MICRO WAVE NEWS

Vol. XXVII No.1 A Report on Non-Ionizing Radiation January 19, 2007

MICROWAVE NEWS • ISSN 0275-6595 • 155 East 77th Street, New York, NY 10021 • (212) 517-2800 • Fax: (212) 734-0316 • E-mail: <mwn@pobox.com> • Web: <www.microwavenews.com> • Editor and Publisher: Louis Slesin, PhD •

Public Health Officials Urge Precaution To Limit Cancer Risk

Three senior members of the public health community—each with extensive experience with electromagnetic field (EMF) health research—have called for precautionary policies to limit leukemia risks to children.

At a public hearing convened by the Connecticut Siting Council (CSC) on January 9, David Carpenter, Raymond Neutra and Daniel Wartenberg testified in support of prudent avoidance, as advocated by the Connecticut Department of Public Health (DPH). Prudent avoidance is a strategy of adopting low-cost ways of reducing human exposures to EMFs.

In a report prepared for the siting council, Peter Valberg of the Gradient Corp., a consulting firm in Cambridge, MA, put forward a 100 mG exposure limit. Michael Repacholi, the former head of the World Health Organization's EMF project in Geneva who is now working on behalf of Connecticut Light & Power Co. and the United Illuminating Co., two electric utilities, has endorsed Valberg's proposal (see *MWN*, November 13, 2006).

The state DPH opposes Valberg's 100 mG guideline as "ill-conceived." Susan Blancaflor, the head of its environmental section, told the CSC that such a target level "does not consitute prudent avoidance" nor does it provide "adequate protection of public health." The DPH favors a 10 mG exposure limit.

The 100 mG standard is "way too high," Carpenter said at the public hearing. "It's misguided." Carpenter is the director of the Institute for Health and the Environment at the University of Albany. From 1980 to 1987, he was the director of the New York State Power Line Project. The project's final report, which highlighted the childhood cancer risk, prompted national attention to EMFs. "The odds are that we are grossly underestimating the real risks, if the risks are real," Carpenter warned.

Valberg held his ground. "I feel very confident that 100 mG is safe," he said. "I would allow my children to be exposed to 100mG—[if this were the case,] I could sleep at night."

While Repacholi agreed that prudent avoidance was a worthy goal, he kept repeating that the science which forms the basis for precautionary policies is somewhere between "weak" and "very weak." "Most scientists believe that there is something strange in the [epidemiological] data [because] these fields just cannot cannot cause cancer," Repacholi said.

"It's not strange," countered Wartenberg, the director of environmental epidemiology at the Robert Wood Johnson Medical School in Piscataway, NJ. "Why would you assume that the epidemiology is wrong? It does not make sense to throw out the childhood epidemiological data." Wartenberg was a member of the National Academy of Sciences–National Research Coun-

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cil (NAS–NRC) panel that issued a report on power-line EMFs in 1996. Two years later, he served on the EMF Working Group assembled by the National Institute of Environmenal Health Sciences (NIEHS). Wartenberg has carried out three meta-analyses on EMF–cancer risks—for the NAS-NRC, for the NIEHS and for the California EMF program.

"I believe there is solid evidence supporting an association between exposure to magnetic fields and the incidence of childhood leukemia," Wartenberg told the CSC. "As a public health professional, I believe strongly that prudent action to limit the exposure and possibly prevent several children from developing cancer is essential unless the costs...outweigh the value of the impact on these children's lives."

Neutra, who ran the $7 million, eight-year California EMF program, said that he would classify power-frequency EMFs as a possible human carcinogen—as the NIEHS and the International Agency for Research on Cancer (IARC) had done in 1998 and 2001, respectively. Neutra, who works for the California Department of Health Services, testified by phone.

"My degree of certainty, like those at NIEHS and IARC was not pulled down by arguments by physicists that physiological or pathological effects from residential power lines was 'impossible' based on the application of physical laws to simplified biological models of cell mechanisms," Neutra wrote in his prepared testimony. "Physicists don't know enough about biology for me to be convinced by their arguments."

Below are excerpts from Carpenter, Neutra and Wartenberg's written testimony submitted to the siting council.

