

## Alternating Current (AC) Electric and Magnetic Fields (EMF)

October 2015

In North America, AC transmission lines operate at a frequency of 60 cycles per second, or hertz (Hz), and EMF from transmission lines is included in the extremely low frequency (ELF) band of the electromagnetic spectrum. ELF EMF is found virtually everywhere that electricity is used in our modern society, including around household wiring, electrical appliances, and transmission lines.

AltaLink recognizes that people are concerned about exposure to ELF EMF, and treats those concerns seriously. AltaLink provides information from unbiased independent sources to people who have questions about the status of ELF EMF health research. AltaLink participates in the Canadian Electricity Association EMF Task Group and also regularly takes measurements of fields near AltaLink's facilities.

### What have national and international organizations concluded?

Research into possible adverse health effects from exposure to EMF has been undertaken extensively for more than 40 years. National agencies, such as Health Canada and the National Institute of Environmental Health Sciences (**NIEHS**) in the United States, have reviewed this research and concluded there are no known adverse health effects to humans from low-level exposure to ELF EMF. Health Canada does not consider that the general public needs to take steps to limit daily exposure to ELF EMF.

International organizations such as the International Agency for Research on Cancer (**IARC**) and the World Health Organization (**WHO**), among other agencies responsible for public health, have convened multi-disciplinary groups of scientists to review the research. These organizations have concluded there is insufficient evidence to support a cause and effect relationship between low-level ELF EMF exposure and any adverse health outcome, including cancer. The WHO concluded, based on their latest in-depth assessment and review of the scientific literature, that "current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."

### What standards or guidelines apply to ELF electric and magnetic fields?

Two independent international scientific organizations, the International Commission on Non-ionizing Radiation Protection (**ICNIRP**) and the International Committee on Electromagnetic Safety (**ICES**)<sup>1</sup>, have conducted reviews of the scientific literature to develop exposure guidelines to protect workers and the general public from well-documented short-term or immediate (acute) biological effects (similar to shocks). These effects can result from direct exposure to high levels of ELF EMF, which are much higher than those typically found in every-day environments.

For the general public, their short-term **electric field** exposure guidelines range between 4.2 and 10 kilovolts per metre (kV/m); **magnetic field** exposure guidelines range between 2,000 and 9,040 milligauss (mG).

These organizations did not find a scientific basis to develop exposure guidelines for low-level, long-term exposures.

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<sup>1</sup> Institute of Electrical and Electronics Engineers (IEEE) committee



**Will the transmission lines or substations generate audible noise?**

Sometimes noise can be heard from high-voltage transmission lines and is made up of a crackle and a lower frequency hum. The noise may be more noticeable in rainy or foggy conditions than in fair weather; however, noise from wind, rain, traffic, or industrial sources often masks the low levels of audible noise generated by the transmission line. Substation transformers produce a low-frequency hum that might be heard close to the substation; and transformer cooling fans create noise when they are operating. AltaLink designs and ensures their transmission lines and substations comply with the Alberta Utilities Commission Rule 012 for noise control.

**Will radio, cellular phone, or wireless internet reception be affected by a transmission line?**

AltaLink's facilities are designed and operated to minimize levels of radio interference and to meet Industry Canada's interference regulations. AM and CB radio reception might be affected, particularly when directly under a transmission line. The type of radio, antenna, and distance from the radio station can affect whether interference is experienced. Higher frequency radio signals, such as FM, cellular phone, and wireless internet, operate above the general range of potentially affected frequencies and should not experience reception problems as a result of a transmission line. AltaLink will investigate if your service provider suggests a transmission line is affecting your service.

**Will television reception be affected by a transmission line?**

Reception of cable TV and satellite TV signals are unaffected by radio noise from transmission facilities. Digital TV signal frequencies are above the general range of potentially affected frequencies and should not experience reception problems as a result of a transmission line. If you think that you might be experiencing poor television reception as a result of a transmission line, please give us a call. Although we cannot do anything about poor reception you had before the transmission line was built, if interference does occur after the line is built, the problem often can be solved by changing or relocating the TV antenna.

