



Electric and Magnetic Fields

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Introduction

For more than 30 years, considerable scientific research and public discussion have focused on the issue of electric and magnetic fields, or EMF, and health.

Scientists around the world have conducted many research studies, and international and domestic government authorities, blue-ribbon scientific panels, independent health organizations and other experts in both the regulatory and scientific communities have reviewed these studies to evaluate the implications for public health.

National Grid monitors and supports ongoing EMF research and tracks the conclusions of leading science and health organizations and government agencies around the world. We rely on these organizations for assessments of EMF research and consult with EMF experts to guide our understanding of this research.

The company advocates open and informed discussion of issues related to EMF and promotes public access to full information on the status of scientific research.

From time to time, our customers have inquiries about EMF. We have prepared this brochure to share information about EMF and to provide links to Internet sites of respected agencies and international scientific organizations that also conduct and monitor EMF research.

What is EMF?

EMF refers to the two types of fields associated with any kind of electricity—electric fields and magnetic fields.

Electric and magnetic fields are produced by both natural and man-made sources that surround us in our daily lives. They occur throughout nature and in our own bodies. The earth itself produces a magnetic field, which is used for compass navigation.

Electric fields are related to voltage. Voltage is analogous to pressure in a water pipe. Higher voltages produce stronger electric fields.

Magnetic fields are related to the amount of current that is flowing. Current is analogous to the rate of fluid flow in a water pipe. Higher currents produce stronger magnetic fields.

For example, the magnetic field generated by a hair dryer is higher when the dryer is operated on its “high” heat setting than on the “low” setting because the high setting draws more current. However, the electric field from the hair dryer will be the same at both settings because the voltage does not change.

There are other differences between electric and magnetic fields. Most buildings and objects block electric fields, but do not block magnetic fields. However, adjacent power lines can sometimes be arranged to lower the EMF of the combined lines.

An important characteristic of both electric and magnetic fields is that their strength diminishes as one moves away from the source. This is similar to the way that the heat from a candle or campfire will diminish as one moves away from it.

This figure of the magnetic field from common sources shows how the strength of the field drops off with distance.

Field Strength and Distance

	6"	1'	2'	4'
Hair Dryer	300	1	_____	_____
Refrigerator	2	2	1	_____
Microwave Oven	200	40	10	2
PC With Color Monitor	14	5	2	_____

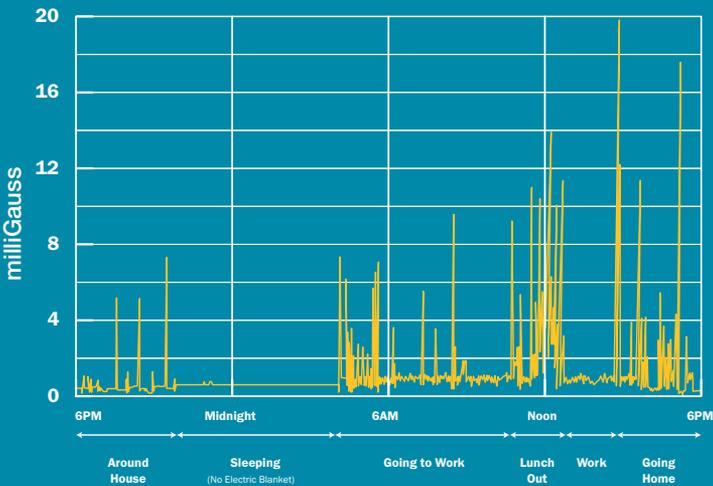
Source: EPA, 1991, *EMF In Your Environment*

For many years, the focus of most research on the potential health effects of EMF has been magnetic fields (not electric fields). In the United States, magnetic fields are measured in units called milliGauss (mG). In other countries, magnetic fields are measured in units called microTesla (μ T). One microTesla equals 10 milliGauss.

Sources and Relative Strength of EMF

EMF is found wherever electricity is generated, delivered or used. Power lines, wiring in homes, workplace equipment, computers, appliances and motors all produce EMF. Our exposure to EMF varies throughout the day depending on the sources of fields we encounter and how close we are to them. For example, the diagram below illustrates a person's exposure to magnetic fields over a 24-hour period. As you

