

FILE

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10134 Clay Street
Montville Township, Ohio 44094

Ohio Siting Board
180 East Broad Street
Columbus, Ohio 43215

May 9, 2007

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PUCO

Reference Project #07-0171-EL-BTX

Dear Siting Board,

Again, I am writing a letter to inform of my concerns over the recent decision by First Energy to consider putting a high-powered line down Clay Street. Although this letter is somewhat repetitive, I feel it bears repeating.

First and foremost, my concern is for the health and safety of the communities involved. I was extremely selective when looking for property and a home to purchase, to avoid high powered tension lines for cancer risk reasons and other health risk reasons.

I have reviewed many studies about this subject. Almost all of them state, while there may not be conclusive evidence of causative affects from EMF, the facts obtained from the studies are too great to ignore or dismiss as coincidence. The EPA warns "There is reason for concern" and advises "prudent avoidance"; in other words they would **not recommend** building near, purchasing near, or residing near high-powered lines; yet the power companies keep trying to press the issue of forcing lines in residential areas, causing so much wasted money on research.

It is evident that burying the lines is safer. If the money put into all the research was used to bury the lines, there would most likely be money to spare. It is unbelievable that this country, as advanced as we are, is still flying wires. Even Europe buries there lines. It is such a shame for those who mistakenly chose to live near high tension lines, or had it shoved upon them by the power companies, now have to pay the consequences.

I am not convinced there is a need for this project. In fact I wonder if First Energy is targeting our area with poor service to shove their power line upon us.

For a year and a half prior to the announcing of this First Energy project, we suffered only one power outage from storm damage due to **lack of foliage upkeep** around the existing First Energy lines in the neighborhood. That repair was completed within four hours.

Since the announcement of this project, we have suffered a power outage for almost eight hours, due to maintenance work being done in the Chardon area; and an outage for approximately six hours from storm damage, again due to lack of foliage upkeep around the existing First Energy lines in the neighborhood.

Now we are suffering fluctuations in power (lights flickering often) which can lead to wear and tear of household motors in washing machines, dryers, dishwashers, sump pumps... This incident was reported to First Energy by a neighbor. **What happened is shocking!**

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First Energy Technicians arrived to their property. The First Energy Technicians somehow broke their electric meter, then proceeded to advise the property owner that they were responsible for arranging for and paying for the repair of the meter broken by the First Energy Technicians.

The First Energy Technicians also proceeded to advise the property owner that this fluctuation of power problem runs from Hambden through Montville, and that the repair cost of the public lines will have to be paid by the property owners in the affected neighborhoods. They advised that First Energy is not responsible for this upkeep.

Another thing I learned from the studies I reviewed is that, if First Energy is allowed to go ahead with the project as proposed, we as property owners stand to lose up to 50% of our property value. I don't hear anyone from any big Company involved, who will be gaining a lot of revenue ensuring that they will reimburse each and every one of those affected appropriately. How can we, or why should we be concerned over the welfare of these Companies?

Again I say, why not bury the lines. In know you say it is not cost effective, but there is obviously no concern by First Energy whatsoever over the loss of property value to all who live along the paths of this proposed line, much less the probable loss of homes.

Buried lines will ultimately be less harmful on the environment and the community involved. Realizing there will be an initial impact from any construction, as there always is; if you bury the lines, the environment around it will be shielded by the casing over the cable as well as the earth around it. It is a safer way to go. **Shouldn't safety be the first concern?**

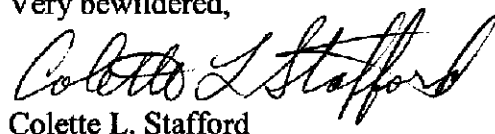
If First Energy had put the money they have already invested in this project, into considering ways to save money in a buried line project, they just may have come up with a more cost effective buried line plan, not to mention a much less stressful plan for all involved in this community. **We in the neighborhoods involved are very stressed by all of this and First Energy Technicians are adding even more stress.**

I sincerely hope serious consideration is put into burying the line. It seems to me, it makes the most common sense when considering the health, safety, and environmental issues. And there is another issue; the environment. Poles and wires do not blend in, and the power emitted from the high-tension wires is very unhealthy for the entire environment.

I'm sure you already have copies of many studies but I have attached just a small fraction of information I have read. Please know, in all fairness, I have also read reports paid for by "Power Companies." I still come up with the same conclusions.

PLEASE CONVINCING US YOU DO CARE ABOUT OUR NEIGHBORHOOD.

Very bewildered,



Colette L. Stafford

c: Senator Tim Grendell
Representative Matt Dolan

Congressman Steven C. LaTourette
Geauga County Commissioners

Montville Trustees
Ted Krauss, First Energy

About Diodes

Classic Diodes

Cell Phone Diode

EMF Research

Catalog and Prices

Other EMF symptoms include:

Eyestrain, headaches, inability to concentrate, neckaches, irritability, depression, memory loss, weakened immune system and, in more extreme cases, birth defects and leukemia in children. Children, unfortunately, are especially susceptible to EMFs.

Electromagnetic Radiation Fields

In 1989, the Electric Power Research Institute praised the methodology of a power line study which linked leukemia, prostate and other cancers in young men with chronic exposure to magnetic fields.

In November, 1989, the Department of Energy reported that "It has now become generally accepted that there are indeed Biological effects due to magnetic field exposure."

Martin Halper, a director of the E.P.A., said in a Fortune Magazine article on magnetic radiation: "In all my years of looking at chemicals, I have never seen a set of epidemiological studies that remotely approached the weight of evidence that we're seeing with ELF electromagnetic fields. Clearly there is something here." (Fortune, Dec. 1990)

An EPA draft report, 1990, recommended that EMF's be considered a Class B carcinogen. This class included formaldehyde, DDT, dioxins, and PCB's. In a later watered down version, the reference to Class B was deleted, with an explanation that said the basic interaction between EM fields and biological interactions leading to cancer are not understood. Yet, in the same report, they suggest there is a causal link between leukemia, lymphoma and cancer in children with exposure to magnetic fields from residential 60hertz distribution systems!

That was over ten years ago. The increase in electric and microwave use for telecommunications has created an environment of electrical pollution that permeates every home, workplace, park and playground.

