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From: Paul H

Attached is a commentary by Dr Karl Maret on questions by David M Aaron Esq. associated with FortisBC Inc. Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project. Project number 3698682.

His understanding and educational history brings high credentials to the smart meter subject as he is considered an expert in both electrical and biomedical engineering.

He has authored 26 scientific publications and has received an Engineering Diploma, Bachelor of Science in Electrical Engineering degree, Master of Engineering, Biomedical Engineering, Doctor of Medicine, and a Post-Doctoral Fellowship in Pulmonary Physiology.

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Commentary on Questions by David M. Aaron Esq.

associated with

FortisBC Inc. Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project ~ Project No. 3698682

By Karl H. Maret

January 23, 2012

Expert Opinion Summary

It is my opinion that the RF Mesh Network Meters that are part of the proposed FortisBC Inc. Automated Metering Infrastructure may constitute a risk of serious damage to health by biological non-thermal mechanisms. The most vulnerable subpopulation would be children, pregnant women, the elderly, individuals with illnesses and electrically hypersensitive persons. It is in the nature of the non-thermal RF pulsations and not the power density levels that constitute the adverse biological effects of the meters.

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The Author

1. I am the President of the non-profit Dove Health Alliance foundation serving to educate the general public on the principles and practices of energy medicine within the field of complementary and alternative medicine including electromagnetic health challenges.
2. My curriculum vitae have been attached to this report as Appendix F.
3. My formal education includes a Bachelor of Science in Electrical Engineering from Queen's University in Ontario, a Master of Engineering degree in Biomedical Engineering from the University of Toronto and a Doctor of Medicine degree from the University of Toronto.
4. I have served as a Biosciences Officer in the Canadian Armed Forces and been honorably discharged following eight years of service.
5. I have served at the Canadian Defense and Civil Institute of Environmental Medicine and carried out applied physiology research for the Defense Research Board.
6. I have completed a four year Post-doctoral Fellowship in Physiology at the University of California in San Diego combining my biomedical engineering skills with a high altitude medical research program.
7. I have become self-educated to the scientific issues associated with contemporary electromagnetic exposure in the environment.
8. I have consulting practices in biomedical engineering as well as complementary and alternative medicine in California.
9. I have given invited testimony to the Senate of the State of Vermont (Jan 26, 2012) on their plans to establish an automated meter infrastructure using RF meters.

Question 1:

We seek your opinion on transmissions by radiofrequencies such as those that will occur from the AMI meters proposed by Fortis ("the Transmissions"). With respect to peak power density of the proposed meters, what comments, if any, do you have on Fortis' response to CSTSIR#1 question 57.7 and CSTS IR#2 question 43.5 as set out:

> 57.7 What is the peak power density of the data signals?
>
> Response:
>
> Peak power density is calculated at the FCC/IC specified distance of 20 cm during active transmission (does not account for duty cycle):
>
> 900 MHz RF Mesh Radio: 0.227 mW/cm2
> 2.4 GHz ZigBee Radio: 0.031 mW/cm2

43.5 Disregarding the average, what are the peak power densities during signaling?

> Response:
> Please refer to the response to CSTS IR No. 1 Q57.7. Note that this peak power density is instantaneous and assuming 100% duty cycle and cannot be compared to Health CanadaSafety Code 6 or other thresholds with a defined averaging window. Empirical peak power density based on the Health Canada measurement standard would be significantly less. Even at the theoretically supported maximum duty cycle of 5%, peak power density would be 5% of 0.227 mW/cm2 or 0.011 mW/cm2.

Dr. Maret Response:

Energy density is the amount of energy radiated in a given region of space per unit volume which is dependent on the distance from the radiator. The highest energy density will be at the antenna of the Smart Meter. Fortis response calculates the power levels at a distance of 20 cm (7.9 inches) from the meter and does not specific the antenna gain of the devices nor the input power nor the pulse width of their digital signal envelope.
I calculate the EIRP = equivalent (or effective) isotropically radiated power which is P times G
where P = power input to the antenna (in appropriate units, e.g., milliwatts or watts) and
G = power gain of the antenna in the direction of interest relative to an isotropic radiator

The following equation calculates Power Density S (in appropriate units, e.g. mW/cm^2)
$S = P*G / (4 \text{ Pi } R^2)$ or $S = EIRP / (4 \text{ Pi } R^2)$ where R is the distance from the transmitter.
This equation has to be modified if there are reflections near the Smart Meter which would increase the power density around the meters and increase the microwaves exposure to persons near the meters.

Fortis specifies a 900 MHz RF Mesh Radio with peak power density 0.227 mW/cm^2 or 227 $\mu W/cm^2$ at 20 cm which gives an EIRP of 1141 mW or 1.141 watt while transmitting. Typical pulse trains are assumed to last a fraction of a second (assumed to be less than 20 milliseconds) during data transmission at full peak power. The data will be encoded appropriately with a digital data stream rapidly switching between on/off conditions.

The transmissions are specified to be variable in duty cycle depending on the demand of the mesh network. They state that the duty cycle will not exceed a maximum of 5% (86,400 seconds/day x 0.05 = around 72 minutes transmission time per day maximally).

The second Zigbee radio is specified to have a peak power density level of 0.031 mW/cm^2 or 31 μW/cm^2 at 20 cm transmitting at 2.4 to 2.45 GigaHertz (GHz) in the same band where WiFi wireless devices operate as well. It is assumed that the Zigbee radio will communicate with wireless appliances in a local Home Area Network (HAN) at a calculated EIRP of 156 milliwatts, which is considerably weaker than the 900 MHz transmitter but may have a higher data communications rate (duty cycle is not specified and I assume would depend on the number of smart appliances in the network). Even though the Zigbee radio operates at about 14% of the 900 MHz transmitter power level, when operational, it will add additional low level non-thermal microwave exposure to the residents of the home. Current WiFi systems in the home typically operate at 100 mW or less so that the Zigbee system operates at 56% higher power levels when compared to WiFi systems.

By averaging the power density over a the day, by multiplying the peak power density by the duty cycle, a much lower average value is obtained which looks quite low when compared the current RF exposure guidelines. These guidelines are based only on heating effects and do not consider any non-thermal biological or health effects. Averaging in this way, which is a commonly accepted practice, tends to obscure the potentially significant biological impact of short burst RF transmissions at peak power density levels which these meters generate. The pulsed nature of the 900 MHz transmission at irregular intervals is quite different than other existing wireless types of transmissions. Current wireless devices tend to be more continuous types of transmissions while in use and of a weaker power density level. No human, animal, cell studies or environmental impact studies involving these types of burst transmission patterns from smart meters have been carried out prior to deployment of these new technologies.

When meters operating at a maximal 5% duty cycle, they will have an averaged power density of 0.011 mW/cm^2 or 11 μW/cm^2 which is the value that will be used for comparison in the following section describing biological effects and health implications at low power density levels.

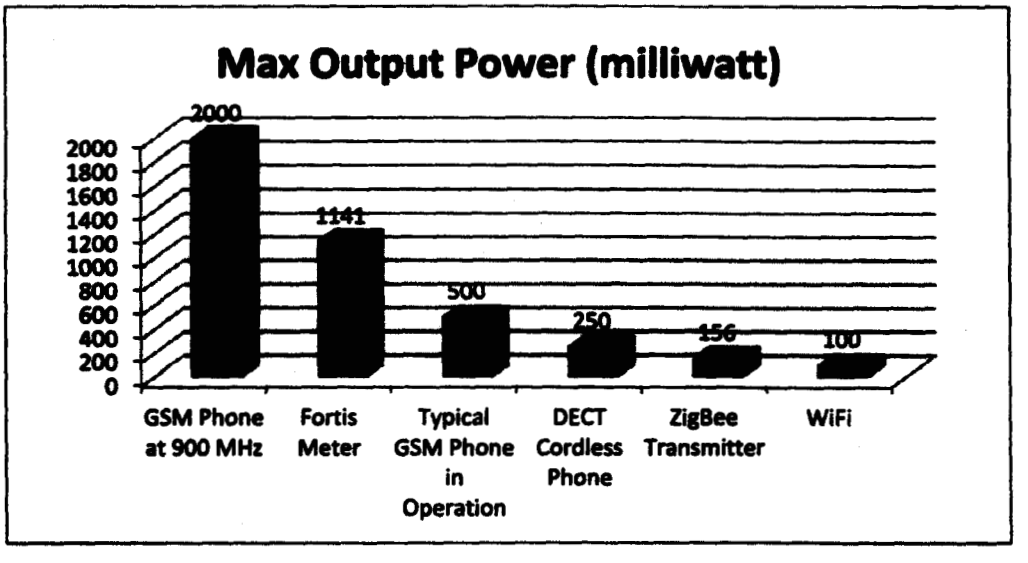
<u>Comparison with other RF transmitters</u>

Comparisons are often made between smart meter emissions and cellular phones. This may be a poor comparison because cell phones radiate more directly into the ear and head when typically used without an earpiece, while smart meters typically irradiate the whole body and are more analogous to wireless antennas such as cordless phone base stations (DECT type) or cell tower radiations. For cell phones, power emissions are described by their Specific Absorption Rate (SAR value in watts/kg or equivalent) which is measured on a fluid-filled head testing system that simulates the suspected absorption of an adult human head. In contrast, cell towers, base stations, WiFi transmitters and smart meter RF emissions are specified in power density levels as they affect whole body absorption and are measured in watts/meter^2 (W/m^2) or microwatt/cm^2 (μW/cm^2) or equivalent units.

Cell phones are capable of transmitting at similar maximum power levels compared to smart meters. For example, the maximum powers that GSM mobile phones are permitted to transmit by the present standards are 2 W (900 MHz) and 1 W (1800 MHz). Because a technique called Time Division

Multiple Access (TDMA) is employed that allows each channel to be used by eight phones, the *average* powers transmitted by a phone are never more than one-eighth of these maximum values (0.25 W and 0.125 W, respectively) and these levels are usually further reduced by a significant amount due to the effects of adaptive power control and discontinuous transmission. The largest output from a phone occurs if it is mainly used at large distances from the base station or shielded by buildings, when the peak powers could approach the values of 2 W (900 MHz). In contrast, the smart meter proposed by Fortis has a power density of 227 $\mu W/cm^2$ at 20 cm giving it a maximum effective radiated power of 1.141 watts as described above which is often higher than a cell phone power output even though the meter's transmission is a short, several millisecond burst of data.

With comparison to other wireless devices, DECT (Digital Enhanced Cordless Telecommunica-tions) cordless phones operate by pulsing every 10 milliseconds (100 Hz) at maximum power levels of 250 mW, essentially under one quarter (22%) of the peak power of the Fortis smart meter (1.14 W). WiFi devices (IEEE 802.11 standard devices) use a maximum of 100 mW (802.11b) or 50 mW (802.11g) which is 8.8% and 4.4% respectively of the peak power level of the Fortis meter.



Maximum power output gives a relative idea of the power of the RF transmitter at the source. What is important is the power density level at a defined distance from the transmitter and the amount of time the transmitters are active. To give that comparison, the values are calculated as follows:

According to the CCST report on smart meters released in 2011, using data from the Electric Power Research Institute (EPRI), a cell phone at the ear having a maximum power density 5000 $\mu W/cm^2$. To calculate total body exposure, physicist D. Hirsch derived comparison values (Hirsch 2011). He assumes the phone to be used with a 1% duty per day giving an average power density at the ear of 50 $\mu W/cm^2$. In order to compare power density levels for whole body exposure, a value of approximately 0.75 $\mu W/cm^2$ is derived.

A FortisBC RF mesh radio meter at 3 feet with a stated maximum duty cycle of 5% would produce an average power density of 0.545 $\mu W/cm^2$. A WiFi Router with maximum power of 100 mW would produce a power density of around 1 $\mu W/cm^2$ at 3 feet. This is also the value given in the CCST report.

It is assumed that the 2.45 GHz Zigbee radio in the Fortis meter monitoring the appliances in the Home Area Network would be working with a 50% duty cycle. This transmitter would produce a power density at 3 feet of 0.74 $\mu W/cm^2$ which is similar to an always-on WiFi router at 3 feet.

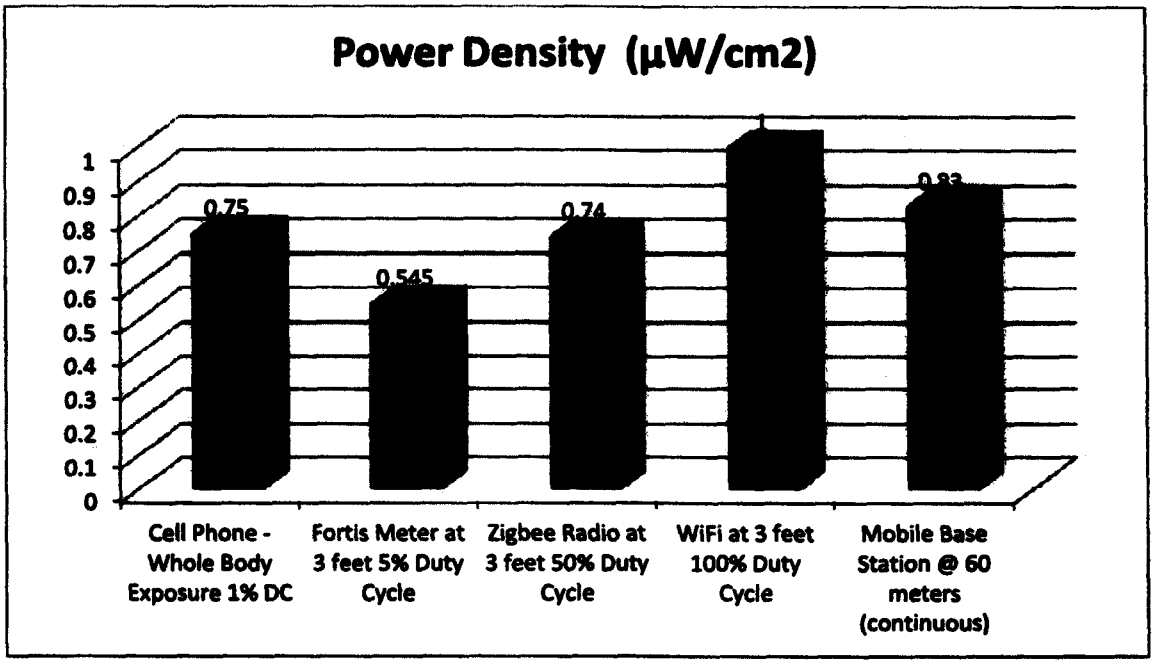
Cell towers, also called mobile base stations, emit radiation continuously and typically lead to maximal power densities between 50 and 100 meters from the antenna where the directional antenna radiation pattern comes closest to the ground. In 2000, the U.K. National Radiation Protection Board (Mann 2000) measured RF energy levels at 118 publicly-accessible sites around 17 mobile phone base stations. The maximum exposure at any location was 0.00083 mW/ cm^2 (0.83 $\mu W/cm^2$) on a playing field 60 meters from a school building with an antenna on its roof. This is the value used here for comparison.

California Council on Science and Technology, "Health Impacts of Radio Frequency from Smart Meters" Final Report April 2011. Available at http://www.ccst.us/publications/2011/2011smart-final.pdf

Hirsch, D. (2011) Comments on the Draft Report by the California Council on Science and Technology "Health Impacts of Radio Frequency from Smart Meters" 31 January 2011. Available at http://www.committeetobridgethegap.org/pdf/110212_RFrad_comments.pdf Accessed 1/2/2013

Mann, S.M.; TG Cooper et al (2000): Exposure to radio waves near mobile phone base stations. Natl Radiol Protec Board (U.K.), June 2000.

The following graph illustrates that the power density levels leading to whole body exposure are quite similar from these wireless devices and antennas.



Questions 2, 3 and 4:

2. What characteristics of the Transmissions, if any, have an effect on human health and/or biology?

3. Does the state of scientific research sufficiently establish that meters transmitting by radiofrequencies (such as the AMI meters proposed by Fortis) constitute a risk of serious as well as irreversible damage to health, through biological effects other than those resulting from heat?

4. What are the health effects of the Transmissions?

Dr. Maret's Response:

The principal characteristic of these Transmissions is their intermittent brief nature with each transmission burst estimated to last a fraction of a second (estimated to be less than 20 milliseconds). During active transmission, the 902 – 928 MHz carrier will be rapidly switched on and off as part of an assumed type of pulse code modulated (PCM) digital data stream being transmitted to the data collector located in the neighborhood. If each meter's electrical transmission were to be compared to sound, it might be characterized as analogous to a sudden gunshot blast or similar burst of sound followed by quiet until the next burst transmission.

The ZigBee radio operating at 2.4 GHz would probably be operating much more frequently analogous to WiFi with its ever-present carrier connection to smart appliances and other devices. In Question 1 assumed it was operating with a 50% duty cycle. I do not have enough information to describe the signal characteristics and modulation patterns of this higher frequency and lower power density signal but I assume it would be analogous to WiFi signaling. The Zigbee radio would operate at around seven times lower power output level but at fairly similar power density levels (see question 1) if it has the assumed higher duty cycle. Neither transmitter is unlikely to cause tissue heating but will still generate low level non-thermal microwave radiation in the home.

One of the most challenging and still controversial question in modern biology is whether weak microwave radiation might produce biological effects via a non-thermal mechanism. International microwave exposure guidelines, including those in the United States and Health Canada Safety Code 6, are based only on thermal heating effects which are well understood and accepted as damaging to tissues when they exceed regulatory guidelines. These guidelines are set principally by biophysics expert groups advising governmental regulatory agencies charged with ensuring that these guidelines are not exceeded. For thermal or heating effects these are wise and prudent guidelines.

The central question facing the current regulators of an automated metering infrastructure using microwave transmitters operating at non-thermal levels in the 900 MHz band is: Are there significant non-thermal biological or health effects over the 20 year lifespan of these RF devices? Over the last two decades there have been a large number of studies showing the biological impact of non-thermal RF radiation, including adverse health effects. The Carpenter Report for Hydro

Quebec (Carpenter 2012) gives an overview of many scientific studies demonstrating adverse biological and health effects at non-thermal exposures. Many researchers in the field of bioelectromagnetics have become convinced by looking at the data generated by thousands of studies over the last 50 years that non-thermal effects are real and potentially damaging to health (Sage and Carpenter 2009) which has been summarized in the Bioinitiative Working Group. Another compilation of the non-thermal effects has been published in the European Journal of Oncology (Giuliani and Soffritti 2010).