Example of 24-Hour EMF Exposure

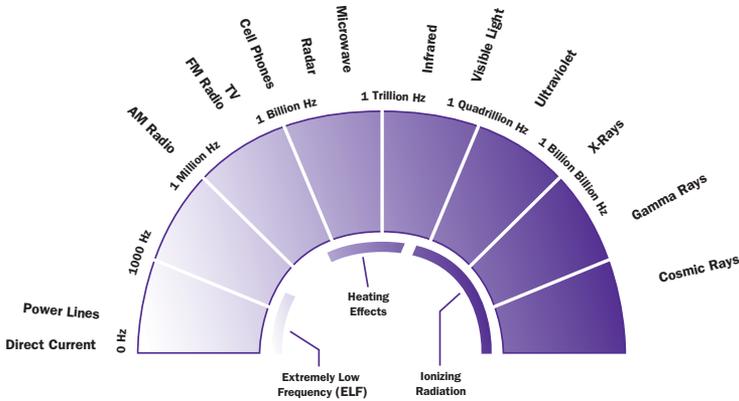


Source: National Institute of Environmental Health and Sciences and US Department of Energy, 1995, *Questions and Answers About EMF*

can see, the person was briefly exposed to relatively high magnetic field levels on numerous occasions while performing activities around the house, working and traveling. All of these instantaneous exposures over the 24-hour period are averaged together to produce a time-weighted average. In this example, the person's 24-hour time-weighted average was 0.5 mG. Most persons in the United States have a 24-hour time-weighted average exposure of less than 1 mG.

Electricity is provided to homes and offices in the United States at a frequency of 60 cycles per second, or 60 Hertz (Hz). Many properties of EMF depend on its frequency. For example, radio frequency fields interact with materials quite differently than fields associated with the use of electricity because they have frequencies much higher than 60 Hz. AM radio operates at a frequency of about 1 million Hz. Cell phones produce EMF at a frequency of about 1 billion Hz, and the red laser in a supermarket scanner operates at almost a quadrillion Hz. We perceive fields at still higher frequencies as visible light, and x-rays, gamma rays and cosmic rays are the highest frequencies in the electromagnetic spectrum. It is important to keep in mind that research on these very high frequency fields does not apply to the EMF associated with 60-Hz electricity.

Electromagnetic Frequency Spectrum



Note: This diagram is intended for illustrative purposes only. Some portions of the electromagnetic spectrum indicated in this diagram are utilized over frequency ranges or bands that may overlap.

Evaluating Potential Health Effects

Scientists judge whether an environmental exposure poses a health risk by evaluating different types of scientific research. The following three types of studies are typically evaluated:

- ▶ **Studies of Groups of People** – Studies in human populations are called epidemiologic studies. Groups of people are evaluated to assess whether exposure to a specific chemical, therapeutic drug or environmental factor is statistically associated with the presence or absence of a specific disease. Scientists often look for evidence that people with a higher exposure to the agent are more likely to get the disease than those who have less exposure to the agent.

The strength of epidemiologic studies is that they are conducted with people in their normal environments, not animals in laboratory environments, and thus they are directly relevant to human health. However, unlike experimental laboratory studies, researchers cannot control the many factors that may affect health, such as the amount of individual exposure, how exposure varies over time from many different sources, or how individual traits such as dietary differences or genetic factors modify the impact. These factors may introduce uncertainty into the studies. So, the results of epidemiological studies are not necessarily indicative of cause and effect relationships. Given the uncertainty associated with epidemiologic studies, it is important to remember that the results of epidemiologic studies cannot be considered alone when coming to a conclusion about whether an exposure causes a biological or health effect. These factors may limit the ability of an epidemiological study to identify the causes of disease or a particular health effect.

- ▶ **Animal studies** – Studies conducted on living animals are examples of in vivo research. Laboratory animals are exposed to a specific agent under controlled conditions to look for changes in body function, measures of health or disease. The exposure levels in the laboratory are often much higher than those that would be experienced in natural settings. Effects that are observed in laboratory animals can help predict effects that could occur in people. The strength of animal studies is that the animals are bred to have similar physical characteristics, are exposed to precisely measured quantities of the agent and are all housed and fed under the same conditions. Cause-and-effect can be directly observed and related to a known level of exposure after repeated experiments. However, there may be some uncertainty about whether the results are relevant to humans. Nevertheless, all chemicals and physical agents known to cause cancer in humans have been shown to cause cancer in animals as well.
- ▶ **Cell studies** – In cell, or in vitro, studies, researchers expose individual cells or groups of cells (tissues) to a specific agent under controlled conditions. Cell studies often are used to investigate the mechanisms by which an exposure could affect biological processes and the tissues of the body. The strength of cell studies is that exposure levels are known and effects on the cells or tissues are observed directly. A weakness of cell studies is that changes in cells or tissues are difficult to observe and to relate to specific health outcomes in a whole organism.

