

# Power Lines



## FactPack – P041



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# Power Lines

Center for Health, Environment & Justice  
FactPack - PUB 041

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## Center for Health, Environment & Justice

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### **Mentoring a Movement**

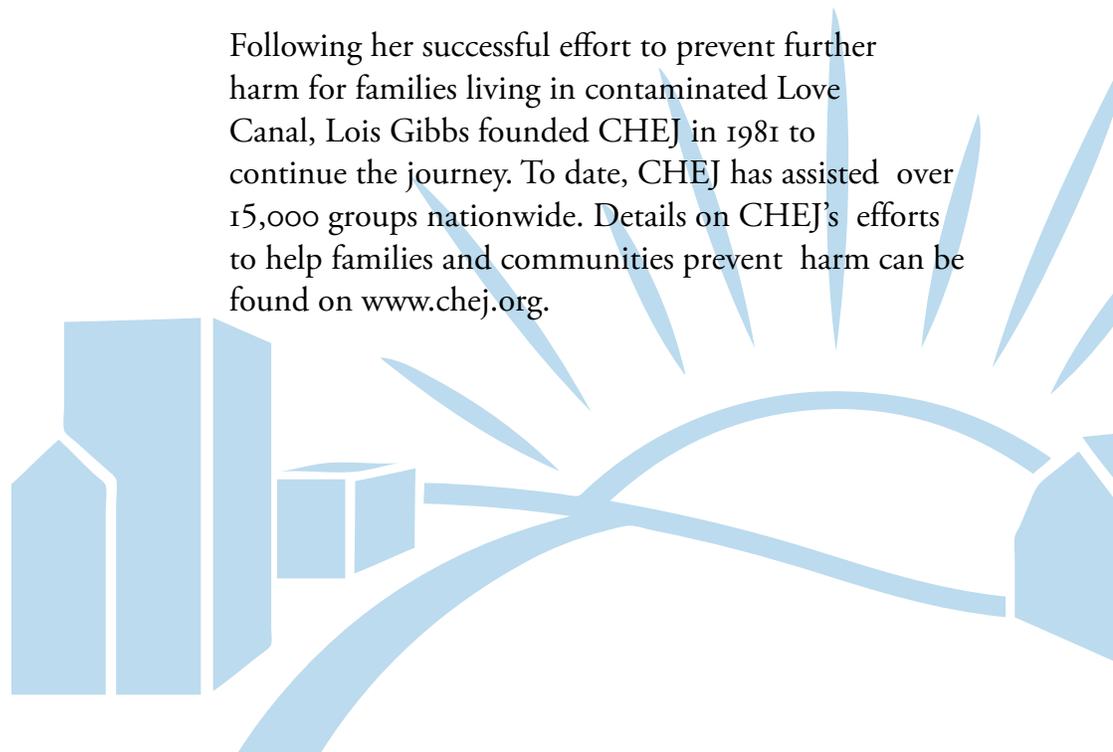
### **Empowering People**

### **Preventing Harm**

#### **About the Center for Health, Environment & Justice**

CHEJ mentors a movement building healthier communities by empowering people to prevent harm caused by chemical and toxic threats. We accomplish our work through programs focusing on different types of environmental health threats. CHEJ also works with communities to empower groups by providing the tools, direction, and encouragement they need to advocate for human health, to prevent harm and to work towards environmental integrity.

Following her successful effort to prevent further harm for families living in contaminated Love Canal, Lois Gibbs founded CHEJ in 1981 to continue the journey. To date, CHEJ has assisted over 15,000 groups nationwide. Details on CHEJ's efforts to help families and communities prevent harm can be found on [www.chej.org](http://www.chej.org).



# Introduction

The Center for Health, Environment, and Justice has developed this fact pack on the health effects of power lines and other electromagnetic sources in response to the numerous requests for information that we have had on this topic. This fact pack includes three types of information:

1. General information about the issue
2. Academic and technical papers
3. General news reports and articles

We have considered materials from government agencies, consulting companies, newspapers, and journals in an effort to provide a thorough introduction to the issues. The intention of this fact pack is to be used as a tool to assist you in educating yourself and others.

Our hope is that reading this fact pack will be the first step in the process of empowering your community to protect itself from environmental health threats. CHEJ can help with this process. Through experience, we've learned that there are four basic steps you'll need to take:

1. Form a democratic organization that is open to everyone in the community facing the problem.
2. Define your organizational goals and objectives.
3. Identify who can give you what you need to achieve your goals and objectives. Who has the power to shut down the landfill? Do a health study? Get more testing done? It might be the head of the state regulating agency, city council members, or other elected officials.
4. Develop strategies that focus your activities on the decision makers, the people, or person who has the power to give you what you are asking for.

CHEJ can help with each of these steps. Our mission is to help communities join together to achieve their goals. We can provide guidance on forming a group, mobilizing a community, defining a strategic plan, and making your case through the media. We can refer you to other groups that are fighting the same problems and can provide technical assistance to help you understand scientific and engineering data and show you how you can use this information to help achieve your goals.

If you want to protect yourself, your family, and your community, you need information, but equally important is the need to organize your community efforts.

Thank you for contacting us.

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## RadTown USA

You are here: [EPA Home](#) [RadTown USA](#) Electric and Magnetic Fields (EMF) Radiation from Power Lines

# Electric and Magnetic Fields (EMF) Radiation from Power Lines

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This page provides information on the invisible lines of force that surround any electrical device that is plugged in and turned on.

### On this page:

- [Overview](#)
  - [Who is protecting you](#)
  - [What can you do to protect yourself](#)
  - [Resources](#)
- 

## Overview

Electric and magnetic fields (EMF) are invisible lines of force that surround any electrical device that is plugged in and turned on. EMF are made up of waves of electric and magnetic energy moving together (radiating) through space. Electric fields are produced by electric charges and magnetic fields are produced by the flow of current through wires or electrical devices.

EMF is commonly associated with power lines. A person standing directly under a high-voltage transmission line may feel a mild shock when touching something that conducts electricity. These sensations are caused by the strong electric fields from the high-voltage electricity in the lines. They occur only at close range because the electric fields rapidly become weaker as the distance from the line increases.

Many people are concerned about potential adverse health effects. Much of the research about power lines and potential health effects is inconclusive. Despite more than two decades of research to determine whether elevated EMF exposure, principally to magnetic fields, is related to an increased risk of childhood leukemia, there is still no definitive answer. The general scientific consensus is that, thus far, the evidence available is weak and is not sufficient to establish a *definitive* cause-effect relationship.

In 1998, an expert working group, organized by the National Institute of Health's National Institute of Environmental Health Sciences (NIEHS), assessed the health effects of exposure to extremely low frequency EMF, the type found in homes near power lines. Based on studies about the incidence of childhood leukemia involving a large number of households, NIEHS found that power line magnetic fields are a *possible* cause of cancer. The working group also concluded that the results of EMF animal, cellular, and mechanistic (process) studies do not confirm or refute the finding of the human studies. The International Agency for Research on Cancer (WHO) reached a similar conclusion.

### RadTown USA Topics

#### Personal Exposure:

- Airport Security Scanning
- Cosmic Radiation During Flights
- CT Scans
- Dental X-ray
- Diagnostic Nuclear Medicine
- Electric and Magnetic Fields (EMF) Radiation from Power Lines
- Internal Radiotherapy: Brachytherapy
- Lasers
- Mammography
- Medical X-Rays
- Microwave Ovens
- Radioactive Materials in Antiques
- Radiation in Tobacco
- Radiation Therapy - External Beam
- Radon in Homes and Buildings
- Sun Exposure
- Television and Computer Screens
- UV Tanning Equipment
- Wireless Technology
- more topics...

#### Printer Friendly Version

EMF (PDF)  
 (1pp, 128Kb)  
 [about pdf format]

## Who is protecting you

In the U.S., there are no federal standards limiting occupational or residential exposure to power line EMF.

About seven states set standards for the width of right-of-ways under high-voltage transmission lines because of potential for electric shock.

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## What you can do to protect yourself

People concerned about possible health risks from power lines can reduce their exposure by:

- **Increasing the distance between you and the source** – The greater the distance between you and the power lines the more you reduce your exposure.
  - **Limiting the time spent around the source** – Limit the time you spend near power lines to reduce your exposure.
- 

## Resources

[California Electric and Magnetic Fields \(EMF\) Program](#) [EXIT Disclaimer](#)

April 9, 2012. California Department of Health Services

This page is about finding a rational and fair approach to dealing with the potential risks, if any, of exposure to EMF in California.

[Electromagnetic Fields](#) [EXIT Disclaimer](#)

April 9, 2012. World Health Organization

This page provides information about electromagnetic fields, answers to frequent questions, international research projects and links to additional resources.

[Electric & Magnetic Fields](#)

April 9, 2012. U.S. National Institutes of Health, National Institute of Environmental Health Sciences

This document provides basic information about electromagnetic fields, information regarding health effects and other related links.



## Magnetic Field Exposure and Cancer

Electric and magnetic fields are invisible areas of energy that are produced by electricity, which is the movement of electrons, or current, through a wire. An electric field is produced by voltage, which is the pressure used to push the electrons through the wire, much like water being pushed through a pipe. As the voltage increases, the electric field increases in strength. A magnetic field results from the flow of current through wires or electrical devices and increases in strength as the current increases. The strength of a magnetic field decreases rapidly with increased distance from its source. Electric fields are produced whether or not a device is turned on, but magnetic fields are produced only when current is flowing, which usually requires a device to be turned on. Power lines produce magnetic fields continuously because current is always flowing through them.

Electric and magnetic fields together are referred to as electromagnetic fields, or EMFs. There are both natural and human-made sources of EMFs. The earth's magnetic field, which causes a compass to point North, is an example of a naturally occurring EMF. Power lines, wiring, and electrical appliances, such as electric shavers, hair dryers, computers, televisions, and electric blankets produce what are called extremely low frequency (ELF) EMFs. ELF-EMFs have frequencies of up to 300 cycles per second, or Hertz (Hz); for example, the frequency of alternating current in power lines is 50 or 60 Hz. Cell phones produce radiofrequency EMFs above the ELF range. For more information about cell phones, see the NCI Fact Sheet Cell Phones and Cancer Risk.

Electric fields are easily shielded or weakened by walls and other objects, whereas magnetic fields can pass through buildings, living things, and most other materials. Consequently, magnetic fields are the component of ELF-EMFs that are usually studied in relation to their possible health effects.

### Why are ELF-EMFs studied in relation to cancer?

Any possible health effects of ELF-EMFs would be of concern because power lines and electrical appliances are present everywhere in modern life, and people are constantly encountering these fields, both in their homes and in certain workplaces. Also, the presence of ELF-EMFs in homes means that children are exposed. Even if ELF-EMFs were to increase an individual's risk of disease only slightly, widespread exposure to ELF-EMFs could translate to meaningful increased risks at the population level.

Several early epidemiologic studies raised the possibility of an association between certain cancers, especially childhood cancers, and ELF-EMFs. Most subsequent studies have not shown such an association, but scientists have continued to investigate the possibility that one exists. No mechanism by which ELF-EMFs could cause cancer has been identified. Unlike high-energy (ionizing) radiation, ELF-EMFs are low energy and non-ionizing and cannot damage DNA or cells directly. Some scientists have speculated that ELF-EMFs could cause cancer through other mechanisms, such as by reducing levels of the hormone melatonin. (There is some evidence that melatonin may suppress the development of certain tumors.) However, studies of animals exposed to ELF-EMFs have not provided any indications that ELF-EMF exposure is associated with cancer (1, 2).

## What is the evidence for an association between magnetic field exposure and cancer in children?

Numerous epidemiologic studies and comprehensive reviews of the scientific literature have evaluated possible associations between exposure to ELF magnetic fields and risk of cancer in children (1, 3, 4). Most of the research has focused on leukemia and brain tumors, the two most common cancers in children. Studies have examined associations of these cancers with living near power lines, with magnetic fields in the home, and with exposure of parents to high levels of magnetic fields in the workplace.

### **Exposure from power lines**

Although a study in 1979 pointed to a possible association between living near electric power lines and childhood leukemia (5), more recent studies have had mixed findings. Currently, researchers conclude that there is little evidence that exposure to ELF-EMFs from power lines causes leukemia, brain tumors, or any other cancers in children (1, 6–10).

### **Exposure in homes**

Many studies have also looked for possible associations between magnetic fields measured in homes and residences and the risk of childhood cancers, especially leukemia. Individual studies have had varying results, but most have not found an association or have found it only for those children who lived in homes with very high levels of magnetic fields, which are present in few residences (11–14).

To develop the most accurate estimates of the risks of leukemia in children from magnetic fields in the home, researchers have analyzed the combined data from many studies. In one such analysis that combined data from nine studies done in several countries, leukemia risk was increased only in those children with the highest exposure (a category that included less than 1

percent of the children); these children had a twofold excess risk of childhood leukemia (15). In another analysis that combined data from 15 individual studies, a similar increase in risk was seen in children with the highest exposure level (16). A more recent analysis of seven studies published after 2000 found a similar trend, but the increase was not statistically significant (17).

Overall, these analyses suggest that if there is any increase in leukemia risk from magnetic fields, it is restricted to children with the very highest exposure levels. But it is possible that this increase is not real, because if magnetic fields caused childhood leukemia, certain patterns would have been found, such as increasing risk with increasing levels of magnetic field exposure. Such patterns were not seen.

Another way that people can be exposed to magnetic fields in the home is from household electrical appliances. Although magnetic fields near many electrical appliances are higher than those near power lines, appliances contribute less to a person's total exposure to magnetic fields because most appliances are used only for short periods of time. Again, studies have not found consistent evidence for an association between the use of household electrical appliances and risk of childhood leukemia (18).

### **Parental exposure and risk in children**

Several studies have examined possible associations between maternal or paternal exposure to high levels of magnetic fields before conception and/or during pregnancy and the risk of cancer in their future children. The results to date have been inconsistent (19, 20). Studies are ongoing to evaluate this question.

### **Exposure and cancer survival**

A few studies have investigated whether magnetic field exposure is associated with prognosis or survival of children with leukemia. Several small retrospective studies of this question have yielded inconsistent results (21–23). An analysis that combined prospective data for more than 3000 children with acute lymphoid leukemia from eight countries showed that ELF magnetic field exposure was not associated with their survival or risk of relapse (24).

## **What is the evidence that magnetic field exposure is linked to cancer in adults?**

Although some studies have reported associations between ELF-EMF exposure and cancer in adults, other studies have not found evidence for such associations.

The majority of epidemiologic studies have shown no relationship between breast cancer in women and exposure to ELF-EMFs in the home (25–28), although several individual studies

have shown hints of an association (29, 30). Several studies conducted in the 1980s and early 1990s reported that people who worked in some electrical occupations (such as power station operators and phone line workers) had higher-than-expected rates of some types of cancer, particularly leukemia, brain tumors, and male breast cancer (1). Some occupational studies showed very small increases in the risks of leukemia and brain cancer, but these results were based on participants' job titles and not on actual measurements of their exposures. More recent studies, including some that considered the participant's job title as well as measurements of their exposures, have not shown consistent findings of an increasing risk of leukemia, brain tumors, or female breast cancer with increasing exposure to magnetic fields at work (29, 31–35).

## Where can people find additional information on EMFs?

The National Institute of Environmental Health Sciences (NIEHS) website has information about EMFs and cancer.

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## INFORMATION SOURCES

- Coalition for Safe Electric Power (703) 820-6558  
 The Labor Institute (NYC) (212) 874-3322  
 (EMF Workbook)  
 Microwave News (212) 517-2800  
 (EMF Packet)  
 National Institute for Occupational Safety & Health 1-800-35-NIOSH  
 (EMF Proceedings Publication No. 91,111)  
 The Undergrounders (904) 243-7200  
 Washington State Department of Health (206) 753-5935  
 ("EMF Reduction: Research Needs")
- W.L. Associates (301) 663-1915  
 (Contractors Annual Review)

## POLITICAL ACTION :

1. Call your local and state representatives
2. Contact your representatives in the U.S. Senate & House of Representatives (202) 224-3121
3. Call the White House (202) 456-1111
4. Call the environmental groups; urge them to get involved

- Audubon Society (212) 979-3000  
 Citizen Action (202) 775-1580  
 Congresswatch (202) 546-4996  
 Greenpeace (202) 462-1177  
 Public Citizen (202) 833-3000  
 Sierra Club (415) 776-2211

ELECTROMAGNETIC FIELD  
 INFORMATION CENTER  
 (301) 990-0160 or (202) 463-6077

How Electromagnetic Fields  
Really Affect UsWHAT ARE EMFs, AND WHAT ARE  
THEIR HEALTH EFFECTS?

"Electromagnetic field" or "EMF" is the term the electric utility industry prefers to use particularly when referring to Electromagnetic Radiation (EMR) in the power frequency and extreme low frequency (ELF) range. It is commonly associated with electric power substations, transmission and neighborhood distribution lines and transformers—both overhead and underground—and also with household wiring and AC powered appliances.

ELF EMFs fall under the category of non-ionizing radiation; their health effects are not obvious or sudden. Unlike the much higher frequency ionizing radiation, such as X-rays and gamma rays, low frequency EMFs affect the human body in subtle and insidious ways. There have been many EMF studies conducted worldwide during the past two decades, and the consistency of their results has led experts to believe that low level EMFs are indeed serious public health hazards and to recommend the practice of "prudent avoidance" to actively reduce exposure.

EMFs penetrate concrete walls and almost everything else (except ferromagnetic materials such as iron and steel), and they easily penetrate the human body into and through the bones. EMFs can affect specific cell functions and hormone production; their effect on the circadian rhythm has also been well documented. EMFs are suspected of indirectly promoting various neurological and psychological disorders as well other serious ailments ranging from learning disabilities and miscarriages to various types of malignancies including breast, ovarian, colon and bone cancer, among others. Lately, media reports have only narrowly focused on the strong link between EMFs and leukemia, lymphoma and brain cancer as established in recent epidemiological studies from Scandinavia.

The debate surrounding EMFs is no longer about whether or not they are harmful—the human studies have sufficiently established that they are—but it is over whether or not implementation of public preventive measures should be delayed any longer. The electric utility industry would delay us indefinitely until further research establishes additional biophysical and biochemical mechanisms by which EMFs harm humans; that would take many years, and cost countless lives. Given the weight of all the available evidence, it would be prudent to start protecting ourselves NOW.

**WHAT EMF LEVELS ARE SAFE?**

In our opinion it is best, especially for children, to avoid prolonged exposure to EMF levels of over 1.0 mG (milligauss). The majority of concerned experts already caution against prolonged exposure to levels of over 2.0mG. In fact, average ambient EMF levels inside normal, unaffected homes typically range between 0.2 and 0.7 mG. At present, no apparent ill effects have been associated with levels below 1.0mG, but the landmark Swedish (Karolinska Institute) epidemiological study of residential EMF exposure indicates that among children constantly exposed to levels above 1.0mG and 2.0mG, leukemia occurs at about double and triple the normal rate, respectively, i.e., the actual EMF safety threshold is substantially lower than 2.0mG.

An internal EPA memorandum issued in October of 1992 notes that the Swedish Karolinska study found "...that children who live in homes with magnetic fields from power lines greater than 3 milligauss (mG) or more were about 4 times as likely to develop leukemia...they found a dose response relationship between EMF exposure and childhood leukemia.

The EPA memo also notes that the Swedish occupational EMF exposure study "...found a strong association with chronic myeloid leukemia...Men were three times as likely to develop this disease if the average magnetic field for their job was 2.9mG or more...Results are mixed for brain tumors, some favor an association." The memo goes on to quote a recent statement by NUTEK (The Swedish State Energy Regulatory Body) "...there is a connection between power frequency magnetic fields and cancer, above all childhood cancer."

**EMFs FROM POWER LINES AND TRANSFORMERS**

Although large power transmission lines are what most people associate with EMF dangers (and they are indeed health hazards), in reality the common neighborhood distribution lines which many people think are telephone lines represent a far more widespread problem. In fact, distribution lines and transformers in the proximity of a home can easily affect potentially dangerous indoor EMF levels of over 3.0mG.

Of major concern are the EMFs from high-radiation-configuration underground power lines and transformers found in many neighborhoods. Typically, transformers connected to buried power lines are either above ground in steel boxes or buried in concrete pits under steel grates. Levels above these lines can often exceed 20.0mG; levels on top of transformers can exceed 200.0mG. Unfortunately people unwittingly spend prolonged periods on or near them. Houses near some types of inadequately shielded transformers and improperly configured underground lines can suffer from high EMF levels.

**WHAT YOU CAN DO ABOUT EMFs**

It is most important to obtain objective information about EMFs, and the Electromagnetic Field Information Center can assist you. We operate on a not-for-profit basis, as our purpose is to spread public awareness about EMF hazards, alert those who are already exposed, and educate the public about EMF SAFETY. The electric power companies provide information too, but their information is far from objective; obviously, they have a vested interest in concealing this issue from the public. Despite the weight and consistency of existing research data on EMF dangers, the electric utility industry still tries to make the public think that EMFs are not harmful to health, just as the tobacco companies still assert that cigarette smoking is not harmful.

We already know enough about the health hazards of EMFs to warrant taking preventive measures, and the first step in practicing EMF SAFETY is to become aware of the EMF levels in places where you spend a significant amount of time. One can rent or purchase a gaussmeter to check EMF levels, but unless the very expensive triaxial meters are used, it is likely that an inexperienced person would consistently get false low readings. You can call us if you need advice or equipment.

It is advisable to have your surroundings tested by a properly trained, independent EMF surveyor who knows where and what to check, since proper EMF testing requires a thorough knowledge of the problem. Power companies may provide free testing, but they may avoid hot spots and testing during high power usage hours. Since EMF levels fluctuate with power usage, it is important to have the survey conducted during a high power usage time so that the readings will accurately reflect your actual exposure.

As part of our ongoing investigations on disease clusters, the Electromagnetic Field Information Center provides free EMF testing for those in the Washington, D.C. area who have suffered from cancer or other unusual ailments with suspected EMF connections. We are interested in the following ailments which seem to occur with regularity in high EMF areas: cancers of all types (especially leukemia, lymphoma, brain and bone cancer), brain tumors, neurological disorders (including learning and hearing disabilities, speech impediments) and neuromuscular diseases and miscarriages. If you aware of any individual cases, clusters or combinations of these illnesses in your neighborhood, please contact us immediately so that we can investigate for an EMF connection. We believe that it is especially important for people being treated for these ailments to have their surroundings tested, because EMF levels may indeed affect their recovery.

**EMFs FROM INDOOR SOURCES**

Current imbalances within a house, usually traceable to malfunctioning or inadequate ground return systems, can produce very high indoor EMF levels. In most houses the metal plumbing system (which serves as a ground return route) and the ground wire which leads up to it, carry most of the ground return current and radiate abnormally high EMF levels. There are also other wiring situations that often produce high EMF levels. This type of problem is just as great a health hazard as are outdoor power lines and transformers, but, fortunately, a home owner can remedy indoor wiring problems relatively easily and inexpensively once the condition is detected.

It is important to become aware of all the hot spots in the house, because such knowledge can help you minimize unnecessary EMF exposure. Naturally, there are certain typical hot spots in every house, and it is helpful to keep them in mind when arranging furniture such as beds and couches. The point of electric service entry (around the breaker switches or fuse box) is always a high EMF area, as are areas near ground return wires and other high current wires. Wires are commonly attached along the basement ceiling, so any areas on the floor above them are potential hot spots. Levels are also high immediately below and above fluorescent lights.

**EMFs FROM APPLIANCES**

Some appliances such as hair dryers and electric shavers have been singled out as major sources of EMFs. However, use of those appliances is limited; as long as they are used minimally, there is probably little need for concern. Backs and sides of television sets and computer monitors are typical hot spots. Microwave ovens, electric ovens, stoves, vacuum cleaners and all high power appliances should be used at safe distances. Many range hood fans radiate very high EMF levels and since they are situated at head level and used for extended periods of time, it would be advisable to minimize their use.

There are also certain high EMF appliances that are often placed near beds: AC powered alarm clocks and AC adapters that are attached to answering machines, cordless telephones, baby monitors, and other devices; they should be placed at least five feet away from the bed. Sleeping near them means prolonged, daily exposure. As with any other EMF source, it is important when using AC adapters, to remember that the fields from these devices radiate through the wall and into the adjacent room.

ELECTROMAGNETIC FIELD  
INFORMATION CENTER  
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# EMF HOW DANGEROUS?

The scientific evidence has not yet determined if 50- and 60-hertz fields compromise health. Even with an effective research program, conclusive answers may be years off. Meanwhile, how should the issue be managed? What should electric power system designers and operators do?

By Earl Hazan, Feature Editor, Elgin G. Enabnit, Jr., Editorial Director and Barry H. LeClef

**T**here can be no doubt that the public fears over the possible hazards of electric and magnetic fields are rising, yet those worries clash with another trend. As the economy expands, demand for electric power is increasing along with the use of computers and other electronic gear.

Utilities across the country are feeling the heat. Since the mid 1980's, power companies have been involved in more than 100 lawsuits involving possible health hazards from transmission lines, especially those near schools. The patchwork of lawsuits, public hearings and local government rulings is having

a direct impact.

Many in the utility industry believe that transmission capacity is not going to get built because of the controversy.

While recent epidemiological studies indicate that the radiation does interact with tissue at the cellular level, exactly how it does so and how harmful it is still remain in question.

While many scientists agree that there are effects, there's a lot of disagreement over whether it's a health hazard or not.

Millions of dollars are being spent on research to come up with definitive answers. The U.S. Environmental Protection Agency (EPA) and the Electric

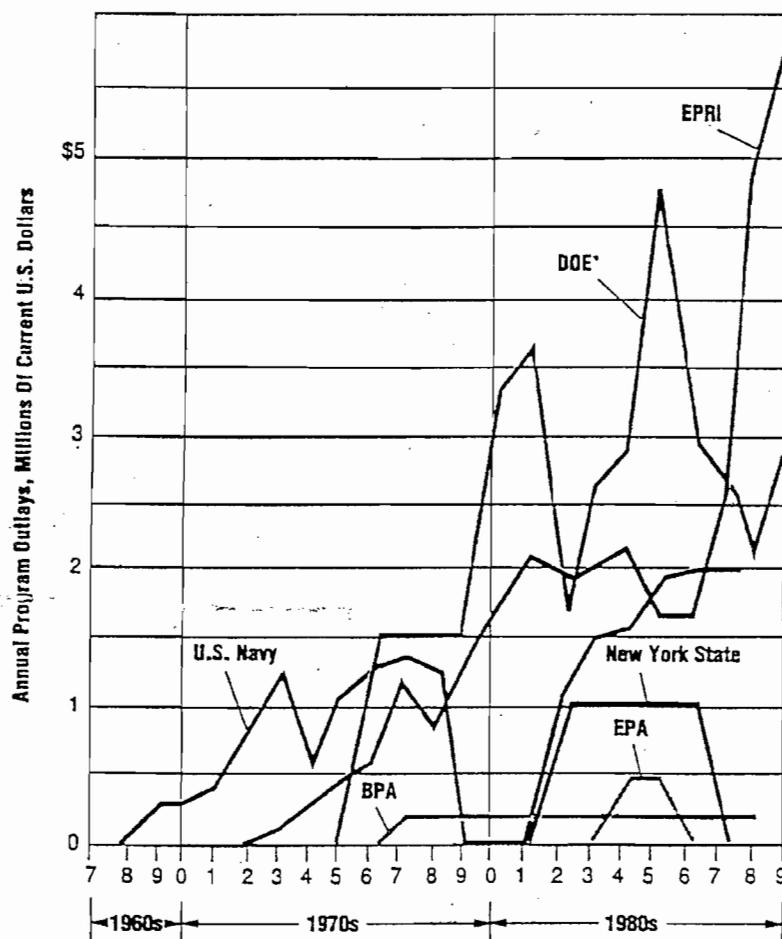
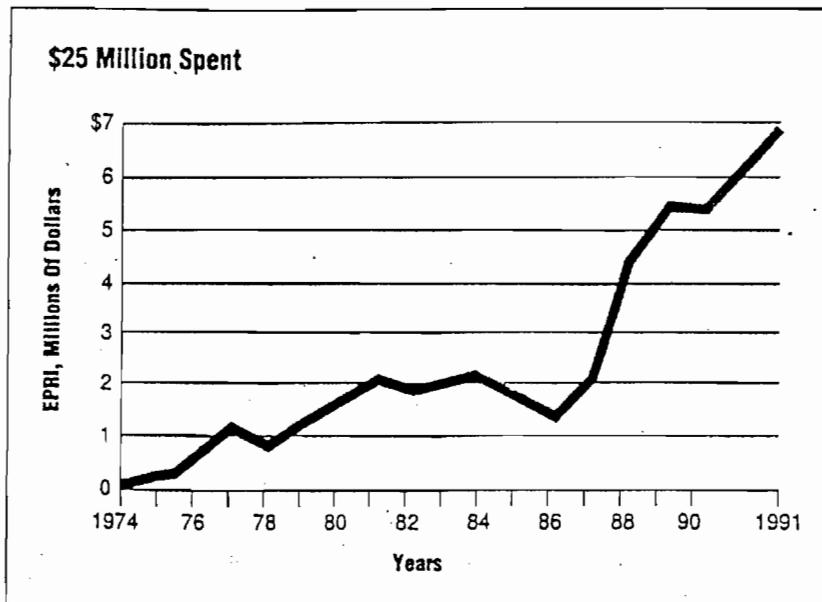
Power Research Institute (EPRI) have studies being conducted to provide answers. EPRI has spent \$25 million (Fig. 1) already on EMF research.

## Basic Knowledge

What is an electric field? What is a magnetic field? What is power frequency? Answers to these questions will help the public understand the debate going on in the media concerning the possible association between adverse health effects and EMF.

First, power frequency is the 60 cycle/sec (60 Hz) alternating current supplied to customers by U.S. electric utilities.

### Where EMF Funding Is Coming From



\* Estimate for years 1975-79

A history of funding for extremely low-frequency bioeffects studies in the United States from 1968 to the present (from "Biological Effects of Power Frequency Electric and Magnetic Fields" listed in "To Probe Further") shows the small sums of money allocated.

Fig. 1. Electric utilities have spent \$25 million on EMF research via EPRI.

An electric field is produced in the house whenever an appliance or light is plugged into an electrical outlet. A magnetic field is produced when the light is turned on (see page 18).

Electric and magnetic fields are produced by natural and man-made sources, and the Earth is the largest natural source of magnetic fields. Lightning is the most common example of a naturally produced electric field. A few of the man-made sources of EMF include home appliances, broadcast dishes and electric power lines.

The broad spectrum of wave forms of energy are arranged in order of the measure of wavelength. The short waves are very powerful and can penetrate anything. X-rays, gamma rays and ultraviolet rays are examples of these kind of waves. The lower end of the spectrum features low-energy waves associated with electric power lines and electric appliances. The energy waves located at this end of the spectrum are very long, very weak and cannot cause a change in molecular structure. In between the very high and very low energy waves are energy waves associated with radio and TV signals, microwave ovens, radar and visible light.

A field meter is used to measure electric fields under power lines, along the edge of R/Ws and in buildings. Magnetic fields are measured with a single coil and meter.

High-voltage lines for bulk power transmission—operating at several ratings ranging from 115 kV up to 765 kV—are a key focus of regulatory and research attention for magnetic field management. This does not so much reflect the actual contribution the lines make to most people's overall magnetic field exposure (fields can be high, but decline rapidly with distance) as it reflects the public's perception of them as a high-field source. In some cases, fear and concern about these lines even predated evidence implicating magnetic fields with health effects.

#### Cost of Construction

New transmission lines cost \$750,000 or more per mile to install, and litigation seeking to remove or reroute them or to block construction because of EMF concern has meant their high visibility can add to their already high cost. Some utilities now include EMF and proximity to people as one of several factors they consider in siting new power lines.

This complicates even more the difficult engineering design trade-offs involving such other environmental factors as height, corona losses, audible noise and radio-frequency interference.

Numerous tower and circuit configurations are employed by utilities for the heavy three-phase conductors used in high-voltage transmission. There are lattice, H-frame, pole, and guyed towers and single circuits, double circuits, and bundled or compact circuits with different phase arrangements. Engineers have long observed and analyzed how the electric and magnetic fields can vary around different mechanical and electrical line configurations. A great deal of such technical knowledge has been gathered and documented for utilities for more than a decade at EPRI's High Voltage Transmission Research Center (HVTRC), operated by General Electric at Lenox, Massachusetts.

### Soviet Union Reports

In the early 1960s, reports from the Soviet Union indicated that electric-switchyard workers acquired various maladies, such as loss of appetite, insomnia, headaches and impotency, after periods of exposure to EMF at work. Although the Soviet studies failed to show a direct cause and effect relationship between electricity and adverse health effects, they did initiate interest among western researchers to further study electric and magnetic fields.

By the early 1970s, EMF biological effects research was under way in Europe and in the U.S. The issue of potential health effects from electric power lines first emerged in the U.S. when residents of Minnesota voiced strong opposition to a proposed power line between North Dakota and Western Minnesota. That interest subsided as studies conducted by the University of Minnesota and the State found no conclusive evidence of potential health effects. The line was built in 1978.

The health-effects issue arose again in the U.S. during hearings held by the New York State Public Service Commission (NYSPSC) on construction of a new transmission line. The New York hearings lasted four years with construction of the line finally approved by the NYSPSC in 1978. However, certain directives from the NYSPSC established interim standards for electric fields from these lines, which directed that for the time being, field strengths from newly

**Dr. M. Granger Morgan**  
Head, Department of Engineering and Public Policy, Carnegie Mellon University

There is a need for utilities, electric manufacturers, public health organizations and others to think strategically about their policy responses. I've categorized things into three blocks. First, minimum responses, a set that I've called prudence, and a set that I've called dramatic responses. Most of the industry has now moved into some form of passive or active information supply. By passive, I mean I wait until you come and ask me. By

active, I come to you and say, "Look, you should know about this. Here are things that I'd like to tell you." Basically I want to talk about three sets of alternative strategies that one might adopt. A strategy of denial makes sense only if there's a reason to believe that virtually it's impossible that there are risks from field exposure and that the problem is likely to disappear as a public issue if it's not talked about. Now at this point, I don't believe either of these is true, but you may only believe that one is the case and, even in that case, you see you would reject probably the option of denial. So, most utilities have now moved onto one of these more pro-active strategies.

Prudence is a phrase that we originated, an idea that we originated and I think, at this point, it is fairly widely misunderstood. So let me try once more to make it clear. The argument goes as follows, for the moment we don't know if fields pose a risk or not. The prudent thing to do, is try to keep people out of fields, when it can be done at modest costs; but not go off the deep end with expensive controls which may not be beneficial. We adopt strategies like this all the time in our private lives. Let me give you a couple of illustrations. I don't know about you, but I eat less charbroiled meat, more broccoli, cauliflower and fiber than I used to. Why?

Well, not because I'm absolutely certain that that's going to protect me from cancer, but because there's some evidence. And it seems prudent that it turns out that, unless you're the president, you can get to like broccoli. Why? Because it just seems the prudent thing to do.

On the other hand, if I go to a ski lodge and the only food on the menu are hamburgers, and other charbroiled meat and

lobsters at \$27 a serving, I don't buy my kids lobster. You know I'm prudent. Occasionally, they can have hamburgers that are charbroiled. I'm trying to move in that direction but not go off the deep end. I don't rent a refrigerator truck to carry fresh broccoli with me wherever I go, and some places I can't get it. So I try to balance the judgment. But in our society,

that's a very hard thing to do for public risk.

We do it all the time in our private lives, but publicly it's tough to do because public risk management, and certainly the legal system, tries to force everything into one of two boxes—safe/hazardous. It just isn't comfortable with the notion that there are some things in the world, which at the moment, are in the category—I don't know. Maybe it is, maybe it isn't. So, in the short term, we ought to pursue a strategy of saying yes, if we can do some things, to get people out of fields that don't cost too much. Let's do them. Let's not go off the deep end because we're not sure. We've got a problem, and, furthermore, we're not sure that the things we're doing, necessarily, are going to improve the situation. That's tough to do in the kind of society we're currently operating in. And so, we need some powerful policy work now, on how to take prudent steps. Maybe legislative remedies are needed in order to do this.

**The prudent thing to do is to keep people out of fields when it can be done at modest costs, but not go off the deep end with expensive controls which may not be beneficial."**

constructed lines should not exceed electric-field strengths from existing lines. Also, the NYSPSC ordered NY utilities to fund research in order to determine if there are adverse health effects from EMF. Results of this study were released in 1987 and the report included results of new, independent EMF-related studies that analyzed possible health-related effects.

Among the studies released was a study conducted by Dr. David Savitz of the University of North Carolina. The study, which was performed in the Den-

ver, CO area, found that children who had cancer were less than twice as likely to live in homes near high-current power lines. However, Dr. Savitz reported, "If one takes into account a margin for error, there may be no correlation at all." Another study conducted by Dr. Richard Stevens of Battelle Pacific Northwest Laboratory was reported by the NY utilities. Dr. Stevens' study, conducted in Seattle, WA, did not find any association between EMF and cancer.

