Testimony by: Magda Havas, Ph.D.

Concerning: Health Effects Associated with Power Lines

Presented to: Steering Committee, Public Hearing on the SE Metro Transmission Line

Date: March 22, 2001

Location: Minnesota, USA.

Q: Please introduce yourself.

A: My name is Magda Havas. I'm an Associate Professor of Environmental & Resource Studies at Trent University (Peterborough, Ontario, Canada). I received my Ph.D. at the University of Toronto in 1980 where I trained as a biologist, ecologist and environmental toxicologist. I completed two years Post Doctoral Research at Cornell University with Professor Gene Likens and then returned to Canada and worked as an Assistant Professor at the University of Toronto and later as an Associate Professor at Trent University. I have served as a member of the Mayor's Committee on Sustainable Development; as a science advisor to CBC; as a member of the Emerging Issues Subcommittee of the International Joint Commission (Canada/US); as a member of the Environmental Appeal Board of Ontario (Ministry of the Environment); and as an advisor to Tribhuvan University in Nepal on their Environmental Sciences Program. At Trent University I have served on the Board of Governors and on Senate (the two key bodies responsible for university governance). I am a member of the Health Research Group and am founder and past Chair of the Energy Working Group which consists of physicians, alternative health care practitioners, environmental scientists, biologists, physicists, and electricians who are interested in the biological effects of energy fields from natural and man-made sources.

My expertise is on the biological and environmental effects of environmental contaminants. I have worked on acid rain, metal pollution, drinking water quality and more recently electromagnetic fields. For the past 15 years I have taught a course on Pollution Ecology which deals with the environmental and health effects of chemical pollutants (asbestos, metals, chlorinated organics, hydrocarbons, air pollution, water pollution, among others) and for the past 4 years I have taught a course on the Biological Effects of Electromagnetic Fields.

Q: Why are you here today?

A: I'm here because I'm concerned about the adverse health effects of electromagnetic fields generated during the production, distribution, and consumption of electricity. For the past 8 years I've been studying this with growing intensity and growing concern.

Based on the literature and my own research I am convince that power frequency electromagnetic fields can and do cause biological effects; that these effects can be both

beneficial and harmful; that we know some of the mechanisms involved and are close to understanding others but that more research in this area of mechanisms and in the area of exposure remains to be done.

Regarding Public Policy and Scientific Evidence: I do not think that it is necessary for public policy makers to wait until ALL the scientific facts about electromagnetic fields are in before they act to protect the public by minimizing exposure. We already have considerable information. What remains to be known in terms of mechanisms is unlikely to significantly change what we already know, and we know enough to act.

1. We know that high **electric** fields and high **magnetic** field have **adverse health effects** based on studies of residential exposure and childhood leukemia, on studies of occupational exposure, and on laboratory experiments.
2. We know that **magnetic fields** above 2.5 milli Gauss (mG) (the range being debated is between 2 and 4 mG) are critical for children under the age of 14 and that magnetic fields at 12 mG (value is between 2 and 12 mG) are critical for adults with estrogen-sensitive breast cancer.
3. We have yet to determine what levels of the **electric fields** are harmful. Values of several thousand volts per meter (V/m) have been suggested for adults but children are likely to be more sensitive as they are to most environmental pollutants. Electric fields below 100 V/m are common in residential settings and we do not know if these cause biological or health effects.
4. We know that the home environment, particularly the **bedroom** is critical for children and that **night-time exposure** may be more important than day-time exposure.
5. We know that disruption of the natural production of **melatonin** is one of the mechanisms involved in the adverse health effects. There is evidence that electromagnetic fields have been implicated in **depression, disturbed sleep**, and higher rates of **suicide**.
6. We know that electromagnetic fields have been linked with **leukemia, lymphomas, nervous system tumors** and **breast cancer** as well as with various **reproductive abnormalities.**
7. We know that electromagnetic fields do not **initiate** cancer (at the levels found in residential and most occupational settings) but seem to **promote** cancer by changes in the rate at which cells divide and differentiate.
8. There is emerging evidence that the **electric field may be interacting with air pollutants.** More research is needed in this area, but if the results from future studies support this relationship then limits may need to be set on high voltage power lines in residential communities.

Knowledge of the specific mechanisms involved is not going to significantly change the harmful exposures (2.5 and 12 mG) mentioned above, unless history repeats itself as it has with lead, asbestos, and DDT. Blood lead levels, deemed safe in the early 1970s, were lowered as more scientific evidence became available.

A prudent avoidance public policy regarding the location of both above and below ground power lines would be to limit the magnetic field to 2 mG or less during peak energy consumption in the residents nearest the power line. This would not be precedent setting since several multinational companies (including the World Bank) have been specifying low levels of power frequency magnetic fields of less than 2 mG for their new building designs. Sweden has guidelines of 3 mG for areas where children play.