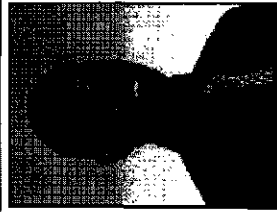
In what is probably the largest study ever conducted on EMF exposure, researchers in Sweden announced in 1992, they had determined a dose-response relationship between exposure to EMFs from power-distribution lines and childhood leukemia.

In the summer of 1996, a U.S. Federal Court ruled that citizens may not bring suit against electric power companies over electromagnetic radiation emissions. Dr. David Carpenter, dean of public health at SUNY in Albany, N.Y., headed the utility industry's New York Power Lines Project, a five million dollar review of the carcinogenicity of magnetic fields. According to Dr. Carpenter, "The Savitz study changed my entire view of the field, and it has enormous implications." Fortune Magazine wrote: "Based of those results, he estimates that up to 30% of all childhood cancers may be attributable to ELF fields." "That's conservative," Dr. Carpenter added.

Breast Cancer Risk in Women: Occupational Exposure to 60-Hertz Magnetic Fields-147
reports from 115 independent studies- Summary was that associations with breast cancer were found- strongest for women who worked in offices and in the telephone industry. For example, women electrical engineers have a 73% greater risk of dying from breast cancer.

Of 35 international research studies on electric field radiation, 33 established a conclusive link between brain tumors, leukemia, and other forms of cancer.

Scientists in Russia have done more studies on EMF than any other country and for decades have been reporting that electric fields cause high blood pressure, chronic stress effects, immune system dysfunction, changes in white and red blood cell counts, increased metabolism, chronic fatigue disorders, and headaches.



Dr. Joseph Mercola
Author of the
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Are EMFs Hazardous to Our Health?

Can electromagnetic fields (EMF) from power lines, home wiring, airport and military radar, substations, transformers, computers and appliances cause brain tumors, leukemia, birth defects, miscarriages, chronic fatigue, headaches, cataracts, heart problems, stress, nausea, chest pain, forgetfulness, cancer and other health problems?

Numerous studies have produced contradictory results, yet some experts are convinced that the threat is real.

Dr. David Carpenter, Dean at the School of Public Health, State University of New York believes it is likely that up to 30% of all childhood cancers come from exposure to EMFs. The Environmental Protection Agency (EPA) warns "There is reason for concern" and advises prudent avoidance".

Martin Halper, the EPA's Director of Analysis and Support says "I have never seen a set of epidemiological studies that remotely approached the weight of evidence that we're seeing with EMFs. Clearly there is something here."

Concern over EMFs exploded after Paul Brodeur wrote a series of articles in the New Yorker Magazine in June 1989. Because of Paul Brodeur's reputation, his articles had a catalytic effect on scientists, reporters and concerned people throughout the world.

In November 1989, the Department of Energy reported that "It has now become generally accepted that there are, indeed, biological effects due to field exposure."

The EMF issue gained more publicity in 1990 when alarming reports appeared in Time, the Wall Street Journal, Business Week and popular computer publications. ABC's Ted Koppel and CBS's Dan Rather both aired special segments on EMFs.

In addition to the long-term health concerns, buying a house with high fields will be an economic

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<u>More Omega-3</u>
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disaster. In a few years, when power line radiation is as well known as asbestos and radon, a house with high fields will be practically impossible to sell. Already there are hundreds of lawsuits regarding EMFs and property devaluation.

EPA Says the Threat Is Real

By 1990, over one hundred studies had been conducted worldwide. Of these, at least two dozen epidemiological studies on humans indicated a link between EMFs and serious health problems. In response to public pressure, the Environmental Protection Agency (EPA) began reviewing and evaluating the available literature.

In a draft report issued in March 1990, the EPA recommended that EMFs be classified as a Class B carcinogen -- a "probable human carcinogen and joined the ranks of formaldehyde, DDT, dioxins and PCBs.

After the EPA draft report was released, utility, military and computer lobbyists came down hard on the EPA. The EPA's final revision did NOT classify EMFs as a Class B carcinogen. Rather, the following explanation was added:"

At this time such a characterization regarding the link between cancer and exposure to EMFs is not appropriate because the basic nature of the interaction between EMFs and biological processes leading to cancer is not understood."

Curiously, this rather unusual logic appears on the same page as the following: "In conclusion, several studies showing leukemia, lymphoma and cancer of the nervous system in children exposed to supported by similar findings in adults in several/ occupational studies also involving electrical power frequency exposures, show a consistent pattern of response that suggest a causal link."

When questioned about the contradictory nature of these statements, the EPA responded that it was "not appropriate" to use the probable carcinogen label until it could demonstrate how EMFs caused cancer and exactly how much EMF is harmful.

This explanation does not satisfy many critics who claim that the EPAs upper management was influenced by political and economic considerations exerted by utility, computer and military lobbyists.

Dental
Diet
EMF - Electro Magnetic Fields
Fluoride
Hypertension
Irradiated Foods
Mercury
Microwaves
Milk and Dairy Products
Mind-Body Therapies
Nutrasweet
Optimal Wellness Links
Prayer/Religion/Faith
Progesterone
Resources
Root Canal
Search Engines
Soy
Sugar

How Do I Measure EMFs?

A Gauss is a common unit of measurement of magnetic field strength. A Gauss meter is an instrument which measures the strength of magnetic fields. Inside a Gauss meter there is a coil of thin wire, typically with hundreds of turns. As a magnetic field radiates through the coil, it induces a current, which is amplified by the circuitry inside the Gauss meter.

Gauss meters may vary in the strength of the magnetic field they are capable of measuring. A meter used for measuring EMFs from power lines, transformers, substations and appliances around the home, for example, should be able to measure as low as .1 mg.

Gauss meters vary widely in price and accuracy. Meters have either a single axis coil or a triple axis coil. Single axis meters are much simpler than triple axis meters to manufacture and thus, are less expensive.

To use a single axis meter you must point the meter's one sensor in three directions -- the x, y and z axis. Then, you combine the three readings in a mathematical equation to calculate the combined field strength. Obviously, its far easier and more accurate to use a 3-axis meter. Triple axis Gauss meters are quite accurate, but they are also more expensive.

