

C A N A D A

PROVINCE OF QUEBEC

DISTRICT OF MONTREAL

DOCKET No. R-3770-2011

RÉGIE DE L'ÉNERGIE / ENERGY BOARD

AUTHORIZATION OF AN INVESTMENT BY
HYDRO-QUEBEC DISTRIBUTION –
ADVANCED METERING PROJECT
PHASE 1

HYDRO-QUEBEC
As Electricity Distributor

Petitioner

-and-

STRATEGIES ÉNERGETIQUES (S.É.) /
ENERGY STRATEGIES (E.S.)

ASSOCIATION QUEBÉCOISE DE LUTTE
CONTRE LA POLLUTION ATMOSPHERIQUE
(AQLPA) / QUEBEC ASSOCIATION TO FIGHT
AGAINST AIR POLLUTION

Intervenors

**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**

**EXPERT REPORT
DAVID O. CARPENTER**

Filed by :

Stratégies Énergétiques (S.É.) / Energy Strategies (E.S.)
Association québécoise de lutte contre la pollution atmosphérique /
Quebec Association to Fight Against Air Pollution (AQLPA)

April 30, 2012

Exhibit SE-AQLPA-7 - Document 1

***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***

Expert Report by David O. Carpenter

Filed by Stratégies Énergétiques (S.É.) / Energy Strategies (E.S.) and the AQLPA

Régie de l'énergie / Quebec Energy Board - Docket no. R-3770-2011

Authorization of an investment by Hydro-Quebec Distribution – Advanced Metering Project Phase 1

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EXPERT OPINION SUMMARY

It is my opinion that the state of scientific research sufficiently establishes a risk that meters transmitting by radiofrequencies as proposed in the present file by Hydro-Quebec may constitute a risk of serious as well as irreversible damage to health, through biological effects other than those resulting from heat. Some individuals or categories of individuals are more susceptible to injury than others (children, pregnant women, elderly, persons with illness, electrosensitive individuals, etc).

Such non thermal effects are reviewed in section 5 of this report.

Therefore, there is justification for examining precautionary or prudent measures that could be applied in addition to the current standards (which are based only on biological effects resulting from heat). Discussion and examples of such possible precautionary or prudent measures are provided in sections 6 and 7 of this report.

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1. THE AUTHOR

1. I am a public health physician, educated at *Harvard Medical School*.
2. My *curriculum vitae* has been filed in the present case as Exhibit C-SE-AQLPA-0060, SE-AQLPA-4, Document 3.

It indicates the various positions I held regarding public health, my participation into various international, national, state and local Committees and the Honors, Awards, Fellowships and Grants I received, as well as over 350 major publications, books and other publications.

3. My current title is *Director of the Institute for Health and the Environment* at the *University at Albany* and *Professor of Environmental Health Sciences* within the *School of Public Health*.

4. Formerly, I was the Dean of the *School of Public Health* at the *University of Albany* and the *Director of the Wadsworth Center for Laboratories and Research* of the *New York State Department of Health*.

5. I served as the Executive Secretary to the New York State *Powerlines Project* in the 1980s, a program of research that showed that children living in homes with elevated magnetic fields coming from powerlines suffered from an elevated risk of developing leukemia.

6. After this, I became the spokesperson on electromagnetic field (EMF) issues for New York during the time of my employment in the Department of Health.

7. I have published several reviews and have edited two books on the Biologic Effects of Electric and Magnetic Fields.

8. I am also a Co-Editor and a Contributing Author of the *BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)*, www.bioinitiative.org.

The *BioInitiative Report* documents bioeffects, adverse health effects and public health conclusions about impacts of electromagnetic radiation (electromagnetic fields including extremely-low frequency ELF-EMF and radiofrequency /microwave or RF-EMF fields).

The public health chapter from this report was subsequently published in a peer-reviewed journal, *Reviews on Environmental Health*, and it and other chapters of the Report were published in the peer-reviewed journal, *Pathophysiology*.

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9. In 2009, I was invited to present to the *President's Cancer Panel on the subject of powerline and radiofrequency fields and cancer*, and have also testified on this issue before the *United States House of Representatives*.

10. In sum, I am a public health physician, professor and former public health school Dean with expertise in electrophysiology, low-frequency electromagnetic fields bioeffects, and radiofrequency (RF) and microwave (MW) radiation bioeffects.

2. THE MANDATE AND THE QUESTION SUBMITTED BY THE REGIE DE L'ENERGIE

11. My services have been retained in the present file by Interveners *Stratégies Énergétiques (S.É.) / Energy Strategies (E.S.)* and the *Association québécoise de lutte contre la pollution atmosphérique / Quebec Association to Fight Against Air Pollution (AQLPA)* to submit an expert report regarding Hydro-Quebec's Petition for authorization of its investments for Phase 1 of its Advanced Meters Project, which constitutes present Docket no. R-3770-2011 of the Quebec Regie de l'énergie (Quebec Energy Board).

12. The Quebec Energy Board, in its recent decision no. D-2012-046 of April 20, 2012, specifically asked that my report addresses « *the state of scientific research as to whether advanced meters transmitting by radiofrequencies as proposed by Hydro-Quebec in the present file may constitute a risk of serious or irreversible damage to health* ».

The Quebec Energy Board further indicated that the phrasing of its above question was a reference to the *Quebec Sustainable Development Act*, which defines the *Precautionary Principle* as follows :

6 (j) "*Precaution*": When there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing the adoption of effective measures to prevent environmental degradation

It is further recognized that the *Precautionary Principle* not only applies to Environmental degradation but also to Public Health issues, among others.

3. THE SMART METERS PROPOSED BY HYDRO-QUEBEC

13. I am informed by my clients that the smart meters proposed by Hydro-Quebec in the present file would include two antennas :

- a) a general use antenna for communication between the meter and other surrounding meters and a router using the 900-928MHz frequencies with a power emitter of 27,48 dBm.
- b) a ZigBee card with antenna for eventual communication between the meter and household appliances that would be using the 2400-2483,5 MHz frequencies with a power emitter of 21,20 dBm.

The ZigBee card with antenna would, however, remain dormant in the first years and would only eventually be activated later by Hydro-Quebec. Only the main antenna using the 902-928 MHz frequencies would be activated during the first years. The radiofrequency emissions from that antenna are hereby described as « the Agent ».

My clients inform me that the Landis+Gyr smart meters commissioned by Hydro-Quebec are about 10 cm deep and that the main emitting antenna using the 902-928 MHz frequencies is in the front and side, at 2-3 cm from the exterior of the meter. There is no other barrier preventing a person from approaching and even touching the meter, therefore being at 2-3 cm from the emitting antenna.

14. I am also informed by my clients that said antenna using the 902-928 MHz frequencies would be continuously in use, transmitting approximately 1440 to 2880 pulsed emissions per day.

15. These smart meters would therefore constantly expose persons in the immediate vicinity of the meter.

On that matter, I wish to stress that duration may be an even more potent contributing factor to RF/MW radiation bioeffects than exposure levels. Chronic, such as all-day exposure, is more likely than short and intermittent exposure, such as cell phone use, to produce harmful health effects. Although the exposure levels may be lower, the accumulated exposure over time has the potential to be greater and to cause greater harm.

16. Persons stationed close to the meters, for example when the meters are located inside the kitchen or another room of a dwelling, will receive considerably higher exposure than do others. RF wave reflection on the walls, metal appliances and furniture inside a dwelling further increase RF exposure of its occupants.

17. I am also informed by my clients that, in most cases, exposure in front of the meters proposed by Hydro-Quebec is substantially higher than behind or on the side of the meters, due to the existence of a reflective metal plate in the back and part of the side of the meter and due to the localization of its emitting antenna.