**Will a Global Positioning System (GPS) receiver be affected by a transmission line?**

Interference from transmission facilities on GPS equipment is unlikely. The signals sent to GPS receivers from satellites have frequencies far above the range of frequencies potentially affected by radio noise from transmission lines. Research has shown transmission lines do not cause errors or malfunctions for modern GPS equipment. Contact AltaLink if you believe your GPS receiver is being affected by AltaLink's facilities.

**How are nearby metal buildings and wire fences affected by a transmission line?**

Electrical charges will not normally accumulate on buildings close to transmission lines because appropriate grounding already exists. AltaLink will help ensure that metal buildings, fences, including electric fences, and other structures close to our facilities are properly grounded to avoid the build-up of an electrical charge and possible nuisance shocks. Let us know if you are planning to put up a new building, fence, or gate near an existing transmission line, and we will advise you on how to ground the new structure and ensure it will not block access to the right-of-way.



**Will my cardiac pacemaker be affected by a transmission line?**

Experimental studies have reported that strong electric and magnetic fields have the potential to affect the function of a pacemaker if these fields exceed a pacemaker's immunity level. Pacemakers are designed to minimize the effect of interference whatever the source and so even though a change in function may be noted, it does not mean that a patient is at risk. Magnetic field levels directly under a transmission line are but a fraction of a pacemaker's immunity level to magnetic fields. Electric field levels under some transmission lines may be comparable to the pacemaker's electric field immunity level. While electric fields may affect some models of pacemakers, this would be most likely **directly** under higher voltage AC transmission lines operating at 500 kV since electric field levels drop rapidly with distance and are shielded by many materials. AltaLink is not aware of any cases of confirmed interference to pacemakers by transmission lines.

In addition, most modern pacemakers are designed to filter out electrical interference or revert to a safe mode of steady pacing (called asynchronous pacing) if interference becomes too great. Your doctor will be able to identify if interference has occurred by reviewing the telemetry data on your next visit. If you have a concern about potential interference from exposure to an electric field, contact your doctor. AltaLink will work together with your doctor to help you determine if your device is immune to electrical fields from a transmission line.

**Will a transmission line be a source of stray voltage?**

Stray voltage can cause behavioural problems in livestock if they perceive a voltage through contact across two points. This is different than a nuisance shock from an ungrounded metallic object that is in close proximity to a transmission line. AltaLink will mitigate nuisance shocks through our normal grounding practices.

Stray voltage problems are primarily related to distribution systems and on-farm wiring, both of which rely on the earth as a path for some of their current to flow. In these circuits, unbalanced loading on electrical panels, the use of distribution system neutrals and/or wiring problems can cause a current to flow into the earth (ground) at the load service point. Transmission lines might influence stray voltages only where long sections of on-farm wiring or distribution lines are built very near and parallel to the transmission lines, causing currents to be induced onto the neutrals of these facilities.

**Is there a difference between AC and Direct Current (DC) transmission lines?**

Since AC and DC differ in frequency, the EMF produced also differs in frequency. For AC equipment, the polarity of the voltage and current change direction at 60 Hz, producing ELF EMF that changes direction at that frequency. For DC equipment, the polarity of the voltage and current remains constant at 0 Hz, producing static fields that also do not change direction. AC and DC fields act independently from each other. Only AC fields are capable of inducing currents and voltages in conductive objects such as fences, buildings, and humans. Corona effects such as audible noise and small amounts of radio interference occur near both AC and DC lines. While corona effects on AC lines are usually higher during wet conditions, corona effects on DC lines are generally higher during fair weather.



## Where can I find further information about AC EMF?

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Further sources of information about AC electric and magnetic fields include:

- ‘A DIALOGUE on ELECTRIC & MAGNETIC FIELDS’ brochure from AltaLink;
- websites and handouts published by health organizations such as WHO and Health Canada; and
- peer-reviewed scientific literature published in health science and electrical engineering journals.