Another thing to watch out for when purchasing or renting a Gauss meter is whether or not it is frequency weighted. Most meters will read the same EMF strength no matter what the frequency.

As the human body appears to be sensitive to both the field strength AND the frequency, Gauss meters used for biological purposes should be "frequency weighted".

This means that if the field is different than 60 Hz the meter will consider the frequency and use it in calculating and displaying the EMF's strength. This feature is why frequency weighted meters will show a higher EMF reading than those meters typically used by electricians and engineers.

Power Lines

An enormous amount of electricity is created at power generating stations and sent across the country through wires that carry high voltages. All power lines radiate electromagnetic fields. The question is: how much are the

Surgery

Thyroid

Vaccines

power lines near YOUR home radiating? The amount of EMFs coming from a power line depends on its particular configuration. Power companies know which power line configurations are best for reducing EMFs but most don't feel the evidence supports costly changes in the way they deliver electricity.

Substations

A substation is an assemblage of circuit breakers, disconnecting switches and transformers designed to substations have been blamed for causing cancer clusters among nearby residents. Paul Brodeur wrote about several such cancer clusters in the July 9, 1990 issue of the New Yorker Magazine.

Transformers

A key component of a utility's electrical distribution network depends upon numerous, small transformers mounted on power poles. A transformer looks like a small metal trash can, usually cylindrical.

Even when the electrical service is underground, you will often see a metal box (usually square) located on the ground near the street. Many people don't realize that when they see a transformer, the power line feeding the transformer is 4000 to 13,800 volts.

The transformer then reduces the voltage to the 120/240 volts needed by nearby homes. Since these transformers can be seen in almost every neighborhood, they are a source of concern.

EMFs near a transformer can be quite high, but due to its small structure, the field strength diminishes rapidly with distance, as it does from any point source. For this reason, having a transformer located near your home is usually not a major source of concern, although just to make sure, everyone should measure the field strength around it.

Home Wiring

If your home has high EMF readings, it is important to determine the sources of the EMF so that remedial action can be taken, if possible. Many times a particular room will have a higher EMF reading. Check to see if the electricity is coming into the house on the wall outside that room. When this is the case, it is usually a good idea to block off that room and only use it for storage purposes.

Sometimes, the source of a high magnetic field is incorrect wiring. If you suspect that your home is wired improperly, obtain the services of a licensed electrician. Warning: Do not touch electric wires, even if you think the current is turned off. If you need to disconnect electrical circuits to determine the source of magnetic fields, you should call a licensed electrician.

Computers

Computers are a complicated subject. Know this: EMFs radiate from all sides of the computer. Thus, you must not only be concerned with sitting in front of the monitor but also if you are sitting near a computer or if a computer is operating in a nearby room.

The Swedish safety standard, effective 7/1/90, specifies a maximum of 0.25 mG at 50 cm from the display. Many US manufactured computers have EMFs of 5 - 100 mG at this distance. And know this too: the screens placed over monitors do NOT block EMFs. Not even a lead screen will block ELF and VLF magnetic fields.

Space does not permit a more thorough discussion of computers. If you use a computer, it is important that you

measure your EMF exposure with a Gauss meter and review the literature concerning the health impacts of computer use.

Electric Blankets and Waterbeds

Electric blankets create a magnetic field that penetrates about 6-7 inches into the body. Thus it is not surprising that an epidemiological study has linked electric blankets with miscarriages and childhood leukemia.

This pioneering work was performed by Dr. Nancy Wertheimer and Ed Leeper, who originally discovered that magnetic fields were linked to childhood leukemia. Similar health effects have been noted with users of many electric blankets and waterbed heaters will emit EMFs even when turned off.

The devices must be unplugged to delete the EMF exposure. Additionally, there is the issue regarding the vibrations that are generated by sleeping on standing water. There is less hard data in this area but some experts are concerned about the consequences.

Electric Clocks

Electric clocks have a very high magnetic field, as much as 5 to 10 mG up to three feet away. If you are using a bedside clock, you are probably sleeping in an EMF equivalent to that of a powerline. Studies have linked high rates of brain tumors with chronic exposure to magnetic fields, so it is wise to place all clocks and other electrical devices (such as telephones and answering devices) at least 6 feet from your bed.

Fluorescent Lights

Fluorescent lights produce much more EMFs than incandescent bulbs. A typical fluorescent lamp of a office ceiling have readings of 160 to 200 mg 1 inch away.

Microwave Ovens and Radar

Microwave ovens and radar from military installations and airports emit two types of radiation – microwave and ELF. Microwaves are measured in milliwatt per centimeter squared (mW/cm²) As of 1/1/93, the U.S. safety limit for microwave exposure is 1 mW/cm², down from a previous 10 mW/cm². The Russian safety limit is .01 mW/cm². All microwave ovens leak and exceed the Russian safety limit. In addition, recent Russian studies have shown that normal microwave cooking converts food protein molecules into carcinogenic substances.

When measuring microwaves from military and airport radar sources, 100% accurate readings can only be found with extremely expensive digital peak-hold meters. Why? Because analog devices begin to drop their reading immediately after the radar sweep passes. Thus, while an analog meter can show whether or not you are being exposed to radar EMFs, analog meters can't show your true exposure. Although thousands of dollars to purchase, digital-hold meters capable of accurately detecting radar EMFs can be rented for several hundred to over a thousand dollars per month.

Telephones and Answering Machines

Telephones can emit surprisingly strong EMFs, especially from the handset. This is a problem because we hold the telephone so close to our head. Place the Gauss meter right against the ear piece and the mouth piece before buying a phone.

Some brands emit no measurable fields and others emit strong fields that travel several inches....right into your brain. Answering machines, particular those with adapter plugs (mini-transformers), give off high levels of EMFs.

Electric Razors and Hair Dryers

Electric razors and hair dryers emit EMFs as high as 200 to 400 mG. This seems alarming, but we don't know if this is worse (or better) than a chronic exposure to a 2-3 mG field. Some EMF consultants recommend that hair dryers not be used on children as the high fields are held close to their rapidly developing brain and nervous system.