My clients have provided me with the following table which would represent the maximal power density at 1 m of a meter at various angles on an horizontal plane viewed from above (0° being the front of the meter and 180° being the back of the meter). My clients inform me this table 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 (answer to commitment 35) in the present case :

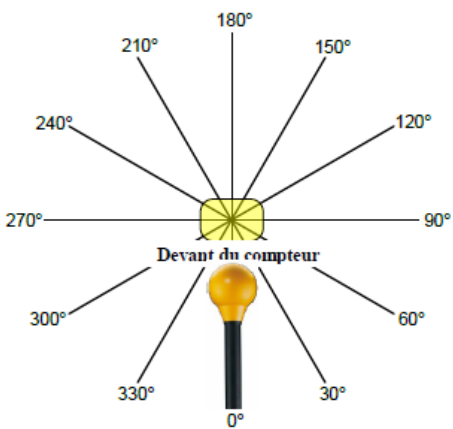
Horizontal plan (View from above) 0° being in front of the meter Meter is at center Measurement device is shown at 0°	Angle (Degree)	Frequency	Maximal power density (at 1 m from meter)
	0°	902,901 MHz	(Highest) 54 680 $\mu\text{W}/\text{m}^2$
	30°	920,604 MHz	38 500 $\mu\text{W}/\text{m}^2$
	60°	912,201 MHz	23 130 $\mu\text{W}/\text{m}^2$
	90°	907,406 MHz	10 090 $\mu\text{W}/\text{m}^2$
	120°	913,396 MHz	5 490 $\mu\text{W}/\text{m}^2$
	150°	908,296 MHz	3 550 $\mu\text{W}/\text{m}^2$
	180°	918,498 MHz	2 010 $\mu\text{W}/\text{m}^2$
	210°	911,257 MHz	4 090 $\mu\text{W}/\text{m}^2$
	240°	925,098 MHz	879,2 $\mu\text{W}/\text{m}^2$
	270°	926,906 MHz	(Lowest) 518,3 $\mu\text{W}/\text{m}^2$
	300°	922,095 MHz	9 540 $\mu\text{W}/\text{m}^2$
	330°	910,088 MHz	26 800 $\mu\text{W}/\text{m}^2$
	360°	912,793 MHz	46 720 $\mu\text{W}/\text{m}^2$

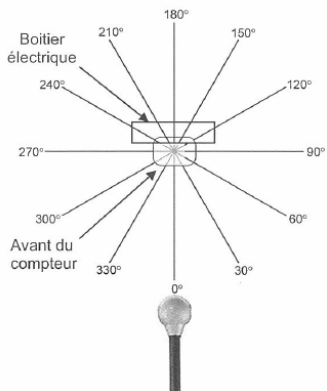
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My clients also inform me of the following similar table contained on page 14 of a report made by YRH (Yves R. Hamel and associates) for Hydro-Quebec and filed as the first part of Exhibit B-0113, HQD-7, Document 4 (answer to commitment 45) in the present case :

Horizontal plan (View from above) 0° being in front of the meter Meter is at center with electrical box behind Measurement device is shown at 0°	Angle (Degree)	Power density (Maximal during transmission) (at 1 m from meter)	Power density (Average during 6 minute observation) (at 1 m from meter)
	0°	(Highest) 55 370 $\mu\text{W}/\text{m}^2$	(Highest) 63,870 $\mu\text{W}/\text{m}^2$
	30°	38 800 $\mu\text{W}/\text{m}^2$	46,850 $\mu\text{W}/\text{m}^2$
	60°	20 440 $\mu\text{W}/\text{m}^2$	28,920 $\mu\text{W}/\text{m}^2$
	90°	5 658 $\mu\text{W}/\text{m}^2$	7,074 $\mu\text{W}/\text{m}^2$
	120°	1 366 $\mu\text{W}/\text{m}^2$	1,706 $\mu\text{W}/\text{m}^2$
	150°	1 633 $\mu\text{W}/\text{m}^2$	1,541 $\mu\text{W}/\text{m}^2$
	180°	3 802 $\mu\text{W}/\text{m}^2$	5,107 $\mu\text{W}/\text{m}^2$
	210°	2 493 $\mu\text{W}/\text{m}^2$	2,864 $\mu\text{W}/\text{m}^2$
	240°	(Lowest) 947 $\mu\text{W}/\text{m}^2$	(Lowest) 0,980 $\mu\text{W}/\text{m}^2$
	270°	1 478 $\mu\text{W}/\text{m}^2$	2,017 $\mu\text{W}/\text{m}^2$
	300°	13 040 $\mu\text{W}/\text{m}^2$	17,630 $\mu\text{W}/\text{m}^2$
	330°	42 330 $\mu\text{W}/\text{m}^2$	57,550 $\mu\text{W}/\text{m}^2$

18. I am also informed by my clients that their witness, Mr. Stephane Belainsky, had made the following observations in his amended report filed as Exhibit SE-AQLPA-0029, SE-AQLPA-2, Document 2 :

- ❑ The exterior meters (6 subjects measured, being visits nos. 2, 3, 4, 5, 6 and 7) had a power density averaging in time **42,2 $\mu\text{W}/\text{m}^2$** (taken at 1 m in front of the meter), with peaks averaging **6695 $\mu\text{W}/\text{m}^2$** . These averages do not include an unexplained atypical measurement of one meter (visit no. 1) which had a power density averaging in time 2400 $\mu\text{W}/\text{m}^2$, with a peak of 49800 $\mu\text{W}/\text{m}^2$; a re-measurement of that same meter at a later date (visit no. 1A) however showed a closer to normal power density averaging in time 88 $\mu\text{W}/\text{m}^2$, with a peak of 8484 $\mu\text{W}/\text{m}^2$.
- ❑ The interior meters facing occupants (two subjects measured, being visits nos. 8 and 10) had a power density averaging in time had a power density averaging in time **136 $\mu\text{W}/\text{m}^2$** (taken at 1 m in front of the meter), with peaks averaging **19 142 $\mu\text{W}/\text{m}^2$** .
- ❑ An additional measurement (visit no. 9) in a children's playroom, **at 3 m behind** a group of 53 meters (located in an adjacent meter room) showed a power density averaging in time **66 $\mu\text{W}/\text{m}^2$** , with a peak of **3198 $\mu\text{W}/\text{m}^2$** .

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I am also informed by my clients that on page 28 of Hydro-Quebec's report (by Mr. François Robichaud) filed as Hydro-Quebec's Exhibit B-0116, HQD-7, Document 7 (answer to commitment 35), measurements taken at 1 m from a residential meter average a power density of **48,64 $\mu\text{W}/\text{m}^2$** , and between **30,76 $\mu\text{W}/\text{m}^2$ and 32,96 $\mu\text{W}/\text{m}^2$** in the case of commercial-institutional-industrial (CII) meters. These measurements are in the same range as those provided above in Mr. Belinsky's report.

My clients inform me that, on page 20 of Hydro-Quebec's report (by Mr. François Robichaud) filed as Hydro-Quebec's Exhibit B-0116, HQD-7, Document 7 (answer to commitment 35), measurements taken inside meter rooms show power densities (which I presume are taken at 1 m) averaging 577,83 $\mu\text{W}/\text{m}^2$, 995,33 $\mu\text{W}/\text{m}^2$, 1053,6 $\mu\text{W}/\text{m}^2$ and 1794,0 $\mu\text{W}/\text{m}^2$. I am informed by my clients that that same report shows on pages 24-27 that, at various locations one meter away outside these rooms, average power densities were measured at 154,40 $\mu\text{W}/\text{m}^2$, 62,35 $\mu\text{W}/\text{m}^2$, 9,95 $\mu\text{W}/\text{m}^2$, 13,69 $\mu\text{W}/\text{m}^2$, 20,59 $\mu\text{W}/\text{m}^2$, 11,28 $\mu\text{W}/\text{m}^2$, 26,15 $\mu\text{W}/\text{m}^2$; the construction materials forming these rooms and their configuration vary and may explain these variations in power densities measured.

19. These results therefore show that :

- Average power densities measured at 1 m from exterior meters do not exceed the exterior-threshold of 1 000 $\mu\text{W}/\text{m}^2$ recommended in the *BioInitiative Report*, which is later described in the present report (save for one atypically high result on one meter which later was re-measured and gave a result below the threshold). We do not have any measurements however at a lesser distance from the meter and are informed that a person may approach and even touch the meter, thus could be located as close at 2-3 cm from the meter.
- Inside meter rooms, average power densities far exceed the interior-threshold of 100 $\mu\text{W}/\text{m}^2$ recommended in the *BioInitiative Report* later described in the present report ; it is however expected that these rooms will not normally be accessed by the public. In one case, the average power density at one meter way from such room is shown to exceed the interior-threshold of 100 $\mu\text{W}/\text{m}^2$ but, in the other cases measured, is inferior to that interior-threshold.
- More problematic, however, are meters situated inside occupied rooms and facing its occupants (meters in a kitchen, etc.), where measurements show the average power density exceeds the interior-threshold of 100 $\mu\text{W}/\text{m}^2$ at 1 m from the meter. We must also keep in mind that we do not have any results at a lesser distance.

- All the above results are less than the recommended threshold of 6 000 000 $\mu\text{W}/\text{m}^2$ of both FCC and Health Canada. These measurements were however all taken at 1 m or more from the antenna; we do not have any measurements at a lesser distance.

It is to be noted that, at very close distance (inside the interior field from the antenna), extrapolation is not easily feasible from measurements taken at further distance. A real measurement is preferable.