David Carpenter: Setting an EMF Limit Based on Negative Rat Studies Instead of the Observed Childhood Leukemia Risk Is "Simply Foolish"

In my judgment, the proposal to establish a magnetic field screening level of 100 mG at the edge of right-of-ways is misguided. It will not be protective of human health, especially to children. As documented by Wartenberg (1998), epidemiological studies of residential exposure to magnetic fields and childhood leukemia show a positive relationship that cannot be explained by random variation. Two independent meta analyses show that prolonged exposure to power line fields of 3 or 4 mG is associated with an increase in the risk of leukemia in children (Ahlbom et al., 2000; Greenland et al., 2000). Furthermore, there is reason to believe that, as with other carcinogens, exposure to lower intensity fields also increases risk of cancer. To devise an exposure standard on the basis of negative rat studies when there is strong evidence of increased risk of leukemia in children associated with magnetic fields from power lines is simply foolish. It is children and other humans that we are supposed to protect, not rats.

Since others are providing detailed comments on human studies, I have been asked to discuss animal and cell culture studies that might provide a mechanistic basis for the relationship between exposure to 60 Hz magnetic fields and leukemia in children. No rodent study, to date, has demonstrated that magnetic field exposure over a range of intensities has resulted in leukemia or lymphoma (Boorman et al., 2000). There are several possible reasons for the failure to find leukemia in this animal model system. Human studies of childhood leukemia have concluded that leukemia results from a combination of two events–one primary event in the prenatal period, probably involving a genetic alteration, followed by an exposure to an environmental factor in the early postnatal period (Kim et al., 2006). Unfortunately, most rodent exposure studies have been of young or adult animals, not with prenatal exposure or exposure of juvenile animals. Repacholi et al. (1997) demonstrated elevation in the rate of lymphoma in transgenic mice predisposed to develop lymphoma after exposure to radiofrequency fields, although the same strain did not develop lymphoma after 50 Hz magnetic field exposure (Harris et al., 1998). There is, however, no evidence that this particular mutation is relevant to human leukemia, while the TEL-AML1 fusion gene which is documented to be associated with up to 25% of all childhood acute lymphocytic leukemia (Kim et al., 2006) has not been studied in an animal model. The Harris et al. (1998) study was of animals 6-8 months of age, which again is not an appropriate model for childhood leukemia because it did not include prenatal or early life exposure. The most convincing animal model which has demonstrated a relationship between risk of lymphoma and magnetic field exposure is the study of Reif et al. (1995) who showed that dogs living in homes that fell in the "very high current" residential category of Wertheimer and Leeper (1979) had a significant 6.8 fold (95% CI: 1.6-28.5) elevated risk of developing lymphoma.

Other animal studies have reported elevations in different kinds of cancer, even though evidence for a relationship in humans is less convincing for any cancer other than leukemia. Mevissen et al. (1998) reported that 50 Hz magnetic fields at 1000 mG caused a significant increase in skin tumors induced by the chemical carcinogen, DMBA. However, other laboratories have not been able to replicate this finding, using somewhat different procedures (Anderson et al., 2000). Svedenstal et al. (1999) have reported DNA damage, which can lead to cancer, using the comet assay applied to brain cells of mice raised under a high-voltage power line. This study confirms that DNA breaks occur with low intensity EMFs, as reported by others (see Lai and Singh, 2004). Goodman and Blank (1998) have reported that magnetic fields alter transcript levels for specific genes. They found that an 80 mG, 60 Hz magnetic field applied for 20 min induces heat shock protein 70 synthesis in mammalian cells. Alteration of this and other genes is another possible pathway to

cancer. Magnetic fields are known to reduce secretion of melatonin in animals and humans, which could relate to elevated risk of breast cancer (Reiter, 1995). Girgert et al. (2005) have shown that 12 mG magnetic fields block the ability of tamoxifen to regulate growth of human breast cancer cells in culture, confirming previous observations.

In my opinion, these animal studies should not be used as the basis for setting standards at right-of-ways for several reasons. Adult rodents exposure is likely not a good model of human childhood leukemia, the cancer of concern, because childhood leukemia depends upon a combination of prenatal and postnatal events. While we do not know the mechanism of cancer induction, induced currents are likely critical, and will be very different in animals of different shapes, again indicating that rodents may not be good models of human childhood leukemia. Finally, we have strong evidence of an association of exposure to magnetic fields of low intensity and leukemia in humans, especially children. The fact that we do not as yet know the mechanism does not change the existence of this association. This evidence of an association between childhood exposure to magnetic fields and leukemia should be the basis for setting standards at the edge of right-of-ways.

