Understanding Electric and Magnetic Fields

BC Hydro
Power smart

Contents

We've provided this booklet to explain electric and magnetic fields (EMF) and to summarize what national and international health and scientific agencies say about EMF.

We've included the following:

Glossary: Look up definitions of technical terms. Terms in the glossary are bolded the first time they are used in the booklet.

FAQs: Look at responses to some of the most frequently asked questions about EMF.

Contact Information: Contact us for more information or to borrow a magnetic field measuring kit.

Resources: Refer to this list for additional details, including links to scientific studies and information from established health authorities.

What we do about EMF

If you're looking to purchase a home that's located near a power line or if there's a new line being proposed for your neighbourhood, you may have questions about living near this type of electrical infrastructure.

The majority of the concerns we hear are about electric and magnetic fields given off by power lines. Electric and magnetic fields, commonly referred to as EMF, are invisible energy fields that are prevalent in our daily lives.

Some key facts and conclusions about electric and magnetic fields from power lines:

- EMF levels decrease rapidly the further you are from the source. This means that by the time EMF from power lines reach your home they're often at lower levels than those already present in your home.
- At the street level, the magnetic field levels from our power lines are actually very low, often lower than the level given off by home appliances.
- Magnetic fields aren't shielded or blocked by putting power lines underground.
- Despite long-term extensive international research over the last 40 years, no health consequences have been established from exposure to EMF at levels less than recommended international guidelines.

What we do about EMF continued

This conclusion is based on research and findings of national and international health authorities including Health Canada and the World Health Organization. We understand the relationship between EMF and health will continue to be the subject of ongoing research which is why we:

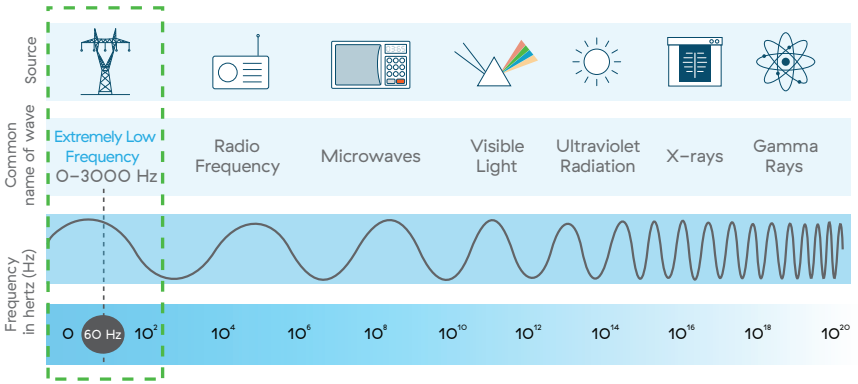
- Communicate openly and provide balanced, accurate information about EMF.
- Commission a regular summary report on the progress of scientific and medical research in this field. These reports, produced by an independent research group are available on bchydro.com/emf.
- Monitor developments with Health Canada and World Health Organization to ensure we follow their guidelines on EMF and power lines.
- Follow all federal and provincial legislation and regulations addressing EMF and ensure all our facilities and lines comply with applicable EMF standards.
- Take appropriate steps to reduce EMF levels in the design of new and upgraded electrical equipment.

What are electric and magnetic fields?

Electric and magnetic fields (EMF) are present everywhere electricity flows. Electrical appliances, household wiring and power lines all produce EMF. These fields are part of a broad range of waves called the **electromagnetic spectrum**, which includes other waveforms such as radiowaves, microwaves, infrared rays and x–rays.

In North America, power line's alternative current (AC) standard frequency is 60Hz. That means the current cycles back and forth 60 times per second. The EMF produced by the power line has the same frequency of 60 Hz, categorizing power line EMF as Extremely Low Frequency (ELF).

FREQUENCIES OF THE ELECTROMAGNETIC SPECTRUM AND COMMON SOURCES



This diagram shows the different levels of energy that make up the electromagnetic spectrum. The energy of waveforms increases exponentially as the frequency moves from low to high.

Source: Institute of Electrical and Electronics Engineers.

Comparing electric and magnetic fields

Although they are often referred to together as EMF, electric fields and magnetic fields are actually two distinct components of electricity.