In response to the public's increased concern over EMF, the Florida legisla-

ture gave the Florida Department of Environmental Regulations (DER) the authority to initiate a review of available information regarding EMF. The DER set up two scientific advisory committees.

The first committee was composed of various U.S. university professors and researchers. The second committee was made up of in-state scientists. Both committees were charged with evaluating existing research on health effects from EMF. Each advisory committee issued a report on EMF, the first in 1985 and the second in 1987. In their conclusions, both committees reported that they could not directly associate adverse health effects to EMF exposure. However, the second committee recommended that standards be established for

electric and magnetic fields at the edge of high-voltage transmission R/Ws. As a result, in 1989, Florida became the first state to approve an electric- and magnetic-field standard.

Since 1975, electric utilities have sponsored EMF research projects coordinated by the Electric Power Research Institute (EPRI), which has spent more than \$25 million on EMF research. In 1989, \$4 million was spent by EPRI on this research and \$6 million was bud-

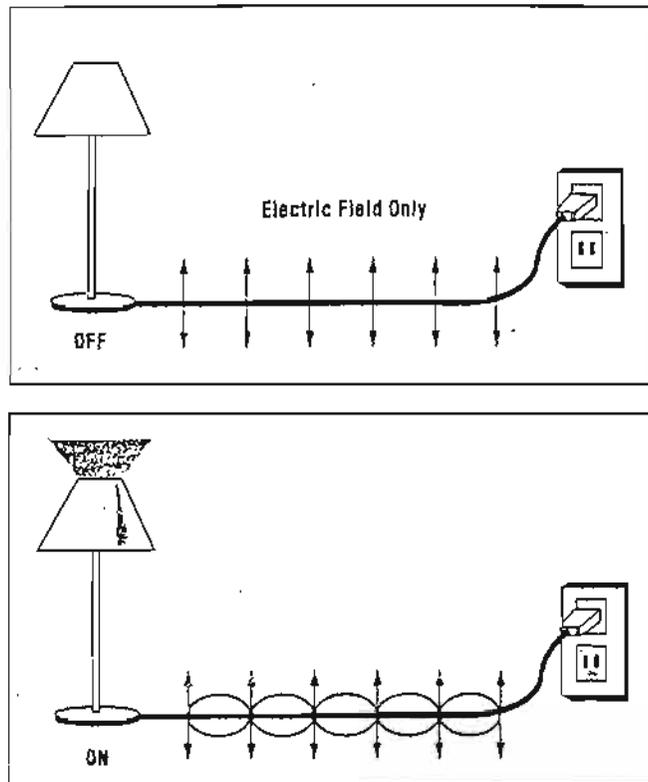


Fig. 2, 3. Only an electric field is produced when a lamp is plugged in. A magnetic field is produced when the lamp is turned on.

geted in 1990. In addition to the research coordinated by EPRI, the Department of Energy and researchers from around the world are searching for answers to the many EMF questions. At present, there is no concrete evidence that there is a health hazard from power lines or other sources of EMF.

**Opposition Viewpoint**

Paul Brodeur, a staff writer for the *New Yorker Magazine* (see box page 23)

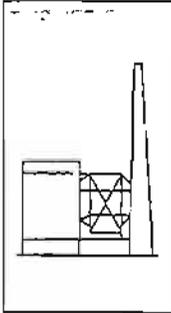
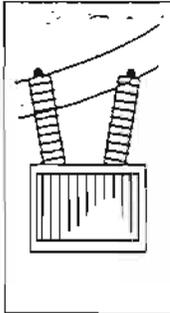
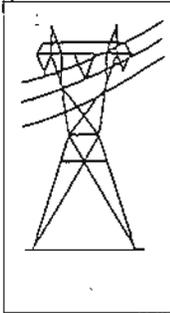
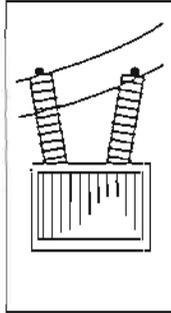
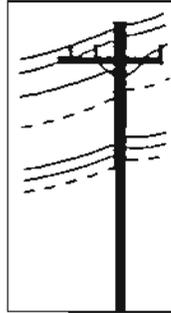
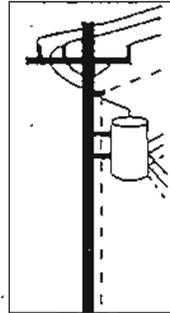
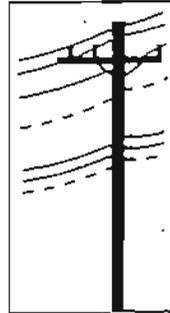
has been responsible for creating a near-panic nationwide with his series of articles on *Currents of Death*, which accuses utilities of flagrantly disregarding the health hazards posed by their systems, and that they were engaged in a gigantic conspiracy to cover up the problem.

Brodeur is no Johnny-come-lately to the environmental scene. He wrote extensively on the hazards of asbestos, which kicked off the lawsuit that ultimately found the Johns Manville Co. liable for damages that were so large, Manville went out of business, closing an industry that was one of the key players in America's economic growth. Brodeur has been recognized for his articles on the destruction of the earth's ozone layer by man-made chemicals and he has won many awards and citations

for his various science-related articles and books.

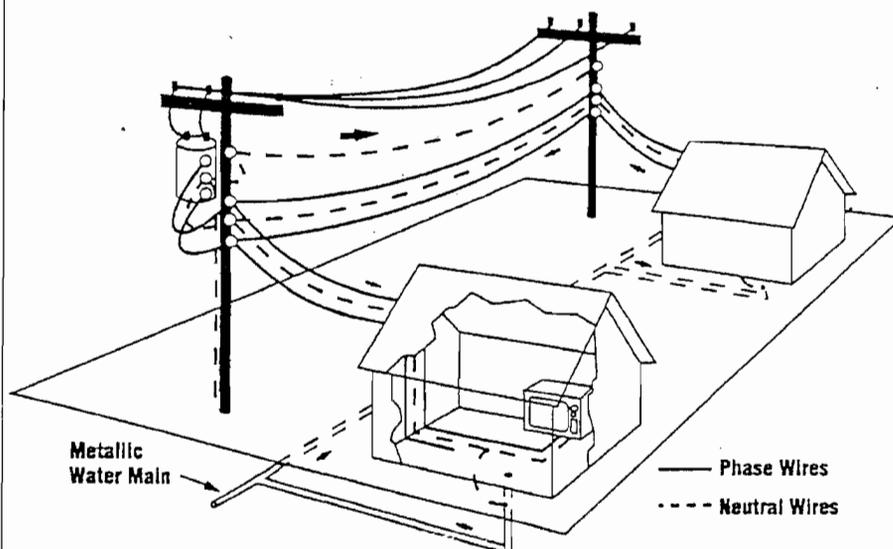
With these impressive credentials, it was a simple task for him to cite statistics, anecdotes about the prevalence of cancer clusters, lawsuits by the dozens (sic) that had already been, or would soon be lost by utilities and how legislators in Washington and on the State level were conspiring with government agencies and the electric utilities to keep the public in the dark. Northeast Utilities found

**Sources Of Magnetic Field Exposure**

						
<p><b>Power-generating Station— 20 kV</b> Primary exposure concern is employees within plant, where fields vary, but can be as high as 3 milliteslas.</p>	<p><b>Step-up Transformer</b> Found within power substations, these transformers produce varying fields.</p>	<p><b>Transmission Lines— 69-765 kV</b> Fields depend on configuration of three-phase lines. balanced phase currents mean fields drop off at <math>1/r^2</math>.</p>	<p><b>Step-down Transformer</b> Inside substations, these transformers produce flux densities.</p>	<p><b>Distribution Primary— 4-35 kV</b> If three-phase lines and neutral line (dashed line) are balanced, drop-off is <math>1/r^2</math>.</p>	<p><b>Distribution Step-down Transformer</b> Surrounding power lines are a greater source of magnetic field exposure than these transformers, whose fields drop off much faster— at <math>1/r^2</math>.</p>	<p><b>Distribution Secondary— 115/230 V</b> Frequently phase lines and neutral are unbalanced, producing a component with <math>1/r</math> drop-off.</p>

Source: *Electric Research & Management Inc.*

## EMF In The Home Environment



Some sources of residential magnetic fields: appliance (television), grounding system and overhead distribution line (primary current, secondary current and net current). The arrows indicate the direction of net current flow at a point in time. The net current may change with changing load, such as appliance usage. Other possible sources include unusual residential wiring, underground distribution lines and nearby high-voltage transmission lines.

**Table 3**  
60-Hz magnetic flux densities near various appliances

Appliance	Magnetic Flux Density, $\mu\text{T}$		
	3 cm	30 cm	1 m
Can Openers	1000-2000	3.5-30	0.07-1
Hair Dryers	6-2000	0.01-7	<0.01-0.3
Electric Shavers	15-1500	0.08-9	<0.01-0.3
Drills	400-800	2-3.5	0.08-0.2
Mixers	60-700	0.6-10	0.02-0.25
Portable Heaters	10-180	0.15-5	0.01-0.25
Blenders	25-130	0.6-2	0.03-0.12
Television	2.5-50	0.04-2	0.01-0.15
Irons	8-30	0.12-0.3	0.01-0.025
Coffee makers	1.8-25	0.08-0.15	<0.01
Refrigerators	0.5-1.7	0.01-0.25	<0.01

Source: WHO, 1987

**Table 1**  
60-Hz electric field levels at the center of various rooms in a typical U.S. home in 1974

Location	V/m
Laundry Room	0.8
Dining Room	0.9
Bathroom	1.2-1.5
Kitchen	2.6
Bedroom	2.4-7.8
Living Room	3.3
Hallway	13.0

Source: WHO, 1984

**Table 2**  
Typical 60-Hz electric field levels at 30 cm from 115-V home appliances

Appliance	V/m
Electric Blanket	250
Broiler	130
Stereo	90
Refrigerator	60
Electric Iron	60
Hand Mixer	50
Toaster	40
Hair Dryer	40
Color TV	30
Coffee Pot	30
Vacuum Cleaner	16
Incandescent Bulb	2

Source: WHO, 1984

Electric and magnetic fields are produced by virtually every use of electricity. Electric field levels in the centers of different rooms in a typical U.S. home are shown in Table 1, while Table 2 lists levels measured 30 cm (about 1 foot) away from various home appliances. The difference in levels between the two tables shows how rapidly the electric field decreases with distance from a source.

These electric field levels are orders of magnitude below those that can exist under transmission lines. Because these data result from limited measurements, they should be considered anecdotal. They do indicate, however, the general range of levels that may be encountered in the home, although wide variability must be expected.

Researchers have also measured magnetic flux densities in the vicinity of nearly 100 different household appliances. Table 3 shows the magnetic flux densities at distances of 3 cm, 30 cm and 1 m from different appliances. At 30 cm, levels range from  $0.03 \mu\text{T}$  to  $30 \mu\text{T}$  (0.3-300 mG). As Table 3 shows, magnetic flux densities decrease rapidly with distance. Unlike electric field levels in the home, magnetic flux densities close to some household appliances are higher than encountered under transmission lines.

that they had been the focus of his article, which was called "Annals of Radiation. Calamity on Meadow Street."

In a similar vein, Arthur H. Bryant, Executive Director, Trial Lawyers for Public Justice (see box page 26), predicts that injury suits concerning EMF will proliferate and he gives notice that cases are coming along that will be argued at great cost to the individual elec-

tric utilities. Bryant outlines, in careful detail, the trends that are making this outcome inevitable:

- The scientific body of literature that shows there is a connection between health effects and the presence of electric lines is growing. According to Bryant, the epidemiological evidence is abundant.

- The concern among the public is

mushrooming and the critical point to be made is that the public is frightened and, therefore, wants remedies.

- Litigation, which was sparse at first, is growing rapidly.

His argument is simple. If it was possible to show a connection between childhood leukemia and trichloroethylene in Woburn, MA, near a W. R. Grace Co. site where the chemical had been

### EXPERT OPINION

Frank Pallone

U.S. Representative, Democrat, New Jersey

When I meet with a group of utility people, the first thing they say to me, is why do we need a federal research program? Why do we need to spend millions of dollars on federal research since the utilities over the years and even more so now, continue to finance research programs?

It is just the notion about the credibility issue. The one thing that was very obvious in all the meetings with my constituents, is that they essentially did not trust the utilities. As much as they compiled research, they were always very suspect of anything that was either done or financed in some way by the utilities. Now, part of the reason for that, I would say, was because the local utility that was putting up the transmission line in my area of New Jersey, was really very reluctant to give any indication that there was any problem with health effects from EMF. That, I guess, kind of fueled the fire. I believe the bottom line is that research has to be done on a federal level by government. Otherwise, it's just not believable by the average person. They're always going to think in the back of their mind that this is something that's biased because it's done by the utilities. Now, that's not to say that the federal government has a tremendous amount of credibility either. That's the first thing that any utility spokesperson ever says to me, "well why if you think that they don't trust the utilities, do you think they're going to trust the federal government?" I don't know, it seems like there's a little more trust in the federal government, maybe if 10 is the best and 1 is the worst, you're 1 and we're 2.

One of the things that I've been very concerned about is that we've lost a certain amount of credibility because of some of the things that happened with the EPA Report, with the Science Advisory Committee. I'm sure you followed how, initially, there was a feeling that internally the EPA report was being suppressed or being changed and that got a lot of attention. I think that was very unfortunate because again lent itself to the notion that the government itself was really not being honest with the public. We even had some problems with the Science Advisory Board in terms of who

they were allowing to testify when we had some hearings a few weeks ago or a few months ago.

One of the things that I've been concerned about is that there really hasn't been in the past, or at least the public doesn't perceive that there's been a place in the past, for them to go to find out answers. One of the important components of my legislation is an information program, a way to disseminate at least what existing knowledge and research there is out there. Let me just tell you a little bit about where I think we're going and then I'll just give you a brief outline of the legislation.

I'm often asked, what is the White House's position? What is the administration's position on this? That's not really clear in terms of



whether or not the administration backs a new comprehensive research program, I don't have any reason to believe they don't, but it's not clear that they would back the legislation that I'm proposing. However, we feel that it's very important to have their support and we are making an effort to try to get that support. Because as you know, if you want to get something passed, it's very hard to do so unless you have the White House Administration and the OMB to go along with it. As far as the legislative activity is concerned, we have support from pretty much all the key people involved. The Bill last year was heard before the Science, Space and Technology Committee; the Chairman of that committee now is George Brown and he is a co-sponsor of legislation. Also Congressman from New York, is the sub-committee chairman that the EMF legislation, will go to within the Science, Space and Technology. We understand that the Science Committee may have its own Bill they will put together and introduce this year. There's also the possibility of legislation being introduced in the Interior Committee, which is the one that initially got involved with

this issue and requested the OTA Report, so they still have a lot of interest.

Let me just tell you a little bit about the Bill, it's a pretty brief summary, if you will. It's essentially a federal program to conduct and coordinate research in potential health effects of human exposure to EMF. The way the Bill is set up, the Department of Energy is the lead agency and they administer the research program in close cooperation with both the EPA and the National Institute of Environmental Health Sciences.

We intend to look at, not only EMF effects from transmission lines, but also from distribution systems and even from appliances and other techniques. In other words, the full range of things that are mentioned in the OTA Report and a lot of what the utilities have been involved with in terms of research. I mentioned the information component, there's an electric and magnetic fields information center set up and in fact \$1 million of each of the five years of appropriations has to be dedicated to that information center. My feeling is that the information component is very important. There's also an advisory committee, the EMF Advisory Committee, in essence, which consists of 12 members chosen from State and Federal Government, academia, scientific and professional organizations. They basically will coordinate the research, review research already done, see what should be prioritized, obviously a lot of things have already been done and they don't need to necessarily be gone over again. This advisory board would essentially make recommendations about where the research should go in light of what's already occurred.

In terms of funding, the Bill authorizes, a \$34 million, five year program, with steady increases in the amount of funding. The first year is \$3 million and then it goes up to \$10 million in the fifth year, and at least \$1 million a year has to be for the information component. I should point out that, increasingly, it's becoming obvious to me that this Bill, which was introduced last year, has become a catalyst for federal agencies to ask for funds and perhaps in the long run to even set up their own programs without legislation.

dumped, it will be easier to follow with a demonstration of the connection between childhood leukemia and magnetic fields produced by nearby power lines. The position adopted by many electric utilities, which implies that there is no cause for concern, opens them up to charges of dishonesty. The fact that they may claim they don't know if EMF is dangerous, is even more damning, when they then state that there is nothing to worry about.

The public's perception must be based on the utility's integrity, according to Bryant. The public must be made to believe that there is no hidden evidence, no lying and no legalistic maneuverings in order to mask the true intent of a published statement. There is no room for euphemisms. In its own self interest, Bryant suggested that the industry undertake remedial actions by moving lines and redesigning others, by being honest and non-legalistic.

#### And On The Other Hand

Dr. Imre Gyuk, Program Manager at DOE on Electromagnetic Research, states unequivocally that despite the presence of biological effects, one cannot make the leap that is required to state that these are also negative health effects. Since none has been demonstrated, there is no need for legislative or legal remedies. In fact, Gyuk argues, there is evidence to show that even the biological effects are not a function of increasing electric and magnetic fields. His research has demonstrated that there exists a discrete area with specific boundaries — a "window" — within which biological effects can be observed. At lower and higher fields the effects disappear. Under these circumstances, according to Gyuk, one could just as easily cite the medical research that shows the positive effects of electricity in promoting faster healing of broken bones to state that electric and magnetic fields are therapeutic in nature and not harmful at all.

Also, on the opposite side to Brodeur and Bryant, is Thomas Watson, a senior partner at Crowell & Moring (see box page 28), a law firm with a long history of fighting suits against electric utilities.

Watson was more sanguine about future prospects relative to the flood of litigation predicted by Brodeur and Bryant. The number of suits will certainly increase, Watson said, with litigation growing in connection with:

- Approvals required for new line

#### James R. Sanford

General Manager, Transmission, Public Service Electric & Gas of New Jersey

We've had several projects where we had concern over EMF, a short transmission line that was proposed to feed a non-utility generator. There was concern in one town. As proposed, the line would be a steel pole line along a railroad siding. We had proposed steel poles because it's in the back of a residential area and also because it's across the highway. Our approach in dealing with the environmental commission and the planning board was to supply them any and all information that we could. They asked for, as rightly they should, for information on both sides of the issue and we supplied them everything we could. Ultimately we found an alternative route, slightly longer, so there was a slight or modest increase but slightly longer included one additional turn, but it

did in fact minimize the residential exposure. Happily for me, as the General Manager of Transmission, all the rest of our transmission at this time is in the underground feeding the City of Newark and Hudson River Waterfront. But we are running into difficulties on a distribution side and a substation side. Load growth in our central area requires some additional substation capacity and our current plans call for two substations to replace temporary unit stations along with a 69-kV wood pole supply network. Public concern has been raised in this location chiefly about the 69-kV pole lines that are planned on public streets.

EMF as well as aesthetics and the required tree trimming have been raised as issues. We're working with those towns trying to find a solution. EMF has also been raised at two other substation siting proposals, one of the sites is along an existing overhead 230-kV line where all we would have to do is tap in and out of the rack and the other one is fed by underground transmission. The point is all four of these substations are delayed. I gave you those couple of examples that have happened to us not for your sympathy but because I think that they expose three costs that we all will face with new construction.

The first cost is dollars. The optimum route might not be the least expensive, but rather one that minimizes heavily populated areas and schools. Prudent avoidance, like art, is in the eye of the beholder which makes it tough, but that may be the way it is.

The second cost is time. It will take longer to develop the consensus needed for approvals. That time must, in my opinion, include listening to local concerns and working out compromises or trying to. Ultimately, of course, the line has to go somewhere, we can expect that the siting process will get longer and longer.

The third cost is image. Hopefully, this is a risk rather than a cost. If we don't attempt to form partnerships, if we don't attempt to inform the customers, if we don't listen, if we attempt to unilaterally push a line or a substation through the process, we stand to change a positive image to a negative one.

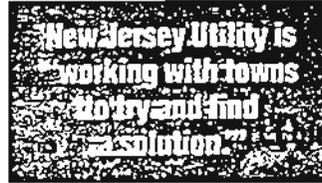
Of course, where there is a risk there is an opportunity, and I believe that we have an opportunity to enhance the image of utilities as corporate citizens. At PSE&G, we believe that customer service is a vital importance, customer service comes in many

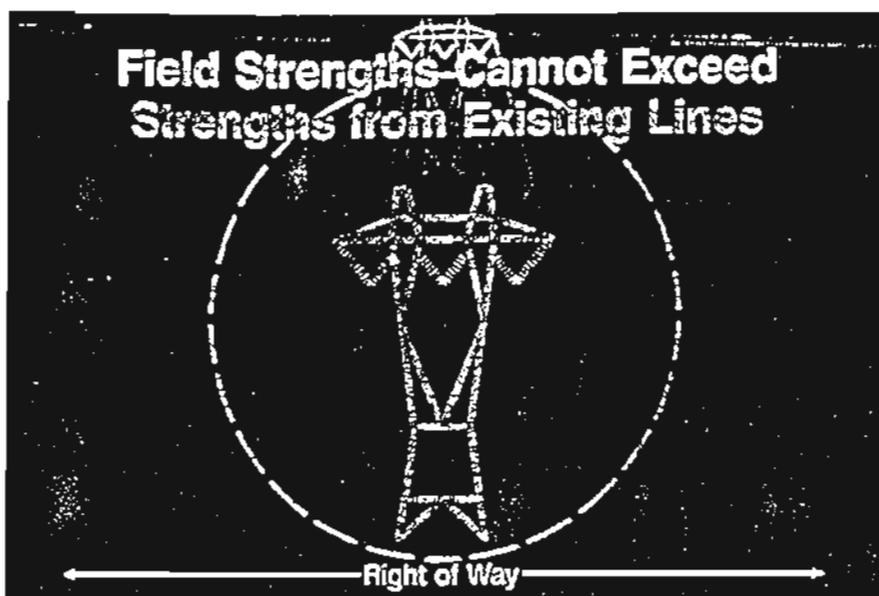
shapes, one of them and one of concern to us here, is balanced and open communications; we are willing to talk to our customers. For several years we've been taking measurements both upon request of our customers

and because we have transmission lines outside our distribution area. These include measurements, both outside and inside the house, discuss the issue and welcome questions. Thus far, all our measurements have been within the range of the oft referred to Carnegie Mellon booklet and, in fact, most have been in the lower range. We have the equivalent of about two people, full time, just taking measurements, while the expense for that kind of a program heads up we feel that we cannot afford not to take the measurements and to share the information with our customers.

We've done several other things to try to communicate with our customers. We've placed advertorials in all the major newspapers in the state. We approached the staff of the Board of Public Utilities with an offer to brief them on the EMF issue and our position. They accepted and we were able to make a presentation to them and answer their questions. We have a speakers bureau that was formed to provide programs on matters of current concern and have added an informational address on EMF. Several of our distribution field locations hold annual meetings with local fire, police, hazardous material response teams and so on to explain our operations and foster our interrelationships. We've started to add EMF as a subject to those meetings.

Finally, but certainly not meant to be least, are the public meetings with concerned communities. Some, like one in Livingston, was a panel discussion format. I think that one was run by the League of Woman Voters. Other meetings are less formal and less structured. We are in the process of developing new advertorial that already has been sent out to update our customers, real estate brokers and the medical profession, our other potential audiences.





## Standards For Field Exposure

### Florida Leads On Setting Standards

Several states have established standards for the strength of electric fields from high voltage transmission lines and Florida has also established magnetic field standards. While some of these have been set as "safe field" standards, some states, especially Florida, have understood that with the incomplete science now available only "prudent exposure avoidance" can be justification for establishing a standard. Current state standards are summarized in the table below. No states have set standards for distribution lines.

### Standards In The International Arena

Standards or guidelines for exposures to power-frequency electric fields exist in Britain, Japan, Poland and the Soviet Union. These foreign standards are not significantly different than state standards in the U.S. For example, guidelines in the Soviet Union recommend that fields in publicly-accessible areas be no greater than 10 kV/m and that fields in permanently occupied areas be no greater than 2 kV/m. There are presently no national regulations in any country limiting exposures to power-frequency magnetic fields from power lines or appliances.

The International Radiation Protection Association, whose mission is to review scientific evidence and propose safety standards, has issued draft exposure guidelines for power-frequency electric and magnetic fields. They call for a limit of 5 kV/m for continuous exposures to electric fields and 2 Gauss (2000 mG) for magnetic fields.

#### State Regulations That Limit Field Strengths On Transmission Line Rights Of Way

State	Field Limit
Montana	1kV/m at edge of RoW in residential areas
Minnesota	8 kV/m maximum in RoW
New Jersey	3 kV/m at edge of RoW
New York	1.6 kV/m at edge of RoW
North Dakota	9 kV/m at edge of RoW
Oregon	9 kV/m at edge of RoW
Florida	10 kV/m (for 500 kV), 8 kV/m (for 230 kV) maximum in RoW 2 kV/m at edge of RoW all new lines. 200 mG (for 500 kV single circuit), 250 mG (for 500 kV double circuit) and 150 mG (for 230 kV) maximum at edge of RoW

construction.

- Condemnation of land required for facilities.
- Cancer phobia claims.
- Damages claimed for reduced value of property near lines.
- Reopening petitions to deny permits already granted and
- Injunctions to stop work based on "new science," which is to say, based on new scientific evidence.

Of interest is the fact that opponents are relying more and more on legal techniques that were usually reserved for tangible products like cars and toys. In this category is the charge of product liability in which electricity is defined as a product and is a danger to the customer to whom it has been sold. In a similar category is trespass action, in which it is claimed that EMF provides an increased risk, which is a form of trespass. Litigants charge that the utility has been negligent in design and operation and have misrepresented the danger by saying that there is nothing to worry about, that there is no problem.

Watson has outlined effective strategy to deal with the public in general and the activists in particular, stressing candid postures and open dialogues. Specifically, he advised:

- Don't underestimate the opposition. Whenever a project is contemplated, litigation planning must be part of the process and it must constitute one of the early activities.
- Don't be afraid. It is important to factor into the project plans those options that deal with the principle of prudent avoidance.

### The Question Of Standards

In response to a question regarding utility liability for lines that might be challenged on the basis of their potential dangers, Arthur Bryant observes that the best one could do would be to demonstrate that all applicable standards had been met.

The dilemma faced by the electric utilities is that few standards have been written and adopted. Ken Wiley, General Manager for the Florida Electric Power Coordinating Group, Inc. (see box at left), relates the strategy used in Florida. In order to set up ground rules that could be understood by everyone and that would provide a guide to the electric utilities, the State has adopted specific values for maximum permissible electric and magnetic fields at the edge of

the right-of-way. Wiley points out that this standard has blunted a lot of criticism of electric utility practices and recommended that a national standard be adopted. The rationale behind this recommendation was that if a standard is adopted, it could be controlled by the electric utility industry to reflect, to a great degree, the present state of the art.

U.S. Representative from New Jersey, Frank Pallone, who has introduced a bill into Congress which would fund EMF research (see box page 19), observes that this kind of a national standard would be suspect if the electric utilities did not attempt to deal with the problem in a more forthright manner. His experience has already revealed that citizen groups have become expert on the subject of EMF and do not trust any recommendations based on research that is financed by the electric utility industry. Data supplied by individual utilities are unacceptable as are data supplied by EPRI. In addition to the public's perception that industry research is at least slanted, if not actually false, the citizen groups accuse the utilities of stonewalling and of being unresponsive to questions about EMF risks.

The climate created by environmentalists makes it imperative for the Government to step into the picture and for the Congress to enact a federal program that would provide a fund of \$34 million for a five-year period to be administered by an advisory committee of 12 members with DOE acting as the lead agency, supported by EPA and the Institute of Environmental Health sciences. The object of the program would be to:

1. Organize an information center.
2. Conduct and coordinate research.

### The Research Scene And Information Programs

While the electric utility industry clearly has been on the defensive regarding the EMF issue, their position has not been characterized by fearful paralysis. The most obvious problem relates to the power of the press and its ability to dramatize purported disasters with the utilities placed in a position of reacting with a feeble, "... yes, but ..." "Brodeur's writing," according to Robert Banks, Publisher of *TID Health and Safety Report*, "is a raw abuse of power hiding under the cloak of scientific respectability. With circular fact checking at the *New Yorker*, the magazine's policy of not publishing letters to the

Paul A. Brodeur

New Yorker Magazine Author: *Currents of Death: Power Lines, Computer Terminals  
And the Attempt to Cover Up Their Threats to Your Health*

I believe that the electric utility industry should undertake such measures to minimize the potential public health hazard before it gets out of control and to demonstrate to the American people that it truly is a responsible industry. I do not, however, believe for a single moment that the electric utility industry will do any such thing. I believe that the utility industry has decided to draw up the wagons. I believe that the chief executive officers of the utilities are listening to their in-house lawyers and the legal defense

firms are even now turning on their meters, meters that cost \$300-400 an hour. I believe that having travelled this far down the slippery path the public relations denial. The utility industry does not have the ability to acknowledge the full extent of the problem facing us. So, the legal battle will begin, how it will end is difficult to predict.

When the asbestos industry began its legal battle in the early 1970s, layers upon layers of insurance, provided by insurance carriers, who under the terms of the coverage, were required to defend the industry in court. It is my understanding, though I admit limited knowledge to this area, that the electric utility is largely health insured.

If that should prove to be the case, and with the kind of mail I have been getting and the kind of reports I have, the following scenario is possible. As the lawsuits proliferate so will out of court settlements, judgments and legal costs. At some point down the road, various segments of the utility industry will be forced to go to various util-

ity commissions for help in the form of rate hikes to pay for the litigation. To begin with, rate hikes may be granted given the inclination of utility—granted, but as costs mount and litigation

grows and compounds itself, the public will come to realize it is being asked to finance the utility's legal defense of the health hazard. When and if, the American people come to the realization that they are being asked to fund the economic purge of lawsuits that thousands of their fellow citizens are bringing, it is possible there will be an unprecedented public outrage.

This public outrage will come and it will have profound political consequences. It may well develop in the nature of regulatory changes in the way the utility industry will be allowed to do business. I believe this to be the writing on the wall.

"I believe that the utility industry has decided to draw up the wagons."

editor, his highly selective use of scientific information coupled with a disregard for the scientific method, Brodeur has crafted a story that strongly appeals to those who believe in the mythology of institutional conspiracy, mendacity and incompetence."

In their quest to counteract Brodeur's (and other's) charges, James Cunningham points to the status of the EMF question in New York and the progress that the New York Power Authority is providing as public information on the subject. Similar programs have been developed by Public Service Electric & Gas Co., Philadelphia Electric Co. and Ontario Hydro. In spite of the time, effort and money being spent by the utilities to keep the public informed, the research activity by independent laboratories holds the key to the public's approval.

Chief among the researchers in the field are Dr. M. Granger Morgan, who heads a research team at Carnegie Mellon University in Pittsburgh, PA, and Dr. David Savitz of the University of North Carolina. Morgan describes the

biological effects that have been noticed in laboratory studies involving electric and magnetic fields, and observed that while effects have been noted on cells with respect to some change in their chemistry, it is important to understand that the experiments, concentrating on individual cells, involve conditions that are very different from those that occur when people are exposed to fields. In summary, Morgan points out that, while there is clear evidence that 60-Hz fields can produce changes in living things, it is not clear that these changes result in risks to public health. Careful and responsible scientists do not yet agree on whether 60-Hz fields pose a risk, and if they do, how serious this risk might be. In the absence of clear-cut evidence, Granger recommends the practice of "prudent avoidance," which means that individuals should take prudent steps to avoid exposure to fields, while avoiding large unjustified expenditures.

Essentially, prudent avoidance proposes that individuals or society first take only those measures to avoid magnetic

field exposures that entail little or modest cost and appear to be prudent, given the current level of scientific understanding about health risks. The Carnegie-Mellon researchers and others have suggested that such measures for individuals might include avoiding the use of (most) electric blankets and sitting back a bit from a computer monitor.

Some proponents have gone so far as to suggest that, for society at large, prudent avoidance could mean widening transmission lines rights-of-way (ROW) and rerouting new lines to avoid areas where people live or work; developing new designs for utility distribution systems, including new low-voltage (secondary) grounding procedures, to mini-

mize associated magnetic fields; developing new approaches to house wiring; and redesigning appliances to minimize or eliminate fields. Many experts would argue that such measures, in fact, represent quite drastic steps. The cost of even a few of them, broadly applied, would be substantial, they say.

But as framers of prudent avoidance

## Arthur Bryant

Executive Director, Trial Lawyers for Public Justice

There are three trends, all of which are converging to make this a very exciting and scary time.

The first is the growing scientific evidence being developed, that indeed there are health risks associated with EMF exposure. There are cases won in the courts for which there have been no epidemiological studies ever successfully conducted. So we now are in double digits and significant double digits about epidemiological studies showing different health risks associated with EMF exposure. There is more than enough to satisfy a lawyer that he or she can go to court and get a judge to allow the case to go to a jury depending on the type of injury and depending on the type of exposure, etc. But the scientific evidence is growing.

The second trend is that the public concern and the public activism in this area is increasing greatly. People are concerned.

The third is increasing litigation about what you can expect in that area and what's taking place. These three trends are converging to make this a critically important area. You need to remember that the scientists, the public interest activists, the lawyers are not motivated by any desire to do harm. They have legitimate, truly felt concerns that need to be addressed, and it needs to be determined, who is right and who is wrong. But no one will benefit, either they or you from an ostrich head in the sand approach, a denying anything exists; that is the worst possible way this whole trend could be handled. In terms of legal developments, let me tell you what is going on from my perspective and what you can expect.

The kind of cases that are being brought up and contemplated fall into three general categories. The first is, inverse condemnation and imminent domain cases. For example, when an electric company wants to put a power line or the government wants to give the electric company the right to put a power line over somebody's property and the property owner sues and says, "look, there are potential health risks associated with this, it's going to decrease the value of my property significantly and I want to either stop it or I want to be compensated for the decrease in the market value of my property that is going to come from the installation of this power line." Those cases are being

brought and they are being won, and you can expect more of them in the future.

Second, somewhat related case, is the Kline versus the Independent School District of Houston case. Houston Lighting Power had sued the Kline School District over 345-kV volt transmission line that crossed school property. The company had instituted condemnation proceedings for 8 1/2 acres of the school district's land and built the power line. It ran within 300 ft of an elementary school, 130 ft from an intermediate school and less than 250 ft from a high school. The superintendent of the school district had raised concerns about what about the health effects of this power line. They got more and more concerned, the electric company did not satisfy these concerns and the school district eventually sued and refused to grant the company the full right-of-way, but the power line meanwhile was there. The jury found that the power company had abused its discretion



in taking the property, awarded \$104,000 as compensation just for the loss of the property for the 3 1/2 years because of the power line. It also found, that in constructing and operating the power line near these schools, the company had acted with reckless disregard and conscious indifference to the rights and welfare of the students and it awarded \$25 million in punitive damages against the company. The judge ordered the company to move the power line and get it away from the school.

It was appealed all the way through in the Texas courts. The order requiring the movement of the power line was upheld, the \$104,000 award was upheld. The finding by the jury, that there was clear and convincing evidence of potential health hazards caused by electromagnetic fields and the appeals court, however, went on to find that because the way Texas law applied to the case, no

punitive damages could properly have been awarded against the company. The awarded \$25 million was vacated and, of course, the power line has now been moved. There will be more litigation like this in the future. There will be more cases over transmission lines and right-of-ways, over injunctions by community groups to try to stop them saying "here are the health risks, don't let them come near us", those will proceed.

And then the third area, of course, is that there will be, and there already are, more personal injury related litigation; workers compensation cases, childhood leukemia cases, people who have houses right next to power lines or transformers and children who come down with leukemia or other health effects that are related or have been associated with EMF, the cases.

I want to give notice and a warning to the utility industry. The notice is, these cases are coming. These cases will be costly even if won. But you need to hear loud and clear, these cases are going to be won. Do not believe anybody who tells you otherwise. Some will be lost, undoubtedly. But some are going to be won and this is the most important point I can make. Some of these cases are going to be won because they have merit. It is not going to simply be a case of the tort system gone haywire, or of runaway juries. I'm telling you, if you were sitting on that jury you would vote for the plaintiff once you got the facts.

Some of these cases are going to win because they have merit and because there truly are cases where under our legal standards we can say people are being injured. Nobody is out there looking to make this up, even the people who you might think are paranoid. They are seeing things that are real and it's coming.

The biggest warning I can tell you is if anybody gets up here and tells you this is all a pile of garbage, that all of these scientists that are coming up with affirmative studies, don't worry about it we've got it covered, that all of these lawyers who are out there looking at cases, don't worry about it, you haven't any exposure to financial possibilities here. If anybody tells you, for your own health and safety, don't worry about it, do not believe them, that's the most important thing for you to understand.

