Energy Networks Association

Comments on the *Corona–Ion Hypothesis*

Revised November 2009

1. Background to EMF research

The Energy Networks Association (ENA) monitors information on the latest EMF (electric and magnetic fields) research and legal developments through its membership, subscriptions to information services and overseas contacts.

For over 25 years there has been a significant research effort worldwide involving hundreds of millions of dollars and hundreds of projects trying to determine if there is a link or a mechanism connecting low frequency EMFs and health effects. Most of the research has centred on the effect of magnetic fields, since their presence in normal environments is pervasive and difficult to avoid. In 1978, an epidemiological study in the United States found an association between the incidence of childhood leukaemia and the size of nearby overhead distribution wires in the street. Since larger wires suggested larger currents and hence larger magnetic fields, it was suggested that there might be an association between low frequency magnetic fields and childhood leukaemia. This set off the research activity across the world which has persisted to the present day.

Some of the more recent reviews of science in this area have been the reports by the:

- Advisory Group on Non-Ionising Radiation (AGNIR) to the National Radiological Protection Board (NRPB) UK of 2001
- International Agency for Research into Cancer (IARC) of 2001
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) of 2003, and
- World Health Organization (WHO) EHC report of 2007

(Note that the NRPB is now part of the Health Protection Agency of the UK.)

The NRPB AGNIR (2001) report came to the conclusion that:

> . . . laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general.

The later reports have generally confirmed this overall view.

There was however some epidemiological evidence, based on the pooling of results of several studies, that prolonged exposure to levels of magnetic fields above a time weighted average of 4 mG is associated with a small increased risk of leukaemia in children. It was concluded that the evidence, including the absence of any proven physical mechanism, was currently not strong enough to justify a firm conclusion that such fields caused this outcome, and thus was insufficient to change existing health guidelines. Based on similar evidence, IARC classified these low frequency magnetic fields as a 'possible carcinogen' (Class 2B) in relation to childhood leukaemia only. The classification should not be interpreted as indicating a causal link. For more discussion of the possible health effects of magnetic fields, see the information brochure *EMF-What we know* on the ENA website (www.ena.asn.au).

Unlike magnetic fields, exposure to low frequency electric fields is limited by shielding by shrubbery, walls, and even clothing. Historically, there is insufficient information about exposures to ***electric fields*** to come to any conclusion about health effects. (Note that the IARC 2B classification of magnetic fields does not apply to electric fields.)

Over the last few years, however, a number of publications have raised the issue of possible indirect effects from electric fields. Strong electric fields from high voltage powerlines can produce small charged particles in the air called 'corona ions'. These ions attach to pollutants in the air and drift away from the power line for distances possibly up to a few kilometres. These ions may be inhaled or deposited on the skin of a person nearby and it is postulated that these charged pollutants will 'stick' to their human host more than would a similar uncharged pollutant particle. This could lead to enhanced pollutant absorption to people living near powerlines with possible health impacts.

Most of this research comes from the group lead by Professor Denis Henshaw at the Department of Physics, University of Bristol in the UK. The physical principles for these effects are generally well understood, but their magnitudes and relevance to health effects are difficult to quantify in the complex and changing environments surrounding power transmission lines in open air.

As part of their 2001 review of health effects, AGNIR concluded that:

> . . . it has not been demonstrated that any such enhanced deposition will increase human exposure in a way that will result in adverse health effects to the general public.

However, it was felt that the corona ion theory merited further consideration, and NRPB AGNIR set up an Ad Hoc Group to complete a further review. The report of this group in March 2004 is an authoritative scientific review of the corona theory and provides the basis for much of the information provided in this present advice.

2. Summary of corona phenomenon

Corona effects are the result of the ionisation of the air by the strong electric fields present at the surface of sharp metallic points, small diameter wires, etcetera, when they are raised to a high voltage. Any electrons entering the field region are accelerated and gain enough energy to ionise air atoms with which they collide. The ion/electron pairs produced are then themselves accelerated and undergo collisions. Only the electron collisions are ionising and produce the avalanche breakdown process confined to the region of air adjacent to the 'corona electrode'. The corona appears as a faint (filamentary) discharge radiating outwards from its source and is the cause of the faint 'crackling' noise sometimes heard in the vicinity of powerlines. The corona ions produced by the line are carried by the wind and disappear with distance from the line as the charged particles recombine or are deposited out.

Airborne pollutants enter the body by inhalation and may then be deposited in the respiratory system. The extent to which inhaled particles deposit in the various regions of the respiratory system depends upon physical factors such as their size, shape and density, as well as charge. The extent of any effect of corona ions on health will depend upon the extent of any increase in exposure to pollutants, the extent to which these pollutants are causes of disease, and the numbers and types of individuals who are exposed.