Electric fields are produced by voltage in a wire, such as a power line. An electric field is also present when an electrical appliance is plugged into an outlet even if it's not turned on. They can be blocked or shielded by objects like buildings or trees.

Magnetic fields are produced when electric current is flowing, so they're only present when an electrical appliance is turned on. As the flow of electricity—the current—increases, the magnetic fields increase. Magnetic fields pass through most objects and can't be blocked as easily as electric fields.

Electric fields	Magnetic fields
Produced by voltage; present any time an appliance is plugged in even if it's turned off.	Produced by current; only present when an appliance is plugged in and turned on.
Measured in volts per metre or kilovolts per metre.	Measured in **gauss** or tesla. 10 milligauss (mG) is equal to 1 microtesla (μT).
Easily shielded by trees, buildings.	Not easily shielded.

For both electric and magnetic fields, the strength of the field decreases rapidly with distance from the source.

Helpful hint

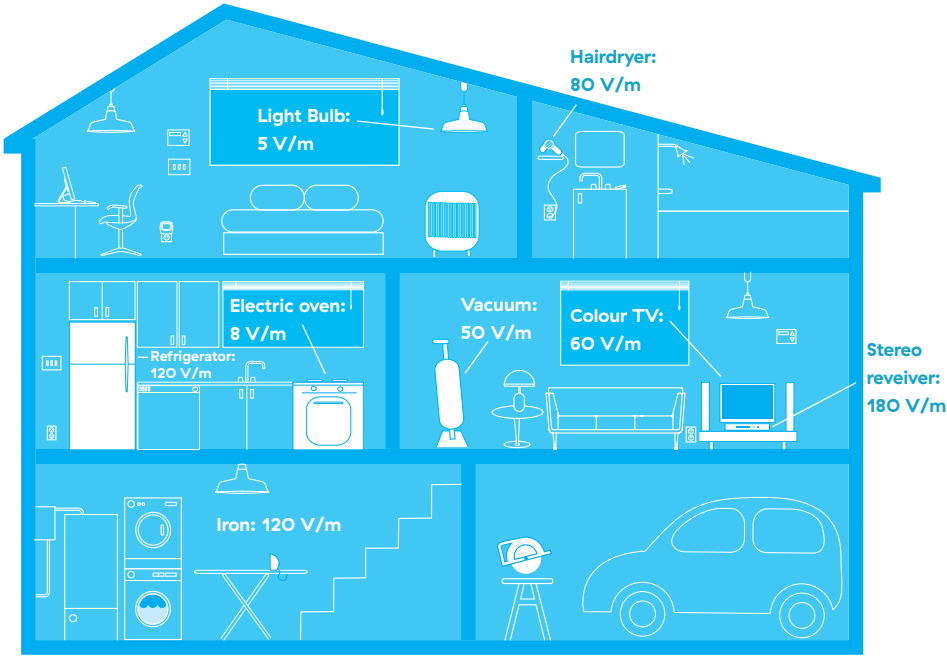
Terms set in bold are explained in more detail in the glossary. For more information related to radio frequency, see the resource section of this booklet.

Electric field strength

- Is directly related to the voltage of the line.
- Also diminishes rapidly with distance from the electrical source.

The strength of electric fields near charged electrical lines remain prettyconstant. Electric fields near a charged line exist even when electricity is not being used. This means the electrical wiring your home is producing electric field constantly even when you aren't using any appliances.

TYPICAL MAGNETIC FIELD LEVELS IN THE HOME



Source: World Health Organization, accessed 2016
All measurements were taken at 30 cm from source.

The electric fields from transmission and distribution lines change very little because of the line's stable voltage. Electric field, like magnetic field, diminishes rapidly with distance.

Electric field can easily be shielded. Trees, fences and buildings naturally reduces electric field strength and the walls and the roof of your home further reduces the electric field strength from equipment outside the home.

ELECTRIC FIELDS AND STARTLE SHOCKS

Most of the interest in possible health effects is related to magnetic fields and not electric fields; however, people may notice the presence of electric fields when they're near power lines.

Conductive objects, like a vehicle, fence line or even the ground can attract an electrical charge when they're near electric fields. When a person touches that object he or she can experience a **startle shock**. This is similar in effect to the small shock you might feel in your house after shuffling your feet on the carpet and touching a door handle.

