November 14, 2018

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Ms. Alsey Davidson
Business Development
NextEra Energy Resources, LLC
700 Universe Boulevard
Juno Beach, FL 33408

RE: EMF Evaluation for Proposed Grazing Yak Intertie Line
And Solar Facility Power Inverters

Dear Ms. Davidson:

This letter report presents the power-frequency (60 Hz) electric and magnetic field (EMF) evaluation for the proposed Grazing Yak Solar Facility underground intertie line. This report also addresses EMF from the proposed power inverters at the proposed Grazing Yak Solar Facility.

Magnetic fields are reported in units of gauss (G), or more typically in units of milliGauss (mG), which are equal to one-thousandth of a gauss (i.e., 1 mG = 0.001 G). Some technical reports also use the unit Tesla (T) or microTesla (µT; 1 µT = 0.000001 T) for magnetic fields. The conversion between these units is 1 mG = 0.1 µT and 1 µT = 10 mG. Electric fields are reported in units of volts per meter (V/m).

Intertie Line

The proposed tie line would connect the proposed Grazing Yak Solar Facility to the existing Golden West Substation. Figure 1 presents a diagram of the proposed underground trench configuration for this tie line, which was used for the computer model. There are two circuits oriented horizontally within the trench. The trench would be located within a proposed 75-foot wide right-of-way (ROW), and it was assumed that the trench would be located within the center of the ROW. NextEra Energy provided the power line geometry and loading information in order to create the computer model and perform the magnetic field calculations.

Loading for the two circuits was provided as 300 amps per circuit phase and it was assumed that the loading would be balanced between the phase conductors and between circuits. The proposed underground cable would be 750 kcmil with a diameter of 1.125-inches. Since the exact location of the individual phase cables cannot be predetermined, it was assumed that the phase cables would have a 1-inch separation between them, with the two circuits separated at 1-foot as shown in Figure 1. Each phase cable would be a direct burial of the cable and would not be contained within a pipe. Since the phasing arrangement for the two circuits cannot be predetermined, it was assumed that the phasing arrangement would be A-B-C A-B-C as a typical phasing arrangement. It was also assumed that the cables would have single-point bonding of the cable sheathes.