A standard textbook on bioelectromagnetics (2007 edition) states: "The biophysical lore prevailing until the late 1980s and lingering to this day is was that, unless the amplitude and frequencies of an applied electric field were sufficient to trigger an excitable membrane, produce tissue heating, or move an ion along a field gradient there could be no effect (on human tissue)...However, this position had to be changed as the evidence for weak (nonthermal) EMF bioeffects became overwhelming." (Pilla 2007).

Nonetheless, the scientific community continues to question the validity of the growing body of scientific research involving non-thermal RF exposure and keeps calling for additional research studies. It is this author's opinion that sufficient scientific data now exists about the non-thermal effects of RF radiation that a prevention-oriented approach to environmental RF radiation be followed. The current deployment of another layer of RF-based radiation from every dwelling has potential biological and health impacts that may only show up after years of exposure. These emissions will add to the current widespread microwave environment in most communities.

Carpenter, D.O. (2012): The State of Scientific Research as to Whether Advanced Meters transmitting by Radiofrequencies, as proposed in the Present Case, may constitute a Risk of Serious or Irreversible Damage to Health. An Expert Report for Regie de l'energie / Quebec Energy Board, Docket no. R-3770-2011, May 14, 2012.

Non-thermal Effects and Mechanisms of Interaction between Electromagnetic Fields and Living Matter. (2010) An ICEMS Monograph. Ramazzini Institute. Edited by Livio Giuliani and Morando Soffritti. European Journal of Oncology Library Vol. 5 National Institute for the Study and Control of Cancer and Environmental Diseases "Bernardino Ramazzini" Bologna, Italy.

Pilla, A. (2007) Mechanisms and Therapeutic Applications of Time-Varying and Static Magnetic Fields. Chapter 11 in Biological and Medical Aspects of Electromagnetic Fields. Barnes and Greenebaum (eds) in HANDBOOK OF BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS, 3rd edition. CRC Press, Boca Raton, FL.

C. Sage, D.O. Carpenter (Eds.), BioInitiative Working Group BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF), 2007. www.bioinitiative.org

Current Exposure Guidelines

Current maximum exposure guidelines are based principally on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommendations made in 1998 and published in Health Physics journal (ICNIRP 1998). These are guidelines only, not health or safety standards, and are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to electromagnetic fields (EMFs). The ICNIRP fails to address potential long-term effects of exposure, such as an increased risk of cancer,

concluding that "available data are insufficient to provide a basis for setting exposure restrictions" (ICNIRP 1998 p.496).

ICNIRP also states "Compliance with the present (1998) guidelines may not necessarily preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers and defibrillators, and cochlear implants. Interference with pacemakers may occur at levels below the recommended reference levels." (p.495) Thus there may be a potential risk for people with these types of devices exposed to RF fields following these guidelines including the possibility of interference from smart meters. It would be prudent to have the effect of smart meter emissions tested on all susceptible devices and ascertain the risk on vulnerable populations that may be adversely affected.

Medical devices are tested for immunity to external RF radiation between 26 MHz and 1 GHz (extended recently to 2.5 GHz in Europe) and must be immune to levels of field strengths of at least 3 volts per meter (V/m) . Higher RF immunity is required with life support equipment which should not be affected by field strengths of 10 V/m. The author is not aware if any testing has been carried out to determine if RF meters transmitting bursts of 900 MHz data have sufficient peak power to adversely trigger any medical devices. In terms of power density levels near the meters, especially if they were located indoors, it is estimated that these levels would be reached from a FortisBC meter at 58 cm or 1.92 feet for a field strength 10 V/m = 26.5 μW/cm2 and at 194 cm or 6.4 feet for a field strength of 3 V/m or 2.4 μW/cm2. Although most implanted pacemakers are able to withstand fairly high levels of RF interference, insulin infusion pumps or other sensitive equipment might be potentially affected.

The FCC and Health Canada Safety Code 6 have essentially adopted these guidelines in formulating their safety recommendation and they are also being cited in the current automated metering infrastructure applications to the BCUC. It should be noted that these guidelines are now almost 15 years old even though a large body of scientific evidence has arisen to show the biological impact of non-thermal radiation which have not been considered by this international private body.

Other countries, especially in Europe have addressed the possible impact on health caused by non-thermal mechanisms. In the United Kingdom, the Stewart Report from the Independent Expert Group on Mobile Phones (IEGMP) in 2000 had as one of its conclusions (Background No. 1.4) that: "There are two direct ways by which health could be affected as a result of exposure to RF radiation. These are by thermal (heating) effects caused mainly by holding mobile phones close to the body, and as a result of possible non-thermal effects from both phones and base stations." (IEGMP, 2000). In addition, the British National Council for Radiation Protection and Measurements (NCRP) did a review in 1986 and <u>explicitly acknowledged the existence of non-thermal effects</u>, including provisions for reduced maximum-allowable limits should certain radiation characteristics occur during exposure (NCRP 1986, Blackman, 2009).

To summarize, the current exposure guidelines adopted by Health Canada Safety Code 6 are closely aligned with ICNIRP and do not consider long-term exposure, modulation patterns of the RF

carrier, and any low level non-thermal effects. The standard is solely concerned with short-term exposures leading to tissue heating effects. Thus these standards do not protect the public from low level chronic exposure which includes emissions from RF mesh network meters.

Blackman, C. (2009) Cell phone radiation: Evidence from ELF and RF studies supporting more inclusive risk identification and assessment. Pathophysiol. 16: 205-216.

IEGMP (2000). Mobile Phones and Health. Report of an Independent Expert Group on Mobile Phones. UK Minster of Public Health. National Radiological Protection Board, Chilton, Oxon: www.iegmp.org.uk

ICNIRP Guidelines for limiting Exposure to Time-Varying electric, magnetic and electromagnetic fields (up to 300 GHz). (1998) Health Physics 74 (4):494-522.

National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.

Advice on Limiting Exposure to Electromagnetic Fields (0-300 Ghz), (2004) Documents of the NRPB, Volume 15 No.2, 2004. www.nrpb.org

Alternative Exposure Guidelines

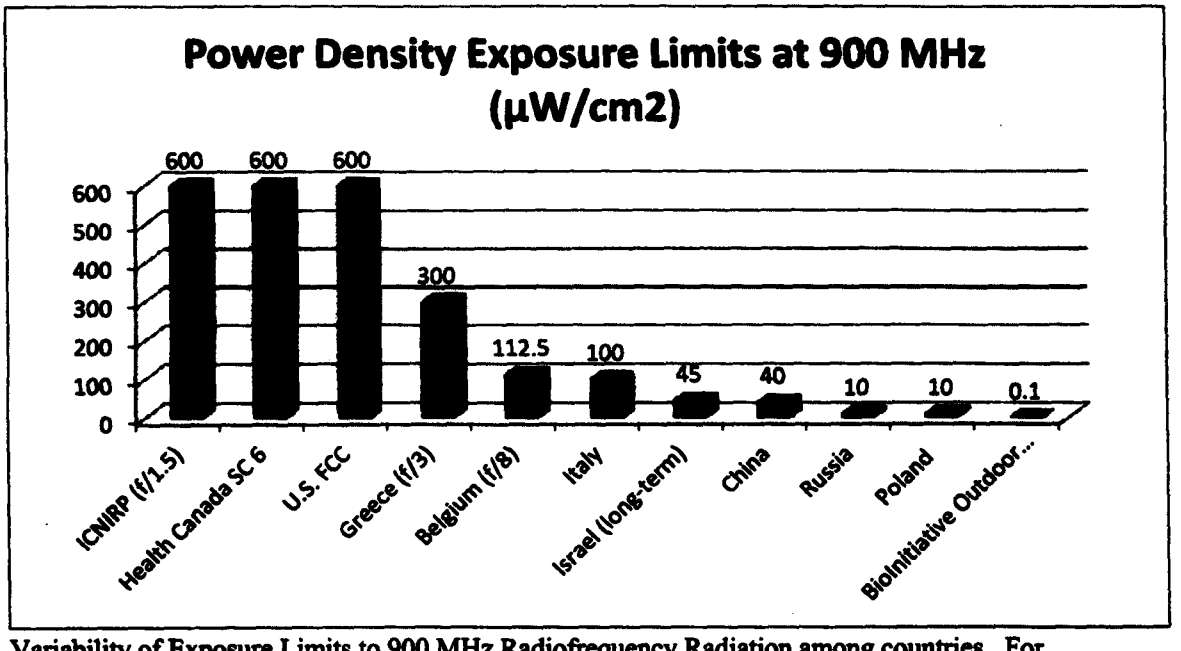
Other countries in the world have lower exposure guidelines and did not follow the ICNIRP exposure criteria. Chief among them is Russia and other formerly East Block nations that had studied the effects of RF radiation for many years and are concerned about non-thermal effects. The scientific basis for the formerly Soviet and now Russian radiofrequency standards was recently described (Repacholi 2012). They considered the results of many studies such as those on mechanisms of biological responses, effects of acute and chronic exposure of animals, and effects on volunteers and workers. Some of the most important studies providing the basis for RF exposure limits were immunological studies (Dronov 1971; Shandala 1982,1985; Varetski 1985; Vinogradov 1985, 1986, 1987, 1991). These studies involved rabbits, guinea pigs, rats and mice and exposure levels between 1 – 500 uW/cm2, all at non-thermal levels.

As a result of an extensive research program, the current Russian exposure standards are 10 $\mu W/cm^2$ (0.1 W/m^2) for the general public which is 60 times lower than ICNIRP exposure standards at 900 MHz. Russian standards for mobile phones are based on power density levels of less 3 $\mu W/cm^2$ at 37 cm from the phone which equates with an EIRP of 52 mW from the phone. These Russian mobile phone guidelines are much less than Canadian and U.S. guidelines. If one compared a FortisBC meter when transmitting at peak power to this Russian standard for mobile phones, a level of 3 $\mu W/cm^2$ would be still present at 174 cm (5.7 feet) from the meter, while a level of 10 $\mu W/cm^2$ would be present at 95 cm (3.1 feet) from the meter.

Other countries such as Poland, Hungary, Bulgaria have the same exposure limits as Russia, while Israel has the same short-term exposure limit as ICNIRP but a long-term (continuous and prolonged exposure) limit of 10 times less or 45 $\mu W/cm^2$ (Frequency / 20). China also has a stricter exposure limit of only 40 $\mu W/cm^2$ which is 15 times lower than Canada's exposure guidelines. An excellent overview of the health effects from non-thermal fields and the need for new exposure guidelines is available from Professor Al Salameh (2011).

As increasing numbers of studies about non-thermal RF exposure began to show significant biological and health effects, an international collaboration of scientists emerged called the BioInitiative Working Group (BWG) which issued a comprehensive report about the state of current research in this area (Sage and Carpenter 2007, 2012). Based on a scientific evaluation of over 2000 studies, this group suggested that new, lower exposure guidelines be applied that take into account long-term exposure, modulation patterns and are in alignment with the Precautionary Principle.

This precautionary approach states if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is ***not*** harmful falls on those taking the action. In alignment with these principles, the BWG suggest, if possible, an outside power density level be less than 1000 $\mu W/m^2$ (0.1 $\mu W/cm^2$) and an indoor exposure limit of 100 $\mu W/m^2$ (0.01 $\mu W/cm^2$). With the Fortis meter operating at peak power, these outdoor limits would exceeded up to a distance of 9.5 meter (31 feet) while the lower indoor limits of 100 $\mu W/m^2$ would be exceeded up to a distance of 30 meters (98.8 feet) from the meter. Thus potential biologically-important power density levels would appear during the brief transmissions quite a distance from the meter using these exposure guidelines.



Variability of Exposure Limits to 900 MHz Radiofrequency Radiation among countries. For comparison, the peak power density of Fortis Meters is 227 $\mu W/cm^2$ at 20 cm distance from meter.

The European Union (EU) has recognized the potential danger of electromagnetic fields and their effect on the environment by passing the 2011 resolution 1815 27/05/2011 in the European Parliament. This resolution suggests that the precautionary principle be applied and that all member nations of the EU take all reasonable measures to reduce exposure to electromagnetic

fields (EMFs), especially to radiofrequencies from mobile phones and other wireless sources including relay antenna base stations (cell towers), and to make risk assessment more prevention oriented. They also recommend precautionary levels that are "as low as reasonably achievable" – the ALARA principle.

Many scientists believe that exposures from all RF sources are ultimately additive so that the body burden from smart meter emission is in addition to those received from other wireless devices, base stations and cell towers, personal use of cell and cordless phones and computers with wireless functionality. Smart meters are a new type of pulsed radiation pattern that is significantly more powerful than existing wireless devices with the exception of cell phones as described above.

Al Salameh, M.S.H. (2011): Waves and Fields of Wireless Communications and Electricity – Health Effects and Unconventional Utilizations. Lambert Academic Publishing, Saarbruecken, Germany ISBN: 978-3-8383-5594-8

Council of Europe, Parliamentary Assembly, Resolution 1815 27/5/2011 (2011): The potential dangers of electromagnetic fields and their effect on the environment. Available at http://iemfa.org/index.php/actueel-mainmenu-6 Accessed Jan 1, 2013.

Dronov S, Kiritseva AI. (1971). Specific features of immunobiological shifts in immunized animals in chronic irradiation with radio waves of super-high frequency. Gig Sanit 7:51–53 (in Russian).

C. Sage, D.O. Carpenter (Eds.),(2007) BioInitiative Working Group BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF.. http://www.bioinitiative.org. Updated in 2012.

Repacholi,M.; M., Y. Grigoriev, J. Buschmann, C.Pioli (2012): Scientific basis for the Soviet and Russian radiofrequency standards for the general public. Bioelectromagnetics Volume 33, No. 8, pages 623-633.

Shandala MG, Vinogradov GI, Rudnev MI, Rudakova SF. 1983.Effects of microwave radiation on cell immunity in conditions of chronic exposure. Radiobiologia 23:544–546 (in Russian).

Shandala MG, Vinogradov GI, Rudnev MI, Naumenko GM, Batanov GV. 1985. Non-ionizing microwave radiation as an inducer of auto-allergic processes. Gig Sanit 8:32–35 (in Russian).

Shandala MG, Vinogradov GI. 1982. Auto-allergic effects of microwave electromagnetic energy in rats with special reference to the fetus and offspring. Vestnik AMN 10:13–16 (in Russian).

Varetski VV, Dyatchenko VN, Rudnev MI, Galich LN, Bassen H. 1985. Exposure conditions and dosimetry for the investigation of biological effects from non-ionizing microwave radiation. Gig Sanit 10:40–43 (in Russian).

Vinogradov GI, Dumanski YD. (1974). Change in the antigen properties of tissues and auto-allergic processes after exposure to ultra-high frequency energy. Byul Eksp Biol Med 8:76–79 (in Russian).

Vinogradov GI, Dumanski YD. (1975). About the sensitizing effect of electromagnetic fields of ultra-high frequency. Gig Sanit 9:31–35 (in Russian).

Vinogradov GI, Batanov GW, Naumenko GM, Levin AD, Trifonov SI. (1985). The influence of non-ionising microwave radiation on auto-immune reactions and antigenic structure of proteins. Radiobiologia 25(6):840–843 (in Russian).

Vinogradov GI, Naumenko GM. (1986). Experimental simulation of the autoimmune reactions under the effect of non-ionising microwave radiation. Radiobiologia 5:705–708.

Vinogradov GI, Naumenko GM, Vinarskaya EM, Gonchar NM. (1987). Biological significance of autoimmune reactions of the organism after exposure to environmental factors. Gig Sanit 1:55–58 (in Russian).

Vinogradov GI, Andrienko LG, Naumenko GM. (1991). Phenomenon of adaptive immunity under the effect of non-ionising microwave radiation. Radiobiologia 31:718–721 (in Russian).

Biological and Health Effects

Evidence for non-thermal microwave effects comes from many types of studies including altered cell responses in in-vitro cell culture studies, animal studies (in vivo), and from epidemiological studies of population exposure from various cell towers, radio and TV transmitters. No studies on the effects of RF mesh meters (such as proposed by FortisBC) on biological tissues, animals or humans have been carried out.

Electromagnetic exposure characteristics can be variable including:

1. frequency or wavelength effects;
2. duration of exposure specifically whether continuous or interrupted and short versus long term or chronic exposure;
3. the modulation pattern of the waves including whether continuous or pulsed fields, and the type of amplitude, frequency, phase or pulsed modulation characteristics.
4. The polarization pattern of the wave can also be a variable.

All these parameters can affect the biological responses to non-thermal waves and also be a factor in thermal microwave exposure. Living systems are highly complex and respond to microwave radiation in many cases in a non-linear manner so that the dose-response relationship can be quite complex (Philips 2004).

Radiofrequency (RF) radiation has many biological effects even at low power density levels. Smart meters transmit at low power density levels compared to existing thermal standards. In the scientific literature low power densities of transmitted power have been known about since the 1970s. Biologist Allan Frey was one of the most active microwave researchers during this time in the U.S. and demonstrated altered animal behavior at 8 $\mu W/cm^2$ (Frey 1979), altered heart rate in frogs at 3 $\mu W/cm^2$ (Frey 1970) and was able to stop isolated frogs' hearts to stop beating at only 0.6 $\mu W/cm^2$ with proper timing in the cardiac cycle (Frey 1968). A summary of this research of low-intensity microwave radiation was already published in the 1980s (Frey 1988).

Frey AH, Seifert E. (1968) Pulse modulated UHF energy illumination of the heart associated with change in heart rate. *Life Sciences* 7 (Part II): 505-512.

Frey AH. (1970) Cardiac and neural effects of modulated RF energy. *Proceedings of the 23rd AnnualConference on Engineering in Medicine and Biology* 12:175.

Frey AH, Wesler L. (1979) Modification of tail pinch consummatory behavior in microwave energy exposure. *Proceedings of the URSI Annual Meeting, June 18-22, Seattle, WA, 1979.*

Frey AH. (1988) Evolution and results of biological research with low-intensity nonionizing radiation. In Marino AA, ed., *Modern Bioelectricity*, Dekker, NY. pp. 785-837.