Startle shocks aren't harmful but understanding how and when they happen can help to reduce surprise if you experience one.

ELECTRIC FIELDS AND HEALTH

In June 2007, the World Health Organization concluded that there are no substantive health concerns related to electric fields at levels generally encountered by the public. (WHO, Fact Sheet No. 322 *Electromagnetic fields and public health,* June 2007)

For more information about electric fields, visit **bchydro.com/emf**.

The remainder of this booklet focuses on magnetic fields as most of the interest in possible health effects is related to them.

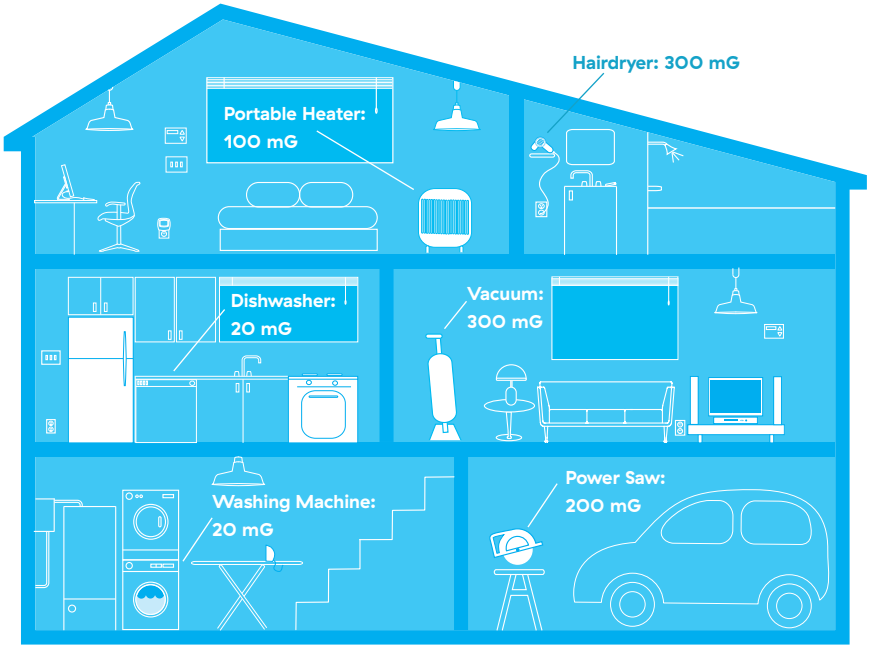
Magnetic field strength

Magnetic **field strength:**

- Is directly related to the amount of current flowing.
- Diminishes rapidly with distance from the electrical source.

For example, the strength of magnetic fields near electrical appliances depends on the current flowing through the appliance, the configuration of the wiring within the appliance, and the distance from the appliance. Due to proximity, magnetic field levels from appliances are often much higher than under power lines; however, the levels fade quickly as you move away from an appliance.