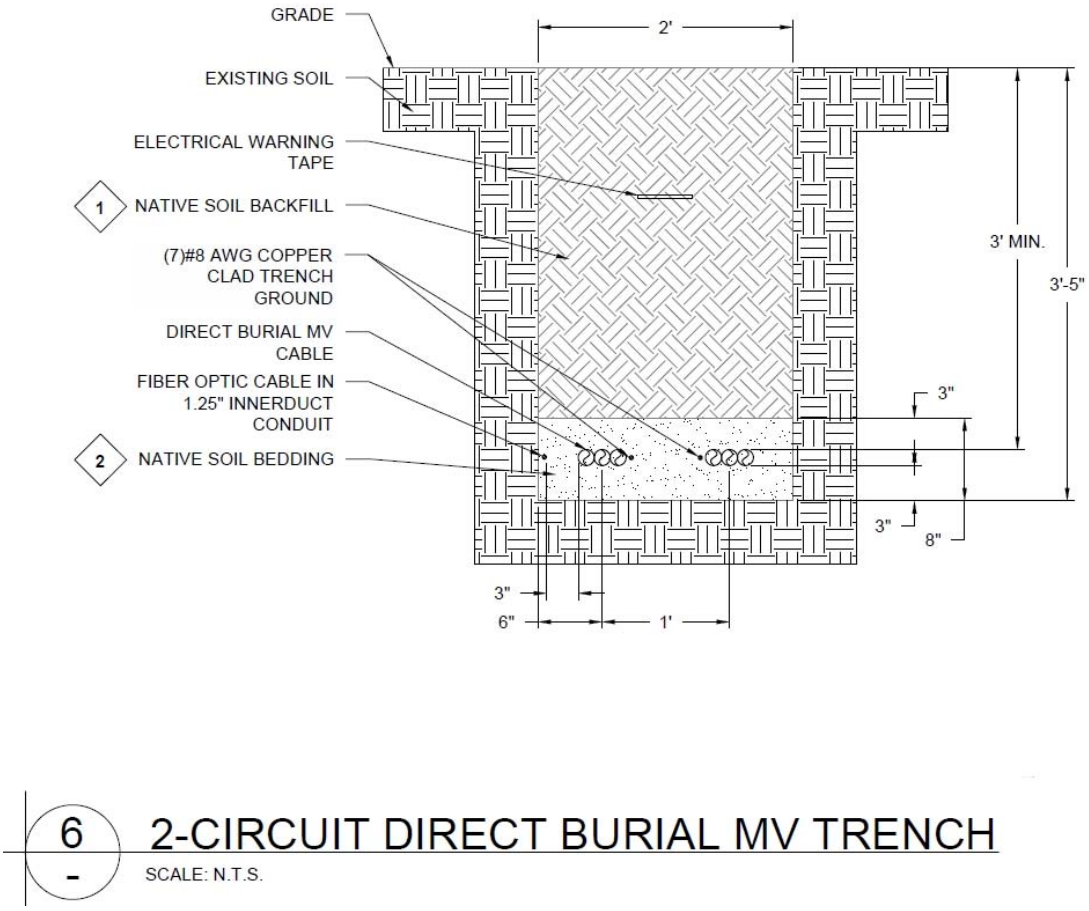

Figure 1. Diagram of the Proposed Grazing Yak Tie Line Underground Trench Configuration from the Proposed Solar Facility to the Golden West Substation

Power-frequency magnetic field calculations were performed using the computer software program "EMF Workstation 2015" which is a software program that was developed for the Electric Power Research Institute (EPRI). The software is designed to calculate the magnetic fields from complex arrays of transmission lines, distribution lines, substation buswork, substation equipment, or user-defined current-carrying line segments. Calculations were performed at 1-meter (3.28-feet) above ground level in accordance with ANSI/IEEE Standard #644-1994: "IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines".

Table 1 presents a summary of the results from this EMF Evaluation. Since the power cables are buried underground, there would be no power-frequency electric field present due to these cables. For magnetic fields, the results of the computer calculations are shown in Figure 2 as a magnetic field versus distance graph from the center of the trench out to each ROW edge. As shown in Table 1 and Figure 2, the calculated magnetic field at each ROW edge is 0.8 mG. The maximum calculated magnetic field within the ROW is 29.0 mG above the center of the trench.

Table 1. Summary of the EMF Evaluation Results for the Proposed Grazing Yak Solar Facility Intertie Line

Location	Electric Field (V/m)	Calculated Magnetic Field (mG)
ROW Edge	0.0	0.8
Center of ROW (Maximum)	0.0	29.0
ROW Edge	0.0	0.8

