



ELECTRIC AND MAGNETIC FIELDS

On a daily basis, most of us are exposed to electric and magnetic fields (EMF) generated by utility power lines as well as household wiring, lighting, computers and other electrical appliances, such as hair dryers, coffee makers, televisions and power tools.

Since the 1970s, scientists have been researching possible human health effects from EMF exposure, particularly certain cancers including brain cancer, lymphoma, breast cancer and leukemia. This extensive research has not proven a link between health risks and EMF.

The Canadian Electricity Association member electric utilities are committed to supporting ongoing EMF research to resolve questions, as well as to providing educational materials and facilitating magnetic field measurement for the public and employees.

What are electric and magnetic fields?

Power frequency (also referred to as extremely low frequency or ELF) electric and magnetic fields are present everywhere that electricity flows. All electrical wires – and the lighting, appliances and other electrical devices they supply – are sources of electric and magnetic fields. Although they are often referred to together as EMF, electric fields and magnetic fields are actually distinct components of electricity. Most of the interest regarding possible health effects is related to magnetic fields. Usually, when the term EMF level is used, it is the magnetic field strength that is being referred to or measured.

X-rays, visible light, radio waves, microwaves and power frequency EMF are all forms of electromagnetic energy making up an electromagnetic spectrum.

Electric vs. Magnetic Fields

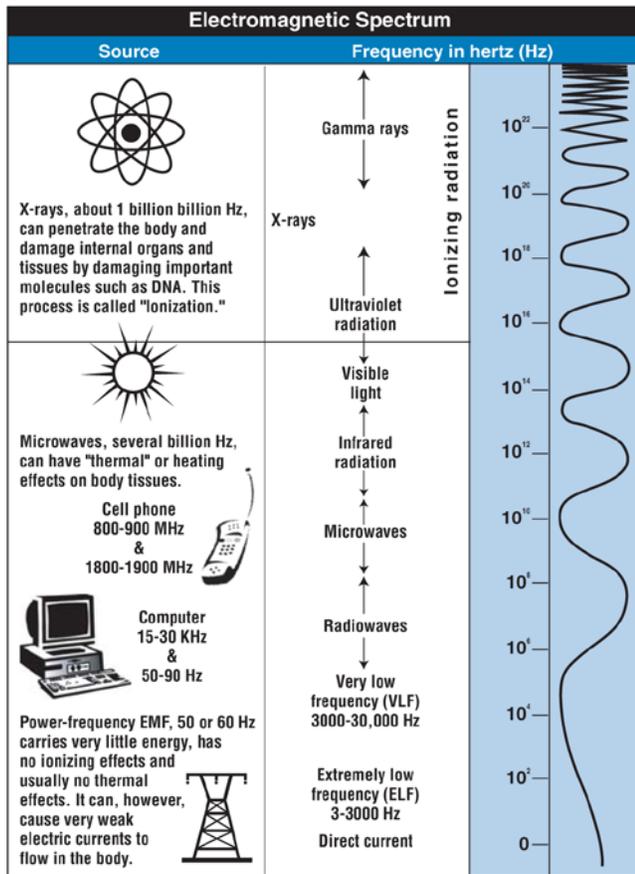
Electric fields are produced by voltage or electric charge. An electric field is present, for example, when an appliance is plugged into an outlet, even if it is not turned on. Electric fields are measured in Volts per metre (V/m); the higher the voltage, the greater the electric field.

Magnetic fields are created by the flow of current in a wire or an appliance. As a result, they are only present in an appliance when it is switched on. As the flow (current) increases, so does the strength of the field.

In North America, magnetic fields in electrical wiring are most commonly measured in milligauss or mG (one thousand milligauss equal 1 gauss). Elsewhere magnetic fields are measured in microtesla or μT (one thousand μT equal 1 mT, one million μT equal 1 tesla). One μT equals 10 mG.



As the Electromagnetic Spectrum chart¹ below shows, one property that distinguishes different forms of electromagnetic energy is the frequency, measured in hertz (Hz). These frequencies are plotted on the right side of the spectrum chart. At the lowest end is static or direct current (DC) electricity with a frequency of 0 Hz. At the upper end (above 10^{16} Hz - that is 10,000,000,000 MHz) it is ionizing radiation produced by ultraviolet, X-ray and gamma ray radiation.



The wavy line at the right illustrates the concept that the higher the frequency, the more rapidly the field varies. The fields do not vary at 0 Hz (direct current) and vary trillions of times per second near the top of the spectrum. Note that 10^4 means $10 \times 10 \times 10 \times 10$ or 10,000 Hz. 1 kilohertz (kHz) = 1,000 Hz. 1 megahertz (MHz) = 1,000,000 Hz.

Power frequency EMF has a frequency of 60 Hz. It is at the lower end of the spectrum near DC electricity and well below the microwave or RF (radio frequency) radiation emitted by cellular phones and radio broadcast transmitters. As noted on the chart, unlike X-rays and gamma rays, power frequency EMFs have little energy and no ionizing or thermal effects on the body.