Prudent Avoidance

Electricity is an inseparable part of our modern day society. This means that EMFs will continue to be all around us. But as Discover Magazine postulated, aside from making our life easier, is electricity also making our lives shorter?

Most experts agree that limited, non-chronic exposure to EMFs is not a threat. For example, it is probably acceptable for a person to be near a toaster in the morning.

BUT, it is not advisable for a person to sleep under an electric blanket, up close, live near a powerline/substation, and sleep in a room where the power enters the home. This person is under an extreme case of chronic exposure. This condition, unfortunately, applies to millions of Americans.

If you wish to follow the EPA's advice and practice "prudent avoidance" then the following advice is offered:

Measure your home, work and school environments with a Gauss meter Measure EMFs both inside and outside your home. Don't let your children play near power lines, transformers, radar domes and microwave towers.

Avoid areas where the field is above 1 mG. Measure the EMFs from appliances both when they are operating and when they are turned off. Some appliances (like TVs) are still drawing current even when they are off.

Don't sleep under an electric blanket or on a waterbed. If you insist on using these, unplug them before going to bed (don't just turn it off). Even though there is no magnetic field when they are turned off, there may still be a high electric field.

Don't sit too close to your TV set. Distance yourself at least 6 feet away. Use a Gauss meter to help you decide where it is safe to sit.

Rearrange your office and home area so that you are not exposed to EMFs from the sides/back of electric appliances and computers. In the home, it is best that all major electrical appliances, such as computers, TVs, refrigerators etc, be placed up against outside walls. That way you are not creating an EMF field in the adjoining room.

Don't sit too close to your computer. Computer monitors vary greatly in the strength of their EMFs, so you should check yours with a meter. Don't stand close to your microwave oven. Move all electrical appliances at least 6 feet from your bed. Eliminate wires running under your bed. Eliminate dimmers and 3-way switches.

Be wary of cordless appliances such as electric toothbrushes and razors. You may choose not to wear a quartz-analog watch because it radiates pulsating EMFs along your acupuncture meridians.

An older mechanical windup watch would be an acceptable alternative. It is also recommended to wear as little jewelry as possible and to take it off at night. Many people have metal sensitivity which can be aggravated by placing it right on the skin. Measure with a gauss meter to be sure.

And last, but not least, always always always remember that EMFs pass right through walls. The EMF you are reading on your Gauss meter could be radiating from the next room...or from outside your home.

Additional Radiation Info:

Eyeglass frames should ideally be made from plastic with no wires in them, otherwise they can serve as an antenna to focus the radio and cellular phone waves directly into your brain.

What EMF Level Is Safe?

There's a heated debate as to what electromagnetic field (EMF) level is considered safe. Since the experts have not come to an consensus, you'll have to decide for yourself... Many government and utility documents report the usual ambient level of 60-Hz magnetic field to be 0.5 mG.

Thus, any reading higher than 0.5 mG is above the "usual" ambient exposure. Many experts and public officials, as well as the few governments that have made an effort to offer public protection, have adopted the 3 mG cutoff point. The EPA has proposed a safety standard of 1 mG. Sweden has set a maximum safety limit of 1 mG.

Dr. Robert Becker, an MD who has been studying the effects of EMFs for 20 years, states a 1mG safety limit in his book *Cross Currents*. When electricians try to solve a magnetic field problem they do their best to drop the level to 1 mG or below.

Dr. Nancy Wertheimer, a Ph.D. epidemiologist who has been studying EMFs for 20 years, has been looking at the epidemiological data in a different way -- she is trying to associate EMF levels with health rather than disease. The level she is coming up with is a cut off of 1 mG. Russian researchers claim that 1/1000ths of a mG should be the standard.

The BioElectric Body believes that there are several stages of health between "optimum wellness", "degenerative disease" and "Cancer". Thus, we maintain our own living and sleeping quarters at 0.5mG and below.

Recommended Reading

Cross Currents The Perils of Electropollution. The Promise of Electromedicine Robert O. Becker, M.D. Jeremy P. Tarcher, Inc., 1990

Currents of Death The Attempt to Cover Up the Threat to Your Health Paul Brodeur Simon and Schuster, 1989

Electromagnetic Man Health & Hazard in the Electrical Environment Cyril W. Smith & Simon Best St. Martin's Press. Inc. 1989

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EMF and Childhood Leukemia

Sep 1, 2006 12:00 PM, By Robert Syfers, Freelance Science Writer

Decades of research have studied possible health effects of exposure to electric and magnetic fields. While the great majority of studies have shown no link between EMF and a variety of maladies, several key epidemiologic studies have caused expert scientific panels to conclude that there is indeed a statistically significant association between power-frequency magnetic fields and the development of childhood leukemia. Nevertheless, laboratory confirmation and a convincing explanation of the nature of this link have eluded researchers and health theorists for some years. EPRI is now addressing two theories that may finally clarify the issue.

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Researchers have been studying the possible health effects of exposure to electric and magnetic fields (EMF) since the late 1960s, and the Electric Power Research Institute (EPRI), Palo Alto, Calif., has been a significant part of this worldwide effort since the Institute was founded in 1973. The early period of EMF study, which extended through the mid-1980s, focused primarily on electric fields, with little to no attention paid to cancer as a health outcome of potential concern. No scientific evidence emerged from that period that would link electric field exposure to adverse health effects in people.

About 20 years ago, the emphasis switched dramatically to the potential relationship between magnetic fields in homes and childhood cancers — particularly leukemia and brain cancer. Soon thereafter, researchers as well as state and federal agencies expanded this concern to cover occupational exposures and a far wider variety of health endpoints, including miscarriage, adult cancers of various types, cardiovascular diseases, and neurodegenerative illnesses such as Alzheimer's and amyotrophic lateral sclerosis (Lou Gehrig's disease). With its members' support, EPRI assumed a major role in this widening effort as well, addressing questions of potential health risk and developing measurement and software tools for researchers.

