination reveals that Greenland [2] data shows that exposure of children to an EMF level of at least 2mG and no more than 5mG is associated with a statistically significant 30% increase in risk of childhood leukemia. The calculated probability of this observed association being due to chance alone was approximately only 13 out of 1000.

Further, exposure of children to an EMF level of at least 3mG and no more than 5mG was associated with a statistically significant 81% increase in risk of childhood leukemia. The probability of this observed association being due to chance alone was approximately only 1 out of 1000.

Most importantly, the data revealed from an examination of Greenland [2] showed that there is a strong statistical association between exposure to EMF levels of between 2-5mG or between 3-5mG and an increase in risk of childhood leukemia.

It is exceedingly unlikely, therefore, that either of these significant results is due to chance. It is also noteworthy that, within this limited window of 2-5mG, examination of the Greenland [2] data is consistent with a dose-response relationship since the childhood leukemia risk associated with 3-5mG EMF

exposure is even greater than the childhood leukemia risk associated with 2-5mG EMF exposure.

Q. Is there regulatory precedent for requiring that human exposure to an agent must be shown to be safe, rather than presumed safe?

A. Yes. As has become abundantly clear over the past several months in the United States to even the casual observer, Federal regulatory authorities require that all drugs, including over-the-counter and prescription pain drugs, must be shown to be safe, not only during testing, but also during market use. This is consistent with the government mandate to actively protect the public, particularly to involuntary, or hidden, exposure to safety risks.

Q. Did the Siting Council identify the importance of determining whether there is a statistically significant increase in the risk of childhood leukemia in children exposed to EMF levels less than approximately 5mG?

A. Yes. The Siting Council expressed concern whether it was known that there was an increase risk of leukemia in children with EMF exposures of less than approximately 5mG [7]. It appears that the Connecticut Siting Council, from the transcript of the October 14, 2004 Evidentiary Hearing, is considering setting a threshold for Safety Buffer Zones of approximately 6mG. From the transcript, we believe that this view is based on the contention that there is not available scientific data that shows that exposure of children to EMF levels of less than 6mG is associated with a statistically significant increase in the risk of childhood leukemia. For this reason, we have examined the data in Greenland [2] in order to determine whether this contention is valid.

Q. Are there policy implications of allowing EMF exposures to children between 2 and 5 mG in the absence of analysis of the leukemia risk in this specific range?

A. Yes. A policy-driven by, "What we don't know, Won't hurt us" runs the public welfare risk of unknowingly exposing a susceptible and involuntary population to a significant cancer risk. It is also in contradistinction to the affirmative obligations imposed on the Siting Council in PA 04-246 "to protect the public health and safety" and also to provide a "buffer zone." Additionally, such a policy runs the risk of subsequent analyses contravening the assumption underlying such a policy – ie., the "We don't know because we didn't look" assumption is easily overridden by further analyses, such as the scientific analysis provided in the current testimony. In this case, data shows a statistically significant increase in the risk of leukemia for children exposed to low levels of EMF, and this data has now been provided to policy makers. The previous public policy of "What we don't know, Won't hurt us" now becomes "What we do know, Will hurt us". Thus the policy makers need to determine whether knowingly exposing children to a statistically significant 30% - 81% increase in the risk of leukemia is an acceptable public health policy directed at an involuntary susceptible population, the children of Connecticut. It also would

need to be determined whether such a policy is consistent with the affirmative statutory obligation to protect the public health and safety. We would strongly argue that such an adverse effect is not an acceptable public health policy.

Q. With the examination of the Greenland [2] data, what are your recommendations regarding the establishment of a safety buffer zone?

A. Consistent with diligent evaluation of the available human data, and with the objective of protecting the health and safety of Connecticut's children, we recommend relying upon the available scientific data and analyses and to avoid prolonged exposures to children greater than 2mG. Given that a hazard has been identified at exposure levels as low as 2mG, it may be argued that a reasonable and cautious approach to protecting the health of children would suggest that exposure thresholds should be closer to the typical (i.e., excluding children residing or otherwise in close proximity to power lines) childhood exposure (approximately 0.6mG). We would prefer this more cautious approach, but from available human data we cannot quantitatively identify a known risk for an increase in childhood leukemia at exposures less than 2mG. However, available data do permit the identification of a statistically significant 30% increase in the risk of childhood leukemia for children exposed to a limited EMF window of only between 2 and 5mG. This observation specifically underscores the potential harm of allowing exposure of children to EMF levels of between 2 and 5mG. Further, since the current discussion regards the projection of EMF values for proposed, but not existing power lines, it is important that the projections for EMF near children that are used to establish the statutory buffer zones be based upon the expected useful life of the proposed overhead power lines, approximately 50 years, and that the projected EMF levels should not be estimated at power consumption levels that are likely to be surpassed during the lifetime of the proposed power line. It is equally important to contemplate that today's regulatory decisions will affect not only today's children and today's children's children, but also today's children's grandchildren. Thus, applicant's current proposal would be expected to have a potential health and safety impact on three generations of Connecticut's children.