No single study, or type of study, is able to address all questions about what may affect our health. Epidemiologic, laboratory and cell/tissue studies must all be considered together because the strengths of one type of study tend to balance the limitations of the other types of studies. In order to conclude that a cause-and-effect relationship exists, scientists look for consistent and strong associations in epidemiology studies that are supported by animal and cell/tissue findings that have been replicated in different laboratories. This is the approach scientists take—considering all studies together to look for patterns that support causality—to get balanced information to develop sound conclusions. It is important to keep this in mind when the results of any new EMF health study are announced, especially if publicity about the study credits it with providing definitive answers on health-related issues.

Reviews of EMF Research

Numerous national and international organizations responsible for health decisions have convened groups of scientists to review the EMF research published to date. These panels have included scientists with diverse skills to reflect the different research approaches required to answer questions about health. The following agencies have organized panels of highly respected scientists to review the research on EMF and health:

The National Academy of Sciences/National Research Council, 1999

“Results of the EMF RAPID program do not support the contention that the use of electricity poses a major unrecognized public health danger.”

The National Institute of Environmental Health Sciences, 2002

“Electricity is a beneficial part of our daily lives, but whenever electricity is generated, transmitted, or used, electric and magnetic fields are created. Over the past 25 years, research has addressed the question of whether exposure to power-frequency EMF might adversely affect human health. For most health outcomes, there is no evidence that EMF exposures have adverse effects. There is some evidence from epidemiology studies that exposure to power-frequency EMF is associated with an increased risk for childhood leukemia. This association is difficult to interpret in the absence of reproducible laboratory evidence or a scientific explanation that links magnetic fields with childhood leukemia.

EMF exposures are complex and come from multiple sources in the home and workplace in addition to power lines. Although scientists are still debating whether EMF is a hazard to health, the NIEHS recommends continued education on ways of reducing exposures. This booklet (see Additional Information) has identified some EMF sources and some simple steps you can take to limit your exposure. For your own safety, it is important that any steps you take to reduce your exposures do not increase other obvious hazards such as those from electrocution or fire. At the current time in the United States, there are no federal standards for occupational or residential exposure to 60-Hz EMF.”

International Agency for Research on Cancer (IARC), 2002

Since 1972, IARC's Unit of Carcinogen Identification and Evaluation periodically has assessed the evidence that various agents are carcinogenic and classified the agents accordingly. In June 2001, a working group met to consider static and extremely-low-frequency electric and magnetic fields. Power-frequency magnetic fields were classified as "possibly carcinogenic," on the basis of "limited" evidence from humans concerning childhood leukemia, "inadequate" evidence from humans concerning all other cancer types, and "inadequate" evidence from animals.

Power-frequency electric fields were judged "not classifiable" on the basis of "inadequate" evidence from both humans and animals.

"IARC has now concluded that ELF magnetic fields are possibly carcinogenic to humans, based on consistent statistical associations of residential magnetic fields over certain strength with a doubling of risk of childhood leukemia. Children who are exposed to residential ELF fields less than 0.4 microTesla [4 mG] have no increased risk for leukemia."

U.K. National Radiological Protection Board (NRPB) Report of an Advisory Group on Non-Ionizing Radiation (AGNIR), 2001

"Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiologic evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukemia in children. ... In the absence of clear evidence of a carcinogenic effect in adults, or of plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukemia in children. Unless however, further research indicates that the finding is due to chance or some currently unrecognized artifact, the possibility remains that intense and prolonged exposures to magnetic fields can increase the risk of leukemia in children."

International Commission on Non-Ionizing Radiation Protection (ICNIRP) Standing Committee on Epidemiology, 2002
Review of the Epidemiologic Literature on EMF and Health

"In the absence of experimental evidence and given the methodological uncertainties in the epidemiologic literature, there is no chronic disease for which an etiological relation to EMF can be regarded as established. ... Among all the outcomes evaluated in epidemiologic studies of EMF, childhood leukemia in relation to postnatal exposures above 0.4 μ T is the one for which there is most evidence of an association. ... On the basis of epidemiologic findings, evidence shows an association of amyotrophic lateral sclerosis with occupational EMF exposure although confounding is a potential explanation. Whether there are associations with breast cancer, cardiovascular disease, and suicide, and depression remain unresolved."

