

## Public Service Commission of Wisconsin (PSC)

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COMMENTS FILED ELECTRONICALLY IN

Wind Siting Rules

1-AC-231

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## Comment:

I posted a previous comment on the PSC website about concerns of Infrasound generated by of the wind turbines. Since posting that comment, I have been contacted by a woman who lives in Byron. The wind turbines went up over a year ago there, and she has not had good sleep since. She experiences a constant hum and a vibration in the floors of her house that prevents her from sleeping at night. She said that between the lack of sleep, flicker and noise from the generators, she might as well be living in downtown Chicago. She is a breast cancer survivor and is worried that all of this will cause her cancer to recur. She also stated that Invenergy sold the wind farm to a utility, WE Energies, who denies responsibility because they did not build the wind farm. They will not even listen to her complaints unless she can put some numbers on the problem.

I was also contacted by Healthy Wind Wisconsin, a group that is trying to get resolution of complaints from people living in wind farms. They told me of a man near Fond du Lac who raises chickens. Since the turbines went up, his adult chickens are sick, and he has seen deformities in his chicks. The deformities seen by the farmer are similar to those reported in a study done by the U.S. Army Aeromedical Research Laboratory (Shannon et al, 1994). In this study, fertilized eggs were exposed to different levels and frequencies of whole-body low frequency vibration. The results revealed increased mortality and birth defects caused by the vibration.

As a biologist, I am concerned. Chick development is used as a model of human embryonic development. Are there implications for people living in the wind farm who want to have children? According to "Excerpts from the Final Report of the Township of Lincoln Wind Turbine Moratorium Committee" people in the Lincoln Township (Kewaunee) wind farm have reported an inability to conceive. There have also been serious birth defects in calves, and cows spontaneously aborting in that wind farm.

Are people in the wind farms experiencing problems with low frequency vibration? According to G.P. van den Berg (2004) "Although infrasound levels from large turbines at frequencies below 20 Hz are too low to be audible, they may cause structural elements of buildings to vibrate." This is borne out in the wind farms as some people complain of hums and vibrations in the floors and windows of their homes and in other structures. If the floor is vibrating, the residents are experiencing whole body vibration.

Infrasound waves are not readily absorbed by matter, so they pass through us. Some people in wind farms say they can feel the sound waves moving through them. As sound moves through any object, it moves the molecules around it. At appropriate frequencies, the sound waves can set up resonances and cause vibrations. If the infrasound or low-frequency sound waves can resonate and vibrate windows in a home as they pass through them, it is easy to visualize how they may vibrate membranes, tissues and organs in the human body as they pass into and through the human body.

From Environmental Impacts of Wind-Energy Projects (2007) Board on Environmental Studies and Toxicology (BEST): "Low-frequency vibration and its effects on humans are not well understood. Sensitivity to such vibration resulting from wind-turbine noise is highly variable among humans. Although there are opposing views on the subject, it has recently been stated (Pierpont 2006) that "some people feel disturbing amounts of vibration or pulsation from wind turbines, and can count in their bodies, especially their chests, the beats of the blades passing the towers, even when they can't hear or see them." More needs to be understood regarding the effects of low-frequency noise on humans." I've heard that the vibrations can be felt in one's body much in the same way as the "deep base" can be felt at a rock concert when standing close to a speaker.

In addition to the acoustic vibrations, the giant spinning wind turbines also produce low-frequency vibrations which travel through the earth, seismic vibrations, in the form of Rayleigh waves. A study done by P. Styles (2005) reported "We have clearly shown that both fixed speed and variable speed wind turbines generate low frequency vibrations which are multiples of blade passing frequencies and which can be detected on seismometers buried in the ground at significant distances away from the wind farms even in the presence of significant levels of background seismic noise (many kilometers)." These results were obtained for turbines much smaller than the 400-500 foot giants that will go up in southern Brown County, and for much smaller arrays. The amount of vibration increases by a factor of 10 for every 100 turbines.

From Frey et al., 2007:

"In coursework description of "Whole Body Vibration" Prof Alan Hedge of Cornell University writes: "Vibrations in the frequency range of 0.5 Hz to 80 Hz have significant effects on the human body. Individual body members and organs have their own resonant frequencies and do not vibrate as a single mass, with its own natural frequency. This causes amplification or attenuation of input vibrations by certain parts of the body due to their own resonant frequencies. The most effective resonant frequencies of vertical vibration lie between 4 Hz and 8 Hz. Vibrations between 2.5 and 5 Hz generate strong resonance in the vertebrae of the neck and lumbar region with amplification of up to 240%. Vibrations between 4 and 6 Hz set up resonances in the trunk with amplification of up to 200%. Vibrations between 20 and 30 Hz set up the strongest resonance between the head and shoulders with amplification of up to 350%. Whole body vibration may create chronic stresses and sometimes even permanent damage to the affected organs or body parts."

The vibrations residents experience in the wind farms, whether acoustic or seismic in origin, can amplify in internal structures and organs in their bodies. Since some people complain of disturbing amounts of vibration in their bodies in wind farms, and structures vibrating in their homes, there can be no doubt that wind farms create vibration problems.