4. STRUCTURE OF THE ANSWER TO THE QUESTION SUBMITTED BY THE REGIE DE L'ENERGIE

20. As indicated above, the Quebec Energy Board has asked me to report on « *the state of scientific research as to whether advanced meters transmitting by radiofrequencies as proposed by Hydro-Quebec in the present file may constitute a risk of serious or irreversible damage to health* ».

21. The answer to this question depends on the level of power density to which the subjects are exposed (itself being dependent on the distance between the source of emission and the subject and the interior or exterior location) and the duration of exposure, and may also vary with other characteristics of the exposure as well as the characteristics of the subjects (adults vs. children, etc.) as indicated in sections 5 and 6 of the present report. The specific characteristics of the advanced meters proposed by Hydro-Quebec in the present file, as communicated to me, were indicated in section 3 of the present report and are further commented in section 7.

Most importantly, the answer to this question depends on whether or not it is recognized that there are sufficient scientific indications of the possibility that radiofrequencies (RF) electromagnetic fields exposure may cause biological and health effects other than those resulting from heat. The scientific community is divided on this issue.

22. In section 5 of the present Report, we enumerate a number of epidemiological and laboratory research linking RF electromagnetic fields exposure with various non-thermal biological effects and their conclusions as well as several meta-analysis of the scientific literature on the subject.

23. In section 6 of the present Report, we elaborate on the lack of unanimity of the scientific community on these non-thermal biological effects and on the emerging notion that Precautionary or Prudent Measures might be appropriate as a means of managing that scientific lack of unanimity, without modifying the existing standards at the moment.

5. EPIDEMIOLOGICAL AND LABORATORY RESEARCH LINKING RF ELECTROMAGNETIC FIELDS EXPOSURE WITH VARIOUS NON-THERMAL BIOLOGICAL EFFECTS

24. It is generally accepted within the relevant scientific community and has been established beyond any reasonable doubt that adverse human health effects occur at far lower levels of RF/MW radiation exposure than those that cause measureable heating, particularly where the wavelength approaches body-part size and thus maximizes absorption, where the wavelength has resonance with the water molecule, where there is a more complex, modulated wave, where there is chronic exposure duration, and where exposed persons lack the capacity voluntarily to remove themselves from the radiation sources. It must, however, be acknowledged that biological effects do not necessarily constitute human health hazards.

25. Some effects are known to occur at several hundred thousand times below the FCC public exposure guidelines and the similar guidelines of Health Canada's Safety Code no. 6 (of 6 000 000 $\mu\text{W}/\text{m}^2$ for the 902-928 MHz bandwidth) which are set based on the assumption, which we believe is incorrect, that there are no adverse health effects at exposures that do not cause easily measureable heating.

It is further to be noted that FCC guidelines also only apply to 30-minute public exposures and Health Canada's Safety Code no. 6 only applies to 6-minute public exposures; they are however being used to infer safety at durations >30 minutes (FCC) and durations >6 minutes (Health Canada's Safety Code no. 6).

26. Exposure to high-frequency RF and MW radiation have been linked to a variety of adverse health outcomes. Some of the many adverse effects reported to be associated with and/or caused by RF/MW radiation include cancer, neurologic, endocrine, immune, cardiac, reproductive and other effects.

27. Studies of isolated cells have shown that RF/MW exposures may cause changes in cell membrane function, cell communication, metabolism, activation of proto-oncogenes, and can trigger the production of stress proteins at exposure levels below the above FCC and Health Canada guidelines. Resulting effects in cellular studies include DNA breaks and chromosome aberrations, cell death including death of brain neurons, increased free radical production, activation of the endogenous opioid system, cell stress and premature aging.

28. Human studies of comparable RF/MW radiation parameters show changes in brain function including memory loss, retarded learning, performance impairment in children, headaches and neurodegenerative conditions, melatonin suppression and sleep disorders, fatigue, hormonal imbalances, immune dysregulation such as allergic and inflammatory responses, cardiac and blood pressure problems, genotoxic effects like miscarriage, cancers such as childhood and adult leukemia, childhood and adult brain tumors, and more.

29. There is consistent evidence for increased incidence of cancer and other adverse effects in individuals who live near to high-power short-wave, AM, FM and TV transmission towers. This is particularly relevant because, like WI-FI and smart meters, radio and TV transmission towers give continuous, whole-body radiation, not just radiation to the head.

30. In addition, it is to be noted that, should the 2.4 GHz ZigBee antennas of the proposed Hydro-Quebec Landis+Gyr meters be activated in the future, their wavelength, at ~ 12.2 cm or ~ 4.8 inches, would be more absorbable by children's and adults' bodies and brains than radio or TV wavelengths. The harmfulness of such radiation therefore likely exceeds that of radio or TV towers. The 2.4 GHz frequency is similar to that used by a microwave oven. Such frequency was chosen for the oven because of its wavelength and harmonic resonance with the water molecule, to ensure the most efficient absorption by living tissues and effective heating by way of the agitation of water at the molecular level.

31. Like second-hand smoke, EMF and RF/MW radiation involve complex mixtures, where different frequencies, intensities, durations of exposure(s), modulation, waveforms and other factors are known to produce variable effects, often more harmful with greater complexity. Decades of scientific study have produced substantial evidence that EMF and RF/MW radiation may be considered neurotoxic, carcinogenic and genotoxic. Sources of fields and radiation include but are not limited to: power lines, navigational radar, cell phones, cordless phones [or Digitally Encoded Cordless Transmission Devices (D.E.C.T.) phones], cell towers, smart meters and their grids or infrastructure, "smart" boards, meters and grids, WiMax and wireless internet (WI-FI).

32. The RF/MW radiation and low-frequency EMF science that currently exists includes hundreds of studies dating back to the 1920s. On the basis of this vast body of literature, many public health experts, myself included, believe that it is likely society will face markedly increased incidence of neurotoxic effects, neurodegenerative diseases, cancers and genotoxicity in the future, resulting from the extreme and mostly involuntary exposure to RF/MW radiation and EMFs.

33. In public health science, it is generally accepted that vulnerable subgroups exist within any human population. This is also recognized specifically for RF/MW radiation and fields. These groups include children, pregnant women, the elderly, those with preexisting illnesses and/or impairments and some individuals who show electrical hypersensitivity. Children are more vulnerable to RF/MW radiation because of the susceptibility of their developing nervous systems. RF/MW radiation penetrates children's brains more than adult's because children's skulls are thinner, their brains smaller, and their brain tissue is more conductive than those of adults, and since it has a higher water content and ion concentrations. The Presidential Cancer Panel found that children 'are at special risk due to their smaller body mass and rapid physical development, both of which magnify their vulnerability to known carcinogens, including

radiation. http://deainfo.nci.nih.gov/advisory/pcp/annualReports/pcp08-09rpt/PCP_Report_08-09_508.pdf. Furthermore, should the ZigBee antenna of the proposed Hydro-Quebec Landis+Gyr meters be activated, absorption of RF/MW energy in tissues of the head of children would even be greater due to the similarity between the wavelength at 2.4 GHz size and the children's head.

34. There is also abundant literature showing that some individuals, described as electrosensitive, may encounter symptoms more intense than other individuals.

35. FCC public RF/MW radiation exposure guidelines (and the similar Health Canada Safety Code no. 6 guidelines) are based on the height, weight and stature of a 6-foot tall man, not children or adults of smaller stature. The guidelines do not take into account the unique susceptibility of growing children to RF/MW radiation exposures. Since children are growing, their rate of cellular activity and division is more rapid, and they are at more risk for DNA damage and subsequent cancers. Growth and development of the central nervous system is still occurring well into the teenage years, such that the neurological impairments predictable by the extant science may have great impact upon development, cognition, learning, and behavior.

36. Prenatal EMF exposure has been identified as a risk factor for childhood leukemia, and is associated with miscarriage. Children are largely unable to remove themselves from exposures to harmful substances in their environments. Their exposure is involuntary.

37. When a smart meter is in operation inside a dwelling, persons in the immediate vicinity have no choice but to allow the meter to expose them to microwave radiation that is much higher than exists naturally on Earth.

38. The evidence for harm from RF radiation as a cause of cancer and other diseases continues to grow. And when we focus on MW radiation, particularly pulse-modulated radiation, on long, non-intermittent duration and on more vulnerable subgroups such as children, we see that the cancer outcome is being firmly established.

Amongst the epidemiologic studies showing cancer outcomes, the following are particularly strong.

This first list is of studies where the whole body is exposed to RF radiation.