U.K. Health Protection Agency (HPA), 2004

The Health Protection Agency is responsible for protecting public health in the UK, including a division of the HPA that handles ionizing and non-ionizing radiation. The HPA stated:

"The evidence to date suggests that in general there are no adverse effects on the health of the population of the UK caused by exposure to ELF EMFs below the guideline levels. However, there are a number of epidemiological studies, including studies from the UK, showing an association between exposure to ELF EMFs at home and/or living close to high voltage powerlines and a small excess of childhood leukemia. At present there is no plausible biological mechanism to explain this excess if real, or certainty about what aspect of ELF EMF exposure, if any, might be responsible." (HPA, 2007)

World Health Organization (WHO), June 2007

The World Health Organization released the most recent review in June 2007 as part of their International EMF Project, which began in 1996 to address public concerns about EMF. Following more than 10 years of experience in evaluating research and advising governments and the public, the Project released a 372-page review of EMF research and health prepared by a collaborative panel of scientists. The WHO concluded the following:

“Given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukemia and the limited potential impact on public health, the benefits of exposure reduction on health are unclear and thus the cost of reducing exposure should be very low.”

Overall, the conclusions of these health review panels have been similar:

- ▶ *None of the panels concluded that EMF is established as the cause of any long-term, adverse effect on health.*
- ▶ *At very high field levels, EMF can cause nerve and muscle stimulation. However, the field levels found in our environment are far too low to cause these effects.*
- ▶ *The strongest evidence for a potential relationship between EMF and health was from epidemiology studies of childhood leukemia. Some studies reported statistical associations between childhood leukemia and magnetic field exposures, while others did not. The data from these studies were combined in a “pooled analysis” so that the investigators could have a larger sample size with which to work. The pooled analysis reported a small association between childhood leukemia and estimates of long-term, average exposure to magnetic fields above 3-4 mG. However, the panels did not conclude that magnetic fields were likely to be a cause of childhood leukemia, because of the lack of support from animal and cellular studies and the role of other factors could not be ruled out. In particular, the WHO recommended conducting further research to understand what could be causing the small statistical association observed in the pooled analyses.*
- ▶ *No consistent increases in cancer were reported in animal studies, nor did researchers find a mechanism that would explain how magnetic fields could initiate disease at the cellular level.*

Overview of the Results of EMF Research

No single study can address all questions, so evaluations must be based on the weight of scientific evidence. National Grid relies on experts to provide interpretations of the research and the science. We also rely on the aforementioned scientific panels that have evaluated the research on EMF and health effects for the current state of the science to guide our policies and operations.

In summary, epidemiologic studies of childhood leukemia have received the most attention because some have reported an association between estimated exposure to magnetic fields from power lines and childhood leukemia. It is important to remember that, in this context, association means “likely to occur together” – not that one is causing the other. In fact, reviews of the extensive animal and cell studies with electric and magnetic field exposure do not find support for the idea that these fields might cause health effects, cellular changes, or diseases. Thus, the consensus of the international scientific community after 30 years of research is that the science has not established a causal link between exposure to EMF and risks to public health.

More Information and EMF Services

National Grid has personnel who are trained to measure EMF in customer locations and along our transmission and distribution lines.

Property owners wishing to have EMF measurements taken should call National Grid's toll-free customer service line at **1-800-322-3223** in New England, or **1-800-642-4272** in New York.

Information and updates about EMF are available on the National Grid website, at **<http://www.nationalgridus.com/emfs>**

National Grid's Position on EMF

National Grid is an international energy delivery business with principal activities in the regulated electric and gas industries. National Grid's position on EMF can be found on the company's website, <http://www.nationalgrid.com/emfs>. The key points follow:

Objective

Electric and Magnetic Fields (EMFs) can be generated from a wide variety of sources, including distribution and transmission power lines and wireless infrastructure. National Grid recognizes that there is some scientific evidence suggesting certain adverse health effects are linked to EMFs. There is also evidence linking an increased risk of certain diseases to proximity to powerlines, though the cause of this is not clear. As a consequence, there is public concern; and we take these issues very seriously.

This public position statement provides a framework for managing the EMF issues facing National Grid. The public position statement helps set the framework within which we will continually assess the scientific evidence in this area, determine any implications for the way in which we conduct our business, and explain to society what the science is telling us.

Scope

This public position statement applies to National Grid and its Subsidiary Companies focused on electricity transmission, electricity distribution and wireless infrastructure. For Associate Companies, National Grid will seek to promote the adoption of statements consistent with the principles set out in this document.

This statement covers the EMFs that arise from transmission or distribution power lines and associated equipment as well as radio-frequency EMFs that arise from wireless infrastructure, including from third-party assets.

