Submitted via email from L. Lloyd Morgan to ccst@ccst.us from Bilovsky@aol.com 1/21/11 at 11:09 a.m
He requested detailed response to his comments
Senior Research Fellow, Environmental Health Trust, 510 841-4362

Comments on California Council on Science and Technology's Smart Meter Report, January 2011

L. Lloyd Morgan, Senior Research Fellow, Environmental Health Trust

Overview

The California Council on Science and Technology (CCST) Smart Meterr Report is based on a 1997 Federal Communications Commission (FCC) exposure standard[1], which has not been revised for 15 years, while the technology on which these standards were based has been changing at an exponential rate. The exposure standard is based on acute (short-term/immediate) thermal (measured temperature change) effects, and is not based on chronic (long-term) effects.

During the intervening 15 years, peer-reviewed scientific studies of humans, animals, and living cells have found that chronic exposures to non-ionizing, non-thermal electromagnetic radiation[2] cause a host of serious problems. Here is a partial list of these problems:

- Human studies found risks for: brain tumors (cancer [1-3], acoustic neuroma[3] [4-6], meningioma[4] [7-9]), parotid gland[5] tumors [10-12], eye cancer [13], testicular cancer and damaged sperm [14-16], and leukemia [17-18];
- Animal studies found single and double strand DNA breaks [19-23], DNA damage to sperm [24-25] as well as blood-brain-barrier leakage with resultant dead neurons and cognitive deficits [26-28];
- Specific modulation techniques studies found a 6-fold difference between the power absorbed from two different modulation techniques by human cells before DNA damage was found [29-30], and;
- Cell studies found genetic damage in human and animal cells including human sperm cells [31-32].

With human, animal and cell studies all showing harmful effects, it is hard to imagine why the exposure standard has not been changed.

Given CCST's assertion that "To date, scientific studies have not identified or confirmed negative health effects from potential non—thermal impacts of RF emissions such as those produced by existing common household electronic devices and smart meters,"[6] is demonsratably false, this Report should be substantially revised, or withdrawn, and the money received for the study returned.

Ironically CCST has just produced another Report, "Trust and Accountability in Science and Technology,' yet has contributed to this very problem with the above assertion.

As the CCST Report states there are alternatives to wireless smart meters (page 24), but the report makes no recommendation stating that these alternatives have tradeoffs of

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1 Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. OET Bulletin 65, Edition 97-01
2 Smart meters create "non-ionizing, non-thermal electromagnetic radiation."
3 A tumor of the acoustic nerve.
4 A tumor of the meninges.
5 A salivary gland located in the cheek, below the ear, exactly where a cellphone is placed.
6 CCST Key Report Finding 3, page 4.

"cost and performance." See An Alternative to Wireless Smart Meters below for an alternative without these tradeoffs.

The CCST Report ignores specific characteristics of microwave radiation. The specific characteristics of smart meter radiation are *unique* to this technology. To understand the characteristics we need to know the carrier frequency,[7] and of far *greater importance*, the modulation technique used to encode the information to be "carried" by the "carrier" signal. Modern modulation techniques are quite complex. This includes the rise and fall times of the digital signal in addtion to the data encoding scheme.

With full and complete knowledge of the smart meters' modulation technique (not disclosed), a Fourier Transform (http://en.wikipedia.org/wiki/Fourier_transform) can be used to determine the large set of individual frequencies embedded in the smart meter's modulation scheme. Each frequency, or combinations of frequencies, could have a unique biological effect. There has NEVER been a scientific study of a *specific modulation* technique on living organisms, whether humans, animals, or cells. Therefore, to blindly assert that, "scientific studies have not identified or confirmed negative health effects from potential non—thermal impacts of RF emissions," is specious.

In the absence of information, and in the presence of a multitude of reports of ill health, incorrect meter readings, electromagnetic interference (EMI) to other electrical equipment (and possibly EMI from other equipment to the smart meter itself), there is a serious dereliction of duty by the government of California to protects its citizens' health and well being.

Yet this report makes no recommendation, as it should, to thoroughly investigate each of these problems.

Microwave Modulation: Different Effects from Different Modulation Techniques

As a general statement, scientific studies that have examined un-modulated RF exposures[8] have rarely reported adverse health effects. But when any form of modulation is introduced, even turning the carrier frequency on and off once every 20 minutes, biologic effects are commonly found.

Here is an example of how important specific modulation techniques can be. When human fibroblast cells were exposed to GSM[9] modulated cellphone radiation, the REFLEX project[10] found that genotoxic (DNA damage) effects began at a SAR=0.3 W/kg[11] [28]. However, in another REFLEX study, which exposed human fibroblast cells to UMTS[12] modulated cellphone radiation, effects were found beginning at a SAR=0.05

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[7] It is called the "carrier frequency" because it "carries" the information embedded into the carrier by the modulation of the carrier.

[8] Variously referred to as "sine wave," "sinusoidal," "continuous wave," and "CW."

[9] GSM is the most common cellphone modulation technique used in second generation cellphones (G2).

[10] REFLEX is a large European Union funded set of studies of the effects of cellphone radiation on human cells. Results have been replicated in many labs across Europe.

[11] SAR: Specific Absorption Rate, the amount of power absorbed when a microwave radiation source is within close proximity to a person. Power density is used when a microwave source is not in immediate proximity to a person. The SAR level can be calculated from the power density level, and vice a versa. The FCC's SAR exposure limit is 1.6 W/kg.

[12] UMTS is the most common cellphone modulation technique used in third generation, "Smart phones" (G3).