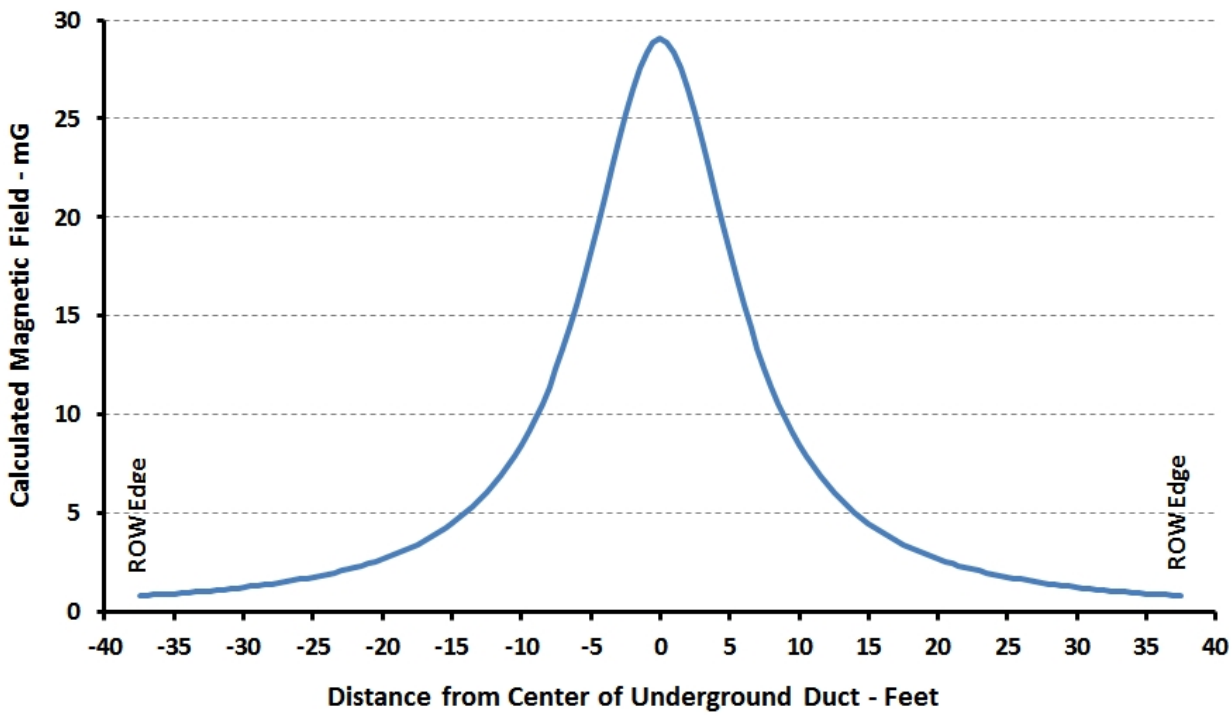

Figure 2. Calculated Magnetic Field Graph Associated with the Proposed Grazing Yak Tie Line Underground Trench Configuration (Across the Right-of-Way)

The calculated magnetic field levels within the ROW and at the ROW edge are less than many typical appliances. For comparison, the magnetic field of several typical household appliances has been measured and typical values are given in in Table 2.

Table 2. Magnetic Fields from Household Appliances

Appliance	Magnetic Field at 12 inches Away (mG)	Maximum Magnetic Field (mG)
Electric Range	3 to 30	100 to 1,200
Electric Oven	2 to 25	10 to 50
Garbage Disposal	10 to 20	850 to 1,250
Refrigerator	0.3 to 3	4 to 15
Clothes Washer	2 to 30	10 to 400
Clothes Dryer	1 to 3	3 to 80
Coffee Maker	0.8 to 1	15 to 250
Toaster	0.6 to 8	70 to 150
Crock Pot	0.8 to 1	15 to 80
Iron	1 to 3	90 to 300
Can Opener	35 to 250	10,000 to 20,000
Blender, Popper, Processor	6 to 20	250 to 1,050
Vacuum Cleaner	20 to 200	2,000 to 8,000
Portable Heater	1 to 40	100 to 1,100
Fans/Blowers	0.4 to 40	20 to 300
Hair Dryer	1 to 70	60 to 20,000
Electric Shaver	1 to 100	150 to 15,000
Fluorescent Light Fixture	2 to 40	140 to 2,000
Fluorescent Desk Lamp	6 to 20	400 to 3,500
Circular Saws	10 to 250	2,000 to 10,000
Electric Drill	25 to 35	4,000 to 8,000

Sources: Illinois Institute of Technology Research Institute (IITRI) 1984. “Household Appliance Magnetic Field Survey”, U.S. Naval Electronic Systems Technical Report No. EO6549-3; Gauger, J.R. 1985. “Household Appliance Magnetic Field Survey", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 9:2436-44; Silva, J.M., Hummon, N.P., Rutter, D.A., and Hooper, H.C. 1989. “Power Frequency Magnetic Fields in the Home”, IEEE Transactions on Power Delivery, Vol. PWRD-4, No. 1, pp.465-478.