The generation of corona ions is dependent on the strength of the electric field on the power line's fittings and conductors—called the surface voltage gradient. Transmission and distribution lines in Australia are designed to a surface voltage gradient much lower than the generally accepted corona inception voltage gradient of 16 kV/cm (see ENA Guideline C(b)1).

The likelihood of corona is reduced by using fittings with rounded corners and by using larger diameter conductors. For very high voltage lines, that is, 275 kV and above, the voltage gradient is reduced (consequently reducing the likelihood of corona) if bundled conductor arrangements are used, that is, two to four conductors per phase separated by 40 cm or so by spacers. Metallic corona rings can also be installed around fittings to spread the voltage gradient over a larger surface area.

Water droplets can cause increases in the conductor surface voltage gradient, increasing the likelihood of corona discharges occurring. This may occur during very moist atmospheric conditions, such as fog or rain, however the effect is temporary.

3. What does Henshaw say?

In the paper ***Corona ions from powerlines and increased exposure to pollutant aerosols'*** by Fews, Henshaw, Wilding and Keitch (1999), the following summary was given:

> In 1998, scientists at the New York Medical Centre reported increased lung deposition of inhaled electrically charged versus electrically neutral aerosols. Powerline cables can ionise the air creating so-called corona ions, which then attach themselves to pollutant aerosols and are carried away by the wind. A current loss of just 0.1 mA per metre from powerlines corresponds to 6.25 x 1014 ions per metre per second potentially emitted into the atmosphere.
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> Measurements of corona ions have been made near 132 kV and other powerlines. These lines commonly emit corona ions. Analysis suggests that at head height, typically 20 percent of pollutant aerosols either become charged or carry excess electric charge. On average the effect extended to 200 metres downwind of powerlines. In one case, the effect extended more than 500 metres from a 275 kV line.
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> Childhood leukaemia is known to be associated with traffic pollution. Near powerlines increased lung deposition of inhaled electrically charged pollutants is expected. This phenomenon could explain the association between high voltage powerlines and childhood leukaemia. The phenomenon also suggests that further research should be undertaken to ascertain whether other cancers or non-cancer illnesses are associated with living near high voltage powerlines.

Henshaw and Fews (2001) calculated that people downwind of power lines might have 20 to 60 percent more particles deposited in their lungs than those upwind. Studies by Knox (2005) and Turner et al. (2009) have found relationships between air pollution and pesticide exposure, and childhood cancers including leukaemia.

Matthews et al. (2007) have also measured corona ion induced atmospheric electricity modifications near HV powerlines. Henshaw, Ward and Matthews (2008) have more recently also postulated that rapidly varying AC electric fields near powerlines may also disrupt circadian rhythms including melatonin levels. This is an effect of electric fields but does not involve corona ions and hence is a different mechanism.

4. The National Radiological Protection Board Study

The NRPB in the UK, now part of the Health Protection Agency, had the Henshaw hypothesis reviewed by an independent AGNIR and a report was published in 2004 (NRPB, 2004). The NRPB considered that some increase in lung deposition of particles is likely as a result of charging by corona ions. However, they said that it appears that there is neither a suitable model available nor information about distributions of particle size and charge, to enable reliable estimates to be made of the size of any increase.

In the NRPB press release of March 2004 accompanying the study, the NRPB said:

> The independent Advisory Group on Non-ionising Radiation has examined evidence relating to whether there could be health effects caused by increased charge on pollutant particles in the atmosphere resulting from the presence of powerlines. It has concluded that any effect of charge is unlikely to have more than a slight influence, if any, on the health of the general population.
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> In the late 1990s it was suggested that the strong electric fields that occur in the vicinity of power lines might increase the adverse effects of atmospheric pollutants on the health of the general public. Such pollutants include radon decay products, chemicals, spores, bacteria and other organisms.
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> The deposition of pollutant particles present in the atmosphere on the skin and in the lungs may be increased if they are electrically charged. High voltage electricity transmission lines may cause corona discharge, which can increase the charge on pollutant particles.

The report by the Independent Advisory Group on Non-ionising Radiation (2004) itself concluded that:

> . . . it seems unlikely that corona ions would have more than a small effect on the long-term health risks associated with particulate air pollutants, even in the individuals who are most affected. In public health terms, the proportionate impact will be even lower because only a small fraction of the general population live or work close to sources of corona ions.

Regarding further research:

> The possible implications for health of the mechanisms discussed in this report do not provide a strong case for further research in this area. It is concluded, therefore, that it is not appropriate that an epidemiological study be carried out.

However the Advisory Group went on to suggest some possible studies that would provide further information on the charge distribution on atmospheric particulate materials and its effect on deposition in the body.