After a period of intense worldwide study through the 1990s, several national and international expert panels convened to evaluate the possible risks posed by EMF environments. Collectively, these deliberations narrowed concern from the broad array of health endpoints that had been studied to only one — childhood leukemia. When the results of many epidemiologic studies (studies that explore the patterns of disease and health in human populations) were evaluated and blended into a single analysis, a moderate association between magnetic fields above 3 to 4 milligauss (mG) and the occurrence of childhood leukemia — up to a doubling of risk — was evident. Because positive associations originated from studies of different designs from different countries, each with its own unique electrical transport system, random chance as a

in this issue



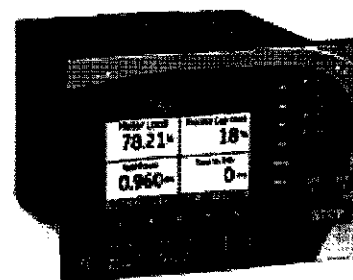
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From a scientific perspective, however, the presence of an epidemiologic association does not, by itself, constitute or substantiate a cause-and-effect relationship, which generally requires supporting results from the laboratory and a plausible mechanism of interaction. Indeed, laboratory studies using animals and cells have not supported a link between magnetic field exposures and childhood leukemia, and scientists have not identified a biophysical mechanism by which the low-level fields measured in homes could plausibly interact with biological tissue. Though random chance has been virtually ruled out, the possibility remains that the study results are somehow skewed or that another, unidentified exposure is involved.

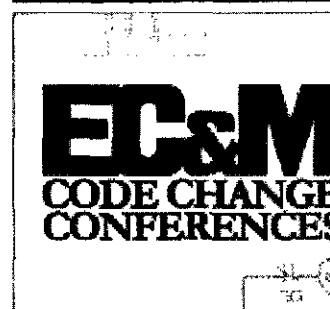
EPRI, through its EMF Health Assessment Program, is working to uncover a rational basis for the unexplained relationship between magnetic fields and childhood leukemia. Over the past seven years, EPRI scientists have shifted the search into high gear, exploring two viable hypotheses, each of which may contribute to the ultimate explanation. One addresses the possibility, as suggested by many epidemiologists in the EMF community, that the link between magnetic fields and childhood leukemia is a product of artifact in study design — that in fact there is no causal basis at all; the prime suspect behind this possibility is a problem known as selection bias. The second hypothesis explores the possibility that an unrecognized exposure, contact current, is the active agent that has operated behind the scenes, with magnetic fields at center stage.

Selection bias. The term *bias* does not imply willful action by the investigator, but rather results from an undetected factor that insinuates itself into a study's execution and unintentionally skews the results. The selection bias hypothesis is based on the fact that the epidemiologic studies in question are virtually all of case-control design; for studies of rare diseases like leukemia, this design is the most practical option.

In a typical EMF case-control study, the distribution of magnetic field exposure across a group of children with leukemia is compared with the exposure distribution of children who are leukemia-free. The children with leukemia are referred to as cases, and those who are disease-free as controls. The control group serves as a reference intended, in the ideal, to reflect the actual distribution of exposure through the greater population from which the cases originated. Thus, if after carefully collecting and analyzing all of a study's data, an epidemiologist were to observe that exposure to an environmental influence was much more common in a set of cases than in a valid set of controls, that observation would suggest that the exposure under study represented a legitimate risk factor. However, the key word above is *valid*, for even if all else is done correctly and meticulously, if the controls are unrepresentative, the study results will be viewed in a dimmer light as possibly skewed by selection bias.

How could selection bias invalidate a result in concept? First, epidemiologists are generally able to identify all, or almost all, of the cases of the disease of interest within a study region — say, a metro area, a state, or a group of states. This is especially true of cancer cases, which are logged into registries that are available for public health surveillance, as well as for research purposes. The problem of selection bias usually concerns the selection and recruitment of controls — hence the expanded term *control selection bias*. If, because of selection pressures, the control group actually enrolled either under- or overrepresents the exposure of interest, then the study results will report risks that are artificially high or low, respectively.

As an example, consider the repeated observation that fewer people from lower socioeconomic groups participate in epidemiologic studies than people in higher socioeconomic strata. Further consider that people in lower strata tend to reside in less desirable neighborhoods — frequently near freeways and very possibly adjacent to transmission or distribution corridors, where magnetic field exposures would be relatively greater than in areas typical for other segments of the population. In the event that potential control subjects from these lower socioeconomic neighborhoods are underrepresented in a study of magnetic fields and childhood leukemia — because of refusal, unavailability, or simply indifference — then their relative absence will skew downward the exposure distribution of the control subjects that are enrolled. In other words, higher magnetic field exposures will falsely appear to be rarer in the background population than in the cases, leading to the suggestion that the magnetic field is a risk factor, when in fact the result is driven by control selection bias.



In 2001, the EMF health assessment program launched a full-scale foray into the question of control selection bias with a workshop in Canada, in which EPRI scientists

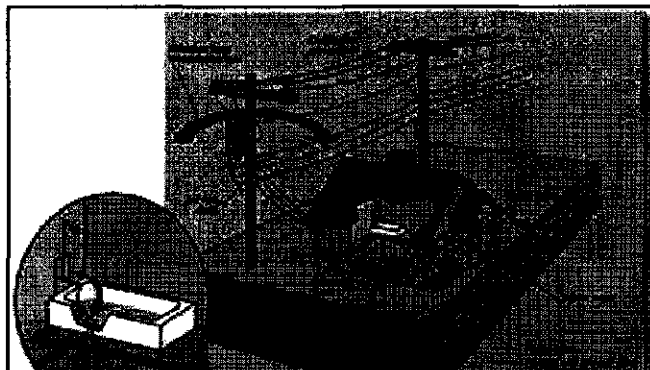
gathered with an international group of eminent epidemiologists to brainstorm the best ideas to guide the program's research. Under the leadership of Gabor Mezei of the EPRI program, the research has been gathering full momentum, with several reports already published in the scientific literature and new studies coming on board. Many of these address the question of selection bias caused by differential participation across socioeconomic strata, as described above. The jury remains out with respect to the extent that control selection bias may have influenced earlier studies.