## Internet Sources of EMF Information

- a) World Health Organization – Summary of EMF Background and Fact Sheets  
<http://www.who.int/peh-emf/about/WhatisEMF/en/>  
<http://www.who.int/peh-emf/publications/facts/fs322/en/index.html>  
<http://www.who.int/peh-emf/publications/facts/fs296/en/index.html>  
<http://www.who.int/peh-emf/publications/Comple DEC 2007.pdf>
- b) Health Canada – Handout on EMF at Extremely Low Frequencies (ELF)  
<http://healthycanadians.gc.ca/environment-environnement/home-maison/emf-cem-eng.php>
- c) Federal-Provincial-Territorial Radiation Protection Committee – Report “Health Effects and Exposure Guidelines Related to Extremely Low Frequency Electric and Magnetic Fields” and Response Statements  
<http://www.hc-sc.gc.ca/ewh-semt/radiation/fpt-radprotect/emf-cem-eng.php>  
[http://www.hydroone.com/OurCommitment/Environment/Documents/EMF/Response\\_statement\\_on\\_EMF\\_Leukemia.pdf](http://www.hydroone.com/OurCommitment/Environment/Documents/EMF/Response_statement_on_EMF_Leukemia.pdf)  
[http://www.hydroone.com/OurCommitment/Environment/Documents/EMF/Health\\_Effects\\_and\\_Exposure\\_Guidelines\\_ELF\\_EMF.pdf](http://www.hydroone.com/OurCommitment/Environment/Documents/EMF/Health_Effects_and_Exposure_Guidelines_ELF_EMF.pdf)
- d) BC Center for Disease Control – Handout on Electric and Magnetic Fields at Extremely Low Frequencies  
<http://www.bccdc.ca/healthenv/ElectromagFields/LowFrequency/PowerLines.htm>
- e) National Institute of Environmental Health Sciences – EMF Questions and Answers  
[http://www.niehs.nih.gov/health/materials/electric\\_and\\_magnetic\\_fields\\_associated\\_with\\_the\\_use\\_of\\_electric\\_power\\_questions\\_and\\_answers\\_english\\_508.pdf](http://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf)
- f) International Commission on Non-Ionizing Radiation Protection  
<http://www.icnirp.org/en/applications/power-lines/power-lines.html>
- g) Canadian Electricity Association  
<http://powerforthefuture.ca/electricity-411/electric-and-magnetic-fields/>  
<http://powerforthefuture.ca/electricity-411/electric-and-magnetic-fields/what-are-electric-and-magnetic-fields/>  
[http://powerforthefuture.ca/wp-content/uploads/2013/07/Electric-and-Magnetic-Fields\\_E.pdf](http://powerforthefuture.ca/wp-content/uploads/2013/07/Electric-and-Magnetic-Fields_E.pdf)
- h) National Cancer Institute - Magnetic Field Exposure and Cancer: Questions and Answers  
<http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields>
- i) Public Health England - Electric and Magnetic Fields  
<http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields>
- j) AltaLink's Website - summary on EMF  
<http://www.altalink.ca/emf>



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Electric and Magnetic Fields

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# IT'S YOUR HEALTH

## Electric and Magnetic Fields from Power Lines and Electrical Appliances

### THE ISSUE

Some people are concerned that daily exposure to electric and magnetic fields (EMFs) may cause health problems.



### ELECTRICITY AND ELECTRIC AND MAGNETIC FIELDS (EMFS)

Electricity delivered through power lines is important in today's society. It is used to light homes, prepare food, run computers and operate other household appliances, such as TVs and radios. In Canada, appliances that plug into a wall socket use electric power that flows back and forth at a frequency of 60 cycles per second (60 hertz). The frequency used with the distribution of electricity from power lines and electrical appliances is different than the frequencies used for [Wi-Fi](#), [cell phones](#), and [smart meters](#).

Every time you use electricity and electrical appliances, you are exposed to electric and magnetic fields (EMFs) at extremely low frequencies (ELFs). The term "extremely low" is described as any frequency below 300 hertz. EMFs produced by the transmission and use of electricity belong to this category.

EMFs are invisible forces that surround electrical equipment, power cords, and wires that carry electricity, including outdoor power lines.

- *Electric Fields:* These are formed whenever a wire is plugged into an outlet, even when the appliance is not turned on. The higher the voltage, the stronger the electric field.
- *Magnetic Fields:* These are formed when electric current is flowing within a device or wire. The greater the current, the stronger the magnetic field.

