

## EPRI EMF Research Information

The Electric Power Research Institute (EPRI) develops and manages science and technology programs for the benefit of electric power companies, their customers, and societies throughout the world. A number of EPRI's research programs address environmental issues associated with electric power technologies. Among these programs is the EMF Health Assessment and RF Safety Program, which has investigated possible health effects from exposure to electric and magnetic fields (EMF) for over 35 years.

It is in the best interest of everyone—government, business, electric companies, and the public—to find an answer to the question of whether exposure to EMF is associated with health effects. EPRI's EMF program is conducting long-term, multidisciplinary research to shed light on this complex scientific area. To maintain the highest standards of objectivity, EPRI carries out much of this research through sponsorship of independent scientists affiliated with major independent universities, laboratories, and consulting organizations. All of the scientists and engineers supported by EPRI are encouraged to publish their findings in peer-reviewed journals. In addition, an external, blue-ribbon scientific advisory committee representing various scientific disciplines provides guidance for EMF program research activities.

Recent evaluations by national and international organizations concerned with public health concluded, on the basis of epidemiologic studies, that exposure to magnetic fields is statistically associated with childhood leukemia. Some evaluations also suggested that EMF might be associated with other conditions, such as amyotrophic lateral sclerosis (ALS, or Lou Gehrig's disease), Alzheimer disease, adult leukemia and brain cancer, and miscarriage. In accord with the conclusions of major health risk evaluations, current research in EPRI's EMF program places a high priority on childhood leukemia. An important part of this research is investigation of hypotheses that could plausibly explain the magnetic field-childhood leukemia association reported in epidemiologic studies. EPRI scientists are also studying exposure issues relevant to miscarriage, investigating EMF and neurodegenerative disease, and monitoring studies of EMF interference with cardiac pacemakers and other implanted medical devices.

Along with its research activities, the EMF program communicates information on EMF science for electric power companies and their customers. This EMF Information Packet is designed to help everyone who uses electricity stay up to date on EMF and health.


The bulk of the material contained in this packet is public information produced by national and international organizations concerned with EMF and public health and is not to be attributed to EPRI.

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# Electric and Magnetic Fields

## Environmental Issues

### Electric and magnetic fields exist everywhere.

The generation, delivery, and use of electricity produce electric and magnetic fields (EMF). Electric fields are produced by voltage, the electrical “pressure” that causes current to flow in a wire or cable; magnetic fields are produced by current, the movement of electric charge. Electric and magnetic fields can be imagined as invisible lines of force that weaken with increasing distance from their source.

Electric and magnetic fields also occur naturally. An electric field is present between the earth and the upper atmosphere; this field can increase and discharge as lightning during thunderstorms. The earth has a magnetic field that is the basis for the magnetic compass. Because these natural fields generally change little from one moment to the next, they are referred to as static fields.

In the electric power system, voltage and current oscillate at the power frequency—60 hertz, or 60 cycles per second, in the United States and 50 hertz in Europe. Similarly, the electric and magnetic fields created by the power system oscillate at the power frequency. When people are exposed to these electric and magnetic fields, imperceptible electric currents are produced in their bodies. Although these currents are weaker than those that result from natural electrical activity in the heart and nervous system, scientists have investigated whether they produce biologic or health effects.

**Possible health effects from exposure to EMF have been studied for over 35 years.** Questions about possible health risks from exposure to EMF first arose in the 1960s and 1970s, when higher voltages for electricity transmission were introduced in the United States. During that period, research focused on electric fields because near and beneath high-voltage transmission lines, electric fields produce more current in the body than magnetic fields do. Overall, studies of electric fields found no evidence of biologic changes that could lead to adverse health effects. EMF research began to focus on magnetic fields in 1979 after Wertheimer and Leeper published an epidemiologic study suggesting that magnetic fields from power lines in Denver might be linked to childhood cancers (epidemiologic studies examine patterns and possible

causes of diseases in human populations). In 1988 Savitz and colleagues published a second study that was generally consistent with these results. Since then, a large number of epidemiologic studies have investigated the possible role of magnetic fields in the development of cancer and other diseases in both children and adults. Studies of most health outcomes, including miscarriage, neurodegenerative diseases such as Alzheimer and Parkinson diseases, and various cancers other than leukemia, have produced either inconsistent or negative results. Studies of childhood leukemia, however, have shown a generally consistent association with residential magnetic fields.