Contact current. Contact current is current that flows within a person when two locations on that person's body are in contact with electrically conductive surfaces at different electrical potentials, or voltages. For example, if the thumb and forefinger are in contact with the top and bottom of an ordinary AA battery, a small current will flow in the loop created by the fingers and the battery. If the fingers are dry, the current will be relatively small, as dry skin has a high electrical resistance; with wet fingers, the moisture will breach the skin's insulation, lowering its resistance so that comparatively more current will flow. Likewise, contact current can travel through portions of the body from one hand to the other or to a foot, should those extremities be in contact with surfaces of different voltages.

The issue of contact current safety goes back to well before the EPRI program became involved with this exposure in terms of the EMF health issue. Underwriters Laboratories, a Northbrook, Ill., not-for-profit product safety testing and certification organization, specifies limits for leakage currents from home appliances of 0.5 to 0.75 milliamperes (mA), depending on the device; the National Electrical Safety Code limits exposure to 5mA in the rights-of-way of high-voltage overhead transmission lines; and guideline-setting bodies, such as the International Commission on Non-Ionizing Radiation Protection and the Institute for Electrical and Electronic Engineers, recommend contact current limits of anywhere between 0.5 and 1.5mA, depending on exposure circumstances. All of these limits are intended to reduce the chance of annoying or even hazardous startle or pain reactions to the exposure. EPRI's EMF research deals with lower exposure levels, which fall below the threshold of sensory perception.

Since 1999, Robert Kavet, program manager for EMF health assessment, has led EPRI's research on contact current as a factor that could explain the association of magnetic fields with childhood leukemia. Actually, the idea of a possible role for contact current in EMF health studies occurred to Kavet in the late 1990s, after the publication of several studies suggesting that one's occupation as a seamstress or tailor was a risk factor for neurodegenerative disease; the studies' authors attributed their results to magnetic field exposure from sewing machines. Kavet visualized the machine operators' manual contact with the machines through an entire workday, and with a quick back-of-the-envelope calculation, Kavet realized that the dose of electricity in the body from contact current, particularly in the extremities, would dwarf the doses associated with magnetic fields from the machines. This line of research led to the development of a personal meter to measure occupational exposures to contact current; the meter was put to work in an EPRI study that reported that occupational exposures to contact current would be more likely to occur when equipment was poorly grounded. At about the time Kavet was considering occupational scenarios, thought was given also to the possibility of residential contact current exposures in children vis-à-vis the childhood leukemia connection with magnetic fields.

How would a child be exposed to contact current in a residence? The most likely exposure, according to EPRI's research, results from grounding practices intended to provide electrical safety and fire protection. In the United States, the National Electrical Code has required that a residence's electrical



(electrically conductive) water pipe within the residence since 1918. As a result of this grounding connection, a small neutral-to-earth voltage — usually less than 1V — will appear on the water pipe, arising from household currents returning via the water

The National Electrical Code requires a connection from a residence's service panel neutral to a nearby water pipe. As a result, the water pipe acquires a small voltage to the earth — usually less than 1V — arising from currents in the grounding system, magnetic field induction on the grounding system from nearby transmission lines, or both. If the drain in the residence's bathtub is conductive — made of metal — the voltage on the water pipe can produce a contact current when a person who is bathing touches the faucet or metal fixtures.

pipe back to the substation or from induction on the neutral system from nearby sources of magnetic fields, such as overhead transmission lines or heavily loaded distribution primaries. This voltage will extend across all contiguous elements of the water system, including the metal water fixtures in a bathtub, sink, or shower (Figure). If the drainpipe sunk into the earth under a bathtub, sink, or shower is also made of metal, a bathing child touching the faucet or water stream will receive a contact current into the arm and through the body; in all but very extreme cases (for example, cases where there is a broken ground connection), these exposures are imperceptible, even to a small child. The current pathway includes the bone marrow (the site of leukemia development), with the highest dose expected in the thinnest extremities, where the current densities must be the greatest — that is, in the lower arm and hand.

Evaluating criteria for plausibility. For contact current to be considered a viable candidate exposure that explained the epidemiology, investigators knew three criteria would have to be satisfied prior to committing to further research:

1. A plausible dose to bone marrow,
2. Strong association of magnetic fields with the source of contact current, and
3. A child's frequent access to exposure.

The failure to verify any one of the three would be a signal to stop this line of investigation.

Dose. If you discuss this issue with Kavet, he'll tell you that one of his heroes is a 16th century scientist named Paracelsus, often referred to as the father of toxicology. Paracelsus put forward an idea that has become central to his field: Everything is poisonous in a high enough dose, and even strong poisons are harmless if the dose is low enough. In other words, "The dose makes the poison." Thus, to be a credible causal candidate, contact current would have to deliver a dose to tissue at levels that, according to biophysical principles, could plausibly elicit biological effects — a characteristic that residential magnetic fields did not provide.

Soon after the initial thoughts about contact current developed, the program teamed with Maria Stuchly and her research team at the University of Victoria to estimate the relationship of contact current exposure to electrical dose inside the body. Stuchly's research group already had extensive experience in using anatomically accurate computer models of the human body to estimate dose from exposure to EMF. The study, published in 2001, reported that small, imperceptible levels of contact current of the magnitude that could occur in the bathing scenario would produce doses in the arm's bone marrow that far exceeded (by factors of hundreds to thousands) the doses calculated from ambient magnetic fields; these were doses at levels that leaped over the hurdles that so challenged magnetic fields.

Association. Since the risk of childhood leukemia was observed to be greater in homes with fields above 3 to 4 mG, the higher values of voltage responsible for producing contact current — known as contact voltage — would necessarily need to coexist with these higher fields with a much greater probability than they would in homes with fields of lower values.

In 2001-2002, Kavet worked on the contact current idea with Enertech Consultants' Luciano Zaffanella, the architect of EPRI's well-known "1000-Home Study" and the "1000 Barron Study" conducted for the U.S. Department of Energy as part of the federal

home, as well as for taking routine measurements of the magnetic field, and applied them in a small pilot study for EPRI in Pittsfield, Mass. The protocol focused largely on home appliances but also included measurements in the bathroom at all possible sites that people might touch on a routine basis. As it turned out, Zaffanella measured a significant voltage between the bath fixtures and the drain in the first two homes he visited.