**Thomas Watson**  
Senior Partner, Crowell & Morlag

The question you might ask is: How much litigation are we going to see? I really don't, at this time, see an avalanche of litigation. I see a continual growth of EMF litigation and I see the biggest increases occurring principally in the tort area. The question really then comes, well what type of litigation will we see? What is coming down the road? Or put another way, what kind of litigation should we be prepared for?

The first type of litigation that we can typically expect to occur is approvals to build lines. Either Public Utility Commission approvals. Some of these occur before zoning boards, city councils, county boards, and government bodies. Essentially, where you are seeking approval to build a new facility. Those cases will have to be continued to be filed because the industry probably cannot, at this point, afford to stop in the tracks and build nothing new but you have to respond to increasing load.

Condemnation cases will follow the same pattern. They usually track after approval. In many instances there is a need to acquire land and basically the volume of condemnation cases or eminent domain cases as they are called as well, follows pretty much the same pattern as the approvals some time period afterwards. One of the things we're likely to see in connection with those cases are more cancer phobia claims.

The other thing we're going to see, is a little more sophisticated presentation by the landowners council, where they bring on public opinion surveys where they attempt to show the recognition of the EMF issue and the view that potential buyers would have in terms of concern about purchasing property that had more than typical EMF exposure in their view. I think you will probably see, as we have, the same thing in other parts of the country, land developers focusing on this issue. In two ways: one, we've seen land developers coming in and testifying as expert witnesses on behalf of individual landowners who had a large track saying the existence of power lines will affect the development of the property and the number of lots we can put on there. We need to have a greater set aside, wider right-of-ways, or set asides beyond the right-of-ways, etc. This is basically deterring the developments, you get less properties out of an individual tract for sale and, therefore, they want extra damages.

I can tell you that there are some industries planning ahead. During the past year, we were approached by several development companies anticipating that they might well have litigation in the future and about the impact of power lines on undeveloped property that they have purchased for development purposes. This did suggest to me that certainly they're planning ahead and giving some thought to this and their think-

ing that if they can develop their land less they'd like to have the difference paid for by those in the utility industry.

We will also see prudent avoidance raised. We have now seen it raised in several condemnation cases as a suggestion that the utilities didn't do everything they could to mitigate the damage to the landowners property.

We will also see proceedings that really are somewhat like the rule making proceedings basically, but you will have witnesses and examine the science and examine the policy options. The end result will be a process whereby some state commission determines whether to issue some kind of a rule to set a standard or to set practices in place that utili-



ties should follow. We will also see reopening petitions where a utility commission is granted approval to build a line. Land has even been acquired in some cases by eminent domain and then the landowner says, "but wait, there's been some new science that should be considered and we would like that whole matter reopened." Of course, if that is done before construction that produces a delay which is sometimes costly and which some utilities have in some circumstances decide the delay was really more than they could take and they've abandoned projects. And that is the hope, of course, that some landowners will have or landowner groups.

We also will see in conjunction with that where commissions say no, no you have to consider this and you have to draw the line at some point consider the science. We have seen injunction actions and that is where the landowner says well, the commission didn't reopen it, or wouldn't reopen it in any event that case is over, I don't even have to ask them I'll bring an injunction action claiming that there is new science out there and that we are going to be irreparably harmed from the construction and operation of this line and we'd like an injunction to stop it.

The other thing we're going to see, I think, is utilities attempting to grapple with the problem of local moratoriums. We're working on a number of those where legislators or groups of legislatures are considering the possibility of moratoriums and we have seen in some instances where a few have already been passed.

Of course, then the utility is put in a position that it can either just take it and not build anything or it may have to question the authority of a local bodies to pass ordinances

which could block the routing of lines that they feel are needed.

I think also we are going to see coming down the road based on the inquiries we had this past year of developers who find that their property is not selling so quickly because of the economic climate or other reasons and who may attribute some of that, if not all of that to utilities plans to construct power lines on their property or power lines that have already been built. Their actions will fall into a number of types of actions, but essentially they will be tort-based and that really brings us to the other category. The one that I've identified as probably the new category of litigation involving EMF and one that I think will increase compared more to other areas.

The types of tort actions you might look at and see down the road are trespass actions, where there is a claim that the field emanates off the utility right-of-way and onto adjacent property and that this somehow constitutes a trespass. I don't believe that should be legally actionable. I don't think a field is matter, but nonetheless (and matter is usually required to have a trespass action) you will see that claim. Nuisance claims, claiming that the fields emanating from the line and the increased risk to health posed by those fields constitute a nuisance. A nuisance in the law basically means depriving someone of the use and enjoyment of their property.

You will see product liability claims. This is a bit of a complex area because in many states the law is settled at least to date that electricity is not a product until it gets to the meter, it's a service. But you will still see claims that it should be treated as a product. Negligence actions, claims that the utility constructed, operated or maintained the facility in a negligent manner or designed it in a negligent manner that allowed people to be exposed to fields which caused them damage. Duty to warn claims, that is the utility has a legal obligation to warn individuals that they are being exposed to fields which could adversely affect their health.

Finally, misrepresentation claims are claims that utilities misrepresented that there was any risk or problem. Let me give you an example. A right-of-way buyer goes out, is negotiating with somebody and near the end of the negotiation the individual says, "Well what have I heard, I've heard something about these fields being a health problem." The utility says, "Don't worry about it, nothing to worry about there, just sign this thing. We've got the check right here for you." I know that doesn't happen in your utility, but it has happened. In fact, all of the actions I just listed, all of these causes of action, we are now working on one or more cases for each one of those that's involved, so there is a considerable amount of activity.

## Electromagnetic Field- Cancer Epidemiological Studies In Progress

Institution	Principal Investigator (s)	Sponsor (s)	Endpoint (s)	No. Of Cases/ Controls	End Date
<b>Residential Studies</b>					
University of Leeds, United Kingdom	David Clayden	Central Electricity Generating Board	All childhood cancer	374/588	1989 <sup>1</sup>
University of Southern California	John Peters	Electric Power Research Institute	Childhood leukemia	232/232	1990
University of Leeds, United Kingdom	Ray Cartwright	Central Electricity Generating Board	Acute lymphocytic leukemia, acute myelogenous leukemia, chronic lymphocytic leukemia, chronic myelogenous leukemia, non-Hodgkin's lymphoma	3200/3200	1990
Maastricht Medical School, Netherlands	Jan Meijers	Maastricht Medical School	All leukemia, brain cancer	3459 people 32-yr follow-up	1991
Karolinska Institute, Sweden	Anders Ahlbom	Karolinska Institute, National Board of Energy	Adult leukemia, adult brain cancer, all childhood cancer	300 leukemia, 425 brain cancer/725; 200 childhood cancer/140	1991
National Taiwan University, Taiwan	Ruey Lin	National Science Council	Childhood leukemia, childhood brain cancer, lymphoma in children	216/422	1991
University of Southern California	Susan Preston-Martin	State of California	Childhood brain cancer	300/300	1993
University of Toronto	Anthony Miller	Ontario Hydro	Childhood leukemia	200/400	1993
University of Helsinki, Finland	Markku Koskenvuo	Imatran Voima Oy <sup>2</sup>	Cancer, childhood cancer	Not Available	1993
Nat. Cancer Institute/ Children's Cancer Study Group, USA	Martha Linet Zdenek Hrubec	National Cancer Institute	Leukemia, acute lymphocytic leukemia in children	1000/1000	1994
Cancer Control Agency of British Columbia, Canada	Richard Gallagher	Electric Power Research Institute, Canadian Electrical Association, Health and Welfare, Canada	Childhood leukemia	395/395	1994
International Agency for Research on Cancer, France	Peter Boyle	International Agency for Research on Cancer	All leukemia	1500/1500	1994
<b>Occupational Studies</b>					
University of Southern California	Joseph Bowman	Electric Power Research Institute	Acute lymphocytic leukemia, acute nonlymphocytic leukemia, chronic lymphocytic leukemia, chronic myelogenous leukemia	232/232	1990
Johns Hopkins University, School of Public Health	Genevieve Matanoski Patrick Breysse	Electric Power Research Institute	All leukemias except chronic lymphocytic type	200/600	1990
Johns Hopkins University, School of Public Health	Genevieve Matanoski Patrick Breysse	National Institute of Environmental Health Sciences	All cancers	391 cancer	1990
University of Bern <sup>3</sup> Switzerland	Christoph Minder	Swiss National Fund	Leukemia, lymphoma	23/177 & 207	1990
Monash Medical School <sup>4</sup> , Australia	Michael Salzberg	Not Available	Glioma	425/850	1991
McGill University, Canada	Gilles Thériault	Hydro-Québec, Ontario Hydro, Electricité de France	Leukemia, brain cancer, skin melanoma	6000/17000	1991
University of North Carolina	David Savitz	Electric Power Research Institute	Leukemia, brain cancer	215 leukemia, 186 brain cancer	1991-92
National School of Public Health, Osvaldo Cruz Foundation, Brazil	Sergio Koifman	Brazilian Research Funding Council	All cancers	347/1129	1992
Wellington Medical School, New Zealand	Neil Pearce Peter Bethwaite	Wellington Medical School	Acute lymphocytic leukemia, acute myelogenous leukemia, acute nonlymphocytic leukemia	300/600	1992
Nat. Institute of Occupational Health, Sweden	Birgitta Floderus	Nat. Energy Admin., Nat. Institute of Occupational Health	Acute lymphocytic leukemia, acute myelogenous leukemia, chronic lymphocytic leukemia, chronic myelogenous leukemia, glioma	200 brain cancer, 300 leukemia/ 1000	1992

<sup>1</sup> Results due in 1990. <sup>2</sup> A Finnish power company. <sup>3</sup> Department of Social and Preventive Medicine. <sup>4</sup> Data in this listing are unconfirmed.  
Source: Microwave News, New York City, November-December, 1989.

noted from the outset, the strategy's effective implementation must be accompanied by behavioral, political and perhaps even legal changes to reduce questions of liability and responsibility that can impede voluntary efforts to manage such an uncertain and undefined risk as EMF exposure. For example, manufacturers who redesign products to reduce magnetic fields fear inviting lawsuits from people who perceive that a redesigned, low-field product confirms a risk with the original equipment.

### **Responsive Chord**

The prudent avoidance strategy seems to be striking a responsive chord among many members of the public, politicians, state utility regulatory commissions, and even some utilities and other affected industries. Some suggest that prudent avoidance is a cautious, conservative approach to possible EMF health risks that is justified, given the large uncertainties. According to critics of the strategy, it dangerously suggests a perception of risk that is not justified by the available biomedical evidence, and will lead to unnecessary, expensive and pos-

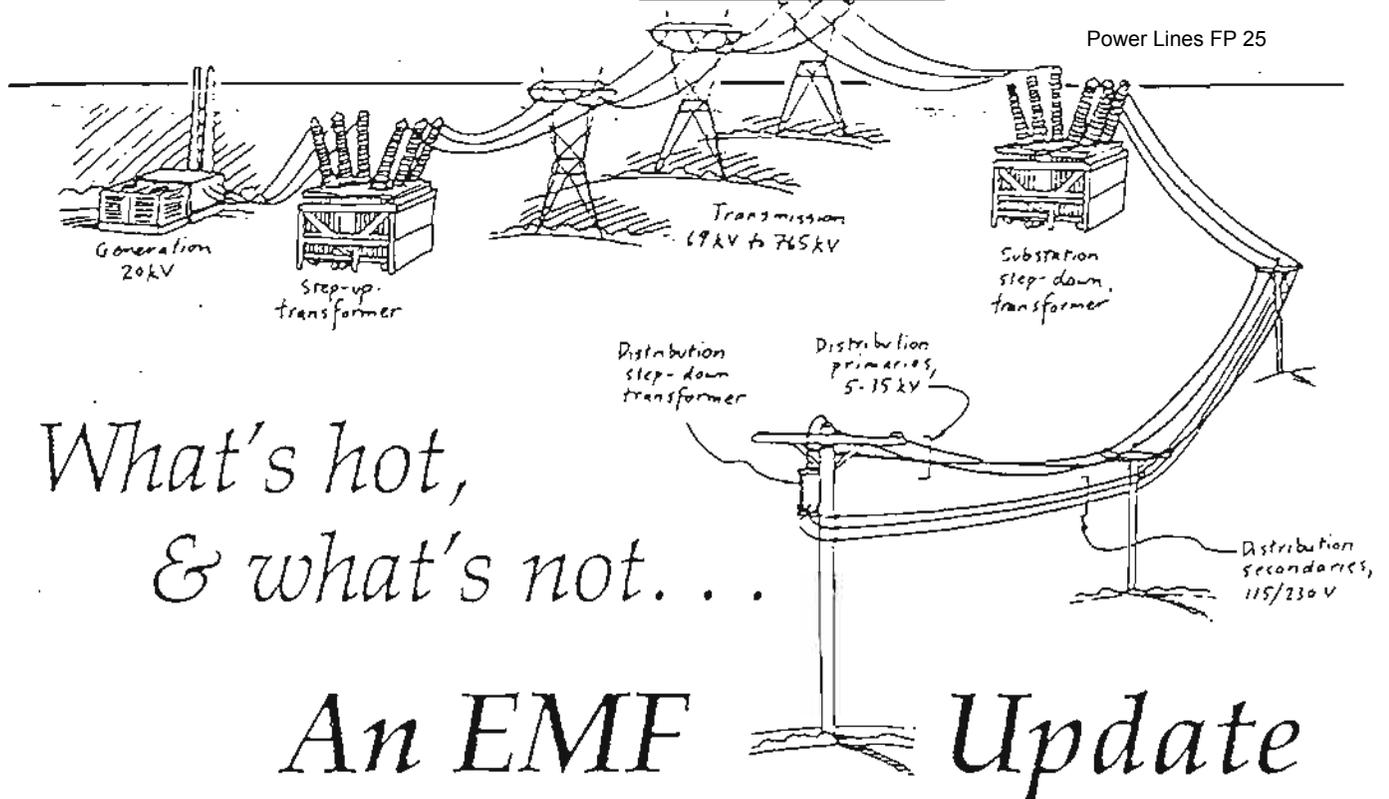
sibly even counterproductive measures to reduce magnetic field exposures.

Prudent avoidance is being broadly interpreted in some quarters to include other public policy responses that may not reduce or change most people's EMF exposure levels or patterns. Regulatory agencies in Florida, New Jersey and New York have already adopted or proposed magnetic field limits along transmission line right-of-ways. Some are considering specific requirements for new lines, such as underground construction, and are even considering applying the regulatory concept of keeping exposures as low as reasonably achievable (known as the acronym ALARA), borrowed from the field of nuclear radiation protection.

In an effort to be responsive to public concern about magnetic field exposures, utility regulators are beginning to set field limits for power lines that, initially approximate the field levels measured for circuits of various voltage ratings in actual use under maximum current loadings. But regulators are already assessing whether those limits are adequate, and some have asked utilities to evaluate and report on options for lowering

magnetic fields from typical levels.

Savitz came onto the scene when he reviewed the original study on the subject by Nancy Wertheimer and Ed Leeper, who reported on leukemia in children living near electric utility lines in Denver, CO. Savitz noted shortcomings in the study relative to the statistical relevance of the Wertheimer-Leeper conclusions. In follow-up work, Savitz cleaned up the statistical anomalies, made actual field measurements in the homes, and found a weak, but statistically significant connection between EMF and health effects. In his comments, Dr. Savitz noted that the EMF study evolves slowly and no hard conclusions can be made yet. The flood of media exposure makes it harder to make epidemiological studies, according to Savitz, because people who are interviewed are already biased in their views because nearly everyone has seen or heard that cancer is linked to EMF by the media. Any answers by subjects on the question, will invariably be exaggerated and an objective assessment will be difficult to achieve. [T&E]



What's hot,  
& what's not...

## An EMF Update

by Ed Randegger

The debate over the danger of electromagnetic fields (EMFs) has generated a lot of heat — but little light.

There is a booklet and a book that we can recommend, the first with caveats, the second wholeheartedly. The booklet, *Electric and Magnetic Fields from 60 Hertz: Electric Power: What do we know about possible health risks?*, was written by Granger Morgan, a professor in the Department of Electrical and Computer Engineering at Carnegie Mellon University. The book, *Cross Currents: The Perils of Electropollution; The Promise of Electromedicine*, is the latest work (1990) of Robert O. Becker, M.D., author of *The Body Electric* and a professor at State University of New York, Upstate Medical Center, and Louisiana State University Medical Center, Shreveport.

As the title makes clear, Morgan's booklet focuses on the 60 hertz "electric power that we use in our homes, offices and factories . . . AC, or alternating current. This is in contrast to the DC, or direct current, that is produced by batteries. An alternating current does not flow steadily in one direction. It alternates back and forth. The power we use in North America alternates back and forth 60 times each second. Scientists call this 60 hertz (Hz) power. In Europe and some other parts of the world the frequency . . . is 50 Hz."

### ABCs of EMFs

Morgan continues in this primer style — much appreciated by those of us who are electrically illiterate — to explain EMFs and how they're measured. The booklet also includes a glossary to help you with unfamiliar terms.

Though simply written, the booklet is packed with information. For example:

*Microwaves do not carry enough energy to break chemical or molecular bonds but they are absorbed by the water in tissue where they can also set up strong currents. This causes heating. If a person like a maintenance worker gets right in front of a very powerful microwave antenna, such as some of those used for radar or communication, significant health damage can result from heating body tissue...*

*While 60 Hz fields can also set up currents in tissue, these currents are much weaker. The amount of heat they generate is trivial compared to the natural heat that comes from the cells of the body. There is no reason to believe that health effects can be caused by such minuscule amounts of heat.*

But when Morgan asks himself: "Do 60 Hz fields pose health risks?" he replies: "The honest answer is that nobody knows for sure." He then spends most of the rest of the booklet — about 35 pages — trying to convince us they don't.

This is hardly a surprise. The booklet was financed by the Department of Energy, the Electric Power Research Institute (power companies), National Science Foundation and Carnegie Mellon. To buttress the illusion of impartiality, Morgan's booklet was reviewed by a number of "experts" who included at least two researchers who found links between EMFs and cancer, David Savitz and Nancy Wertheimer (page 22, *Environ* No. 7).

But Morgan does recommend "prudent avoidance," a term he coined, of EMF hazards. Among things to avoid, he cites electric blankets, water beds, bedside electric clocks, and power lines near homes. There's nothing about the backs of TV sets and computers or poorly wired houses, copiers, etc.

Morgan devotes a full page to arguing that EMFs are more benign than other causes of cancer. He makes "bold" recommendations that smokers give up their addiction and that families stay out of radon-infested houses. Excellent advice.

But then he breaks the believability barrier by claiming that pepper, celery, mushrooms, tea and coffee are more dangerous than EMFs. And he echoes dermatologists who warn that you should stay out of sunlight. We and many others avoid that bit of "prudent avoidance," almost guaranteed to bring on a case of seasonal affective disorder or SAD. Sources for Morgan's "facts" are the National Academy of Sciences (see how NAS fires employees not subservient to chemical companies on page 9) and the Department of Health and Human Services which includes the Food and Drug Administration (see aquaculture coverup page 10).

Morgan also said: "Cancer deaths occurred in significant numbers well before 60 Hz fields became a common feature of everyday life. Their number has not shown any dramatic increase as the country has electrified." He supplies no source for that statement.

This from a professor who uses such pompous phrases as: "Anything more we say will go beyond science and involve judgments and values." A specialist in "risk analysis" who heads the Department of Engineering and Public Policy at Carnegie Mellon should know better. But then again maybe he shouldn't.

Here's Becker's comment in *Cross Currents* on Morgan's style of risk analysis:

*These scientists can calculate the number of expected deaths from cancer in a population exposed to a 60 Hz electric power transmission line, compare that number with the expected number of deaths in the same population from cigarette smoking, and declare that the transmission line poses less hazard. While all of this may look very scientific, I believe it is nonsense. The basic defect in this type of analysis is that the present scientific data are accepted as the final word, never to be revised or updated."*

Becker left out one other factor. Risk analysts are hired guns. And they know who's buying their bullets.

Dale Hattis, a geneticist at the Center for Technology, Policy, and Industrial Development at Massachusetts Institute of Technology, and David Kennedy, a writer at Harvard University's John F. Kennedy School of Government, wrote in MIT's *Technology Review* in May/June 1986:

*... industry groups have often suggested that environmental controversies be resolved by experts capable of critically evaluating specific facts.*

*There is only one problem with this call for authoritative, scientific risk assessment: such a commodity does not exist [emphasis added]. In classical times, there was a great demand for the skills of soothsayers in reading entrails, and there is a similar amount of wishful thinking going on today. The fact is that the science behind risk assessment is not up to the challenge of consistently providing accurate answers about the degree of risk individuals or populations face from health hazards.*

Hattis and Kennedy could have added that there are plenty of risk analysts ready to provide the answers industry wants — for a price.

Becker makes no claims that he has written an EMF bible. He recognizes that EMF research is just producing its first sparks. And he recognizes that EMFs — "The Promise of Electromedicine" — can cure as well as kill. But up to here most of the interest has been in "The Perils of Electropollution."\*

I'll be focusing on the "perils" portion, too. But *Environ* will deal with the "promise" one of these issues.

The "how-to-do-it" portion of this book is Chapter 12: "The Risk and the Benefit: What You Can do."

#### Do's and don'ts

Becker's first rule-of-thumb deals with "the ambient field" produced by the electric transmission network inside and outside a home. In Chapter 12, Becker wrote that the "theoretically safe level" for continuous exposure to 60-Hz fields is .3 milligauss (mG). But "because of practical considerations" he ups his maximum acceptable ambient field exposure to 1 mG. An mG is the unit used to measure EMFs. Electric fields are measured in kilovolts per meter (kV/m). Electric fields are much less pervasive than EMFs which are not stopped by most materials.

Becker explains that trying to shield a home from EMFs originating outside a home — such as with aluminum siding — is a "practical impossibility." He points out that ambient-field levels in cities often exceed 3 mG; in the suburbs they're usually 1-3 mG and in rural areas they should drop below 1 mG.

That means if you live in New York, Los Angeles or other metropoli polluted by toxic chemicals, you're probably also being electrocuted.

As bad as this is, Becker, like Morgan, points out that the ambient levels are dwarfed by electric-powered conveniences in our homes. Becker warns us that these conveniences add "to the overall ambient field strength. Remember, however, that the duration of exposure is important."

Becker supplies much more detail than Morgan for household EMF sources. These include discussions of electric clocks; hairdryers; electric heaters; microwave ovens; and small radio transmitters found in cordless and car phones, toys, security systems. His usual advice, like Morgan's, is to be wary.

But Becker's best advice won't be found in Morgan. Here's some of the best of Becker:

Electric Stoves — Produces 50 mG at 18 inches above a 12-inch burner. Few cooks stand above the burner and, as

\* Reviewers Note: Chapter 11 on "The New Plagues" should have been deleted from *Cross Currents*. I can't believe that EMFs are responsible for AIDS victims inhaling heroin "shooting galleries." And I suspect EMFs, if involved at all, are but one possible trigger for chronic fatigue syndrome, autism, fragile X syndrome, sudden infant death syndrome, etc. Becker always adds disclaimers — but the scare factor is still there.

Becker wrote, "field strength drops off in the normal fashion, and the usual exposure to this field is not constant or long term." That contrasts with gas ranges which constantly emit a recognized toxic, natural gas. So this choice is easy: use electric stoves.

**Fluorescent lights** — As ecologic architect Richard L. Crowther pointed out in *Environ* No. 10, they can be dangerous, especially the new energy-saving fluorescents being touted by the Environmental Protection Agency and "environmentalists." Becker points out that a "10-watt fluorescent lamp produces a magnetic field at least 20 times greater than a 60-watt incandescent bulb.

"The circular fluorescent tubes... often installed in floor and desk lamps produce a similar field, and the user's head is often only a foot or so away. The ceiling fluorescent fixtures, with several 20-watt tubes, produce a field greater than 1 milligauss near the heads of office workers below." That means all fluorescent lights, including those providing "full-spectrum" light, can create dangerous EMFs.

Becker said "that small amount of monetary savings gained by the use of these lights hardly justifies the potential risks" in homes, work places, or schools where people are exposed to the fields for long periods.

Of course EPA doesn't agree. It claimed Jan. 15 that new "energy efficient" fluorescents could reduce the nation's power consumption 10% saving industry \$18 billion a year. EPA signed up 24 companies for its "Green Lights" program without considering how much it could cost industry in sick employees.

It's the type of program EPA Administrator William K. Reilly loves: a catchy slogan, little or no cost and no substance. If EPA was really interested in cutting energy consumption it would be showing industry how to use natural light. But there's no money in that.

**Television** — Since many of us spend hours in front of our televisions, viewers can receive an unhealthy dose of EMFs while being entertained and informed.

The bigger the screen, the stronger the field. How far away would you have to sit from a giant screen?

**Personal computers** — Becker proves he's human by erring in his belief that most homes have a computer as well as a TV set. But his comments on the EMF hazards of computers are on point. He believes that the most dangerous models are those with attached keyboards that force the operator to sit within 15-18 inches of the screen.

### Big MacZap

When I read this, I was baffled because the computers I use all have detached keyboards and I have a set of "computer glasses" that were prescribed for maximum clarity between 30 and 36 inches. Becker recommends sitting at least 30 inches from the screen.

But then I looked at the design of old-fashioned Macs and I saw the problem. The tiny screen forces an operator to sit

## Currents of Drivel

For more than a year readers have asked for a review of Paul Brodeur's *Currents of Death*. I found it a windy, unreadable diatribe designed only to scare and make money — all heat, no light. And I felt EMF apologists would use it to discredit legitimate fears. But I didn't want to say that because readers seemed to find something in it I didn't.

Then *Whole Earth Ecolog* was published and I found reviewer Robert Horvitz agreed with me. Horvitz said Brodeur took "any skepticism about even the flakiest claims of injury from EMFs as proof that the doubter must be part of a massive conspiracy hatched by the U.S. military, the electric utilities and the computer manufacturers, who want to wreak a holocaust on the public and cover up their evil plan. For Brodeur, there's no such thing as a different interpretation of ambiguous data. There are no errors in the research of the pro-harm camp, fatal errors in every study from the no-harm camp. Reasonable people don't disagree; you're either pro-Life or pro-Death.

"This is nonsense. It does a real disservice to the complexity of the scientific issues, and to the honest researchers in both camps trying to figure them out. The breakthroughs in understanding which are likely to emerge from this controversy are probably still cloaked in unresolved questions that Brodeur would dismiss as lame excuses for reactionary caution." Amen.

—ER

close to the Mac and instead of coming out the back, the maximum EMF comes out the side. If you have a "classic" Mac, you might want to look for a replacement or at least install "Elf Armor" that smothers the 60-Hz field.

What I failed to find in Becker was any reference to the weak electric field that runs through all computer operators because their hands are on the keyboard. We saw a presentation on this at a University of Washington office hazards workshop more than 5 years ago and have heard nothing about it since.

There are some things that TVs and computers have in common that raise other questions. The most obvious is that, as Becker wrote, "electronic radiation goes through wood and other usual building materials. If the TV set (computer) is placed with its back against an inside wall, radiation will be present in the adjoining room, just as if there were no wall present. Consequently, an infant's or child's bed should not be placed against a wall opposite a television set, regardless of the set's field strength." Maybe not an adult's either.

And as both Morgan and Becker pointed out TVs and computers share another apparent problem that has been

little thought about, let alone studied: EMFs of more than 60 Hz. Morgan wrote:

*A large study, recently completed in several laboratories, exposed chicken eggs to short pulses of magnetic fields that repeated at 100 times per second (100 Hz)...This study observed a larger fraction of defects in exposed eggs than in eggs that were not exposed to fields. Because the fields were very different from 60 Hz and the defects were not found in all laboratories, the implications of these results for 60 Hz field exposure are not clear. There are many electronic products like video displays, TVs, speed controllers and dimmer switches which produce low-frequency pulsed fields that turn on rapidly, so these results cannot be ignored.*

Here is what Becker wrote on TVs, but it's also relevant for computers:

*The TV set is . . . a broadband radiating source, meaning that it gives off a variety of frequencies, from the 60-Hz power frequency to radio frequencies in the MHz (megahertz or a million hertz) range. Since the picture is made up of separate horizontal lines, each constantly generated from left to right (the raster sweep), every TV set contains a unique circuit (the 'fly-back' circuit) that*

*returns the line sweep to the left side of the screen at the end of each line. The fly-back circuit operates in the VLF (very low frequency) range, generally around 17 kHz (1,700 Hz), and this frequency is a major part of the total frequencies given off. When you sit in front of the set, you are being irradiated with a wide range of frequencies, with the strongest components probably being the 60-Hz frequency and the 17-kHz fly-back frequency.*

*There has been little research directed at any frequency except 60-Hz, because electric companies have paid for most of the research. They're only interested in their product which is delivered at 60 Hz.*

And the Reagan-era Environmental Protection Agency's policy was: "What they don't know won't hurt them — or at least they won't bitch about it." The aquaculture article on page 10 indicates that things haven't changed. It seems President Bush and his minions, also, are more interested in killing than curing.

#### Press for research

But the pressure for federal research funding is growing. Both Morgan and Becker point out that we don't know nothin' yet.

## Meter readings vary with territory

Electromagnetic fields, unlike other environmental toxics, are easy to measure. Do-it-yourself equipment is available and at least one meter — the Trifield — is affordable.

As its name implies, The Trifield, provided to us by Baubiologie Hardware (see ad on page 22), measures EMFs, electric fields and radio/microwave fields. It also has a setting that summarizes EMFs and electric fields to give you a better reading of real dangers.

EMF measurements include common manmade 60-hertz (Hz) plus its harmonic frequencies from 30 to 1,000 Hz. The measurements are "frequency weighted. . . to gauge the currents induced inside the body, which are proportional to field strength multiplied by frequency."

This is factored into the Trifield dial which indicates "safe," "borderline," and "high readings."

Trifield's guesses, all anyone can make at this point, are that for EMFs 1 milligauss (mG) is safe, 1-3 mG are borderline, and more than 3 is high. For electric fields the "safe" range is less than 1 kilovolt/meter (kV/m); "borderline" about 1-2.5 kV/m; and "high" above 2.5 kV/m.

In normal use, the radio/microwave measurement probably will only register around a microwave oven or an extremely unsafe area such as in the path of a microwave beam. That could happen in a high-rise apartment. If you get a high microwave reading, you don't have to ask: "What's cookin'?" It's you.

Our Trifield trials failed to pick up even "borderline" radio/microwave readings, except around ovens, where we tried the Trifield — Fort Collins, Denver and points in-between.

We were happy with the Trifield and hope to use one on any house we visit and pass along a report, but its complex

dial doesn't make it easy to get precise readings. So we borrowed a 60-Hz Magnetic Dosimeter manufactured by Integrity Electronics Research from the city-owned Fort Collins Light and Power. All readings in this article were made with the Dosimeter. That means only 60-Hz EMFs were measured — those related directly to the power generated by electric companies — which represent only part of your daily dose of EMFs.

First we found that the ambient readings in Fort Collins — outside and inside buildings — seem quite low. They ranged down to .2 mG inside and out. I would need to know what the "natural" EMF reading would be in order to judge that figure. As far as I know it would be impossible to get a "natural" figure anywhere in the world now since manmade EMFs penetrate everywhere.

Most of the outdoor ambient readings we found in Fort Collins were between .2 and .5 with some running to more than 1 mG. And in many cases I couldn't figure out why. I had fixed on the idea that heavy traffic and the electric gear at busy corners with stoplights was responsible for jumps over 1 mG. But I was stuck at the busiest corner in town and got a .3 reading.

#### Power grid readings

I had to be within 2 inches of a 50 kilovolt (KV) transformer in order to get a 20 mG reading. Ten feet away the reading was .5 mG. Because of a fence, I wasn't able to get within 2 inches of the equipment at a substation that was fed by the biggest lines in town held up by concrete poles. But at the fence the reading was only 15 mG and it dropped off to .8 within a few steps.

Architect Richard L. Crowther, who has worked with electricity all of his life, got outdoor readings of .5-1 mG in residential Denver where power lines are on poles. It seemed to make little difference in Fort Collins whether the lines were on poles or underground. The lowest readings went down to .2 mG and there

And despite a White House effort to suppress an EPA report that pointed to possible EMF hazards and the need for research, the report was released a couple of months behind schedule.

Paul Raeburn, science editor of Associated Press, on Dec. 14 reported: "D. Allan Bromley, a White House science adviser, and James O. Mason, assistant secretary of health and human services, told EPA officials they were concerned the public would misinterpret the report's conclusions" that EMFs might be health hazards.

### Government 'withholding'

One of the report's authors, David Bayliss, told Raeburn: "What is the use of having an Environmental Protection Agency if you're going to withhold information from the public?"

Raeburn reported Jan. 14 that Bromley also tried to pack the EPA panel picked to review the report with "scientists" who scoff at EMF dangers. One of Bromley's picks, Yale University physicist Robert Adair, said anyone who believes EMFs are a problem "is a nitwit."

But EPA unanimously rejected Bromley's choices, and the review committee endorsed the report calling for resumption of federal funding for EMF research. One of those whom Bromley picked to testify against the report (most representing the utility industry) was Adair. But review committee member Richard Wilson, who teaches physics at Harvard, noted: "Physicists don't normally know biology."

So now it's up to EPA to bide by the report and lobby for funding to renew EMF research that it cut off in the 1980s.

Both Morgan and Becker will cheer if that happens, though probably for different reasons. So will we, but we don't expect to get hoarse soon.

### Sources

*Electric and Magnetic Fields from 60 Hertz Electric Power: What do we know about possible health risks?* by the Department of Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213. You should be able to find it at your local power company or public utility.

*Cross Currents* by Robert O. Becker, M.D. Just published in trade paperback for \$12.95 by Jeremy P. Tarcher, Inc., 5858 Wilshire Blvd., Suite 200, Los Angeles, CA 9036.

were "hot spots" over 1 mG in both overhead and underground areas.

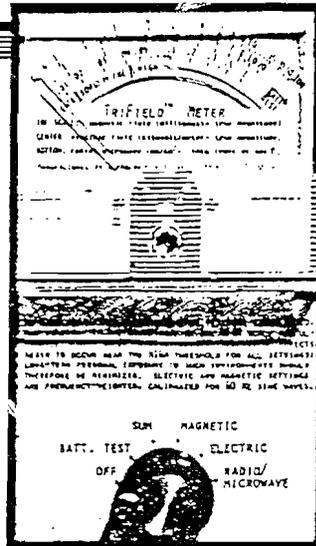
Professor M. Granger Morgan notes in *Electric and Magnetic Fields from 60 Hertz Electric Power*: "Responsible utilities... take steps to correct unsafe situations." The key to low ambient readings in Fort Collins may be a "responsible utility" that tries to rig lines to cancel out EMFs. This can also be done in household appliances but usually isn't.

The computer industry has managed to slash emissions of 60-Hz EMFs from its products. For example, the back of our 6-year-old computer generates a field too high for the Dosimeter to measure, the back of the year-old computer hits "only" 51 mG. Screen contact on the new computer is about 15 mG and at working range, about 30 inches, it's about .8 mG. The old computer's screen registers about 38 mg but at working range it's only about .8 mG. Our laser printer registers 2 mG on contact.

Our measurements of early generation Macintosh computers confirmed the problems detailed by Robert O. Becker, M.D., in *Cross Currents*. But a trip to a computer dealer convinced us that all new computers with detachable monitors and keyboards have relatively low readings. New classic Macs still are a problem.

As Becker points out, beware of school computers. They were often donated by companies who swapped to new safer models. In this case, older's not better. Perhaps the greatest mistake that can be made is to buy an old computer in order to avoid the odors of outgassing. You may be trading a smell for a heavy dose of EMFs.

The worst thing we found was our copier which poured out up to 60 mG. And it's difficult to get away from a copier. You can't put in single sheets standing 30 inches away.



Television turned out to be no apparent problem at least in the 60 Hz field—3.8 mG in contact with screen and an ambient .3 mG 5-feet away. A VCR added little or nothing. A phonograph also emitted a low dose.

The much maligned electric blanket earned its bad reputation with a reading of 34-40 mG. Turned off it was .8 mG and unplugged it was .4 mG. The ambient reading was .3. We understand that new electric blankets will use the cancellation principle to drop the 60-Hz readings, but John Banta of Baubiologie Hardware pointed out that they still will be dangerous because they touch the skin.

### Waterbed woes cool

There are a lot of reasons not to sleep on waterbeds and one of them used to be EMFs.

But apparently they have been rewired. A friend checked this out by getting a high reading with the TriField on an old waterbed heater and then going to a waterbed store. After scaring the salesman to death by going in with a meter, he learned the new heaters have very low fields.