- a. Dode AC, Leao M, Tejo FdeAF, Gomes ACR, Dode DC, Dode MC, Moreira CW, Condessa VA, Albinatti C and Calaffa WT. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais State, Brazil. *Sci Total Environ* 409: 3649-3665:2011. This study shows higher rates of

cancer in people living close to cell phone towers than for people living further away.

- b. Oberfeld G. Environmental Epidemiology Study of Cancer Incidence in the Municipalities of Hausmannstatten & Vasoldsberg (Austria), 2008. This government-commissioned study found significantly increased cancer risk relative to a lower-exposure reference category, 23x higher for breast cancer and 121x higher for brain tumors, with strong exposure-effect relations.
- c. Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A and Perucci CA. Adult and childhood leukemia near a high-power radiostation in Rome, Italy. Am J Epidemiol. 155: 1098-1103: 2002. The authors show that there is a significant elevation of childhood leukemia among residents living near to Vatican Radio, and that the risk declines with distance away from the transmitter.
- d. Ha M, Im H, Lee M, Kim HJ, Kim BC, Gimm YM and Pack JK. Radiofrequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer. Am J Epidemiol 166: 270-279: 2007. Leukemia and brain cancer in children in Korea were investigated in relation to residence within 2 km of AM radio transmitters. There was a significant elevation in rates of leukemia but not of brain cancer.
- e. Park SK, Ha M, Im HJ. Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. Int Arch Occup Environ Health. 2004 Aug;77(6):387-94. This study found higher mortality areas for all cancers and leukemia in some age groups in the area near the AM towers.
- f. Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliot P. Cancer Incidence near radio and television transmitters in Great Britain. I – Sutton-Colfield transmitter, and II. Al high-power transmitters. Am J Epidemiol 1997; 145(1):1-9 and 10-17. In the first study, there was a statistically significant increase in cancer; in the second, a small but significant increase in adult leukemia.
- g. Hocking B, Gordon IR, Grain HL, Harfield GE. Cancer incidence and mortality and proximity to TV towers. Medical J of Australia. 1965;165:601-605. At extremely low exposure levels, there was an association between increased childhood leukemia incidence and mortality and proximity to TV towers.
- h. Grayson JK. Radiation exposure, socioeconomic status, and brain tumor risk in the US Air Force: A nested case-control study. Am J Epidemiol 1996; 143:480-6. This

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study found an association between exposure to ELF and RF/MW radiation and brain tumors.

- i. Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. *Sci Total Environ* 1996;180:9-17. This study showed huge increases in leukemia and Non-Hodgkin's lymphomas.
- j. Eger H, Hsagen KU, Lucas B, Vogel P and Voit H. The influence of being physically near to a cell phone transmission mast on the incidence of cancer. *Umwelt-Medizin-Gesellschaft* 17, 4; 1-7 : 2004. Over the period 1994-2004 individuals living within 400 meters of a cell phone tower had three times rates of cancer compared to those living further away.

39. The strongest evidence for harm from RF radiation comes from studies of individuals using cell phone for prolonged periods of time, which gives a localized exposure to the ipsilateral brain, auditory nerve and parotid gland in the cheek.

- a. Hardell L, Carlberg M, Soderqvist F and Mild KH. Meta-analysis of long-term mobile phone use and the association with brain tumours. *Internat J Oncology* 12 : 1097-1103. In ten studies of glioma, cell phone use for more than ten year gave an OR of 1.2 (95%CI=0.8-1.9). For ipsilateral cell phone use for more than 10 year the OR = 2.0 (1.2-3.4). There was also a significant relation for acoustic neuroma and ipsilateral cell phone use for ten years or more, but no relation for meningioma.
- b. Levis AG, Minicuci N, Ricci P, Gennaro V and Gabisa S. Mobile phones and head tumours. The discrepancies in cause-effect relationships in the epidemiological studies – how do they arise? *Environ Health* 2011, 10,59. When studies that were blinded, free from errors and bias were considered cell phone use for more than ten years resulted in a near doubling in ipsilateral glioma and acoustic neurona.
- c. Myung SK, Ju W, McDonnell DD, Lee YJ, Ksazinet G, Cheng CT and Moskowitz JM. Mobile phone use and risk of tumors : A meta-Analysis. *J Clin Oncology* 10.1200/JCO.2008.21.6366. Reviewed 465 publications that reported on 12344 cases of cancer and 25572 controls. Risk of developing brain cancer was OR+1.8 for more than ten years use.
- d. The INTERPHONE Study Group. *Internatl J Epidemiology* 2010; 1-20. Brain tumour risk in relation to mobile telephone use : results of the INTERPHONE international case-control study. While ever vs. never using a cell phone did not increase risk of brain cancer, there was a significant OR= 2.18 for use for ten or

more years, OR=1.82 for use for 1640 hours or more and OR=1.31 for more than 270 calls, all for glioma.

40. Additional studies show neurologic, immune, endocrine, reproductive and cardiac, adverse health effects from low-dose, chronic exposure to RF/MW radiation in humans:

- a. Volkow ND, Tomasi D, Wange GJ, Vaska P, Fowler JS, Teland F, Alexoff D, Logan J and Wong C. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. JAMA 305 : 808-814 : 2011. In healthy participants and compared with no exposure, 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna. This shows direct effects of RF radiation on the brain with cell phone use.
- b. McCarty DE, Carrubba S, Chesson AL, Frilor C, Gonzalex-Toledo E and Marino AA. Electromagnetic hypersensitivity : Evidence for a novel nuerological syndrome. Internat J Neurosci 121 : 670-676 : 2011. In a female physician who is electrosensitive, blinded application of EMFs triggered temporal pain, headache, muscle twitching and skipped heartbeats within 100 s of field application. This study was already filed in the present case as Exhibit C-SE-AQLPA-0037.
- c. Papageorgiou CC, Hountala CD, Maganioti AE, Kyprianou MA, Rabavilas AD, Papadimitriou GN, Capsalis CN. Effects of WI-FI signals on the p300 component of event-related potentials during an auditory hayling task. J Integr Neurosci 2011 Jun;10(2):189-202. This study concludes that WI-FI exposure may exert gender-related alterations on neural activity.
- d. Altpeter ES, Roosli M et al. Effect of Short-wave magnetic fields on sleep quality and melatonin cycle in humans: The Schwarzenburg shut-down study. Bioelectromagnetics 27:142-150, 2006. Sleep quality improved and melatonin excretion increased when the transmitter was shut down.
- e. Abelin T et al. Sleep disturbances in the vicinity of the short-wave broadcast transmitter Schwarzenburg. Somnologie 9:203-209, 2005. There is strong evidence of a causal relationship between operation of a short-wave radio transmitter and sleep disturbances in the surrounding population.
- f. Hutter HP et al. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup Environ Med 2006;63:307-313, 2006. There was a significant relation of some symptoms, especially headaches, to measured power density, as well as effects on wellbeing and performance.

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- g. Preece AW, Georgious AG, Duunn EJ, Farrow SC. Occup Environ Med 2007 64:402-8. Compared to control village, there were highly significant differences in the reporting of migraine, headache and dizziness military and cell phone antenna systems.
- h. Robertson HA et al. Low-frequency pulsed electromagnetic field exposure can alter neuroprocessing in humans J. R. Soc. Interface (2010) 7, 467–473 doi:10.1098/rsif.2009.0205. A functional magnetic resonance imaging study demonstrated how the neuromodulation effect of extremely low-frequency magnetic fields influences the processing of acute thermal pain. The study concludes that magnetoreception may be more common than presently thought. This study was already filed in the present case as Exhibit C-SE-AQLPA-0043, SE-AQLPA-5, Document 10.
- i. Buchner K, Eger, H. Changes of clinically important neurotransmitters under the influence of modulated RF fields – a long-term study under real-life conditions. Umwelt-Medizin-Gesellschaft 24(1):44-57, 2011. There is clear evidence of health-relevant effects, including increase in adrenaline/noradrenaline, subsequent decrease in dopamine from a new MWemitting base station. During counterregulation, trace amine PEA decreased and remained decreased. Clinically documented increases in sleep problems, cephalgia, vertigo, concentration problems and allergies followed the onset of new microwave transmissions.
- j. Eliyahu I, Luria R, Hareuveny R, Margaliot M, Neiran N and Shani G. Effects of radiofrequency radiation emitted by cellular telephones on the cognitive functions of humans. Bioelectromagnetics 27: 119-126: 2006. A total of 36 human subjects were exposed to PM MW and were tested on four distinct cognitive tasks. Exposure to the left side of the brain slows left-hand response time in three of the four tasks.
- k. Barth A, Winker R, Ponocny-Seliger E, Mayrhofer W, Ponocny I, Sauter C and Vana N. Occup Environ Med 65: 342-345: 2008. A meta-analysis for neurobehavioural effects due to electromagnetic field exposure emitted by GSM mobile phones. The authors looked at 19 studies of cognitive function in cell phone users, and found in the meta-analysis that there is evidence for a decreased reaction time, altered working memory and increased number of errors in exposed persons.
- l. Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J and Pauser G. Effects of exposure to base station signals on salivary cortisol, alphaamylase and immunoglobulin A. Biomed Environ Scie 23: 199-207: 2010. This was a human experimental study with exposure to PM MW radiation wherein immune indicators

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were monitored after five 50-minute sessions. The researchers found dose-dependent changes in cortisol and alpha-amylase.