Although the scientific community is still divided about the issue of whether non-thermal RF radiation is harmful, a large body of scientific data exists showing biological responses and health effects in many types of animals, cell cultures and human exposures. In Table 1 below, relevant studies have been ranked from lowest to highest power density levels, with none of the studies exceeding 11 microwatts per square centimeter. This level corresponds to the emission of Fortis smart meter at 20 cm with a 5% duty cycle. It is clear that biological and health effects have been documented at power density levels comparable to emissions from smart meters. Since the emissions from RF utility meters have not been studied in terms of Specific Absorption Rate (SAR), only studies where power density levels were known are included here. A complete list of

good quality studies compiled by Levitt and Lai with defined low level RF exposures in terms of either power density levels or SAR values is included in Appendix A.

Table 1: Scientific Studies demonstrating Biological Effects at Low Exposure Levels

Model	Exposure conditions Power density	Reported Biological Effect	References
Human	0.000000001 $\mu W/cm^2$	Altered EEG in humans' brain waves & behavior	W. Bise (1978), Low power radio-frequency and microwave effects on human electroencephalogram and behavior. *Physiological Chemistry and Physics*, 10(5):387- 398.
Human	0.002 $\mu W/cm^2$	Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problems	Altpeter *et al.* (1995, 1997), Study on health effects of the shortwave transmitter station of Schwarzenburg, Berne, Switzerland, Study No. 55, Swiss Federal Office of Energy).
Human	0.01 $\mu W/cm^2$	Human sensation	Kolbun and Sit'ko (1987), Sensory indications by the human body of EHF-range electromagnetic radiation. *Mechanisms of Biological Action of Electromagnetic Radiation: Proceedings of the Pushchino Symposium*, 27- 31 Oct. 1987,
Rats and rabbits	0.01 – 0.5 $\mu W/cm^2$	Changes in EEG	Shandala M G, Dumanskii U D, Rudnev M I, Ershova L K and Los I P (1979). Study of nonionizing microwave radiation effects upon the central nervous system and behavior reactions. *Environ Health Perspect*, 30,115.
Rats and Rabbits	0.06 $\mu W/cm^2$	Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, structural changes in liver, spleen, testes, and brain	Dumanskij & Shandala (1974), The biologic action and hygienic significance of electromagnetic fields of superhigh and ultrahigh frequencies in densely populated areas. *Biologic Effects and Health Hazards of Microwave Radiation, Proceedings of an International Symposium*,Warsaw, 15-18 Oct. 1973,
Human	0.1 $\mu W/cm^2$	EEG brain waves altered under exposure to cell phone signal	L. Von Klitzing (1995), 'Low-Frequency pulsed electromagnetic fields influence EEG of man.' Physica Medica, Vol. 11, No. 2, pp. 77-80
Mice	0.168 $\mu W/cm^2$	Progressive decrease in number of newborns and irreversible infertility after 5 generations exposure to radiation from 'antenna park'.	I.N. Magras and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics, 18(6), pp. 455-461.
Human	0.3 $\mu W/cm^2$	Impaired motor function, reaction time, memory and attention of schoolchildren	A.A. Kolodynski and V.V. Kolodynska (1996), Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia. *The Science of the Total Environment* 180:87-93
Frogs	0.6 $\mu W/cm^2$	Cardiac arrhythmias and sometimes cardiac arrest	Frey, 1986. Evolution and results of biological research with low-intensity nonionizing radiation. *Modern Bioelectricity*, A.A. Marino, ed., pp. 785-837. New York, NY: Dekker
Human	0 – 4 $\mu W/cm^2$	Altered white blood cell activity in schoolchildren	H. Chiang et al., 1989. Health effects of environmental electromagnetic fields. *Journal of Bioelectricity* 8(1):127-131
Human	1 $\mu W/cm^2$	Headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion	V. B. Simonenko et al., 1998. Influence of electromagnetic radiation in the radiofrequency range on the health condition of an organized collective. *Voenno-meditsinskiy zhurnal* CCCXIX(5):64-68
Guinea Pig	1 $\mu W/cm^2$ 2.375 GHz	Neutrophil stimulation and Complement titers	M.G. Shandala and G.I. Vinogradov, 1978. Immunological effects of microwave action. *Gigiyene i Sanitariya*, no.10:34-38, US Joint Publication Research Service JPRS 72966, pp. 16-21 Mar 1979
Fruit Fly	1 – 10 $\mu W/cm^2$ GSM 900 and 1800	Reproductive capacity and induced cell death	Chavdoula ED et al, 2010 Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: Detection of apoptotic cell-death features. Mutation Research 700 pp. 51–61
Mice	1.053 $\mu W/cm^2$	Irreversible infertility in mice after 3 generations	Magras I.N. and T.D. Xenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics, 18(6), pp. 455-461.
Rats	2.5 $\mu W/cm^2$	Breakdown of blood-brain barrier (GSM phones)	Salford et al., (1997), Blood brain barrier permeability in rats exposed to electromagnetic fields from a GSM wireless communication transmitter. In: *Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine*, June 8-12, 1997, Bologna, Italy,
Cultured Chicks	2 - 4 $\mu W/cm^2$	Acetylcholine ion channels in cultured chick myotubes	Tamburello and B.M. Zani (1988), Microwave effects on acetylcholine-induced channels in cultured chick myotubes. *Bioelectromagnetics* 9(4):363-372.
Human Whole body	4 – 10 $\mu W/cm^2$	Lower memory function / visual reaction time in children slowed in tests living near transmitters	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. Journal of Bioelectricity, 8: 127- 131
Human: Women	5 $\mu W/cm^2$ 4.3 V/m exposure	Effects on Immune System in Women over 2 years	Boscolo et al 2001 Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. Science of the Total Environment Vol 273 (1-3), pp 1-10

Human	5 $\mu W/cm^2$	Leukemia, skin melanoma & bladder cancer near TV & FM transmitter	H. Dolk, G. Shaddick, P. Walls, C. Grundy, B. Thakrar, I. Kleinschmidt and P. Elliott (1997) Cancer incidence near radio and television transmitters in Great Britain. Am J Epidemiology 145(1) P 1-9
Human	5 $\mu W/cm^2$	Biochemical and histological changes in liver, heart, kidney, and brain tissue	V.S. Belokrinitskiy (1982), 'Hygienic evaluation of biological effects of nonionizing microwaves', *Gigiyena i Sanitariya* 6:32-34, JPRS 81865, pp. 1-5
Human	5 - 10 $\mu W/cm^2$	Nervous system activity impaired	Dumanski and Shandala (1974), The Biological Action and Hygenic Significance of Electromagnetic Fields of Superhigh and Ultrahigh frequencies in Densely Populated Areas,' from Biological Effects and Health Hazards of Microwave Radiation. Proceedings of an International Symposium, Warsaw 15-18 October, 1973, Polish Medical Publishers, Warsaw, 1974
Fruit Fly	10 $\mu W/cm^2$ GSM 900 and 1800 1- 21 min/day, 5 days	Reproductive capacity of the fly decreased linearly with increased duration of exposure.	D.J. Panagopoulos, L.H. Margaritis, The effect of exposure duration on the biological activity of mobile telephony radiation, Mut. Res. 699 (2010) 17–22. D.J. Panagopoulos, L.H. Margaritis, The effect of exposure duration on the biological activity of mobile telephony radiation, Mut. Res. 699 (2010) 17–22.
Human	10 $\mu W/cm^2$ (1170 test subjects)	Impaired / reduced short-term memory function and significant differences in visual reaction time	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. *J. Bioelectricity* 8(1):127-131
Animals	10 $\mu W/cm^2$	Damaged mitochondria, nucleus of cells in hippocampus of brain	V.S. Belokrinitskiy (1982), Destructive and reparative processes in hippocampus with long-term exposure to nonionizing microwave radiation. *Bulletin of Experimental Biology and Medicine* 93(3):89-92. In U.S.S.R. Report, Effects of Nonionizing Microwave Radiation, No. 7, JPRS 81865, pp. 15-20.
Animals	10 $\mu W/cm^2$	Redistribution of metals in the blood, bones, brain, heart, liver, lungs, kidney, muscles, spleen and skin	O.I. Shutenko, I.P. Kozyarin and I.I. Shvayko (1981), Effects of superhigh frequency electromagnetic fields on animals of different ages. *Gigiyena i Sanitariya, no.* 10:35-38, JPRS 84221, pp. 85-90.
For Comparison			
Fortis Meter	11 $\mu W/cm^2$ 900 MHz RF Mesh Radio	**Peak Power Density at 5% Duty Cycle**	Calculated as peak power density of 227 $\mu W/cm^2$ x 0.05 (DC) at 20 cm distance = 11 $\mu W/cm^2$

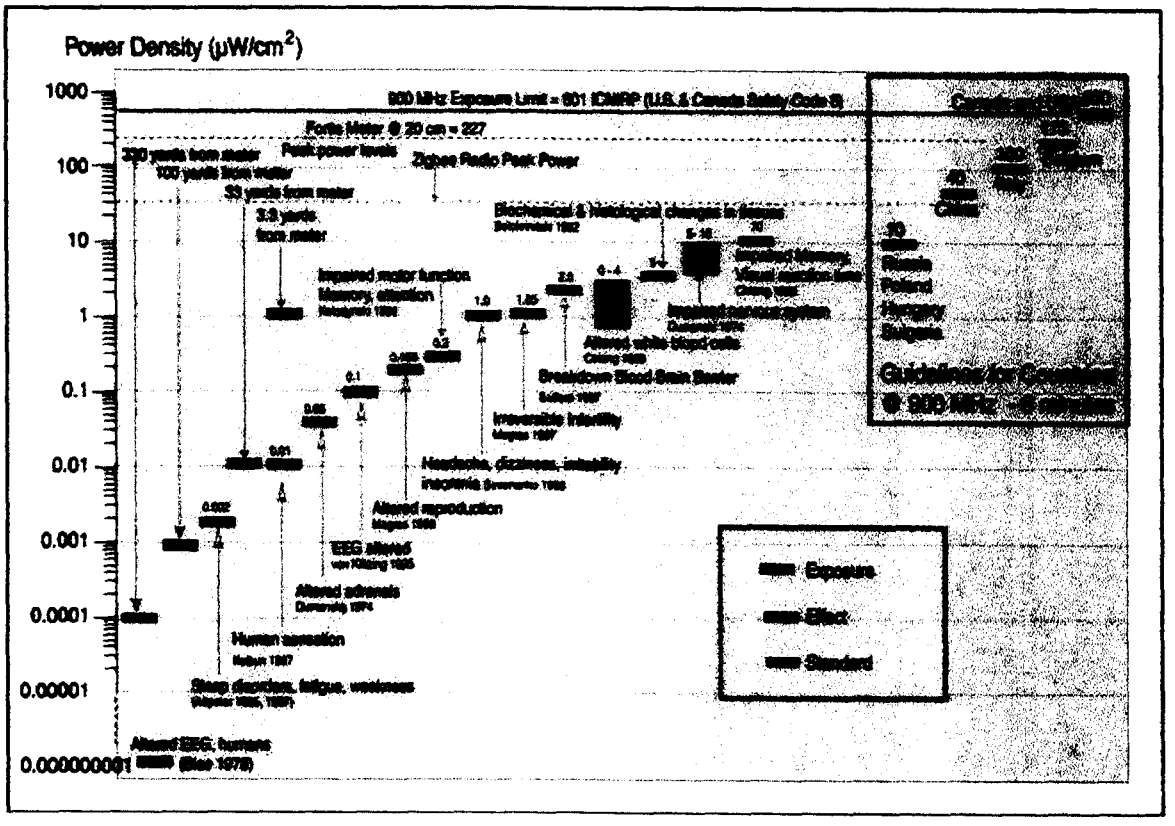


Diagram 1: Effects of Low intensity Microwave Exposure in various Animals and Human Studies. References to specific studies are listed in Table 1 (above).

Human Low Level Provocation Study

Three ministries within the Dutch government commissioned the TNO Physics and Electronics Laboratory in the Netherlands to carry out double-blind experiments on human volunteers to study the effects radiation mimicking common residential exposure to third generation (UMTS) cell towers. Exposure was for only 45 minutes at field strengths of only 0.7 V/m, equivalent to 0.13 $\mu W/cm^2$. These are extremely low levels (4615 times lower than the thermal exposure limit of 600 $\mu W/cm^2$) and the effects are entirely non-thermal at these exposures. Exposed subjects frequently reported one or more of the following: dizziness and nausea, shortness of breath, numbness and tingling, inability to concentrate, irritability, nervousness, headaches, fatigue, weakness, muscle pains, heart palpitations and chest pain. (Zwamborn 2003). These types of responses are similar to those reported by electrically hypersensitive people discussed in more detail later.

Zwamborn A, Vossen S, van Leersum S, et al. (2003): Effects of global communication system radio-frequency fields on well-being and cognitive functions on human beings with and without subjective health complaints. TNO-report FEL-03- C148. The Hague: TNO Physics and Electronic Laboratory.

Selected In Vitro Cell Culture Studies

Many of these effects were found from in-vitro cell culture studies. In addition there are changes in cells from oxidative stress following EMF exposure. Details can be found in Appendices B and C.

In addition to in-vivo studies on animals and humans, there are many in-vitro studies on cell cultures that have demonstrated non-thermal effects. A cross-section of these studies is shown in Table 2 below. Cell culture studies have shown both single strand and double strand DNA damage, cellular stress especially through the production of heat shock proteins, oxidative stress , altered gene expression, alteration in signal transduction pathways, to name only the most common effects from non-thermal exposure. Notable is the finding that there are specific frequency and amplitude biological windows originally identified by Bawin, Adey and Blackman. They affect calcium efflux from cells and affect enzyme systems such as ornithine decarboxylase. The work of Blank and Goodman and is also notable in demonstrating direct effects of low level electromagnetic field exposure on gene activation and transcription which is part of a cellular stress response which, over time, has a high probability to permanently damage health. Blank 2004a, 2004b, 2011).

While it is not important for the purposes of this report to go into detail of the various effects observed or the postulated mechanism of action of these non-thermal effects described within the bioelectromagnetics community, the fact that these effects are being observed repeatedly under many diverse experimental conditions, suggests that increasing levels of microwave exposure in the environment can have potential health consequences that may only appear after many years exposure.

Table 2: Selected Examples of Non-thermal Effects of Microwaves on Cells

Cells Studied	Effects	Reference
Preloaded synaptosomes	Changes in calcium efflux	Lin-Liu S and Adey W R (1982). Low frequency amplitude modulated microwave fields change calcium efflux rates from synaptosomes. *Bioelectromagnetics*, 3, 309.
Reuber 35 hepatoma cells	Ornithine decarboxylase	Byus C V, Kartun K, Pieper S and Adey W R (1988). Increased ornithine decarboxylase activity in cultured cells exposed to low energy modulated microwave fields and phorbol ester tumor promoters. *Cancer Res*, 48, 4222.
AMA human epithelial cells	Cell proliferation	Velizarov, S., P Raskmark, S Kwee (1999) The effects of radiofrequency fields on cell proliferation are non-thermal. Bioelectrochemistry and Bioenergetics 48 (1) pp. 177-180
Human Neuroblastoma cells	Change in calcium ion efflux from brain tissue	S. K. Dutta et al, (1986). Microwave radiation-induced calcium ion flux from human neuroblastoma cells: dependence on depth of amplitude modulation and exposure time. *Biological Effects of Electropollution*, S. Dutta and R. Millis, eds., pp. 63-69. Philadelphia, PA: Information Ventures
Human lymphocytes	53BP1 DNA-breaks co-localizing foci	Marková, E., Lena Hillert, Lars Malmgren, et al (2005) Microwaves from GSM Mobile Telephones Affect 53BP1 and v-H2AX Foci in Human Lymphocytes from Hypersensitive and Healthy Persons. Environ Health Perspect. 113 (9) pp. 1172-1177
Lymphocytes, E.Coli cells	Chromatin conformation	Belyaev, I.Y., Shcheglov, V.S., Alipov, E.D., Ushakov, V.L. (2000) Non-thermal effects of extremely high frequency microwaves on chromatin conformation in cells in vitro: Dependence on physical, physiological and genetic factors. *IEEE Transactions on Microwave Theory and Techniques*, vol. 48, str. 2172-2179
Rat atrocities and porcine brain capillary endothelial cells	Permeability of an in vitro model of the blood-brain barrier (BBB)	Schirmacher, A., S. Winters, S. Fischer, J. Goeke, et al. (2000) Electromagnetic fields (1.8 GHz) increase the permeability to sucrose of the blood-brain barrier in vitro. Bioelectromagnetics Volume 21(5) pp. 338-345

Rat brain cells	DNA damage as measured with comet assay	Lai H and Singh N P (1997). Melatonin and a spin-trap compound block radiofrequency electro-magnetic radiation-induced DNA strand breaks in rat brain cells. *Bioelectromagnetics*, 18, 446.
Human mast cell line, HMC-1	Expression of the proto-oncogene c-kit, the transcription factor Nucleoside diphosphatekinaseB and the apoptosis-associated gene DAD-1	Harvey C, French P-W. (2000) Effects on protein kinase C and gene expression in a human mast cell line, HMC-1, following microwave exposure. Cell Biol Int 23 pp.739-748
Human endothelial cell line	Activation of the hsp27/p38MAPK stress pathway	Leszczynski, D., Joenvaara, S., Reivinen, J. and Kuokka, R. (2002) Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood-brain barrier-related effects. Differentiation 70, 120–129
Human peripheral blood cultures	Micronucleus frequency (from phase-modulated wave)	d'Ambrosio, G., R. Massa, M.R. Scarfi, O. Zeni (2002) Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. Bioelectromagnetics 23 (1) pp. 7-13.

Non-thermal microwave effects from in-vitro cell culture studies show a variety of responses and are used by scientists to study potential mechanisms of the non-thermal effects. All these studies do not appear to involve heating effects and occur at exposure levels significantly below the current exposure guidelines. Living systems are highly complex and respond to microwave radiation in many cases in a non-linear manner so that the dose-response relationship can be quite complex (Philips 2004).

Blank,M.; R. Goodman (2004a): Initial interactions in electromagnetic field-induced biosynthesis, J. Cell. Physiol. 199 : 359–363.

Blank,M.; R. Goodman (2004 b): A biological guide for electromagnetic safety: the stress response electromagnetic initiation of transcription at specific DNA sites, Bioelectromagnetics 25 : 642–646.

Blank, M. and R. Goodman (2011): DNA is a fractal antenna in electromagnetic fields. International Journal of Radiation Biology , Vol. 87, No. 4, Pages 409-415

Philips, A. (2004) Are we measuring the right things? (Windows, viewpoints and sensitivity). Chapter 12 in Electromagnetic Environments and Health in Buildings Derek Clements-Croome (editor), Spon Press, London 2004.