A microwave oven, however, ran up a 14 mG reading and an electric range was 18-19 mG 3-inches from the burner. We don't recommend you stand on the burner. A short distance away the reading dropped to an ambient kitchen .5 mG. A coffeemaker hit 10 mG at 1-inch; an electric mixer 4 mG at 2-inches; a refrigerator .9 mG on contact; and a compactor 10 mG.

A hair dryer was 10-13 mG at a usable distance — beauticians be wary. A clothes dryer was 1.1 mG at contact front. A small space heater was 15 mG at 2 inches but ambient at 4 feet.

Check out your utility and see if it has a monitor to lend. If it does, you've probably got a good utility. And we recommend a TriField for checking a wider range of dangers.

— Ed Randegger

# What can you do about EMF pollution?

Few of us are ready to "go Amish" and pull the plug on our electrified lifestyles. But even Amish farmers aren't insulated from stray microwaves, passing cellular phones, two-way radios, etc. To check this, just set your car radio to AM and drive around. Whenever you get static, you're in a strong EMF. You'll get a lot of static even if skies are clear.

But there are things that can and should be done. At the top of the list are things you have no control over — better design and control of power delivery systems and household appliances.

For example, David Carpenter, dean of the School of Public Health at State University of (Albany) New York told Bruce Tomaso of the Dallas Morning News he'd asked "a senior engineer who works for one of the major appliance manufacturing companies in the U.S." if electric blankets could be made safer.

"He said it would be a piece of cake," Carpenter told Tomaso. "But his company would never do that. If they did, that would be to admit that the products they've been selling cause cancer, and they'd be sued by everybody."

That's a sad commentary on the U.S. legal system in an age when too many lawyers are trying to get rich by exploiting their clients' woes. But it indicates that appliances could be redesigned to shrink EMFs.

Tomaso, quoting a senior engineer with a Texas utility, pointed out that you can't run away from EMFs. The engineer said every customer of his utility has a distribution line running along alleys or property lines near their homes. He said typical readings at a 10-year-old Dallas-area home would show its occupants living within 50 feet of a 138,000-volt transmission line creating an EMF nearly as strong as that linked to cancer in various studies.

But even if the line weren't there, customers still would encounter similar fields throughout their homes. One foot away from a 13-inch color television set, the (EMF) field would be 6 to 10 times as strong as the outdoor line. A foot from away from a microwave oven, the jolt would be 60 times as strong as the transmission line EMF.

## Inexpensive Monitor

We talked to John Banta, of Baubiologie by Banta, Pacific Grove, CA., about these figures. He mentioned a couple of other possible offenders including our computer and rheostat switches to dim lights and control fans.

He suggested buying the cheapest possible battery powered radio and listening for static near various household appliances. For a total investment of about \$12 for radio and battery, we checked out his tip. Banta was right.

The stereo system (radio/phonograph) beamed no static to our \$12 monitor. But when the color TV was turned on, pure static prevailed up to a couple of feet from the screen and didn't stop until we backed about 6 feet away from the front of the set. The microwave oven with digital clock created total static within a foot of its door, whether the oven was turned on or not, but static ceased

beyond that distance, even at 100% power, clearly delineating the safety and hazard zones for us. Rheostat wall switches blotted out reception up to a foot away. The computer also buzzed the portable radio, but only within a couple of inches. Our copier, with digital display, was the worst, giving the ultimate buzz.

Surprisingly, no artificial light sources, incandescent or fluorescent, created static, including the unshielded ends of the full-spectrum tubes in the light table. In the alley under power lines, transformers only infrequently brought on mild static. The experts appear to be right: houses have more dangerous EMFs than normal household distribution lines. But that's definitely not true of major electric power lines, booster stations and power generators including dams and power stations — whether powered by coal, oil, gas or atoms. Nor is it true of communications links such as broadcast antennas of all sizes, power or microwave transmitters or relay stations. An engineer said that one call from a cellular phone in a car next to yours could give you a year's dose of EMF.

So the old rule of avoiding home and workplace sites within viewing distance of a major transmission point of any sort is a good one.

We asked Louis Slesin of Microwave News if underground lines would solve any problems. He said earth doesn't muffle EMF fields, but that an electrical engineer told him that if the lines were laid correctly — equal transmission levels in each direction — fields would tend to cancel out. Slesin confirmed Banta's cheap radio approach to detecting EMF problems. He, of course, has more sophisticated monitors, and he reported that the laser printer in his office would send his electrical yardstick "right off the scale." He also explained that our microwave oven created static off or on because of the digital clock dial. A recheck with the radio confirmed that the digital display on our copier was the static maker.

## Some safety tips

The first rule for lowering your EMF exposures, since elimination is impossible, is:

- 1) Don't put all your EMFs in one room. Spread them out as much as possible to reduce your simultaneous EMF load.
- 2) Stay as far away from the field sources as possible. This simply means: don't put your nose in your TV or computer screen, and when the microwave starts to cook, go to your own safe distance, or another room, until the cooking is over. And chuck electric blankets and water beds before they fry you.
- 2) Make sure your house has been wired by professionals. Every outlet should be grounded. This won't solve all EMF problems but you'll avoid what Slesin calls "stray currents."
- 4) Don't waste money on gadgets to reduce EMFs. Some are supposed to absorb, realign, concentrate or reradiate a broad spectrum of wavelengths. They don't.
- 5) Try learning from the pigs: If you feel (or sense) an EMF, try to get away from it.

FOR IMMEDIATE RELEASE

Power Lines FP 31

## **\*CCST STUDY LEAVES SMART METER HEALTH QUESTIONS UNANSWERED\***

Report Admits that Smart Meter Radiation “Continues to be of Concern”

San Francisco- A coalition of health and environmental advocates opposing radiation-emitting ‘smart’ meters today questioned the recommendations of a report released yesterday, calling the installation of 10 million wireless meters throughout California “a giant experiment on the population.” The California Council on Science and Technology (CCST) released a draft of their Smart Meter report yesterday- a response to Assemblymember Jared Huffman’s (D-San Rafael) request and question, “Are the FCC Safety Standards adequate to protect people from harm?”

**The CCST report** answers that the FCC safety standards are adequate for thermal impacts yet non-thermal impacts from radiation emitting devices like Smart Meters is still unknown. Despite this uncertainty, the report inexplicably gives the green light for continued installation.

Cindy Sage of Sage Associates, a professional environmental consultant who last week released a study showing that ‘smart’ meters likely exceed already high FCC limits on human exposure to microwaves, said “Installing millions of RF transmitters in peoples’ homes when we already have substantial scientific evidence about the risks of chronic, low-level RF is a risk not worth taking. Especially without any discussion, or disclosure to the public about trade-offs made without their knowledge or consent.”

The CCST study found that radiation from a ‘Smart’ Meter is forty times as high as a wireless wifi router, contradicting PG&E’s previous claim that the meters emit a minute fraction of the radiation of common household devices.

“Comparing wireless meters to other wireless devices that are voluntary, and which many people choose not to use is not a fair comparison to

government-mandated meters that expose people in their homes 24 hours a day.” Sage says.

Stop Smart Meters!, the EMF Safety Network, and other groups opposing ‘smart’ meters continue to receive reports from hundreds of people experiencing health impacts after the wireless meters are installed, including sleep problems, headaches, tinnitus and nausea. The California Public Utilities Commission has received over 2000 complaints of health impacts. The CCST report failed to interview anyone reporting health symptoms, and neglected to cite peer-reviewed findings of non-thermal biological damage from low level RF emissions.

“The costs for having guessed wrong is likely to have enormous economic and public health consequences for Californians for decades to come,” Sage concludes.

\*\*\*

Contact: Joshua Hart, Director,  
Stop Smart Meters! [info@stopsmartmeters.org](mailto:info@stopsmartmeters.org)  
More information: <http://stopsmartmeters.org>

## One Response to **CCST STUDY LEAVES SMART METER HEALTH QUESTIONS UNANSWERED**

1.

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[SanDiegan](#) says:

January 15, 2011 at 7:00 pm

David O. Carpenter: Report on CCST Review of Health Effects of Smart Meters

Dr. David O. Carpenter, expert in public health and wireless technologies, reports

negatively on the review of the California Council for Science and Technology's "Health Impacts of Radiofrequency from Smart Meters". Dr. Carpenter provides his expert opinion, "This document is not an accurate description of the state of the science on the issue of radiofrequency fields, and is full of inaccuracies", further noting it "is obvious that no persons with medical or biological expertise participated in this report." Dr. Carpenter's expert comments on the extensive dangers of smart meters are backed up with his specific concerns about the CCST report, with scientific realities and facts apparently not taken into consideration by the CCST. This confirms SMH comments on the CCST report. (SMH)

go to <https://www.schoolmoldhelp.org/content/view/2145/65/> to read the original, signed report by Dr. Carpenter as a pdf.

Institute for Health and the Environment  
and Department of Environmental Health Sciences  
School of Public Health  
University at Albany, State University of New York

This is a report on the review of the California Council on Science and Technology document, "Health Impacts of Radiofrequency from Smart Meters". I am a public health physician and former Dean of the School of Public Health at the University at Albany. I have been involved in review and analysis of studies on electromagnetic fields, including radiofrequency fields, for many years. I served as the Executive Secretary to the New York State Powerlines Project in the 1980s, and have published several reviews on the subject and have edited two books. In addition I was invited to present to the recent President's Cancer Panel on the subject of powerline and radiofrequency fields and cancer.

This document is not an accurate description of the state of the science on the issue of radiofrequency fields, and is full of inaccuracies. My specific concerns are as follows:

1. The benefit of the smart meters is entirely to the utilities, and is economic in nature. If they install smart meters they can fire those individuals who at present are employed to go around reading meters. Thus this is a job-killing proposal, and will increase

unemployment in a state that already has too much.

2. When a smart meter is installed residents have no choice in the matter nor ability to avoid exposure. But every individual has the option to use or not use other personal wireless devices, until more is known about health consequences of chronic RF exposure. There is a major difference between an exposure which an individual chooses to accept and one that is forced on individuals who can do nothing about it.

3. The statement “The potential for behavioral disruption from increased body tissue temperatures is the only biological health impact that has been consistently demonstrated and scientifically proven to result from absorbing RF within the band of the electromagnetic spectrum that smart meters use” is totally wrong. In the first place there are many adverse health effects other than “behavioral disruption” demonstrated as a result of tissue heating. The evidence for increased risk of brain tumors, acoustic neuromas and parotid gland tumors in individuals who have used a cell phone for 10 years or more is consistent, and the tumors occur only on the side of the head where the phone is used. There is also strong and consistent evidence for increased risk of leukemia in individuals who live near to high power AM radio transmission towers, even though this report characterizes such exposures as being “quite low” and show in Figure 7 that they are lower than the RF fields from smart meters.

4. The statement “The scientific consensus is that body temperatures must increase at least 1°C to lead to potential biological impacts from the heat” is totally wrong, and makes it obvious that no persons with medical or biological expertise participated in this report. Every enzyme system in the body is exquisitely sensitive to temperature, and increases activity by even a fraction of a degree increase in temperature. In fact all RF generates heat, and what is defined as “nonthermal” is only a function of our ability to measure the temperature increase.

5. The statement “While concerns of brain cancer associated with mobile phone usage persist, there is currently no definitive evidence linking cell phone usage with increased incidence of cancer” is incorrect. The evidence is strong and consistent among studies looking at long-term and intensive use of cell phones. The AM radio studies mentioned

above are also relevant, particularly because like smart phones radio transmission towers give whole body radiation, not just to the head.

6. The statement “There currently is no conclusive scientific evidence pointing to a non-thermal cause-and-effect between human exposure to RF emissions and negative health impacts is inaccurate, and depends totally on what one defines as “conclusive”. In biology and medicine there is nothing that is 100% proven. We rely on statistical significance and weight of evidence when drawing conclusions about health effects. When one uses these definitions there is conclusive scientific evidence for adverse health effects in humans.

7. The evidence for adverse effects of radiofrequency radiation is currently strong and grows stronger with each new study. Wired meters with shielded cable do not increase exposure. The report clearly indicates that “smart meters could conceivably be adapted to non-wireless transmission of data. However, retrofitting millions of smart meters with hard-wired technology could be difficult and costly.” Clearly the answer to this dilemma is not to install wireless smart meters to begin with.

Thank you for the opportunity to comment on this faulty report, and on the general issue of smart meters. Their use is unwise from both a public health point of view, which is where my expertise lies, but and also from a purely short and long-term economic point of view.

Yours sincerely,

David O. Carpenter, M.D.

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# Powerlines linked to leukemia in B.C. report

By Pamela Fayerman, Vancouver Sun January 13, 2009



Cecil Dunn, a spokesman for the Tsawwassen Residents Against Higher Voltage Overhead Lines(TRAHVOL), stands under the lines along 53A Street. In his hand is a EMF tester, which measures the electromagnetic field.

**Photograph by:** Stuart Davis, Vancouver Sun

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**METRO VANCOUVER** -- Living close to high-voltage power lines may produce one additional case of leukemia every two years in B.C., according to “ballpark assumptions” by B.C. Centre for Disease Control environmental health experts.

The projection by Dr. Ray Copes, director of the environmental health services division and Prabjit Barn, an environmental health scientist, is in an article headlined “Is living near power lines bad for our health?” in the November issue of the B.C. Medical Journal (BCMJ).

Government spokesman Jake Jacobs said the government was not influenced by the article when it decided to offer to buy homes along a controversial, upgraded B.C. Hydro right of way in Tsawwassen.

“The government had already made that decision several months ago,” Jacobs said in an interview. “The homeowners were offered this olive branch because of the high anxiety and because it was deemed as the reasonable thing to do.”

Cecil Dunn, spokesman for the property owners who spent nearly five years fighting the power-line upgrade, which was completed last year, said there are only a few days left for the owners to decide if they want to take part in the Home Purchase Offer Program.

It was expected that most owners of the 138 properties under the power line will seek appraisals, the first step in the process towards government purchase of the properties.

Dunn said he was not surprised the decision to buy the homes was made independent of the latest medical research.

“The government has always been aware of the liability but wouldn’t admit it. Now they are trying to quiet us down before the next provincial election.”

In the BCMJ article, Copes and Barn say that the International Agency for Research on Cancer regards as “sufficiently well established” the evidence that electromagnetic fields (EMF) are “associated” with childhood leukemia. Association does not show proof of cause but it is commonly a level of evidence found in epidemiological studies, such as those done decades ago which showed an association between smoking and lung cancer.

The B.C. authors focus on a 2005 British study which found that there is an increased risk of 69 per cent for leukemia in children living within 200 metres of power lines. The risk is increased to 23 per cent if children live 200 to 600 metres of the lines. In Tsawwassen, the power lines literally run right over more

than 100 homes.

Copes said there have been so many studies that have found an association between power lines and childhood leukemia that “while one cannot presume EMF causes cancer, one also cannot ignore the pattern that has emerged over several studies.”

“The relative risk is modest but it is not zero,” said Copes, adding the British study was used to come up with the B.C. figure of one extra case every two years.

“Using current B.C. leukemia rates and assuming similar proportions of the population live near high voltage lines, on a statistical basis, there may be one additional leukemia in B.C. every two years. To eliminate this risk, one would need to achieve a separation distance of 600 metres between every high voltage power line and the nearest residence,” he said.

In 2005, the most recent year for which comprehensive B.C. Cancer Agency data exists, 38 children in B.C. were diagnosed with leukemia. The Fraser health region, which encompasses Tsawwassen, was the region with the highest tally of both children and adults diagnosed with leukemia. It is also the most populated region in the province.

About 520 adults are diagnosed with leukemia across the whole province each year.

Barbara Kaminsky, chief executive officer of the Canadian Cancer Society’s B.C. and Yukon division, said she had not read the article, but while one additional case every two years may not seem like a significantly increased risk, “if it is your son or daughter, then it is a big deal.”

Kaminsky said her organization has not changed its position from 2006 when it submitted a brief to the Environmental Assessment Office and the B.C. Utilities Commission that while there is insufficient evidence to either rule out or confirm a definitive link between exposure to EMF and leukemia, the potential carcinogenic effect does engender public concern, and so when it is practical to do so, power

lines in close proximity to homes and schools should be avoided.

Sun Health Issues Reporter

pfayerman@vancouversun.com

[Click here to check out Pamela Fayerman's blog, Medicine Matters](#)

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The Province (Vancouver, B.C.), September 6, 2007

## REPORT BUTTRESSES ARGUMENT AGAINST POWER LINES

[Rachel's introduction: A new scientific report joins others in raising serious public health concerns over long-term exposure to electromagnetic fields from high-voltage power lines.]

By Brian Lewis, The Province

A scientific report released late last week joins others in raising serious public-health concerns over long-term exposure to electromagnetic fields from high-voltage power lines.

This one was compiled by international scientists, researchers and public-health professionals from the University at Albany in New York state, and concludes that existing limits are inadequate for public health.

Such emissions are linked to increased cases of childhood leukemia and adult cancers later in life.

The new report recommends that allowable exposure to EMFs be limited to about one milligauss (an EMF measurement).

That got the attention of the Tsawwassen Residents Against Higher Voltage Overhead Lines, a group trying to block the B.C. Transmission Corp.'s plan to replace two existing 138-kilovolt transmission lines that run through their back yards, parks and the local high school with 40-metre towers carrying 230-kilovolt power lines to Vancouver Island.

Evidence at last year's B.C. Utilities Commission hearing, which gave the project a green light, was that the new high-voltage lines will emit 149 milligauss -- or almost 150 times the report's recommended EMF levels.

The problem here is that the linkage of EMF exposure to cancer has not been proven absolutely, unlike tobacco use or exposure to asbestos.

But increasingly, studies conclude such links exist, and the Tsawwassen residents' group has turned to the Supreme Court of Canada, where it seeks leave to appeal on the grounds that if an EMF health risk is even suspected, the project shouldn't be built.

This is called the "precautionary principle," and it's been adopted by some governments and jurisdictions, including the United Nations.

But the residents' group says concerns reach beyond caution. During the utilities commission hearing, the group introduced affidavits from 58 households showing an above-average rate of cancer among family members -- and among household pets -- along the power-line route.

However, despite the residents offering a viable route or construction alternatives to reduce or eliminate these risks, the provincial Crown corporation and Gordon Campbell's government have refused to back down on the proposed routing.

The residents' group thinks it knows why.

"If we're successful in court, it'll set a huge precedent for the government and the BCTC because much more due diligence will have to be applied to these projects," says group co-chairman Cec Dunn.

Adds director Bernadette Kudzin: "Because the B.C. transmission grid is so old, the Tsawwassen project is only the start of a lot of upgrading -- this is all about money."

Kudzin is particularly concerned about the lines crossing South Delta Senior Secondary School's grounds.

"Most of the high-school kids in our neighbourhood go to that school, so they live under these power lines 24/7," she says.

Group members also point out that the existing 28-year-old limit of 833 milligauss, which the transmission corporation often cites, is only for short-term exposure. They say there are no EMF limits in Canada for long-term exposure.

For its part, the transmission corporation is fully aware of the studies but says it's sticking with the current EMF guidelines even though this latest report say they're not good enough.

Clearly, only the country's highest court will be able to decide this issue.

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1 of 1 DOCUMENT

The Evening Standard (London)

April 25, 2006 Tuesday

## POWER LINES ARE LINKED TO CANCER; EXCLUSIVE: New guidance to take children out of danger zones

BYLINE: NICHOLAS CECIL

SECTION: B MERGE; Pg. 1

LENGTH: 376 words

THE first official recognition of a link between overhead power lines and childhood leukaemia is made today.

The Evening Standard can reveal that ministers are considering issuing public health guidelines on the issue.

Parents and campaigners have been worried for decades about children living near electricity lines and pylons but scientists have been divided.

However, a special group meeting today is looking at the siting of new and existing homes near power lines or proposed cable networks.

Experts are intending to propose draft planning guidance. More cables could be put underground.

A second panel is examining electromagnetic fields within the home and what advice should be offered to householders, guidance for electricians and recommendations on British standards and wiring recommendations.

In a sign that the Government is taking such fears seriously, ministers are to consider introducing "precautionary measures".

Government health advisers accept there is a weak "association" between prolonged exposure to power frequency fields and childhood leukaemia. The Health Protection Agency (HPA) is therefore urging Health Secretary Patricia Hewitt to consider precautionary moves.

The National Radiological Protection Board in the UK, now part of the Health Protection Agency, warned in 2004 that the leukaemia risk to children may be doubled by exposure to electrical fields.

The experts found that around 300,000 people may be exposed to potentially unsafe levels.

Ministers are set to take action once they have received a highly-detailed report later this year. Dr Michael Clark, the HPA's scientific spokesman, said: "We issued our advice to Government after finding a weak association between childhood leukaemia and living near major power lines. There is the possibility of a low risk, there is no definite risk, therefore we are advising the Government to consider precautionary approaches."

A health department spokesman: "There is no new evidence to suggest a link between power lines and childhood

POWER LINES ARE LINKED TO CANCER; EXCLUSIVE: New guidance to take children out of danger zones The Evening Standard (London) April 25, 2006 Tuesday

cancers. However, we realise this is an important issue which has caused anxiety.

That is why the Department of Health commissioned and funded the biggest study of its kind into cases of childhood cancer in proximity to high voltage power lines."

LOAD-DATE: April 25, 2006

LANGUAGE: ENGLISH

PUBLICATION-TYPE: Newspaper

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## Childhood leukaemia risk doubles within 100 metres of high voltage power lines

15 Sep 2004

The biggest ever publicly funded UK study (1) into power lines and child cancer has found that children under the age of 15 living within 100 metres of high-voltage power lines have close to twice the risk of developing leukaemia. Children aged 0-5 are the most vulnerable so their risk is likely to be even higher.

This result from the OXFORD CHILDHOOD CANCER RESEARCH GROUP study, headed by Gerald Draper analysed and compared 33 years of data (from 1962 to 1995) on 35,000 children diagnosed with cancer, with their distance to the nearest electricity transmission line. These latest findings from the Draper study of a direct effect on childhood leukaemia from U.K. power lines follow from the acknowledged International studies that the risk of childhood leukaemia is doubled for magnetic field exposures above 0.4 microtesla, well below that seen under high voltage powerlines.

We have learned that " preliminary results" of the latest Draper study, funded to run from 1997-2001 were known as long as 3 years ago and were formally shown confidentially to the U.K. Department of Health in May 2003, but to date has not as yet been entrusted to the public.

We of the Trentham Environmental Action Campaign, an independent research and activist group, concerned about adverse health effects from power-lines, believe it to be absolutely scandalous that 3 years after telling the Department of Health of these latest U.K. findings, it is only as a consequence of our intervention that we are now able to make these findings public.

There appears to have been a determination to withhold the Draper Report for as long as possible.

Trentham has a high voltage powerline crossing many of the houses and there are a significant number of households with young children within 100 metres of the line. Our concerns are also shared by REVOLT, Powerwatch and Electromagnetic Hazard and Therapy, organisations which have also voiced concerns about the health risks of electromagnetic fields for many years.

Our campaign group has been in constant contact with the Government, Mr George Hooker at the Department of Health and the National Radiological Protection Board [NRPB]. We have also been deeply disappointed in the organisations' continuing denial of the problem despite their knowing about these new study results. The NRPB already acknowledges that there is international consensus on the fact that the incidence of childhood leukaemia is doubled at a magnetic field of 0.4 microtesla, which is exceeded under most powerlines. In March 2004, the NRPB reduced the national magnetic field exposure guidelines from 1,600 microtesla to 100 microtesla [3].

They said "In the light of these findings (the association between exposure to magnetic fields and childhood leukaemia) and the requirement for additional research, the need for further precautionary measures should be considered by government". However, 100 microtesla is still 250 times higher than the level (0.4 microtesla) at which the risk of developing childhood leukaemia is doubled.

Electromagnetic fields from powerlines are also linked to adult cancers, depression and suicide. Our Trentham group carried out a local survey which produced extremely worrying results. Depression, miscarriages, headaches, insomnia (with its attendant chronic health problems due to immune system damage) were much more common in the people who lived near the powerline, compared with those who lived further away. Some of these health problems were also found in the important California Health Department report [4] of 2002.

The leukaemia link has now been repeatedly demonstrated. The government should take our nation's health seriously enough to stop allowing houses to be built near high-voltage lines and to remove overhead powerlines from residential areas.

The Minister for Housing and Planning, Keith Hill, in a letter dated July 2004, said "We are aware that there is continuing debate about the effect of living under power lines and whether this can have adverse long-term health effects.

We are of the opinion that power lines are unlikely to have significant effects on the environment". Is this a government statement about people's health or about the environment? Is this confusion, or spin?

It is time the government and planners took the health issue seriously, and reversed their policy of favouring developers, clearly ignoring the risk to children's health. New housing near powerlines should be restricted, and existing lines through residential areas phased out.

Only 50 years ago developing childhood leukaemia was an almost certain death sentence. Due to dramatic improvements in treatment, about 80% of children who suffer from the most common form of childhood leukaemia (ALL, acute lymphoblastic leukaemia) now live for more than 5 years after treatment, but childhood leukaemia remains the largest child killer disease. Survivors often suffer ongoing adverse health complications. The number of children developing leukaemia has been steadily growing over the last 50 years. In 2001, Dr Sam Milham reported [5] a link between the growth in electricity supply and the growth in leukaemia incidence in the USA.

We ignore this at our peril.

[1] Draper G, Vincent T, Kroll M & Swanson J - Childhood cancer and electromagnetic field exposures from powerlines - Department of Health funded 1997-2001, RRX 46 (as yet still unpublished)

[2] International Scientific Conference on the incidence, causal mechanisms and prevention of childhood leukaemia and other cancers. Westminster, 6-10th September 2004. See: <http://www.leukaemiaconference.org>

[3] See: <http://www.nrpb.org> for details of their announcements and downloadable publications

[4] Neutra R R, DelPizzo V & Lee G M - An Evaluation of the possible risks from electric and magnetic fields (EMFs) from power lines, internal wiring, electrical occupations & appliances, 2002, California Department of Health & Human Services, The Program, Oakland, California. <http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html>  
See commentary  
on: <http://www.electric-fields.bris.ac.uk>

[5] Milham S & Ossiander E M - Historical evidence that residential electrification caused the emergence of the childhood leukaemia peak Medical Hypotheses, 2001, 56(3) 290-295

Further information about powerlines and health problems (including the Trentham survey) can be found on the following websites

TEAC <http://www.revolt.co.uk/trentham> Media (only) Tel: 01782 658648 Mobile 07963915428 ( Maureen A)

EMH&T <http://www.em-hazard-therapy.com> Simon Best 01730 816 799 (media only)

Powerwatch <http://www.powerwatch.org.uk/contents.asp>

REVOLT <http://www.revolt.co.uk>

This press release has been issued by the Trentham Environmental Action Campaign  
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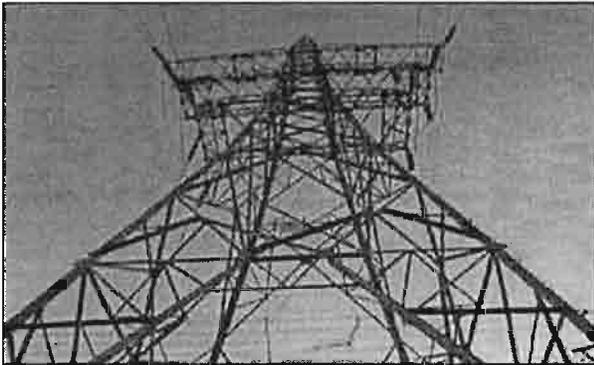
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## BBC News Online: Health

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Tuesday, 6 March, 2001, 13:19 GMT

### Watchdog confirms pylon cancer link



The UK Government's radiation watchdog has admitted there is a "weak association" between electromagnetic fields and increased risk of childhood leukaemia.

The National Radiological Protection Board's investigation has reviewed all the evidence about health.

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*The evidence doesn't only relate to power lines, it's down to the effects of electrical power around the house*

**Sir Walter Bodmer, NRPB**

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This includes a study of 3,000 children in the US, Europe and New Zealand, published late last year, which suggested that pylons could double the risk of childhood leukaemia.

The NRPB's study, chaired by respected scientist Sir Richard Doll, has concluded that the increased danger is slight as the ordinary risk is only one in 20,000 children.

Although the evidence is weak, the watchdog calls for further detailed research to explain "anomalous" studies.

#### **'Weak' evidence**

Sir Walter Bodmer, NRPB chairman, told the BBC: "The evidence doesn't only relate to power lines, it's down to the effects of electrical power around the house.

"The evidence is weak, but it's the responsibility of a body like ours to state the scientific case as it is, and leave policymaking to government."

More than 23,000 homes in the UK are situated near power lines and it has previously been suggested by campaigners that the electromagnetic fields surrounding the cables can trigger leukaemia.

Janette Smith, from north Yorkshire, said that three members of her family had contracted cancer since they moved to a house close to power lines.

She said: "We are relieved to hear the report, because many people have disputed the fact that it could be the pylons.

"If it has caused cancer in children, there is a possibility that it will cause cancer in adults."

### 'Buffer zone'

Opponents are calling for a mandatory 50-metre (160-ft) "buffer zone" each side of the lines. In the US, legislation prevents new homes being built near power lines.

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*If it has caused cancer in children, there is a possibility that it will cause cancer in adults*

**Janette Smith, Campaigner**

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But some campaigners claim that "hissing" cables can extend the risk several hundred metres from power lines.

Research by Professor Denis Henshaw and Dr Peter Fewes, at the University of Bristol, suggests power lines produce electrically charged particles called "corona ions".

According to their controversial theory, these attach themselves to airborne pollutants such as exhaust fumes, giving them an electrical charge and making them more likely to be deposited in the lungs when inhaled.

Some UK parents have engaged lawyers over the issue but studies have mainly been inconclusive.

A study by Bristol University scientists in 1999 identified a "causal" link between pylons and leukaemia. But a number of other studies, including one involving Canadian children, have failed to prove a link.

In a statement, the Electricity Association said: "The considerable body of evidence that has been accumulated over the last two decades clearly suggests that magnetic fields do not cause cancer or any other disease.

"If it is indeed the guidance of the NRPB that this is no longer the case, we would like the Board to clarify what needs to be done as an industry."

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### Related to this story:

[Pylons 'treble cancer particles' \(02 Dec 99 | Health\)](#) [Pylons safe, says 'definitive' research \(03 Dec 99 | Health\)](#) [Battle lines drawn in pylon debate \(03 Dec 99 | Health\)](#)

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(2007)

## University of Albany, New York– August 31 / **Serious Public Health Concerns Raised Over Exposure to Electromagnetic Fields (EMF) from Power Lines and Cell Phones**

An international working group of scientists, researchers and public health policy professionals (The BioInitiative Working Group) has released its report on electromagnetic fields (EMF) and health. It raises serious concern about the safety of existing public limits that regulate how much EMF is allowable from power lines, cell phones, and many other sources of EMF exposure in daily life.

Electromagnetic radiation from such sources as electric power lines, interior wiring and grounding of buildings and appliances are linked to increased risks for childhood leukemia and may set the stage for adult cancers later in life. A report from the BioInitiative Working Group ([www.bioinitiative.org](http://www.bioinitiative.org)) released on Friday, August 31<sup>st</sup> documents the scientific evidence that power line EMF exposure is responsible for hundreds of new cases of childhood leukemia every year in the United States and around the world.

The report provides detailed scientific information on health impacts when people are exposed to electromagnetic radiation hundreds or even thousands of times below limits currently established by the Federal Communications Commission (US FCC) and International Commission for Non-Ionizing Radiation Protection in Europe (ICNIRP). The authors reviewed more than 2000 scientific studies and reviews, and concluded that the existing public safety limits are inadequate to protect public health. From a public health policy standpoint, new public safety limits, and limits on further deployment of risky technologies are warranted based on the total weigh of evidence.

The report documents scientific evidence raising worries about childhood leukemia (from power lines and other electrical exposures), brain tumors and acoustic neuromas (from cell and cordless phones) and Alzheimer's disease. There is evidence that EMF is a risk factor for both childhood and adult cancers.

Public health expert and co-editor of the Report Dr. David Carpenter, Director, Institute for Health and the Environment at the University of Albany, New York says *"this report stands as a wake-up call that long-term exposure to some kinds of EMF may cause serious health effects. Good public health planning is needed now to prevent cancers and neurological diseases linked to exposure to power lines and other sources of EMF. We need to educate people and our decision-makers that "business as usual" is unacceptable."*

Health questions about power line EMFs were initially raised by Nancy Wertheimer, a Colorado public health expert and Ed Leeper, an electrical engineer in 1979. Wertheimer noticed that children were twice or three times as

likely to have leukemia tended to live in homes in the Denver, CO area close to power lines and transformers. Now, there are dozens of studies confirming the link, but public health response has been slow in coming, and new standards to protect the public are necessary.

Brain tumor specialist Dr. Lennart Hardell, MD, PhD and Professor at University Hospital in Orebro, Sweden is a member of the BioInitiative Working Group. His work on cell phones, cordless phones and brain tumors is widely recognized to be pivotal in the debate about the safety of wireless radiofrequency and microwave radiation. *"The evidence for risks from prolonged cell phone and cordless phone use is quite strong when you look at people who have used these devices for 10 years or longer, and when they are used mainly on one side of the head.*

Brain tumors normally take a long time to develop, on the order of 15 to 20 years. Use of a cell or cordless phone is linked to brain tumors and acoustic neuromas (tumor of the auditory nerve in the brain) and are showing up after only 10 years (a shorter time period than for most other known carcinogens). *"This indicates we need research on more long-term users to understand the full risks"* says Dr. Hardell.

Dr. Hardell's work has been confirmed in other studies on long-term users. A summary estimate of all studies on brain tumors shows overall a 20% increased risk of brain tumor (malignant glioma) with ten years of use. But the risk increases to 200% (a doubling of risk) for tumors on the same side of the brain as mainly used during cell phone calls. *"Recent studies that do not report increased risk of brain tumors and acoustic neuromas have not looked at heavy users, use over ten years or longer, and do not look at the part of the brain which would reasonably have exposure to produce a tumor."*

Wireless technologies that rely on microwave radiation to send emails and voice communication are thousands of times stronger than levels reported to cause some health impacts. Prolonged exposure to radiofrequency and microwave radiation from cell phones, cordless phones, cell towers, WI-FI and other wireless technologies have linked to physical symptoms including headache, fatigue, sleeplessness, dizziness, changes in brainwave activity, and impairment of concentration and memory. Scientists report that these effects can occur with even very small levels of exposure, if it occurs on a daily basis. Children in particular are vulnerable to harm from environmental exposures of all kinds.

Co-editor of the report, Cindy Sage of Sage Associates says *"public health and EMF policy experts have now given their opinion of the weight of evidence. The existing FCC and international limits for public and occupational exposure to electromagnetic fields and radiofrequency radiation are not protective of public health. New biologically-based public and occupational exposure are*

*recommended to address bioeffects and potential adverse health effects of chronic exposure. These effects are now widely reported to occur at exposure levels significantly below most current national and international limits."*

Biologically-based exposure standards are needed to prevent disruption of normal body processes. Effects are reported for DNA damage (genotoxicity that is directly linked to integrity of the human genome), cellular communication, cellular metabolism and repair, cancer surveillance within the body; and for protection against cancer and neurological diseases. Also reported are neurological effects including changes in brainwave activity during cell phone calls, impairment of memory, attention and cognitive function; sleep disorders, cardiac effects; and changes in immune function (allergic and inflammatory responses).

Sage says *"the Working Group recommends a biologically-based exposure limit that is protective against extremely-low frequency (power line) and radiofrequency fields which, with chronic exposure, can reasonably be presumed to result in significant impacts to health and well-being"*.

Contributing author Dr. Martin Blank, Columbia University professor and researcher in bioelectromagnetics says *"cells in the body react to EMFs as potentially harmful, just like to other environmental toxins, including heavy metals and toxic chemicals. The DNA in living cells recognizes electromagnetic fields at very low levels of exposure; and produces a biochemical stress response. The scientific evidence tells us that our safety standards are inadequate, and that we must protect ourselves from exposure to EMF due to powerlines, cell phones and the like."* He wrote the section on stress proteins for the BioInitiative Report.

Contact: [info@bioinitiative.org](mailto:info@bioinitiative.org) (open on August 31, 2007)

Report: available at [www.bioinitiative.org](http://www.bioinitiative.org) (on August 31, 2007)

Title: BioInitiative: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)

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## THE WALL STREET JOURNAL.

### **Link Between EMF, Brain Cancer Is Suggested by Study at 5 Utilities --- But Industry-Funded Work Finds No Leukemia Risk, Unlike Earlier Research**

By Jerry E. Bishop. Wall Street Journal. (Eastern edition). New York, N.Y.: Jan 11, 1995. pg. B.6

#### Abstract (Summary)

A 1994 STUDY of French and Canadian utility workers found that workers receiving the most exposure to magnetic fields ran a risk of developing leukemia about 2.4 times higher than employees not exposed to the fields. In an article yesterday, the increased risk was misstated as 12.4 times higher. (WSJ Jan. 12, 1995)

The association between brain cancer and exposure to an electromagnetic field, or EMF, was stronger in the new study than in any previous population studies. However, unlike previous studies, the new one failed to find any increased risk of leukemia associated with EMF exposure.