Zaffanella and Kavet discussed the results the day the measurements were taken, becoming excited over the possibility that this voltage could be the missing link in the relationship between magnetic fields and childhood leukemia. The idea made immediate sense to the researchers: A bathing scenario meant that an immersed child's hand would be at least damp, if not saturated with water, which would reduce the skin's electrical resistance to an insignificant value. The small pilot study of 36 homes also reported data that suggested a positive association between the residential magnetic field and the voltage from the residential water line to earth, the source voltage for contact current exposure in the bath. This study's success triggered a larger effort in the Denver area, site of the two most important early EMF studies. In a measurement study that included visits to 191 residences, Kavet and colleagues reported a positive association between the residential magnetic field and both the voltage from the water line to earth and the voltage that a child would experience in the bathtub.

Though the measurement programs produced valuable data, they could not by themselves show how the infrastructural characteristics of communities would contribute to a set of empirical observations. Zaffanella and his associate Jeff Daigle, working closely with Kavet, produced the Contact Voltage Modeler (CVM), a program that makes it possible to specify a neighborhood's features — its geography, electrical distribution system, and water system — and then to identify the factors influencing residential magnetic fields, the voltage from residential water lines to earth, and the interrelationship of the two. The results supported the hypothesis that if a broad variety of neighborhoods in an extended geographic region (like those in epidemiologic studies) were simulated, a strong relationship between the magnetic fields and the water-line-to-earth voltages would be observed.

Frequent access. In addition to the induction of genetic or chromosomal anomalies that initiate carcinogenesis, the pathway to malignancy in most cases involves other influences and exposures that, though not genotoxic themselves, nudge the already-affected cells toward a malignant state. The past 60 years of cancer research has shown that exposures subsequent to the initiation stage need to occur on a relatively frequent or repeated basis to have noticeable effects. Thus, any exposure being considered as responsible for associations with magnetic fields would also have to occur reasonably often.

Anecdotally, many parents may recall that their young children, while bathing, indulged in exploratory play with the water fixtures or the water stream. Working with researchers at the University of California at Berkeley, EPRI supported a survey of parents using interview and diary techniques to assess the extent to which children from younger than one year to five years old engage in behavior that would produce exposure. The results indicated that roughly 80% of the children studied indeed displayed evidence of such behavior, and that beyond the age of one (when their arm's reach lengthened), this behavior increased.

The testing phase. With the criteria of dose, association, and frequent access satisfied, EPRI's research into the contact current hypothesis has accelerated from the plausibility phase to hypothesis testing by means of a multidisciplinary strategy. In 2003, the program joined forces with the School of Public Health at UC Berkeley, which since 1995, under the leadership of Patricia Buffler, has been conducting the Northern California Childhood Leukemia Study, the most intensive U.S. investigation yet of the environmental, genetic, and biochemical risk factors for childhood leukemia. The merger is a true bonanza for the EPRI program, not only allowing research into contact currents and magnetic fields but offering the program a significant opportunity to expand its research into control selection bias as well.

In 2006, following a competitive bidding process, EPRI began research at UC San Francisco with Scott Kogan to develop a genetically engineered mouse that will model

reported, including both Sweden and the United Kingdom. The results of these efforts will emerge within the next five years and, when factored in with other research developments around the world, will determine future directions for the program.

A critical component of the EPRI program today, as for the past 18 years, is the advice and counsel of an independent advisory group of eminent scientists. The Scientific Advisory Committee meets on an annual basis to thoroughly review the program and offer recommendations. The committee remains informed of significant developments year-round and maintains an active relationship with the members of the program's Area Council. Working together with all of its advisors, EPRI's EMF health assessment program is committed to unraveling the critical uncertainties to ensure electric and magnetic field environments are compatible with public health and safety.

Background information for this article was provided by Rob Kavet, manager, Occupational Health and Safety Program and EMF Health Assessment and Radio-Frequency Safety Program, EPRI, Palo Alto, Calif.

Sidebar: A Short History of EMF Research

Questions about possible health effects from exposure to power-frequency electric and magnetic fields (EMF) in the United States first arose in the late 1960s and early 1970s, following the introduction of extra-high-voltage (765kV) overhead transmission. The founding of EPRI in 1973 provided the U.S. electric power industry with an ideal organizational structure for investigating concerns about EMF health questions. For over a decade, EPRI's EMF research agenda, coordinated with a U.S. Department of Energy (DOE) EMF research program, focused mainly on electric fields.

Two noteworthy studies played a major role in redefining the EMF research agenda. The first study, published in 1979 by Wertheimer and Leeper, reported an association between residential proximity to heavily loaded distribution lines and childhood cancer mortality (including mortality from leukemia) in the Denver metropolitan region. In this study, exposure within a residence was assessed using so-called wire codes based on visual aspects of lines, such as line type (for example, single-, 2-, and 3-phase primaries and secondaries) and wire thickness (a crude index of line loading), and their distance from the residence. This scheme for exposure characterization became known as the Wertheimer-Leeper wire code. The authors' suggestion that magnetic fields could be responsible for the reported association could be neither substantiated nor refuted.

In 1988, a team headed by David Savitz published a second study. The Savitz study differed from the Wertheimer and Leeper study in its use of a more recent set of childhood cancers and a study design that included actual residential measurements of magnetic (and electric) fields as well as wire codes. Also, in accordance with accepted contemporary practice, the Savitz study analyzed cancer incidence (new diagnoses) rather than mortality statistics, which had been used in the earlier study. Once again, associations were seen between wire codes and childhood cancers. In addition, the study showed that homes with higher wire codes had higher measured magnetic fields, although, interestingly, the association with cancer reported for the measured fields was weaker than the association based on wire codes.

Publication of the Savitz study marked a permanent change in the focus of EMF research. By this time, a large body of research supported by both DOE and EPRI had failed to uncover any acute hazard associated with electric field exposure. With the release of the Savitz results, attention shifted sharply to magnetic fields, and worldwide interest in potential health effects from EMF exposure grew virtually overnight. Magnetic fields were now regarded by the public as a ubiquitous, unexplored exposure that could potentially contribute to a variety of health risks and, moreover, could affect children. Health effects of concern included not only cancers of different types but also endpoints such as pregnancy outcomes and neurodegenerative diseases (e.g., Alzheimer's disease) related to both residential and occupational settings.