Over the period of time from 1980 to 2002, ISO-NE reported an increase in peak load of nearly 74% (April 20, 2004 ISO-NE Presentation to New Hampshire Industries of the Future www.nhiof.org/workshops/atcpresentations/babula.ppt).

Currently, during approximately 50% of the time the load experienced in the transmission system is greater than 15 GW. From data provided by applicant in their September 27, 2004 filing, the median annual increase in average load from 1999 to 2003 can be calculated as 1.87%. Further, in applicant's September 27, 2004 response to interrogatory, applicant states, "Over at least the past several years the peak load in New England has grown faster than load levels during the off peak periods due to significant increases in both the number and use of air conditioning equipment by residential and commercial customers. As New England's peak load increases, there has been a corresponding, but smaller, increase in average load

levels. It is reasonable to expect that this trend will continue." As the proportion of time spent at higher load levels increases in the future, the average load will also increase.

In applicant's response to interrogatory from March 19, 2004, it becomes clear that there may be substantial under-prediction of future peak demand, "...the companies estimate that peak load growth in SWCT could be as high as 2% per year over the next ten years, assuming normal weather conditions. Extreme weather conditions occur in any given year could add roughly 10% to that year's peak demand." Indeed, as a base case, the NEPOOL CELT Report-April 2004 prepared by ISO-NE (http://www.iso-ne.com/Historical_Data/CELT_Report/2004_CELT_Report/) predicts peak load will be 27.9 GW in 2010 and 29.9 GW in 2013. With extreme weather, 27.7GW could be surpassed in 2008 and 30 GW obtained in 2013. With economic growth better than a predicted "base case" demand would be expected to increase a further 5-8% for any particular period of time, further pushing up actual median and peak load values. Additionally, from applicant's original application (p. F-18), applicant documented an historical increase in peak load from 1997 to 2002 of 4.07% annually, further supporting that peak load in the future may rise more rapidly than currently predicted by applicant.

Peak exposures may be medically important. Short exposures, lasting for as little as two hours, cause DNA damage in whole animal experiments in which animals were exposed to EMF or control conditions and laboratory investigators were blinded to the treatment [11].

Emphasizing the importance of considering the policy implications over the longer-term, actual published data shows an increase in the incidence of childhood leukemia, in contrast to assertions by applicant's consultant earlier in this hearing that there has not been an increase in childhood leukemia (March 25, 2004 Transcript, page 241, lines 19-22). Over a similar period of time in which power consumption has been observed to increase substantially, from the 1970's through the 1990's there was a parallel increase in the incidence of childhood leukemia, with an approximately 40% increase in Europe [12], and an approximately 18% increase in the U.S [13]. Hence, increases in both power consumption and childhood leukemia appear to track each other over time periods approaching a generation.

Importantly, applicant provides substantial emphasis in argument and declaration with respect to engineering reliability concerns of the 27.7 GW and 30GW peak load cases, but fails to provide a similar level of emphasis on children's safety. While this position with respect to its expected current and future customers is applicant's prerogative as a for-profit utility, by virtue of the public interest and State legislation, the Connecticut Siting Council has had imposed on it dual statutory responsibilities that concern reliability as well as health and safety. In this deliberation, on balance, the level of forecasting for children's health should be at least, if not more, conservative than the forecasting for engineering reliability.