Full Cost Accounting and Decision Making: Decisions are often made (or not made) based **on short-term accounting to minimize economic costs. If full cost and long-term accounting is considered then hospital stays** and **sick leave** have to be factored into the equation and in the long-term this is likely to be costly.

Legitimate Debate and the Scientific Process: I'm also concerned that as scientists we do a poor job explaining how science is done and how it should be interpreted. Consequently the public is confused by scientific disagreement presented by the press. They are unable to judge whether the disagreement is motivated by a legitimate desire to understand some aspect of the world or if it is motivated by other concerns.

The current scientific debate about electromagnetic fields is tainted. It is motivated by concerns other than a desire to better understand the biological effects of electromagnetic fields. While there is some legitimate debate and disagreement about the harmful effects, the mechanisms involved, and the specific exposure characteristics there is also an element of deception and bias.

Sadly this type of activity is not unusual and is certainly not restricted to EMF issues. Manipulation of scientists; attempts to discredit individuals and to cut off their funding; publication of red herrings and other attempts to mislead the public have occurred time and again with asbestos, DDT, tobacco, lead, acid rain, endocrine disrupters. When industry feels threatened it reacts and not always in the most honorable way. Few scientists are comfortable and willing to speak out when this is the case.

The statements below were published in the National Research Council (1997) document entitled "Possible Health Effects of Exposure to Residential Electric and Magnetic Fields" in a section devoted to occupational exposure.

> *Across a wide range of geographic settings . . . and diverse study designs . . . workers engaged in electrical occupations have often been found to have slightly increased risks of leukemia and brain cancer* (Savitz and Ahlbom 1994, NRC p. 179).
>
> *Matanoski et al. (1993) . . . found little support for increased risk due to increased average fields, but increasing field levels at peak exposure were associated with increased leukemia risk* (NRC, p. 180).
>
> *Floderus et al. (1993) . . . the most highly exposed workers were estimated to have a 3-fold increased risk of chronic lymphocytic leukemia and a 1.6-fold increased risk of total leukemia. Brain-tumor was increased by a factor of 1.5 in the highest category* (NRC, p. 180).

> *. . . a large well-designed study of utility workers in Canada and France provided evidence of a 2- to 3-fold increased risk of acute myeloid leukemia among men with increased magnetic field exposure (Theriault et al. 1994). Brain cancer showed much more modest increases (relative risk of 1.5-2.8) with increased magnetic field exposure* (NRC, p. 180).
>
> *Savitz and Loomis (1995) . . . Leukemia mortality was not found to be associated with indices of magnetic-field exposure, whereas brain-cancer mortality was associated. Brain cancer mortality generally was found to increase in relation to accumulative exposure, reaching a relative risk of 2.3-2.5 in the most highly exposed workers* (NRC, p. 180).
>
> *All three studies found no evidence of confounding by the presence of workplace chemicals* (NRC p. 180).
>
> *A series of three studies reported an association between electrical occupations and male breast cancer (Tynes and Andersen 1990; Matanoski et al. 1991; Demers et al. 1991) . . .* (NRC, p. 181).
>
> *Female breast cancer in relation to electrical occupations was evaluated by Loomis et al. 1994 . . .a modest increase in risk was found for women in electrical occupations, particularly telephone workers . . .* (NRC p. 181).
>
> *The relative risks in the upper categories of 2-3 reported in the high quality studies of Floderus et al. 1993 and Theriault et al. 1994 cannot be ignored* (NRC, p. 181).

Yet this is exactly what NRC did. It ignored some vital information in its executive summary on the health effects of electromagnetic fields where it states that:

> *. . . the current body of evidence does not show that exposure to these fields presents a human health hazard."* (NRC, p. 2).

How they can make that statement based on the previous references they also cite is not something I can comprehend.

Q: How can scientists examine the same data and come up with different interpretations?

A: First we must differential between a deliberately biased attempt to defend a particularly view and between a legitimate disagreement with a genuine desire to understand what is happening. I'm going to assume the later for my answer.

Scientists who study electromagnetic fields fall into one of three categories. They can be theoreticians, lab scientists, or field scientists.

Theoreticians approach a problem from the perspective of the basic underlying theory. Einstein is a prime example. He predicted results based on his theories and others tested them once the tools became available. If the theory is wrong so are the predictions. When data contradict

theory we have to revisit the theory rather than discard the data. Physicists have disregarded the data because it doesn't fit their theory of ionization and thermal effects that occur and are readily explained at high electromagnetic frequencies. They don't have a theoretical mechanism that explains the effect at power frequencies (60 Hertz) so they disregard the data.