5. The Draper 2005 Study

Draper et al. (2005) conducted an epidemiological study of childhood leukaemia near transmission lines based on extensive data available in the UK. They found an increased risk of childhood leukaemia with distance from transmission lines up to 200 metres and more weakly up to 600 metres. In discussing their results, Draper et al. (2005) and Swanson et al. (2006) noted that the risk effect was evident at distances where the magnetic field from the powerlines would be very low and not the main source of fields. They were unable to propose a suitable explanation for their observations. They considered the Henshaw hypothesis using a simple model with their data (comparing upwind and downwind locations) but found no evidence in their data to support the mechanism proposed by Henshaw.

6. Bracken Study

Because of the current interest in the corona ion issue, Bracken et al. (2005) recently published some work that they performed on this issue in the early 1990s. They concluded that:

> Based on this study, AC transmission lines appear to have a minor impact on potential long-term exposure to space charge (ions and/or charged aerosols) beyond the ROW (right of way).

7. Corona Ion Study at Queensland University of Technology, Brisbane Queensland

The International Laboratory for Air Quality and Health, Queensland University of Technology (QUT), Brisbane Australia has been performing experimental studies involving dispersion of corona ions near transmission lines in Queensland over the four year period 2005 to 2009. The aim of the project was the development of a model for quantitative assessment of the processes occurring during the transport and dispersion of corona ions and combustion aerosol.

The research has shown that large sections of overhead high voltage transmission lines in South-East Queensland are essentially corona-free. Although ion concentrations at approximately 76 percent of the powerline sites exceeded the absolute mean urban outdoor value, less than 20 percent of the sites exhibited relatively high ion concentrations exceeding 1000 cm^{-3}. QUT therefore concluded that the resulting ion concentrations are rarely high enough to be of any concern with regards to health effects. Both air ion and charged particle concentrations decrease rapidly with distance from the lines and merge with background values within a distance of about 200 metres from the lines.

Within this project, it is intended to continue the studies on ion measurements near motorways and to investigate other possible sources such as vegetation which may affect results of measurements of ion emissions from powerlines. This will enable the assessment of the significance of ions emitted by powerlines in relation to other sources. Further details of this study can be found in published papers such as Fatokun et al. (2008) and Jayaratne et al. (2008).

8. Tasmanian study of adult cancer

An epidemiological study by Lowenthal et al. (2007) of records of adult cancer in Tasmania found that adults who had lived within 300 metres of transmission lines in childhood, particularly early childhood, had increased risks of developing leukaemia, lymphoma, myeloma, and related disorders as adults. The study involved 854 cases diagnosed with these conditions in Tasmania between 1972 and 1980. The risk decreased as residential distance from transmission lines increased. The study was unable to explain the results obtained. The 'corona ion' hypothesis was mentioned as

a possible explanation for the results but the study was unable to test the hypothesis on the data. The study authors caution that the study is based on relatively small numbers and recommend further epidemiological and laboratory research on the effects of prenatal and early post-natal exposures.

9. World Health Organisation Report

The WHO (2007) Environmental Health Criteria Report on EMF considered in detail the many health endpoints that have been considered in association with EMF and also reviews varies biophysical mechanisms (in Chapter 4) which could explain the possible interactions. One of these is the 'corona ion' effect in the vicinity of high voltage powerlines. WHO concludes that:

> It seems unlikely that corona ions will have more than a small effect, if any, on long-term health risks, even in the individuals who are most exposed.

10. Overall conclusions

The 'corona ion' hypothesis by Professor Denis Henshaw of Bristol University in the UK is based on work proposing a theoretical mechanism involving the effect of electric fields producing corona ions, against an extensive background of research into the effects of magnetic fields on health.

Henshaw's theoretical mechanisms involving corona ions and pollutant particles have not been proven by health studies on real populations near transmission lines. Epidemiological studies near transmission lines have shown some increased risk of health effects, particularly childhood leukaemia, at distances greater than expected to be influenced by the magnetic fields from the lines. However the explanation for these health effects is not clear. Possible proposed explanations include effects due to magnetic fields, electric fields, corona ion effects, experimental problems, methodological uncertainties and socioeconomic issues.

The report by the NRPB Independent Advisory Group on Non-ionising Radiation (2004) concluded that:

> . . . it seems unlikely that corona ions would have more than a small effect on the long-term health risks associated with particulate air pollutants, even in the individuals who are most affected. In public health terms, the proportionate impact will be even lower because only a small fraction of the general population live or work close to sources of corona ions.

This view was confirmed by the more recent review by WHO (2007).

In general, overseas studies of corona ion effects have related to transmission lines with voltages of greater than 110 kV where corona ion production is more likely. In Australia most transmission and distribution lines are designed to have surface voltage gradients under normal operating conditions which are much less than the levels where corona ions are formed. This has been confirmed from measurements in recent studies by QUT in Brisbane which was summarised earlier in this document.

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