Effects of Modulation Patterns

The type of modulation used in wireless signals influences the extent to which the RF radiation affects living tissues. There are windows of both frequency and power density levels that cause a biological response in contrast to higher power density levels where there may be no effect. (Bawin 1975, 1978; Blackman 1989; Del Re 2006). Each type of modulation of a carrier frequency may convey specific 'information' to the living body and some modulation patterns are more bioactive than others depending on the physical reactivity of specific tissues. Current safety standards do not take this issue into account and are thus inadequate in protecting the public in terms of chronic exposure to some forms of extremely low frequency (ELF) modulated RF carrier signals.

Since no studies have been carried out with the pulsed modulation patterns of intermittent transmissions from RF mesh network meters, it would be erroneous to simply assume that they have no biological or health impact, especially since adverse neurological responses to their emissions has been reported in electrically hypersensitive individuals in self-reporting surveys.

Low intensity microwaves with different modulation patterns can have quite different effects, even when they are of the same frequency and intensity. A good overview of the importance of considering modulation patterns in risk assessment has recently been published (Blackman 2009). The following references all have demonstrated that modulation patterns can have an effect in living systems.

Arber, S.L., and Lin, J.C. (1985): Microwave-induced changes in nerve cells: effects of modulation and temperature. Bioelectromagnetics, 6 (3): 257–270.

Bawin, S.M. , L.K. Kaczmarek, W.R. Adey, (1975) Effects of modulated VHF fields on the central nervous system, Annals of the New York Academy of Sciences 247: 74–81.

Bawin, S.M. , A.R. Sheppard,W.R. Adey,(1978): Possible mechanism of weak electromagnetic field coupling in brain tissue, Bioelectrochemistry & Bioenergetics 5: 67–76.

Blackman, C.F. , L.S. Kinney, D.E. House, W.T. Joines (1989): Multiple power-density windows and their possible origin, Bioelectromagnetics 10 (2) : 115–128.

Blackman, C. (2009) Cell phone radiation: Evidence from ELF and RF studies supporting more inclusive risk identification and assessment. Pathophysiol. 16: 205-216.

Baranski, S. (1972) Histological and histochemical effects of microwave irradiation on the central nervous system of rabbits and guinea pigs. Am. J. Phys. Med. 51: 182–190.

Del Re,B., F Bersani, P.Mesirca, G.Giorgi (2006) :Synthesis of DnaK and GroEL in *Escherichia coli* cells exposed to different magnetic field signals. Bioelectrochemistry Volume 69 (1) : 99-103.

Campisi, A., Gulino, M., Acquaviva, R., Bellia, P., Raciti, G., Grasso, R., Musumeci, F., Vanella, A., and Triglia, A. (2010): Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. Neurosci. Lett. 473(1): 52–55.

d'Ambrosio, G., Massa, R., Scarfi, M.R., and Zeni, O. (2002): Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. Bioelectromagnetics, 23(1): 7–13.

Frey, A.H., Feld, S.R., and Frey, B. (1975): Neural function and behavior: defining the relationship in biological effects of nonionizing radiation. Ann. N. Y. Acad. Sci. 247(1) pp. 433–438.

Hung, C.S., Anderson, C., Horne, J.A., and McEvoy, P. (2007): Mobile phone 'talk-mode' signal delays EEG-determined sleep onset. Neurosci. Lett. 421(1): 82–86.

Luukkonen, J., Hakulinen, P., Ma¨ki-Paakkanen, J., Juutilainen, J.,and Naarala, J. (2009) Enhancement of chemically induced reactive oxygen species production and DNA damage in human SHSY5Y neuroblastoma cells by 872 MHz radiofrequency radiation. Mutat. Res. 662: 54–58.

Markkanen, A., Penttinen, P., Naarala, J., Pelkonen, J., Sihvonen, A.P., and Juutilainen, J. (2004): Apoptosis induced by ultraviolet radiation is enhanced by amplitude modulated radiofrequency radiation in mutant yeast cells. Bioelectromagnetics, 25(2): 127–133.

Oscar, K.J., and Hawkins, T.D. (1977) Microwave alteration of the blood-brain barrier system of rats. Brain Res. 126(2): 281–293.

Sanders, A.P., Joines, W.T., and Allis, J.W. (1985): Effect of continuous-wave, pulsed, and sinusoidal–amplitude–modulated microwaves on brain energy metabolism. Bioelectromagnetics, 6(1): 89–97.

Concerns about Nighttime Meter Emissions

Microwave radiation exposure from RF mesh network and Home Area Network Zigbee transmitters occurring during sleep may adversely affect our biological and circadian rhythms, the daily physiological regulatory cycles. Smart Meters will pulse intermittently day and night and may have an adverse effect on sleep cycles. Unlike the users of cellphones who do not use them during sleep, RF mesh network meters will continue to emit low levels of pulsed RF radiation intermittently all night long.

Exposure to microwave /radiofrequency fields affect the neuroendocrine system causing neuroendocrine chemical modulations and neurobehavioral reactions. Already in 1970s it was known that resonant absorption within the cranium may result in the focusing of energy and the production of electromagnetic "hot spots" in the brain (Johnson & Guy 1972). Microwaves may disturb the critical hormonal regulatory areas including the hypothalamic-pituitary axis through "low intensity" exposure. The body may elicit "different responses relative to the timing of the exposure with respect to circadian rhythm" (Michaelson 1982).

At night, while sleeping, the body is principally in a repair mode and the exposure to microwave radiation from these meters may potentially be more damaging than exposure during the day. It is vital that long-term exposure studies during the night be carried out to determine if pulsed microwave radiation from the meters could have an adverse biological effect on the population. One of the most common complaints from exposure to existing smart meter installations are sleep disturbances which mostly disappear when the person is removed from the environment near the meters (see page 28 on Electrically Hypersensitive Population).

Johnson, C.C. & A.W. Guy (1972) Nonionizing electromagnetic wave effects in biological materials and systems. Proc IEEE, 60: 692.

Michaelson, S.M. (1982) The Influence of Radiofrequency/ Microwave Energy absorption on physiological regulation. Br. J. Cancer 45, Suppl. V: 101-108.

Long Term Effects of Microwave Emissions

The majority of scientific studies have been done on short-term effects of microwaves at various power density levels. However, there is evidence of cumulative effects with long term irradiation. Mice exposed to low intensity radiofrequency radiation (RFR) became less reproductive and after five generations were sterile (Magras 1997). This also shows that the effects of RFR can pass from one generation to another. It must be remembered that current Health Canada Safety Code 6 and ICNIRP guidelines only deal with short-term exposures to microwaves and do not address long-term effects.

Populations living near cell towers are exposed to low level radiation on a continuous basis. In France, radiofrequency sickness symptoms were found in women living within 300 meters of the tower with the principal symptoms being fatigue , sleep disturbances, headaches, irritability, depressive tendency. Symptoms were worse closer to the antennas. (Santini 2003). Immune system effects were found in women after 2 years exposure in an Italian study where power density

levels of 5 $\mu W/cm^2$ equivalent to electric field strengths of 4.3 V/m near radio antennas (Boscolo 2001). Further adverse health effects were found in studies near shortwave transmitters in Switzerland (Altpeter 1995) and a longwave transmitter at Konstantynow, Poland (Flakiewicz 1992). Other biological outcomes have also been reported after long-term exposure to RFR. Two early studies showed biological effects after repeated, prolonged exposure but not after short-term exposure (Baranski 1972; Takashima 1979). An extensive overview of the biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays has been recently compiled (Levitt and Lai 2010).

Another report on the long term effects of microwave radiation was documented by Lilienfield following the deliberate irradiation of U.S. embassy personnel during the Cold War in Moscow and Eastern European embassies over a number of years. Modulation information contained phase, amplitude and pulse variations with modulated signals being transmitted 48 hours or less at a time at power density levels between 2 - 28 $\mu W/cm^2$. Symptoms that were found in embassy personnel included dermographism, reproductive problems in females during pregnancy and childbearing, malignant tumors in women and benign tumors in men, hematological alterations and effects on mood and well-being including irritability, depression, loss of appetite and concentration. (Lilienfield 1978). These symptoms are very similar to reports from RFR exposure near cell towers reported in Egypt (Abdel-Rassoul 2007) and in Spain (Navarro 2003).

These studies clearly suggest that long-term effects can be quite different than short-term exposure and that current exposure guidelines do not consider these long-term effects in any way. Although modulation patterns from various transmitters and cell towers are different in quality than emissions from smart meters, there is a clear need to evaluate these new smart meter RF transmissions on the long-term health of the population.

Abdel-Rassoul, G., El-Fateh, O.A., Salem, M.A., Micgael, A., Farahat,F., and Salem, E. (2007): Neurobehavioral effects among inhabitants around mobile phone base stations. Neurotoxicology, **28**(2): 434–440.

Altpeter ES, Krebs Th, Pfluger DH, von Kanel J, Blattmann R, Emmenegger D, Cloetta B.(1995): *Study of Health Effects of Shortwave Transmitter Station of Schwarzenburg, Berne,Switzerland.* Study No. 55, Swiss Federal Office of Energy 1995.

Baranski, S. 1972. Histological and histochemical effects of microwave irradiation on the central nervous system of rabbits and guinea pigs. Am. J. Phys. Med. **51**: 182–190.

Flakiewicz W, A. Cebulska-Wasilewska (1992) Biological effects of electromagnetic field on randomly selected human population residing permanently close to the high power, long wave radio transmitter, and Trandescantia plant model system in situ. *International Wroclaw Symposium on Electromagnetic Compatibility 1992*, pp. 72-76.

Magras, I.N. and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics, 18(6), pp. 455-461.

Levitt B.B. and H. Lai (2010): Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18: 369–395.

Lilienfield, A.M., Libauer, G.M., Cauthen, J., Tonascia, S., and Tonascia, J. (1978): Evaluation of health status of foreign service and other employees from selected eastern European embassies. Foreign Service Health Status Study, Final Report; Contract No. 6025-619037 (NTIS publication P8-288 163/9) Washington, D.C.; National Technical Information Service, U.S. Department of Commerce.

Navarro, A.E., Sequra, J., Portole´s, M., and Go´mez-Perretta de Mateo, C. (2003): The microwave syndrome: a preliminary study in Spain. Electromagn. Biol. Med. **22**(2-3): 161–169.

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Responsiveness of Humans to Electromagnetic Radiation

The human nervous system is very sensitive to electromagnetic stimuli. The electric and magnetic fields produced in the body by a nearby electromagnetic source may cause both thermal and non-

thermal biological effects. The effects of magnetic fields vary with frequency, and are probably greatest in biological tissue containing small amounts of magnetite. Magnetite (Fe3O4) is a naturally occurring oxide of iron.

There are 5 million single domain magnetite crystals per gram for most tissues in the human brain and more than 100 million crystals per gram of pia and dura mater in the brain (Kirschvink 1992a, b). That means the average human adult brain weighing 1350 grams (Blinkov 1968) and composed of 100 billion neurons would contain around 6.75 billion magnetite crystals capable of responding to microwave radiation. In a newborn's brain weighing 375 grams there would be 1.9 billion magnetite crystals and the thinner skull would allow 2.5 times more microwaves to penetrate into brain tissue (Gandhi 1996).

If we consider the human adult neocortex containing between 19.3 billion (females) and 22.8 billion neocortical neurons (males) (Pakkenberg 1997), then the ratio of RF sensitive magnetite crystals to neurons is around 1:3. The microwave absorption by magnetite represents a plausible mechanism for coupling non-thermal levels of radiation into the human nervous system (Kirschvink, 1996).

Since RF mesh radio meter emissions involves whole body exposure, it is not unreasonable to compare it to RF emissions from mobile phone base stations which also lead to low power density whole body exposure, even though they transmit continuously rather than the intermittent burst data transmissions experienced from the meters. Regarding base station emissions, Khurana et al. (2010) and Kundi & Hutter (2009) showed that chronic exposure of above 0.05 - 0.1 $\mu W/cm^2$ is associated with cardiac problems, increased cancer risk and adverse neurobehavioral symptoms. Pulsed RF/microwaves can be more biologically active than non-pulsed radiation (Belyaev 2005). A number of good-quality studies have convincingly demonstrated significant bioeffects of pulsed microwaves as discussed earlier.

Smart meters use pulsed signals and will transmit intermittently day and night for their useful life of 20 years. The anticipated population exposure from pulsing RF transmitters on the residence and business of every utility customer is totally new and may have unforeseen consequences that are difficult to quantitate at the beginning stages of exposure of the general population. A recent study has shown that pulsed low frequency electromagnetic field exposure can alter neuro-processing in humans (Robertson 2010). Pakhomov has given an extensive overview of former Soviet and Russian research with pulsed RF radiation. Modulation often was the factor that determined the biological response to irradiation, and reactions to pulsed and continuous wave emissions at equal time-averaged intensities in many cases were substantially different (Pakhomov 2000). Duration of exposure may be no less important than power density for the non-thermal microwave effects (Belyaev 2005).

Scientific research over last five decades has established that non-thermal levels of radiofrequency radiation have a variety of biological effects and could potentially lead to serious health effects. Science does not deal with certainties but only with answering hypotheses of potentials risks. It cannot be definitively established at this point that irreversible damage to health would occur since

no specific research using the unique modulation patterns emitted by these AMI meters has been carried out. However, it would be erroneous to assume that because AMI meters do not cause heating of tissues that long-term health effects could not occur or are impossible.

In summary, there is now sufficient evidence that non-thermal effects on living tissue must be seriously considered to protect against biological and long-term health effects of RF radiation. Extensive scientific explanations for the likely mechanisms involved in non-thermal EMF field exposure at power density levels considerably below current safety guidelines including Health Canada Safety Code 6 guidelines and the U.S. FCC guidelines, now exist (Sage 2007, 2012; Giuliani & Morando, 2010; Levitt and Lai 2010). Non-thermal mechanisms are likely to involve several biological processes including resonance effects, body and cellular water dielectric effects, free radicals and oxidative stress mechanisms, and quantum effects associated with coherent water domains inside cells and body tissues.

It is my opinion, that the current scientific literature on non-thermal RF radiation effects on living systems, including humans, supports the need for lower exposure guidelines in order to protect populations from long-term exposure at low power density levels. The RF Mesh Network Meters that are part of the proposed FortisBC Inc. automated metering infrastructure <u>may constitute a risk of serious damage to health by non-thermal mechanisms.</u>

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Lack of Medical Practitioner Awareness

At present there appears to be a much greater awareness of microwaves effects on health by physicians in Europe compared to Canada or the United States. Anecdotal reports about various effects on wellbeing and health have led to an increased awareness by general practitioners (Leitgeb 2005; Huss 2006; Röösli 2008) with more demands for research over the last 15 years (Kundi 1998). Because of different research priorities, more research has been concentrated on the effects of cell phone radiation than on low level exposure from base station radiation and cell tower emissions (WHO 2006). As a result, there is much less data available on the effects of low level non-thermal radiation on health than would be desirable based on the widespread increase of low level microwave power densities in the environment to which the current low levels emissions from smart meters also contribute. Regulatory agencies, principally public utility commissions, have typically not demanded environmental impact studies or raised questions about possible health effects from these types of emissions. As awareness about "electromagnetic pollution" grows (Leitgeb 2005) and more electromagnetic hypersensitivity is being reported (Leitgeb 2003, Navarro 2003), physicians and researchers are increasingly becoming more familiar with these issues.

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Question 5:

If the Transmissions can have health effects and if people are vulnerable to health effects of the Transmissions, are some persons more vulnerable than others?

Dr. Maret Response:

The vulnerable subgroups in the general population who are more susceptible to RF radiation from the Transmissions are pregnant women, the elderly, immune compromised individuals, and infants and children. Children are especially at risk because they have thinner skulls into which radiation can penetrate more deeply, their brains are smaller with a higher water content and ion concentrations, and they have a developing nervous system. (Kheifets 2005, Gandhi 1996). Perhaps most vulnerable are people who are electrically hypersensitive who will be discussed in more detail below. Another vulnerable subpopulation are people using electrical implanted devices such as pacemakers, insulin pumps or other medical devices that may also be susceptible to RF interference. All these groups may have potentially long-term health effects that may only become apparent over ten or more years of consistent exposure. Evidence supporting a public health risk from the increasing wireless technologies has grown substantially over the last two decades (Sage 2009). Although there is clear evidence of risk from wireless technologies, the magnitude of the risk is uncertain at this time. This is also true for RF wireless utility meters which have not been formally studied by scientists.

Electrically Hypersensitive People

Long-term or excessive exposure to electromagnetic radiation may initiate physiological changes that may lead to a person becoming more sensitive to electromagnetic fields. (Saunders 2003). This is known as electromagnetic sensitivity or electromagnetic hypersensitivity (EHS). Most of the time this condition is self-reported based on personal experiences. A review of EHS concluded that in population-based studies, an association was repeatedly observed between symptoms and exposure to electromagnetic fields in the everyday environment (Röösli 2008).

While some individuals report mild symptoms and react by avoiding the fields as best they can, others are so severely affected that they cease work and change their entire lifestyle. According to the World Health Organization (WHO) symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). Other symptoms include ringing in the ears, headaches, depression, sleep disruption among others. A more extensive list of symptoms is in Appendix E.

EHS resembles multiple chemical sensitivities (MCS), another disorder associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterized by a range of non-specific symptoms that lack apparent toxicological or physiological basis or independent verification. A more general term for sensitivity to environmental factors is Idiopathic Environmental Intolerance (IEI), which originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the WHO in 1996 in Berlin (WHO 2005). According to the

WHO, IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people.

The prevalence of EHS has been reported in various studies. In population-based surveys, it was assessed to be 3.2% in California and 1.5% in Sweden (Röösli 2004), 4% in the UK (Eltiti 2007), 5% in Switzerland (Schreier 2006) and 8-10% in Germany (Röösli 2008). In a Swiss questionnaire survey involving 429 questionnaires, 394 reported symptoms. The most common complaints were sleep disorders (58%), headaches (41%), nervousness or distress (19%) and fatigue (18%). Complainants related their symptoms most commonly to cell phone towers also called mobile base stations (74%), mobile phones (36%) and cordless phones (29%).