What might the health effects of this vibration be? In the study mentioned earlier, increased embryonic mortality was the main outcome of whole-body low frequency vibration of fertilized chicken eggs, but some of the experimental chicks showed deformities. In biology, agents that cause birth defects are called teratogens. Each teratogen produces a specific range of effects in a species. You can think of the drug thalidomide which had the specific effect of causing people to be born without limbs. The experimental observations of low-frequency vibration teratogenic effects in animals are:

- In chickens: crossed beaks, missing eyeballs and missing bony structures in the skull. Some disorientation and muscular weakness and malformed feet were also seen in experimental chicks (Shannon et al, 1994)

The problems with animal reproduction reported in the wind farms in Wisconsin are lack of egg production, problems calving, spontaneous abortion (embryonic mortality), stillbirth, miscarriage and teratogenic effects:

- In chickens: Crossed beaks, missing eyeballs, deformities of the skull (sunken eyes), joints of feet/legs bent at odd angles (Jim Vollmer, personal communication)
- In cattle: missing eyes and tails (updated Excerpts from the Final Report of the Township of Lincoln Wind Turbine Moratorium Committee)

It is disturbing to me that in chickens and cows in separate wind farms (separated by 50 miles) similar teratogenic effects are being observed, namely missing eyeballs. Based on the correlation of effects seen experimentally and those seen in the wind farm in chickens, these defects may be due to low frequency vibration. Jim Vollmer, the farmer who owns these chickens, reports that the tin structures on his farm buildings vibrate. If the infrasound/ low- frequency sound is strong enough to vibrate structures on his farm as it passes through, what is it doing to the delicate connections and circulation inside the developing chicken embryos, and inside people, as it passes through them?

Some of the other health effects that have been reported in the Kewaunee wind farm (and other wind farms) could also be explained by low frequency vibration. From updated "Excerpts from the Final Report of the Township of Lincoln Wind Turbine Moratorium Committee " (betterplan.squarespace.com):

Animal health problems in the Srnkas' formerly award-winning herd include cancer deaths, ringworm, mange, lice, parasites, cows not calving properly, dehydration, mutations such as no eyeballs or tails, cows holding pregnancy only 1 to 2 weeks and then aborting, blood from nostrils, black and white hair coats turning brown, mastitis, kidney and liver failure. . . .

Mr. Srnka and neighbors report serious health effects on not just dairy cows. Health problems in residents include

- sleep loss
- diarrhea
- headaches
- frequent urination
- 4 to 5 menstrual periods per month
- bloody noses: Mr. Srnka had cows bleed to death from uncontrollable bleeding from the nostrils
- inability to conceive

According to scientific literature, low frequency vibration could result in the urge to urinate (Frey et al, 2007) , menstrual irregularities, embryonic mortality (Penkov, 2007) , which may be interpreted as inability to conceive or spontaneous abortion, birth defects in animals, and kidney problems in animals (Skilianov et al, 2005) . All of these effects have been reported in the Kewaunee wind farm.

Many of the remaining health problems in this wind farm could be explained by infrasound/ low- frequency sound exposure or vibroacoustic disease, which is caused exposure to low frequency sound waves over long periods of time. According to Alves-Pereira and colleagues (2007) , The clinical symptoms of vibroacoustic disease (in people) are: Stage 1- slight mood swings, indigestion and heartburn, mouth or throat infections and bronchitis. Stage 2- chest pain, definite mood swings, back pain, fatigue, fungal, viral and parasitic infections, inflammation of the stomach lining, pain and blood in urine, conjunctivitis and allergies. Stage 3- psychiatric disturbances, small nose bleeds, varicose veins and hemorrhoids, duodenal ulcers, spastic colitis, decrease in visual acuity, headaches, severe joint pain, intense muscular pain and neurological disturbances. In experiments done on rats, low frequency sound has been shown to cause severe trauma to the cells lining the respiratory tract (Oliveira et al., 2001) and the delicate brush cells lining the respiratory tract fuse together.

Infrasound has been shown to damage numerous systems, including the liver and testes, of laboratory animals under experimental conditions , and some effects on people have been noted at 100 decibels. From Infrasound Toxicology Summary, 2001:

"When male volunteers were exposed to simulated industrial infrasound of 5 and 10 Hz and levels of 100 and 135 dB for 15 minutes, feeling of fatigue, apathy, and depression, pressure in the ears, loss of concentration, drowsiness, and vibration of internal organs were reported. In addition, effects were found in the central nervous system, the cardiovascular system, and the respiratory system. Synchronization phenomena were enhanced in the left hemisphere. Visual motor responses to stimuli

were prolonged, and the strength of effector response was reduced. Heart rate was increased during the initial minutes of exposure. Depression of the encephalic hemodynamics with decreased venous flow from the skull cavity and was observed. Heart muscle contraction strength was reduced. Respiration rate was significantly reduced after the first minute of exposure." Reference 29, Karpova et al., 1970.

Given this, it does not surprise me that people in the wind farm complain of malaise, lack of concentration, vibration, and cardiovascular effects, among others. Infrasound at very low frequencies has measured nearly 100 decibels in a 17 turbine wind farm (van den Berg, 2004). What levels of infrasound have been recorded in the middle of a 100 unit wind farm comprised of GE 1.5 MW turbines? At what threshold are effects of infrasound seen with continuous exposure? We need answers.

Is the level of low- frequency sound in a wind farm sufficient to result in vibroacoustic disease? An investigation of a home in a wind farm revealed that the home had levels of Infrasound and low- frequency vibration conducive to the formation of vibroacoustic disease (Alvez-Pereira et al 2007, In-Home Wind Turbine Noise is Conducive to Vibroacoustic Disease posted on [www.wind-watch.org](http://www.wind-watch.org)). More investigations like this need to be done, as not all homes in a wind farm will be affected equally by these agents. In people with occupational exposure to low frequency sound, it can take 10 years to reach stage 3 vibroacoustic disease. Therefore, to know the full health effects of wind turbines, we need to look at older wind farms as well.