EMFs can occur separately or together. For example, when you plug the power cord for a lamp into a wall socket, it creates an electric field along the cord. When you turn the lamp on, the flow of current through the cord creates a magnetic field. Meanwhile, the electric field is still present.



## POWER LINES AND YOUR HOME

EMFs are strongest when close to their source. As you move away from the source, the strength of the fields fades rapidly. This means you are exposed to stronger EMFs when standing close to a source (e.g., right beside a transformer box or under a high voltage power line), and you are exposed to weaker fields as you move away.

When you are inside your home, the magnetic fields from high voltage power lines and transformer boxes are often weaker than those from household electrical appliances.

Electric fields can be shielded using materials such as metal. Things like buildings and trees—and even the ground when power lines are buried—can block electric fields.

## CANADIANS EXPOSURE TO EMFS AT EXTREMELY LOW FREQUENCIES (ELFS)

On a daily basis, most Canadians are exposed to EMFs generated by household wiring, lighting, and any electrical appliance that plugs into the wall, including hair dryers, vacuum cleaners and toasters. In the workplace, common sources of EMFs include computers, air purifiers, photocopiers, fax machines, fluorescent lights, electric heaters, and electric tools in machine shops, such as drills, power saws, lathes and welding machines.

## EXPOSURE IN CANADIAN HOMES, SCHOOLS AND OFFICES PRESENT NO KNOWN HEALTH RISKS

There have been many studies on the possible health effects from exposure to EMFs at ELFs. 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.

The [International Agency for Research on Cancer \(IARC\)](#) has classified ELF magnetic fields as “possibly carcinogenic to humans”. The IARC classification of ELF magnetic fields reflects the fact that some limited evidence exists that ELF magnetic fields might be a risk factor for childhood leukemia. However, the vast majority of scientific research to date does not support a link between ELF magnetic field exposure and human cancers. At present, the evidence of a possible link between ELF magnetic field exposure and cancer risk is far from conclusive and more research is needed to clarify this “possible” link.

Health Canada is in agreement with both the World Health Organization and IARC that additional research in this area is warranted.

## REDUCE YOUR RISK

Health Canada does not consider that any precautionary measures are needed regarding daily exposures to EMFs at ELFs. 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.

## THE GOVERNMENT OF CANADA'S ROLE

Health Canada, along with the World Health Organization, monitors scientific research on EMFs and human health as part of its mission to help Canadians maintain and improve their health.

International exposure guidelines for exposure to EMFs at ELFs have been established by the [International Commission on Non-Ionizing Radiation Protection \(ICNIRP\)](#). These guidelines are not based on a consideration of risks related to cancer. Rather, the point of the guidelines is to make sure that exposures to EMFs do not cause electric currents or fields in the body that are stronger than the ones produced naturally by the brain, nerves and heart. EMF exposures in Canadian homes, schools and offices are far below these guidelines.

## FOR MORE INFORMATION

- Health Canada’s [Electric and magnetic fields](#) at: [www.hc-sc.gc.ca/ewh-semt/radiation/cons/electri-magnet/index-eng.php](http://www.hc-sc.gc.ca/ewh-semt/radiation/cons/electri-magnet/index-eng.php)
- The World Health Organization – Electromagnetic fields and public health:
  - [Exposure to extremely low frequency fields](#) at: [www.who.int/mediacentre/factsheets/fs322/en/index.html](http://www.who.int/mediacentre/factsheets/fs322/en/index.html)
  - [Extremely low frequency](#) at: [www.who.int/docstore/peh-mf/publications/facts\\_press/efact/efs205.html](http://www.who.int/docstore/peh-mf/publications/facts_press/efact/efs205.html)
  - [Extremely low frequency fields and cancer](#) at: [www.who.int/docstore/peh-emf/publications/facts\\_press/efact/efs263.html](http://www.who.int/docstore/peh-emf/publications/facts_press/efact/efs263.html)



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## FOR INDUSTRY AND PROFESSIONALS

- The International Agency for Research on Cancer (IARC) *Volume 80 – Non-ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields* at: <http://monographs.iarc.fr/ENG/Monographs/vol80/volume80.pdf>
- IARC Carcinogen classifications at: <http://monographs.iarc.fr/ENG/Classification/index.php>