- m. Avendano C, Mata A, Sanchez Sarimiento CA and Doncel GF. Use of laptop computers connected to internet through WI-FI decreases human sperm motility and increases sperm DNA fragmentation. *Fert Steril*, 2012, In press. In this study human sperm were exposed to WI-FI from a laptop, and were found to show reduced motility after a 4-hour exposure. The results are consistent with other publications (see Agarwal et al., *Fert Steril* 89: 124-128: 2008) that reported that those who use cell phone regularly have reduced sperm count.
- n. Baste V, Riise T and Moen BE (2008) *Int J Epidemiol* 37: 369-377: 2008. Radiofrequency electromagnetic fields: male infertility and sex ratio of offspring. This is a study of Norwegian Navy personnel chronically exposed to RF fields on the job. The rates of infertility were related to level of exposure in a dose-dependent fashion.

41. Many cellular and animal studies, of which the following are but a few, support conclusions of cancer, genotoxicity, neurotoxicity and other health outcomes from RF/MW radiation.

- a. Sinha R. Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats. *Int. J. Radiation Biol.* 84:6:505-513, 2008. This study concluded that the radiation was sufficient to alter the levels of thyroid hormone as well as emotional reactivity compared to controls.
- b. Nittby H, Grafstrom G, Tian DP, Malmgren L, Brun A, Persson BRR, Salfors LG and Eberhardt J. *Bioelectromagnetics* 29: 219-232: 2008. This study showed cognitive impairment in rats after long-term exposure to PM MW radiation. This study of rats shows that after 2 hours per week for 55 weeks there was impaired memory for objects in exposed as compared to sham animals.
- c. Kimmel S et al. Electromagnetic radiation: Influences on honeybees (*Apis mellifera*). A significant difference between non-exposed and fully irradiated bees was the result of the influence of high-frequency PM RF/MW radiation.
- d. Panagopoulos DJ et al. Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna. *Int. J Radiat Biol*, 86;(5):345-357, 2010. The PM MW radiations at 900 and 1800 MHz decreased the reproductive capacity by cell death induction, with an increased bioactivity “window” at 10 $\mu\text{W}/\text{cm}^2$, and still evident down to 1 $\mu\text{W}/\text{cm}^2$.

- e. Everaert J, Bauwens D. A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding house sparrow (*passer domesticus*). *Electromagnetic Biology and Medicine*, 26:63-72, 2007. Long-term exposure to higher-level low-intensity PM MW radiation negatively affects the abundance or behavior of House Sparrows in the wild.
- f. Magras I, Xenos T. RF Radiation-Induced Changes in the Prenatal Development of Mice. *Bioelectromagnetics* 18:455-461, 1997. Near almost 100 TV and FM broadcast transmitters, with exposure levels between 0.168 $\mu\text{W}/\text{cm}^2$ and 1.053 $\mu\text{W}/\text{cm}^2$, found in the more exposed groups testicular damage and decreasing size of litters to irreversible infertility.
- g. Balmori A. Electromagnetic pollution from phone masts. Effects on wildlife, *Pathophysiology* 2009. This large review of wildlife effects concludes, "pulsed telephony microwave radiation can produce effects on nervous, cardiovascular, immune and reproductive systems," including damage to the nervous system by altering EEG and changes to the blood-brain barrier, disruption of the circadian rhythms (sleep-wake) by interfering with the pineal gland and hormonal imbalances, changes in heart rate and blood pressure, impairment of health and immunity towards pathogens, weakness, exhaustion, growth problems, problems in building the nest or impaired fertility, embryonic development, hatching percentage, genetic and developmental problems, problems of locomotion, promotion of tumors and more.

42. Exposure thresholds for harmful effects are lowered in human populations and individuals when duration is increased.

43. While nearly all the lower frequency bands have already been allocated by public authorities in developed countries for specific types of radio transmissions, and transmission of ever more information content on any given channel requires greater bandwidth, each new deployment undermines further the integrity of the population's health. Engineers who design these systems have no training that would qualify them to consider the effects on biologic systems, which is why public health scientists need to be called in to policymaking prior to contracting and deployment, not after the fact.

44. The following studies explain the mechanisms of interaction between RF/MW radiation and biologic systems at the cellular level.

- a. The cell membrane recognition process -- which includes signal transduction and 'heat-shock protein' release -- was first discerned by Litovitz and his co-workers at Catholic University of America in the mid-1990s.

Below are a few references that make the point.

- i. Litovitz, T., C. Montrose, et al. (1994). "Superimposing spatially coherent electromagnetic noise inhibits field induced abnormalities in developing chick embryos." *Bioelectromagnetics* 15(2): 105-113.
 - ii. DiCarlo, A., J. Farrell, et al. (1998). "A simple experiment to study electromagnetic field effects: Protection induced by short term exposures to 60 Hz magnetic fields." *Bioelectromagnetics* 19(8): 498-500.
 - iii. Penafiel, L., T. Litovitz, et al. (1997). "Role of modulation on the effect of microwaves on ornithine decarboxylase activity in L929 cells." *Bioelectromagnetics* 18(2): 132-141.
 - iv. Dicarlo, A. L., Michael T. Hargis, L. Miguel Penafiel, Theodore A. Litovitz, A. (1999). "Short-term magnetic field exposures (60Hz) induce protection against ultraviolet radiation damage." *International journal of radiation biology* 75(12): 1541-1549.
 - v. Litovitz, T., C. Montrose, et al. (1990). "Amplitude windows and transiently augmented transcription from exposure to electromagnetic fields." *Bioelectromagnetics* 11(4): 297-312.
 - vi. Litovitz, T., M. Penafiel, et al. (1997). "The role of temporal sensing in bioelectromagnetic effects." *Bioelectromagnetics* 18(5): 388-395.
 - vii. Litovitz, T., L. Penafiel, et al. (1997). "Role of modulation in the effect of microwaves on ornithine decarboxylase activity in L929 cells." *Bioelectromagnetics* 18: 132-141.]
 - viii. Litovitz, T., D. Krause, et al. (1993). "The role of coherence time in the effect of microwaves on ornithine decarboxylase activity." *Bioelectromagnetics* 14(5): 395-403.
- b. Cell membrane reaction is lipid peroxidation.
- i. Serban, M. and V. Ni (1994). "Lipid peroxidation and change of plasma lipids in acute ischemic stroke." *Romanian journal of internal medicine= Revue roumaine de médecine interne* 32(1): 51.

- ii. Vilen, B., S. Jeney, et al. (2010). "Evidence of lipid peroxidation and protein phosphorylation in cells upon oxidative stress photogenerated by fullerenes." *Biophysical chemistry*.
- iii. Maaroufi, K., E. Save, et al. (2011). "Oxidative stress and prevention of the adaptive response to chronic iron overload in the brain of young adult rats exposed to a 150 kilohertz electromagnetic field." *Neuroscience*.
- iv. Nelson, S. K., S. K. Bose, et al. (1994). "The toxicity of high-dose superoxide dismutase suggests that superoxide can both initiate and terminate lipid peroxidation in the reperfused heart." *Free Radical Biology and Medicine* 16(2): 195-200.
- v. Alvarez, J. G. and B. T. Storey (1989). "Role of glutathione peroxidase in protecting mammalian spermatozoa from loss of motility caused by spontaneous lipid peroxidation." *Gamete research* 23(1): 77-90.
- vi. Devasagayam, T., K. Bloor, et al. (2003). "Methods for estimating lipid peroxidation: An analysis of merits and demerits." *Indian journal of biochemistry & biophysics* 40(5): 300-308.

c. Free-Radical Damage :

- i. Ozgur, E., G. Güler, et al. (2010). "Mobile phone radiation-induced free radical damage in the liver is inhibited by the antioxidants n-acetyl cysteine and epigallocatechin-gallate." *International journal of radiation biology*(00): 1-11.
- ii. Gutteridge, J. and X. C. Fu (1981). "Enhancement of bleomyciniron free radical damage to DNA by antioxidants and their inhibition of lipid peroxidation." *FEBS letters* 123(1): 71.

d. mRNA :

- i. Yan, J. G., M. Agresti, et al. (2009). "Qualitative Effect on mRNAs of Injury-Associated Proteins by Cell Phone Like Radiation in Rat Facial Nerves." *Electromagnetic Biology and Medicine* 28(4): 383-390.
- ii. Yan, J. G., M. Agresti, et al. (2008). "Upregulation of specific mRNA levels in rat brain after cell phone exposure." *Electromagnetic Biology and Medicine* 27(2): 147-154.