Laboratory scientists are accustomed to controlling all of the essential factors that might affect the results of a particular experiment and often work on systems that have minimal variability. They work on systems that have a high signal to noise ratio. This is true for cellular biologists and experimental physicists. Provided they expose their test "organisms" to realistic conditions, they have some of the most powerful tools to determine the underlying mechanisms involved in a particular response.

Field scientists are unable to control many of the external variables although they have techniques to determine their relative contribution to an end result. They work on systems that have a low signal to noise ratio. Epidemiologists and ecologists fit into this category. They are often the first to determine associations between environmental stresses and biological response but are not able to ascertain the underlying mechanisms.

Q: How do we interpret the textual products of scientific investigation?

A: Just as law has its "legalese" and requires interpretation by experienced lawyers, science also needs to be interpreted. A simple statement made with great care by a scientist is not always interpreted properly by the public. For example, in 1994, Ontario Hydro released a document based on a recently completed study on cancer rates among their electric utility workers.

They stated, and I quote:

1. *No association was observed between occupational exposure to EMF and cancer overall among electric utility workers.*

    2. *The study results indicated no association between most cancers, including lymphoma, male breast cancer and melanoma, and exposure to magnetic fields.*

    3. *The Analysis did show a statistically significant association between cumulative exposure to magnetic fields and a rare form of adult leukaemia: acute non-lymphoid leukaemia and a sub-type acute myeloid leukaemia.*

    4. *According to the study authors, this did not provide definitive evidence of a causal association.*

    5. *These results are compatible with the findings of previous studies that demonstrated associations between EMF exposure and leukaemia, and as such cannot be ignored.*

    6. *Further research will be required, however, to determine causal association.*

Interpretation:

The first statement is generic. It includes smokers with lung cancers (for example) and this can skew the results. No respectable scientist has stated that EMF are associated with ALL forms of cancer. Hence this statement is true but is somewhat misleading as though it is refuting a scientifically held view, which it is not.

The second statement begins to focus on the cancers that have been associated in other studies with EMF exposure. It found no statistically significant association for the cancers listed.

The third statement focuses on one type of cancer that has been associated with cumulative exposure to magnetic fields. Now we have a specific cancer (a rare form of adult leukaemia) and a specific type of exposure (cumulative magnetic fields).

The fourth statement is misleading. Epidemiological studies are **not intended** to provide "definitive evidence of a causal association". Someone who doesn't understand that distinction will think that "yes while there is an association it is NOT causal" and this is an **incorrect interpretation** of that statement.

The fifth and sixth statements are straight forward. Laboratory studies are needed to address the final statement dealing with causality.

Q: What is the evidence that childhood cancers are linked with power frequency magnetic fields in the home?

A: The first person to examine this question was Nancy Wertheimer. Wertheimer noticed that many of the children who had died of cancer in Denver Colorado lived in homes that were located near power lines and transformers. At that time studies from the former Soviet Union began to appear reporting that men exposed to high voltages in switch yards were experiencing health problems. She wondered if there was a link between the cancers she was observing and the electromagnetic fields generated by power lines. Ed Leeper provided her with a surrogate measurement, the wire code that was based on the distance from power lines and on the thickness and number of conductors (wires) distributing electricity. Their results, which appeared in the American Journal of Epidemiology (1979), reported an increased incidence of childhood leukemia, lymphomas, and nervous system tumors for children exposed to very high current configuration (VHCC) corresponding to 2.5 mG.

This was a revolutionary study. Up to that point power frequency (60 Hertz) electromagnetic fields were assumed to be benign.

More than a dozen studies have been conducted in different countries to test the Wertheimer and Leeper hypothesis. About half of them found a statistically significant association between childhood cancers and exposure to magnetic fields.

The key findings from these studies are as follows:

1. Of the three childhood cancers (leukemias, lymphomas, nervous system tumors), leukemias are the ones found to be most often associated with magnetic field exposure. [Note that the same cancers as well as breast cancer are frequently reported in the occupational epidemiological studies of EMF exposure.]
2. Children under the age of 14 and especially children under the age of 6 are the most sensitive presumably due to their rapid growth (Green et al. 1999).
3. Critical distances appear to be approximately 50 m (150 feet) from a power line
4. Critical magnetic fields are at or above 2 mG.
5. Daytime spot measurements give the lowest odds ratios (ratio of observed to expected number of cases) while median night measurements give the highest. Hence the bedroom is deemed to be the most important environment in terms of electromagnetic hygiene for children.

Two studies concerned with the health effects of electromagnetic fields have just been released this month (March 2001). One of the studies, conducted by the eminent epidemiologist Sir Richard Doll, who was the epidemiologist linking lung cancer with cigarette smoking in the 1960s and who has been critical of the findings of power line studies, now **admits** an association of increased risk of childhood leukemia with elevated magnetic fields. This study is important because it is the first **official** statement from a major health organization in the UK, the National Radiation Protection Board, associating childhood cancer and power frequency (50 Hertz) magnetic fields. The report is carefully worded and is intended to minimize concern. It down plays the number of children who are likely to die from leukemia because of their exposure to power lines.