## RELATED RESOURCES

- Health Canada, *It's Your Health*:
  - Safety of Wi-Fi Equipment at: [www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/wifi-eng.php](http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/wifi-eng.php)
  - Safety of Cell Phones and Cell Phone Towers at: [www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/cell-eng.php](http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/cell-eng.php)
- For safety information about food, health and consumer products, visit the [Healthy Canadians](http://www.healthycanadians.gc.ca) website at: [www.healthycanadians.gc.ca](http://www.healthycanadians.gc.ca)
- For more articles on health and safety issues go to the *It's Your Health* web section at: [www.health.gc.ca/iyh](http://www.health.gc.ca/iyh)

You can also call toll free at  
1-866-225-0709 or TTY at  
1-800-267-1245\*

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## **Electromagnetic fields and public health Exposure to extremely low frequency fields**

The use of electricity has become an integral part of everyday life. Whenever electricity flows, both electric and magnetic fields exist close to the lines that carry electricity, and close to appliances. Since the late 1970s, questions have been raised whether exposure to these extremely low frequency (ELF) electric and magnetic fields (EMF) produces adverse health consequences. Since then, much research has been done, successfully resolving important issues and narrowing the focus of future research.

In 1996, the World Health Organization (WHO) established the International Electromagnetic Fields Project to investigate potential health risks associated with technologies emitting EMF. A WHO Task Group recently concluded a review of the health implications of ELF fields (WHO, 2007).

This Fact Sheet is based on the findings of that Task Group and updates recent reviews on the health effects of ELF EMF published in 2002 by the International Agency for Research on Cancer (IARC), established under the auspices of WHO, and by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2003.

### **ELF field sources and residential exposures**

Electric and magnetic fields exist wherever electric current flows - in power lines and cables, residential wiring and electrical appliances. **Electric** fields arise from electric charges, are measured in volts per metre (V/m) and are shielded by common materials, such as wood and metal. **Magnetic** fields arise from the motion of electric charges (i.e. a current), are expressed in tesla (T), or more commonly in millitesla (mT) or microtesla ( $\mu$ T). In some countries another unit called the gauss, (G), is commonly used (10,000 G = 1 T). These fields are not shielded by most common materials, and pass easily through them. Both types of fields are strongest close to the source and diminish with distance.

Most electric power operates at a frequency of 50 or 60 cycles per second, or hertz (Hz). Close to certain appliances, the magnetic field values can be of the order of a few hundred microtesla. Underneath power lines, magnetic fields can be about 20  $\mu$ T and electric fields can be several thousand volts per metre. However, average residential power-frequency magnetic fields in



homes are much lower - about 0.07  $\mu\text{T}$  in Europe and 0.11  $\mu\text{T}$  in North America. Mean values of the electric field in the home are up to several tens of volts per metre.

## **Task group evaluation**

In October 2005, WHO convened a Task Group of scientific experts to assess any risks to health that might exist from exposure to ELF electric and magnetic fields in the frequency range  $>0$  to 100,000 Hz (100 kHz). While IARC examined the evidence regarding cancer in 2002, this Task Group reviewed evidence for a number of health effects, and updated the evidence regarding cancer. The conclusions and recommendations of the Task Group are presented in a WHO Environmental Health Criteria (EHC) monograph (WHO, 2007).

Following a standard health risk assessment process, the Task Group concluded that there are no substantive health issues related to ELF electric fields at levels generally encountered by members of the public. Thus the remainder of this fact sheet addresses predominantly the effects of exposure to ELF magnetic fields.

## **Short-term effects**

There are established biological effects from acute exposure at high levels (well above 100  $\mu\text{T}$ ) that are explained by recognized biophysical mechanisms. External ELF magnetic fields induce electric fields and currents in the body which, at very high field strengths, cause nerve and muscle stimulation and changes in nerve cell excitability in the central nervous system.

## **Potential long-term effects**

Much of the scientific research examining long-term risks from ELF magnetic field exposure has focused on childhood leukaemia. In 2002, IARC published a monograph classifying ELF magnetic fields as "possibly carcinogenic to humans". This classification is used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals (other examples include coffee and welding fumes). This classification was based on pooled analyses of epidemiological studies demonstrating a consistent pattern of a two-fold increase in childhood leukaemia associated with average exposure to residential power-frequency magnetic field above 0.3 to 0.4  $\mu\text{T}$ . The Task Group concluded that additional studies since then do not alter the status of this classification.