"It is disappointing that our results don't provide a clearer picture {of the cancer-EMF link} when combined with the previous studies of electrical workers and particularly electric utility workers," said the two University of North Carolina epidemiologists who carried out the study. It was funded by the Electric Power Research Institute, Palo Alto, Calif.

#### Full Text (835 words)

Copyright Dow Jones & Company Inc Jan 11, 1995

#### Corrections & Amplifications

A 1994 STUDY of French and Canadian utility workers found that workers receiving the most exposure to magnetic fields ran a risk of developing leukemia about 2.4 times higher than employees not exposed to the fields. In an article yesterday, the increased risk was misstated as 12.4 times higher. (WSJ Jan. 12, 1995)

A possible link between brain cancer and exposure to the magnetic fields that surround power lines and electrical equipment was found in a huge, industry-supported study of workers at five electric utilities.

The association between brain cancer and exposure to an electromagnetic field, or EMF, was stronger in the new study than in any previous population studies. However, unlike previous studies, the new one failed to find any increased risk of leukemia associated with EMF exposure.

Because their results were at variance with earlier studies, researchers were extremely cautious about drawing any conclusions.

"It is disappointing that our results don't provide a clearer picture {of the cancer-EMF link} when combined with the previous studies of electrical workers and particularly electric utility workers," said the two University of North Carolina epidemiologists who carried out the study. It was funded by the Electric Power Research Institute, Palo Alto, Calif.

Moreover, the study doesn't "resolve the fundamental question of whether magnetic fields cause cancer," said the two researchers, David A. Savitz and Dana P. Loomis.

Nevertheless, the study is likely to intensify the long-bubbling debate over whether EMF exposure can cause cancer. Not only was the study sponsored by the electric utility industry itself, it also involves the largest group of workers -- 139,000 -- yet studied for the effects of EMF exposure.

Publication of the new study in the American Journal of Epidemiology, originally scheduled for today, was delayed by the journal until next week and copies of the formal report were unavailable. However, both the Electric Power Research Institute and the University of North Carolina released summaries of findings.

According to the summaries, the overall death rate from cancer was only 86% that of the general population,

reflecting the fact that employed workers usually are healthier than the general population. Of the 139,000 employees who had worked at the five utilities between 1950 and 1986, the researchers counted 20,733 deaths.

Because of hints found in the earlier studies, the researchers focused on the deaths from two relatively rare types of cancer, leukemia and brain cancer. During the 36 years, there were only 164 deaths from leukemia and 144 from brain cancer.

It was when the researchers compared the rates of brain cancer among groups of workers according to their exposure to the magnetic fields that they found indications of an increased risk. Men who had worked long periods in jobs where exposure to EMF was the highest had 2.3 times the risk of dying of brain cancer as men who worked in utility jobs where exposure was the lowest, according to the summaries.

Both the Electric Power Research Institute and the university, however, emphasized that, contrary to earlier findings, the new study failed to find any indication that the risk of leukemia increased with higher exposures.

In contrast to the new study, a 1994 report of a similar study of workers at one French and two Canadian utilities found that those with the highest exposure to EMF ran a risk of dying of leukemia about 12.4 times higher than those who had lower exposures to the fields.

A third study, this one of workers at Southern California Edison Co., published in 1993, failed to find any increased risk of leukemia or brain cancer.

The two North Carolina researchers said it wasn't clear why the results of the studies varied so markedly. They noted, however, that it is impossible to know accurately how much exposure to magnetic fields each worker had over a period of many years. Each study used a different method to estimate past exposure.

In their study at the five utilities, the researchers estimated each dead worker's exposure by measuring the current exposures in a wide variety of utility jobs and then counting the amount of time each worker spent in the various jobs over the years. Cable splicers, linemen and electricians, for example, are the jobs with the highest exposures today, while managers and administrative workers have the lowest exposures.

The researchers also noted that their own study relied on death certificates to determine cause of death rather than medical records as in the other studies. Death certificates are often misleading in stating the actual cause of death.

The Electric Power Research Institute emphasized that the results "have not clarified the relationship between EMF exposure and cancer." The "inconsistencies" among the various studies, it said, "underscore our limited understanding of the risks of exposure to EMF."

The five utilities that participated in the North Carolina study were Carolina Power & Light Co., Virginia Electric Power Co., PECO Energy Co., the Tennessee Valley Authority and Pacific Gas & Electric Co.

Credit: Staff Reporter of The Wall Street Journal

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## Mike Adams ~ Discovery Of Magnetic Sensors In Fish And Rats May Explain Why Some People Can 'Feel' Wi-Fi, Smart Meters, Power Lines And Electropollution

Posted on [July 11, 2012](#) by [Gillian](#)

[Natural News](#) | July 11 2012

*NaturalNews* ~ It is well known that many people are sensitive to electromagnetic pollution. Wi-fi gives them headaches. Being near high-voltage power lines can bring on migraines. Using a cell phone unleashes similar symptoms. Until recently, there was no medically-understood mechanism by which electromagnetic waves could be sensed by humans. But now, thanks to some fascinating science summarized here, that mystery may be closer to being solved.

Scientists from the University of Munich, led by geophysicist Michael Winklhofer, say they've located and identified "internal compass needles" in the noses of rainbow trout. These are called magnetosensory cells, and they turn out to be far more sensitive to magnetic fields than anyone previously thought.

As [TGdaily.com](#) reports:

The cells sense the field by means of micrometer-sized inclusions composed of magnetic crystals, probably made of magnetite. These inclusions are coupled to the cell membrane, changing the electrical potential across the membrane when the crystals realign in response to a change in the ambient magnetic field.

"This explains why low-frequency magnetic fields generated by powerlines disrupt navigation relative to the geomagnetic field and may induce other physiological effects," said Winklhofer.

### Electro-smog is getting worse by the day

While the study did not look for magnetosensory cells in humans, their identification in fish proves that biological systems can (and do!) create these highly sophisticated "instruments" which sense electromagnetic fields. As any physics student knows, electricity and magnetism are much the same thing: Rotate a coil of wire around a magnet and it produces electric current. High-voltage power lines, inversely, produce a magnetic field.

As the number of modern devices emitting electromagnetic fields continues to rise, people are becoming increasingly concerned about the cumulative effects on their mental and physical health. Some of the sources of electromagnetic pollution — sometimes called "electro-smog" — which exist right now include:

- Smart meters
- Mobile phones
- Wi-fi broadband

- Circuit breaker boxes
- Power supplies to computers and appliances
- Treadmills and exercise equipment
- Cell phone towers
- Commercial radio and TV transmissions
- Hair dryers, blenders and other high-amperage home appliances

While each device seem harmless on its own, the combined effects of them all may cross a threshold that theoretically could be sensed by humans who may also have magnetosensory cells.

Some humans also have an uncanny ability to always know which direction is North, even when lacking obvious environmental cues such as star configurations (at night) or patterns of sunlight (during the day). Is it possible that some humans possess magnetosensory cells and unknowingly use them to “feel” which way is North?

### **Magnetosensory cells already detected in rats**

There appears to be evidence that these cells already exist in rats. A study published in Synapse in 2009 is entitled, “[Magnetosensory function in rats: localization using positron emission tomography.](#)”

It reports:

Exposure to the magnetic field stimulated cerebellar uptake of fluorodeoxyglucose compared to the sham exposure in the same animals. The activated region was located in the posterior central cerebellum. The results indicated that magnetosensory evoked potentials in rats were associated with increased glucose utilization in the cerebellum, thereby supporting earlier evidence that electromagnetic field transduction occurred in the brain.

So it’s not just fish and pigeons; it’s also rats and rabbits. This is strong evidence that magnetosensory cells are probably widely found across many species, possibly including humans. This may therefore explain why some people experience neurological disruption when in the presence of persistent electromagnetic fields.

The answer to all this? Move to the country, toss your cell phone, and get back to nature. Modern society is toxic to biology.

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## Magnetic Fields

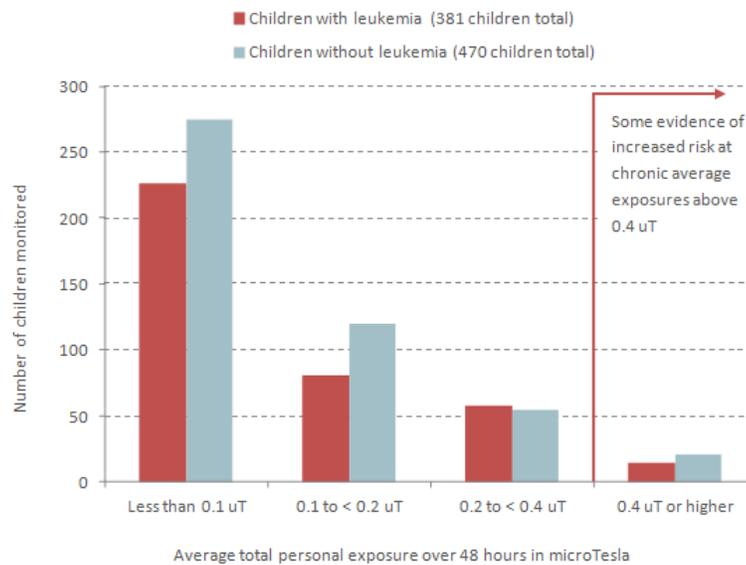
RADIATION – Possible Carcinogen (IARC 2B)

PROFILE ENVIRONMENTAL ESTIMATE OCCUPATIONAL ESTIMATE

Calculating lifetime excess cancer risk requires an estimate of intake (or dose, in the case of extremely low frequency magnetic fields) and a [cancer potency factor](#). Although numerous studies on the effects of exposure to extremely low frequency magnetic (ELFM) fields have been conducted, no published cancer potency factor is available. There is some consensus that **chronic exposure to ELFM fields above 0.4 microTesla may be associated with an increased risk of developing childhood leukemia.**<sup>1</sup>

In Canada, two studies of childhood leukemia conducted in the 1990s measured individual exposure to ELFM fields over 48 hours. **Average exposures were 0.4 microTesla or higher for approximately 5 percent of the children monitored.** Average exposures were higher in provinces with higher percentages of electric heating use, apartments and attached dwellings, and for children living in close proximity to transmission or distribution lines.

1990s: Canadian Childrens' Measured Exposure to Extremely Low Frequency Magnetic Fields <sup>2,3</sup>



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Review

## Exposure to electromagnetic fields (non-ionizing radiation) and its relationship with childhood leukemia: A systematic review

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ABSTRACT

Childhood exposure to physical contamination, including non-ionizing radiation, has been implicated in numerous diseases, raising concerns about the widespread and increasing sources of exposure to this type of radiation. The primary objective of this review was to analyze the current state of knowledge on the association between environmental exposure to non-ionizing radiation and the risk of childhood leukemia. Scientific publications between 1979 and 2008 that include examination of this association have been reviewed using the MEDLINE/PubMed database. Studies to date have not convincingly confirmed or ruled out an association between non-ionizing radiation and the risk of childhood leukemia. Discrepancies among the conclusions of the studies may also be influenced by confounding factors, selection bias, and misclassification. Childhood defects can result from genetic or epigenetic damage and from effects on the embryo or fetus, which may both be related to environmental exposure of the parent before conception or during the pregnancy. It is therefore critical for researchers to define *a priori* the type and “window” of exposure to be assessed. Methodological problems to be solved include the proper diagnostic classification of individuals and the estimated exposure to non-ionizing radiation, which may act through various mechanisms of action. There appears to be an urgent need to reconsider exposure limits for low frequency and static magnetic fields, based on combined experimental and epidemiological research into the relationship between exposure to non-ionizing radiation and adverse human health effects.

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Abbreviations: AML, acute myeloid leukemia; ALL, acute lymphoid leukemia; EMR, electromagnetic radiation; ELF-EMR, extremely low-frequency electromagnetic radiation; ICNIRP, International Council of Non-Ionizing Radiation Protection; NIR, non-ionizing radiation; LF-EMR, low-frequency electromagnetic radiation; RF, radio frequencies.

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### 1. Introduction

Humans have been constantly exposed to electromagnetic radiation, including sunlight, cosmic rays, and terrestrial radiations. However, a substantial increase in exposure, especially to low-frequency electromagnetic radiation (EMR), started in the early

## Is living near power lines bad for our health?

Ray Copes, MD,  
Prabjit Barn, MSc

**T**he debate of whether there are adverse effects associated with electromagnetic fields from living close to high-voltage power lines has raged for years. While research indicates that large risks are not present, the possibility of a relatively small risk cannot be conclusively excluded.

Electromagnetic fields (EMFs) are produced by electrical appliances, electrical wiring, and power lines, and everyone is exposed to them at some level. Numerous studies have investigated EMF exposure and health. Although earlier studies did suggest associations between exposure and a variety of health effects including brain cancer, breast cancer, cardiovascular disease, and reproductive and developmental disorders, most of these associations have not been substantiated by more recent research. One notable exception to this is the association with childhood leukemia, which the International Agency for Research on Cancer regards as sufficiently well established to rate extremely low frequency magnetic fields as a "possible" human carcinogen.<sup>1</sup>

The first study to link childhood leukemia with residential EMF exposure was published in 1979<sup>2</sup> and since then, a number of studies have found weak associations to support this original finding. Studies investigating childhood leukemia as a health outcome of EMF exposure have used

measured and calculated magnetic fields, as well as distance of homes to power lines, as an exposure measure. Studies using magnetic field strength as an exposure measure have found that exposures greater than the range of 0.3 to 0.4  $\mu$ T lead to a doubling risk of leukemia, with very little risk below this level.<sup>1</sup> This exposure range is approximately equal to a distance of 60 m within a high-voltage power line of 500 kV.

However, a more recent study showed an elevated risk of leukemia among children living in homes with distances much greater than 60 m from high voltage power lines.<sup>3</sup> This study involved close to 30 000 matched case-control pairs of children living in the United Kingdom. It was found that children living in homes as far as 600 m from power lines had an elevated risk of leukemia. An increased risk of 69% for leukemia was found for children living within 200 m of power lines while an increased risk of 23% was found for children living within 200 to 600 m of the lines.<sup>3</sup> This study was notable in that it found some elevation of risk at much greater distances than previous studies.

Although distance of homes from power lines can be considered a crude measure of exposure, the results of this study do merit attention. A limited understanding exists of how exposure to EMF can affect health. The underlying biological mechanism is unknown, making it difficult to determine which measure of EMF is most appropriate when evaluating health outcomes. Use of residential proximity may be a reasonable surrogate for direct measurements of EMF, but may also reflect other factors that are related to proximity to high voltage lines.

If the association found in the UK study does reflect a causal relationship, what are the potential impacts in BC? Using current BC leukemia rates<sup>4</sup> and assuming similar proportions of the population live near high voltage lines, on a statistical basis, there may be one additional leukemia in BC every 2 years. To eliminate this risk, one would need to achieve a separation distance of 600 m between every high voltage power line and the nearest residence. While this could be done, it would require substantial changes to existing land use patterns and would require significant resources. While it can be argued that this action is consistent with some forms of the precautionary principle, based on best available evidence, one can achieve much greater risk reduction or health benefits if resources are directed to other larger, better established risks.

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Dr Copes is the director of BCCDC's Environmental Health Services Division. Ms Barn is an environmental health scientist at BCCDC.

## American Journal of Epidemiology

[Current Issue](#) | [Archive](#)[January 15, 2009, 169:2](#) > [Residence Near Power Lines and...](#)

## ARTICLE LINKS:

[Fulltext](#) | [PDF \(289 K\)](#)**Residence Near Power Lines and Mortality From Neurodegenerative Diseases: Longitudinal Study of the Swiss Population.**

## ORIGINAL CONTRIBUTION

American Journal of Epidemiology. 169(2):167-175, January 15, 2009.

Huss, Anke 1; Spoerri, Adrian 1; Egger, Matthias 1,2; Roosli, Martin 1

**Abstract:**

The relation between residential magnetic field exposure from power lines and mortality from neurodegenerative conditions was analyzed among 4.7 million persons of the Swiss National Cohort (linking mortality and census data), covering the period 2000-2005. Cox proportional hazard models were used to analyze the relation of living in the proximity of 220-380 kV power lines and the risk of death from neurodegenerative diseases, with adjustment for a range of potential confounders. Overall, the adjusted hazard ratio for Alzheimer's disease in persons living within 50 m of a 220-380 kV power line was 1.24 (95% confidence interval (CI): 0.80, 1.92) compared with persons who lived at a distance of 600 m or more. There was a dose-response relation with respect to years of residence in the immediate vicinity of power lines and Alzheimer's disease: Persons living at least 5 years within 50 m had an adjusted hazard ratio of 1.51 (95% CI: 0.91, 2.51), increasing to 1.78 (95% CI: 1.07, 2.96) with at least 10 years and to 2.00 (95% CI: 1.21, 3.33) with at least 15 years. The pattern was similar for senile dementia. There was little evidence for an increased risk of amyotrophic lateral sclerosis, Parkinson's disease, or multiple sclerosis.

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# Papers

## Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study

Gerald Draper, Tim Vincent, Mary E Kroll, John Swanson

Editorial by  
Dickinson and  
p 1294

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BMJ 2005;330:1290-3

### Abstract

**Objective** To determine whether there is an association between distance of home address at birth from high voltage power lines and the incidence of leukaemia and other cancers in children in England and Wales.

**Design** Case-control study.

**Setting** Cancer registry and National Grid records.

**Subjects** Records of 29 081 children with cancer, including 9700 with leukaemia. Children were aged 0-14 years and born in England and Wales, 1962-95. Controls were individually matched for sex, approximate date of birth, and birth registration district. No active participation was required.

**Main outcome measures** Distance from home address at birth to the nearest high voltage overhead power line in existence at the time.

**Results** Compared with those who lived >600 m from a line at birth, children who lived within 200 m had a relative risk of leukaemia of 1.69 (95% confidence interval 1.13 to 2.53); those born between 200 and 600 m had a relative risk of 1.23 (1.02 to 1.49). There was a significant ( $P < 0.01$ ) trend in risk in relation to the reciprocal of distance from the line. No excess risk in relation to proximity to lines was found for other childhood cancers.

**Conclusions** There is an association between childhood leukaemia and proximity of home address at birth to high voltage power lines, and the apparent risk extends to a greater distance than would have been expected from previous studies. About 4% of children in England and Wales live within 600 m of high voltage lines at birth. If the association is causal, about 1% of childhood leukaemia in England and Wales would be attributable to these lines, though this estimate has considerable statistical uncertainty. There is no accepted biological mechanism to explain the epidemiological results; indeed, the relation may be due to chance or confounding.

### Introduction

The electric power system produces extremely low frequency electric and magnetic fields. Since 1979 there has been concern that these fields may be associated with cancer. Concern has concentrated on

magnetic rather than electric fields and on childhood leukaemia in particular. A pooled analysis of nine studies that met specified quality criteria found that children living in homes with 24 hour average fields of  $\geq 0.4 \mu\text{T}$  have twice the risk of leukaemia.<sup>1</sup> In 2001 the International Agency for Research on Cancer classified extremely low frequency magnetic fields as “possibly carcinogenic” on the basis of “limited” epidemiological evidence and “inadequate” evidence from animals.

Magnetic fields in homes arise mainly from low voltage distribution wiring, house wiring, and domestic appliances. Only a small fraction of homes are close to high voltage overhead power lines (transmission lines), but in these homes the power line is likely to be the main source of magnetic field.

It is not known which period of life, if any, is relevant to induction of cancer by magnetic fields. We investigated whether proximity of home address at birth to transmission lines in England and Wales is associated with increased risks of childhood cancer.

### Methods

#### Cases and controls

We identified nearly 33 000 cases of cancer in children born 1962-95 in England and Wales, diagnosed before age 15 years in England, Wales, or Scotland over the same period, from the National Registry of Childhood Tumours. We obtained birth information for just over 31 000 cases. For each case we selected from birth registers a control matched for sex, date of birth (within six months), and birth registration district. The final dataset comprised 29 081 matched case-control pairs (9700 for leukaemia) that we could map with respect to transmission lines.

#### Calculation of distance from power lines

We looked at overhead power lines forming the National Grid in England and Wales—that is, all 275 and 400 kV overhead lines (the highest voltages used) plus a small fraction of 132 kV lines. We obtained the grid references of all 21 800 pylons concerned. Using



This is the abridged version the full version is on [bmj.com](http://bmj.com)

*dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html*

## **EXECUTIVE SUMMARY OF THE CALIFORNIA EMF RISK EVALUATION FOR POLICYMAKERS AND THE PUBLIC**

### **WHY AND HOW THE EVALUATION WAS DONE:**

*On behalf of the California Public Utilities Commission (CPUC), three scientists who work for the California Department of Health Services (DHS) were asked to review the studies about possible health problems from electric and magnetic fields (EMFs) from power lines, wiring in buildings, some jobs, and appliances. The CPUC request for review did not include radio frequency EMFs from cell phones and radio towers. Reviewer 1, Vincent Delpizzo, Ph.D., is a physicist and epidemiologist; Reviewer 2, Raymond Richard Neutra, M.D., Dr.P.H., is a physician epidemiologist; and Reviewer 3, Geraldine Lee, Ph.D., is an epidemiologist with training in genetics. All three have published original research in the EMF area and have followed the field for many years. They were assisted in their reviews by DHS toxicologists, physicians, and epidemiologists.*

### **THE CONCLUSIONS AFTER REVIEWING ALL THE EVIDENCE:**

- *To one degree or another, all three of the DHS scientists are inclined to believe that EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage.*
- *They strongly believe that EMFs do not increase the risk of birth defects, or low birth weight.*
- *They strongly believe that EMFs are not universal carcinogens, since there are a number of cancer types that are not associated with EMF exposure.*
- *To one degree or another they are inclined to believe that EMFs do not cause an increased risk of breast cancer, heart disease, Alzheimer's Disease, depression, or symptoms attributed by some to a sensitivity to EMFs. However,*
- *All three scientists had judgments that were "close to the dividing line between believing and not believing" that EMFs cause some degree of increased risk of suicide, or*
- *For adult leukemia, two of the scientists are "close to the dividing line between believing or not believing" and one was "prone to believe" that EMFs cause some degree of increased risk.*

### **HOW AND WHY THE CONCLUSIONS DIFFER FROM THOSE OF OTHER RECENT REVIEWS:**

*While there are important differences between the three DHS reviewers' conclusions, the DHS scientists are more inclined to believe that EMF exposure increased the risk of the above health problems than the majority of the members of scientific committees convened to evaluate the scientific literature by the National Institutes of Environmental Health Sciences Working Group (NIEHS) in 1998, the International Agency for Research on Cancer (IARC) in 2001, and the British National Radiological Protection Board (NRPB) in 2001. These other committees all assessed EMFs as a "possible" carcinogen for childhood leukemia. Thus, like the DHS panel, these other three panels were not much swayed by theoretical arguments of physicists that residential EMFs were so weak as to make any biological effect impossible. NIEHS additionally assessed EMFs as a possible carcinogen for adult lymphoid leukemia and NRPB assessed a possible link with Lou Gehrig's Disease. The three DHS scientists differed in that they had a somewhat higher degree of belief that EMF is linked with these three diseases and gave credence to evidence of a link to adult brain cancer and miscarriage that the other panels either didn't consider or characterized as "inadequate." There are several reasons for these differences. The three DHS scientists thought there were reasons why animal and test tube experiments might have failed to pick up a mechanism or a health problem; hence, the absence of much*

support from such animal and test tube studies did not reduce their confidence much or lead them to strongly distrust epidemiological evidence from statistical studies in human populations. They therefore had more faith in the quality of the epidemiological studies in human populations and hence gave more credence to them.

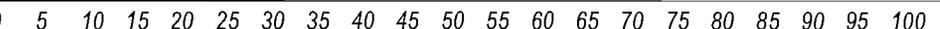
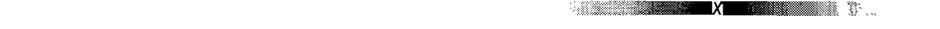
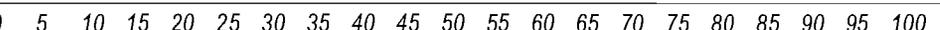
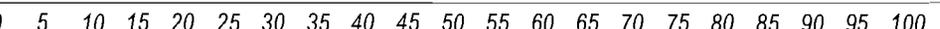
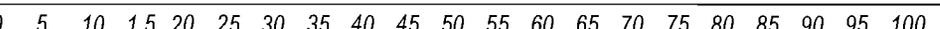
With the exception of miscarriage, which is common, the other diseases for which EMFs may be a contributing cause (childhood leukemia, adult brain cancer, Lou Gehrig's Disease) have low incidence, with rates between 1/100,000 and 1/10,000 a year. Even doubling such rates and accumulating them over a childhood or a lifetime leaves accumulated lifetime risks between 1/1,000 and 1%. Thus the vast majority (99%–99.9%) of highly exposed people would still not contract these diseases. Furthermore, calculations suggest that the fraction of all cases of the above-mentioned conditions that one could attribute to EMFs would be no more than a few percent of the total cases (if any). However, if EMFs do contribute to the cause of these conditions, even the low fractions of attributable cases and the size of accumulated lifetime risk of highly-exposed individuals could be of concern to regulators. Indeed, when deemed a real cause, estimated lifetime risks smaller than these (1/100,000) have triggered regulatory evaluation and, sometimes, actual regulation of chemical agents such as airborne benzene. The uncommon, accumulated high EMF exposures implicated by the evidence about these conditions come from unusual configurations of wiring in walls, grounded plumbing, nearby power lines, and exposure from some jobs in electrical occupations. There are ways to avoid these uncommon accumulated exposures by maintaining a distance from some appliances, changes in home wiring and plumbing, and power lines. However, to put things in perspective, individual decisions about things like buying a house or choosing a jogging route should involve the consideration of certain risks, such as those from traffic, fire, flood, and crime, as well as the uncertain comparable risks from EMFs.

While rodent and chicken egg studies provide little or no support for EMF effects, some studies on early-model higher emitting video display terminals (VDTs) and two new epidemiology studies in humans suggest that EMFs might cause a substantial proportion of miscarriages. Miscarriages are common in any case (about 10 per 100 clinically diagnosed pregnancies) and the theoretical added risk for an EMF-exposed pregnant woman might be an additional 10 per 100 pregnancies according to these two studies. If truly causal this could clearly be of concern to individuals and regulators. However, the type of EMF exposures implicated by these two new epidemiological studies (short, very high exposures) probably come from being within a few inches of appliances and unusual configurations of wiring in walls and grounded plumbing, and only rarely from power lines. Since the majority of people come into contact with non-obvious sources of these fields on a daily basis, it may not be possible to avoid the majority of such exposures in modern life, even if we avoided the obvious sources like some appliances.

Seventy-five percent of the women in the studies had at least one of these brief high exposures during a given day. Even one exposure a day, if experienced regularly during pregnancy, seemed to increase the risk of miscarriage. Nonetheless, the majority of pregnant women with such exposures did NOT miscarry.

**FOR PURPOSES OF POLICY ANALYSIS, HOW DID THE THREE SCIENTISTS EXPRESS THEIR JUDGMENT THAT THE ABOVE DEGREES OF RISK MIGHT BE REAL?**

The EMF Program's policy analysis required each of the three DHS scientists to express in numbers their individual professional judgments that the range of added personal risks suggested by the epidemiological studies were "real." They did this as a numerical "degree of certainty" on a scale of 0 to 100. For the conditions with the most suggestive evidence of EMF risk, the three scientists each came up with a graph that depicts their best judgments with a little "x" and the margin of uncertainty with a shaded bar. The differences in certainty between the three reviewers arises primarily from how sure they were that they could rule out study flaws or other explanatory agents and how much the evidence on one disease influenced certainty in the findings for other diseases.

CONDITION	REVIEWER	DEGREE OF CERTAINTY IN SOME AMOUNT OF ADDED PERSONAL RISK
CHILDHOOD LEUKEMIA (REVIEWED THE 19 EPIDEMIOLOGY STUDIES)	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 
	2	
	3	
ADULT LEUKEMIA (REVIEWED THE 43 EPIDEMIOLOGY STUDIES)	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 
	2	
	3	
ADULT BRAIN CANCER (REVIEWED THE 29 EPIDEMIOLOGY STUDIES)	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 
	2	
	3	
LOU GEHRIG'S DISEASE (ALS) (REVIEWED THE 7 EPIDEMIOLOGY STUDIES)	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 
	2	
	3	
MISCARRIAGE (REVIEWED THE 10 VDT, 3 ELECTRIC BLANKET, 2 PERSONAL EXPOSURE STUDIES)	1	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 
	2	
	3	

**WHAT ASPECT OF THE “EMF MIXTURE” WOULD NEED TO BE MITIGATED (IF ANY)?**

*A variety of electrical phenomena are present in the vicinity of power lines, in-home wiring, plumbing, and appliances. These include EMFs with a variety of frequencies and orientations, stray currents from contact with grounded plumbing, and air pollution particles charged by electric fields. The epidemiological studies primarily implicate the magnetic fields or something closely correlated with them. Some researchers think that associated high- or low- frequency stray contact currents or charged air pollution particles are the true explanation rather than magnetic fields. The actions one would take to eliminate the fields are not always the same as one would take to eliminate the currents or the charged particles. There are some situations where different costly measures would be required to address the above-mentioned three possible explanations. There are other situations where one or more inexpensive avoidance actions will address all three. This additional uncertainty about what aspect of the mixture might need to be mitigated will thus provide a challenge for policymakers. The California EMF program funded policy projects to explore options that could be pursued in the face of these uncertainties (see [www.dhs.ca.gov/ehib/emf](http://www.dhs.ca.gov/ehib/emf)). These are available to guide CPUC and other state agencies in policy formation. DHS is making no recommendations at this time.*

**WHAT RESEARCH GAPS EXIST?**

*Determining whether stray contact currents or charged air pollution particles are really common enough to explain the epidemiology would be highly policy relevant. Certain suggestive test tube and animal studies await replication. Epidemiology of common conditions which could be studied prospectively, like miscarriage and sudden cardiac death, would be policy relevant and could give a better understanding of what aspect of the EMF mixture might be biologically active.*

**NIEHS REPORT on**  
**Health Effects from Exposure to Power-Line**  
**Frequency Electric and Magnetic Fields**

Prepared in Response to the 1992 Energy Policy Act  
(PL 102-486, Section 2118)



National Institute of Environmental Health Sciences  
National Institutes of Health

Dr. Kenneth Olden, Director

Prepared by the  
NIEHS EMF-RAPID Program Staff

NIH Publication No. 99-4493

Supported by the NIEHS/DOE





## DEPARTMENT OF HEALTH &amp; HUMAN SERVICES

Public Health Service

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National Institutes of Health  
National Institute of  
Environmental Health Sciences  
P. O. Box 12233  
Research Triangle Park, NC 27709

May 4, 1999

Dear Reader:

In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act. The Congress instructed the National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health and the U.S. Department of Energy (DOE) to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to extremely low frequency electric and magnetic fields (ELF-EMF). The EMF-RAPID Program had three basic components: 1) a research program focusing on health effects research, 2) information compilation and public outreach and 3) a health assessment for evaluation of any potential hazards arising from exposure to ELF-EMF. The NIEHS was directed to oversee the health effects research and evaluation, and the DOE was given the responsibility for overall administration of funding and engineering research aimed at characterizing and mitigating these fields. The Director of the NIEHS was mandated upon completion of the Program to provide this report outlining the possible human health risks associated with exposure to ELF-EMF. The scientific evidence used in preparation of this report has undergone extensive scientific and public review. The entire process was open and transparent. Anyone who wanted "to have a say" was provided the opportunity.

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although sporadic findings of biological effects have been reported. No indication of increased leukemias in experimental animals has been observed.

The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results. The human data are in the "right" species, are tied to "real life" exposures and show some consistency that is difficult to ignore. This assessment is tempered by the observation that given the weak magnitude of these increased risks, some other factor or common source of error could explain these findings. However, no consistent explanation other than exposure to ELF-EMF has been identified.

Page 2

Epidemiological studies have serious limitations in their ability to demonstrate a cause and effect relationship whereas laboratory studies, by design, can clearly show that cause and effect are possible. Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between exposure to ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiological findings.

The NIEHS concludes that ELF-EMF exposure cannot be recognized at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In my opinion, the conclusion of this report is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

The interaction of humans with ELF-EMF is complicated and will undoubtedly continue to be an area of public concern. The EMF-RAPID Program successfully contributed to the scientific knowledge on ELF-EMF through its support of high quality, hypothesis-based research. While some questions were answered, others remain. Building upon the knowledge base developed under the EMF-RAPID Program, meritorious research on ELF-EMF through carefully designed, hypothesis-driven studies should continue for areas warranting fundamental study including leukemia. Recent research in two areas, neurodegenerative diseases and cardiac diseases associated with heart rate variability, have identified some interesting and novel findings for which further study is ongoing.

Advocacy groups have opposing views concerning the health effects of ELF-EMF. Some advocacy groups want complete exoneration and others want a more serious indictment. Our conclusions are prudent and consistent with the scientific data. I am satisfied with the report and believe it provides a pragmatic, scientifically-driven basis for any further regulatory review.

I am pleased to transmit this report to the U.S. Congress.

Sincerely,

Kenneth Olden, Ph.D.  
Director

# EXECUTIVE SUMMARY

## Introduction

Electrical energy has been used to great advantage for over 100 years. Associated with the generation, transmission, and use of electrical energy is the production of weak electric and magnetic fields (EMF). In the United States, electricity is usually delivered as alternating current that oscillates at 60 cycles per second (Hertz, Hz) putting fields generated by this electrical energy in the extremely low frequency (ELF) range.

Prior to 1979 there was limited awareness of any potential adverse effects from the use of electricity aside from possible electrocution associated with direct contact or fire from faulty wiring. Interest in this area was catalyzed with the report of a possible association between childhood cancer mortality and proximity of homes to power distribution lines. Over the next dozen years, the U.S. Department of Energy (DOE) and others conducted numerous studies on the effects of ELF-EMF on biological systems that helped to clarify the risks and provide increased understanding. Despite much study in this area, considerable debate remained over what, if any, health effects could be attributed to ELF-EMF exposure.

In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act (PL 102-486, Section 2118). The Congress instructed the National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health and the DOE to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to ELF-EMF. The EMF-RAPID Program had three basic components: 1) a research program focusing on health effects research, 2) information compilation and public outreach and 3) a health assessment for evaluation of any potential hazards arising from exposure to ELF-EMF. The NIEHS was directed to oversee the health effects research and evaluation and the DOE was given the responsibility for overall administration of funding and engineering research aimed at characterizing and mitigating these fields. The Director of the NIEHS was mandated upon completion of the Program to provide a report outlining the

possible human health risks associated with exposure to ELF-EMF. This document responds to this requirement of the law.

This five-year effort was signed into law in October 1992 and provisions of this Act were extended for one year in 1997. The Program ended December 31, 1998. The EMF-RAPID Program was funded jointly by Federal and matching private funds and has been an extremely successful Federal/private partnership with substantial financial support from the utility industry. The NIEHS received \$30.1 million from this program for research, public outreach, administration and the health assessment evaluation of ELF-EMF. In addition to EMF-RAPID Program funds from the DOE, the NIEHS contributed \$14.5 million for support of extramural and intramural research including long-term toxicity studies conducted by the National Toxicology Program.

### **NIEHS Conclusion**

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although sporadic findings of biological effects (including increased cancers in animals) have been reported. No indication of increased leukemias in experimental animals has been observed.

The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results. The human data are in the "right" species, are tied to "real-life" exposures and show some consistency that is difficult to ignore. This assessment is tempered by the observation that given the weak magnitude of these increased risks, some other factor or common source of error could explain these findings. However, no consistent explanation other than exposure to ELF-EMF has been identified.

Epidemiological studies have serious limitations in their ability to demonstrate a cause and effect relationship whereas laboratory studies, by design, can clearly show that cause and effect are possible. Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between exposure to ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this

association is actually due to ELF-EMF, but it cannot completely discount the epidemiological findings.

The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

The interaction of humans with ELF-EMF is complicated and will undoubtedly continue to be an area of public concern. The EMF-RAPID Program successfully contributed to the scientific knowledge on ELF-EMF through its support of high quality, hypothesis-based research. While some questions were answered, others remain. Building upon the knowledge base developed under the EMF-RAPID Program, meritorious research on ELF-EMF through carefully designed, hypothesis-driven studies should continue for areas warranting fundamental study including leukemia. Recent research in two areas, neurodegenerative diseases and cardiac diseases associated with heart rate variability, have identified some interesting and novel findings for which further study is ongoing.