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Raymond Neutra: Unswayed by Physicists' Arguments

In our 2002 Risk Evaluation my review of the literature led me, like a scientific advisory committee at the NIEHS in 2001, to classify power frequency EMFs as a "Possible Human Carcinogen" based on the childhood and adult lymphocytic leukemia epidemiology. This is the classification used by the International Agency for Research on Cancer (IARC). That classification includes agents like coffee, which I doubt will turn out to be carcinogenic and fiber glass which probably will. Thus, to be more specific and to format our conclusions in a way that could be used by our policy analysis contractors, the California program scientists went further in their hazard classification, Each reviewer also provided a "degree of certainty that EMFs at the 95th percentile of residential exposure caused an increased risk of disease 'to some degree'" My degree of certainty about this fell in the "close to the dividing line between believing and not believing " that the two fold increase in childhood leukemia rates in children with home exposures above 3 milliGauss was indeed caused by EMFs and not due to bias or confounding. A doubling of childhood leukemia rates translates to an added lifetime risk of 100/100,000. If real this would be well above the 1/100,000 *de minimis* risk level used for carcinogenic regulation in California. "Close to the dividing between believing and not believing" was defined by our program as being somewhere between 40 and 60 on a certainty scale ranging from 0-100. My degree of certainty, like those at NIEHS and IARC was not pulled down by arguments by physicists that physiological or pathological effects from residential power lines was "impossible" based on the application of physical laws to simplified biological models of cell mechanisms. Physicists don't know enough about biology for me to be convinced by their arguments. My certainty was also not pulled down by the null results of toxicological studies using high intensity pure 60 Hz magnetic fields. Prior to these studies being done I had gone on record that they were prone to falsely exonerate EMFs. This is because they assume that EMFs, like chemicals will produce large effects when given at very high doses. But the epidemiological evidence suggests that this is not

so. Also EMFs next to power lines are a complex mixture of frequencies, fluctuating dosing schedules, polarizations etc. Testing the carcinogenicity of pure 60 Hz fields and concluding the power line EMFs are safe is like testing caffeine for carcinogenicity and after getting null results declaring that espresso coffee with its many chemical ingredients is not carcinogenic. Therefore the mostly null toxicology results pulled my certainty down only a little. I therefore was most influenced by the epidemiological evidence, which has, since 2002 been further supported by additional studies. The fact that the associations seen in the studies are not large compared to the resolution power of the studies keeps me from being more strongly certain they are causal in nature.

The policy question before regulators of power lines is:

"How certain must you be of how much disease before you would pass from inaction to cheap or to expensive EMF avoidance?"

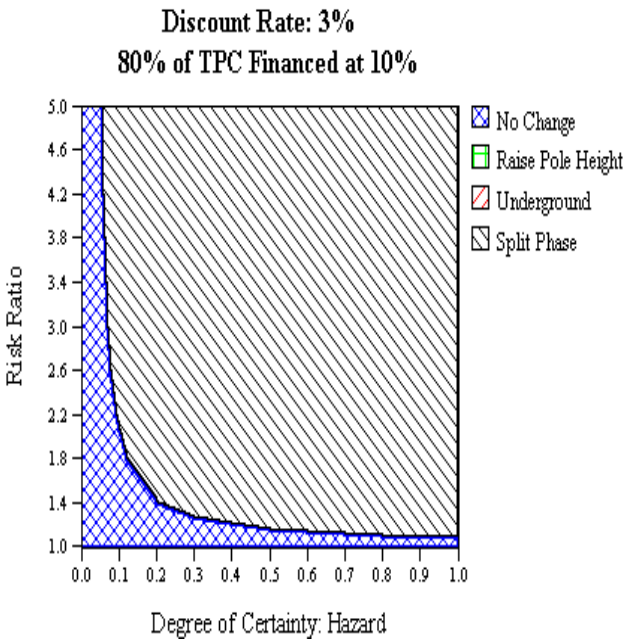
The answer to this question is only partly driven risk estimates from professionals like me, costs and ethics are important too. So decision makers trying to balance the interests and values of stakeholders in society are the ones that have to answer this question.

It turns out that the answer to this question varies with stakeholders depending both on their special interests and on the ethical framework that they bring to the problem at hand.

The California Public Utilities Commission (CPUC) has authorized utilities to claim in their rate base around 4% of new transmission project costs in no and low cost EMF avoidance as long as it produces at least 15% reduction in fields. The per mile costs of doing this is less than those quoted below for retrofitting existing lines. It is my impression that the "no and low cost (4% project cost) avoidance that has been routinely carried out with new transmission lines in California since the early 1990s almost always achieves a magnetic field at the edge of right of way well below the100 mG that Connecticut utility companies are proposing as a criterion number. The CPUC did not provide a cost benefit rationale for this policy. But a reading of our policy projects suggests that a modest degree of certainty that the childhood leukemia associations are causal in nature could justify the policy on a cost benefit basis.