- iii. Simbürger, E., A. Stang, et al. (1997). "Expression of connexin43 mRNA in adult rodent brain." *Histochemistry and cell biology* 107(2): 127-137.
 - iv. Chen, J., H. C. He, et al. (2010). "Effects of Pulsed Electromagnetic Fields on the mRNA Expression of RANK and CAII in Ovariectomized Rat Osteoclast-Like Cell." *Connective Tissue Research* 51(1): 1-7.
- e. Epigenetic changes.... environmentally induced genetic change:
 - i. Migliore, L. and F. Copped (2009). "Genetics, environmental factors and the emerging role of epigenetics in neurodegenerative diseases." *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis* 667(1-2): 82-97.
- f. Micronuclei formation :
 - i. Tice, R. R., G. G. Hook, et al. (2002). "Genotoxicity of radiofrequency signals. I. Investigation of DNA damage and micronuclei induction in cultured human blood cells." *Bioelectromagnetics*, 23(2): 113-126.
 - ii. Lerchl, A. (2009). "Comments on "Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes" by Schwarz et al. (Int Arch Occup Environ Health 2008: doi: 10.1007/s00420-008-0305-5)." *Int Arch Occup Environ Health* 82(2): 275-278.
 - iii. Vijayalaxmi and T. J. Prihoda (2009). "Genetic damage in mammalian somatic cells exposed to extremely low frequency electro-magnetic fields: a meta-analysis of data from 87 publications (1990-2007)." *Int J Radiat Biol* 85(3): 196-213.
 - iv. Sannino, A., M. Sarti, et al. (2009). "Induction of adaptive response in human blood lymphocytes exposed to radiofrequency radiation." *Radiat Res* 171(6): 735-742.
- g. DNA repair disruption :
 - i. Brusick, D., R. Albertini, et al. (1998). "Genotoxicity of radiofrequency radiation. DNA/Genetox Expert Panel." *Environ Page 21 – Amended Declaration of Dr. David O. Carpenter, M.D. Mol Mutagen* 32(1): 1-16.

- ii. Belyaev, I. Y., E. Markova, et al. (2009). "Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes." *Bioelectromagnetics* 30(2): 129-141.
- iii. Sun, L. X., K. Yao, et al. (2006). "[Effect of acute exposure to microwave from mobile phone on DNA damage and repair of cultured human lens epithelial cells in vitro]." *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi* 24(8): 465-467.
- h. Immune response suppression :
 - i. Lyle, D. B., P. Schechter, et al. (1983). "Suppression of Tlymphocyte cytotoxicity following exposure to sinusoidally amplitude-modulated fields." *Bioelectromagnetics* 4(3): 281-292.
 - ii. Elekes, E., G. Thuroczy, et al. (1996). "Effect on the immune system of mice exposed chronically to 50 Hz amplitude-modulated 2.45 GHz microwaves." *Bioelectromagnetics* 17(3): 246-248.
 - iii. Dabala, D., D. Surcel, et al. (2008). "Oxidative and Immune Response in Experimental Exposure to Electromagnetic Fields." *Electromagnetic field, health and environment: proceedings of EHE'07*: 105.
 - iv. Surcel, D., D. Dabala, et al. (2009). "Free Radicals, Lipid Peroxidation and Immune Response in Experimental Exposure to Electromagnetic Fields." *Epidemiology* 20(6): S118.

45. As indicated above, the Quebec Energy Board has asked me to indicate if these research show that RF exposure « *may constitute a risk of serious or irreversible damage to health* ».

The above non-thermal biological effects do indeed constitute a risk serious damage to health.

Furthermore, such damage may be irreversible or reversible only with difficulty. For example, cancer may be reversible if treated early, but its treatment may be extremely invasive on the patient and is not always successful. Treatment for brain cancer may leave permanent neurologic impairment, even if the patient survives. Persistent headache and loss of attention may result in impaired learning in children, with life-long consequences. Neurological impairments such as Alzheimer are not reversible and their progression may only be slowed down in certain cases.

6. THE DIVISION WITHIN THE SCIENTIFIC COMMUNITY AND THE EVOLUTION TOWARDS PRECAUTION AND PRUDENCE

46. The scientific community is divided in its acceptance of the numerous research findings like the above showing a link between RF exposure and non-thermal health effects.

In section 6.1, I will discuss this division within the scientific community and how it affects the standard setting organizations.

In section 6.2, I will examine the recent evolution of various organizations towards the adoption precautionary measures, as a manner of taking into account scientific uncertainty even as the standards on RF exposure remain unchanged at the moment.

6.1 The division within the scientific community

47. The numerous research findings showing a link between RF exposure and non-thermal health effects, as those enumerated above in section 5, are denied by those who believe that RF/MW exposures that do not cause measureable heating cannot have biological effects.

48. Many in the physics and engineering communities indeed assume that RF fields are not supposed to affect biological systems other than by heating, because they do not have sufficient energy to break chemical bonds and create charged particles (ions). Electromagnetic fields at frequencies equal or higher than ultraviolet light (such as x-rays and gamma rays, with short wavelengths and high frequencies) are classified as ionizing radiation because they have sufficient energy to create charged particles (ions) by breaking chemical bonds and cause direct damage to DNA, resulting in mutations. It is well accepted that ionizing radiation can cause nonthermal biological effects including genetic mutations and cancer. Nonionizing radiation on the other hand (with long wavelengths and low frequencies, which includes visible light as well as RF and other frequency bands with common applications) is assumed to have only thermal effects. However this view has been shown to not be correct by studies since the 1970s by an accumulation of epidemiological and laboratory research which had clearly demonstrated biological effects and, indeed, human health hazards, at RF/MW exposures that do not have sufficient energy to directly break chemical bonds.

Medical and biological research findings showing nonionizing radiation having non-thermal biological effects are therefore are therefore considered an anomaly under conventional theory.

As mentioned in the research listed in section 5, the evidence for increased risk of brain tumors, acoustic neuromas and parotid gland tumors in individuals who have used a cell phone

for 10 years or more is consistent, and the tumors occur only on the side of the head where the phone is used. There is also strong and consistent evidence for increased risk of leukemia in individuals who live near to high power AM radio transmission towers.

These demonstrated non-thermal biological effects of RF exposure are however not supposed to exist under conventional physics theory.

49. Standards setting organizations aimed at regulating RF exposure have for a long time been dominated by physicists and engineers, often with close ties with the industry, with few input from biological and medical science. As mentioned later in section 6.2, this has only been recently been evolving.

Standards setting organizations also often explicitly take into account the economic impacts of the standards when faced with scientific uncertainty.

Both because of their training and because of their ties with the industry, members of most of these organizations have been reluctant to take the above biological findings into account into the exposure limits they set. At present, the exposure limits set by FCC and Health Canada as well as those set by various other standard setting organizations are based solely on biological effects resulting from heat.

Furthermore, these limits are based on the incorrect biological assumption that body temperatures must increase at least 1°C to lead to potential biological impacts and the impacts of absorbing RF within the band of the electromagnetic spectrum that smart meters use would only be limited to behavioral disruption. These limits do not take into account the scientific research that show tissue heating may result in many adverse health effects other than “behavioral disruption”. These limits also do not take into account the accepted biological fact that every enzyme system in the body is exquisitely sensitive to temperature and may increase activity by even a fraction of a degree increase in temperature. What is defined as “nonthermal” effect is therefore partly a function of our ability to measure the temperature increase.

50. To understand the seriousness of this Agent of PM RF/MW radiation in interaction with populations and individuals, we need to consider some basic facts in addition to the many relevant and reliable studies above. Shortwave, AM, FM, TV, smart meters and cell phone frequencies are harmful to human health even when at low intensity if exposure is continuous or prolonged.

There are only a few of the many studies of RF/MW radiation infrastructure such as base stations that fail to show adverse effects.

51. Standards setting organizations have until now generally refused to accept epidemiological and laboratory research findings linking RF electromagnetic fields exposure with various non-thermal biological effects, as being inconclusive and requiring further research.