In 2011 a survey was conducted on wireless utility meters (smart meters) with 443 respondents reporting a variety of symptoms (Halteman 2011). The respondents were principally from California (78%), 93% were over 40 years old, 73% were women and 49% reported themselves to be EMF sensitive. 76% indicated they had wireless utility meters installed in their neighborhood, town or city for at least 6 months and 41% reported that the meters had been installed in their home. The top health issues since new meters were installed were sleep issues (49%), stress, anxiety and irritability (43%), headaches (40%), ringing in the ears (38%) and heart problems (26%). 94% of the respondents would have preferred to have retained their analog electromechanical utility meters and 92% felt they should not have to pay for retaining their old meter.

Of those respondents who experienced sleep problems, 34% had them with no smart meters in their home and 66% reported them following the smart meter installation. From this survey it appears that half of the respondents who were EMF sensitive people had the greatest health impact from these meters and hence this population is especially vulnerable to the RF emissions. Pulsed RF radiation has a negative effect on sleep that has been documented in several studies (Borbely 1999, Mann 1996, Huber 2000, Hutter 2006).

As societies industrialize and the technological revolution continues, there has been an unprecedented increase in the number and diversity of electromagnetic field (EMF) sources. These sources include mobile or cell phones and their base stations, wireless network devices, cordless phones, Bluetooth devices and now the wireless utility meters and associated "smart" appliances. These devices continue to be studied prompted by concerns about possible health risks due to their EMF emissions. Below is a graph that describes the rising prevalence of people in various countries who consider themselves to be electrosensitive or report EHS (Hallberg 2006). If this trend is correct, then the health problems reported by this as yet small subgroup of the general population (currently less than 10%) may soon grow considerably larger and become a potential public health crisis. An overview of the public health implications of wireless technologies have been outlined by Sage and Carpenter (Sage 2009).

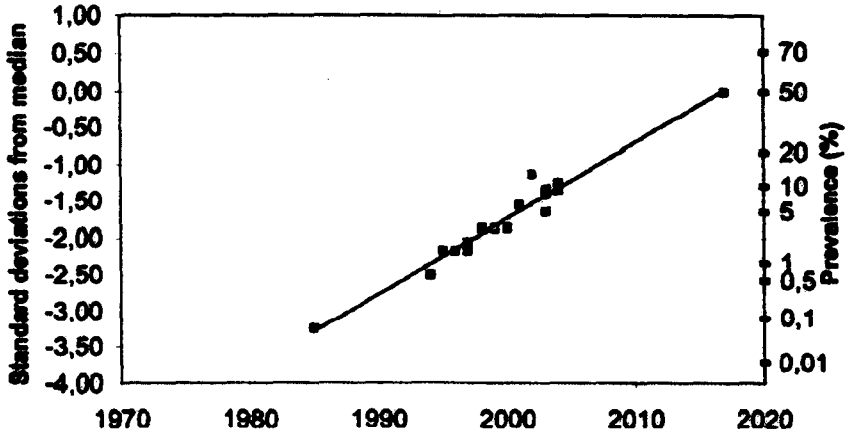

Figure 1. The prevalence (%) of people around the world who consider themselves to be electrosensitive, plotted over time in a normal distribution graph. The endpoint at 50% is an extrapolated value. Variation explained is 91%, the endpoint not included.

Graph 1 of Electrosensitive Population courtesy of

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Question 6:

Please comment on Fortis' answer to CSTS IR#2 questions 50.7.3 and 50.7.4 as set out:
50.7.3 Does Fortis BC believe that eliminating the RF signal from a Smart Meter would enable a person to eliminate RF signals from their personal environment? Please explain.

Response:
FortisBC does not believe it is possible for any customer to eliminate RF signals from their personal environment, even those in rural environments. Both natural (from earth and even human bodies) and man-made RF signals are constantly present all around us.

50.7.4 To what extent would this reduction likely limit an individual's exposure to RF signals throughout a year? Please quantify.

Response:
Considering the extremely low level of RF emissions associated with AMI, it is difficult to quantify to what extent the provision of an opt-out option may potentially reduce an individual's exposure, however based on these extremely low levels, and considering the multiple sources of natural and man-made RF signals, it is clear that that such a reduction from an AMI meter would not significantly reduce an individual's total exposure.

Dr. Maret Response:

While it is true that modern wireless technologies are now commonplace and add to the general exposure of microwaves to which utility customers are exposed, there are an increasing number of people who elect to minimize their exposure to these technologies. People suffering from electrohypersensitivity are especially vulnerable and often strive to eliminate as many RF sources as possible from their environment. Utility RF meters would add an unwanted burden that could be fully eliminated with wired or fiber-optic metering systems.

The background radiation from natural sources is extremely low around 0.000,001 $\mu W/m^2$ or 0.000,000,0001 $\mu W/cm^2$ By comparison, the general background RF levels in urban areas when last measured by the U.S. Environmental Protection Agency in 1986 was around 50 $\mu W/m^2$ or 0.005 $\mu W/cm^2$ which is 50 millions times higher than the natural environment (EPA 1986). With the wireless revolution over the last 25 years, including cell towers, cordless phones and WiFi systems in homes, it is undoubtedly higher now.

Already in 2000, in Sweden, the radiofrequency and microwave radiation levels in urban areas were approximately ten times higher than they were in the 1980s—and most of the increase was due to wireless communications, according to Dr. Yngve Hamnerius of Chalmers University of Technology in Göteborg, Sweden. Hamnerius measured radiation levels in the 30 MHz-2 GHz frequency range at 26 sites across Sweden with varying levels of urbanization. In cities, the median power density was 0.05 $\mu W/cm^2$, with a 61% average contribution from GSM cell tower base stations. (Microwave News, July/August 2000).

If we accept a 0.05 $\mu W/cm^2$ background levels in metropolitan areas similar to Sweden's 2000 levels, a smart meter transmitting with peak power levels of 9 $\mu W/cm^2$ at one meter distance from the meter would be briefly exceeding the ambient background levels by 180 times. By averaging the power density levels (by including duty cycle considerations) one would obtain a lower averaged power density figure. However, it is the sudden pulsations when the meter transmits that might cause potential biological or health effects and needs to be the key consideration in this question.

By not making the meters mandatory and offering any utility customer an opt-out option, utility customers would have the choice to minimize their exposure from a house-mounted RF meter. Since the power density falls off with the square of the distance, exposure to pulsing RF radiation from a sufficiently far neighbor's meter would be considerably less.

EPA (1986) The Radiofrequency Radiation Environment: Environmental Exposure Levels and RF Radiation Emitting Sources, EPA 520/1-85-014, U.S. Environmental Protection Agency, July.

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Question 7:

Please comment specifically on Fortis' responses to British Columbia Sustainable Energy Association (BCSEA) Information Request (IR) No. 2, question 101.1, which is set out as follows:

> 101.1 Is Fortis aware of research studies on RF energy and health that distinguish between possible health effects of the quantum of RF exposure and possible health effects of sudden pulsations of RF exposure?
>
> Response:
>
> No, FortisBC is not aware of peer reviewed research studies on RF energy and health that distinguish between possible health effects of the quantum of RF exposure and possible health effects of sudden pulsations of RF exposure. All effects of RF signals on biological tissue are based on the physics of interactions between electromagnetic fields and the tissue. The formal method for performing calculations of these interactions is quantum electrodynamics, though classical physics approaches are a good approximation for all confirmed biological and health effects. Therefore, whether the RF exposure is a result of a pulse of electromagnetic wave, a burst of RF signal, or a continuous wave exposure, all are appropriately described as a quantum RF exposure. It should be noted that the assessment of biological or health responses to radiofrequency fields does not depend upon knowledge of the mechanism of interaction. When responses to radiofrequency fields are found, then scientists develop and test hypotheses to describe and understand the mechanism of interaction. If there is a measurable physical effect of radiofrequency exposure, then scientists anywhere in the world should be able to reproduce and confirm the effect independent of any hypothesis proposed to explain the observed effect.

Dr. Maret Response:

This is a key question about the biological responses of living systems to RF energy and whether traditional electrodynamics approaches are specifically applicable to living systems, especially in-vivo, and if different types of modulation patterns affect organisms differently. It appears that quantum physical processes take place at a macroscopic level inside living organisms given them unusual sensing properties. The current approach to the biophysics of RF exposure makes the underlying assumption that living system can be studied from the perspective of equilibrium thermodynamics. Yet living system operate far from equilibrium thermodynamics instead behaving in a state of dynamic order reflecting quantum coherent properties operating within the structured water inside cells and tissues (Ho 2008, 2012). Because coherent energy is stored locally at every point, the organism is exquisitely sensitive specifically to weak signals.

Water within living organisms is highly structured and fundamentally different from bulk water. The general scientific community has not yet appreciated that vicinal water (structured water near membranes and protein boundary layers) appears to have quantum coherent properties and that it appears to behave with liquid crystalline properties. In 1995, quantum physicists Del Giudice and Preparata and others showed through quantum electrodynamics (QED) theory that water had coherence as a fundamental property in its ground state arising from the exchange of radiation

absorption resonances of the water molecule (Arani 1995). This was part of the creation of a fundamental quantum electrodynamic theory of matter as outlined in Preparata's book ***QED Coherence in Matter*** (Preparata 1995). An important implication of quantum electro-dynamical (QED) interactions in condensed matter is the development of long-range forces within cells and tissues acting over distances far exceeding chemical bond lengths and giving rise to spatial domains within which all atoms and molecules oscillate in-phase with an endogenous coherent "classical" electromagnetic field.

When there is a very strong coupling between the matter quantum fields and the electromagnetic fields, domains of coherence appear spontaneously. Their size is determined by the wavelength of the particular molecular spectral line involved. This electromagnetic field then becomes very strong and is trapped within the coherence domain by total internal reflection. Del Giudice showed that water has quantum properties forming coherent domains of around 100 nanometers in size (Del Giudice 2002). The consequence of these understandings is that the structural properties of coherent cell water makes living systems much more sensitive to ambient electromagnetic fields than would be the case from purely equilibrium thermodynamics considerations.

Smith reports that an important consequence of coherence in water is the 'multiple-frequencies-effect'. In free-space, the velocity with which electromagnetic radiation travels (the velocity of light) is constant. The usual equation is frequency times wavelength equals velocity. Within a coherent system such as body water, the constant parameter becomes its coherence length. This makes velocity proportional to frequency. When external radiation interacts with many coherent domains, it does not interact with individual molecules; it only interacts with an entire massive domain (Smith 2004).

Additionally, next to hydrophilic surfaces water forms massive exclusion zones (EZ) that are highly structured and act in a quasi-crystalline manner (Zheng 2003, 2006; Pollack 2001, 2008). The water in these EZ is restricted in motion, relatively ordered and has different properties than bulk water. It also responds to outside electrical fields and various forms of radiation (Pollack 2012). EZ can be quite large involving tens thousands of layers of water molecules or more. Pollack refers to EZ water as "liquid crystalline water" and says that this type of structured water was already described a hundred years ago by William Bate Hardy (Hardy 1936). Because of these unique body water properties one can expect living systems to demonstrate unique sensitivities to EM radiation.

The human body consists about two thirds of water. All proteins in the body exist in hydrated states surrounded by layers of structured water. Protein and hydration shell behave as one dynamically coherent unit. Water gives flexibility to proteins, reduces the energy barrier between reactants and products, and increases the probability of quantum tunneling by transient compression of the energy barrier in enzymes. As water and enzyme systems are impacted by EM radiation, they can be changed at non-thermal power densities. Structural and kinetic effects of non-thermal microwaves on the important central nervous system enzyme acetylcholinesterase in-vitro has been reliably demonstrated (Barteri 2005).

Many of the original impulses to apply quantum physics to biological systems stem from the quantum physicist Herbert Fröhlich in the 1970s and 1980s. He had proposed that highly ordered processes existed in the body whereby the vibrations of large molecules or components of biological tissue (and the way they interact with each other) could lead to the existence of a band of frequencies into which energy could be absorbed, leading to a "coherent state" of vibration. Such molecular interactions are characterized by collective (cooperative) behavior with long-range phase correlation (coherence). Many biochemical interactions are non-linear in nature which involves the channeling of supplied energy into coherent modes. Because water and living systems have macroscopic coherent properties which have their origin in quantum physical processes they help to explain long range effects and entanglement (as originally defined by Schrödinger) and may explain the underlying physics involved in electromagnetic (and chemical) sensitivities or hypersensitivity phenomena increasingly seen today.

Fröhlich also considered whether quite small oscillating electric fields might put energy into this coherent state thereby triggering significant biological changes. (Fröhlich 1983, 1988). He further showed that within a coherent system, the range of the forces of interaction greatly increased at resonance. From this perspective, living biological systems appear to behave in a manner roughly similar to a radio receiver. A radio can detect and amplify an extremely small signal against a background of very much larger signals. It does this when the receiver is tuned using a resonant circuit to the frequency of the carrier wave. Indeed, cell and tissues have biological windows that respond to specific frequencies and power levels in releasing calcium ions (Ca^{++}) which are very selective over a narrow range (Bawin 1976, 1978; Blackman 1982). Fröhlich stressed that "It would be wrong, however to conclude that the investigation of fractions of a system e.g., particular molecules, would exhibit a non-linear response to microwaves, for only the whole active biological system shows such properties." (Fröhlich, 1980)

The body water having a liquid crystalline character becomes part of the structured connective tissue matrix providing intercommunication between each cell and the crystalline matrix (Oschman 2000). This liquid crystalline matrix is sensitive to electromagnetic fields and utilizes jump conduction of protons (positive electricity) along hydrogen-bonded chain of water molecules (Pomes 1998). An intricate regulatory acupuncture communication system exists in the body that is sensitive to external electromagnetic fields. (Ho 1998, 2012). Cellular and tissue water demonstrates a collective structure that undergoes a phase transition affecting the state of the cell and its biological function. EMFs act through perturbing the collective structure of cell water and the coherent domains existing within it. These are essentially quantum physical processes which makes organisms exquisitely sensitive to external fields. External microwave radiation, if it has the appropriate energy, acts by pumping energy into the system of oscillations within the coherent domains and changing their resonance condition (Wu 1992). A good overview of the practical applications of these quantum physical process and their associated non-thermal electromagnetic fields as applied to energy medicine therapies is outlined by Williams (2007) in *The Scientific Basis of Integrative Medicine.*

These quantum biophysical considerations have important implications for future RF exposure standards which would need to consider non-thermal biological mechanisms which have been reported for several decades of scientific research. It is too early to confidently define the long-term health implications of these macroscopic quantum processes in our body; however it is likely that they may include greater incidence of electromagnetic hypersensitivity conditions, sleep disorders and other neurobehavioral imbalances, oxidative stress and DNA changes leading possibly to cancer and neurodegenerative diseases.

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Question 8:

Please provide any comment you may have on the statements/assumptions contained in the attached paper by Jeff Gilbert on behalf of Itron. How to the emissions from the meters described by Mr. Gilbert in this paper compare to the emissions from the proposed Fortis AMI meters? Do you agree with Mr. Gilbert as to the existence of potential hazards with respect to RF energy exposure? Please specifically provide your opinion as to whether Itron has sufficiently minimized "the potential hazards of RF energy exposure".

Dr. Maret Response

On page 5 of Jeff Gilbert's report on behalf of Itron characterizes their residential location devices as either Endpoint devices, specifically Encode Receiver Transmitters (ERT), or Meter Based Devices, electric meters with integrated radios, namely the Centron and the Sentinel.

End Point Devices

Their 41/45-series ERT has an Effective Isotropic Radiated Power (EIRP) of 0.74 mW to give a power density value of 0.00015 mW/cm2 which is very low and relates most likely to a gas meter radio transmitter. Their model 110G ERT has an EIRP of 204.17 x 1.072 (antenna gain) = 218.9 mW to give a power density at 20 cm distance of 0.0435 mW/cm^2 or 43.5 μW/cm^2. These two devices have lower power density levels compared to Fortis AMI meter peak power density specified at 0.227 mW/cm^2 which gives the 41/45 ERT an emission at 0.07% and the 100G ERT at 19 % respectively of the specified FortisBC AMI meter.

Meter Based Devices

Itron's Centron meter has an EIRP of 341.2 mW which gives a power density level at 20 cm of 0.068 mW/cm^2 or 68 μW/cm^2 . This is lower than the Fortis' meter which has an EIRP of 1141 mW to give a power density density level at 20 cm of 0.227 mW/cm^2 making the Fortis AMI meter 3.34 times (334%) more powerful than the the Centron meter.

Itron's Sentinel meter has an EIRP of 251.2 mW x 1.62 (antenna gain) = 406.94 mW which gives a power density level at 20 cm of 0.081 mW/cm^2. This is lower than the Fortis AMI meter which has an EIRP of 1141 mW to give a power density density level at 20 cm of 0.227 mW/cm^2 making the Fortis AMI meter 2.8 times (280%) more powerful than Centron's Sentinel meter.

It should be noted that all meters are below the FCC reference guidelines of 0.61 mW/cm^2 (610 μW /cm^2) and are only concerned with thermal health effects, which is the only consideration in the Itron report. Mr. Gilbert is apparently not concerned about any non-thermal effects and thus minimizes any potential biological impact from Itron's meters. His statement in the summary that "Itron is concerned with the potential hazards of RF energy exposure and seeks to minimize this exposure whenever possible" is clearly only concerned with the thermal impacts of RF energy. His engineering assessment of the Itron meters seeks to demonstrate that their meters fall below the thermal guidelines for RF exposure set out by the FCC and Health Canada. Biological responses at lower RF exposure power density levels than those produced by Itron's meters have been recorded in the scientific literature (see answer in Section 2) thus leading to the possibility that long term health effects are still very much possible.

Question 9:

For the purpose of the analysis of health effects, are the emissions from the AMI meters proposed by Fortis' the same as (or comparable to) the emissions from the meters proposed by Hydro-Quebec as described in the attached report of Dr. Carpenter with a revised date of May 14, 2012?

Dr. Maret Response:

The Carpenter Report on Page 5 shows a table that has been translated from the one submitted on page 11 of Hydro-Quebec's report (by Mr. François Robichaud) filed as Hydro-Quebec's Exhibit B-0116, HQD-7, Document 7 shows maximal measurement of 54,680 μW /m2 at one meter distance in front of the meter. This value translates to an Effective Isotropically Radiated Power (EIRP) of 0.6871 watts from the meter assuming no reflections (using formula Power density S (measured) = EIRP / (4 Pi R^2) where distance R= 1 meter). The meters are manufactured by Landis + Gyr. According to the report, meters are estimated to send 1440 to 2880 pulsed emissions per day. No transmission envelope information (total duration of the data packet transmission) is specified and it is assumed that the meters transmit for around 1/50th of a second or around 20 milliseconds. If this is correct, the maximal cumulative daily transmission time per meter would be 2880 transmissions x .02 seconds/transmission or 58 seconds total per day equivalent to a 0.067% duty cycle. If the envelope were longer than 20 milliseconds, the duty cycle would be larger.

