

Possible Health Effects of Exposure to Residential Electric and Magnetic Fields,

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Those of us living near power lines can breathe a little easier knowing that the National Research Council of the National Academy of Sciences has determined that we are safe from power-line electromagnetic fields (EMF) in the following sense: As scientists we know that we cannot prove the negative, that cancer from power-lines is impossible; but we can determine the absence of the proof of a positive link between cancer and EMF. The Academy panel determined the later, the lack of a positive link. The panel's main conclusion follows: "Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."

Physicists have long been skeptical of the 1979 paper by Nancy Wertheimer and Ed Leeper that began the controversy on the potential danger of power lines. Wertheimer and Leeper [1] reported a weak association (a correlation) between childhood leukemia and the wire code classification of power lines near residences. The wire-code classifications are based on the current capacity of the power lines. However, a correlation does not prove causality; other factors can correlate with the wire-code designations and "confound" the data, resulting in false conclusions. This is particularly true for power lines since the Academy and others conclude that "Magnetic fields from external wiring, however, often constitute only a fraction of the field inside the home." When the magnetic fields in homes are measured, a large problem is discovered with the wire-code based data. In particular, the internal magnetic fields in the house do not correlate with the wire-code predictions since the internal fields predominate. The Academy panel report includes the following conclusion: "Magnetic fields measured in the home after diagnosis of disease in a residence have not been found to be associated with an excess incidence of childhood leukemia or other cancers." That would end the story except for the existence of a "weak but statistically significant" association between childhood leukemia and the power-line wire codes. The Academy is uncertain as to the cause of the weak association, but it concludes that the link with magnetic fields is not proven: "More important, no association between the incidence of childhood leukemia and magnetic-field exposure has been found in epidemiologic studies that estimated exposure by measuring present-day average magnetic fields. Studies have not identified the factors that explain the association between wire codes and childhood leukemia."

It is very difficult for epidemiologists to determine true associations of very small (or zero) effects on relatively rare death modes since the confounding affects confuse the data. Over one hundred EMF epidemiology studies have been carried out. Many conclude that EMF epidemiology has reached its practical limitations, particularly when one considers the difficulty of doing good EMF dosimetry on great numbers of people. However, the panel opens the door for more work in this area by stating, "... the epidemiologic evidence is not entirely persuasive for two modest numbers of homes with the high-wire-code categories." In 1960 Hill established criteria by which one can assign causality from epidemiologic data. It is clear that the childhood leukemia data dramatically fail to satisfy Hill's criteria in assigning causality to EMF.

After many years of biomedical EMF experimentation, the Academy panel found no convincing cancer links with biological systems. The Academy report concludes as follows: "... typical residential exposures (0.1 to 10 mGauss) do not produce significant in vitro effects that have been replicated in independent studies.... The overall conclusion, based on evaluation of these studies, is that exposure to electric and magnetic fields at 50-60 Hz induce changes in cultured cells only at field strengths that exceed typical residential field strengths by factors of 1,000 to 100,000." With regard to total living systems, the Academy report concludes that "There is no convincing evidence that exposure to 60-Hz electric and magnetic fields causes cancer in animals." The Academy report further concludes as follows: "There is no evidence of any adverse effects on reproduction or development in animals, particularly mammals, from exposure to power frequency 50- or 60-Hz electric and magnetic fields.... The general conclusion from these studies is that power-frequency electric and magnetic fields are not directly a genotoxic agent: If they were, a wider range of positive responses would have been observed."

The rejection of the claims for an EMF-cancer effect are not surprising since the Academy panel concludes that "typically externally induced currents are 1,000 times less than the naturally occurring currents." These results are to be expected since basic physics calculations show that the electric fields from the time-varying magnetic fields from power lines are much less than the electric fields from natural thermal motion in the body. The basic physics results alone are not a sufficient proof, but they certainly are a strong guidepost that we are safe from EM fields near power lines.

At the Academy's press conference the Chair of the panel, Charles Stevens, was asked how the Academy's report compared to the results of the Oak Ridge [2] and American Physical Society POPA [3] reports. He responded that the Academy agreed with the results of these two studies, but that the Academy did a better job of proving their results. Of course, the multidisciplinary and well-financed Academy study did a good job, but it did not do some of the tasks that the APS-POPA report did. For example, the Academy did not give conclusions on the occupational data, which, in my view, clearly fail to give a viable cancer link. In addition, the Academy did not consider the breadth and depth of the physics papers of Robert Adair, referencing but one of his works. The 1995 APS conclusion on cancer mechanisms continues to be valid, as stated here: "No plausible biophysical mechanisms for the systematic initiation or promotion of cancer by these power line fields have been identified." Unfortunately, the Academy panel failed to emphasize the basic physics because it wanted primarily to emphasize the experimental biomedical and epidemiological data. Lastly, the Academy panel did not consider economic effects. I would agree with this omission in that it makes no sense to consider a cost/benefit analysis if there is "no conclusive and consistent evidence" of cancer, but it would have been useful to point out the extravagant waste of billions of dollars without a known life being saved. Along the same lines, the Academy study avoided picking a "safe" level for living in magnetic fields because the panel "wouldn't know how to pick the level." Similarly, Stevens deflected the "prudent avoidance" trap of requiring mitigation without proof of a cancer cause by stating, "It is a personal decision; we wouldn't know what to suggest people avoid." Nevertheless, our society continues to add an extra 4% to power-line construction costs to satisfy the prudent avoidance theory in spite of the "innocent" verdict by the Academy and others.

It is amazing that the Academy was able to produce a unanimous report since one-half of the panel members are professional ELF/EMF researchers. This coalition collapsed somewhat after the press gave absolutist headlines of "Panel Finds EMFs Pose No

Threat" and "Panel of Scientists Finds No Proof of Health Hazards From Power Lines." Recognizing the present lack of viable cancer data, three panelists, the president and two former presidents of the Bioelectromagnetics Society, later cautioned against the attitude that "a lack of confirmed proof at this point in the study of EMF effects means that the question can be ignored." And, indeed, the Academy panel states that "Continued research is important, however, because the possibility that some characteristic of the electric or magnetic field is biologically active at environmental strengths cannot be totally discounted." The congressional-mandated ELF research program will be completed in about 2 years. At that time one would expect a follow-up analysis of the all the ELF data and a debate on funding levels on ELF research.

At the press conference one could almost feel the ghost of Paul Brodeur, author of *CURRENTS OF DEATH* and *THE GREAT POWER LINE COVER-UP: HOW THE UTILITIES AND THE GOVERNMENT ARE TRYING TO HIDE THE CANCER HAZARD POSED BY ELECTROMAGNETIC FIELDS*. Stevens was asked about authors who make "a career scaring people." Stevens adroitly ducked the question by stating that "we didn't go into the sociology of this."

1. N. Wertheimer and E. Leeper, *Am. J. Epidemiology* 109, 273-284 (1979).
2. HEALTH EFFECTS OF LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS. Presidential Committee on Interagency Radiation Research and Policy Coordination, Oak Ridge Associated Universities, Oak Ridge, TN, 1992.
3. D. Hafemeister, *Am. J. Phys.* 64, 974-981 (1996).

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