Framework

Electric and Magnetic Fields can arise from many sources including household appliances, electrical distribution and transmission facilities and equipment, mobile telephones and radio-transmission devices. Research is ongoing to improve our understanding of the effects of EMFs.

The balance of evidence remains against both power-frequency and radio-frequency EMFs causing ill health. The World Health Organization has classified power-frequency EMFs as “possibly” carcinogenic. This scientific position is reflected in the views of the regulatory bodies in the countries in which we operate.

We also recognize that scientific developments on EMFs do not depend on international boundaries. This public position statement establishes the common threads applicable across all of our operations.

Our public position statement as regards EMF has seven central principles:

- 1 We recognize that the societies in which we both operate and live hold a variety of views on EMFs. In view of the scientific position and the fact that EMFs are of concern to some, we take the issue very seriously.
- 2 In all our operations, as a minimum we comply with EMF regulations, guidelines or practices in force in the countries and different jurisdictions in which we operate. Where other companies (such as telecommunications operators) use our assets, we expect them similarly to comply with the relevant regulations, guidelines or practices.
- 3 We support the view of regulators and governments that the EMF issue warrants consideration for a precautionary approach and we look to them to decide on any measures that may be necessary, as they can evaluate the science and weigh up costs and benefits on behalf of society as a whole.

4 To mitigate the amenity impact of new overhead transmission lines, we always endeavor to route them:

- ▶ along formal Rights of Way in countries where they exist; or
- ▶ away from existing buildings where they do not.

In order to ensure safety clearances and to help us maintain our network, we do not encourage built development immediately beneath our lines. We will work with planning bodies to promote the sustainable use of land under our lines. These steps will usually result in EMF exposures being lower than would otherwise be the case.

5 We recognize that scientific understanding of the effects of EMFs is improving. We review all relevant scientific developments in this area from across the world and assess any implications for the way in which we operate.

6 We support high-quality research into EMFs, and make the results available for scientific review.

7 We communicate in an open manner with those who have an interest in EMF matters, and make available information that will help society's understanding of EMFs. We will participate openly and constructively in debate on precautionary approaches appropriate to the EMF issue.

In support of this public position statement, each Subsidiary Company will ensure that:

- ▶ A plan is put in place to ensure all elements of this public position statement of relevance to its business are implemented.
- ▶ All regulatory and legal requirements are met for both new and existing lines and infrastructure.
- ▶ All breaches, suspected breaches and areas of vulnerability to prosecution are investigated and if appropriate prompt corrective actions taken. Associate Companies will be encouraged to put similar arrangements in place.

Related Group Policies and Other Documents

- ▶ Framework for Responsible Business.
- ▶ Environment policy.
- ▶ Safety and Occupational Health policy.
- ▶ Terms of Reference of the Risk and Responsibility Committee.

Prepared by National Grid with assistance from Exponent™

Additional Information

A large amount of information about EMF and health effects is available, ranging from stories in the media and on websites to reports and summaries by health agencies and organizations. The Internet is a valuable and convenient source of information on this topic. However, if you decide to research EMF on the Internet, it is important to consider the background and credentials of the person or organization that is providing the information. As with any subject on the Internet, websites may be posted by individuals who may not have the professional expertise that is required to evaluate scientific research.

For accurate and up-to-date information, it is best to consult websites of independent scientific organizations who have the expertise and mandate to evaluate these issues. We look to these organizations because their conclusions have undergone scrutiny by other scientists in the field regarding their accuracy.

The sites listed below were selected because they are produced and maintained by scientific organizations and provide up-to-date summaries designed for the general public on the issue of EMF and health. These sites, sponsored by federal agencies and professional organizations in the US and elsewhere, provide information that reflects the work of many experienced scientists.

Scientific Organizations in the US:

- ▶ National Cancer Institute (NCI) – <http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields>
- ▶ National Institute of Environmental Health and Safety (NIEHS) – <http://www.niehs.nih.gov/health/topics/agents/emf>

Scientific Organizations Outside of the US:

- ▶ World Health Organization, International EMF Project – <http://www.who.int/peh-emf/about/WhatisEMF/en/>
- ▶ Canada – Health Canada – http://www.hc-sc.gc.ca/iyh-vsv/environ/magnet_e.html
- ▶ Australia – Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) – http://www.arpansa.gov.au/radiation/protection/factsheets/is_emf.cfm
- ▶ United Kingdom – Health Protection Agency (HPA) – <http://www.hpa.org.uk/radiation/faq/emf/index.htm>

40 Sylvan Road
Waltham, MA 02451
www.nationalgridus.com

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