Exposure and guidelines

Both electric and magnetic fields are strongest at the source – whether it is a power line or an appliance such as a hair dryer, or dishwasher – and decrease rapidly when you move away from the source. Magnetic field exposure from power lines depends primarily on the current the wires carry and an individual's distance from the lines. While electric fields are easily shielded by trees, fences and other materials that are capable of conducting electricity, magnetic fields pass through most objects.

In Canada, there are no guidelines or standards on acceptable levels of residential EMF exposure. Health Canada's *It's Your Health* fact sheet on *Electric and Magnetic Fields from Power Lines and Electrical Appliances* states, "Health Canada does not consider that any precautionary measures are needed regarding daily exposures to EMFs at ELF's. There is no conclusive evidence of any harm caused by exposures at levels found in Canadian homes and schools, including those located just outside the boundaries of power line corridors."² (See the following page for other information sources on EMF standards.)

Research

Scientists around the world have been researching possible human health effects of EMF since the 1970s. There are two main types of research which make up the body of scientific knowledge around EMF: epidemiological studies and laboratory studies. These studies provide pieces of the puzzle but no single study can give us the whole picture.

¹ Courtesy of the National Institute of Environmental Health Sciences and the National Institutes of Health, National Institute of Environmental Health Sciences (NIEHS) Website, http://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf, accessed July 2013.

² Health Canada, "Electric and Magnetic Fields from Power Lines and Electrical Appliances," Health Canada Website, http://www.hc-sc.gc.ca/hl-vs/alt_formats/pdf/iyh-vsv/viron/magnet-eng.pdf, accessed July 2013.

EMF Exposure Guidelines

In the absence of sufficient data to allow a long-term EMF exposure guideline to be established, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) have proposed exposure guidelines which protect workers and the general public from well-documented immediate biological effects that can result from direct exposure to fields well above those typically found in living environments. These immediate biological effects could include: stimulation of nerves and muscles, functional changes in the nervous system, stimulation of hair and other tissues, shocks, burns, and elevated tissue temperatures.

Typical Canadian exposures fall well below these international guidelines.

- The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published "Guidelines for Limiting Exposure to Time Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)" in April 1998. It is available at <http://www.icnirp.de/documents/StatementEMF.pdf>.
- The Institute of Electrical and Electronics Engineers, Inc. (IEEE) produced "C95.6-2002 IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields 0 to 3 kHz 2002". This technical document is available for purchase at <http://standards.ieee.org/findstds/standard/C95.6-2002.html>.
- The Health Canada summary of health effects and exposure guidelines is available at <http://www.labour.gov.sk.ca/radiation/>.

Epidemiological Studies

In epidemiological studies, researchers try to establish whether there is a statistical association (mathematical link) between selected groups of people with certain types of exposure and certain kinds of disease.

The stronger the statistical association, the greater the probability that the particular exposure may cause the disease. However, epidemiological studies alone cannot establish a cause and effect relationship because other possible causes, that could explain the statistical relationship, cannot be ruled out.

Some epidemiological studies have suggested a possible statistical association between exposure to magnetic fields and some diseases, including childhood leukemia.

Laboratory Studies

Laboratory studies involve exposing cells, tissues, humans and/or animals to EMF under controlled conditions. These studies allow researchers to closely control EMF exposure and provide detailed information about any small scale biological changes that EMFs may cause.

Laboratory studies have not confirmed that magnetic fields are a cause of any disease.

Conclusions to date

In light of the evidence and research to date, a number of conclusions have been drawn by international research organizations on the health risks associated with EMF:

- Health Canada's 2012 Fact sheet: *Electric and Magnetic Fields from Power Lines and Electrical Appliances* states:

"There have been many studies on the possible health effects from exposure to EMFs at ELF. While it is known that EMFs can cause weak electric currents to flow through the human body, the intensity of these currents is too low to cause any known health effects. Some studies have suggested a possible link between exposure to ELF magnetic fields and certain types of childhood

cancer, but at present this association is not established.”³

- Following a 10-year review of scientific research on effects from exposure to electromagnetic fields, the World Health Organization’s International EMF Project states:

“In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge about biological effects exist and need further research.”⁴

- The Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC), organized under Health Canada’s Radiation Protection Bureau, issued a Position Statement in January, 2005 stating that adverse health effects from exposure to power frequency EMFs at levels normally encountered in homes, schools and offices have not been established.⁵

In November 2008 the FPTRPC issued a Response Statement to Public Concerns regarding Electric and Magnetic Fields (EMFs)

from Electrical Power Transmission and Distribution Lines which concluded “it is the opinion of the Federal-Provincial-Territorial Radiation Protection Committee that there is insufficient scientific evidence showing exposure to EMFs from power lines can cause adverse health effects such as cancer. Therefore, a warning to the public to avoid living near or spending time in proximity to power lines is not required.”⁶

- A 1999 report by the U.S. National Institute of Environmental Health Sciences (NIEHS) following a seven-year EMF research programme concluded:

“The NIEHS believes that the probability that EMF exposure is truly a health hazard is currently small. The weak epidemiological associations and lack of any laboratory support for these associations provide only marginal scientific support that exposure to this agent is causing any degree of harm.”⁷

- The World Health Organization International Agency for Research on Cancer (IARC) has classified power frequency EMF as a 2B carcinogen – a possible carcinogen based on unanswered questions of the statistical association between magnetic field exposure and childhood leukemia. IARC found no consistent evidence that childhood EMF exposures are associated with other types of cancers or that adult EMF exposures are associated with increased risk of any kind of cancer. Other 2B Possible Carcinogens include coffee, pickled vegetables and gasoline engine exhaust.⁸

³ Health Canada, “*Electric and Magnetic Fields from Power Lines and Electrical Appliances*,” Health Canada Website, http://www.hc-sc.gc.ca/hl-vs/alt_formats/pdf/iyh-vsv/environ/magnet-eng.pdf, accessed July 2013.

⁴ The World Health Organization (WHO), “*The International EMF Project Publications*,” World Health Organization Website, <http://www.who.int/peh-emf/project/en>, accessed July 2013.

⁵ Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC), “*Extremely Low Frequency: Position Statement for the General Public on the Health Effects of Power-Frequency (60 Hz) Electric and Magnetic Fields – Issued on January 20, 2005*,” Government of Saskatchewan Website, <http://www.lrws.gov.sk.ca/position-statement-health-effects-power-frequency-electric-magnetic-fields>, accessed July 2013.

⁶ Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC), “*Response Statement to Public Concerns Regarding Electric and Magnetic Fields (EMFs) from Electrical Power Transmission and Distribution Lines (Nov. 8, 2008)*,” Health Canada Website, <http://www.hc-sc.gc.ca/ewh-semt/radiation/fpt-radprotect/emf-cem-eng.php>, accessed July 2013.

⁷ The National Institute of Environmental Health Sciences and the National Institutes of Health, “*Electromagnetic Fields Associated with the Use of Electric Power: Questions and Answers*,” National Institute of Environmental Health Sciences (NIEHS) Website, http://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf, accessed July 2013.

⁸ The World Health Organization (WHO), “*Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields*,” World Health Organization: International Agency for Research on Cancer Website, <http://monographs.iarc.fr/ENG/Monographs/vol80/index.php>, accessed July 2013.

What Lies Ahead for EMF Research and Policy

EMF research is ongoing, and from time to time health agencies and organizations, such as Health Canada and the World Health Organization, review the new studies and confirm or update their position statements on EMF.

As well, these agencies are looking to create “precaution-based policies” to guide their actions on EMF and other issues. Precaution-based policies are intended to address issues where there is some basis for concern, but no scientific certainty of a cause and effect relationship.

Generally a precaution-based policy requires that there is enough evidence to do a risk analysis or a cost/benefit analysis when considering policy options. It is not intended to be a replacement for scientific understanding. The Government of Canada document on precaution is available at: http://www.pco-bcp.gc.ca/index.asp?lang=eng&page=information&sub=publications&doc=precaution/precaution_e.htm.

The World Health Organization website also contains information of precaution at: http://www.who.int/peh-emf/meetings/archive/Precaution_Draft_2May.pdf.

What are Canadian utilities doing?

The Canadian electricity industry continues to support scientific research on EMF and possible long-term effects on people. The Canadian Electricity Association (CEA) and member companies also work to communicate accurate and up-to-date information to the public and employees about EMF.

For more information on EMF and the Canadian electricity industry, please visit our website at www.electricity.ca.

To Learn More

For more information on EMF, contact your local electricity provider. More information about EMF issues can be found at:

- Health Canada, “Electric and Magnetic Fields from Power Lines and Electrical Appliances,” Health Canada Website, http://www.hc-sc.gc.ca/hl-vs/alt_formats/pdf/iyh-vsv/environ/magnet-eng.pdf.
- Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC), “Extremely Low Frequency: Position Statement for the General Public on the Health Effects of Power-Frequency (60 Hz) Electric and Magnetic Fields,” Government of Saskatchewan Website, <http://www.lrws.gov.sk.ca/position-statement-health-effects-power-frequency-electric-magnetic-fields>.
- Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC), “Response Statement to Public Concerns Regarding Electric and Magnetic Fields (EMFs) from Electrical Power Transmission and Distribution Lines (Nov. 8, 2008),” Health Canada Website, <http://www.hc-sc.gc.ca/ewh-semt/radiation/fpt-radprotect/emf-cem-eng.php>.
- The National Institute of Environmental Health Sciences and the National Institutes of Health (sponsored by the Electric and Magnetic Fields Research and Public Information Dissemination (EMF RAPID) Programme, “Electromagnetic Fields Associated with the Use of Electric Power: Questions and Answers”, National Institute of Environmental Health Sciences (NIEHS) Website, http://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf.
- The World Health Organization (WHO), “The International EMF Project Publications,” World Health Organization Website, <http://www.who.int/peh-emf/project/en>.