TYPICAL MAGNETIC FIELD LEVELS IN THE HOME

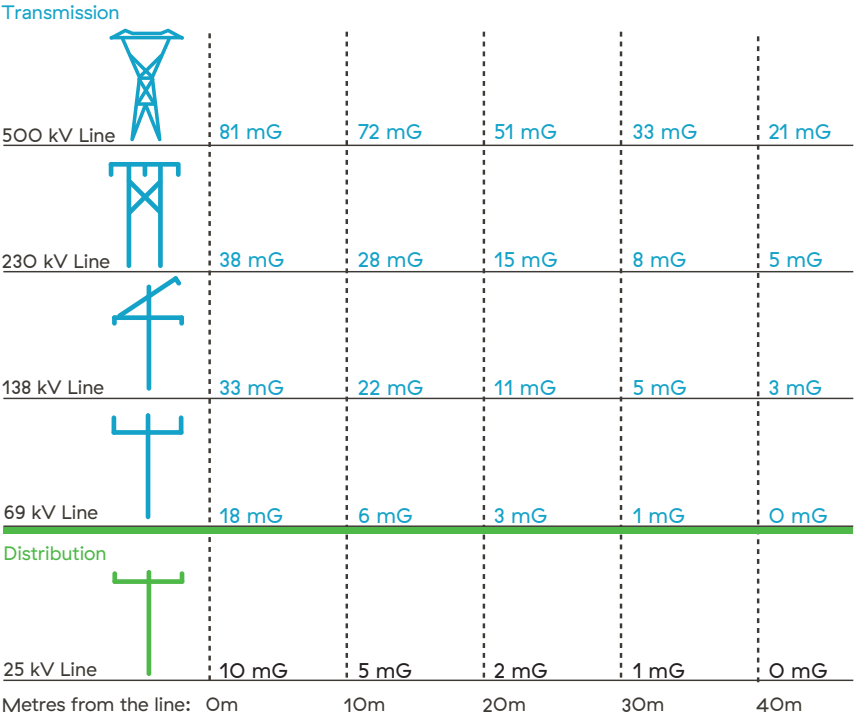


Source: *EMF in your Environment*, U.S. Protection Agency, 1992.
All measurements were taken 15cm from the sources.

Magnetic field strength (continued)

Just like appliances, the magnetic field levels from power lines depend on the current flowing on a line, the configuration of the wiring, and a person's distance from the line. The current on a transmission line will depend on the electrical load, or how much electricity is being used at any given time. In B.C. variations in current follow a fairly typical pattern, with peaks in the morning and evenings, and higher demand in the winter than the summer.

TYPICAL MAGNETIC FIELD LEVELS NEAR TRANSMISSION AND DISTRIBUTION LINES



The levels in this diagram are based on typical field levels that would be measured on most BC Hydro power line corridors in each voltage class. They are calculated using average line current and typical line heights. These levels are for general information only and are often different from levels found in EMF profiles produced specifically for new projects. Typically, a project-specific EMF profile shows the highest magnetic field levels possible during a specific line's lifetime, a condition rarely encountered and used for the purpose of line design.

TYPICAL MAGNETIC FIELD LEVELS NEAR SUBSTATIONS

Beyond the substation fence, the magnetic field produced by the equipment within the station is typically indistinguishable from the background levels from other sources. Generally, the strongest magnetic field around the outside of a substation comes from the power lines entering and leaving the station.

There is a misconception that the transformers within substations are a high source of magnetic field. Modern power transformers are built to keep the magnetic field in the core of the transformer to maximize its efficiency.

Magnetic fields & health

The question of whether exposure to electric and magnetic fields (EMF), in particular magnetic fields, causes adverse health effects has been the subject of numerous scientific studies over the last four decades with increasing quality.

The extensive health research and scientific knowledge surrounding EMF includes both **epidemiological studies** and **experimental studies** in animals, tissues and cells. These epidemiological studies and experimental studies provide pieces of the puzzle but no single study or even all the studies of just one type can give us the whole picture.

In epidemiological studies, researchers try to establish if there's a statistical association between the exposure of certain groups of people and diseases they experience. Some epidemiological studies have suggested a weak association between exposure to magnetic fields and childhood leukemia. It's unclear, however, whether exposure to magnetic fields actually caused the disease.

Some studies don't include magnetic field measurements when trying to determine an association and no epidemiological study has provided direct evidence that would permit drawing the conclusion that EMF is a cause of cancer or other adverse health effects.

Experimental studies involve exposing cells, tissues and animals to magnetic fields under controlled conditions. These studies allow researchers to closely control magnetic field exposure and provide information about any small scale biological changes that magnetic fields may cause. Experimental studies haven't provided a basis to conclude that magnetic fields are the cause of any disease. Scientists at Health Canada have been at the forefront of experimental studies to assess whether magnetic fields might cause or promote the development of cancer, but in decades of research they haven't found persuasive evidence for this hypothesis.

Many reputable health authorities such as the World Health Organization and Health Canada have conducted thorough reviews of all the different types of studies and research on EMF and health. These health authorities have examined the scientific **weight-of-evidence** and have determined that when all of the epidemiological and experimental studies are considered together, the consensus is that there is no **cause-effect relationship** between exposure to magnetic fields and human health.

We recognize that there are members of the public who remain concerned with the scientific findings to date, and we'll continue to monitor the scientific developments related to EMF.