Further measurements described on Page 6 of the report show a maximal measurement of 55,370 μW/m^2 at one meter distance in front of the meter. This value translates to an Effective Isotropic Radiated Power (EIRP) of 0.698 watts which is similar to the measurement described earlier.

According to the data supplied (see question 1) the peak power density of the Fortis meter containing a 900 MHz mesh radio at 20 cm is 0. 0.227 mW/cm2 or 227 μW/cm^2 which translates into an EIRP of 1.141 watts or 63% higher power than the Landis + Gyr meters described in the Carpenter Report. At one meter distance the Fortis meter would be expected to have a Peak Power Density of 90.80 mW/ m^2 or 90,800 μW/m^2 which is equivalent to 9.08 μW/cm^2 (or 0.0091 mW/cm^2).

Using the data supplied in question 1, the Fortis meter can support a maximal duty cycle of 5%. At that duty cycle, the average power density at 1 meter would be 0.454 μW/cm^2 or 0.000454 mW/cm^2.

At 20 cm distance from the meter and with a 5% duty cycle, a higher average power density is calculated to be:

S = (EIRP x Duty Cycle) / (4 pi R^2 or (1141 mW x 0.05) / 4 x 3.1415 x $(20\ cm)^2$ which equals 0.011 mW/cm^2 as specified in question 1 of the report. At a 5% duty cycle the meter would be active 0.05 x 24 hours x 60 minutes = 72 minutes of transmissions per day.

Question 10:

Please provide any comment you may have on the statements/assumptions contained in the attached Health Canada document "It's Your Health" dated December, 2011. Particularly, indicate, with reasons, whether you agree with the conclusion stated therein, i.e.:

Survey results have shown that smart meters transmit data in short bursts, and when not transmitting data, the smart meter does not emit RF energy. Furthermore, indoor and outdoor survey measurements of RF energy from smart meters during transmission bursts were found to be far below the human exposure limits specified in Health Canada's Safety Code 6.

Based on this information, Health Canada has concluded that exposure to RF energy from smart meters does not pose a public health risk.

Dr. Maret Response:

Health Canada document "It's Your Health" references the RF exposure limits in Health Canada's Safety Code 6, which concern themselves only with thermal effects of RF energy. Canada's exposure limits do not consider non-thermal biological or possible health effects in setting their standards. While it is a true statement that smart meters do not emit RF energy when not transmitting data, the important issue from a biological perspective is the frequency and repetition of the number of data bursts sent over time. This is expressed as the duty cycle which may vary based on the number of meters in the mesh network surrounding the meters and the way the software is programmed to send data to the collector.

Outdoor exposure would be greatest near the meters if the meters are located on the outside of buildings. Indoors exposure levels depend on the construction of buildings, the presence of any reflective surfaces, proximity to the meter and other factors such as the duty cycle. Indoor power density levels would be lower than outside by an order magnitude at least but must be measured to ascertain their true value under operational conditions.

If thermal effects are the only criteria for evaluating possible health effects of the AMI meter RF energy radiation, then Health Canada's statement that "exposure to RF energy from smart meters do not pose a public health risk" would be correct. However, if non-thermal standards were to be considered in setting lower exposure standards, as has been the case in other countries such as Russia, Switzerland and China, then the RF emissions from smart meters might represent a potential long-term public health risk. Similarly, if Precautionary Levels were adopted as recommended by the BioInitiative Report (described on page 7 of the Carpenter Report for Hydro Quebec) then stricter guidelines of 1000 $\mu W/m^2$ for outside exposure and 100 $\mu W/m^2$ for indoor exposure (compared to the current

levels of Health Canada's Safety Code 6 which allow up to 6,000,000 $\mu W/m^2$ in either location) might demonstrate potentially greater risk for health and wellbeing.

With the specified peak power density levels of 0.227 mW/m^2 of the 900 MHz mesh radio at 20 cm from the meter represents 37% of the thermal exposure guidelines assuming a 100% duty cycle. Closer to the meter at 12.3 cm (4.8 inches), the exposure guidelines with continuous use would be exceeded based on thermal considerations. While it is doubtful that thermal exposure guidelines would be exceeded under normal operation, the non-thermal effect from the meters RF radiation is the matter of greater concern, in my opinion, and may potentially pose a long-term public health risk.

Until this matter is clearly settled by targeted scientific studies of the effect of pulsed RF exposure from smart meters on humans, animals, insects and cell cultures, the Precautionary Principle ought to be employed. Concerned scientists have called for more conservative exposure guidelines (as suggested in the Bioinitiative Working Group) of 1000 $\mu W/m^2$ outdoors and 100 $\mu W/m^2$ indoors to be temporarily adopted. If the B.C. Utility Commission wanted to ensure that all new RF technology implementation by its utilities meets the highest safety standards for population exposure, these non-thermal exposure guidelines would be recommended.

Question 11:

Do the following exposure characteristics relate to health effects, if any, that may be caused by Fortis' proposed AMI meters?
a. the extent and amount of fluctuations in RF levels;
b. the frequency with which instances of RF emissions occur; and/or
c. the speed at which the emissions are flashing on and off.

Dr. Maret Response:

With reference to part a., I have not seen specific data on the stability of RF power levels during burst transmissions from the meters. I estimate that some type of digital pulse-coded modulation scheme would be used to encode the RF carrier signal between 902 – 928 MHz from the meter as the data is transmitted. Frequencies used within this band would vary with each specific transmission based on the algorithm used by the meter manufacturer. The digital signal is of the nature of very rapid on/off pulses (data packets) which might be completed within a few milliseconds and most likely no longer than 20 milliseconds (estimate) based on my experience with other smart meters in California. While the digital signal is "on" (logic state 1) the 900 MHz RF carrier is radiating at peak power levels and during the momentary "off" state (logic state 0) the RF carrier is suppressed. Details of the modulation scheme have not been provided and are usually proprietary to the manufacturer of each meter.

With reference to question b. and c.:
The asynchronous repetition rate of burst transmissions within the 902 to 928 MHz frequency band will be variable depending on the number of meters in the mesh network, the system requirements for house-keeping and other factors. They would need to be measured in the field once the mesh network of meters were deployed. The total transmission during the day is described by the duty cycle which is specified to be at maximum 5% or at most 72 minutes per day. In practice it may be considerably less initially but it could grow over time depending on the programming of the meters. I assume that the meters will be able to be programmed remotely and have the duty cycle changed based on utility decisions. The larger the duty cycle, the greater would be the cumulative exposure.

Since I have not been given the data envelope information it is difficult to estimate the number of burst transmissions per day impacting the customer.

With a 1% duty cycle and a burst transmission time of 5 milliseconds, I estimate that there would be [0.01(Duty cycle) x 86,400 second/day] / 0.005 seconds (transmission time) = 172,800 burst transmissions during the 864 seconds or 14.4 minutes per day, for example .

With a 0.1% duty cycle and a 10 millisecond transmission time there would be 8640 burst transmissions per day for a total transmission time of 86,400 x 0.001 = 86.4 seconds total.

Question 12:

12. What comments do you have with respect to Fortis' failure to further consider these emission characteristics, as admitted by Fortis in its response to CSTS IR#2, question 20.1?

Dr. Maret Response:

By not considering any non-thermal effects and focusing only on thermal effects from averaged power density considerations, FortisBC is minimizing potential risks to sensitive utility customers who may receive their RF mesh network meters which could lead to adverse health effects becoming apparent over the 20 year life of the meter. Other aspects of this question are largely covered by the earlier responses.

Question 13:

Do you agree with Fortis' response to CSTS IR#1 - 7.1 as set out:

7.1 Would Fortis BC expect the referenced customer health concerns to exist with respect to non-RF communication technology?

Response:
FortisBC does not consider that there are health concerns founded on accepted science regardless of whether the AMI system uses RF or non-RF technology.

Dr. Maret Response:

I do not agree with this response at all. The basis for their answer is that unless there are thermal considerations, RF microwave fields are basically harmless according to currently accepted science. This is simply not true based on the various studies describing non-thermal biological responses described earlier. Living systems evolved with natural fields oscillating almost entirely in the extremely-low-frequency (ELF) spectrum with resonance peaks between 8 and 32 Hz, called the earth Schumann resonances. Experiments by Wever (1974) showed that shielding subjects from this natural Schumann radiation in volunteers who lived in underground steel bunkers resulted in shift of their body-clock circadian rhythm going into a free-running mode with a 25-hour day or longer. Provision of a weak 10 Hz field would maintain synchronism and reestablish lost synchronicity. Thus living systems, including humans, are naturally attuned to earth electro-magnetic rhythms which are adversely affected by modern telecommunications technologies.

Communications technologies have specifically impacted pineal gland melatonin hormone synthesis and release. In a study of women living near to radio and television transmitters, researchers found no effect on urinary melatonin metabolite excretion among pre-menopausal women, but a strong effect in post-menopausal women (Clark 2007). The pineal gland in the brain responds to pulsed magnetic fields changing melatonin production (Yaga 1993). Lowered melatonin production is another mechanism that adversely affects biological signaling and has a negative effect on health. It has been shown that cell phone use lowers melatonin metabolites in the urine (Burch 1997). Imbalances in the production of melatonin can lead to sleep disturbances, decreased free radical scavenging, immune system imbalances and contribute to the development of neurological diseases. Utility workers exposed to higher low frequency magnetic fields have lower melatonin production and are more at risk for (Noonan 2002). Until studies are carried out, it is not known whether the pulsed RF mesh network meter emissions affect melatonin metabolism. By going with a non-RF meter any potential neurobehavioral issues could be avoided.

There are no significant levels of natural energy at RF/ microwave frequencies. In the last 50 years the natural electromagnetic environment has been literally overwhelmed with man-made RF / microwaves which has been further accelerated with the advent of digital communication techniques. These fields oscillating a hundreds of millions and billions of times a second (MHz and GHz frequencies) are systematically interrupted or pulsed at low frequencies. The current deployment of RF meters as part of the automated metering infrastructure is only the latest layer of

microwaves to be added to the "technical fields pollution." If wired or fiber-optic meters had been chosen to communicate electrical usage information, the non-RF option, then no microwaves would be generated involuntarily from the sides of houses.

The transmissions of the meter are far-field emissions and impact the entire body at fairly low, non-thermal levels. At increasing distance from the transmitter the human body takes on the properties of a radio antenna with the absorption of radiated energy determined by the physical dimensions of the trunk, limbs and head (Adey 2004). A 900 MHz smart meter radio has a wavelength of 33 cm and a half wavelength of 16.5 cm which would resonate most naturally with the dimensions of the head (see diagram). The wavelength of the 2.4 GHz Zigbee radio is 12.5 cm (5 inches) and may potentially create resonances an infant's head (Weinberger 2002).

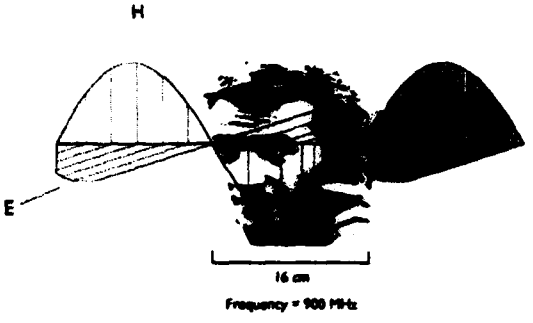

Diagram courtesy of Weinberger and Richter (2002) suggesting the head as a lossy resonator of electro-magnetic radiation.

Fiber-optic or wired meters would avoid any RF microwave radiation in the home environment and eliminate exposure of the occupants to these frequencies. This option was not considered by FortisBC as it would likely be more expensive.

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Question 14:

Please comment on these responses from Fortis

27.0 The CSTS IR#1 question was:

How is "intensity (strength) defined? Has there been consideration of the amount/extent of fluctuation of RF levels with respect to the proposed meters? Has there been consideration of the power of emissions during the signaling phase with respect to the proposed meters?

Fortis's response was:

The "intensity (strength) of a RF field is commonly expressed in units of power density defined as Watts per square meter (W/m2) or equivalent units. The questions regarding RF levels and power during signaling are covered by Safety Code 6. Please refer to the response to BCSEA No. 1 Q 55.5.

BCSEA IR No. 1 Q 55.5 was:

Q. Please explain why the duty cycle is given as a range. Does the duty cycle range apply to each specific installed meter, or to the fleet of meters? Will some installed meters be at the low end of the range while others are at the high end of the range? What factors determine the length of the duty cycle for a particular meter; for the fleet of meters?

Fortis's Response:

With a hierarchical mesh structure, meters will relay upstream and downstream traffic within the RF mesh. The total number of transmissions will include the scheduled reads, on-demand reads, alarms/alerts along with the network traffic needed for command and control (synchronization, security, data integrity and dynamic network resiliency) . Based on data gathered from a large, representative OpenWay network deployment (using 2 load profiles reads + one register read+ one event read per day), distribution of the duty cycle is graphed in the Itron while Paper (Wireless Transmissions: An Examination of OpenWay Smart Meter Transmissions in a 24-Hour Duty Cycle), provided as Appendix BCSEA IR1 55.5.

CSTS's Question in IR2, 27.1 was:

Your reference to Safety Code 6 and BCSEA IR No. 1 Q 55.5 did not answer our question as to whether there has been consideration by FortisBC of the amount/extent of fluctuation of RF levels with respect to the proposed meters. Kindly answer this question directly without reference to further materials.

Fortis's Response:

FortisBC was aware that the exposure characteristics of the proposed meters would comply with Safety Code 6 before submitting its Application but did not make a specific study of how the RF levels would vary over time. It is not clear what may be meant by the "amount/extent of fluctuation of RF levels with respect to the proposed meters" beyond the responses provided. Please also refer to the response to CSTS IR No. 2 Q 18.1.

CSTS's 18.1 was again a follow up to earlier questions in IR No. 1.

Q. What is the frequency and extent of fluctuation of RF levels with respect to the proposed meters? Is the on/off manner in which emissions occur analogous to the fluctuating emission levels of a strobe light? At what speed are the emissions flashing on and off? How often? What is the frequency with which an RF emission occurs? What is the duration of each transmission.

Fortis's response:

The frequency of the RF signals from the FortisBC advanced meters is between 902 MHz and 928 MHz. The RF level will fluctuate depending on whether the advanced meter is transmitting or not. The RF exposure from the meters at a mean duty cycle of 0.06% will be 0.000056 mW/cm2 and decline with distance to far lower levels.

The signals from the advanced meters will be more like that of a flashlight that is turned on and off for short irregular periods. A strobe light analogy suggests an extremely powerful and regularly repeating signal, which is not like that of an advanced meter.

With respect to the frequency, speed, and duration of signals, please refer to Appendix BCSEA IR 1. 55.5 and 55.8, CSTS IR No. 2 Q. 35.1, CEC IR No. 2 Q 34.1 and Q 34.4.

BC Hydro has commissioned reports to further quantify the duty cycle and the number of transmissions for the same ITRON meters that FortisBC has selected for use in the proposed AMI project. The real-world measured data collected during these studies suggests that the total duty cycle and the number of transmissions for the max, min and average meter will be reduced from the numbers FortisBC has provided in the Application and in response to CEC IR No. 2 Q 34.1. Please refer to Appendix CEC 34.1 for these studies and their conclusions.

Dr. Maret Response:

If the meter power density specified in Question 1 with a peak power density of 0.227 mW/ cm^2 (227 $\mu W/cm^2$) at 20 cm from the meter (100% duty cycle), then with a 0.06 % duty cycle specified in their answer here, an average power density level of 0.000,056 mW/ cm^2 (0.056 $\mu W/cm^2$) would occur at a distance of 31.2 cm or 1 foot from the meter. At 20 cm from the meter the average power density with a 0.06% duty cycle would be 0.136 $\mu W/cm^2$ which is 2.4 times higher.

It is important to reiterate the importance of considering the non-thermal burst transmissions from the meter. The transmission characteristics become minimized by looking at only average power density levels which are more important from the thermal or heating perspective. Clearly there are no expected heating effects from the meters unless a person stands 12 cm or closer right next to the meter and the meter was operating at 100% duty cycle.

As to the characterization that the meter is more like a flashlight than a strobe light, it minimizes the nature of the transmission which is more analogous to flash bulb going off since there are short, greater than 1 watt peak power pulses that occur irregularly. These pulses could potentially initiate a cellular stress response if the person were close enough to the meter. Clearly a strobe light analogy describes a device that tends to repeat regularly, which is not the case with the meters.

The other aspects of the signal characteristics were covered already in earlier answers to the questions.

Question 15:

Please comment on these responses.

File number 2, CSTS IR No.2 , question 44.1

Q. 44.1 In vitro studies are plentiful and are considered expert means of performing research. Please explain further why Exponent is discounting them and substantiate the statement that epidemiological studies and in vivo studies provide more direct information on human health.

Response:

In its description of the hazard identification step of a human health risk assessment, the Exponent report states "This process considers epidemiology studies of humans in their natural environment, experimental laboratory studies of humans or laboratory animals (in vivo studies), and laboratory studies of cells and tissues (in vitro) that may provide evidence for a mechanism – the way in which the exposure interacts with biological tissues. These three types of studies provide different but complementary information to determine how an exposure affects biological organisms. Only human and animal studies of RF exposure are considered in this report because they provide more direct information on human health than in vitro studies." (pp. 3-4)

Thus, in vitro studies are but one of the weight of the evidence considered in a standard health risk assessment. Regarding RF fields in particular, consider the comments of ICNIRP (2009) and the AGNIR (2012) regarding the contribution of in vitro studies to their assessments of potential health risks of radiofrequency fields. Please also see the response to CSTS IR 2 Q 26.1.

ICNIRP – Exposure to high frequency electromagnetic fields, biological effects and health consequences (2009)
...when using simplistic cell-based [in vitro] systems to assess toxicity, it is important to recognize that cells are finely-balanced homeostatic machines that respond to external stimuli through complex pathways. As toxicity can be the result of a multitude of cellular events, and because cell culture systems often lack essential systemic contributors to overall absorption, distribution, metabolism and excretion, as well as to the
complex interactions and effects of the immune, endocrine and nervous system, it is clear that no in vitro assays can completely mimic the in situ condition in animals and humans of complex interactions between stem cells, proliferating progenitor cells and terminally differentiated cells within a tissue and between tissues (Bhogal et al 2005). In vitro investigations therefore only contribute to toxicity testing and risk assessment but, standing alone, they are insufficient predictors of toxicity and hazard. This is certainly also true with respect to investigations of cellular effects from RF radiation and this should be kept in mind when evaluating these data (p. 97)

.