In a complex generating 150 megawatts of electricity, there will be some electrical pollution. Wind turbines create "dirty electricity" which has been implicated in a variety of symptoms (Havas, M. 2006). David Colling of Ontario, who has studied the dirty electricity created by wind farms, describes the effects on people as being "like living inside a microwave." The effects are reduced with buried cables, but there are still effects, especially around substations. (See David Colling`s YouTube videos on electrical pollution and wind turbines)

If not carefully constructed, electricity from the turbines can overload rural power grids, back up into people`s homes and barns, and into the ground, creating ground currents. All electricity generated has to complete a circuit and flow back to the site of production through the neutral return wire. There are grounding rods on the neutral return wires, so that some current can constantly flow down the grounding rods and through the earth back to the substation, more when the wire is overloaded or corroded. A Minnesota study found that up to 70% of the neutral current returns to the substation via the earth, in some areas, in the form of ground current.

Dr. Duane Dahlberg has stated "Dairy operators are frequently required by state codes to construct equipotential planes in their barns as a means of avoiding electric shocks for the cows. Unfortunately the equipotential plane is a good conductor which attracts a greater percentage of the ground currents, causes the cows to be exposed to greater continuous currents, and frequently increases stray voltage effects . . . On dairy farms, current in the ground is associated with behavioral, health and production effects in cows." These effects have occurred in Mr. Srnkas cattle in the Lincoln Township wind farm. 100 turbines (with dangerous levels of rotor shaft voltages, up to 1200 volts) and 80 miles of cable carrying up to 150 megawatts of electricity will need to be grounded also, resulting in more current in our ground to get into homes. The electricity generated has to find its way back to the wind farm, a portion of which will travel through the ground in currents and become concentrated in the wind farm as it makes its way back. Ground currents enter our homes through plumbing and other conduits creating magnetic fields. Wertheimer, Savitz, and Leeper published a paper in 1995 that showed an association between cancer and conductive plumbing in residences, suggesting an increased cancer risk for persons with elevated magnetic fields from ground currents.

The utility can contribute to electrical pollution in another way when they connect the neutral on the primary side of the transformer serving a farm to the neutral on the secondary of the transformer. The National Electrical Code (NEC), which covers farm wiring, requires that the secondary neutral be hard wired to a building`s water system, structure and electrical ground rod. So, if the transmission line neutral is overloaded, more current from the electrical transmission neutral flows into the plumbing and structures on the farm. Here in Wisconsin currents can be measured flowing through the grounds of the transmission lines, as opposed to California where much larger neutral cables are used and current cannot be measured at the ground.

Electricity from the neutral or from ground currents flowing through plumbing can result in EMF and contact currents. According to a study done by Douglas (1993), the electric current flowing through water pipes and other grounding paths may be the largest magnetic field source in the home other than appliances.

Exposure to electromagnetic fields (EMF) has been linked to the formation of amyotrophic lateral sclerosis (Lou Gehrigs disease) and is considered "possibly carcinogenic" by the International Agency for Research on Cancer. A study in Turkey demonstrated that men who worked around low frequency EMF had higher levels of genotoxic effects in their lymphocytes. Genotoxic events are mutations which may result in cancers or other adverse outcomes. Children are especially susceptible to the effects of EMF (Kheifets, 2005); exposure above 0.4  $\mu$ T has been linked to the formation of childhood leukemia (Ahlbom et al, 2001, Angelillo and Villari, 1999). Rates of childhood cancer have been found to be increased for children living within 600 meters of electrical transmission lines at time of birth (Draper et al, 2005). Experts have argued that we should do all we can to reduce exposure to EMF in children and fetuses (Carpenter and Sage, 2008). Building 150 megawatt electricity generating complex around families seems unwise to me. It would make more sense to put wind farms in unpopulated areas.

Exposure to more than one of these agents at a time, as occurs in wind farms, may result in especially detrimental health effects. From the research literature it appears that the combination of both whole body vibration and low frequency noise is particularly dangerous. Low frequency sound alone is not genotoxic, but when combined with vibration, chronic occupational exposure has genotoxic effects (Silva et al., 1999, 2002). This result has been replicated in laboratory animal experiments, demonstrating the mutations are definitely due to the combination of whole body vibration and low frequency noise. Again, genotoxic effects can result in cancer, and cancers have occurred in cattle in the Lincoln Township wind farm. Yet, to my

knowledge, no one has studied genotoxic events in wind farms, or even the mortality rates in herds or people in the wind farms.

When I first looked at the list of symptoms being reported from the wind farm in Lincoln Township, I doubted such seemingly disparate symptoms could all be caused by wind turbines. A survey of scientific literature revealed plausible explanations for them based on exposures to infrasound/low frequency sound, vibration and electrical pollution.

We may all be exposed to some of these agents each day, but we know wind farms create these forms of pollution, increasing the dosage (and duration) of exposure for people living inside the wind energy complex. The scientific literature tells us of detrimental health effects from prolonged occupational exposure to these agents including vibroacoustic disease, genotoxic effects and embryonic mortality. People and animals in the wind farms seem to be suffering the very effects the science would predict for overexposure to these agents.

Many research studies demonstrate that the detrimental effects of exposure to these agents increase in severity with increasing time of exposure. It concerns me that there are no scientifically-established safe levels for continuous exposure to this combination of agents. In occupational exposures people can go home after 8 hours of work and have 16 hours for their bodies to actively recover from the exposures, 64 hours on the weekend. People in a wind energy complex don't get that break from exposure. Safe levels are likely to be considerably lower for the elderly, those with underlying health problems, pregnant women, children and fetuses. The standards we have also do not take into consideration the compounding of effects which can result from exposure to multiple agents at one time. Based on the chicken embryo studies, any level of exposure to low frequency vibration may pose some risk to developing embryos, as no threshold effect was observed (Shannon et al., 1994).

We have reports of animals in the wind farms here in Wisconsin with reproductive problems. Scott Srnkas cows suffer spontaneous abortion, problems calving, birth defects such as missing eyeballs and tails - all since the wind turbines. Jim Vollmer has seen changes in his chicken's reproduction - lower hatch rates and birth defects such as missing eyeballs and crossed beaks. Ann Wirtz has reported reproductive problems in her alpacas. Since the wind farm became operational, they have not been able to accomplish a live birth - pregnancy always results in miscarriage or stillbirth. There are other reports of chickens no longer laying eggs, and there may be more reports of reproductive effects of which I am not aware.