The new research included epidemiologic studies investigating leukemia in children and leukemia and brain cancer in a large cohort of 140,000 workers from five participating U.S. utility companies; laboratory studies of leukemia and other cancers in a variety of rodent bioassay models; and large residential and occupational magnetic field exposure assessment and engineering studies. One notable residential research effort was the "1000-Home Study," which provided insights into the sources and levels of residential magnetic fields that remain valid today. Not surprisingly, the major sources of residential magnetic fields were found to be outdoor distribution lines and residential grounding systems. Transmission lines were also a dominant source, but the fraction of homes affected was very small.

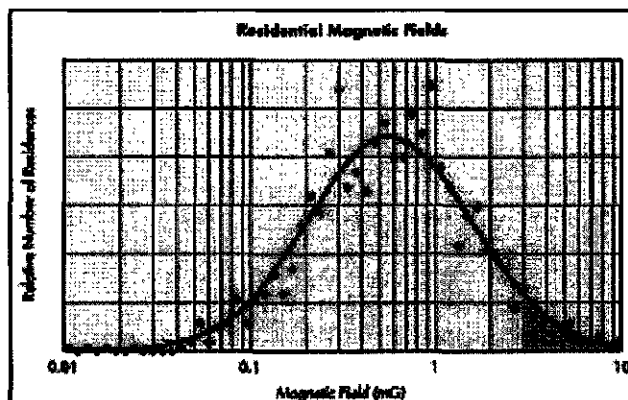
EPRI also initiated a field management program and developed instrumentation and software for characterizing electric and magnetic field environments. The EMDEX meter and its derivatives are now the standards for measuring residential and occupational magnetic fields, and EMF and TLWorkstation software have provided EPRI members with valuable tools for estimating both electric and magnetic fields in residential and occupational settings. Indeed, EPRI's efforts in measurement instrumentation were largely responsible for critical advances in exposure assessment and epidemiology.

To help transfer EMF measurement technology to EPRI's members, the program conducted the "EMDEX Occupational Study" and the "EMDEX Residential Study" from the late 1980s to the early 1990s. The studies benefited from extensive industry participation, with 55 companies involved in the occupational study and 39 in the residential study. The research provided insights into exposure levels in the power company workplace relative to exposures outside the workplace, and the range of exposure levels to be expected across the general population. The occupational survey indicated that power company workplace exposures exceeded those normally associated with environments outside the workplace.

At the federal level, Congress enacted the EMF Research and Public Information Dissemination (EMF-RAPID) Program in 1992, when it became clear that questions about EMF had attained a high profile in the scientific and public mainstream nationwide. The EMF-RAPID Program (supported in part by contributions from EPRI members) 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 [extremely low frequency EMF, which includes power-frequency fields]." The National Institute of Environmental Health Sciences (NIEHS) was charged with overseeing the health research and conducting a thorough EMF risk evaluation.

The 1999 NIEHS final report to Congress concluded that "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." This conclusion was qualified with the following statement: "The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results."

Two years after submission of the NIEHS report, a panel of experts at the International Agency for Research on Cancer (IARC), a branch of the World Health Organization (WHO) and the world's foremost agency concerned with cancer risk assessment, conducted an evaluation of the scientific literature on EMF and, specifically, its potential link to cancers of all types. The panel's deliberations were strongly influenced by two



According to EPRI's 1000-Home Study, magnetic field strength in U.S. residences is distributed roughly

literature that were

published in 2000, one by a group of scientists in the United States and the other by a group of European scientists. Both groups arrived at the same fundamental conclusion: that childhood leukemia incidence was associated with average residential magnetic fields above 3 to 4 mG (0.3 to 0.4 μ T), with an approximate doubling of risk above this range of exposure levels. According to EPRI's "1000-Home Study," about 5% of residences in the United States have an average magnetic field above 3 mG, and less than 3% are above 4 mG (Figure). The magnetic field from a heavily loaded transmission line will fall off to less than 3 mG about 500 feet from the line, with correspondingly lower exposures for a lighter electrical load.

The IARC panel concluded that magnetic fields were a "possible" (IARC category 2B) human carcinogen, based on the "limited" evidence on childhood leukemia from epidemiologic studies and the lack of supporting evidence from cell and animal studies. The evidence concerning all other cancers was insufficient to form a basis for IARC's conclusion. To put this classification in perspective, coffee, pickled vegetables, chloroform, and welding fumes are among over 200 other exposures included in IARC's "possible" carcinogen category. IARC stated that the association between childhood leukemia and magnetic fields was not likely to be due to chance but conceded that epidemiologic artifacts could not be excluded. IARC also evaluated power-frequency electric fields, which by then were incorporated into several residential and occupational epidemiologic studies; electric fields were classified as a category 3 exposure (not classifiable as to carcinogenicity in humans), since the evidence was inadequate to assign even a "possibly hazardous" designation.

Other risk assessments have supported the IARC panel's conclusion. All the major assessments relied heavily on EPRI-sponsored research, and EPRI scientific staff were significantly involved in the panel deliberations held by both NIEHS and IARC. The presence of a credible industry-sponsored research program opened a seat at the table for EPRI. The next major development in EMF health assessment will be WHO's publication of its "EMF Environmental Health Criteria," which will summarize and evaluate the relevant scientific literature and offer recommendations for further research. Scheduled for release in 2006, the report is likely to trigger a reassessment of research priorities, as well as further worldwide public interest in the EMF issue. Rob Kavet, program manager for EMF health assessment, served as an observer to the final review of the report in October 2005, allowing EPRI to have a voice in the discussions and input to the final WHO report.

The credibility of EPRI's EMF health assessment work and the industry's commitment to research were highlighted in a September 2000 column in the *Wall Street Journal* by Marianne M. Jennings, a professor of legal and ethical studies. In contrasting other industries' approaches to well-publicized health and safety issues, she singled out the electric power industry's approach to EMF with praise, stating that "perhaps the best example of an industry willing to use the truth to set itself free was the electric utility sector.... EMF was managed with ethics and an attitude: If EMF is a problem, we manage it early and make it right. If it's a false alarm, we have the credibility and trust earned with voluntary action and disclosure at the moment of truth."

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