Over the last 30 years there have been many in vitro studies on potential cellular effects of RF. These studies gave insight into the basic mechanisms by which effects might be induced in more complex animal or human organisms. Interpretation is, however, limited by anomalous cell behavior generated by the culture conditions and other factors which limit the extrapolation to humans. The studies conducted so far have not provided consistent evidence of biological effects under non-thermal RF exposure conditions (p. 148).

Advisory Group on Non-Ionizing Radiation (AGNIR) for the Health Protection Agency of Great Britain – Health Effects from Radiofrequency Electromagnetic Fields, Report of the independent Advisory Group on Non-Ionizing Radiation (2012)

However, these [in vitro] studies have their limitations. The main disadvantage is that isolated cells do not experience the many interactions that would normally take place in a whole organism and hence their response to stimuli is not necessarily the same as it would have been in an experimental animal or human ... adverse cellular changes may not be harmful to the whole organism as organisms have protection and repair mechanisms. Hence a cellular change does not imply an effect on the whole organism and neither a change at the cellular level nor a change of the whole organism necessarily results in a health effect (p. 80).

The in vitro biological changes due to RF field exposures reported so far are relatively small, which makes experimental confirmation difficult. Even if these changes were confirmed the health implications would be hard to assess and would require further studies using experimental animals or humans. However the results from in vitro studies can be useful to suggest possible mechanisms and indicate areas of further research (p. 81).

Dr. Maret Response:

I agree with the assessment that the three types of studies give complementary information about the effects of electromagnetic exposure. In vitro studies can give more detailed information regarding various potential mechanisms of altered cell functioning as well as potential damage from electromagnetic radiation to specific cells or cell components such as DNA. That these biological effects do occur has been clearly described earlier and substantiated with pertinent references to the literature. While it is true that in vitro cell culture studies are highly specialized and allow the experimenter to potentially control more exposure parameters, the in vivo studies on living animals give information regarding the complex response of the whole organism including adaptive responses to the imposed fields.

In experiments with living organisms there are more potential variables operating and clear-cut answers may require many experiments to repeat significant findings. Obviously there can be many genetic, nutritional, environmental parameters during the animal's development and other confounding variables such as an organism's protective, adaptive or repair mechanism(s) to the electromagnetic field exposure. Animal studies are carried out because it would often not be ethical to expose humans to these field exposures deliberately. There is however mounting evidence from epidemiological studies of humans living near microwave antenna arrays, such as cell towers, base stations, FM and TV transmitters, that biological and health effects occur at low intensity non-thermal levels. Human provocation studies in the Netherlands have also established a health effect at very low exposure levels described earlier.

I don't agree with the statement "The studies conducted so far have not provided consistent evidence of biological effects under non-thermal RF exposure conditions" There have been a wide range of neurobehavioral adverse responses observed that are similar in nature and occur especially in sensitized individuals. These effects typically begin to occur after an extended exposure time of

months to years with health effects appearing in certain individuals based most commonly on their neurophysiological and immunological adaptive capacity.

It is my opinion that the overall weight of the human exposure studies suggests that non-thermal RF radiation levels have a potent potential for adverse health outcomes and that a precautionary approach is now warranted. This is also a social question regarding the level of potential risk society is willing to accept with the current exposure guidelines. A valuable contribution to this social issue has been provided by the large international insurance company Swiss Re in their report "Electrosmog – a phantom risk" (Brauner 1996).

The scientific method involves the testing of hypotheses and developing appropriate interpretations of experimental data. It seldom provides definitive answers, especially in such complex issues as electromagnetic field exposure in living organisms. While more research is always desirable to gain a better understanding of long-term risk, it should not be the ultimate obstruction to taking action to minimize potential health damage to the population once they become apparent to a sufficient number of scientists.

Brauner, Christian (1996): Electrosmog – a phantom risk. Issued by the Swiss Reinsurance Company, Zurich, Switzerland. Available at http://www.emfbioshield.com/ElectrosmogEng.pdf

Question 16:

What comments do you have, if any, regarding Fortis' response to CSTS 5 IR#2, question 44.4 as set out?

44.4
Does exposure assessment, as discussed in the Exponent Report at pages 8, 9 & 47, take into consideration cumulative effects of prolonged exposure to low doses?

Response:

The evaluation of potential health effects of any exposure considers the duration of exposure with regard to the potential for biological changes or health effects to evolve over time. Safety Code 6 addresses the potential cumulative build-up of heat in tissues by time-averaging exposure to radiofrequency fields and so prevents adverse effects of exposure.

Dr. Maret Response:

The evaluation of potential health effects of any RF exposure has to consider the duration of exposure. Health Canada Safety Code 6 addresses the potential cumulative build-up of heat in tissues by time-averaging exposure to radiofrequency fields to prevent adverse effects of exposure. The averaging time specified in the standard is related to the thermal time constant in humans. A six minute time, chosen by some standards like the ICNIRP, corresponds to the thermal time constant of sensitive tissues like eyes and testes. These time constants relate to the body's thermoregulatory responses like increased blood flow which are the primary concern when setting thermal exposure standards. As mentioned earlier, these standards do NOT concern themselves with low level, non-thermal RF exposure safety guidelines.

Non-thermal effects continue to be controversial and have long been denied by many biophysicists to even be possible. Volkow's work (2011) has clearly demonstrated using PET scans that increased glucose utilization in various brain tissues occurred after non-thermal RF power density exposure in humans. Clearly non-thermal RF radiation can cause neurophysiological changes in the brain. Other aspects of long-term exposure were discussed earlier (see page 22).

Nonetheless, the nature of cumulative RF exposure is controversial because few epidemiological studies have utilized long-term monitoring instrumentation directly on exposed subjects. These types of monitors are now available for these types of measurements. Long-term studies take time and are costly. Human exposure to low level base station radiation has shown long term adverse health effects as described earlier. With the mounting number of epidemiological studies describing long term effects of RF radiation that now exist, it is my opinion that a precautionary approach is necessary rather than extrapolating the absence of risk as is currently being done with the higher exposure guidelines promulgated by the ICNIRP and Health Canada Safety Code 6. Israel has adopted long- term exposure levels that are ten times lower than their short-term exposure guidelines. Russia and China have similarly set lower exposure standards based in part on long term exposure concerns.

In addition, the type of modulation, the temporal nature of the pulsing RF signals, the presence of critical biological windows at resonant power density levels, and the vulnerability to exposure within the circadian cycle are all involved when considering long-term exposure as described in questions 2,3 and 4 earlier.

With reference to the response to question 44.4 stated above, I believe it is misleading to state that "Safety Code 6 addresses the potential cumulative build-up of heat in tissues by time-averaging exposure to radiofrequency fields and so prevents adverse effects of exposure" since this approach only seeks to mitigate thermal thresholds from being exceeded. The statement might better have been expressed by saying "...by time-averaging exposure to radiofrequency fields and so prevents adverse effects of RF exposure leading to tissue heating effects." This would clarify their reasoning and the criteria being used for claiming the "prevention possible adverse health effects" which from their perspective do not involve non-thermal radiofrequency fields.

Volkow ND, Tomasi D, Wang G, Vaska P, Fowler JS, Telang F, Alexoff D, Logan J, Wong C (2011), Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism. JAMA. 305 (8):808-813. doi: 10.1001/jama.2011.186

Appendix A: A list of studies reporting biological effects at low intensities of Radiofrequency Radiation (RFR). These exposure levels are comparable to Smart Meters emissions.

Data in Table courtesy of Levitt B.B. and H. Lai (2010): Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18: 369–395. References to the studies are in their paper.

Author	Exposure Conditions	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Balmori (2010) (in vivo) (eggs and tadpoles of frog)	88.5–1873.6 MHz Cell phone base station emission 2 months		3.25	Retarded development
Belyaev et al. (2005) (in vitro)	915 MHz, GSM 24 & 48 hr	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz GSM, UMTS 24 & 72 hr	0.037		DNA repair mechanism in human white blood cells
Blackman et al. (1980) (in vitro)	50 MHz, AM at 16 Hz	0.0014		Calcium in forebrain of chickens
Boscolo et al. (2001) (in vivo) (human whole body)	500 KHz-3 GHz, TV broadcast		0.5	Immunological system in women
Campisi et al. (2010) (in vitro)	900 MHz, CW or 50-Hz AM, 14 days, 5, 10, 20 min per day, CW- no effect		26	DNA damage in human glial cells
Capri et al. (2004) (in vitro)	900 MHz, GSM 1 hr/day, 3 days	0.07		A slight decrease in cell proliferation when human immune cells were stimulated with mitogen and a slight increase in the number of cells with altered distribution of phosphatidylserine across the membrane.
Chiang et al. (1989) (in vivo) (human whole body)	People lived close to AM radio and radar installations for more than one year		10	People lived and worked near AM radio antennae and radar installations showed deficits in psychological and short-term memory tests.
De Pomerai et al. (2003) (in vitro)	1 GHz 24 & 48 hr	0.015		Protein damages
D'Inzeo et al. (1988) (in vitro)	10.75 GHz CW 30-120 sec	0.008		Operation of acetylcholine-related ion-channels in cells. These channels play important roles in physiological and behavioral functions.
Dutta et al. (1984) (in vitro)	915 MHz, sinusoidal AM at 16 Hz	0.05		Increase in calcium efflux in brain cancer cells.
Dutta et al. (1989) (in vitro)	147 MHz, sinusoidal AM at 16 Hz 30 min	0.005		Increase in calcium efflux in brain cancer cells.
Fesenko et al. (1999) (in vivo) (mouse- wavelength in mm range)	From 8.15 - 18 GHz 5 hr to 7 days direction of response depended on exposure duration		1	Change in immunological functions.
Forgacs et al. (2006) (in vivo) (mouse whole body)	1800 MHz, GSM-217 Hz pulses, 576 µs pulse width;	0.018		Increase in serum testosterone.

	2hr/day, 10 days			
Guler et al. (2010) (In vivo) (rabbit whole body)	1800 MHz AM at 217 Hz, 15 min/day, 7 days		52	Oxidative lipid and DNA damages in the brain of pregnant rabbits
Hjollund et al. (1997) (in vivo) (human partial or whole body)	Military radars		10	Sperm counts of Danish military personnel, who operated mobile ground-to-air missile units that use several RFR emitting radar systems, were significantly lower compared to references.
Ivaschuk et al. (1999) (in vitro)	836.55 MHz, TDMA 20 min	0.026		A gene related to cancer.
Jech et al. (2001) (in vivo) (human partial body exposure- not included)	900 MHz, GSM- 217 Hz pulses, 577 µs pulse width; 45 min; narcoleptic patients	0.06		Improved cognitive functions.
Kesari and Behari (2009a) (in vivo) (rat whole body)	50 GHz; 2hr/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2009b) (in vivo) (rat whole body)	50 GHz; 2hr/day, 45 days	0.0008		Reproductive system of male rats
Kesari et al. (2010) (in vivo) (rat whole body)	2450 MHz, 50-Hz modulation, 2 h/day, 35 days	0.11		DNA double strand breaks in brain cells.
Kwee et al. (2001) (in vitro)	960 MHz, GSM 20 min	0.0021		Increased stress protein in human epithelial amnion cells.
Lebedeva et al. (2000) (in vivo) (human partial body)	902.4 MHz, GSM 20 min		60	Brain wave activation.
Lerchl et al. (2008) (in vivo) (hamster whole body)	383 MHz (TETRA), 900 and 1800 MHz (GSM) 24 hr/day, 60 days	0.08		Metabolic changes.
Magras and Xenos (1999) (in vivo) (mouse whole body)	'Antenna park'-TV and FM-radio, Exposure over several generations		0.168	Decrease in reproductive function.
Makova et al. (2005) (in vitro)	915 and 905 MHz, GSM 1 hr	0.037		Chromatin conformation in human white blood cells.
Mann et al. (1998) (in vivo) (human whole body)	900 MHz GSM pulse-modulated at 217 Hz, 577 µs width, 8 hr		20	A transient increase in blood cortisol.
Marinelli et al. (2004) (in vitro)	900 MHz CW 2 - 48 hr	0.0035		Cell's self-defense responses triggered by DNA damage.
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz CW and 3000 MHz pulse-modulated 2 µs pulses at 400 Hz Single (0.5-12hr) or repeated (15-60 days,	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin.

	7-12 hr/day) exppsure, CW-no effect			
Nittby et al. (2007) (in vivo) (rat whole body)	900 MHz GSM 2hr/wk, 55wk	0.0006		Reduced memory functions.
Novoselova et al. (1999) (in vivo) (mouse whole body-wavelength in mm range)	From 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 5 hr		1	Functions of the immune system.
Novoselova et al. (2004) (in vivo) (mouse whole body-wavelength in mm range)	From 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 1. 5 hr/day, 30 days		1	Decreased tumor growth rate and enhanced survival.
Pavicic et al. (2008) (in vitro)	864 and 935 MHz, CW, 1-3 hrs	0.08		Growth affected in Chinese hamster V79 cells.
Panagopoulos et al. (2010) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		1 - 10	Reproductive capacity and induced cell death.
Panagopoulos and Margaritis (2010a) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death.
Panagopoulos and Margaritis (2010b) (in vivo) (fly whole body)	GSM 900 and 1800 1- 21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure.
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz , 90% AM, 24 hrs	0.0004		Increased proliferation rate in human astrocytoma cancer cells.
Perssson et al. (1997) (in vivo) (mouse whole body)	915 MHz-CW and pulse-modulated (217-Hz, 0.57 ms; 50-Hz, 6.6 ms) 2-960 min; CW more potent	0.0004		Increase in permeability of the blood-brain barrier.
Phillips et al. (1998) (in vitro)	813.5625 MHz (iDEN); 836.55 MHz (TDMA) 2 hr and 21 hr	0.0024		DNA damage in human leukemia cells.
Polonga-Moraru et al. (2002) (in vitro)	2.45 GHz 1hr		15	Change in membrane of cells in the retina.
Pyrpasopoulou et al. (2004) (in vivo) (rat whole body)	9.4 GHz GSM (50 Hz pulses, 20 µs pulse length) 1-7 days postcoitum	0.0005		Exposure during early gestation affected kidney development.
Roux et al. (2008a) (in vivo) (tomato whole body)	900 MHz		7	Gene expression and energy metabolism.
Roux et al. (2008b) (in vivo) (plant whole body)	900 MHz		7	Energy metabolism.

Salford et al. (2003) (in vivo) (rat whole body)	915 MHz GSM 2 hr	0.02		Nerve cell damage in brain.
Sarimov et al. (2004) (in vitro)	895-915 MHz GSM 30 min	0.0054		Human lymphocyte chromatin affected similar to stress response.
Schwartz et al. (1990) (in vitro)	240 MHz-CW and sinusoidal modulation at 0.5 and 16 Hz, 30 min, effect only observed at 16-Hz modulation	0.00015		Calcium movement in the heart.
Schwarz et al. (2008) (in vitro)	1950 MHz UMTS 24 hr	0.05		Genes in human fibroblasts.
Somosy et al. (1991) (in vitro)	2.45 GHz, CW and 16 Hz square-modulation, modulated field more potent than CW	0.024		Molecular and structural changes in cells of mouse embryos.
Stagg et al. (1997) (in vitro)	836.55 MHz TDMA duty cycle 33% 24 hr	0.0059		Glioma cells showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division.
Stankiewicz et al. (2006) (in vitro)	900 MHz GSM 217 Hz pulses-.577 ms width 15 min	0.024		Immune activities of human white blood cells.
Tattersall et al. (2001) (in vitro)	700 MHz CW, 5-15 min	0.0016		Function of the hippocampus.
Velizarov et al. (1999) (in vitro)	960 MHz GSM 217 Hz square-pulse, duty cycle 12% 30 min	0.00002 1		Decrease in proliferation of human epithelial amnion cells.
Veyret et al. (1991) (in vivo) (mouse whole body)	9.4 GHz 1 μs pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, direction of response depended on AM frequency	0.015		Functions of the immune system.
Vian et al. (2006) (in vivo) plant	900 MHz		7	Stress gene expression.
Wolke et al. (1996) (in vitro)	900, 1300, 1800 MHz, square-wave modulated at 217 Hz; Also 900 MHz with CW, 16 Hz, 50 Hz and 30 KHz modulations	0.001		Calcium concentration in heart muscle cells of guinea pig.
Yurekli et al. (2006) (in vivo) (rat whole body)	945 MHz GSM, 217 Hz pulse-modulation 7 hr/day, 8 days	0.0113		Free radical chemistry.

Appendix B: Oxidative Stress Mechanisms involved in EMF Exposure.