## **Background**

### *Program Oversight and Management*

The 1992 Energy Policy Act created two committees to provide guidance and direction to this program. The first, the Interagency Committee (IAC), was established by the President of the United States and composed of representatives from the NIEHS, the DOE and seven other Federal agencies with responsibilities related to ELF-EMF. This group receives the report from the NIEHS Director and must prepare its own report for Congress. The IAC had responsibility for developing a strategic research agenda for the EMF-RAPID Program, facilitating interagency coordination of Federal research activities and communication to the public and monitoring and evaluating the Program.

The second committee, the National EMF Advisory Committee (NEMFAC), consisted of representatives from public interest groups, organized labor, state governments and industry. This group was involved in all aspects of the EMF-RAPID Program providing advice and critical review to the DOE and the NIEHS on the design and implementation of the EMF-RAPID Program's activities.

## Background Paper on "Power Line Fields and Public Health"

March 29, 1996

To: Panel on Public Affairs, American Physical Society

From: David Hafemeister  
Physics Department  
California Polytechnic State University  
San Luis Obispo, CA 93407  
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Re: Background Paper on "Power Line Fields and Public Health"  
(an update of the May 8 and Dec. 15, 1995 papers)  
(Sec. I and VIII published, Amer. J. Physics 64, 974-981 (1996))

- I. Introduction.
- II. Summary and Conclusions.
- III. Review of ELF/EMF Reviews and Responses.
- IV. Epidemiology and Cancer Data.
- V. Biological and Biophysics Experiments.
- VI. Theoretical Mechanisms.
- VII. Prudent Avoidance and Mitigation Costs.
- VIII. Selected Bibliography

### I. Introduction.

This paper has been reviewed in draft by ELF/EMF researchers, by POPA, by the American Journal of Physics (Sec. I and VIII) and by others, but its contents are the sole responsibility of the author. Comments appreciated.

The interaction of electric and magnetic (EM) fields with matter has been studied by physicists for over a century. Calculations based on the classical equations of Maxwell and the equations of quantum mechanics have long been used to estimate the strengths and characteristics of the EM interactions with condensed matter, molecules, atoms and particles. Experiments have shown that these equations successfully represent the interactions, thus allowing physicists to use these interactions to investigate the basic properties of matter. The bibliography in this

Resource Letter will extend this subject matter into the region of 50 Hz (European) and 60 Hz (U.S.), the extremely-low-frequency electromagnetic fields (ELF/EMF) interacting with biological matter.

Physicists are often asked about the potential health hazards of ELF/EMF. In 1979, an epidemiology study by N. Wertheimer and E. Leeper reported an enhanced rate of leukemia for children living near 60-Hz electrical power lines in Denver, Colorado. This study catalyzed the wide-spread opinion that it is dangerous to live near electrical power lines. However, this study has been widely criticized inasmuch as the assignments of wire configurations (type of nearby power lines) to residences were made subjectively and with the investigators' knowledge as to whether an afflicted child or control had lived there. Furthermore, cumulative data on childhood leukemia has been inconsistent and inconclusive, considered by some to suggest only a weak association with ELF/EMF. By late 1995 there were well over 100 published epidemiological studies in the general scientific literature. These studies fueled public concerns about the possibility that ELF/EMF can promote cancer. In response to this concern, many disciplines are carrying out wide-ranging research programs to determine if there is a positive linkage between ELF/EMF and cancer. In 1991, Congress asked the National Academy of Sciences/National Research Council (NAS/NRC) to evaluate the literature on possible health effects of ELF/EMF. The Academy is expected to report its results in 1996. In addition, the 1992 Energy Policy Act established a \$65 M five-year program on ELF/EMF research, which is being reviewed by the NAS/NRC. A much longer version of this paper can be obtained at <http://www.calpoly.edu/~dhafemei>.

#### ELF/EMF Source Terms

Since the 5,000 km wavelength of 60-Hz radiation is much larger than the relevant distances from power lines and appliances, the nonradiative, near-field terms are considerably larger than the radiative terms. In practice, only 1 milliwatt is radiated from a 10 km section of a 60 Hz, 500 MW power line which is only  $10^{-12}$  of the transmitted power. To a very good approximation the electric field from a power line is determined from its charge distribution (or its voltage) from Gauss's law while the magnetic field is determined from the current flow with Ampere's law. Since power lines have opposing, separated currents, the electric and magnetic dipole moments per unit length produce EM fields that diminish as the inverse square of the distance.

Several state regulations limit the fields from transmission lines to about 10 kV/m for the E fields and about 200 mG for B fields. (The mG unit is the standard unit for most U.S. regulations and publications in this area. For SI units, 1 microT = 10 mG, 1 T = 10,000 Gauss.) Some city regulations seek to constrain B fields to less than 2 mG, a

direction that is supported at the national level by those who believe there are harmful biological effects. There are public guidelines for ELF/EMF at 1000 mG because pacemakers can exhibit abnormal pacing characteristics in 60 Hz fields above that threshold and because of induced body currents.

A typical U.S. home has the Earth's constant magnetic field of about 450 mG and a 60-Hz background magnetic field level (primarily not from power lines) that ranges from 0.5 mG to 4 mG with an average value of 0.9 mG. Five percent of the homes have fields above 2.9 mG, and 1% are above 6.6 mG. For comparison sake, one study reports that electrical powerline workers experience an average field of 11 mG. Typical transmission power lines produce average fields at distances of 30 and 60 meters as follows:

	E (V/m at 30/60 m)	B (mG at 30/60 m)
115 kV	0.07/0.01	1.7/0.4
230 kV	0.3/0.05	7.1/1.8
500 kV	1.0/0.3	12.6/3.2

As a simple example, a two wire 500 MW transmission line at 500 kV draws 500 amperes in opposing directions in the two wires. From Ampere's law a single wire of 500 A produces a field of 33 mG at a distance of 30 m. If two opposing currents of 500 A are separated by 4 meters, the field will be 4.4 mG (in the plane of the wires). By reducing the separation to 1 m, the field falls to 1.1 mG. At a doubled distance of 60 m, the field from the single conductor is 17 mG and the fields from the paired conductors are 1.1 mG for a 4-meter separation and 0.3 mG for 1-meter separation. Motor and appliance electrical coils produce either magnetic dipole or quadrupole fields that diminish as the inverse square or cube of the distance, respectively. Average fields at a distance of 30 cm are: color television (7 mG), microwave (4 mG), analog clocks (15 mG), electric razors (20 mG, 100 mG at 15 cm) and hair driers (1 mG, 300 mG at 15 cm).

### Electric Fields in Biological Matter

E fields are greatly reduced in biological matter from their values in air external to the body. Since the boundary conditions on Maxwell's equations require the real current density in the body to almost equal the displacement current density outside the body, the 60-Hz electric field from a power line is diminished by seven to eight orders of magnitude inside the human body. This factor reduces the maximum allowable E field of 10,000 V/m at the edge of the right-of-way of a power line to an internal electrical field of only  $10^{-3}$  to  $10^{-4}$  V/m. A smaller 60-Hz E field of 100 V/m, the same magnitude as the earth's surface field, will produce an E field in the body of about  $10^{-5}$  to  $10^{-6}$  V/m. These values of internal E fields should be compared to the

internal field in the human body from thermally driven charge-density fluctuations in the human body. Since the E field from the charge of a proton at ten Bohr radii is a very considerable  $6 \times 10^{+9}$  V/m, it is not surprising that fluctuations in the electric dipolar fields from Brownian motion can contribute meaningfully. Thermal fluctuations in the electrolyte of the biological resistors cause E-field fluctuations that appear as voltage fluctuations. Estimates of the Johnson-Nyquist noise voltages give root-mean-square average E-field fluctuations of about  $2 \times 10^{-2}$  V/m within the electrolyte of a 20 micron cell. The fluctuating E fields in the electrolyte are considerably larger than the internal fields of  $10^{-6}$  to  $10^{-3}$  V/m from power lines.

Since cellular membranes have a much higher electrical resistance than the electrolyte between the cells, there is considerably less current flow through the cellular membranes from external sources. The potential across a cellular membrane is about 50 millivolts. Since the thickness of a cellular membrane is only 5-10 nm, very large E fields of about  $10^7$  V/m are produced in the membrane. Thermal fluctuations in the membrane are of the order of a microV, considerably less than the potentials of 50 mV across the membrane. As in the case of the cellular electrolyte, the noise fields in the cellular membranes are considerably larger than the ELF E fields induced in the membranes.

If there were any health problems from EM fields, it is generally believed that the B fields, and not the E fields, would be the cause of health problems because the E field is effectively shielded by the human body while the B field is not shielded.

### Electric Fish

Some animals have specialized organs to sense weak EM fields, a fact that is not relevant to potential health effects. Electric rays and electric eels produce very large electric discharges. The freshwater electric eel whose body is mostly an electric organ generates stunning 2 msec pulses of one ampere at 500 volts, for a peak power of almost 500 watts and an energy of one Joule per pulse. Whereas these pulsed fields have a low duty cycle, some freshwater fish produce continuous electric fields with amplitudes on the order of 10 V/m, frequencies from DC to 10 kHz, and power on the order of 10 mW. These so called weakly-electric fish sense their environment and communicate by modulating and detecting modulations in the electric current through their skin.

Sharks can detect external fields of less than 1 microV/m at frequencies of the order of 1 Hz with their long electric sensing organs, the Ampullae of Lorenzini. As the shark crosses the earth's B field lines, the Lorentz force induces electric fields in the ampullae that the shark detects and uses for navigation. Sharks also locate prey by sensing

electric fields emanating from the prey's muscles and nerves during respiration and movement. Some amphibians, salamanders, and even a mammal, the duck-billed platypus, possess low-frequency electric sensory systems used for detecting weak electric fields generated by their prey's muscle activity. Electrosensory systems are not found in terrestrial animals because the high impedance of air attenuates the electric current and power in the electrostatic field to below detectable levels. At the other end of the spectrum, it takes strong E fields of the order of 10,000 V/m to give humans a tactile sensation, by torquing body hairs that become polarized as they attract static electric charges.

### Magnetic Fields in Biological Matter

Power line magnetic fields are often constrained by "prudent avoidance" to about 200 mG at the edge of a right-of-way, but in practice they are usually less than 2 mG for those living near power lines. By applying Faraday's law to this range of 2-200 mG, one obtains E fields of between 4-400 microV/m. These values are considerably less than the natural Johnson-Nyquist E fields of 0.02 V/m.

Walking in the earth's magnetic field of about 400 mG produces "electromotive force" voltages from Faraday's law. Walking in a constant magnetic field does not generate currents, but it is interesting to calculate the E fields generated by walking. By moving very slowly at the rate of 0.1 m/s, an internal E field of 4 microV/m is developed (corresponding to 2 mG of ELF/EMF). If one runs very fast at 8 m/s (18 mph), an internal E field of 400 microV/m is developed (corresponding to 200 mG).

Rotations (or twirling) of the human body in the Earth's magnetic field of about 400 mG creates radial electric fields, giving rise to currents in the human body. A tilt of the head of 45 degrees in the slow time of 1.6 seconds will create an electrical field of 4 microV/m, corresponding to a 60-Hz field of 2 mG. A fast nod in 0.16 seconds creates an electric field of 40 mV/m, corresponding to a 60-Hz field of 40 mG.

### Biogenic Magnetic Materials

Some bacteria have tightly coupled chains of single domain, superparamagnetic magnetosomes, magnetite ( $\text{Fe}_3\text{O}_4$ ) or greigite ( $\text{Fe}_3\text{S}_4$ ) particles, that allow them to magnetically navigate vertically to find food. Chains of many magnetite grains, 50 nm on a side, have been observed in these bacteria. Because the magnetic interaction of these bacterial magnetic chains in the Earth's magnetic field is many times the thermal energy, the bacteria maintain their orientation with respect to the Earth's magnetic field. Since the magnetosome dipole relaxation times are much longer than 1/60 second in water in the earth's magnetic

field, the bacteria do not oscillate significantly in 60-Hz fields.

Honey bees navigate by observing changes as small as 0.6% in the Earth's magnetic field (2.5 mG out of 400 mG). Other studies have shown that other animals, such as sea turtles and homing pigeons, can navigate using the Earth's magnetic field as a guide. In order to navigate to precision, it is necessary to have many magnetosomes with a permanent dipole moment which are able to maintain their direction in the Earth's magnetic field while being buffeted by Brownian thermal fluctuations.

Small magnetite crystals with average diameters of 33 nm, in some cases 200 nm, have been reported (but the work has not yet been replicated) in the human brain by using transmission electron microscopy. The level of magnetite is very low, of the order of one part in  $10^9$  of the mass of the brain, much less than the magnetite fraction in magnetic bacteria of about 1%. It has not been shown that these magnetic particles are relevant for ELF/EMF and public health. If the magnetosomes are too small, they lack the ability to strongly torque in a weak magnetic field at 60 Hz. If the magnetosomes are large, the magnetite becomes multidomained, and the increased viscous torques dominate. In order to enhance this magnetic interaction it would be necessary to have very long chains of magnetosomes within a cell (which has not been observed) acting coherently. Calculations show that for fields less than 50 mG, viscosity damps out the induced oscillations to amplitudes less than those from thermal fluctuations. It has been conjectured that the large magnetic fields of a magnetosome next to a cell might affect the flux of calcium ions through its membrane, but this should not be influenced significantly by weak 60-Hz magnetic fields.

### Stochastic Resonance and Squared Dependence

Under certain circumstances, the addition of a small amount of input noise to a larger input signal can greatly increase the output signal and the output signal-to-noise ratio. The phenomena has been labeled "stochastic resonance" though the process does not involve ordinary resonance. Such stochastic-resonance enhancements have been observed in the mechanoreceptor hair cells of cray fish. It is highly speculative to connect stochastic resonance to predict enhanced ELF/EMF sensitivity in biological matter. Since the addition of a small input signal to a larger input noise does not result in an increased output signal-to-noise ratio, it would not seem that the stochastic resonance phenomena would enhance ELF/EMF sensitivity in biological matter.

Both the EM torque and force are proportional to the first power of the oscillating EM fields. Since the time average of a sine wave is zero, the average energy imparted to a system over many oscillations cannot be proportional to the first power of E or B. Since the time average of the

sine squared is nonzero, the projected biological effects would be expected to be proportional to the square of the oscillating fields ( $E^2$  or  $B^2$ ). This does not rule out a linear dependence for the case of constant or quasi-DC fields as observed at 1-2 Hz for sharks and bees. Since human epidemiology data do not show consistent, meaningful associations with cancer for those living in very high field regions, such as sleeping under electric blankets, working on electrical power lines, or working on electric railways, a squared dependent relationship has not been demonstrated.

### Radon Near Power Lines

Henshaw, et al. (reference 38) report that naturally occurring radioactive daughters of radon are enhanced near power lines. After the daughters attach themselves to aerosols, the neutral aerosols are attracted by the gradient of the E-field towards the power line. Because the contaminated aerosols oscillate with the power frequency, they would tend to plate out more frequently on the skin. The aerosols containing the radioactive radon daughters would also be inhaled into the lungs in a strong enough concentration to cause cancer.

Detractors of this theory respond as follows: Radon concentrations in open air near power lines are very slight. The half-lives of the radon daughters are relatively short, thus making the transition to humans at a distance problematical. Some epidemiology data shows an association with magnetic fields, but essentially none show an association with electric fields. Residences beyond the right-of-way of power lines do not have considerable elevated electric fields. One would expect enhanced lung cancer which is not reported in excess near power lines, rather than the usual suspects of leukemia and brain cancer. Lastly, one would expect the radioactive aerosols to plate out on the power lines or on the skin in comparison to lung deposition.

### Cancer Mechanisms

Chemicals, such as unburned carbon, and EM radiation at frequencies above the visible region have sufficient energy to directly initiate cancer. Visible light breaks bonds in the process of photosynthesis but is not usually suspected of causing cancer. The energy of a hydrogen bond is about 0.1 eV and that of a carbon-carbon single covalent bond is 3.6 eV. The photon energy from 60-Hz radiation of  $2.5 \times 10^{-13}$  eV is, of course, insufficient to directly break chemical bonds. Thus, new interaction mechanisms would have to be proposed to predict possible health problems from ELF/EMF. It is known that very large EM fields affect membrane permeability and the recombination of ion radicals.

Cancer can be initiated by direct damage to the genetic material of cells (genotoxicity), or it can be promoted by increasing the probability that a genotoxic exposure will cause cancer (epigenetic activity or promotion). Direct cancer effects are exemplified by the breaking of chemical bonds in DNA, while indirect effects could promote the likelihood, severity or speed that cancer might be caused once the DNA bonds had been broken. It is conjectured that ELF/EMF could supply currents, torques, or forces in the body that could enhance the risk of cancer, such as the reduction of melatonin from the pineal gland from the action of ELF/EMF on magnetite in the brain. Or, ELF/EMF could be part of a multistep biological process. In order to clearly establish these conjectures, it is necessary to demonstrate a meaningful combination of positive findings from epidemiology and biomedical-biophysical experiments, which are consistent with a theoretical biophysical mechanism. The stronger the evidence from epidemiology, the lesser the requirement to have a consistent theoretical mechanism in order to take a public policy position, but conversely, weak epidemiology evidence should be treated with great caution.

## Epidemiology

By 1995 over 100 additional epidemiological studies have examined various possible associations between public health and ELF/EMF from power lines, appliances and other devices. Most of this literature is concerned with the power-line frequencies of 50 Hz and 60 Hz and magnetic fields in the region of 1-10 mG. Scientific review panels have generally concluded that the combined data show at best a weak association with ELF/EMF and at worst that the findings are mutually inconsistent and inconclusive. Epidemiology examines disease and health in human populations by identifying associations between the occurrence of human diseases and the possible causes of those disease. Because epidemiology searches for correlations between a particular disease and environmental or other factors, it does not directly prove causality because there can be other explanations for correlations. However, when there is, for example, a very strong association between cancer and exposure, such as a strong linear correlation between the amount of additional cancer and the rate of smoking, the epidemiology data and the fact that the smoke contains known carcinogens are considered as the proof of causality. On the other hand, the association between cancers for non-smoking family members and the rate of smoking in the home is quite weak. This epidemiology data has been accepted by the regulatory process as significant because of the strength of the other evidence (experiments and mechanisms). The tobacco industry and others consider this conclusion as political, based on weak data.

Because less than robust epidemiology data can be misinterpreted, Sir Austin Bradford Hill in his Presidential Address to the Section of

Occupational Medicine at the Royal Society of Medicine (U.K.) presented a list of suggested criteria by which to judge whether an association was indeed causal. The criteria list is not necessarily all-encompassing, but it gives very useful benchmarks:

1. Strength: Is there a strong correlation between disease and ELF/EMF fields?
2. Consistency: Have the same results been obtained by different researchers in different locations?
3. Specificity: Does ELF/EMF produce the same types of cancer in similar proportions to other groups similarly exposed?
4. Temporality: Since there is a latency period for cancer, are the measurements of ELF/EMF in the present the same as in the past?
5. Biological Gradient: Do higher "doses" of ELF/EMF cause more cancer than lower doses? Is there an approximate proportionality of risk and dose, as in the case of the probability of additional lung cancer and the number of cigarettes smoked per day?
6. Plausibility: Does the biological data on conjectured cancer promotion by ELF/EMF converge on a plausible, consistent biological-biophysical mechanism?
7. Coherence: One should expect coherence between the data and the mechanism. In general, most mechanisms that attempt to connect ELF/EMF and cancer would predict that enhanced exposures of ELF/EMF would enhance cancer rates.
8. Experiment: Are the various in-vitro (cells in culture) and in-vivo (complete living systems) experiments consistent among themselves and with a theoretical mechanism?
9. Analogy: Is the connection between ELF/EMF and cancer analogous to situations where the proof is more substantial. Does one have to have "new" physics to understand this connection?

Review panels have concluded that Hill's criteria do not lead to a link between ELF/EMF and cancer. The scientific panels that have reviewed the ELF/EMF epidemiology data have separated the results by the type of cancer. For example, recently three studies of ELF/EMF on electrical workers have appeared. The 1993 California study reported no association with either leukemia or brain cancer. The 1993 Canadian-French study reported an association with leukemia and astrocytoma, out of the 32 cancer types studied. Because these studies do not make corrections for multiple comparisons, one would expect a study of this many different types of cancer to produce 1 or 2 "significant" correlations even if there were no real associations, that is 1 or 2 "false positives." (In addition, this study suffers from internal inconsistencies.) By contrast, the 1995 Savitz/Loomis study reported no association with leukemia, but they reported an association with brain cancer with weak statistics.

For these epidemiology studies, it is necessary to estimate the individual ELF/EMF doses. In the best epidemiological experiments, the magnetic doses have been measured for the electrical workers, but there are limits to these estimates. It is unclear whether the exposure metric should be the product of magnetic field strength times the duration of exposure, or proportional to the square of the field as dictated by basic physics (neglecting nonlinear cellular mechanisms), the direction and magnitudes between ELF and Earth B fields, or the harmonic content, or a frequency window.

### Biophysics and Medical-Physics Experiments

Many types of experiments have been carried out to examine the possible interaction of ELF/EMF and biological matter, such as: (a) direct effects (heating, induced electric current, energy of charged molecules, excitation of molecules, changes in membrane potential); (b) direct forces on electric charges or electric moments; (c) resonant interactions (ion cyclotron or paramagnetic resonance); (d) torques on magnetic moments; (e) free-radical chemistry; (f) temporal average or spatial intensification of weak ELF/EMF waves. There have been many positive and negative findings from in-vivo and in-vitro experiments with ELF/EMF. Usually the researchers with positive findings do not claim a causal connection between cancer and ELF/EMF, but rather that the data is part of the findings that might make such a connection possible. The scientific review panels and review articles have pointed out the continuing problem with replicating experimental results on cells and animals. This failure to find positive links between ELF/EMF and cancer is consistent with those who say that such health effects should be very unlikely because ELF/EMF forces ( $10^{-10}$  pN at 100 mG) are much less than both typical biological forces (5 pN myosin muscle molecules) and background forces from thermal oscillations ( $10^{-9}$  pN). Because biological systems are very complex, this argumentation cannot be considered to be a sufficient proof of no health effects, but it is a very strong guideline.

### Mitigation, Litigation, Regulation, and Cost/Benefit

In a rational world, risks to human life would be reduced by prioritized spending on mitigation that ranked all the choices in terms of money per life saved (or money per year of life-saved), including estimates for benefits to the natural world. Since the ELF/EMF issue should be joined with other risks in society, it is useful to conclude with some broader topics. Thus, society is concerned with relative rates of risk reduction and costs of mitigation. Cost estimates by the U.S. General Accounting Office for ELF/EMF mitigation from power lines, not covering appliances, have been substantial. Some of GAO's estimates are: \$2 million/mile to bury transmission lines in fluid-filled steel pipes to reduce magnetic fields by 99%, \$200 billion to bury transmission lines nationwide near

homes with fields greater than 1 mG, \$250 billion to reduce average exposure to less than 2 mG from all transmission and distribution lines. After an examination of the data described in this review, in 1995 the American Physical Society concluded: "No plausible biophysical mechanisms for the systematic initiation or promotion of cancer by these power line fields have been identified. Furthermore, the preponderance of the epidemiological and biophysical/biological research findings have failed to substantiate those studies which have reported specific adverse health effects from exposure to such fields. While it is impossible to prove that no deleterious health effects occur from exposure to any environmental factor, it is necessary to demonstrate a consistent, significant and causal relationship before one can conclude that such effects do occur. From this standpoint, the conjectures relating cancer to power line fields have not been scientifically substantiated."

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## II. Conclusions.

II.1. General Conclusion: The scientific literature and the reports of review panels show no consistent, significant link between cancer and the 60-Hz ELF fields. This literature includes epidemiology studies, research on biological systems, and the analyses of theoretical mechanisms. This result is consistent with those that have advanced arguments that there can be no such link. The preponderance of the epidemiology and biophysical/biological research findings have failed to substantiate those studies that have reported specific adverse health effects from the exposure to 60-Hz ELFs. It is always possible that some minor carcinogenic connection might be found, but the present data do not establish that connection. For expenditures for mitigation to be justified, there should be some consistent, meaningful combination of the following factors: (a) A plausible coupling mechanism at the cellular level exists, (b) the coupling must produce consistent biochemical changes, (c) the biochemical changes must be detrimental, (d) meaningful epidemiology data should determine the degree of danger, and finally, (e) upper-bound ELF mitigation costs should be comparable to those for other dangers mitigated in society. For cases where the epidemiology association is very strong, then clearly the other criteria are less important. For cases where the epidemiology association is weak, then clearly the other criteria must be considered. The current cost of ELF is more than a billion dollars a year, an amount which clearly cannot be justified on the basis of applying the above criteria to the data. This cost has been driven by the combination of unlimited "prudent avoidance" in a fearful society.

II.2. Reviews of the ELF Data (Sec. III). None of the approximately dozen scientific panels that have carried out comprehensive reviews of the data has concluded that there is an established link ELF and cancer.

II.3. Epidemiology (Sec. IV): The scientific panels that have reviewed the ELF epidemiology data have found them inconsistent and inconclusive. It is necessary when comparing the data to separate the results by cancer type. For example, consider the recent case of three studies of electrical workers and a fourth study of non-electrical workers in Sweden. The 1993 California study reported no association of EMF with either leukemia or brain cancer while the 1993 Canadian-French study reported an increase in leukemia, and a modest association of ELF with brain cancer. The 1995 Savitz/Loomis study reported no association of ELF with leukemia, but they did report an association with brain cancer. The 1993 Swedish study reported an association of ELF with leukemia, but they did not report an association with brain cancer. Thus, these four "best studies" report very contradictory results. One has to look at the Savitz/Loomis data in Sec. IV.4 to gain some understanding for the statistics involved in making these judgments. It is very difficult to statistically determine relative risk factors of less than two for rare modes of death because of the many confounding factors.

II.4. Biology and Biophysics Experiments (Sec. V): The scientific review panels, the review articles, and the research papers that we have investigated do not claim a causal link between ELF and cancer. In addition, the review panels and review articles have pointed out that there is a large problem with replicating the experimental results.

II.5. Theoretical Mechanisms (Sec. VI): No plausible biophysical mechanism for the systematic initiation or promotion of cancer by these extremely weak ELF's has been identified. The lack of epidemiology evidence and experimental evidence establishing a link between ELF and cancer is consistent with the biophysical calculations that rule out the carcinogenic effects because the thermal noise fields are larger than the fields from ELF. Since quantum mechanics, thermal noise fluctuations, and cancer promotion are all statistical effects, it is difficult to derive a proof that is a necessary and sufficient condition to preclude all cancer promotion. However, these fundamental calculations are a significant guide post to conclude that the ELF-cancer link, if any, should be extremely difficult to detect because of its small, if any, magnitude.

II.6. Prudent Avoidance (Sec. VII.1): Spending considerable funding to mitigate ELF under the guidance of "Prudent avoidance" would make sense if the ELF risk was documented and some measure of cost-effectiveness could be determined. This is not the case for the alleged adverse effects from ELF/EMF. Since prudent avoidance does not place a limit on

mitigation costs, it allows fear to propel society's institutions to spend more than \$1 billion per year (Florig. Bromley states a \$23 billion total by 1993). Prudent avoidance runs counter to the prioritization of spending on a cost-effectiveness basis. In normal courtroom practice, the plaintiff has the burden to prove damages or risks in order to obtain action from the society, and it should be in the ELF case as well. The misused, quasi-legalistic, prudent avoidance concept essentially states to the public that there is a likely possibility of danger to them and that we should begin to spend money to mitigate the risk, if any.

II.7. Who will speak on the ELF issue? The study of ELF has become a multidisciplinary effort and therefore many different professional voices are needed to comment on this issue. Thus, the National Academy of Sciences (NAS/NRC) is examining the ELF issue. Unfortunately, the NAS/NRC will only assess whether there is a health risk from ELF without consideration of economics. If the conclusions of this paper are correct, one would assume that the NAS/NRC will conclude that the ELF risk has not been proven. However, because one cannot prove there is no risk, there will be uncertainties and the final answer can only establish an upper limit, D, on risk. Since the NAS will not address the cost for mitigation, the upper bound error bar (D) can be used as an argument for mitigation funding. Clearly, a broader approach is needed. Because physicists have worked on many aspects of this multidisciplinary topic, our views are relevant, and consistent with those of the American Medical Association and others. In exploring this issue, I have learned that many ELF-researchers would not be troubled if we had a statement that stated the simple concepts of (1) don't scare society with ELF, (2) don't spend billions to mitigate. On April 22, the American Physical Society passed on "Power Line Fields and Public Health" (available at this [www](#) site).

II.8. Journalism: The number of newspaper stories on ELF rose from 233 in 1992 to 548 in 1993 (S. Friedman, Quill, Jan. 1995). The number of magazine stories rose from 101 in 1992 to 216 in 1993. The writings of P. Brodeur have been followed with headlines of "Is My Electric Blanket Killing Me" to "Chilling Possibility: That A Power That Has Improved Life Could Also Destroy It" to "Warning: Electricity Can be Hazardous to Your Health." Even when an article is even-handed, the caption at the top read, "Steps to Protect Yourself from Danger -- Real and Potential."

"Epidemiology, the Press and the EMF Controversy" by D. Wartenberg and M. Greenberg (Public Understanding Sci 1, 382-394, 1992) conclude that the press has not evaluated investigators claims, nor have they put risks in context. My conclusion is that the science and relative risk methodology of ELF/EMF often undercut the quality of journalism in a free and fear-prone society.

### 3.5 What Do the Occupational Studies Say?<sup>7</sup>

The following studies show, in most cases, a relationship between EMFs and cancer among electrical and telephone workers. Office workers, although not included in these studies, are exposed to the same 60 Hz EMFs as are electric and telephone workers.

Year	Researchers	Workers Studied	Conclusions
1985	Neal Pearce Wellington School of Med., NZ	Study of electrical workers	Found an increased risk of leukemia among electricians and radio and television repairers and assemblers in New Zealand.
1987	Terry Thomas National Cancer Institute	Study of electrical workers	Found an increased risk of brain cancer, but not as a result of their EMF exposure. When he removed those cases which had been exposed to lead, soldering fumes, and organic solvents, the risk for brain cancer among the remaining workers was much less than that for the general population.
1989	Genevieve Matanowski Johns Hopkins University	Studied dose response relationship for cancers in male NY telephone workers (cable splicers, central office workers, installation and repair) 1976-1980	Cable splicers were nearly twice as likely to contract all types of cancer as company workers who did not work on telephone lines. Risks for leukemia and lymphoma were particularly high. Central office workers exposed to peak fields from switching equipment were more than 3 times as likely to get prostate cancer and more than 2 times as likely to get oral cancer as coworkers who were less exposed. Two cases of male breast cancer were found.
1990	Susan Preston-Martin Wendy Mack U. Southern Cal.	Study of workers in various electrical jobs	Found that men who worked for 10 years or more in a variety of electrical occupations had a 10 times greater chance of getting brain cancer.
1990	Joe Bowman U. Southern Cal.	Dose response analysis of Pearce study	Measured average magnetic field exposures for various occupations in Pearce study and found no dose response. Welders, for example, had the highest exposure to EMF but no leukemia cases.
1990	David Thomas Hutchinson Cancer Research Institute, Seattle	Study of 250 male breast cancer patients	Found strong correlation with jobs that involved exposure to EMFs. Men whose jobs involved some exposure were nearly twice as likely to have breast cancer as men with no exposure. Men with the highest exposure--electricians, utility linemen, power workers--had 6 times the risk of developing breast cancer as workers with no exposure.
1992	Brigitta Floderus NIOH, Sweden	Study of male workers	Found that men exposed to similar levels of magnetic fields at work had three times the expected incidence of chronic lymphocytic leukemia (CLL).

<sup>7</sup> This factsheet is based on information contained in a three-part article: Robert Pool, "Is There an EMF-Cancer Connection?" Science, September 7, 21 and October 5, 1990, and Microwave News, September/October 1992, p. 1.

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### 3.4 What Do the Residential Studies Say?<sup>4</sup>

By "residential studies" we mean those studies that investigated the relationship between EMFs and incidence of cancer (or other illnesses) among people living near power lines. These studies are important because EMFs emitted from power lines are 60 Hz fields. VDTs and other office equipment also emit 60 Hz fields. In all of these studies, cancer was associated with EMF strength of only 2-3 mG.<sup>5</sup>

#### The Residential Studies<sup>6</sup>

Year	Researchers	Subjects Studied	Conclusions
1979	Nancy Wertheimer Ed Leeper U. of Colorado	Study of EMF exposure of 344 children who died of cancer between 1950 and 1973.	Found correlation between childhood cancer and high EMF exposure from power lines as estimated by a wire coding index. Children from high exposure homes are 2-3 times as likely to develop leukemia, lymphoma and nervous system disorders as those from low exposure homes.
1980	David Savitz U. of Colorado Medical Center	Replication of above study. An analysis of 356 childhood cancer cases in Denver between 1976 and 1983.	Found risk ratio of 1.5 which means that children with exposure to power line EMFs were 1½ times as likely to develop cancer as children with low exposure to EMFs.
1990	John Peters U. of Southern California	Study of 230 childhood cancers (leukemia victims) in Los Angeles area between 1980 and 1987.	Found that children living in homes near high current power lines had a 2½ fold increased risk of leukemia. Indicated a threshold of about 2 mG for increased childhood leukemia risk. ( <i>Microwave News</i> , March/April 1991)
1992	Anders Ahlborn Maria Feychting Karolinska Institute Stockholm, Sweden	Study of ½ million people living near power lines for over 25 years.	Found that children exposed to average fields of 3 mG or more in their homes had close to four times the expected rate of leukemia. ( <i>Microwave News</i> , September/October 1992)

<sup>4</sup> This factsheet is based, in part, on information contained in a three-part article: Robert Pool, "Is there an EMF-Cancer Connection?" *Science*, September 7, 21 and October 5, 1990.

<sup>5</sup> Paul Brodeur, "The Magnetic-Field Menace," *MacWorld*, July 1990.

<sup>6</sup> Four other residential studies have looked for correlations between EMFs and childhood cancer with mixed results: one found an increased risk of nervous system cancers; another found no risk; two other studies found higher risks for various cancers, but they were not statistically significant.

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WORLD HEALTH ORGANIZATION  
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**

**Summary of Data Reported and Evaluation**

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Static and extremely low-frequency (ELF) electric and magnetic fields

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Last updated: 7 March 2002

# STATIC AND EXTREMELY LOW-FREQUENCY (ELF) ELECTRIC AND MAGNETIC FIELDS

## MAGNETIC FIELDS (EXTREMELY LOW-FREQUENCY) (Group 2B) ELECTRIC FIELDS (EXTREMELY LOW-FREQUENCY) (Group 3) ELECTRIC FIELDS (STATIC) (Group 3) MAGNETIC FIELDS (STATIC) (Group 3)

For definition of Groups, see Preamble Evaluation.

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### 5. Summary of Data Reported and Evaluation

#### 5.1 Exposure data

Static electric and magnetic fields arise from both natural and man-made sources, whereas electric and magnetic fields in the extremely low-frequency (ELF) range (3–3000 Hz) are mostly associated with man-made sources. These are numerous and include electric power systems, electric and electronic appliances and industrial devices. Environmental levels of ELF fields are very low. Exposure levels for the general population are typically 5–50 V/m for electric fields and 0.01–0.2  $\mu\text{T}$  for magnetic fields. Considerably higher exposure occurs for shorter durations and in some occupational settings.

It should be noted that the earth's magnetic field (25–65  $\mu\text{T}$ , from equator to poles) is a static field to which everyone is exposed.

Measurements of electric and magnetic fields are used to characterize sources and levels of exposure to humans. The capabilities of instruments to measure such fields have advanced in recent years, particularly for magnetic fields. In addition to simple, easy-to-use hand-held survey instruments, there are now portable personal exposure meters capable of recording and describing the statistical, threshold, frequency and waveform characteristics of magnetic field exposure. The limiting factor in exposure assessment is not instrumentation but the lack of a consensus as to what exposure characteristics should be measured that are biologically relevant.

Computational methods are available to calculate fields and their parameters for instrument calibration, laboratory exposure systems and certain categories of indoor and outdoor sources. The difficulties in the use of computation methods to characterize exposure to magnetic fields include the lack of complete knowledge as to the magnitude, direction and location of all relevant current flows on conductors. Such difficulties pose special challenges to the use of calculations of ELF magnetic fields to estimate historical exposure from power lines. Where computational methods are used to calculate human exposure in epidemiological studies, it is desirable to understand the overall uncertainty in the calculated values.

In order to understand the effects of electric and magnetic fields on animals and humans, their electrical properties have to be considered. Static magnetic fields, which are not attenuated by the organism, can exert forces on moving charges, orient magnetic structures and affect the energy levels of some molecules. Static and ELF electric fields are greatly attenuated inside the body.