However, the epidemiological evidence is weakened by methodological problems, such as potential selection bias. In addition, there are no accepted biophysical mechanisms that would suggest that low-level exposures are involved in cancer development. Thus, if there were any effects from exposures to these low-level fields, it would have to be through a biological mechanism that is as yet unknown. Additionally, animal studies have been largely negative. Thus, on balance, the evidence related to childhood leukaemia is not strong enough to be considered causal.

Childhood leukaemia is a comparatively rare disease with a total annual number of new cases estimated to be 49,000 worldwide in 2000. Average magnetic field exposures above 0.3  $\mu\text{T}$  in

homes are rare: it is estimated that only between 1% and 4% of children live in such conditions. If the association between magnetic fields and childhood leukaemia is causal, the number of cases worldwide that might be attributable to magnetic field exposure is estimated to range from 100 to 2400 cases per year, based on values for the year 2000, representing 0.2 to 4.95% of the total incidence for that year. Thus, if ELF magnetic fields actually do increase the risk of the disease, when considered in a global context, the impact on public health of ELF EMF exposure would be limited.

A number of other adverse health effects have been studied for possible association with ELF magnetic field exposure. These include other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease. The WHO Task Group concluded that scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukaemia. In some instances (i.e. for cardiovascular disease or breast cancer) the evidence suggests that these fields do not cause them.

## **International exposure guidelines**

Health effects related to short-term, high-level exposure have been established and form the basis of two international exposure limit guidelines (ICNIRP, 1998; IEEE, 2002). At present, these bodies consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits.

## **WHO's guidance**

For high-level short-term exposures to EMF, adverse health effects have been scientifically established (ICNIRP, 2003). International exposure guidelines designed to protect workers and the public from these effects should be adopted by policy makers. EMF protection programs should include exposure measurements from sources where exposures might be expected to exceed limit values.

Regarding long-term effects, given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia, the benefits of exposure reduction on health are unclear. In view of this situation, the following recommendations are given:

- Government and industry should monitor science and promote research programmes to further reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure. Through the ELF risk assessment process, gaps in knowledge have been identified and these form the basis of a new research agenda.
- Member States are encouraged to establish effective and open communication programmes with all stakeholders to enable informed decision-making. These may include improving coordination and consultation among industry, local government, and citizens in the planning process for ELF EMF-emitting facilities.
- When constructing new facilities and designing new equipment, including appliances, low-cost ways of reducing exposures may be explored. Appropriate exposure reduction

measures will vary from one country to another. However, policies based on the adoption of arbitrary low exposure limits are not warranted.

### **Further reading**

WHO - World Health Organization. Extremely low frequency fields. Environmental Health Criteria, Vol. 238. Geneva, World Health Organization, 2007.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields. Lyon, IARC, 2002 (Monographs on the Evaluation of Carcinogenic Risks to Humans, 80).

ICNIRP - International Commission on Non-Ionizing Radiation Protection. Exposure to static and low frequency electromagnetic fields, biological effects and health consequences (0-100 kHz). Bernhardt JH et al., eds. Oberschleissheim, International Commission on Non-ionizing Radiation Protection, 2003 (ICNIRP 13/2003).

ICNIRP – International Commission on Non-Ionizing Radiation Protection (1998). Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Physics 74(4), 494-522.

IEEE Standards Coordinating Committee 28. IEEE standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz. New York, NY, IEEE - The Institute of Electrical and Electronics Engineers, 2002 (IEEE Std C95.6-2002).

### **For more information contact:**

WHO Media centre

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E-mail: [mediainquiries@who.int](mailto:mediainquiries@who.int)



## **Federal-Provincial-Territorial Radiation Protection Committee – Canada**

### **Response Statement to Public Concerns Regarding Electric and Magnetic Fields (EMFs) from Electrical Power Transmission and Distribution Lines**

**- Issued on November 8, 2008 -**

The Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) is aware of public concerns about possible health risks from exposure to EMFs in living and school environments, arising from electrical power lines located nearby. The FPTRPC developed both a Position Statement\* on the health effects of EMFs and a Response Statement† concerning childhood leukemia, to help address these issues.