C.D. Georgiou: Biological damage by EMF-induced oxidative stress mechanism

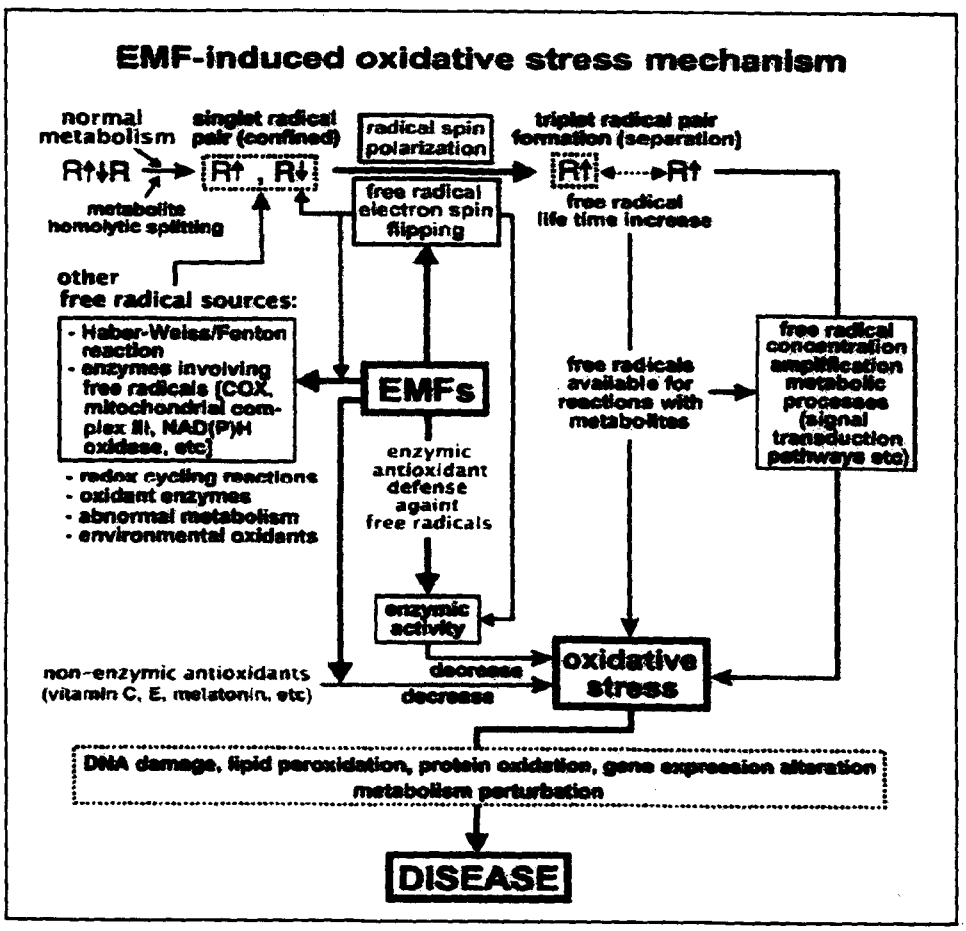


Fig. 8. Diagram of the EMF-induced oxidative stress mechanism. Free radicals are generated by normal metabolism, which involves biochemical homolytic splitting of numerous metabolite molecules, and the formation of singlet free radical pairs. EMFs mostly affect confined free radical pairs; one radical may be immobilized e.g. by attachment to an enzyme surface, with the partner radical able to diffuse around it (or both free radicals may be so attached); or the radical pairs can be localized within a membrane at the time of their creation or immobilized by proteins and DNA. Under these confined conditions and due to magnetic fields from the spin of protons adjacent to free radicals, EMF exposure makes them experience distinct local magnetic fields that can cause electron spin flipping, radical separation and concentration increase (by extending their life time). Electron spin polarization can be caused also on free radicals coming from other sources (such as the Haber-Weiss/Fenton reaction etc), as well as on those localized in the reactive centers of enzymes that catalyze free radical reactions. For antioxidant enzymes in particular, this may result in activity decrease and, subsequently, in the lowering of cell enzymic antioxidant defense. EMFs can also lower non-enzymic antioxidant defense (e.g. decrease in normal melatonin concentration etc) by non-linear metabolic processes, which, in addition, can amplify further the primary EMF effect of free radical concentration increase. This, therefore, will result in amplification of oxidative stress to levels beyond the antioxidant capacity of the cell, and, consequently, in disease development

Source: Non-thermal Effects and Mechanisms of Interaction between Electromagnetic Fields and Living Matter. (2010) An ICEMS Monograph. Ramazzini Institute. Edited by Livio Giuliani and Morando Soffritti. European Journal of Oncology Library Vol. 5 National Institute for the Study and Control of Cancer and Environmental Diseases "Bernardino Ramazzini" Bologna, Italy.

Appendix C: Proposed Mechanism for Oxidative Stress Pathways from Cell Phone Radiation leading to Infertility and Cancer according to Dr. Desai's research group

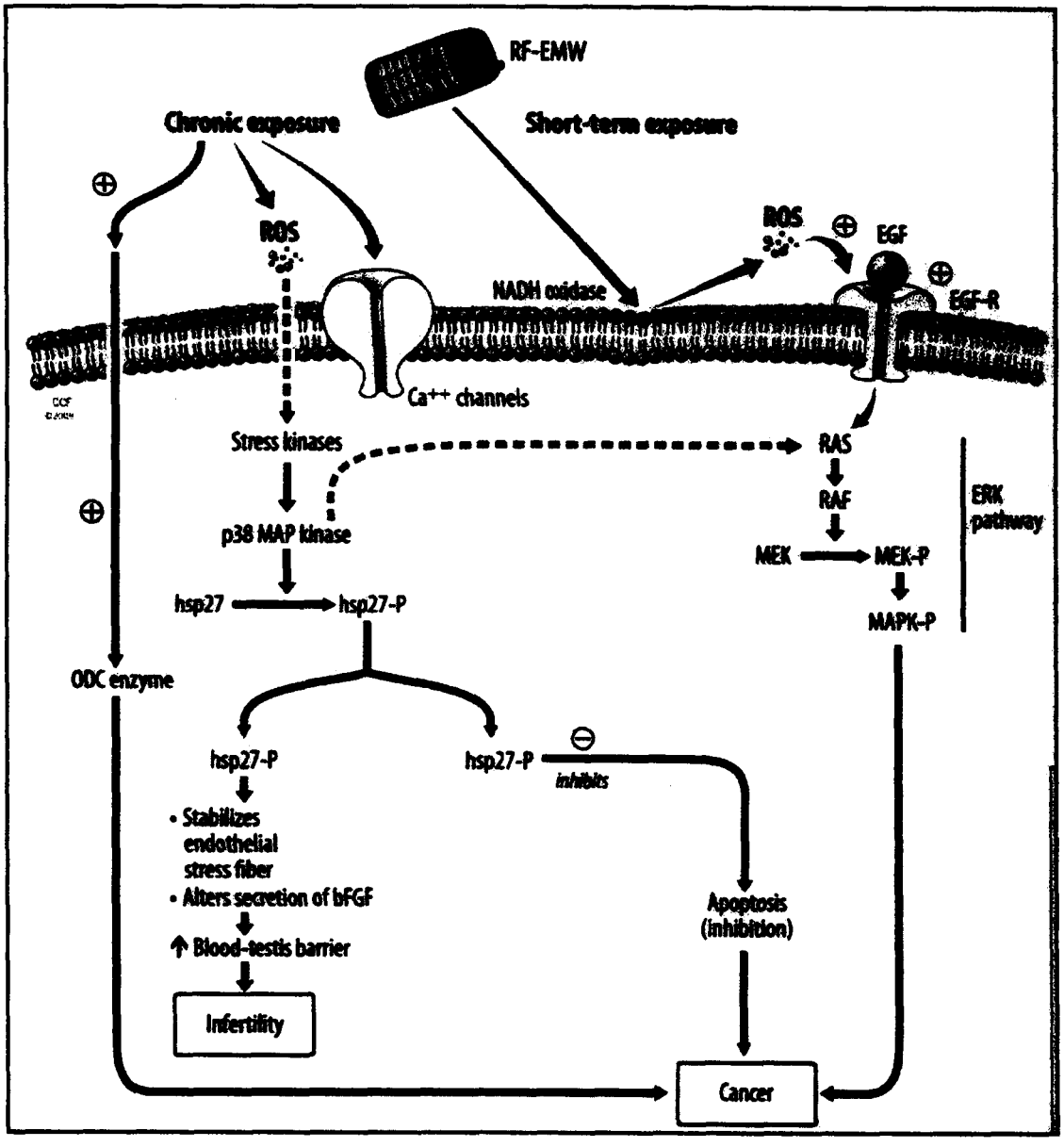
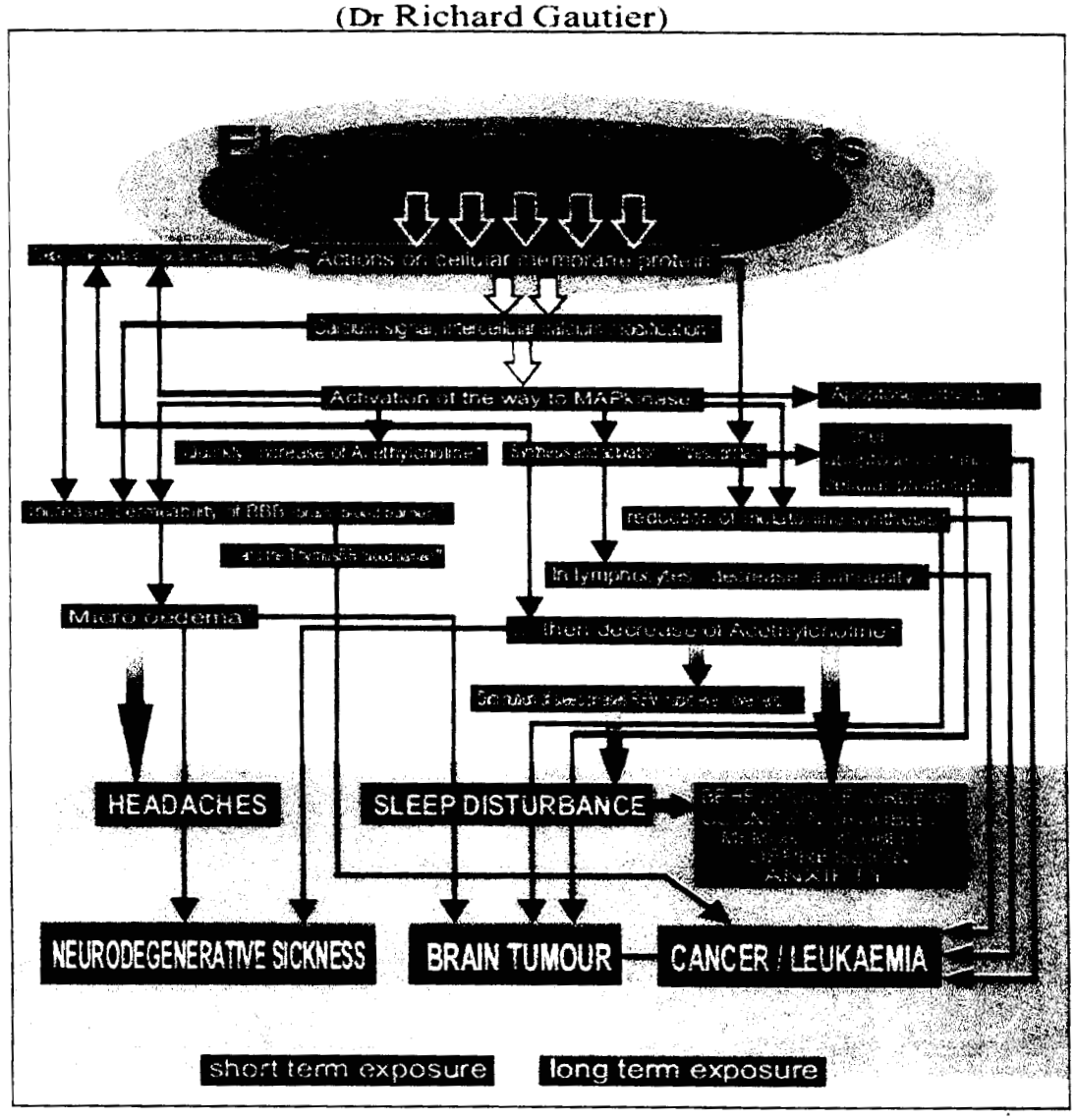


Diagram courtesy of Dr. Desai in Desai NR et al. (2009) Pathophysiology of Cell Phone Radiation: Oxidative Stress and Carcinogenesis Reprod Biol Endocrinol 7:114 , Oct 22, 2009

Appendix D: Proposed Mechanisms of EMF Impacts on Health according to Dr. Richard Gautier of France

Diagram of mechanisms linked to electromagnetic fields (EMF) exposure

(Dr Richard Gautier)



Source of Document:

References to support the individual steps are available at: http://www.next-up.org/divers/csif_cem_emf.php

Appendix E: Symptoms of Electro Hypersensitivity

SYMPTOMS OF ELECTRO HYPERSENSITIVITY					
Neurological		Cardiac	Respiratory	Dermatological	Ophthalmologic
headaches	depression	palpitations	sinusitis	skin rash	deteriorating vision
difficulty concentrating	anxiety	pain or pressure in the chest	asthma	facial flushing	pain or burning in the eyes
muscle and joint pain	confusion and spatial disorientation	low or high blood pressure	bronchitis	itching	pressure in/behind the eyes
memory loss	fatigue	shortness of breath	pneumonia	burning	floaters
dizziness	weakness	arrhythmias			cataracts
nausea	tremors	slow or fast heart rate		swelling of face and neck	
irritability	muscle spasms				
numbness	leg/foot pain				
tingling	"Flu-like" symptoms				
hyperactivity	fever				
altered reflexes	insomnia				
digestive problems	abdominal pain	testicular/ovarian pain/swelling	enlarged thyroid	great thirst	dehydration
nosebleeds	internal bleeding	hair loss	pain in the teeth	deteriorating fillings	Light sensitivity
swollen lymph nodes	loss of appetite	hypoxia	allergies	frequent urination and incontinence	night sweats
immune abnormalities	redistribution of metals within the body	ringing in the ears (tinnitus or similar chronic ear-noise)	impaired sense of smell	altered sugar metabolism	dryness of lips, tongue, mouth, eyes

Table courtesy of *Canadian Initiative to stop Wireless, Electric, and Electromagnetic Pollution* Part of the document Talking to your Doctor. Available at : http://www.weepinitiative.org/talkingtoyourdoctor.pdf

Appendix F: CV of author of report, Karl H. Maret

CURRICULUM VITAE

Name:	**KARL HELMUTH MARET**
Date of Birth:	14 April 1948 in Hamburg, Germany
Marital Status:	Single
Address:	430 Cliff Drive, Aptos, CA 95003
Telephone:	(831) 688-1133 Fax: (831) 688-8898
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Educational History:

1964-1967 **Engineering Diploma,** School of Engineering, Memorial University, St. John's, NL, Canada

1967-1969 **Bachelor of Science in Electrical Engineering** (Honors). Queen's University, Kingston, Ontario,Canada

1972-1974 **Master of Engineering, Biomedical Engineering.** University of Toronto, Toronto, Ontario, Canada. Thesis: "An Automated Method to Measure Pulmonary Extravascular Water Volume."

1973-1979 **Doctor of Medicine,** University of Toronto, Toronto, Ontario, Canada.

1978-1982 **Post-Doctoral Fellowship in Pulmonary Physiology.** School of Medicine, University of California San Diego (UCSD), La Jolla, California, USA. Worked under Dr. John B. West.

Employment History:

1969-1973 **Medical Associate Officer / Bioscience.** Active Military Service. Defense and Civil Institute of Environmental Medicine, Toronto, Ontario. Rank of Captain in the Canadian Armed Forces. Aerospace Medical Research with emphasis in high altitude and diving physiology as well as Human Engineering studies. Honorable Discharge in 1973.

1974-1976 **Consultant in Biomedical Engineering.** Department of Anaesthesia, St. Michael's Hospital, Toronto, Ontario, Canada. Pulmonary research.

1977-1978 **Lecturer in Preventive Medicine, Nutrition and Holistic Health.** The Fashioners of Manas, Inc. Educational Foundation, Columbus, Ohio, USA.

1978-1982 **Consultant and Research Fellow.** Department of Pulmonary Physiology, University of California San Diego. Head of Biomedical Engineering for the development of all scientific instrumentation and logistics for the successful 1981 American Medical Research Expedition to Mt. Everest.

1982-Present	**President, Maret Consulting Services.** Consultation in Biomedical Engineering, Energy Medicine Instrumentation, Environmental Research, Complementary and Alternative Medicine Technologies.
1983-1994	**President, The Fashioners of Manas Educational Foundation**, San Diego, CA . A non-profit educational foundation bridging the Creative Arts and Complementary and Alternative Medicine
1985-1993	**Private Consultation Practice** in Complementary and Alternative Medicine. Eukroisis Aesentis, 3330 Sixth Ave, San Diego, CA
1995-1997	**Private Consultation Practice** in Complementary and Alternative Medicine. 5230 Carroll Canyon Rd., San Diego, CA 92121
1997- Present	**Private Consultation Practice** in Complementary and Alternative Medicine. Dove Center for Integral Medicine, 9099 Soquel Dr., Aptos, CA 95003
1996- Present	**President – Dove Health Alliance Foundation.** Networking and lecturing globally in Energy Medicine and Complementary and Energy Medicine. (www.dovehealthalliance.org)
2003- 2009	**Partner in Heart-Mind Communications.** A educational company providing seminars in Heart and Cardiovascular Wellness.

Languages: Fluent in German and English (Spoken and written).

Honors and Achievements:

1969	**Dean's Prize in Engineering**. Association of Professional Engineers Special Merit Award. President of the Engineering Society, Memorial University, St. John's, NL
1971	**Professional Engineer** registered in the Province of Ontario, Canada.
1975	**Participating Scientist** in the High Altitude Physiology Expedition to Mt. Logan, Yukon
1979- 1982	**Francis B. Parker Fellowship** in Pulmonary Medicine, UC San Diego, La Jolla, CA.
1981	**Head Engineer** and member of successful American Medical Research Expedition to Mt.Everest. Developed first miniature digital barometer and other ambulatory instrumentation for use on top of Mt. Everest.

1982	**Faculty Member**, University for Humanistic Studies, San Diego, CA.
1987 - 1988	**Lecturer** in Biochemistry & Nutrition, Pacific College of Oriental Medicine, San Diego.
1990 - 1992	**Lecturer** in Nutrition, Institute of Psycho-Structural Balancing, San Diego, CA.
1994 - 1996	**Consultant & Lecturer**, Pan America School of Natural Healing, Nevis,West Indies.
1995 - 1998	**Trustee** Dove Healing Trust, Southampton and London, UK.
1999 - 2000	**Member – Medical, Scientific and Academic Council**, International Society for the Study of Subtle Energy and Energy Medicine, Arvada, CO.
2000	**Program Chair**, Council Grove Conference, Council Grove, KS April.
2000	**Program Chair** of 10th Annual Meeting, International Society for the Study of Subtle Energy and Energy Medicine, Arvada, CO.
2005- 2008	**Member of Board of Directors and Treasurer**. International Society for the Study of Subtle Energy and Energy Medicine, Golden, CO.
2011-2012	**President** International Society for the Study of Subtle Energy and Energy Medicine. Lafayette, CO.
2012- present	**Wisdom Council**, International Society for the Study of Subtle Energy and Energy Medicine. Lafayette, CO.

Professional Memberships

Member, New York Academy of Sciences

Member, American Association for the Advancement of Science

Honorary Member, German Society for Energetic and Informational Medicine

Member, International Society for the Study of Subtle Energy and Energy Medicine

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