The difficulty stems from the fact that, although links have been demonstrated repeatedly between RF electromagnetic fields exposure and non-thermal biological effects, there is *a lack of a comprehensive biological theory explaining why these effects take place*, and therefore *causality* cannot, at the present time, be demonstrated with certainty.

Also in some cases, experimental results could not be duplicated; in some cases attempts to duplicate results showed negative results or variations in the results. These discrepancies are however normal in the research process; they indicate that biological systems are complex and that different variables need to be isolated in order to fully understand these systems. Research is still needed in order to determine to what extent non-thermal biological effects may vary with frequency, with modulation and depend on the pulsed (instead of continuous) character of RF emissions. Emissions from smart meters are pulsed and a recent study by McCarty et al has shown that certain symptoms may be caused primarily by field transitions (off-on, on-off) rather than the presence of the field itself (This research was already filed as Exhibit C-SE-AQLPA-0037 and is mentioned in section 5 of the present report). There also may be variance between the levels of reaction of different subjects for reasons that still remain to be explained. This is what the research process is about. In biology and medicine there is nothing that is 100 % proven; our understanding of various illnesses such as cancer and Alzheimer for example is still largely incomplete. We rely on statistical significance and weight of evidence and, therefore, on judgment, when drawing conclusions about health effects.

Standard setting organizations have so far however generally been reluctant to take into account these biological findings.

52. For instance, the FCC-appointed guideline-setting Commission, ASTM-IEEE, in 1991 referred in its conclusions to RF/MW radiation, the Agent, as a 'Hazard,' specifically setting a 'Hazard Threshold.'

It had however been discovered that, even amongst the 120 studies chosen by the Committee to prove the validity of its Hazard Threshold, there were 15 studies that concluded adverse effects at levels lower than the Hazard Threshold, thus disproving its validity. Three of these studies actually showed adverse effects at less than 10 percent of the Hazard Threshold. FCC did not take those into consideration when setting its guidelines.

53. Industry also largely controls the funding of research in this matter, which represents an additional difficulty.

6.2 The evolution towards Precaution and Prudence

54. In 2007, the *BioInitiative Report*, to which I participated, was aimed at « *restoring the balance* », by providing a more comprehensive review of the scientific research available, including those research that demonstrated a link between RF exposure and non-thermal biological effects, research that standard setting organizations were failing to properly take into account.

55. Generally speaking, standards setting organizations have not modified their standards on RF exposure subsequent to the *BioInitiative Report* and have expressed the view it was inconclusive. Some have also reproached this review to place too much emphasis on the research that showed positive results and less on those that showed negative results. This has to be put into the context that the *BioInitiative report* was aimed at « *restoring the balance* » on these research.

What we have seen however in the past few years is an evolution of decision makers towards the application of the *Precautionary Principle*, as a manner of integrating scientific research that links RF exposure to non thermal biological effects, without modifying the standards at the moment.

This evolution towards the application of the *Precautionary Principle* intervenes as further research results continue to become available that confirm these links RF exposure to non thermal biological effects.

These new research were helped in part by the review of earlier scientific literature provided by the *BioInitiative report*.

As mentioned earlier, the public health chapter from the *BioInitiative report* was subsequently published in a peer-reviewed journal, *Reviews on Environmental Health*, and it and other chapters of the *Report* were published in the peer-reviewed journal, *Pathophysiology*.

Furthermore, new meta-analysis strengthen the observations that links between RF exposure and non thermal biological effects do exist. Among others, we mentioned in section 5 the following :

- a. Hardell L, Carlberg M, Soderqvist F and Mild KH. Meta-analysis of long-term mobile phone use and the association with brain tumours. *Internat J Oncology* 12 : 1097-1103. In ten studies of glioma, cell phone use for more than ten year gave an OR of 1.2 (95%CI=0.8-1.9). For ipsilateral cell phone use for more than 10 year the OR = 2.0 (1.2-3.4). There was also a significant relation for acoustic neuroma and ipsilateral cell phone use for ten years or more, but no relation for meningioma.

- b. Myung SK, Ju W, McDonnell DD, Lee YJ, Ksazinet G, Cheng CT and Moskowitz JM. Mobile phone use and risk of tumors: A meta-Analysis. J Clin Oncology 10.1200/JCO.2008.21.6366. Reviewed 465 publications that reported on 12344 cases of cancer and 25572 controls. Risk of developing brain cancer was OR+1.8 for more than ten years use.
- c. Barth A, Winker R, Ponocny-Seliger E, Mayrhofer W, Ponocny I, Sauter C and Vana N. Occup Environ Med 65: 342-345: 2008. A meta-analysis for neurobehavioural effects due to electromagnetic field exposure emitted by GSM mobile phones. The authors looked at 19 studies of cognitive function in cell phone users, and found in the meta-analysis that there is evidence for a decreased reaction time, altered working memory and increased number of errors in exposed persons.
- d. Vijayalaxmi and T. J. Prihoda (2009). "Genetic damage in mammalian somatic cells exposed to extremely low frequency electro-magnetic fields: a meta-analysis of data from 87 publications (1990-2007)." Int J Radiat Biol 85(3): 196-213.

56. Medical and biological experts have started to become more present in various international or national organizations aimed at issuing standards or recommendations.

Standard organizations are starting to become more aware as to the need of ensuring independence of their committee members as well as public representation.

As Maisch (2001) mentioned in *Radiofrequency/Microwave Radiation and the International Agency for Research on Cancer (IARC). The problem of conflict of interest & commercial influence in WHO agencies and the need for public interest representation*, http://www.next-up.org/pdf/who_conflict.pdf, « the IARC requirements (pre 2005) for handling conflict of interest were revised and made more transparent as a direct result of a series of critical articles published in *The Lancet Oncology* and *The Lancet* in 2003 that questioned the credibility of the IARC. Among a number of concerns, the articles highlighted concerns about “the inappropriate influence of invited specialists who had links to industry”. As a result of the concerns, *The Lancet* introduced the Policy Watch section that summarized the key findings of every IARC Monograph meeting up to 12 months before the corresponding Monograph was published. As a result of this ‘surveillance’ of the IARC Monograph process, by 2005 IARC had revised its conflict of interest policy in line with the Lancet’s Policy Watch (Collingridge, D., Increased transparency in IARC Monograph programme, *The Lancet Oncology*, Vol. 6, October 2005. [http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045\(05\)70364-8/fulltext](http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(05)70364-8/fulltext), Accessed May 3, 2011.). »

Exhibit SE-AQLPA-7 - Document 1

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

Expert Report by David O. Carpenter

Filed by Stratégies Énergétiques (S.É.) / Energy Strategies (E.S.) and the AQLPA

Maisch however contended that inappropriate influence of invited specialists who had links to industry in IARC meetings was still a major issue that needed to be addressed. In his article, he specifically mentioned Dr. Michel Plante of Hydro-Quebec as one of those problematic invited participants that had links with the industry.

57. As early as of 1990, the US Environmental Protection Agency ("EPA") had determined RF/MW radiation a "probable carcinogen".

During that period, reputed author Paul Brodeur created a stir by the publication of a series of articles alleging a cover-up of serious human health effects.

58. In 2011 the World Health Organization's International Agency for Research on Cancer (WHO-IARC) identified RF radiation as a possible human carcinogen.

59. The *American Academy of Environmental Medicine* recently issued a position paper on « Electromagnetic and radiofrequency field effect on human health » and made the following specific recommendations :

- a. An immediate caution on smart meter installation due to potentially harmful RF exposure.
- b. Accommodation for health considerations regarding EMF and RF exposure, including exposure to wireless smart meter technology.
- c. Recognition that electromagnetic hypersensitivity is a growing problem worldwide and
- d. Use of safer technology, including for smart meters, such as hard-wiring, fiber optics or other non-harmful methods of data transmission.

60. Although the existing standards are not being changed, the Parliamentary Assemblies of the European Community and of the Council of Europe both have issued recommendations in favor of a more cautious approach towards RF exposure, referring to the *BioInitiative Report*.

61. The World Health Organization's International Agency for Research on Cancer (WHO-IARC)'s 2011 classification of RF radiation as a possible human carcinogen itself opens the door to a more prudent approach even when the existing standards are met.

62. Other national or local organizations have also recommended prudence in various countries.

As an example, Health Canada, although it did not change its standards solely based on health effects, has recommended prudence in RF exposure in the following terms in a memo issued in October 2011 (http://www.hc-sc.gc.ca/ahc-asc/media/advisories-avis/2011/2011_131-eng.php), even when its own existing standards are met :

The International Agency for Research on Cancer's (IARC) recent classification of RF energy as "possibly carcinogenic to humans" is an acknowledgement that limited data exists that suggests RF energy might cause cancer. At present, the scientific evidence is far from conclusive and more research is required.