People living in the Lincoln Township wind complex have reported an inability to conceive. It appears, from the scientific literature, that vibration is a reproductive hazard which can result in miscarriage, stillbirth and other changes in the reproductive system of women (Balichiyeva, 1993, Marinova, 1976, Penkov, 2007, Seidel, 1993). In rats it can reduce the blood flow to the reproductive organs (Nakamura 1996). What happens to little girls growing up in the wind farms, experiencing the continual "deep base" type vibration that people feel in their bodies and the microseismic vibrations? Are their reproductive organs affected? What about their egg cells experiencing the low frequency sound and vibration, a combination which could be genotoxic? Girls are born with all the egg cells they will ever have.

To my knowledge, no one has even studied the fertility rates or rates of birth defects in people and animals in wind farms, or in people exposed to wind farms. We need concrete scientific proof that the vibration, acoustic and electrical pollution created by wind farms will not cause disease, birth defects or infertility in anyone, before continuing to build them.

I've heard arguments for wind energy stating that it reduces coal emissions and therefore also reduces birth defects caused by those emissions. Based on the reports out of the wind farms, there could be far worse reproductive consequences in people or animals (infertility, spontaneous abortion or miscarriage, stillbirth, and birth defects) as a result of wind energy than there ever was from coal emissions or nuclear power in this country. This needs to be studied. In Europe vibration exposure is recognized as a potential reproductive hazard (EU Directive 92/85/EEC), and vibration or EMF exposures can result in reproductive problems in people, or animals under experimental conditions (Al-Akhras, 2008, Brown et al., 1992, Hardell and Sage, 2008, Kim et al, 1999, Lahijani et al, 2007, Penkov, 2007, Seidel, 1993, Uysal et al, 2004).

On many levels wind farming raises concerns, but none more than the health complaints of residents of wind farms. One cannot read the updated report from Lincoln Township without being concerned. The problems being reported are not just nuisances. When complaints arise in the wind farms, people, homes and farms should be monitored for low frequency sound/infrasound, vibration and electrical pollution. If this were done on a regular basis, we would know what levels and combinations of these agents may cause health effects, but since health complaints have been ignored, and studies have not been done, those levels are not defined.

People living in the wind farms need rights and protection. As it stands, complaints are often ignored. There should be requirements for health care practitioners to report all health problems in wind farms, for investigations into complaints and for resolution of problems -not at the resident's expense. If neighbors suffer ill effects, turbines should be shut down until the problems are resolved. It is beyond my comprehension that an individual farmer is allowed to make a decision to put up a power plant with a giant industrial turbine, atop a skyscraping tower, without community approval. The community suffers burdens and hazards because of that decision. It should be a decision of the entire community whom it affects.

If wind turbines are coming to the area, organizations such as Healthy Wind Wisconsin recommend documenting everything - property value, the views from one's property, the wildlife that frequents one's home, well water quality, noise levels on a clear calm night, health records, electrical pollution, and more. They recommend this because more problems and more lawsuits are anticipated as this virtually unregulated industry continues to grow.

The residents of a wind farm are not just being "stressed out" by the wind farm, there are physical forces acting on their bodies as a result of the wind farm, physical forces that may do permanent damage. If we were putting up nuclear power plants, and we had reports of animals around them not able to successfully reproduce or being born without eyeballs, and also had some people reporting an inability to conceive, we would halt any new construction until it had been studied. In wind farms, this is exactly what we are seeing.

I realize there may be technical difficulty in ascertaining the amount of vibration set up inside one's body, but I am asking you to invoke the precautionary principle and suspend wind farm development until the reproductive effects of wind farms, here in Wisconsin, have been studied. If you move forward before studies have been done, people's reproductive rights may be violated.

In March, when Governor Doyle signed a bill banning BPA in baby bottles and cups for children, he stated "It seems to me that if there is a question of (safety), the balance we should strike is on protecting our children." I agree with Governor Doyle. I want my children protected. And people in the wind farm want to have children. Elderly people, stay-at-home moms, children, and babies are in these wind farms 24/7 being bathed in low frequency sound/infrasound, vibration and electrical pollution. If we are going to err in the siting of wind turbines, it should be on the side of safety for the people.

Thank you for your consideration,

Lynne Knuth, Ph.D.

P.S. I attended the recent meeting with the Brown County Board of Health and Board of Human Services. I wish everyone in this state had been able to hear the testimonials of the people who are suffering in industrial wind projects here in Wisconsin. We live in the best country in the world, a country that cares about people, founded on the principle that all men are created equal and have equal rights under the law. Each life is equally valuable. To hear that the wind siting council referred to people suffering in wind farms as "collateral damage" is disturbing. Collateral damage may be unavoidable in military operations, but it is not acceptable in day to day life. The life of each person suffering in a wind farm is as valuable as the life of each legislator living in Madison. I'd like to see them switch places; then we'd get some wind farm legislation that makes sense.

If people are going to suffer because of a new technology, we do not move forward with it, but instead we come up with a better solution. There are better solutions to our country's problems.

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Angelillo IF, Villari P. Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis. *Bull World Health Organ* 1999; 77 (11): 906 - 915

Al-Akhras MA Influence of 50 Hz magnetic field on sex hormones and body, uterine, and ovarian weights of adult female rats. *Electromagn Biol Med.* 2008; 27(2):155-63.