The second study, from Germany by Joachim Schuz and colleagues (2001), has gone even further. In this study they report a statistically significant association, with an odds ratio of 3.2, (3.2 fold increased risk) between childhood leukemia and magnetic field exposure **during the night**. Since children spend 8 or more hours each day sleeping, the bedroom becomes a very important environment in terms of electromagnetic hygiene. Reducing electromagnetic fields in the bedroom reduces the overall exposure and thus the risk of leukemia.

Q: How do you interpret the studies that do not show a statistically significant association with electromagnetic fields and childhood cancers?

A: There are several reasons why this might be the case.

1. Laboratory studies have shown that electromagnetic fields at power frequencies (60 Hertz) do not <u>initiate</u> cancer but rather <u>promote</u> cancer or the growth of cancerous cells already in the body. Therefore, electromagnetic fields from power lines will not induce leukemia but will promote the growth of leukemia (and presumably other forms of cancer) that already exists in the body.

   If these electromagnetic fields promote cancer then the cancerous cells have to be present before they can be promoted. Hence some studies show an increased incidence of

leukemia, others of lymphomas, others of brain tumors and still others of breast cancer. These results are not inconsistent if electromagnetic fields are acting as cancer promoters.

2. Furthermore, in some epidemiological studies the average exposure did not reach 2 mG which has been identified as a critical limit for children (e.g. Fulton et al. 1980, mean high current value was 1.8 mG). In these studies you would not expect to find an increased incidents since the magnetic field level was not sufficiently high.
3. Also, in some studies very few children were exposed to the high fields (above 2 mG). For statistical significance of a cancer that has a low frequency we often need a large sample size. If the sample size is too small, the results will not be statistically significant because of a lack of statistical power. One way to overcome the small sample size is to combine several studies in a meta-analysis. This has been done and those studies show a small (in terms of population) but statistically significant increase in the risk of childhood cancers. I might add that this risk is small from a population perspective but it is not small for the parents who lose a child to leukemia.
4. Also, we lack information on "real" exposure. All of our measurements are based on a short sampling time or surrogate measurements such as wire codes. The longest time most individuals are measured for their magnetic field exposure is 24 hours. Can you image determining your likelihood of getting skin cancer from the sun based on your exposure to the sun during a 24-hour period taken at random? The fact that so many studies are showing a statistically significant association is remarkable and disturbing.
5. And finally, we have no "zero" exposure, no true controls because everyone who uses electricity is exposed to electromagnetic fields. Using cigarettes as an analogy what we are comparing in these studies is the 2-pack-a-day cigarette smoker with the 2-cigarette-a-day smoker. We do not have non-smokers who are not exposed to second hand smoke for our controls.

Q: What are the sources of electromagnetic fields within the home?

A: Within the home there are three potentially important sources of electromagnetic fields. They include appliances, indoor wiring and outdoor wiring. Individuals can do much to reduce their exposure from appliances and indoor wiring but can do little if the primary source of the magnetic field is the outdoor wiring.

Based on childhood epidemiological studies the bedroom is a particularly important environment. Bedroom electromagnetic fields can be reduced in a number of ways and can go far in promoting electromagnetic hygiene. Electric alarm clocks, radios and baby monitors can be moved away from the bed. Electric blankets can be unplugged once they warm up a bed. Beds can be moved away from panel or fuse boxes and electric heaters. Electric heating coils in ceilings and floors generate high magnetic fields. These fields can be reduced by turning down the night-time thermostat. Some older homes have knob and tube wiring that can also generate high magnetic fields and in other homes an improperly balanced return current can produce high magnetic fields. Although costly, an electrician can update the wiring to current wire codes and can balance the return current and thus reduce magnetic fields associated with indoor wiring. Hence, there is much that individuals can do to reduce their exposure.

The problem is that individuals have no way of reducing electromagnetic fields in a home if the primary source is from power lines run by public utilities.

Q: Do you have any final comments you would like to make?

A: Yes.

To protect the most vulnerable individuals in our population, namely children under the age of 14, magnetic fields need to be kept below 2 mG, especially in the bedroom (but also in other environments where children spend their time, schools for example). This recommendation is specific and enforceable. We have similar standards for drinking water that are set to protect the most vulnerable individuals in the population. Since individuals cannot alter their electromagnetic environment if the primary source is from power lines, it is up to public policy makers to minimize this type of exposure. If this recommendation of 2 mG or less became part of public policy and was enforced, it would significantly improve the electromagnetic environment in which we all live.

Thank you for listening.