Exposure to ELF electric and magnetic fields results in induction of electric fields and associated currents in tissues. The magnitudes and spatial patterns of these fields depend on whether the external field is electric or magnetic, its characteristics (e.g. frequency, magnitude, orientation and waveform) and the size, shape and electrical properties of the exposed body. This is a basic physical mechanism for interaction of ELF magnetic fields with tissues. The induced electric field increases with the frequency of the external field and the size of

the object. A well-established effect of induced fields above a threshold level is the stimulation of excitable cells. Typical residential exposure results in very small induced electric fields, while some occupational exposure and exposure directly under very high-voltage power lines may result in electric fields of the order of 1 mV/m in some tissues. Non-perceptible contact currents under some conditions are calculated to produce electric fields exceeding 1 mV/m in the bone marrow of a child. Residential levels of ELF electric and magnetic fields produce much lower fields in tissues.

Beyond this well-established interaction mechanism, a number of hypotheses have been advanced: radical pair mechanisms, ion charge-to-mass resonance mechanisms, stochastic resonance, action on biogenic magnetite, etc. Theoretical and experimental evidence for the relevance of these mechanisms is being sought actively.

There are well established in-vivo and in-vitro exposure systems that can provide electric fields of up to the order of 150 kV/m and ELF magnetic fields up to 2 mT. Magnetostatic fields up to 5.0 T can be produced in the laboratory.

## 5.2 Human carcinogenicity data

### *Effects in children*

Since the first report suggesting an association between residential ELF electric and magnetic fields and childhood leukaemia was published in 1979, dozens of increasingly sophisticated studies have examined this association. In addition, there have been numerous comprehensive reviews, meta-analyses, and two recent pooled analyses. In one pooled analysis based on nine well conducted studies, no excess risk was seen for exposure to ELF magnetic fields below 0.4  $\mu$ T and a twofold excess risk was seen for exposure above 0.4  $\mu$ T. The other pooled analysis included 15 studies based on less restrictive inclusion criteria and used 0.3  $\mu$ T as the highest cut-point. A relative risk of 1.7 for exposure above 0.3  $\mu$ T was reported. The two studies are closely consistent. In contrast to these results for ELF magnetic fields, evidence that electric fields are associated with childhood leukaemia is inadequate for evaluation.

No consistent relationship has been seen in studies of childhood brain tumours or cancers at other sites and residential ELF electric and magnetic fields. However, these studies have generally been smaller and of lower quality.

The association between childhood leukaemia and high levels of magnetic fields is unlikely to be due to chance, but it may be affected by bias. In particular, selection bias may account for part of the association. Case-control studies which relied on in-home measurements are especially vulnerable to this bias, because of the low response rates in many studies. Studies conducted in the Nordic countries which relied on historical calculated magnetic fields are not subject to selection bias, but suffer from very low numbers of exposed subjects. There have been dramatic improvements in the assessment of exposure to electric and magnetic fields over time, yet all of the studies are subject to misclassification. Non-differential misclassification of exposure (similar degrees of misclassification in cases and controls) is likely to result in bias towards the null. Bias due to unknown confounding factors is very unlikely to explain the entire observed effect. However, some bias due to confounding is quite possible, which could operate in either direction. It cannot be excluded that a combination of selection bias, some degree of confounding and chance could explain the results. If the observed relationship were causal, the exposure-associated risk could also be greater than what is reported.

Numerous studies of the relationship between electrical appliance use and various childhood cancers have been published. In general, these studies provide no discernable pattern of increased risks associated with increased duration and frequency of use of appliances. Since many of the studies collected information from interviews that took place many years after the time period of etiological interest, recall bias is likely to be a major problem.

Studies on parental occupational exposure to ELF electric and magnetic fields in the preconceptional period or during gestation are methodologically weak and the results are not consistent.

*Effects in adults***Residential exposure**

While a number of studies are available, reliable data on adult cancer and residential exposure to ELF electric and magnetic fields, including the use of appliances, are sparse and methodologically limited. None of the studies reported so far has included long-term or personal measurements. Although there have been a considerable number of reports, a consistent association between residential exposure and adult leukaemia and brain cancer has not been established.

For breast cancer and other cancers, the existing data are not adequate to test for an association with exposure to electric or magnetic fields.

**Occupational exposure**

Studies conducted in the 1980s and early 1990s pointed to a possible increased risk of leukaemia, brain tumours and male breast cancer in jobs with presumed exposure to ELF electric and magnetic fields above average levels. The interpretation of these studies was difficult mainly due to methodological limitations and lack of appropriate exposure measurements. Also, a bias towards publication of positive findings could not be excluded.

Several large studies conducted in the 1990s of both leukaemia and brain cancer made use of improved methods for individual assessment of occupational exposure to magnetic fields, and to potential occupational confounders, mainly through the combined use of systematic workplace measurements, individual job history descriptions, and the development of associated job–exposure matrices. However, because the exposure within occupational groups is highly variable, job–exposure matrices do not eliminate all uncertainties regarding the workers' exposure levels. Some of these studies reported increased cancer risk for intermediate or high magnetic field exposure categories. There was no consistent finding across studies of an exposure–response relationship and no consistency in the association with specific sub-types of leukaemia or brain tumour. Evidence for cancers at other sites was not adequate for evaluation.

Although the assessment of exposure to electric fields is difficult, these fields have been measured occasionally in populations of workers using individual exposure meters. Across the studies, no consistent association of electric field strengths with any particular malignancy was noted.

**5.3 Animal carcinogenicity data**

Four long-term bioassays have been published in which the potential oncogenicity in experimental animals of exposure to ELF magnetic fields was evaluated in over 40 different tissues using standard chronic toxicity testing designs. Three of the studies were conducted in rats (two in both sexes including one with restricted histopathological evaluation, and one in females only) and one in mice (males and females). Three of the four studies (two rat studies and one mouse study) provide no evidence that exposure to ELF magnetic fields causes cancer in any target organ. The fourth found an increased incidence of thyroid C-cell tumours (adenomas plus carcinomas) in male rats exposed to ELF magnetic fields at two intermediate flux densities, which did not demonstrate a dose–response relationship, and a marginal increase at the highest flux density. In the lowest-exposure group, thyroid C-cell carcinomas significantly exceeded control response and were above the historical control range. Thyroid C-cell carcinomas were not seen in male mice, female mice or female rats exposed chronically to ELF magnetic fields in these oncogenicity bioassays.

A long-term oncogenicity bioassay of more limited design that was conducted to identify possible effects of exposure to ELF magnetic fields on the induction of leukaemia and lymphoma or of brain cancer in mice generated negative results.

Two multistage carcinogenesis studies combining exposure to *N*-methyl-*N*-nitrosourea with exposure to static or 50-Hz magnetic fields were performed in the same laboratory using an uncharacterized outbred rat strain. The first study demonstrated an increase in mammary tumour incidence with exposure to the fields regardless of exposure to *N*-methyl-*N*-nitrosourea. The second study showed no effect at similar exposure levels.

Eleven multistage carcinogenesis studies combining exposure to 7,12-dimethylbenz[*a*]anthracene with exposure to 50- or 60-Hz magnetic fields were performed in three different laboratories. One laboratory performed six 13-week studies and one 27-week study aimed at addressing exposure–response relationships for different magnitudes of exposure to magnetic fields. These studies reported significant increases in mammary tumour incidence at higher exposure levels. A pooled analysis of exposure–response from these studies yielded an average slope significantly different from zero. A second laboratory conducted three studies (two of which were considered inadequate to assess tumour incidence) to replicate these findings at the highest field strengths, but saw no enhancement of mammary tumorigenesis by exposure to ELF magnetic fields in one study, in which the sham control incidence was low enough to detect an increase. In the two other studies, high incidences of mammary tumours in sham controls limited comparisons to possible increases in tumour multiplicity; none were found. The third laboratory studied the impact of intermittent exposure to magnetic fields and saw no changes in tumour incidence or tumour multiplicity in either of two experiments.

Eight studies were performed in five different laboratories on promotion and/or co-promotion of skin tumorigenesis by 50- or 60-Hz magnetic fields using conventional mouse strains. The results of these studies were generally negative. However, a suggestion of accelerated progression to malignancy was observed in one study and a change in tumour multiplicity was observed in another. There was no consistent pattern of response in these studies, which were of effectively equivalent design. One study using a transgenic mouse model demonstrated an acceleration of skin tumorigenesis by ELF magnetic fields.

Three studies have been performed using the enzyme-altered liver foci model in rats or mice to determine tumour promoting and co-promoting effects of 50-Hz magnetic fields (0.5–500  $\mu$  T). No enhancement of liver foci by magnetic field exposure was reported in two studies in rats. In the third study which used ionizing radiation with and without exposure to magnetic fields, the incidence of basophilic liver foci was significantly increased in exposed mice. This finding was not associated with a significant increase in liver cancer incidence.

Multistage studies have been carried out in both mice (conventional and transgenic strains) and rats to evaluate the effects of ELF magnetic fields on the development of leukaemia and lymphoma. In no study did exposure to ELF magnetic fields cause an increased incidence of leukaemia or lymphoma.

One study was performed to identify possible promoting effects of ELF magnetic field exposure on the induction of neurogenic tumours. The results of this study showed no enhancement of neurogenic tumour induction.

## 5.4 Other relevant data

### *Reproductive effects in humans and animals*

Taken as a whole, the results of human studies do not establish an association of adverse reproductive outcomes with exposure to ELF electric and magnetic fields. Such adverse outcomes have been reported in a few studies, particularly at higher field intensities and in people exposed for longer durations. With exposures from video display terminals, a greater number of studies have been performed and these generally found no adverse reproductive effects.

Experiments with many different mammalian and non-mammalian experimental models consistently indicate lack of adverse effects on reproduction and development from exposure to strong static magnetic (0.25–1.0 T) and ELF electric (up to 150 kV/m) fields. Static magnetic fields with high spatial gradients and those mixed with alternating fields have been reported to affect embryonic development in frogs and mice, although the number of studies is small.

Prenatal exposure to ELF magnetic fields generally does not result in adverse effects on reproduction and development in mammals. When effects are observed, they usually consist of minor developmental anomalies. Non-mammalian classes of animals (fish, frogs, birds) show inconsistent effects of ELF electric and magnetic fields on development (including increased malformations).

#### *Other effects in humans*

Due to the small number of immunological and haematological studies in humans and very small sample sizes within the reported studies, no health-related conclusions can be drawn from the data on immunological and haematological effects after exposure to ELF electric and magnetic fields.

In humans, the principal element of neuroendocrine response to exposure to ELF electric and magnetic fields that has been investigated is the circadian production and release of melatonin. No effect on melatonin was seen following night-time exposure of human volunteers to 50 or 60-Hz magnetic fields under controlled laboratory conditions. In contrast, a small reduction in melatonin concentration has been observed in occupational and residential environments, but it is difficult to distinguish between effects of the magnetic field and those of other environmental factors.

Apart from established perceptual responses in humans to ELF electric fields at levels of tens of kilovolts per meter and the occurrence of magnetophosphenes (faint, flickering visual sensations) in response to exposure to relatively strong ELF magnetic fields (> 10 mT at 20 Hz), few behavioural effects of exposure to ELF electric and magnetic fields have been observed. Changes in electroencephalograms, cognition, mood, sleep electrophysiology and cardiac response tend to be few, subtle and transitory when they do occur during exposure. The evidence from epidemiological studies of residential and occupational exposure to ELF electric and magnetic fields in relation to the incidence of neurodegenerative disease, depression and suicide and cardiovascular disease is generally weak and inconsistent.

#### *Other effects in animals*

Studies to evaluate immune function and host resistance in animals have given negative effects for exposure to ELF electric and magnetic fields. In-vitro exposure of immune system cells generally did not cause changes in proliferation capacity.

Apart from occasional changes in some haematological parameters in one rat study, no consistent effects on blood formation were seen in experimental animals or their offspring exposed to either static magnetic fields or to 50- or 60-Hz electric and/or magnetic fields.

Most animal studies of endocrine function concern the pineal gland and melatonin, because of concerns related to cancer. Fewer studies have been carried out on the effects of exposure to ELF electric and magnetic fields on the pituitary hormones or those of other endocrine glands.

Some, but not all, studies of the effects of 50- or 60-Hz electric and magnetic fields in rodents show a reduction in pineal and/or serum melatonin concentrations. Differences in response have been reported for linearly polarized compared with circularly polarized magnetic fields. No convincing effect on melatonin concentrations has been seen in non-human primates chronically exposed to 50- or 60-Hz electric or magnetic fields.

With the possible exception of short-term stress (duration of minutes) following the onset of exposure to ELF electric fields at levels significantly above perception thresholds, no consistent effects have been seen in the stress-related hormones of the pituitary–adrenal axis in a variety of mammalian species.

Animals can perceive ELF electric fields (threshold 3–35 kV/m) and respond with activity changes or aversion. Such responses are generally not observed with magnetic fields.

Although exposure to magnetic fields has been reported to influence spatial learning and memory in rodents, it appears that no long-term behavioural deficits occur due to exposure to static or ELF electric and magnetic fields.

#### *Genetic and related effects*

A few studies on genetic effects have examined chromosomal aberrations and micronuclei in lymphocytes from workers exposed to ELF electric and magnetic fields. In these studies, confounding by genotoxic agents (tobacco, solvents) and comparability between the exposed and control groups are of concern. Thus, the studies reporting an increased frequency of chromosomal aberrations and micronuclei are difficult to interpret.

Many studies have been conducted to investigate the effects of ELF magnetic fields on various genetic end-points. Although increased DNA strand breaks have been reported in brain cells of exposed rodents, the results are inconclusive; most of the studies show no effects in mammalian cells exposed to magnetic fields alone at levels below 50 mT. However, extremely strong ELF magnetic fields have caused adverse genetic effects in some studies. In addition, several groups have reported that ELF magnetic fields enhance the effects of known DNA- and chromosome-damaging agents such as ionizing radiation.

The few animal studies on cancer-related non-genetic effects are inconclusive. Results on the effects on in-vitro cell proliferation and malignant transformation are inconsistent, but some studies suggest that ELF magnetic fields affect cell proliferation and modify cellular responses to other factors such as melatonin. An increase in apoptosis following exposure of various cell lines to ELF electric and magnetic fields has been reported in several studies with different exposure conditions. Numerous studies have investigated effects of ELF magnetic fields on cellular end-points associated with signal transduction, but the results are not consistent.

### 5.5 Evaluation

There is *limited evidence* in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to childhood leukaemia.

There is *inadequate evidence* in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to all other cancers.

There is *inadequate evidence* in humans for the carcinogenicity of static electric or magnetic fields and extremely low-frequency electric fields.

There is *inadequate evidence* in experimental animals for the carcinogenicity of extremely low-frequency magnetic fields.

No data relevant to the carcinogenicity of static electric or magnetic fields and extremely low-frequency electric fields in experimental animals were available.

#### Overall evaluation

Extremely low-frequency magnetic fields are *possibly carcinogenic to humans (Group 2B)*.

Static electric and magnetic fields and extremely low-frequency electric fields are *not classifiable as to their carcinogenicity to humans (Group 3)*.

For definition of the italicized terms, see Preamble Evaluation.

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## Leukaemia, brain tumours and exposure to extremely low frequency magnetic fields: cohort study of Swiss railway employees

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**Aims:** To investigate the relationship between extremely low frequency magnetic field (ELF-MF) exposure and mortality from leukaemia and brain tumour in a cohort of Swiss railway workers.

**Methods:** 20 141 Swiss railway employees with 464 129 person-years of follow-up between 1972 and 2002 were studied. Mortality rates for leukaemia and brain tumour of highly exposed train drivers (21  $\mu$ T average annual exposure) were compared with medium and low exposed occupational groups (i.e. station masters with an average exposure of 1  $\mu$ T). In addition, individual cumulative exposure was calculated from on-site measurements and modelling of past exposures.

**Results:** The hazard ratio (HR) for leukaemia mortality of train drivers was 1.43 (95% CI 0.74 to 2.77) compared with station masters. For myeloid leukaemia the HR of train drivers was 4.74 (95% CI 1.04 to 21.60) and for Hodgkin's disease 3.29 (95% CI 0.69 to 15.63). Lymphoid leukaemia, non-Hodgkin's disease and brain tumour mortality were not associated with magnetic field exposure. Concordant results were obtained from analyses based on individual cumulative exposure.

**Conclusions:** Some evidence of an exposure-response association was found for myeloid leukaemia and Hodgkin's disease, but not for other haematopoietic and lymphatic malignancies and brain tumours.

# States' Efforts to Mitigate the Public's Exposure to EMFs, as of April 30, 1994

FROM: US GENERAL ACCOUNTING OFFICE JUNE 1994 ELECTROMAGNETIC FIELDS  
GAO/RCED-94-115

State	Actions taken
California	California adopted no-cost/low-cost (prudent avoidance) guidelines for new and upgraded transmission facilities.
Colorado	On November 30, 1992, the Colorado Public Utilities Commission ruled that prudent avoidance would be the standard procedure when utilities plan, site, construct, and operate transmission lines.
Connecticut	According to a state official, the state is studying how to address EMFs. Currently, the state's "best management practices" policies require utilities to implement nonspecified methods to reduce EMFs. Moreover, Connecticut also implements a "voluntary exposure control" policy that encourages concerned individuals to educate themselves about the EMF issue in order to make informed choices about reducing or avoiding exposure to EMFs.
Florida	According to state officials, the state has (1) limited magnetic fields at the edges of rights-of-way to 150 mG for new lines equal to less than 230 kV and 200 mG for 500-kV lines and (2) required utilities to submit EMF information to the Public Service Commission when proposing to build transmission lines.
Illinois	In March 1992, the Illinois Department of Public Health and Illinois Environmental Protection Agency, in a report to the state legislature, recommended that utilities reduce EMF levels by implementing "prudent" measures, such as buying wider rights-of-way for transmission lines, avoiding schools and population centers when erecting transmission lines, and using low-EMF configurations for transmission lines.
New Jersey	According to state officials, New Jersey has (1) reached informal agreement for utilities to identify schools and school facilities within 100 feet of transmission lines and to measure EMFs at these locations and (2) adopted an informal prudent avoidance policy that it implements case by case, as utilities file applications to build or remodel transmission lines.
New York	New York has (1) adopted an interim standard limiting magnetic field levels to 200 mG at edges of rights-of-way for new power lines, (2) directed utilities to model EMF levels throughout the state, and (3) requested utilities to identify schools near transmission lines of 69 kV or more. EMF research is funded through state agencies and private organizations.
Ohio	The state generally practices its prudent avoidance policy when utilities apply to site new power lines and requires utilities to minimize the exposure of schools, hospitals, nursing homes, community centers, and churches to EMFs. The Ohio Power Siting Board approves applications for power lines and rights-of-way after utilities (1) examine the nature and impact of EMFs on residences, farms, highways, recreation areas, and other places of assembly near the planned facility and determine how to mitigate these impacts; (2) estimate EMFs at the edges of the planned rights-of-way under various load scenarios; and (3) detail the utility's consideration of EMFs, both generally and specifically for the proposed project.

(continued)

" FEDERAL EFFORTS TO DETERMINE HEALTH EFFECTS ARE BEHIND SCHEDULE "

REPORT TO THE CHAIRMAN COMMITTEE ON NATURAL RESOURCES, HOUSE OF REPRESENTATIVES

Appendix II  
 States' Efforts to Mitigate the Public's  
 Exposure to EMFs, as of April 30, 1994

State	Actions taken
Rhode Island	Rhode Island formally endorses prudent avoidance. In addition, it requires utilities to (1) produce electricity at the lowest cost and in an environmentally friendly manner and (2) provide data on potential public health impacts, including increased EMF exposure, for planned transmission projects.
Texas	According to a state official, Texas has no formal EMF policies but implements a de facto prudent avoidance policy for new transmission projects. In March 1992, the state's Electro-Magnetic Health Effects Committee endorsed the state's informal prudent avoidance policy but recommended that the Public Utility Commission not expand existing transmission line routing criteria to include concerns about EMF health effects. The Committee also recommended that the state not set EMF standards through guidelines, regulations, or legislation.
Wisconsin	The state requires utilities to favor resource options that decrease EMFs, such as demand-side management programs, when planning future electric resources. When applying for new transmission lines or upgrading existing ones, utilities must (1) use new designs that will reduce EMF levels in a cost-effective manner (referred to as the "best available control technology"); (2) identify schools, hospitals, day care centers, and homes within 300 feet of the planned project and estimate EMF levels along the power line corridor; and (3) file plans detailing how they will reduce EMFs. Utilities also fund EMF research, including research on the uniform measurement of EMF levels.

# Electromagnetic Fields (EMFs), Extremely Low-Frequency (ELF) and Radiofrequency (RF): What are the Health Impacts?

by Alex Quinn

Particularly now that wireless communications are so closely integrated into our daily lives, electromagnetic fields (EMFs) are all around us.

Our cities, especially the larger ones, are perpetually shrouded in an invisible electrosmog, a 'sea' of EMFs through which we swim every day.

But does this momentous development in civilisation come with health effects – and if so, can we do anything to reduce them?

## TOP FACTS

- Electromagnetic fields (EMFs) are all around us, and come in two forms: ELF-EMFs and RF-EMFs
- ELF-EMFs are produced by power lines and many domestic appliances, while RF-EMFs are produced by mobile phones and other communication devices
- Both pose their own set of health problems
- We provide some ideas of how to reduce your EMF exposure

What is ELF-EMF and what are its sources?

It's important to realise that there are two main forms of EMF: radiofrequency (RF)-EMF and extremely low-frequency (ELF)-EMFs. The frequency range of ELF-EMF is 1–300 Hz, and the Earth's natural geomagnetic field strength varies from around 60  $\mu\text{T}$  (microtesla) at the magnetic poles to around 30  $\mu\text{T}$  at the equator.

Many man-made sources of ELF-EMF exist. Prime among these artificial sources are power lines and electronic appliances, with vacuum cleaners, electric can-openers, microwave ovens, shavers and hair dryers among the most powerful. These appliances emit ELF-EMF at field intensities ranging from 17.44 to 164.75  $\mu\text{T}$ , measured from 5 cm away. Since the intensity of magnetic fields decreases dramatically with increased distance from the source, the corresponding range of magnetic field intensities at 50 cm is 0.12–1.66  $\mu\text{T}$ .

Magnetic field ( $\mu\text{T}$ ) at discrete distances from the surface of appliances computed from direct measurements							
Appliance type	No.	5 cm	$\pm$ SD	50 cm	$\pm$ SD	100 cm	$\pm$ SD
Television	73	2.69	1.08	0.26	0.11	0.07	0.04
Kettle, electric	49	2.82	1.51	0.05	0.06	0.01	0.02
Video-cassette recorder	42	0.57	0.52	0.06	0.05	0.02	0.02
Vacuum cleaner	42	39.53	74.58	0.78	0.74	0.16	0.12
Hair dryer	39	17.44	15.56	0.12	0.10	0.02	0.02
Microwave oven	34	27.25	16.74	1.66	0.63	0.37	0.14
Washing machine	34	7.73	7.03	0.96	0.56	0.27	0.14
Iron	33	1.84	1.21	0.03	0.02	0.01	0.00
Clock radio	32	2.34	1.96	0.05	0.05	0.01	0.01
Hi-fi system	30	1.56	4.29	0.08	0.14	0.02	0.03
Toaster	29	5.06	2.71	0.09	0.08	0.02	0.02
Central heating boiler	26	7.37	10.10	0.27	0.26	0.06	0.05
Central heating timer	24	5.27	7.05	0.14	0.17	0.03	0.04
Fridge/freezer	23	0.21	0.14	0.05	0.03	0.02	0.01
Radio	23	3.00	3.25	0.06	0.04	0.01	0.01
Central heating pump	21	61.09	59.58	0.51	0.47	0.10	0.10
Cooker	18	2.27	1.33	0.21	0.15	0.06	0.04
Dishwasher	13	5.93	4.99	0.80	0.46	0.23	0.13
Freezer	13	0.42	0.87	0.04	0.02	0.01	0.01
Oven	13	1.79	0.89	0.39	0.23	0.13	0.09
Shower, electric	12	30.82	35.04	0.44	0.75	0.11	0.25
Burglar alarm	10	6.20	5.21	0.18	0.11	0.03	0.02
Food processor	10	12.84	12.84	0.23	0.23	0.04	0.04
Extractor fan	9	45.18	107.96	0.50	0.93	0.08	0.14
Cooker hood	9	4.77	2.53	0.26	0.10	0.06	0.02
Speaker	8	0.48	0.67	0.07	0.13	0.02	0.04
Hand blender	8	76.75	87.09	0.97	1.05	0.15	0.16
Tumble dryer	7	3.93	5.45	0.34	0.42	0.10	0.10
Food mixer	6	69.91	69.91	0.69	0.69	0.11	0.11
Fish-tank pump	6	75.58	64.74	0.32	0.09	0.05	0.01
Computer	6	1.82	1.96	0.14	0.07	0.04	0.02
Electric clock	6	5.00	4.15	0.04	0.00	0.01	0.00
Electric knife	5	27.03	13.88	0.12	0.05	0.02	0.01
Hob	5	2.25	2.57	0.08	0.05	0.01	0.01
Deep-fat fryer	4	4.44	1.99	0.07	0.01	0.01	0.00
Tin/can opener	3	145.70	106.23	1.33	1.33	0.20	0.21
Fluorescent light	3	5.87	8.52	0.15	0.20	0.03	0.03
Fan heater	3	3.64	1.41	0.22	0.18	0.06	0.06
Liquidizer	2	3.28	1.19	0.29	0.35	0.09	0.12

Table 1. ELF-EMFs produced by domestic appliances. Taken from IARC Monograph Volume 80 (2002).

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has set limits of 1 mT (millitesla) for occupational exposure to ELF-EMF, and 200  $\mu\text{T}$  for general public exposure. While these limits are not breached by individual man-made sources, additive effects must also be considered, as we shall see.

What is RF-EMF and what are its sources?

The frequencies of RF-EMFs are considerably higher than ELF-EMFs, ranging from 100 kHz to 300 GHz. As its name suggests, the main uses of RF-EMF are in broadcasting information. In today's data-driven world, this means that RF-EMF is constantly around us: it is produced by things such as mobile phone base stations, cordless phones, utility 'smart' meters, remote control toys, wireless networks, radar and baby monitors. In addition, there are various natural sources of RF-EMF, including the Earth, the Sun and other black body radiators.

Here's a shocking statistic: did you know that having a cordless phone base station in your house can expose you to the same level of RF-EMFs as having a mobile phone mast in your back garden?

Do EMFs pose health problems?

The mainstream view is that the only potential danger from EMFs stems from their heating effects on tissue, in the case of RF-EMF, or of electrical currents induced in the body for ELF-

EMF. However, there is strong evidence to suggest that the athermal effects of ELF- and RF-EMFs also contribute to various health problems.

“ There is strong evidence to suggest that the athermal effects of ELF- and RF-EMFs also contribute to various health problems ”

### Childhood leukaemia

According to the BioInitiative report, evidence indicates that risk of childhood leukaemia in young boys doubles when they are exposed to ELF-EMF levels of 1.4 mG (milligauss), while other studies indicate that leukaemia risks begin at 2, 3 and 4 mG. This occurs in the context of an ICNIRP limit of 1000 mG.

The BioInitiative report also found that ELF-EMFs interfered with recovery from childhood leukaemia: if a child was exposed to levels of  $\geq 2$  mG during recovery, their risk of death increased by 300%, while at levels of  $\geq 4$  mG that risk increased to 450%.

### Alzheimer's disease

ELF-EMF has also been found to increase the risk of Alzheimer's disease by increasing levels of a protein called amyloid beta, a leading risk factor for Alzheimer's.

### Melatonin

EMFs have also been found to decrease the levels of melatonin in the body. Melatonin is produced in the pineal gland of the brain, which produces melatonin when it directly or indirectly detects low light levels. EMFs may interfere with this mechanism because the brain confuses them with light waves, thus suppressing the pineal gland's melatonin production. Melatonin is an absolutely vital hormone. It acts as a powerful antioxidant, and has been found to aid in the prevention of Alzheimer's, depression, cardiovascular diseases, insomnia, mood disorders, tinnitus and various cancers.

### Brain and auditory nerve cancers

RF-EMFs have been given a 2B classification – possibly carcinogenic – by the International Agency for Research on Cancer (IARC). They have been found to be possible causes of acoustic neuromas and brain tumours called gliomas. Studies have shown that using cordless phones, which produce RF-EMFs, can increase the risk of brain tumours by up to 470% after  $\geq 10$  years of

use when habitually used on one side of the head. Mobile phones, in the same scenario, can increase the risk by up to 200%. Both mobiles and cordless phones can trigger reactions in people who suffer from electrohypersensitivity.

“ RF-EMFs have been given a 2B classification – possibly carcinogenic – by the International Agency for Research on Cancer (IARC). They have been found to be possible causes of acoustic neuromas and brain tumours called gliomas

”

What about interactions between EMFs and other factors?

Of course, EMFs don't affect us in isolation: everyone living in a city, for example, is bombarded by numerous chemical toxins and other environmental pollutants, and many of them take multiple pharmaceutical drugs – in addition to constant EMF exposure. We are at an early stage of investigating and defining these complex interactions, but existing research indicates that these combinations can have both beneficial and adverse effects. For example, in vitro DNA damage was caused by a 7 mT magnetic field in combination with ferrous chloride, but not with either agent alone. Other combinations of EMFs and agents enhanced analgesia and neural performance.

Call to action: Reduce your EMF exposure!

Thus, you should take as many steps as possible to reduce your exposure to EMFs. Suggested strategies include:

- Using fiber-optic cables for your broadband
- Using wired connections whenever possible
- Keeping mobile and cordless phones away from your body
- Using wired baby monitors: children are more effected by EMFs than adults
- Keeping wireless routers or cordless phones out of regularly used bedrooms or children's bedrooms
- Reducing time spent in calls when using mobile or cordless phones
- Reducing children's exposure to wireless devices as much as possible
- Avoiding using microwave oven
- Avoiding placing wireless computers on your lap
- Avoiding allowing your children to use remote-control toys for long periods of time, if at all

# Contra Costa Times

## News

### PG&E, Concord man in power-line faceoff

By Andrew McGall [amcgall@bayareanewsgroup.com](mailto:amcgall@bayareanewsgroup.com)



A PG&E helicopter lands workers on top of a PG&E tower that sits on the property owned by Bruce Borjesson, who has a contract with PG&E saying they can't work on this tower until a court dispute between Bruce and PG&E is settled, in Concord, Calif., on Wednesday, June 3, 2015. Borjesson says his home is too close in relation to the power towers and lines and he is fighting to have PG&E move the tower away from his home.

CONCORD -- A rural resident woke up this week to the noise of helicopters lowering three PG&E workers and materials to the power line tower standing next to his house.

"Get out here, get off my property. You're not allowed here," Bruce Borjesson yelled at the workers perched some 50 feet above. They did not respond.

Borjesson got into a pickup -- with a 20-foot power boat still hitched to it -- and drove down his dusty road to protest to the crew working Wednesday morning in an improvised equipment yard and helipad in the open space above Pine Valley Road.

The next day, the state Public Utilities Commission also told the company to stay off his property while it reconsiders his health-related protest against a \$54 million revamp of the power line running 27 miles from Antioch to Orinda.

PG&E is staging the overhaul near Borjesson's home, using three helicopters to ferry workers and materials to the towers in the central county portion of the line.

Borjesson has been trying to get the utility to move the power line that stands a few feet from the back of his house. He worries about the health effects of the electrical and magnetic fields - EMF -- that the line generates and about PG&E doubling its capacity.

EMF health effects have been debated and studied, but no clear health threat has been established.

At the helipad Wednesday, a waiting Concord police officer, who said he had been sent at PG&E's request, strolled over to mediate.

"I'm not going to let this mega-corporation roll over me," Borjesson told Concord police Officer Russ Norris, who patiently listened while a man with a "security" patch on his shirt took pictures.

PG&E says it will raise the power lines higher above Borjesson's house to reduce the EMF exposure, but it will not move the house or the tower.

Such confrontations began late last year when Borjesson, a retired iron worker who also ran a construction crane company, saw a notice of the power-line upgrade posted in a field off his private road near Kaiser Quarry Road at the foot of Mount Diablo.

He lodged the only formal protest of the project, asking that the utility giant move the tower. Its 230,000-volt line hangs some 30 feet above his third-floor bedroom.

The PUC rejected his protest but is weighing his request for reconsideration.

PG&E says it is replacing the wire and upgrading structures in the 27-mile-long line to meet growing East Bay demand. It is raising the lines on some towers by 15 to 16.5 feet more than required to reduce the strength of electrical and magnetic fields above schools and residences.

"This is an important project that will benefit 130,000 East Bay customers," said PG&E spokeswoman Tamar Sarkissian. It will "enhance the reliability and safety of our electric transmission system," she said.

PG&E says its EMF actions are meant to address the public's concerns. "They are not based on scientific proof that EMF is a health issue," it says.

California's EMF review panel concluded in its 2002 final report that electric and magnetic fields "can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's disease and miscarriage."

The three-scientist panel found the risks very low but noted that the state regulates chemical exposures with even lower risks. Studies since then have added little more certainty.

The PG&E upgrade was exempted from a more rigorous review because the PUC agreed that the \$54 million project was replacing or improving existing structures.

Borjesson's attorney scoffs at the maintenance description for a project of such scope and cost.

"What PG&E really did was tell the PUC that they were exempt from a bunch of environmental restrictions," said Jason Granskog. "I don't believe they're entitled to that exemption."

In approving the project, the PUC noted Borjesson's health concern.

"PG&E has in an abundance of caution proposed to modify its facilities to raise the height of the three towers near (Borjesson's) house to enable EMF reduction at the ground level," it said in its Jan. 2 ruling.

The utility this week said it expects to cut the ground-level EMF there by 15 percent. But his bedroom is on the third floor, not ground level, Borjesson said.

The PUC has for decades required low- or no-cost steps to reduce exposure.

Borjesson says PG&E consistently misled him. When he first protested, he said, company employees told him they might move the three towers nearest his house, then told him they might move his house.

Then, he said, they told him those actions would be too expensive.

In an email Thursday, the utility said it discussed options but made no offers.

PG&E also sent a contractor to measure the EMF at his house. When the measurements inside and out and upstairs were all essentially the same, "he told me there was limited power in the line," because they were working on it, Borjesson said.

PG&E says measurements were made, and Borjesson was given a copy of the results that he signed. For customer privacy reasons, it would not reveal the results. Borjesson said he had no such document.

"They led the Borjessons down the wrong path," Granskog said.

[http://www.contracostatimes.com/breaking-news/ci\\_28260943/pg-e-concord-man-power-line-face-ff](http://www.contracostatimes.com/breaking-news/ci_28260943/pg-e-concord-man-power-line-face-ff)

<http://www.npr.org/templates/story/story.php?storyId=103537250>

## **Building Power Lines Creates A Web Of Problems**

by [Christopher Joyce](#)

[Morning Edition](#), April 28, 2009 · To create a new energy economy using much more solar and wind power, the Obama administration needs to build thousands of miles of new transmission lines. Despite the promise that these are needed to get more green energy from solar and wind generators, the proposal faces a host of obstacles.

Chris Miller, president of the Piedmont Environmental Council and an advocate of renewable energy, points out that new transmission lines may not be dedicated just to "green" electrons.

"There is a real potential that what you are expanding is the capacity to move coal-fired electrons," says Miller, "and that the cheapest power supplies, which are the dirtiest plants, will have access to markets they didn't use to."

And here's something else to consider: Does everyone really want renewable energy brought in from distant producers over power lines subsidized by the federal government?

Maybe not, says Ian Bowles, the energy secretary for Massachusetts. Bowles says that might undercut homegrown wind projects in New England. "When you decide upfront [that] transmission is the problem, you've put your hand on the scale and said, 'We want to help out particularly those remote sources of wind and green electricity.' "

The man picked by President Obama to resolve these questions is Jon Wellinghoff, the new chairman at the Federal Energy Regulatory Commission.

"I think everybody has to play ball," Wellinghoff says. "I think that we have to realize that we're all in this together, and that nationally, we do have a huge problem."

### **In Whose Backyard?**

Wellinghoff says local and state politics can be daunting. "You have to do siting. Where are they going to go? And that's where you get very contentious," he says. "In whose backyard are you going to run the line?"

For a power line to cross 10 states, each of those states must approve that siting.

Wellinghoff hopes he'll soon have the authority to overrule states if they balk. FERC had that power until recently when a federal court took it away, and now the Senate Energy Committee is writing a bill that would give it back to FERC. The bill has strong support from members of Congress who want to see a new grid built quickly.

Energy Secretary Steven Chu says that no matter how much authority it has, the Energy Department shouldn't play the bully by simply declaring eminent domain when it wants to build a new line. He says states and citizens have to be partners, and enjoy some of the benefits.

"If you just go in and say, 'I'm going to pass a law that has a huge stick,' " Chu says, "what will invariably happen is that you end up in lawsuits."

Among these uncertainties, one thing is sure — making the grid smarter and greener will cost a huge amount of money. Chu says that could be well over \$100 billion over several decades.