Alves-Pereira M. Castelo Branco NA. Vibroacoustic disease: biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling. *Prog Biophys Mol Biol.* 2007 Jan-Apr; 93(1-3):256-79. [Progress in biophysics and molecular biology]

Balichiyeva DV. Vibration in parental occupation as a risk factor in the health and development of offspring. *Reprod Toxicol* 1993 Sep-Oct; 7(5):492-3

Abstract:

The results of this research are based on a complex evaluation of labor conditions of workers in a number of vibration-exposed occupations (machinists, excavators, operators of drilling wells, bulldozer operators, embryoiderers in tambour shops, weavers, and others) based on sociologic studies of 923 persons (including 532 men and 371 women), clinical and experimental data (1,119 white rats), and mathematical modeling methods. Special features of the effect of vibration on the reproductive system are apparent: in men, suppression of sex function is noted, and there is an increase in the frequency of spontaneous abortion in women who are not in contact with vibration as a result of genome changes in the male reproductive cells; in the women there was an increase in the frequency of menstrual disorders, swelling of the walls of the vagina and uterus, spontaneous abortion, toxicosis of both halves of pregnancy, and stillbirths. The adverse effects of vibration on the offspring are transmitted through both the female and the male parents. A high frequency of deviations in anthropometric indices is noted, as well as infant death and sickness in children at an early age. It was established that vibration-exposed occupations in one or both parents significantly increases the risk for the offspring according to the indices indicated above and even more, to a large degree, in combination with harmful habits (smoking, drinking alcohol). In the experiments on animals, a decreased probability of birth and viability of the offspring were shown in association with vibration exposure of the parents. A system was developed for the prevention of reproductive and developmental injury in which the following measures were important: a decrease in vibration load for men and women; family planning, taking into consideration the vibration danger in the occupation of the parents; a healthy way of life; effective use of labor and social vacations for increasing reproductive health, reinforcement of the public health service for pregnant women, newborns, and weak children taking into consideration the professions with vibration danger for parents as a risk group.

Briese V, Fanghänel J, Gasow H. Effect of pure sound and vibration on the embryonic development of the mouse. *Zentralbl Gynakol.* 1984; 106(6):379-88.

Brown KM, Doynov PG, Barber MK, Litovitz TL, Litovitz TA. Effects of extremely low frequency electromagnetic fields on chicken embryogenesis. *Toxicologist* 1992 Feb; 12(1):100

Abstract:

Only a few epidemiological studies have examined the effects of extremely low frequency electromagnetic fields (ELF) on embryogenesis. Taken together, these studies are inconclusive and suffer from an inability to control for a variety of potential

maternal influences on the embryo. In the present study we have examined the direct effects of ELF on chicken embryogenesis. Fertile, unincubated chicken eggs were placed in a Helmholtz coil inside each of two incubators. An electromagnetic field was created in the coil in one incubator by currents produced by a generator. These eggs were exposed to different frequencies, magnetic field strengths, and pulse shapes which were monitored along with temperature, vibrations and relative humidity. Eggs in the other incubator were not exposed to generated ELF. On average, twice as many abnormal embryos developed from eggs continuously exposed for 48 h to 60 Hz/L uT sinusoidal fields than from unexposed eggs. Most of these abnormalities were neural tube defects. This study suggests that embryonic processes, particularly the formation of the brain and spinal cord, are directly sensitive to ELF.

Carpenter DO, Sage C. Setting prudent public health policy for electromagnetic field exposures. *Rev Environ Health*. 2008 Apr-Jun; 23(2): 91-117.

Celikler S, Aydemir N, Vatan O, Kurtuldu S, Bilaloglu R. A biomonitoring study of genotoxic risk to workers of transformers and distribution line stations. *Int J Environ Health Res*. 2009 Dec; 19(6): 421-30.

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Duane A. Dahlberg, Ph.D. Ground Currents An Important Factor in Electromagnetic Exposure.

Frey, B.J., and P.J. Haddon. Noise Radiation from Wind Turbines Installed Near Homes: Effects on Health. [www.windturbinehealthhumanrights.com](http://www.windturbinehealthhumanrights.com). Feb, 2007.

Hardell L. Sage C. Biological effects from electromagnetic field exposure and public exposure standards. *Biomed Pharmacother*. 2008, Feb; 62(2): 104-9.

Abstract:

During recent years there has been increasing public concern on potential health risks from power-frequency fields (extremely low frequency electromagnetic fields; ELF) and from radiofrequency/microwave radiation emissions (RF) from wireless communications. Non-thermal (low-intensity) biological effects have not been considered for regulation of microwave exposure, although numerous scientific reports indicate such effects. The BioInitiative Report is based on an international research and public policy initiative to give an overview of what is known of biological effects that occur at low-intensity electromagnetic fields (EMFs) exposure. Health endpoints reported to be associated with ELF and/or RF include childhood leukaemia, brain tumours, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, breast cancer, miscarriage and some cardiovascular effects. The BioInitiative Report concluded that a reasonable suspicion of risk exists based on clear evidence of bioeffects at environmentally relevant levels, which, with prolonged exposures may reasonably be presumed to result in health impacts. Regarding ELF a new lower public safety limit for habitable space adjacent to all new or upgraded power lines and for all other new constructions should be applied. A new lower limit should also be used for existing habitable space for children and/or women who are pregnant. A precautionary limit should be adopted for outdoor, cumulative RF exposure and for cumulative indoor RF fields with considerably lower limits than existing guidelines, see the BioInitiative Report. The current guidelines for the US and European microwave exposure from mobile phones, for the brain are 1.6 W/Kg and 2 W/Kg, respectively. Since use of mobile phones is associated with an increased risk for brain tumour after 10 years, a new biologically based guideline is warranted. Other health impacts associated with exposure to electromagnetic fields not summarized here may be found in the BioInitiative Report at [www.bioinitiative.org](http://www.bioinitiative.org).