Guidelines & exposure recommendations

Health Canada has reviewed the current scientific findings regarding exposure to Electric and Magnetic Fields (EMF) and concluded:

> *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.*
>
> (Health Canada, 2016)

AS A RESULT:

> *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.*
>
> (Health Canada, 2016)

The World Health Organization (WHO) has also looked at questions around EMF. In June 2007, WHO released a comprehensive report on possible health effects of exposure to extremely low frequency electric and magnetic fields. In this report, WHO stated that the evidence related to childhood leukemia is not strong enough to be considered causal. (WHO, Fact Sheet No. 322 Electromagnetic fields and public health, June 2007)

In 1998, the International Commission on Non–Ionizing Radiation Protection (ICNIRP) developed voluntary exposure guidelines. ICNIRP is a formally recognized, international non–profit organization made up of independent scientific experts that are responsible for providing guidance and advice on non–ionizing radiation protection for people and the environment. In its guidelines update in 2010, ICNIRP recommends a residential magnetic field exposure limit of 2,000 **milligauss (mG)** and an occupational exposure limit of 10,000 mG.

These voluntary guidelines were developed to address short–term exposure only. ICNIRP determined that evidence for health effects from long–term exposure is insufficient to establish exposure standards. ICNIRP continues to monitor the research in this area.

WHO endorses the guidelines established by ICNIRP. As of 2016, there has been no change to WHO's position despite annual ICNIRP workshops and meetings on electromagnetic fields and health. You can find details of these meetings on WHO's EMF project site.

Moving forward we'll continue to monitor developments with Health Canada and World Health Organization to ensure we follow their guidelines on EMF and power lines.

Frequently asked questions

CAN I AVOID EXPOSURE TO EMF IF I STAY AWAY FROM POWER LINES?

No. EMF is found wherever there is electricity, whether in household wiring, electrical appliances, or power lines. Your exposure is determined by how strong the field is at its source, how far you're from the source, and how long you remain near the source. EMF is strongest at the source and fades rapidly as you move away.

CAN YOU ELIMINATE EMF BY BURYING THE LINES UNDERGROUND?

No. The ground will shield electric fields, but magnetic fields will still pass through.

SOMETIMES I FEEL ELECTRICITY IN THE AIR WHEN I'M UNDER A POWER LINE. WHAT'S HAPPENING?

Electric fields exist around all wires that carry electricity. Electric fields can sometimes be noticeable directly under high voltage power lines. This feeling can be discomforting (arm hair stimulation or tingling), but it's not unsafe or a health risk.

I RECEIVED A SHOCK WHEN I TOUCHED MY CAR THAT WAS PARKED NEAR A POWER LINE—WHAT CAUSES THAT?

This is called a "startle shock." It may occur when conductive objects (including people) are located within a power line's electric field and become electrically charged. When a person with a different level of induced charge contacts an object or another person, the charge is equalized (discharged) between the two bodies and the person may receive a startle shock. A startle shock will not harm the recipient but could cause surprise.

WHY IS EMF CLASSIFIED AS A CARCINOGEN?

EMF is not a carcinogen but instead is classified as a "possible carcinogen", or 2B carcinogen, by the International Agency for Research on Cancer (IARC). This classification is the weakest of three categories used by IARC to classify potential carcinogens. Other everyday items in this category include aloe vera, gasoline engine exhaust and pickled vegetables.

The 2B classification acknowledges that concerns have been raised from some epidemiological studies but conclusive evidence hasn't been found despite extensive and ongoing research.

HOW HAS BC HYDRO TAKEN PRECAUTIONS TO REDUCE POTENTIAL EMF RISKS?

Our approach is modeled after recommendations by the World Health Organization to take reasonable precautionary measures. Examples include open communication with the public, monitoring the science on EMF and the way we design our projects including increasing ground clearances and the pole position within rights–of–way.

DOES BC HYDRO HAVE MAGNETIC FIELD MEASURING KITS?

Yes, we loan magnetic field measuring equipment. The Magnetic Field Measurement Kit comes with a gauss meter and a booklet that explain how to take measurements. To borrow a kit please contact us.

HOW DOES EMF AFFECT ME IF I HAVE AN IMPLANTED MEDICAL DEVICE?

The guidelines and exposure recommendations set out in this booklet are for the average population and can't directly address the requirements of people with implanted medical devices like heart pacemakers. For more information and advice about EMF, contact the device manufacturer and the clinician who implanted the device.