Power Inverters

In addition to calculating the EMF levels associated with the proposed Grazing Yak Solar Facility underground intertie line, EMF levels for the proposed Grazing Yak Solar Facility power inverters were also evaluated. For this assessment, field measurement data from other solar facility power inverters were used to evaluate field levels at the proposed solar facility perimeter fence. Power invertors are housed within metallic housings which effectively grounds the power-frequency electric field outside of the housing. Measured electric field levels were about 0.0 to 16 V/m in close proximity to power inverters (within a few inches of the equipment) and diminish quickly with distance away from the inverter. Measured magnetic fields can reach up to 2,500 mG in close proximity to power inverters (within a few inches of the equipment). However, magnetic field levels decrease rapidly with distance away from the inverter. At approximately 2-feet from the invertor, measured magnetic fields decreased to a range of about 25 mG to 200 mG depending upon the location of the measurement with respect to the invertor. At approximately 10-feet and farther away from the inverter, magnetic fields were further reduced to minimal background levels.

A review of the Preliminary Grazing Yak Solar Facility Site Plan (dated 10/23/2018) showed that the closest power inverter to the property line was over 100-feet away from the proposed perimeter fence. Therefore, power-frequency electric and magnetic fields due to the proposed power inverters should be negligible at the perimeter fence.

This report completes the EMF evaluation for proposed Grazing Yak Solar Facility underground intertie line and power inverters. If additional analysis of the underground intertie line is required, please let me know.

Sincerely Yours,

H. Christopher Hooper

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Guide to
EMF and Health

What is "EMF"?

"EMF" is an abbreviation for "electric and magnetic fields" or "electromagnetic field." EMF results from all uses of electricity.

When an electric device is plugged into a working socket, there is an electric field around the device and its cord, even if the device is turned off.

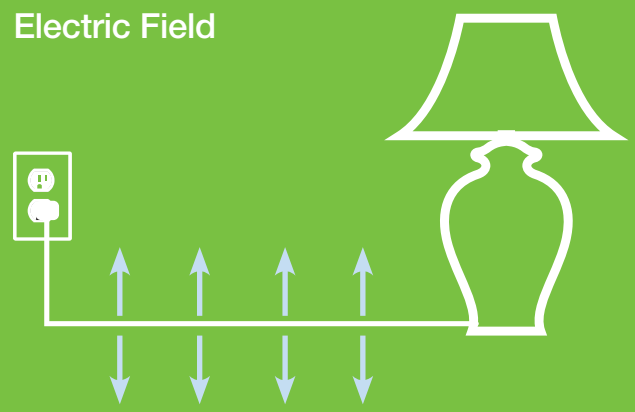
When the device is turned on, there is also a magnetic field around the device and its cord. Therefore, both an electric field and a magnetic field exist around an operating electric device and its cord.

Some people are concerned that EMF, specifically the magnetic field resulting from the use of electricity, could cause adverse health effects.

This guide addresses common questions and scientific research on EMF. Findings from the national and international public health authorities about EMF are quoted in the last pages of this guide, and links to their websites are provided there.

Comparison of electric and magnetic fields

Electric Field

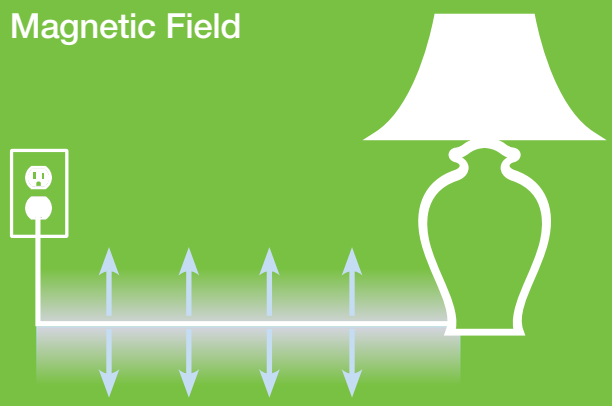


Lamp plugged in but turned off. Voltage produces an electric field.