Health Canada reminds cell phone users that they can take practical measures to reduce RF exposure. The department also encourages parents to reduce their children's RF exposure from cell phones since children are typically more sensitive to a variety of environmental agents. As well, there is currently a lack of scientific information regarding the potential health impacts of cell phones on children.

What consumers can do:

- Limit the length of cell phone calls
- Replace cell phone calls with text messages or use "hands-free" devices
- Encourage children under the age of 18 to limit their cell phone usage

63. In the *BioInitiative Report*, we had recommended, as a prudent measure, to limit RF exposure to a maximal power density of 1000 $\mu\text{W}/\text{m}^2$ outside and 100 $\mu\text{W}/\text{m}^2$ inside.

This can be accomplished even as the existing standards remain unchanged for the moment.

64. In the history of public health, there are numerous examples of the serious consequences that were incurred as a result of officials' omission to take proper precautionary measures after initial scientific observations showed early warning. See a major review in : Late lessons from early warnings: the precautionary principle 1896-2000, published by the EEA (European Environment Agency), http://www.eea.europa.eu/publications/environmental_issue_report_2001_22 .

65. In its *Draft Precautionary Framework for Public Health Protection* of 2003 (http://www.who.int/peh-emf/meetings/archive/Precaution_Draft_2May.pdf), the World Health Organization insists (on page 4) that precautionary measures are not aimed at becoming a substitute for standard setting. Standards must be set on scientific certainty or consensus, while precautionary measures manage uncertainty.

According to the *Draft Precautionary Framework* of the World Health Organization (which refers, on this, to the European Commission Communication on "The Precautionary Principle",

February 2000, http://europa.eu.int/eur-lex/en/com/cnc/2000/com2000_0001en01.pdf), when an uncertainty or a risk is identified, the option selected as a precautionary measure should be a) proportional to the desired level of protection, b) non-discriminatory in its application, c) consistent with the measures already adopted in similar circumstances or using similar approaches, d) based on an examination of the potential benefits and costs of action or lack of action (including where appropriate and feasible, an economic cost/benefit analysis), e) subject of review, in the light of subsequent scientific data and f) when possible, assign responsibilities for collecting such new scientific data.

The *Draft Precautionary Framework* of the World Health Organization is filed as an annex to the present report.

66. In its March 2000 *Backgrounder on Electromagnetic Fields and Public Health* (http://www.who.int/docstore/peh-emf/publications/facts_press/EMF-Precaution.htm), the World Health Organization had also developed the notion that precautionary measures are of a different nature than standards, the former being a form of uncertainty or risk management. In addition to the notion of Precautionary Principles, it accepted the lesser notion of Prudent Avoidance, being defined as taking simple, easily achievable and low cost avoidance measures, even in the absence of a demonstrable risk. On the Precautionary Principle itself, the Backgrounder also referred to the February 2000 European Commission guidelines mentioned above.

The World Health Organization *Backgrounder on Electromagnetic Fields and Public Health* is filed as an annex to the present report.

67. In 2003, the Canadian government issued a *Framework for the application of precaution in science-based decision making about risk* (<http://www.pco-bcp.gc.ca/docs/information/publications/precaution/Precaution-eng.pdf>), which referred to similar principles.

The *Framework* identified five *General Principles of Application of Precaution* :

- ❑ The application of precaution is a legitimate and distinctive decision-making approach within risk management
- ❑ It is legitimate that decisions be guided by society's chosen level of protection against risk.
- ❑ Sound scientific information and its evaluation must be the basis for applying precaution; the scientific information base and responsibility for producing it may shift as knowledge evolves.

- ❑ Mechanisms should exist for re-evaluating the basis for decisions and for providing a transparent process for further consideration.
- ❑ A high degree of transparency, clear accountability and meaningful public involvement are appropriate.

According to this document, the *Precautionary Measures* should be designed around 5 principles :

- ❑ Precautionary measures should be subject to reconsideration, on the basis of the evolution of science, technology and society's chosen level of protection.
- ❑ Precautionary measures should be proportional to the potential severity of the risk being addressed and to society's chosen level of protection.
- ❑ Precautionary measures should be non-discriminatory and consistent with measures taken in similar circumstances.
- ❑ Precautionary measures should be cost-effective, with the goal of generating (i) an overall net benefit for society at least cost, and (ii) efficiency in the choice of measures.
- ❑ Where more than one option reasonably meets the above characteristics, then the least trade-restrictive measure should be applied.

The Canadian government *Framework for the application of precaution in science-based decision making about risk* is filed as an annex to the present report.

7. PRECAUTIONARY AND PRUDENT MEASURES THAT MAY BE APPLICABLE IN THE CONTEXT OF THE PRESENT CASE

68. As mentioned in section 3, results on Hydro-Quebec's Landis+Gyr proposed meters have showed the following :

- Average power densities measured at 1 m from exterior meters do not exceed the exterior-threshold of $1\,000\ \mu\text{W}/\text{m}^2$ recommended in the *BioInitiative Report*, which is later described in the present report (save for one atypically high result on one meter which later was re-measured and gave a result below the threshold). We do not have any measurements however at a lesser distance from the meter and are informed that a person may approach and even touch the meter, thus could be located as close at 2-3 cm from the meter.
- Inside meter rooms, average power densities far exceed the interior-threshold of $100\ \mu\text{W}/\text{m}^2$ recommended in the *BioInitiative Report* later described in the present report ; it is however expected that these rooms will not normally be accessed by the public. In one case, the average power density at one meter way from such room is shown to exceed the interior-threshold of $100\ \mu\text{W}/\text{m}^2$ but, in the other cases measured, is inferior to that interior-threshold.
- More problematic however are meters situated inside occupied rooms and facing its occupants (meters in a kitchen, etc.), where measurements show the average power density exceeds the interior-threshold of $100\ \mu\text{W}/\text{m}^2$ at 1 m from the meter. We must also keep in mind that we do not have any results at a lesser distance.
- All the above results are inferior to the recommended threshold of $6\,000\,000\ \mu\text{W}/\text{m}^2$ of both FCC and Health Canada. These measurements were however all taken at 1 m or more from the antenna; we do not have any measurements at a lesser distance.

69. One of the precautionary or prudent measures that could be examined in the present case would consist in using hard wired technology instead of wireless communication in deploying the smart meters. (California Council on Science and Technology's report issued in 2011 under the title "Health Impacts of Radiofrequency from Smart Meters" also envisioned the possibility of deployment of hard-wired smart meters throughout California, but only as a retrofit option to be considered if requirements evolve at a later date. To that, I had answered it would be easier and less costly to install hard-wired smart meters to begin with). It is however not the purpose of my present report to determine if, in view of the costs and benefits of deploying hard-wired smart meters and in view of the extent of the problems identified in the previous section, such option would be appropriate in accordance with the previously-stated guidelines on Precautionary and Prudent Measures.

Alternate precautionary or prudent measures to be examined could also include, among others :

- Deploying hard-wired technology at least in the most problematic cases, such as when the meters are situated inside a residence, facing its occupants or when the more fragile population is involved (children, pregnant women, elderly, persons with illness, etc).
- Moving to the outside those problematic interior meters (or at least moving the antenna outside if feasible).
- Positioning the meters and antennas in order to ensure a proper safety distance, so that both the maximal exposure standards and the BioInitiative prudent maximal exposure recommendations are complied with (both inside and outside). As seen earlier, the principal problem to be resolved is with interior meters facing occupants.

As a further alternative, an opting out option may also be considered. But, in some cases, such an option will not resolve the issue, such as when a person is exposed to RF emissions from a meter not his own. An example of this situation occurs when meters from several different clients are collocated inside the apartment of one of them.

Here again, I stress that it is not the purpose of my present report to determine if, in view of their costs and benefits, the above measures would be appropriate in accordance with the previously-stated guidelines on Precautionary and Prudent Measures.

8. CONCLUSIONS

70. It is consequently my opinion that the state of scientific research sufficiently establishes a risk that meters transmitting by radiofrequencies as proposed in the present file by Hydro-Quebec may constitute a risk of serious as well as irreversible damage to health, through biological effects other than those resulting from heat. Some individuals or categories of individuals are more susceptible to injury than others (children, pregnant women, elderly, persons with illness, etc).

Such non thermal effects are reviewed in section 5 of this report.

Therefore, there is justification for examining precautionary or prudent measures that could be applied in addition to the current standards (which are based only on biological effects resulting from heat). Discussion and examples of such possible precautionary or prudent measures are provided in sections 6 and 7 of this report.

Dated this 30th day of April, 2012



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