IS THERE A CONNECTION BETWEEN EMF AND ELECTROMAGNETIC HYPERSENSITIVITY (EHS)?

According to the World Health Organization, electromagnetic hypersensitivity (EHS) has no clear diagnostic criteria and there is no scientific basis to link EHS to EMF.

Resources

If you'd like to learn more about EMF, we recommend the following sources:

OUR EMF WEBSITE

Our website is always being updated with new information. It also has links to the resources listed below.
bchydro.com/emf

EMF AND HEALTH: REVIEW AND UPDATE OF THE SCIENTIFIC RESEARCH

This report was prepared by an independent, technical and scientific research firm to assess the current status of research regarding the potential for health effects from exposure to EMF.
bchydro.com/emf

RADIO FREQUENCY & BC HYDRO'S SMART METERS

This site includes information on radio frequency and BC Hydro's Smart Meters.
bchydro.com/smartmeters_safety

HEALTH CANADA

This fact sheet contains basic information about EMF, typical Canadian exposures and Health Canada's role. *It's Your Health Fact Sheet: Electric and Magnetic Fields at Extremely Low Frequencies*
hc-sc.gc.ca/hl-vs/iyh-vsv/environ/magnet-eng.php

BC CENTRE FOR DISEASE CONTROL

This site includes statements from experts, information on scientific studies and resources for more information.
bccdc.ca/health-info/health-your-environment/electro-magnetic-exposures

WORLD HEALTH ORGANIZATION

This site from the United Nations health agency provides links to EMF fact sheets, extensive research publications and general information about EMF.
who.int/peh-emf/en

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

The US National Institute site provides information on research conclusions and results and overall information regarding EMF.
niehs.nih.gov/health/topics/agents/emf/index.cfm

CANADIAN ELECTRICITY ASSOCIATION

The Canadian Electricity Association (CEA) is the professional association of electrical companies across Canada. You'll find information about the CEA's commitments to safety and EMF research on the site.
emf.electricity.ca

Glossary

Cause–effect relationship: A relationship between two variables where one factor directly causes or influences the other.

Conductive object: in electrical engineering, a conductor is a type of material or object that allows the flow of electrical current in one or more directions. Metal is a common conductive material.

Electromagnetic spectrum: The range of electromagnetic waves, starting with long, low–frequency waves and spanning out to short, high frequency waves. The order of the spectrum is radio waves, microwaves, radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x–rays, and gamma radiation.

Epidemiological studies: Epidemiological studies look at patterns of disease occurrence in human populations and the factors that influence these patterns. These studies are observational in that they examine and analyze people in their normal daily lives to try to determine and correlate their health events with exposure factors.

Experimental studies: Experimental studies involve exposing cells, tissues and animals to a specific agent, such as EMF, under carefully controlled conditions to determine if the agent is the cause of a disease.

Extremely low frequency (ELF) fields: Extremely low frequency refers to electromagnetic fields in the range of 0–3000 Hz.

Field strength: The strength of an electric field, measured in volts per metre (V/m) or of a magnetic field, measured in gauss (G) or milligauss (mG).

Gauss or milligauss: Magnetic fields are measured in units of gauss (G) or tesla (T). Gauss is the unit most commonly used in Canada, while tesla is more commonly used internationally. Most magnetic field levels related to electrical devices are only a fraction of a gauss so it's more common to measure magnetic levels in units of milligauss (mG). A milligauss is 1/1000 of a gauss.

Startle shock: A small discharge or shock that's noticeable but not dangerous.

Weight–of–evidence review: A weight–of–evidence review critically evaluates the strength of the evidence for causality for a particular exposure and disease. It entails a comprehensive assessment of all relevant scientific research, in which each of the studies is critically evaluated and more weight is given to studies of better quality.

If you're interested in measuring magnetic field levels in your home, magnetic field measuring equipment is available on loan. The Magnetic Field Measurement Kit includes a gauss meter with a pamphlet that explains how to take measurements. To borrow a kit, please contact us at 604 699 7678 or toll free at 1 866 647 3334.

For more information:

Visit: **bchydro.com/emf**

Phone: **604 699 7678** or toll-free at **1 866 647 3334**

Email: **emf@bchydro.com**

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