Havas M. Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis *Electromagn Biol Med*. 2006; 25(4): 259-68. Abstract

Electric Transmission Lines Individual Rights vs Utility Rights of Public Domain  
By Donald Hillman, Ph.D., Professor Emeritus, Michigan State University. 2005.

Kheifets L, Repacholi M, Saunders R, van Deventer E. The sensitivity of children to electromagnetic fields. *Pediatrics*. 2005, Aug; 116(2): e303-13.

Abstract:

In today's world, technologic developments bring social and economic benefits to large sections of society; however, the health consequences of these developments can be difficult to predict and manage. With rapid advances in electromagnetic field (EMF) technologies and communications, children are increasingly exposed to EMFs at earlier and earlier ages. Consistent epidemiologic evidence of an association between childhood leukemia and exposure to extremely low frequency (ELF) magnetic fields has led to their classification by the International Agency for Research on Cancer as a "possible human carcinogen." Concerns about the potential vulnerability of children to radio frequency (RF) fields have been raised because of the potentially greater susceptibility of their developing nervous systems; in addition, their brain tissue is more conductive, RF penetration is greater relative to head size, and they will have a longer lifetime of exposure than adults. To evaluate information relevant to children's sensitivity to both ELF and RF EMFs and to identify research needs, the World Health Organization held an expert workshop in Istanbul, Turkey, in June 2004. This article is based on discussions from the workshop and provides background information on the development of the embryo, fetus, and child, with particular attention

to the developing brain; an outline of childhood susceptibility to environmental toxicants and childhood diseases implicated in EMF studies; and a review of childhood exposure to EMFs. It also includes an assessment of the potential susceptibility of children to EMFs and concludes with a recommendation for additional research and the development of precautionary policies in the face of scientific uncertainty.

Kim YW, Cho JY, Lee JS, Kang SH, Cho MK, Kim YM. Evaluation of fetal abnormalities in mice continuously exposed to 60 Hz electromagnetic fields for 6 months. *Teratology* 1999 May;59(5):29A-30A

Abstract:

To evaluate the possible effects of electric and magnetic fields to fetal abnormalities, 60 female BALB/c mice (initial age 6 weeks) were divided into 5 groups and an equal number of male mice were also divided into 5 groups. Twelve mice of each group were exposed continuously at 60 Hz field of 5 kV/m, 30 kV/m, 0.5 mT (5 G) or 1.5 mT (15 G) for 20-22 weeks, and then mice under the same condition were mated and were exposed continuously. Pregnant mice were sacrificed on day 17-18 postconception. The rate of fetal abnormalities was 10% in 5 kV/m, 15.2% in 30 kV/m, 20.3% in 5 G and 14.3% in 15 G, but 5.3% in the control group. The pregnancy rate was not different significantly. Exposure of electromagnetic fields induced early fetal death, late fetal death and abnormalities such as cleft palate, exencephaly as well as minor anomalies. Especially 5 G induced early fetal death but 15 G and 30 kV/m caused late fetal death and abnormalities (P less than 0.05). In some dead embryos of early periods, a single ventricle was noted. Hypertrophy, degeneration and disarray of cardiac muscle were found in the same heart. Congestion and hemorrhage were noted in lungs. Nodular formation of endocardial cushion was found in the area of aortic and pulmonary valves. Diffuse congestion was found in atrium and ventricle. It appears that 5 G influences early fetal period but 15 G and 30 kV/m influence late fetal periods. It can be insisted that electric and magnetic fields are environmental factors in fetal abnormalities at the permissible safety limits of them by the guidelines of several international associations.

Lahijani MS, Nojooshi SE, Siadat SF. Light and electron microscope studies of effects of 50 Hz electromagnetic fields on preincubated chick embryo. *Electromagn Biol Med.* 2007; 26(2):83-98. [Electromagnetic biology and medicine]

Abstract:

We investigated the effects of an electromagnetic field (EMF) of 50 Hz, 1.33-7.32 mT on sections of preincubated white leghorn chicken embryos using light, SEM and TEM microscopes. Five hundred healthy, fresh, and fertilized eggs (55-65 g) were divided into three groups of experimental (n = 18-20), control (n = 60), and sham (n = 50). Experimental eggs (inside the coil) were exposed to 15 different intensities (1.33-7.32 mT) for morphological surveys and to the known most effective intensities for light, scanning electron microscopy (SEM), and transmission electron microscopy (TEM) studies. Sham groups were located inside the same coil with no exposure for 24 h before incubation. Control, sham, and experimental groups were then incubated in an incubator (38 +/- 0.5 degrees C, 60% humidity) for 4 days. At the end of this period, embryos were removed from their shells, prepared for morphometric, light, and SEM/TEM studies. Results of light microscopic studies (serial sections, 6mu) and morphometric data showed significant differences between different groups (P < 0.005). Larger and abnormal brain cavities, spina bifida, monophthalmia, microphthalmia, anophthalmia, and growth retardation were shown on SEM. TEM sections demonstrated that the nucleus was condensed, the nuclear envelope disappeared, and mitochondria degenerated. Golgi apparatus and endoplasmic reticulum were the least affected organelles. The Telencephalon was the most affected region, and the retina was altered more than the lens. We conclude that EMFs affect the brain, especially the Telencephalon and eye of preincubated-exposed chick embryo at the morphological and cellular level, nuclei are the most affected part, and our data agrees with "Ubeda's windows effects" of EMFs on preincubated chick embryos.

Li P, McLaughlin J, Infante-Rivard C. Maternal occupational exposure to extremely low frequency magnetic fields and the risk of brain cancer in the offspring. *Cancer Causes Control.* 2009, Aug; 20(6):945-55. [Cancer causes & control : CCC]

Luo Q, Yang J, Zeng QL, Zhu XM, Qian YL, Huang HF. 50-Hertz electromagnetic fields induce gammaH2AX foci formation in mouse preimplantation embryos in vitro. *Biol Reprod.* 2006, Nov; 75(5):673-80.