» Produced by voltage.

» Measured in kilovolts per meter (kV/m).

Magnetic Field



Lamp plugged in and turned on. Current flow now also produces a magnetic field.

» Produced by current flow.

» Measured in milligauss (mG) or microtesla (μT).

Is EMF "radiation" like medical X-rays or ultraviolet sunlight?

No. Radiation is a scientific term that simply describes how energy travels from a source. For example, a rock tossed into a pond is a source of energy where it lands and causes ripples that radiate out in circles - that is radiation. TV and radio broadcast towers, power lines, appliances, and home wiring all have fields that radiate out from the source.

Radiation also refers to very different fields, such as those from medical X-rays or the ultraviolet part of sunlight. Exposure to fields from those sources can damage the DNA in cells, which can lead to cancer. A good example is overexposure to sunlight, which can lead to skin cancer. The damage occurs by a process called ionization, so scientists categorize those fields as "ionizing" radiation.

EMF from power lines, electrical appliances, and home wiring, however, is not strong enough to damage DNA, so it is not the same as radiation from medical X-rays or the ultraviolet part of sunlight. EMF, therefore, is categorized as "non-ionizing."

The capability to damage DNA is determined by the "frequency" of the source. Frequency means how rapidly the field changes direction back and forth and is measured in Hertz (Hz).

For a source to produce enough energy to damage DNA, it must be at a frequency of approximately ten thousand billion Hertz. By comparison, EMF from the use of electricity is at a frequency of only 60 Hertz in Canada and the U.S.

Comparison of field frequencies

Source of Field	Lowest Frequency Field of Source (Hertz)
Ionizing Radiation	
Medical X-rays	1,000,000,000,000,000,000
Most ultraviolet sunlight	10,000,000,000,000,000
Non-Ionizing Radiation	
Visible light	100,000,000,000,000
Radio broadcast at a low frequency	10,000
Electricity	60

What are the EMF levels from common sources?

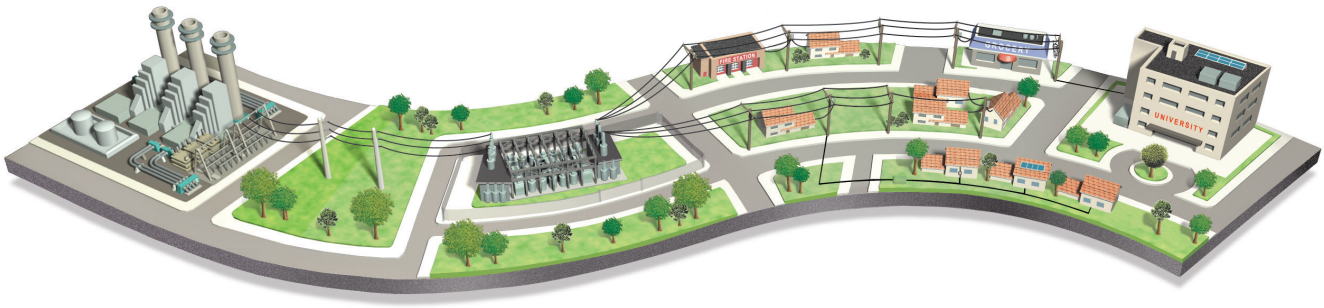
Examples of EMF sources* (in milligauss)

Coffee makers	7
Distribution line upper level of typical average	20
Dishwashers	20
500-kV transmission line typical average at edge of right-of-way	30
Distribution line typical maximum above underground line	40
Florescent lights	40
Distribution line typical maximum under overhead line	70
Blenders	70
500-kV transmission line typical average under the line	87
Toasters	100
Hair dryers	300
Can openers	600

EMF is created wherever electricity is present. As people change activities or locations during a day, they are exposed to a variety of sources of EMF and a wide range of field levels. EMF levels typically drop off quickly with distance from a source.