This idea is illustrated in the following graph taken from the cost benefit analysis prepared by Professor Detlof von Winterfeldt and colleagues as part of the California EMF program. On the horizontal axis of the graph one has the "degree of certainty that EMF exposure causes an increased risk of some degree" ranging from 0 to 1.00. On the vertical axis we have possible degrees of increased risk ranging from no increased risk to a five-fold increase of childhood leukemia risk.

You will see two zones, a large zone shaded with diagonal lines to the reader's upper right and a narrower cross hatched zone to the lower left. The latter cross hatched zone represents the combinations of epidemiological risk and the certainties that they are "real" which would lead a cold blooded economist who values a child's life at $5 million dollars to advise against no and low cost EMF avoidance measures. For example at a 0.2 degree of certainty of a 1.4 fold increased risk of childhood leukemia would not be high enough for him to advise any avoidance. My



0.4-0.6 "close to the dividing line of believing and not believing" that the 2 fold increase in childhood leukemia rates is "real" would lead the cold blooded economist to recommend that you use the no and low cost "split phasing" to reduce magnetic fields. However even if I were 100% convinced that EMFs caused a fivefold increased risk, the economist would not recommend undergrounding the lines. A child's life is not of sufficient worth to the cold-blooded economist to warrant that expense. We found that not all stakeholders were enthusiasts of this kind of cost-benefit approach, but regulators, engineers and economists find it useful. Accordingly Professor von Winterfeldt's analysis covers both the cost benefit approach as well as an ethical analysis of the rights and duties of the various stakeholders. I have provided a published article on the project to my colleagues in Connecticut and the full report and flexible decision models can be found on our web site at <www.dhs.ca.gov/ehib/emf>

The "right to know" principle would dictate that utility companies should provide residents near the line with what remediation is proposed and what right of way magnetic fields are predicted and actually achieved. The CPUC did not require our utilities to provide this information. However during the California EMF program, utilities shared other EMF information prepared by our department by means of "bill stuffers." Limiting this notification to some particular milligauss level, particularly 100 mG, which is so high that notifications will almost never be given, will precipitate arguments about the rationale for choosing that mG level that would be hard to resolve on a scientific basis. Perhaps the advice of Mark Twain, one of Connecticut's most distinguished citizens is relevant here: "Tell the truth, you will please half the people and surprise the rest."

This suggests that routine disclosure should be done regardless of milligauss levels. It is true that this will sometimes pre-

cipitate questioning and arguing. However, the costs of no and low cost avoidance in new transmission lines and in reacting to residents adjacent to the proposed transmissions lines should be considered as a fraction of the revenues of the utility during the lifetime of the proposed project.

Below I quote from the California Policy Options document that our department sent to CPUC in 2002. They have chosen only to deal with new transmission lines and not with the other policy issues detailed below.

[*continues...*]

Daniel Wartenberg: Solid Scientific Evidence Supporting an EMF–Childhood Leukemia Association

I have been asked to offer comments on the Connecticut Siting Council's Draft Electric and Magnetic Field Best Management Practices For the Construction of Electric Transmission Facilities in Connecticut (Sept. 28, 2006 draft), hereafter, BMP. The BMP suggests that many public health agencies believe that, "there is no established link between adverse health effects and EMF exposure (p.2)," and that other study groups concluded that, "there is no consistent evidence that exposure to typical power-line MF causes adverse health effects (p.2)." On the basis of these views, and the Council's desire to focus its policy on "prudent avoidance," the Council proposes a screening level based on no-effect levels determined through animal experiments modified by traditional safety factors, leading to an acceptable level of less than 100 mG at peak load averaged over 24 hours at the edge of the Right of Way.

STATEMENT

I believe there is solid scientific evidence supporting an association between exposure to magnetic fields and the incidence of childhood leukemia. I base this opinion on my review of the literature, my participation on two expert review panels and my conduct of three commissioned meta-analyses. There are four important issues to consider:

> (1) is there evidence of an association between exposure to magnetic fields and childhood cancer;
> (2) if so, is it likely that this association might be due to bias;
> (3) if so, is it likely that this association might be due to confounding;
> (4) given the data, what is the estimated impact of these exposures;
> (5) in light of these estimates, are there appropriate actions that should be taken to limit risk.

I consider each, in turn.