Hundreds of studies have investigated whether exposure to power-frequency magnetic fields produces biologic effects in laboratory animals and cells and, if so, through what biologic and biophysical mechanisms. The vast majority of laboratory studies of animals exposed to magnetic fields at or above levels to which humans could be exposed have not reported adverse effects. Cell studies have reported inconclusive or inconsistent results.

Several organizations concerned with public health have convened expert panels to evaluate possible health risks from exposure to EMF. These organizations include the National Institute of Environmental Health Sciences (NIEHS) in the United States, the National Radiological Protection Board (NRPB; now the Radiation Protection Division of the Health Protection Agency) in the United Kingdom, and the International Agency for Research on Cancer (IARC), a branch of the World Health Organization. These panels and also a California Department of Health Services (CDHS) panel concluded, on the basis of epidemiologic studies, that average residential magnetic fields measuring 3 to 4 milligauss (0.3 to 0.4 microtesla) or above are associated with roughly a doubling of childhood leukemia risk. (Only about 5 percent of homes in the United States have magnetic fields greater than 3 milligauss) The NIEHS and CDHS also concluded that magnetic fields in the workplace cannot be dismissed as a possible cause of adult leukemia. CDHS further identified other health outcomes, including adult brain cancer, miscarriage, and amyotrophic lateral sclerosis (ALS, or Lou Gehrig’s disease), as possibly linked to magnetic

field exposure. In 2007 the World Health Organization released an EMF health risk evaluation that supported previous conclusions regarding evidence for an association between magnetic field exposure and childhood leukemia but found much weaker evidence for a link with adult cancers, miscarriage, or ALS.

**There is no conclusive evidence that exposure to EMF causes health effects.** Despite the epidemiologic association of magnetic fields with childhood leukemia, a cause-and-effect relationship cannot be inferred. For moderate epidemiologic associations, data from laboratory studies are usually critical to determine whether a causal link exists. For example, exposures or agents (such as ionizing radiation and benzene) that are known to cause cancers in humans also cause cancers in laboratory rodents. Such laboratory evidence should also be complemented by an understanding of the mechanisms by which exposures or agents interact with biologic tissue. For magnetic fields, lifetime studies of rodents have not identified adverse effects, and scientists have not discovered a mechanism by which the low-level fields found in homes could interact with tissue. In the absence of supporting laboratory and mechanistic evidence, scientists are investigating the possibility that certain factors in study design generated the epidemiologic results or that magnetic fields occur along with another exposure that could plausibly contribute to leukemia development.

**Scientists continue to investigate the possible relation between EMF and health effects.** EMF research is continuing throughout the world. At the Electric Power Research Institute (EPRI), the EMF research program places the highest priority on resolving uncertainties about EMF and childhood leukemia. In fact, EPRI is the only U.S. organization currently funding a

multidisciplinary research program in this area. The program's scientists have investigated the possible influence of magnetic field exposure on the long-term survival of children who already have leukemia and are looking into the possible role of inadvertent error in epidemiologic study designs.

EPRI research is also exploring the hypothesis that an alternate exposure, contact current, is responsible for the magnetic field-childhood leukemia association. Contact current flows through the body when a person simultaneously touches two conductive surfaces that are at different voltages. An important property of contact current is that imperceptible amounts produce appreciably higher electrical doses in tissue than exposure to residential magnetic fields does; more importantly, tissue doses are high enough to plausibly cause biophysical changes. EPRI research suggests that exposure to contact current is associated with exposure to magnetic fields. Although this finding supports the contact current hypothesis, further research will be necessary before answers can be found.

The EPRI program includes work in other areas of possible concern, such as neurodegenerative disease, miscarriage, and magnetic field interference with the functioning of cardiac pacemakers and other implanted medical devices. In addition, EPRI scientists have conducted cutting-edge research to clarify the scientific basis for EMF exposure guidelines and to accurately assess occupational EMF exposures.

### Contact Information

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