Further, the reliability of (i) available empirical human data demonstrating statistically significant increases in leukemia in children exposed to a limited window of EMF of between only 2 and 5mG, (ii) the empirical data demonstrating substantial increases in power consumption over the past several decades, and (iii) the empirical data demonstrating increases in the incidence of leukemia in children over the past several decades, far surpass the reliability of applicant's future meteorological and economic forecasting capabilities. Finally, for these reasons together with the affirmative obligation now imposed on the Connecticut Siting Council under PA 04-246 to protect the health and safety of Connecticut citizens, particularly Connecticut children, and the expected longevity of the proposed lines, the 2mG edge buffer zone should be calculated at a load of at least 30 GW.

Q. Did the Linet et al [10] review article, introduced by applicant's supplemental testimony dated October 12, 2004, contribute any new scientific data?

A. No. The review article [10] did not provide any original or new scientific data but instead provided an opinion expressed by Dr. Linet. Additionally, the opinion article by Linet did not refute the conclusions by each of the independent scientific panels, the National Research Council, the National Institutes for Environmental Health Sciences, the National Radiological Protection Board, the International Agency for Research on Cancer, the International Commission for Non-Ionizing Radiation Protection, and the California Health and Human Services Agency that there is a statistically significant association between EMF levels and childhood leukemia.

Q. Has Dr. Linet also authored scientific articles suggesting a statistically significant association between elevated levels of EMF and childhood leukemia?

A. Yes. In the Ahlbom meta-analysis [3], Linet – who was a co-author and contributor to the publication - and colleagues write, "In summary, the 99.2% of children residing in homes with exposure levels < 0.4 μT had estimates compatible with no increased risk, while the 0.8% of children with exposures ≥ 0.4 μT had a relative risk estimate of approximately 2, which is unlikely to be due to random variability." In this ICNIRP report, Linet and colleagues state, "There has been a large body of high quality data for childhood cancer…Among all the outcomes evaluated in epidemiologic studies of EMF, childhood leukemia in relation to postnatal exposures above 0.4 microT is the one for which there is most evidence of an association."

Q. Does the statement by Linet et al [10] that there is not a dose-dependent effect of EMF on the incidence of childhood leukemia reflect a consensus of scientific opinion?

A. No. Some authors have suggested that there is a dose-dependent effect. For example, the Greenland meta-analysis [2] created a model that suggests a dose dependent increase in risk above 1mG. Dose-dependence is present when a larger dose is associated with a greater, albeit not necessarily proportional, increase in effect.

Dose-dependence may be present, but obscured, in small sample numbers. Comparison of the results from the three major meta-analyses also refutes the assertion by Linet [10]. Wartenberg [1] identified a statistically significant 34% increase in risk of childhood leukemia for children exposed to 2mG or more. Greenland [2] identified a statistically significant 83% increase in risk of childhood leukemia for children exposed to 3mG or more. Ahlbom [3] identified a statistically significant 100% increase in risk of childhood leukemia for children exposed to 4mG or more. Further, our analysis described above which extends the analysis presented by Greenland [2] shows that within the limited exposure window of 2-5mG, there appears to be evidence of dose-dependence since the 3-5mG EMF exposure window childhood leukemia risk is even greater than the 2-5mG EMF exposure window childhood leukemia risk.

Q. Does the statement by Linet et al [10] that "the results of experimental studies did not support the biological plausibility of the association" include a review of all relevant scientific experimentation since 1998?

A. No. Linet et al. cites the 1998 NIEHS Working Group Report [14] and a limited number of additional references. In particular, her opinion article does not include a large number of previously cited and unrefuted scientific investigations from a diverse array of independent laboratories that have met the EMF criteria of the Working Group and have demonstrated that EMF levels more closely approximating environmental levels are associated with significantly increased DNA damage, changes in stress response, acceleration of electron transport chemical reactions, generation of oxygen free radicals, and alterations in signal transduction [15-30]. Linet's opinion article [10] further does not cite an evolving and strong line of scientific investigation and laboratory work that has tied *in vivo* cancer susceptibility with EMF to variations in genetic background [31-37], potentially explaining why certain genetic backgrounds make exposure to EMF, as to other carcinogens, more likely to result in cancer in the exposed individual. Indeed, since the 1998 NIEHS Working Group review [14], and because of the Working Group's call for research at EMF levels more closely approximating environmental levels, the plausible mechanisms for EMF causing cancer in laboratory studies have been importantly extended. A broad spectrum of laboratory evidence supporting multiple potential mechanisms for lower intensities of ELF EMF to cause cancer in humans have now been provided in the scientific literature.

Q. Does this conclude your supplemental testimony?

A. Yes.

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