EVIDENCE OF ASSOCIATION

More than 100 epidemiologic studies have been conducted in over 10 countries using a wide variety of study designs and ways of measuring exposure to EMFs, both in the residence and occupationally. To summarize these studies, the weight of evidence approach has been applied several times, by both individuals and expert panels. There have been over two dozen expert panel reviews of the EMF issue, far too many to review here. Two reviews, in which I participated, were conducted in the United States. The first panel was convened by the National Research Council of the National Academy of Sciences. After several years of meetings, workshops and deliberations, the group reported in the Executive Summary that, "Living in homes classified as being in the high wire-code category is associated with about a 1.5-fold excess of childhood leukemia (p.3)."[1] The second panel, convened by the National Institute of Environmental Health Sciences (NIEHS), was instructed to follow the procedures developed by the International Agency for Research on Cancer. The Working Group concluded that, "ELF EMF are possibly carcinogenic to humans (Group 2B)."[2] This was based principally on "the results of studies on childhood leukemia in residential environments and on CLL [chronic lymphocytic leukemia] in adults in occupational settings." My most recent meta-analyses, conducted for the California Department of Health Services, reported that the risk for leukemia was elevated and statistically significant, particularly at the higher exposure cut-points.[3] There was some evidence that supported an exposure-response gradient. Two pooled analyses of childhood leukemia statistically significantly elevated risks for those children at the highest exposure categories (>3 or 4 mG).[4,5]

As a result of all of these studies, their apparent consistency, and the lack of an accepted mechanism of action that might have been used to justify the extrapolation of possible health effects from animals to humans, I do not understand the logic or reasoning behind the use animal experiment data in the determination of a safe exposure level to limit childhood cancer risk. It is my belief that the human cancer epidemiologic data are more relevant in assessing the potential hazards to humans.

BIAS

In 1999, I reviewed the EMF literature for the California Department of Health Services. I concluded that it is unlikely that selection bias can be the sole explanation of the reported associations between exposure to magnetic fields and childhood cancer incidence. In a paper I published as part of that review,[6] I stated that, "given the wide variety of study populations and measurement protocols, it is unlikely that a single design flaw has resulted in consistent effects across all studies and can be the sole explanation for the reported associations."

CONFOUNDING

If an agent, in this case wire codes or magnetic field intensity, is correlated both with an outcome, such as childhood leu-

kemia, and other factors, the role of those other factors, even if carcinogenic, does not invalidate the primary relationship. Rather, those other factors are called confounders and must be adjusted for in the analyses to try to derive a measure of the independent effect of the primary factor, as has been done in many of the EMF studies. One study shows that for another factor that itself is associated with both EMF exposure and childhood leukemia to be sufficient to explain the observed associations between EMF exposure and childhood cancer, that factor would have to be a very strong risk factor for childhood leukemia.[7] It seems unlikely, but not impossible, that a major risk factor for leukemia could have gone largely unnoticed throughout all the studies conducted to date. However, to have credibility for its presence, investigators will need to identify this unknown factor, specifically, and demonstrate statistically that it imparts a large enough leukemia risk to explain the observed association between EMF exposure and leukemia. This is a tall order and has yet to be demonstrated despite the large number of studies conducted and the many potential risk factors assessed.

POTENTIAL IMPACT

Often, in developing policy, it is useful to estimate the effect of an intervention. In this case, estimates of the magnitude of the elevated risk to children living in higher exposure areas (based on the pooled analyses and meta-analyses) can be combined with estimates of number of children living in higher exposure areas (based on household surveys) with the annual average incidence of childhood cancers to estimate the number that likely are due to exposure to EMF if, in fact, the observed association is causal. Three studies have estimated the potential number of childhood leukemia cases attributable to EMF exposure.[3 4 8] If the reported associations are causal, these studies suggest that as many as 120-175 additional cases per year in the US/North American may result from residential exposure alone.

PRECAUTIONARY PRINCIPLE

In an article I published with Dr. Dale Jamieson,[9] I address these concerns explicitly in the context of the Precautionary Principle. In that piece, specifically addressing the EMF issue, we argue that, "since the scientific uncertainty is unlikely to be resolved in the foreseeable future, policy decisions must be based on the possibility of risk and the cost and technology of reducing exposure." Given the potential impact cited above, the question is whether it is a better strategy to: (a) accept the science as proven and have government act to reduce exposures; (b) view the data as inconclusive and ignore the exposure in order to save remediation costs; or, (c) to prudently lower exposures of greatest concern in case the possible risk is shown eventually to be true. As a public health professional, I believe strongly that prudent action to limit the exposure and possibly prevent several children from developing cancer is essential unless the costs (monetary and otherwise) outweigh the value of the impact on these childrens' lives.

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