Public concerns appear to arise from periodic media reports and from dubious Internet websites which contain inaccurate, unsubstantiated, controversial or contradictory statements regarding EMF-health issues. Concerns may result in public opposition to the proposed construction of new high-voltage power lines or upgrades of existing ones. Opposition to such proposals is often influenced by factors other than health issues (e.g. aesthetics). In addition, some individuals and organizations are promoting precaution by advising the public to limit their time spent near power lines or to avoid being near lines.

Like household electrical appliances, power lines emit power-frequency EMFs. The intensity of the EMFs from such lines depends on wiring and tower configurations, as well as the line voltage, the current being carried and distance from the lines. EMFs from power lines and electrical appliances diminish rapidly with increasing distance. For magnetic fields, the contribution from power lines to the levels in most homes and other buildings is very small to negligible when compared to the fields in close proximity to operating electrical appliances and building wiring.

During the past three decades, a large number of scientific studies have been carried out throughout the world. These studies include laboratory investigations with biological organisms, and epidemiological analyses that examine the possible link between ill health and EMF exposure. The conclusion by the majority of experts in this subject area is that, while some epidemiological studies suggest a weak statistical link between EMFs and certain types of cancer, other epidemiological studies and the bulk of laboratory studies do not substantiate this link. Based on the weak epidemiological evidence from childhood leukaemia studies, the International Agency for Research on Cancer has classified power-frequency magnetic fields as “possibly carcinogenic to humans” (the same classification applied to, for example, coffee and pickled vegetables).

International EMF exposure guidelines based on established findings have been developed in order to protect against immediate (acute) effects on nervous system

functions. Science-based guidelines for protection against possible health effects such as cancer that may result from long-term (chronic) exposure have not been established. Given the lack of convincing scientific evidence on such effects, there are no national guidelines in Canada limiting exposure of the public to power-frequency EMFs.

Public concern over the EMF-health issues has led to recent demands for power line regulators to apply the Precautionary Principle (PP) to proposed construction of new high-voltage power lines or to the upgrade of existing ones. PP is a public policy approach for risk management of possible but unproven adverse health effects. The extent of PP approaches range from monitoring scientific developments and providing information to stronger measures such as action for lowering exposures. Any precautionary measures to be taken should be proportional to the level of risk and its associated uncertainty, the severity of the health outcome and the level of societal benefit. In the context of power-frequency EMFs, health risks to the public from such exposures have not been established; therefore, it is the opinion of FPTRPC that any precautionary measures applied to power lines should favour low cost or no cost options.

Most power lines and electrical facilities in Canada fall within provincial jurisdictions. The federal government involvement is for authorization of the construction and operation of international power lines and designated inter-provincial lines coming under federal jurisdiction. On request, the federal government participates in environmental assessment reviews for the proposed construction of new high-voltage power lines or upgrade of existing ones by providing expert information or knowledge. The possible effects of EMFs on human health are one of several environmental issues considered when conducting these reviews.

In summary, 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.

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\* Position Statement for the General Public on the Health Effects of Power-frequency (60 Hz) Electric and Magnetic Fields; issued by the Federal Provincial Territorial Radiation Protection Committee – January 20, 2005

† Response Statement to the Issue of Power-Frequency Magnetic Fields and Childhood Leukemia – Issued on January 20, 2005.





## **Federal-Provincial-Territorial Radiation Protection Committee – Canada**

### **Response Statement to the Issue of Power-Frequency Magnetic Fields and Childhood Leukemia – Issued on January 20, 2005**

The Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC) is aware of concerns about possible health risks from exposure to power frequency electric and magnetic fields (EMFs). In response, the FPTRPC developed a Position Statement to address the issue\*. Of particular interest is the risk of cancer from living near power lines and other sources of EMFs. These concerns appear to arise as a result of the controversial and contradictory findings in scientific research, especially from epidemiological studies.