Marinova G, Svetoslavova E, Mateeva E. Industrial vibrations and their repercussions on the basic functions of the genital system in women Akush Ginekolo (Sofia). 1976; 15(1):74-8. [Akusherstvo i ginekologija]

Nakamura H, Ohsu W, Nagase H, Okazawa T, Yoshida M, Okada A. Uterine circulatory dysfunction induced by whole-body vibration and its endocrine pathogenesis in the pregnant rat. *Eur J Appl Physiol Occup Physiol.* 1996;72(4):292-6.

Abstract

Effects of whole-body vibration on normal pregnancy were studied in the rat. Uterine blood flow and five endocrine functions corticosterone (CS), estradiol (E2), progesterone (P), prostaglandin E2 (PGE2) and prostaglandin F2 alpha (PGF2 alpha) concentration were measured in rats exposed to whole-body vibration with an acceleration of 10 m.s-2 at a frequency of 8 Hz. While no change in uterine blood flow was observed in control rats, uterine blood flow was significantly decreased 75 and 90 min after exposure to vibration. The uterine blood flow at 15 and 30 min was increased by pretreatment with intraperitoneal injections of angiotensin II (AII). In contrast, in AII pretreated rats exposed to the vibration, uterine blood flow was significantly reduced 90 min after exposure. The CS concentration was increased by vibration independently of the pretreatment with AII. Neither E2 nor PGF2 alpha concentration were changed by the vibration with or without AII administration. The P and PGE2 concentrations were both decreased by vibration in the absence of AII, while the decrease in PGE2 induced by the vibration was also found in AII-treated rats. The present results indicated that the pregnant rats subjected to whole-body vibration responded with changes in uterine and ovarian function. The observed decrease in uterine blood flow may have been the result of reduced PGE2 concentration resulting from an indirect effect of vibration.

Oliveira MJ, Pereira AS, Castelo Branco NA, Grande NR, Aguas AP. In utero and postnatal exposure of Wistar rats to low frequency/high intensity noise depletes the tracheal epithelium of ciliated cells. *Lung.* 2001; 179(4):225-32.

Abstract:

Chronic exposure of men or rodents to low frequency/high intensity (LFHI) noise causes a number of systemic changes that

make up the so-called vibroacoustic disease (VAD), a disorder that includes alterations of the respiratory system, namely, of its epithelial layer. We have investigated here the susceptibility of the tracheal epithelium of Wistar rats to in utero and postnatal exposure to LFHI noise by comparing its ultrastructure with that of the tracheal epithelium of control rats and of animals exposed to LFHI noise only after reaching adulthood (8 weeks of age). Scanning electron microscopy (SEM) of the inner surface of rat trachea was used to determine the relative areas covered by ciliated and non-ciliated cells. In rats that were exposed in utero and postnatally to LFHI noise, we observed that out of 100 microm<sup>2</sup> of tracheal epithelium only 31 +/- 14 microm<sup>2</sup> were covered by cilia, whereas in control rats; ciliated cells occupied an average of 60 +/- 18 microm<sup>2</sup> out of 100 microm<sup>2</sup> of the epithelium; this difference between the two groups was statistically significant ( $p < 0.05$ ). In rats that were exposed to LFHI noise only after reaching adulthood, cilia covered 55 +/- 22 microm<sup>2</sup> out of 100 microm<sup>2</sup> of the luminal surface of the trachea, a value that, although lower than that of controls, was not found to be statistically different. We conclude that (1) the tracheal ciliated cells are damaged by exposure of rats to LFHI noise if the animals are kept under this environmental aggression during in utero and postnatal periods; (2) tracheal ciliated cells from adult rats are more resistant to the deleterious effects of LFHI noise than pleura or lung alveolar cells that were shown before to undergo marked changes upon chronic exposure of rats to LFHI noise. These findings suggest a note of caution regarding pregnant women and young children: they should be prevented from areas where LFHI noise occurs, namely, in aircraft and textile industries where this type of environmental hazard is often present.

Pearce MS, Hammal DM, Dorak MT, McNally RJ, Parker L. Paternal occupational exposure to electro-magnetic fields as a risk factor for cancer in children and young adults: a case-control study from the North of England. *Pediatr Blood Cancer*. 2007, Sep; 49(3):280-6.

Penkov A. Influence of occupational vibration on the female reproductive system and function.

Akush Ginekol (Sofiiia). 2007; 46(3):44-8. [Akusherstvo i ginekologija]

Abstract:

The relevant literature on the effects of occupational vibration was analyzed in order to obtain information concerning a possibly health risk on the female reproductive organs. Vibration exposure can probably contribute to the pathogenesis of disorders of female reproductive organs (decrease in uterine blood flow, menstrual disturbances, and anomalies of position) and disturbances of pregnancy (abortions, stillbirths). Experimental animal studies on the reproduction function suggest harmful effects on the fetus, and dystrophic and morphological changes in the uterus and ovaries in animals.