* Field levels from U.S. National Institute of Environmental Health Sciences (NIEHS) EMF Questions & Answers, pages 33-35 (median level at 6 inches from appliances), page 36 (distribution lines), and page 37 (transmission lines). As noted by NIEHS, field levels of transmission lines can approximately double during peak loads which occur about 1% of the time.

Electricity - from generating station to you



Are electric transmission lines necessary?

Yes, electric transmission lines are a vital part of the system that brings electricity to our homes. Most of the electricity people use comes from generating stations that are located away from populated areas. Transmission lines deliver electricity from those generating stations to substations located near populated areas. From those substations, distribution lines deliver electricity to homes, schools, businesses, office buildings, hospitals, and other locations. Therefore, transmission lines are an essential link, delivering electricity from where it is generated to where people use it.

Are there any EMF exposure guidelines?

Yes. Two international expert groups – the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) – have issued EMF exposure guidelines. These guidelines are based on avoiding very high levels of exposure that can produce short-term biological responses, such as the perception of a faint flickering of light or a tingling on the skin.

Both groups of experts have concluded that no adverse health effects occur at EMF levels below their exposure guidelines.

EMF levels under a typical 500-kilovolt (kV) high-voltage transmission line are 95 percent below the 9,000 milligaus level.

The U.S. and Canadian governments have not issued any limits or guidelines for public exposure to power frequency EMF.

Typical EMF levels from power lines* compared to EMF exposure guidelines (in milligauss)

IEEE exposure guideline for general public	9,040
ICNIRP exposure guideline for general public	2,000
500-kV transmission line typical average under the line	87
Distribution line typical maximum under overhead line	70
Distribution line typical maximum above underground line	40
500-kV transmission line typical average at edge of right-of-way	30
Distribution line upper level of typical average	20

* Field levels from U.S. National Institute of Environmental Health Sciences (NIEHS) EMF Questions & Answers, pages 33-35 (median level at 6 inches from appliances), page 36 (distribution lines), and page 37 (transmission lines). As noted by NIEHS, field levels of transmission lines can approximately double during peak loads which occur about 1 percent of the time.

What types of research have been done on EMF and health?

There are three basic types of scientific studies used to determine whether exposure causes a health effect:

1. Clinical studies of humans. These studies typically compare biological functions, such as heart rate or hormone levels, at different exposure levels.
2. Epidemiology studies. These studies typically compare the rate of a particular health effect in groups of people who have different estimated exposures. Epidemiology studies try to determine if there appears to be a "statistical association" between the estimated exposure and a health effect. Because people are exposed to many things, it can be difficult for these studies to determine if a health effect is associated with an estimated exposure or with some other exposure or condition that was not taken into account in the study.
3. Laboratory studies of cells or animals. These studies compare cells or animals with no exposure with those exposed to various levels to determine if exposure damages the cells or causes a health effect in animals.

Each type of study has been used to research EMF extensively. Many studies have been done at much higher EMF exposure levels than people are exposed to in everyday life.

The U.S. National Institute of Environmental Health Sciences has pointed out no single study or type of study can provide a definitive answer to the question of whether EMF exposure causes a health effect.

How much research has been done on EMF and health?

Scientists have been conducting studies for more than 40 years to determine whether EMF can cause adverse health effects.

The studies have looked for a relationship between EMF and leukemia, breast cancer, brain cancer, DNA damage, cancer clusters, birth defects, immune system damage, nervous system damage, Alzheimer's disease, Lou Gehrig's disease, Parkinson's disease, high blood pressure, heart disease, sleep disruption and a variety of other diseases and conditions.