The outcome of a recently conducted pooled analysis of several epidemiological studies shows a two-fold increase in the risk of leukemia in children living in homes, where the average magnetic field levels are greater than 0.4 microtesla (4 milligauss)<sup>†</sup>. The explanation for this elevated risk estimate is unknown, but the authors of the pooled analysis suggest that it may be accounted for, in part, by selection bias of cases and controls in the original studies used for the pooled analysis. However, the number of subjects in the greater-than-4-milligauss group is very small, and thus the significance of the finding is questionable. More refined statistical and epidemiological methods will be needed to clarify this finding. Further, no mechanism has been identified in the research literature that supports the suggestion that these fields can cause or promote the development of cancer.

It is the opinion of FPTRPC that the epidemiological evidence to date is not strong enough to justify a conclusion that EMFs in Canadian homes, regardless of locations from power lines, cause leukemia in children.

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\* Position Statement for the General Public on the Health Effects of Power-frequency (60 Hz) Electric and Magnetic Fields; issued by the Federal Provincial Territorial Radiation Protection Committee – January 20, 2005

<sup>†</sup>Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, Linet M, McBride M, Michaelis J, Olsen JH, Tynes T and Verkasalo PK. A pooled analysis of magnetic fields and childhood leukaemia. *Br J Cancer*. 2000;83(5):692-698.



## 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

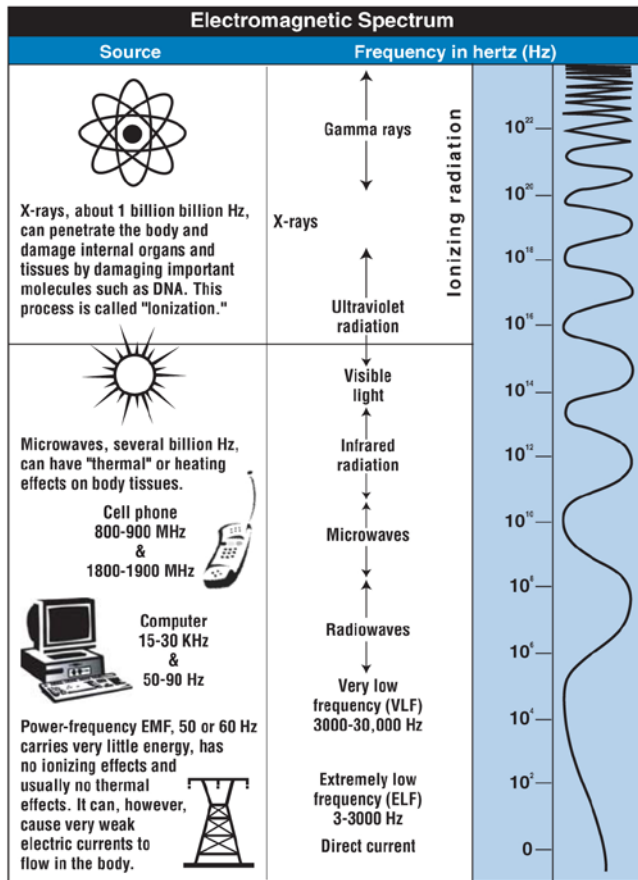
Electric fields are produced by voltage or electric charge. An electric field is present, for example, when an appliance is plugged into an outlet, even if it is not turned on. Electric fields are measured in Volts per metre (V/m); the higher the voltage, the greater the electric field.

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  $\mu\text{T}$  (one thousand  $\mu\text{T}$  equal 1 mT, one million  $\mu\text{T}$  equal 1 tesla). One  $\mu\text{T}$  equals 10 mG.



As the Electromagnetic Spectrum chart<sup>1</sup> 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."<sup>2</sup> (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.

<sup>1</sup> 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](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.

<sup>2</sup> 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](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.”<sup>3</sup>

- 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.”<sup>4</sup>

- 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.<sup>5</sup>

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.”<sup>6</sup>

- 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.”<sup>7</sup>

- 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.<sup>8</sup>

<sup>3</sup> 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](http://www.hc-sc.gc.ca/hl-vs/alt_formats/pdf/iyh-vsv/environ/magnet-eng.pdf), accessed July 2013.

<sup>4</sup> 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.

<sup>5</sup> 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.

<sup>6</sup> 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.

<sup>7</sup> 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](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.

<sup>8</sup> 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](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](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](http://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](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](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>.



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