Seidel, H. Selected health risks caused by long-term, whole-body vibration. *AM J Ind Med*. 1993, Apr; 23(4):589-604

Shannon SG, Moran AW, Shackelford LC, Mason KT. Effect of vibration frequency and amplitude on developing chicken embryos. NTIS Technical Report (NTIS/AD-A288517) (USAARL-95-1) 1994 Oct;:34

Abstract:

Fertilized chicken eggs were incubated and exposed repeatedly to whole-body vibration forces with frequencies ranging from 5 to 50 Hz, and amplitudes ranging from 0.09 to 4.93 Gz(rms). The timing and duration of exposure were selected to model pregnant women flying Army helicopters 3 hours per day, 5 days per week. Factors associated with chicken embryo mortality were: frequency, amplitude, amplitude transmission, and timing of the exposure. As the magnitude of the exposure increased, mortality increased. No clear HRA threshold values were identified due to the retrospective discovery of protocol problems. The use of an entire tray of eggs as the unit of amplitude measure was invalid due to the differences in vibration amplitude transmission at each egg station. However, mortality thresholds were proposed using a logistic model that controlled for the differences in vibration amplitude noted at various egg stations. No extraneous factors such as month of incubation, flock, and incubator were significant in analysis of variance modeling. Controlling for the amplitude transmission, we found very strong effects of vibration on embryonic development and mortality. Exposure of chicken embryos to vibration above 2.0 Gz should be avoided. Exposures as low as 1.0 Gz are harmful at certain frequencies. Congenital malformations occurred in chicks exposed to vibration, but in none of the control chicks. The malformation syndrome was characterized by crossed beaks and missing eyes. We observed several experimental chicks with malformed feet, sensory disorientation, and muscular weakness. Further studies are required to define and validate these findings. Whole-body vibration exposures are harmful to the developing chicken embryo. Until further laboratory and epidemiological studies of this potential health hazard on animal and human pregnancy outcomes are completed, pregnant Army aviators should not fly in rotary-wing aircraft. We believe the vibratory aspect of the rotary-wing aircraft environment is a fetal health hazard.

Silva MJ; Carothers A; Castelo Branco NA; Dias A; Boavida MG. Sister chromatid exchange analysis in workers exposed to noise and vibration. *Aviat Space Environ Med*. 1999, Mar; 70(3 Pt 2):A40-5.

Silva MJ; Dias A; Barreta A; Nogueira PJ; Castelo-Branco NA; Boavida MG. Low frequency noise and whole-body vibration cause increased levels of sister chromatid exchange in splenocytes of exposed mice. *Teratog Carcinog Mutagen*. 2002; 22(3):195-203. Abstract:

Chronic exposure to low frequency (LF) noise and whole-body vibration (WBV) induces both physiological and psychological alterations in man. Recently, we have shown that long-term occupational exposure to LF noise and WBV produces genotoxic effects in man expressed as an increase in sister chromatid exchange (SCE) levels in lymphocytes. The objectives of the present study were to investigate whether the observed effect could be reproduced in a murine model and, if so, which of the agents, LF noise alone or in combination with WBV, would be instrumental in the SCE induction. SCEs were analyzed in spleen lymphocytes of mice exposed to LF noise alone and in combination with WBV for 300 and 600 hr. An effect at the cell

cycle kinetics level was also investigated. The results revealed significant increases in the mean SCE number per cell and in the proportion of cells with high frequency of SCEs (HFCs) in lymphocytes of mice submitted to combined noise and WBV over controls. No significant differences were found between single noise-exposed and control mice. A cell cycle delay was observed exclusively in the noise and WBV exposure groups. In conclusion, we demonstrated that, as in exposed workers, prolonged exposure to the combination of LF noise and WBV determines an increase in SCE level in mice while LF noise alone is not effective in SCE induction.

Sklianov IuI, Pravotorov GV, Balueva OI, Vakulin GM. [Morpho-functional characteristic of kidneys in mother, fetus and the offspring subjected to vibration of industrial frequency during gestation]  
Source: Morfologija. 2005; 128(4):29-32. [Morfologija (Saint Petersburg, Russia)]

Styles , Stimpson I, Toon S, England R, and M. Wright. Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms. July 18, 2005.

Taggart LC, Alem NM, Frear HM. Effect of vibration frequency and acceleration magnitude of chicken embryos on viability and development, phase I. NTIS Technical Report (NTIS/AD-A231 723) 1990 Nov;: 18 pp.

Uysal II, Celik I, Salbacak A, Karabulut AK, Soylu R, Oznurlu Y. The Effects Of Electromagnetic Fields On Embryonic Development: Morphological Investigations On Rat Embryos Cultured In Vitro. Reprod Toxicol 2004 July; 18(5): 752

van den Berg, G.P. Do wind turbines produce significant low frequency sound levels? 11th International Meeting On Low Frequency Noise and Vibration and its Control. Maastricht The Netherlands 30 August to 1 September 2004

Wertheimer, Nancy, David Savitz, Ed Leeper. 1995. "Childhood Cancer in Relation to Indicators of Magnetic Fields from Ground Current Sources. Bioelectromagnetics. 16:86-96 (1995).

Abstract:

This study examines childhood cancer risk in relation to certain factors likely to indicate magnetic field exposure from ground currents in the home. Substantial ground currents are most often found in homes having conductive plumbing, in which an uninterrupted metallic path in the water pipes and water main connects the grounding systems of neighboring houses. Information on plumbing conductivity was obtained from water suppliers for the homes of 347 cases and 277 controls identified in an earlier study of magnetic field exposure and childhood cancer in the Denver area. An increased cancer risk was observed for children in homes with conductive plumbing: The matched odds ratio was 1.72 (1.03-2.88) and increased to 3.00 (1.33-6.76) when analysis was limited to cases and controls who were residentially stable from the reference date to the study date. A measurement metric likely to indicate active ground currents (measurements having above-median intensity and a nonvertical orientation of < 55 degrees from the horizontal) was identified. In contrast to measured field intensity alone, for which only modest associations with cancer have been reported, this metric shows a high and significant cancer risk [matched O.R. = 4.0 (1.6-10.0)] consistent over a range of intensity and angle cutpoints. Such elevated nonvertical fields were also associated with cancer in an independent data set, which was gathered to study adult nonlymphocytic leukemia in the Seattle area. The associations of cancer with conductive plumbing and with this exposure metric both suggest that cancer risk is increased among persons with elevated magnetic field exposure from residential ground currents.

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I affirm that these comments are true and correct to the best of my knowledge and belief.

Lynne Knuth, PhD