EMF - health effects research totals* more than

44 years – 2,900 Studies – $490 Million Spent

* Repacholi M, "Concern that 'EMF' magnetic fields from power lines cause cancer." Sci Total Environ (2012), doi:10.1016/j.scitotenv.2012.03.030, page 3. [citing PubMed]

What do expert public health authorities take into account when assessing if exposure causes a health effect?

Expert public health authorities, such as the World Health Organization, follow three basic principles when evaluating scientific research:

1. All of the relevant studies must be considered – not just the studies that support one conclusion or another.
2. For the results of a study to be credible, generally the study should be replicated (consistent results are obtained when the study is repeated by independent researchers).
3. The results of different types of studies, particularly epidemiology studies and laboratory experiments using live animals, should be consistent to conclude whether there is a health effect.

Environmental Health Criteria 238, Extremely Low Frequency Fields (page xiii): http://www.who.int/peh-emf/publications/elf_ehc/en/index.html

What conclusions have public health authorities reached about whether EMF causes health effects?

The EMF health research has been examined by governmental public health authorities and public health organizations in more than 160 reports.

Some of the most prestigious scientific organizations, such as the U.S. National Cancer Institute and the World Health Organization, have evaluated studies on EMF effects. None has found that exposure causes or contributes to cancer or any other disease or illness. Their reviews generally conclude that while some epidemiology studies report an association with childhood leukemia, which warrants further research, the scientific studies overall have not demonstrated that EMF causes or contributes to any type of cancer or other disease.

Some examples of the conclusions reached by public health authorities follow:

U.S. National Cancer Institute – *Magnetic Field Exposure and Cancer*

"No consistent evidence for an association between any source of non-ionizing EMF and cancer has been found."

"No mechanism by which ELF-EMFs... could cause cancer has been identified. Unlike high-energy (ionizing) radiation, EMFs in the non-ionizing part of the electromagnetic spectrum cannot damage DNA or cells directly."

"Studies of animals have not provided any indications that exposure to ELF-EMF is associated with cancer."

Health Canada – *Electric and Magnetic Fields from Power Lines and Electrical Appliance*

"The vast majority of scientific research to date does not support a link between ELF [extremely low frequency] magnetic field exposure and human cancers. Health Canada does not consider that any precautionary measures are needed regarding daily exposures to EMF at ELF. 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."

Australian Radiation Protection and Nuclear Safety Agency – *Electricity and Health*

"The scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields found around the home, the office or near power lines is a hazard to human health."

World Health Organization – *About Electromagnetic Fields*

"A number of epidemiological studies suggest small increases in risk of childhood leukemia with exposure to low frequency magnetic fields in the home. However, scientists have not generally concluded that these results indicate a cause-effect relation between exposure to the fields and disease (as opposed to artifacts in the study or effects unrelated to field exposure). In part, this conclusion has been reached because animal and laboratory studies fail to demonstrate any reproducible effects that are consistent with the hypothesis that fields cause or promote cancer."

"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."

Where else can I find information about EMF and health?

Here are some good places to start:

- U.S. National Cancer Institute "Magnetic Field Exposure and Cancer," National Cancer Institute Fact Sheet, **http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields**
- Health Canada: Electric and Magnetic Fields from Power Lines and Electrical Appliances, **http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/magnet-eng.php**
- Australian Radiation Protection and Nuclear Safety Agency: Electricity and Health, **http://www.arpansa.gov.au/radiationprotection/Factsheets/is_electricity.cfm**
- World Health Organization website:
  - What are electromagnetic fields?, **http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html**
  - Electromagnetic fields and public health, Fact Sheet No. 322, **http://www.who.int/mediacentre/factsheets/fs322/en/index.html**

EMF and Health

Informational Handout

May 2017

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