Reid Detchon, director of the Energy Future Coalition advocacy group, says Americans have paid big money for a collective benefit before.

"If you accept that there's a national objective here, just as we did with the [national highway system](#), then you create the national authority to expedite that at the federal level," Detchon says.

[Eventually, that national authority will have to decide who's going to pay for the new grid.](#)

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# South Redondo Beach Residents Believe Stray Voltage Is Causing Unexplained Illnesses

February 9, 2012 11:45 PM

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**SOUTH REDONDO BEACH (CBS)** — A group of SoCal mothers believe electricity is making their families sick. CBS2's Paul Magers spoke with these residents to find out why they think nearby power lines and their neighborhood substation is creating unsafe living conditions.

"This is my hair loss from one shower," said Lori Barber, a resident in the Knob Hill neighborhood, as she held up a large clump of hair.



(credit: CBS)

daughter has been experiencing a variety of gastrointestinal problems and that half of her esophagus is paralyzed — all for unexplained reasons.

These women live in a neighborhood lined with schools and churches and a Southern California Edison substation, which sends out electricity to the city of Redondo Beach.

"I absolutely worry about health issues, I have three young children," remarked Doris Donlou-Richmond, Barber's neighbor.

Mary Contreras is yet another local mother who said her



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The substation is immediately apparent when first entering South Redondo Beach. Many residents said they did not even realize the substation was there until after they purchased their homes. The first five homes to be built on the Barber family's street were used to house the Edison employees that worked at the facility. Edison had initially planned to tear them down and expand the substation. Instead, the company sold the homes in the '90s.

The Barbers bought one of those residences in April 2010 and their baby Adelaide was born in November of that same year. Three months later, the Barbers said their daughter was diagnosed with unexplainable gastrointestinal issues.

"I can't help but believe it's related to living here," Barber said. "I have a 14-month-old baby girl that was just in the hospital last month with issues that we still don't 100 percent have answers for or that just don't make sense."

Contreras lives around the corner, directly behind the substation, and also became concerned when her son and daughter became ill and she began to suffer headaches daily.

"My son, he was diagnosed with a tumor and with a lot of joint problems," Contreras said.



(credit: CBS)

These residents believe electromagnetic fields (EMFs) generated by the Edison power lines are the root of all their health problems, despite there being no definitive proof.

Barber's husband, Tom, showed us the power lines surrounding his home.

"We have a situation that we have electricity from high from both sides, high from over there and underground from in front of the house," he said. "You're in your own boxed-in microwave."

The residents have already asked for Southern California Edison employees to measure the EMFs in all of their homes. Edison notes on its paperwork that one milligauss is the average reading in most houses. The company reported that this community had readings that ranged between 4.1 and 32.6.

Edison said EMF readings vary based on what is inside a home and that not all readings relate to power lines.

Doris Donlou-Richmond has EMFs ranging from 5.4 to 13.9 on her property and an electrically-charged gas line. The gas company marked her meter “11 Volts” – alerting employees to stay clear.

“It’s been three and a half years, they haven’t resolved the issue, and there’s no notation on my account other than they are not allowed to touch my gas line due to it being electrically charged,” Richmond said.

Another neighbor purchased the Edison home closest to the substation. Simona Wilson believes something called “stray voltage” has been seeping into her shower and has jolted her body, causing nerve damage.

“When we learned about Simona’s situation, we kind of thought it was interesting, and we started reaching out to people,” Barber said.

Wilson vacated her home last September and has filed a lawsuit claiming that Edison was aware of the stray voltage for the past 20 years. She recently underwent a hysterectomy, a medical issue she also believes is linked to the Edison substation.

“I just feel horrible that we’re sitting here together while one of our neighbors is having surgery,” said Barber, adding, “Obviously, we’re not the only people on this block that have an issue and if you didn’t raise hell about it [SoCal Edison wouldn’t] come to your house.” CBS2 took these residents’ concerns straight to Edison.

“Certainly, I don’t dismiss customers’ frustration but to sort of characterize that we have not been engaged in trying to solve issues, you know, it’s unfortunate,” said Steve Conroy, of SoCal Edison.

“The first complaint that we actually received was around 2004, and it had to do with an issue of stray voltage,” Conroy said.



(credit: CBS)

Edison later corrected that comment in an email, stating they made disclosures about EMF readings and were aware of stray voltage issues as early as 1999 — years before some of the women involved moved into the neighborhood.

Conroy went on to cite scientific studies to suggest that there was no direct correlation between EMF levels and health concerns.

“There’s no evidence to say EMF is safe,” according to Dr. De-Kun Li, Ph.D., of the Kaiser Foundation Research Institute. He has studied electromagnetic fields and possible health effects for 15 years.

Li said no one is certain which EMF levels are safe and which are dangerous. However, his research recently linked EMF exposure to miscarriages and asthma. He says even though there is no federal standard on EMFs, people need to take precautions.

“My study shows above two milligauss could be potentially problematic, particularly when exposed for a long time,” Li said.

That limit is way below the EMF readings in the South Redondo Beach neighborhood. That’s why Barber said she and her family moved out last November.

“I’m leaving,” Contreras said. “I can’t stand to put my children, and my husband and myself at risk.”

“If Edison is not willing to buy back our house or give us back what we’ve put into it, we’ve potentially lost it,” Lori Barber said.

And, for many families in the area, there are still too many questions left unanswered.

“I want to know why I have electricity in my gas line and I want it fixed,” Richmond said.

“There are substations in neighborhoods that don’t have EMFs or stray voltage – so, why does this one?” Barber asked.

Some residents said they were concerned about the possible effect of the electricity on nearby schools.

Alta Vista Elementary School sent a note home to parents after CBS2 reported on the situation earlier this week, saying both Southern California Edison and the gas company have checked the school and believe there’s no threat.

Edison representatives said they will work with Simona Wilson’s family on the stray voltage issue and said she could even hire the contractor of her choice to fix the problem. Edison also said they were working with the gas company to determine if there was any stray voltage on the gas line.



## Despite odds, Fauquier can prevail against power line

By Lawrence Emerson, Editor

Citizens still have a chance to help stop construction of a high-voltage electrical transmission line through eastern Fauquier, from Warrenton to the Vint Hill area, according to an energy policy analyst.

“I do believe in the system and think our voices need to be heard,” Piedmont Environmental Council staff member Rob Marmet told about 110 people at a forum Thursday night. “I am optimistic that if you make a valid case . . . logic will prevail.

“It is not impossible,” Mr. Marmet added. But, “it does not happen often.”

With decades of experience fighting and trying to mitigate such projects, the PEC hosted the June 4 forum at Vint Hill’s Old Bust Head Brewery.

Fauquier citizens, government agencies and organizations have scrambled to oppose the 230-kilovolt line since its surprising re-emergence as a possibility this spring. After months of community meetings and analysis, Dominion Virginia Power abandoned the line, known as “Option A,” in August 2013.

The lines would hang from steel poles up to 100 feet tall along a right-of-way 120 feet wide.

Dense residential development, schools, cemeteries, battlefields and conservation easements made the route impractical, Dominion representatives determined.

But, in a rare move, the State Corporation Commission staff this year ordered reconsideration and notified property owners in the route — after the first of two public hearings in Richmond. The second hearing will take place Wednesday, Aug. 4 — a critical date for those affected.

Mr. Marmet and fellow PEC staffers urged citizens to write letters to the SCC.

He explained the three-member commission’s “judicial process” that will lead to a decision early next year.

Fauquier's board of supervisors, school board and water/sewer authority, along with the PEC, the Brookside homeowners' association and new citizens' group, all have filed as "intervening parties" in the process.

"There are no Perry Mason moments" in the SCC hearings, "except in cross examination" of expert witnesses, Mr. Marmet explained.

Each of the intervening parties has a lawyer who can participate in the Aug. 4 proceedings before a State Corporation Commission hearing examiner in Richmond. The hearing examiner will make a recommendation to the three-member commission. Elected by the General Assembly, those three commissioners serve six-year terms.

"This is a judicial proceeding," Mr. Marmet said. The commissioners "are doing what they think the law requires.

"They care a great deal about reliability (of electrical service); that is a touchstone. That makes it very difficult for those of us who care about other things."

PEC for years has advocated a state code amendment that would require utility companies "to fully mitigate" construction of power lines — including the viewshed for up to three miles, said Dan Holmes, the organization's state policy director.

But, state law provides compensation only landowners directly affected — with lines across their property — and potentially those within 60 feet, said Merle Fallon, a Warrenton lawyer representing Eastern Fauquier Neighbors Against Option A.

[http://www.fauquiernow.com/index.php/fauquier\\_news/article/fauquier-despite-odds-fauquier-can-prevail-against-power-line-2015](http://www.fauquiernow.com/index.php/fauquier_news/article/fauquier-despite-odds-fauquier-can-prevail-against-power-line-2015)

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WHIP-AT-LARGE

HOWARD WOLPE  
THIRD DISTRICT, MICHIGAN

Congress of the United States  
House of Representatives  
Washington, D.C. 20515

August 13, 1991

Power Lines FP 110  
CO-CHAIRMAN,  
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Mr. William T. McCormick, Jr.  
Chairman of the Board and Chief Executive Officer  
CMS Energy Corporation  
Fairlane Plaza South, Suite 1100  
330 Town Center Drive  
Dearborn, Michigan 48126

Dear Mr. McCormick:

I have just reviewed the testimony of the hearing held by the Investigations and Oversight Subcommittee on August 6, 1991 to examine Consumers Power Company's proposed high-voltage power line. I am writing to urge you to announce a moratorium on this project.

Testimony received at the hearing raised serious questions concerning the need for the proposed power line. It is clear that exposure to electromagnetic fields (EMF) poses a potential risk of adverse health effects. I believe that it is incumbent upon Consumers Power -- as a public utility company -- to demonstrate that it has taken all prudent actions to avoid unnecessary public exposure to such potential risks. Based on the testimony received at the hearing, there is no evidence that Consumers Power has considered cost-effective alternatives to constructing this power line.

Testimony was received demonstrating that there is sufficient potential for energy efficiency improvements in the Consumers Power service territory to meet future demand without building this power line and exposing citizens to the potential risk associated with EMF. And I would emphasize that these energy efficiency improvements could be realized at a lower cost than power purchased over the proposed line.

In my view, Dr. Sagan, the witness representing the Electric Power Research Institute (who appeared at the suggestion of Consumers Power Company) was correct in concluding that in light of the current state of scientific knowledge, it would not be prudent to make costly modifications to existing power lines. However, even Dr. Sagan begrudgingly agreed that it would be prudent to avoid potential health risks associated with the construction of a new power line if demand could be met in a less risky manner at a "lower cost" than the power line itself.

Mr. William McCormick, Jr.  
August 12, 1991  
Page Two

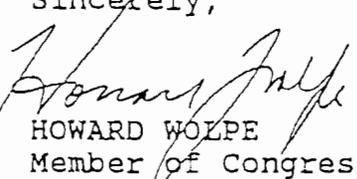
The Consumers Power witness, Mr. Michael Morris, stated that questions concerning the need for this power line will be ultimately settled in land condemnation proceedings in the County Courts. I submit that such proceedings are an entirely inappropriate way to establish our State's energy policy. However, Mr. Morris also indicated that the company would welcome the opportunity to demonstrate the need for the proposed power line "in another forum." I believe that the Michigan Public Service Commission (MPSC) would be the appropriate forum for such a determination of need.

I would, therefore, strongly urge you to halt efforts to construct this power line and request that the MPSC conduct a proceeding to determine if the proposed line is needed. Such a proceeding would allow both proponents and opponents of the power line to make their case in an appropriate public forum.

In closing, I would like to make one final point. In the wake of the controversy surrounding this power line, the elimination of 500 Consumers Power jobs, the outages due to the storm in July, and a series of unfavorable rulings by the MPSC and the courts, there is no doubt that public confidence in Consumers Power Company has seriously eroded. There would be no better way for the Company to begin to rebuild its public credibility than by announcing a moratorium on this power line. If Consumers Power persists in its efforts to push this power line through without a public review of need, its public credibility will only suffer further -- which clearly would not be in the long-term best interests of the Company.

I trust that you will give this matter serious consideration.

Sincerely,



HOWARD WOLPE  
Member of Congress

HW:kel

cc: The Honorable David Bonior  
The Honorable William Broomfield  
The Honorable Dave Camp  
The Honorable Bob Carr  
The Honorable Barbara-Rose Collins

June 1990

A Monster in My Neighborhood

A monster resides in my neighborhood. It has injured, even killed some; drastically affected the lifestyles of everyone on my street. Yet, those responsible for it are unconvinced of its destructive capacity.....

We live on a quiet street in the village of Shadyside, Ohio. My wife, Kathy, and I were excited to find a home next to our high school and college friends, Mark and Lana. The four of us have mutual interests, from coaching Little League baseball to various scouting activities. We have even vacationed together. Our daughter, Marci, is six months older than their Ashley; our son, Bart, is a half-year older than their Shayla. But our "Dick Van Dyke Show" existence has become more like the "Twilight Zone."

Just as we were closing the deal on our house, a neighbor girl's heart stopped. It was determined that her natural electric system had faltered. After repeated heart failures, a device was implanted in her chest to ensure a quick restart in the event of future system interference.

After settling into our new place, Kathy informed me she was pregnant with our second child. (Marci was nearly three.) But Kathy suffered a miscarriage, her first. The monster had struck again.

Summer came. Our small, above-ground swimming pool became THE place for Marci and Ashley. They also spent hours on the newly erected swingset in our backyard. Then, one day, Ashley began to limp. Her joints swelled and she developed a rash. Our local doctors were dumbfounded. Upon their recommendation, Ashley was sent to Children's Hospital in Pittsburgh. Extensive testing eliminated rheumatoid arthritis, but the possibilities of leukemia, lupus, and Henoch Schenlein Purpura remained. Additional tests revealed the latter. Ashley was then treated for this extremely rare (it occurs three times a year in the entire Ohio Valley) malady. She completely recovered. But three months later, Brianne, the 18-month-old daughter of our upstairs tenant, was diagnosed with the same disorder. To say the least, something strange was happening.

We wondered whether the swimming pool had somehow affected Ashley...but Brianne was never in its water. Did the well-water Ashley's grandfather gave her to drink cause the limp? No, because Brianne never drank any. Maybe, then, it was the electrical substation located 70 feet from and in direct line with our backyard.

Built in 1941 and surrounded by an eight-foot-high chain link fence, this unit emits a constant and quite distracting hum. Its lightning rod has been regularly used; its security light casts an eerie yellowish shadow over our yard each night.

Soon, Bart and Shayla were born into the neighborhood. They, of course, became fast friends. Then Kathy suffered her second miscarriage. We recovered and became satisfied with two healthy, beautiful children. Suddenly, in the summer of 1988, Bart experienced his first seizure. Neither Kathy nor I was home at the time. My mother-in-law, who was babysitting for us, got help. These seizures continued at two- and three-week intervals until the fall. Bart was placed on medication. It kept him problem-free for six months. Then he began suffering a new type of seizure: He awoke with short jerks and, once up, would fall back down. After three days of this, I noticed the substation had "grown." In fact, a mobile unit had been put into service to enable maintenance on the main structure. I asked exactly when the mobile unit had been installed. Sure enough, it was the same day Bart began having his new attacks.

My father-in-law had recently retired from American Electric Power. I expressed my substation concerns to him. My remarks were immediately disputed. He told me that people daily work on or near turbines and high-voltage wires, with no ill effects. (He had just recovered from his second major cancer operation.) I then provided him articles I'd read about the subject in "New Yorker," "Discover," "Business Week," and "Newsweek." To put my mind at ease, my father-in-law decided to set up a meeting between me and a few AEP executives. Before such occurred, however, Bart had more seizures, each time while the power company was working on the substation.

Our family doctor had told us about his most difficult seizure-control case: a man named Jerry. I went by Jerry's house...it abutted high-voltage lines. A first-grade teacher commented that a mutual acquaintance had a daughter diagnosed with epilepsy. I drove to the house...high-voltage lines ran directly through the yard. In addition to these two cases, I've heard of at least three other epilepsy incidences where high-voltage wires were involved. Eventually, even my father-in-law began to believe in the electrical monster.

Kevin, Brianne's father, came to me last spring with some heart-breaking news: His unborn child would come into this world without a fully developed left arm. I also know of two neighborhood people who died of brain tumors. (The 69,000-volt wires that emanate from the substation run directly past their houses.) Last winter, another neighbor had successful surgery to remove a brain tumor.

I finally decided to approach the power company concerning these "coincidences." First, I journeyed to their Bellaire office to talk to a very interested Mr. Reese. He accompanied me to the president's office. There, Mr. Jack Welshe, a true "company man," became defensive. He was clearly uncomfortable answering my questions. Within days, Mr. Reese came to our house. He brought along a publication from Carnegie-Mellon University in Pittsburgh: "Electric and Magnetic Fields from 60-Hertz Electric Power: What Do We Know About Possible Health Risks?" It was written in non-technical language to discuss consumer questions regarding possible dangers involving power lines. Inside, I found some extremely interesting text:

- o Page 10 -- "Scientists have found that fields can produce changes in the functioning of individual nerve cells and the nervous system."
- o Page 15 -- "...studies show effects on chemicals called neurotransmitters which send signals between nerves," and that "there is some indication that some people respond more than others."

Shortly after reading this literature, I was called by Mr. Sam Henderson, a regional manager for Ohio Power, a subsidiary of AEP. He told me about his four-year-old grandson who often acted "silly" when big power trucks were nearby. I asked Mr. Henderson if he was possibly implying that Bart was just taking these seizures. His reply: "You know how kids are." (This man is a regional manager for this company???) I angrily hung up the phone and called my father-in-law. I wanted another meeting with higher management personnel. Soon, a Mr. Andy Molato and a Mr. Brendan Ware came to Bellaire to meet with me. Mr. Ware was particularly effective in expressing his concern, but yet disagreement, with much of what I said. He finally stated that a logical connection exists between smoking and emphysema, but no such logic links substations with seizures. I then asked him if there was possibly a connection between a disorder involving electrical charges in the brain and the electromagnetic and electric fields radiated by a substation. I decided to investigate this matter.

I travelled to Columbus, Ohio, and spent two days in the Ohio State University Medical Library. Some of the titles a med-school friend and I found: "Effects of Simulated Atmospheric and 100-Hertz Magnetic Fields on Audiogenic Seizures in Rats," "Reliable Induction of Generalized Seizures in Hippocampal Kindling Triggered with Low-Frequency Electrical Stimulations," and "Effects on the Nervous System by Exposure to Electromagnetic Fields." There was an incredible amount of information relating to this subject, all obviously contrary to Mr. Ware's assessment.

I mailed my findings to Mr. Charles Heller, Ohio Power's president. He then forwarded such to an assistant. The company response was predictable. Since this time, I've heard of another neighborhood girl, a teenager, afflicted with Henoch Schenlein Purpura. Yes, she lives next to high-voltage lines.

"Currents of Death," by Mr. Paul Brodeur, and "Cross Currents," by Dr. Robert Becker, are two books I've read that are certainly making the general public aware of studies concerning power company practices. I was, though, very disappointed in Dr. Becker's conclusion that the only option is to surrender and move. This goes against all those things I've tried hard to instill in the young men I coach on football and baseball fields.

In conclusion, we have moved...our old house sits abandoned. But I'm not quitting. I continually collect ammunition (studies) to fight the monster. I realize I cannot kill him, but I can, at the very least, make his handlers more responsible for him.

# # # # #

MARK BOWER  
4696 Smithfield Street  
Shady side Ohio 43947

# Washington County

## Parents lead fight against power line

High-voltage proposal mobilizes Greene County residents; more research urged on health effects of electromagnetic fields

Sunday, June 24, 2007

By Janice Crompton, Pittsburgh Post-Gazette

Plans for a high-voltage power line through Washington and Greene counties have met with heavy opposition from property owners, creating what has been estimated by local officials to be the loudest citizens outcry in a generation.

But one group of residents in particular has mobilized to fight the plan like no other. Parents.

April Ricci, of Jefferson, Greene County, is determined to stop plans by Allegheny Power to construct a 37-mile, 500-kilovolt power line near the home she shares with husband, Albert Ricci III, and their three children, ages 11, 8 and 5. The line would also pass within 1.5 miles of the Jefferson-Morgan Elementary School.

Ms. Ricci has distributed petitions door-to-door, attended numerous meetings and gatherings, and organized opposition forces.

Although the line will not run through her property, Ms. Ricci's resistance is perhaps fiercer than that of her neighbors due to the death of her infant daughter 13 years ago.

The couple's first daughter, Sarah, was born with a rare tumor in her heart and lived only one day. Doctors were baffled, Ms. Ricci said, telling her that the odds of such a mass were about 10 million to one. They could not determine the cause, and ran tests to rule out genetic abnormalities.

She granted doctors' requests to keep her daughter's heart for further testing.

"When I was pregnant, I never drank, smoked, or even took a Tylenol," she remembers.

Living in Georgia at the time, the couple, who were from southwestern Pennsylvania, returned home confused and heartbroken.

"I just thought, 'Why did this happen to me? I'm being punished for something.' "

The couple went on to have three healthy children at their home in Greene County with memories of little Sarah and still no clue what killed her.

It wasn't until Allegheny Power began unveiling its plans for the power line that would be



Darrell Sapp, Post-Gazette  
The Ricci family, from left, Bo, 8; Olivia, 5, holding Teddy, the kitten; April Ricci; A.J., 11; and Albert Ricci in front of their Jefferson home. They are concerned about their home's proximity to Allegheny Power's proposed high-voltage power line that would run from North Strabane to Dunkard in Greene County, continuing into Virginia. Click photo for larger image.

strung on 120-foot to 140-foot towers, that the Riccis began thinking about the possible correlation between Sarah's death and similar towers near their home in Georgia.

The couple lived and worked near high-voltage towers, and Ms. Ricci said she recalled a time when she was pregnant when she and her husband and some friends rode all-terrain vehicles beneath the power lines.

"I heard them crackling," she said of the overhead lines. "It literally gives me the chills now. I think, 'Oh my God, I was so stupid,' I knew nothing."

### **Protecting their children**

The loud crackling and humming of power lines makes property owner Juliann Cernuska wary. She said a sympathetic power company field technician she encountered in the local post office warned her that she "wouldn't believe how loud," the power line would be.

"He said he'd never experienced anything like it," she said.

Allegheny Power purchased an easement in 1976 on the 24-acre property that Ms. Cernuska and her husband Steve bought and built a home on 10 years ago. She estimates the power line right of way will be about a football field away from her home, which fronts on Route 188 in Jefferson.

The Cernuskas are considering moving if the project is approved. Their son Cameron, who turned 7 on Wednesday, suffers from asthma, and Ms. Cernuska questions her parenting abilities if she stays. She has seen health studies and reports that indicate a possible link between childhood leukemia and power lines.

"Do you knowingly drink water that's poisoned? Do you knowingly live in a house with asbestos?" she said. "How can I stay and be a good parent?"

Those feelings of guilt and concern have racked parents all along the power line route, from North Strabane in Washington County, where a new power station is planned, to Dunkard in southern Greene County, where the power line is expected to connect with a junction and continue east 240 miles into Virginia.

The Pennsylvania portion of the line is meant to serve growing energy needs in northern Washington County, according to the power company, while the eastward line will supply northern Virginia, which is in critical need of new energy.

The state Public Utility Commission is expected to take up Allegheny Power's application for the Pennsylvania line this summer with several public hearings.

The U.S. Department of Energy held a hearing earlier this month to gather input on a plan to designate much of the northeastern U.S. as a national interest electric transmission corridor -- or NIETC -- which would give the federal government authority to overrule state decisions involving electric transmission lines under certain conditions.

Ms. Ricci spoke at the hearing, recounting Sarah's story for two DOE panelists and passing out her daughter's photo in the hope of influencing their decision.

If a state denies a permit, makes no decision within one year, or places too many conditions on a power company permit, the Energy Act of 2005 gives the federal government backstop authority to grant construction permits, superseding state and local regulations.

### **Health risks questioned**

Organized opposition, in the form of local officials and a citizens group, Stop The Towers, has discouraged residents from harping on health and safety issues because effects can't be

proven and won't be taken under consideration by state or federal authorities.

Despite years of testing and studies, there still isn't enough science to determine the health effects of power lines, according to M. Granger Morgan, an electricity expert who has studied the issue for about a decade.

People are routinely exposed to electromagnetic energy through household appliances, but "because power lines are big and highly visible, they tend to get more attention," said Mr. Morgan, head of the Department of Engineering and Public Policy and professor of electrical and computer engineering at Carnegie Mellon University.

Mr. Morgan serves as chair of the U.S. Environmental Protection Agency Science Advisory Board, the Electric Power Research Institute Advisory Council and the Scientific and Technical Council for the International Risk Governance Council of Geneva, Switzerland. He is a fellow of the American Association for the Advancement of Science, the Institute for Electric and Electrical Engineers, and the Society for Risk Analysis.

Exposure to electromagnetic fields -- or EMF -- drops off rapidly with distance in the vicinity of high-voltage power lines, Mr. Morgan said.

There are studies that have indicated a possible link between EMF, childhood leukemia and other forms of cancer. Because childhood leukemia is fairly rare, affecting about one in 14,000 children, according to Mr. Morgan, it has been difficult to study, and there is not a clear connection with EMF.

Still, specific findings involving power lines have included biological changes in animals, such as effects on melatonin and other hormone levels, and changes in molecules and cells in the body.

### **Prudent avoidance**

Because of the findings and lack of concrete evidence so far, Mr. Morgan has proposed a policy called "prudent avoidance," suggesting power companies limit exposure whenever possible through modest investments of money and effort. Meant to be a common sense approach, it argues against drastic action or inaction until science provides a clearer picture of risk.

Some property owners have complained about the size of the 200-foot right of ways used for the towers, but the company says cutting such a large swath not only protects against falling lines, it lessens the effects of EMF as well.

"If you're standing at the edge of our right of way, you're not getting any more exposure than if you were standing in front of an appliance in your home," said company spokesman David Neurohr.

"Common sense is why you have a right of way and a buffer zone," he said.

April Ricci and other parents have said they want to see power companies further study the effects of EMF and power lines. They are also promoting the possibility that power lines near Jefferson-Morgan Elementary be buried, perhaps in the abundant mining shafts that have been abandoned over the years.

Unless they can prove it's not technologically feasible, electric utilities in Connecticut now are required to bury power lines near schools, playgrounds, and day care facilities, thanks to a law that was designed to be a precautionary measure against possible EMF exposure. The cost to bury utility lines is significantly higher than above-ground construction.

"Why would they pass a law if there was nothing to it?" said Ms. Ricci. "How much money can you put on a person's life? How many people have to die?"

## ELECTRIC POWER DELIVERY FROM THE COMMUNITY POINT OF VIEW

By

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STATEMENT)Synopsis

Historically, most American communities have accepted the argument made by their utility suppliers that the cheapest and best way to distribute electric power in their community was through the use of overhead lines. Many of these companies have also argued that the only benefit in having underground distribution systems was that of enhanced visual pleasure hence the entire cost of placing utilities underground should be borne by the property owners immediately adjacent to the affected lines. These arguments, however, may now be shown to be obsolete and no longer valid if one takes the point of view that the utility service provided should be done at the lowest overall cost to the community.

Since the Spring of 1987, there have been a series of technical studies and political maneuverings in Florida that are beginning to show conclusively that from the overall community point of view, underground systems, though more costly to install, actually result in significantly lower total costs. Documented evidence clearly shows underground systems to be far superior to overhead systems from the safety aspect and in terms of storm damage resistance and recovery. There is also ample evidence that underground is at least equivalent to overhead and may be superior in terms of operations and maintenance costs. Finally, there are benefits not yet quantified for the underground systems over the overhead systems in regard to public health (magnetic field exposure) and for the environment (leaching of toxic chemicals from preservative treated poles, the disposal of the poles, and the plants which manufacture them).

Evidence to date indicates that the savings from just the reduced economic losses associated with weather induced outages or the savings from reduced loss of life would each be enough to make underground systems more cost effective.

Introduction

The fundamental issue discussed in this paper is the comparison of the two basic options available for the delivery of electric power; overhead lines vs underground cable and the resulting question of who should pay. The approach discussed is what has become at least a four phased state-wide effort that evolved from a simple investigation by one small town in Northwest Florida to beautify itself through the undergrounding of its utilities. The phases to date are the following:

1. The Pilot Study by the author as part of a committee investigation into the cost of converting the city's overhead lines to underground.

2. The analysis conducted by the Florida Public Service Commission (PSC).
3. The independent Cost Analysis Study by the University of Central Florida.
4. Reactions to the three studies.

The Pilot Study

The effort began when the City Council of Fort Walton Beach, Florida, appointed the author to head a committee in the Spring of 1987 to investigate the feasibility of converting all overhead lines in the city to underground service as an aid to enhancing the beauty of the city. The committee also included representatives from the local electric company (Gulf Power), the local telephone company (CENTEL), the local TV Cable company, (Warner), as well as the City's engineering staff. As no funds were allocated for the effort, it was important that a low level of effort approach to the problem be developed. The electric utility argued for a city-wide survey approach first to see what the public was willing to pay. The chair argued that benefits must be first identified prior to asking the public what they would be willing to pay. The chair offered to address the benefits question if the corporate members would address the cost. The telephone company representative proposed a sampling method approach to costing and supported the chair's offer. This became the approach used except that the author's investigation extended longer than did the company participation.

After the cost figures had been developed the telephone company concluded that they would continue their present policy of gradually converting their entire system to underground at no cost to the public as it was more economical for the company to have an all underground system. The TV Cable company concluded that they were amenable to go either way but that if a decision were made to go underground, they would like to do it on a gradual basis. The electric company was willing to put its system underground but only if the local rate payers paid 100% of the cost. They further argued that they did not accept the total cost concept and that the issue of total system cost to the community was not appropriate for discussion or for analysis.

The conclusion reached by the chairman was that the aesthetic benefit to underground systems was probably the least important of all the reasons and that improved conditions of safety to both the public and the utility employees along with economic savings associated with storm damage resistance and recovery were of major concern and deserved further investigation. Further, a survey of the fifty states showed a definite trend towards the undergrounding of all distribution systems. Finally, the emerging issue of public health (potential carcinogenic linkages be-

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tween electromagnetic fields and human proximity) coupled with the safety and storm issue made the overall question sufficiently important to elevate the study to the PSC level. Prior to discussing what happened in trying to attract the interest of the PSC, let us discuss the specific findings of the Pilot Study.

### Safety Issues

The lack of public awareness of the extent of the safety issue is marked by the lack of a central agency at the state level in Florida for the collection of data relating to safety. The Florida Public Service Commission maintains a data bank in regard to members of the public who are injured or killed by accidentally coming into contact with live wires directly. The Department of Labor maintains the data bank concerning the accidents involving utility employees, and the Departments of Transportation and Motor Vehicles and Highway Safety maintain the data bank which includes accidents relating to vehicle impact on electric power and telephone roadside equipment (poles, transformers, etc.)

Consider first the accidental contacts made by members of the public; e.g. tree trimming, boat launching, operation of building machinery, etc.) These data show that for the four investor owned electric utilities in Florida (Florida Power and Light, Florida Power, Tampa Electric, and Gulf) for the period of January 1981 through December 1987 there were 118 deaths occurring over 57,077 miles of circuit or .207 deaths per 100 miles of line. On the other hand, for the underground case, these same four companies had 17,810 miles of line and only one death for the same period. This results in a factor of .0056 deaths per 100 miles of line hence the normalized kill ratio is 36.9 deaths on the overhead system for every death on the underground system.

One interesting note concerning the protection of the public through regulations is that Florida Statute 366.04 says that the standards of safety adopted for the utility system is prescribed in the National Electrical Safety Code and that adherence to the standards therein shall constitute acceptable and adequate protection and safety of the public. The National Electrical Safety Code Committee, however, disavows any standards at all concerning public safety.(1) Their standards relate only to the installation and maintenance of the systems by utility workers and that they have one set of rules for overhead systems and another for underground systems.

The second issue of safety concerning accidental contact relates to the safety of individual lineman employees of the utility companies. A study [2] released in 1988 ranked electric power line workers in the fourth most dangerous work profession and fifth worst for all occupations with a death rate of 50.7 per 100,000 workers. Data from the Florida Department of Labor shows that for the period 1981 through 1986 for the four regulated utilities, there were 10 disabling injuries and 4 deaths involving overhead line work and no disablement or deaths at all for

underground system workers.

The third area of safety concerns the safety of vehicular traffic. Data concerning accidents, injuries, and deaths of people in vehicles striking poles, guy wires and pad mounted transformers are kept in two separate locations. The Department of Transportation (DOT) maintains data relating to the rural and urban roads maintained by DOT and the remainder of data relating to all other roads in the state is maintained by the Department of Motor Vehicles and Highway Safety. These combined data banks show that for all the urban roads in Florida there are about five accidents per day involving poles and guy wires. These accidents result in about 25 deaths per year. The accident summary for pad mounted transformers is non-existent. So few accidents occur that there is no assigned category for them.

The transportation industry has long investigated ways and means to reduce highway and roadway accidents. In one recent article [3] an analysis of more than a thousand vehicle/pole accidents was made and the conclusion reached was that for accidents which involved poles within 5 feet of the curb, the total cost of all the accidents combined could be covered by any of the three corrective measures: (a) putting the wires underground and putting street lights on break-away poles, or (b) putting all poles on one side of the street, or (c) moving all poles at least ten feet back from the street. A final conclusion reached was that the lives injuries, and property damage saved by any of these methods, if converted to dollars, would pay for the corrective measure taken in less than twenty years.

### Storm Damage

Though no data was obtainable from the electric power companies on this issue during the pilot study, CENTEL noted that when the last major hurricane went through Tallahassee in 1985 their outside plant was about 50% overhead and 50% underground and their cost to repair the overhead system was \$729,480 and only \$7,130 to repair their underground system

In addition to wind damage susceptibility electric power and communication lines are subject to voltage transients due to nearby lightning strikes. Electrical machinery and electronic equipment, particularly computers, are vulnerable to transients and underground systems appear to be less subject to these transients than are overhead systems. Though no specific data was obtainable during this study it is obvious that there are two areas of concern. First is the cost of lost business when voltage transients destroy memory and other functions within a computer and second is the cost of damage to a customer's equipment itself due to the surges or dips.

The lack of available data in conjunction with the intuitive belief that such damage could be significant lent weight to the argument that this study should be followed by a more in-depth study by the PSC or some other organization with greater resources and more ability to gain access to company data.

[South Delta Leader \(Richmond, B.C., Canada\)](#), May 23, 2008

## STUDENTS WALK OUT

[Rachel's introduction: The Tsawwassen Residents Against Higher Voltage Overhead Lines (TRAHVOL) have released their own document, written by Dr. Bruce Owen with the University of B.C., on the potential effects of electromagnetic fields. "If ever there was a case for adopting the '[Precautionary Principle](#)' it is this one," he writes.]

By Kristine Thiessen, South Delta Leader

Hundreds of South Delta students plan to walk out of school today, Friday, to protest an overhead power lines project.

Connor Broadfoot, a Grade 10 student at South Delta Senior Secondary, is among the students attempting to show the provincial government that Tsawwassen youth are against the B.C. Transmission Corporation's plan to upgrade power lines through a residential neighbourhood and the school's property.

He created a group on the social networking site Facebook called "Powerlines protest," which as of late Wednesday afternoon had 358 members. Many people who joined are listed as attending South Delta Secondary with a number from Southpointe Academy.

Broadfoot said in a phone interview the walk-out will take place at noon after the school's lunch hour. The students will protest at Dennison Park during their third block of class.

"I feel it needs to be done," he said.

Broadfoot is concerned the electromagnetic fields emitted from the new, higher voltage lines will contribute to instances of cancer. And if heavy seismic activity occurred and the power poles fell, he said, "they could create serious damage and panic."

BCTC and provincial Energy Minister Richard Neufeld have said the EMF levels emitted by the new poles are well within international health standards.

In a recent media release, BCTC media spokesperson Chris Rathbone pointed to an interview on CBC's Early Edition with the Vancouver Coastal Health Authority's Dr. Patricia Daly.

Said Daly, "The available scientific evidence that we have right now does not indicate that there's any adverse health effects from exposure to these types of fields at the levels that people would normally experience in their homes or in the workplaces. And I think most experts in B.C. agree with that."

With regard to the potential link to childhood leukemia, Daly said some studies, not all, have suggested there is an association.

"But those studies do suffer from some methodological problems, and that's why the experts do conclude that right now we don't have any evidence of any long-term health effects from this type of exposure because these studies, by and large, if you look at all of them, have not found associations."

The Tsawwassen Residents Against Higher Voltage Overhead Lines ([TRAHVOL](#)) have [released their own document](#), written by Dr. Bruce Owen with the University of B.C., on the potential effects of electromagnetic fields.

"If ever there was a case for adopting the "Precautionary Principle" it is this one," he writes.

For the [complete document](#) visit <http://www.trahvol.com/>.

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