W/kg [29]. In other words, a UMTS modulated signal is 6 times more efficient in causing DNA damage to human cells than is a GSM modulated signal.

Reports by Richard Tell Associates, Inc.

Richard Tell Associates, Inc. produced two reports for PG&E that PG&E provided to some of its customers[13] [33-34].

These two reports discuss various power density values (e.g. 8.8 μW/cm^2) but NEVER described these values as *average power* density values, which is what they are. This is important and appears to be an attempt by PG&E to hide the true nature of the smart meters' radiation.

What matters is the *peak power*, not the average, power. The average power may cause little or no effect, while the peak power could be very dangerous. For example if the same cumulative sound power that reaches our ears during the duration of a song, say 3 minutes, were instead to reach our ears over one-tenth of a second, the peak power would be 1,800 times larger and could easily cause severe damage to our hearing.

To calculate peak power density, from the average power density, divide the duty cycle into the average power density. On PDF page 36[14] the duty cycle[15] is 0.00000347. If the average power density from a smart meter as reported in the Summary Section of the Supplemental report is 8.8 μW/cm^2, at a distance of 1 foot (PDF page 32), then the peak power density is 2.54 W/cm^2 (8.8 μW/cm^2/0.00000347= 2.6 W/cm^2).

The FCC designates the frequency band used by smart meters for use by "Amateur (33 cm) [radio operators]/various secondary (ISM and license free)" transmissions.

The FCC defines the power density exposure limit in mW/cm^2 as f/1500, where f is the frequency in MHz. The smart meter frequency range is 902-928 MHz (PDF page 32). Therefore the exposure limit is 0.601 to 0.618 mW/cm^2. The smart meters' peak power density is far beyond this exposure limit (>4,200 times).

Ah, but here comes catch-22! Because the exposure limit was based on heating effects, and because it takes time for a human body to increase its temperature, the FCC's power density exposure limit is averaged over 6 minutes.

CCST's Report should recommend that the State of California pass a resolution asking the Federal government to revise the exposure limits based on the peer-reviewed science studies that have reported health and/or damaged DNA effects since 1997.[16]

Given the multiple reports of electromagnetic interference (EMI) from smart meters (garage door openers, cordless phones, baby monitors and pace makers), clearly smart meters are creating substantial EMI (perhaps the result of the extraordinarily high peak power density). The FCC requirements for use of this frequency band states, "Part 15 of the FCC's rules provides for the operation of unlicensed devices. As a general condition of operation, Part 15 devices may not cause any harmful interference to authorized services and must accept any interference that may be received. In addition, all services and devices operating in the 915 MHz (902 - 928 MHz) … band must accept any interference received from industrial, scientific and medical equipment." [35]

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[13] The Richard Tell Associates Supplemental Report [34] is also cited by the CCST Smart Meter Report (page 9)

[14] I have a PDF of the combination of the two Richard Tell Associates reports (available upon request).

[15] Duty cycle is the fraction of time the smart meter is transmitting.

[16] The current exposure limit was published in 1997.

CCST's Report should recommend that all citizens who report EMI to their equipment be forwarded as a formal EMI complaint to the FCC.

An Alternatives to Wireless Smart Meters

By its nature, no matter how secure wireless transmissions *appear* to be, they are vulnerable to hacking. This could result in all electricity, natural gas, and water being simultaneously turned off.

There is an existing infrastructure that would, at minimal expense allow for installation of wired smart meters. This infrastructure is pre-existing at virtually every site where smart meters are installed. It is immune from hacking. It is the landline phone system.

Although approximately 40% of these telephone wires are no longer in use, reconnecting them at the telephone companies' switching facilities is simple.

There would be no performance tradeoff if the "wired through phone line" (AKA landline phone system) method were to be implemented. The only applicable "tradeoff" of the landline phone method would be the cost of retrofitting the poorly thought through wireless method. If this option had been chosen initially, it would likely have been less expensive than the wireless option because there was already a pre-existing under utilized infrastructure in place. The cost of creating a wireless data collection infrastructure would not be required. The cost already incurred, was the result of bad decision-making, and should be born by the decision-makers, not by the public.

Even when an existing landline phone remains in use, it is a trivial matter to design a smart meter to landline interface that would wait until a dial tone is available. Because the duration of a given transmission is very short, such use of the landline by a smart meter would likely be less than one second.

Conclusions

- The CCST Report is based on an existing FCC standard that has not been updated for 15 years, is based only on short-term effects from heating, and ignores long-term effects.
- The CCST Report should recommend that California send a Resolution to the Federal government asking that the exposure limits be revised based on the findings of science studies published since 1997.
- The CCST Report is patently wrong when it states, "scientific studies have not identified or confirmed negative health effects from potential non—thermal impacts of RF emissions."
- The CCST Report requires substantial revision to reflect what scientific studies have found concerning negative human health effects and/or DNA damage to animal and cells, or if not revised, should be withdrawn and all monies returned to the government of California.
- An alternative to wireless smart meters exists. The wireless smart meter program should be abandoned in favor a wired system using the pre-existing landline phone system. Without regard to the cost wasted on a bad decision, this system would be less expensive and would be secure from hacking.
- The CCST should recommend a moratorium on wireless smart meter installations until such time that the wired smart meter alternative is available.

- The State of California, its counties and cities are derelict in their duties to protect its citizens' health and well being given the multitude of uninvestigated reports by its citizens.
- The CCST report should recommend the State of California direct the California Public Utilities Commission (CPUC) to investigate all citizens reports as described below.
- The CPUC is derelict in its duty
  - To adequately regulate PG&E, whether
    - Natural gas transmission pipe lines as witnessed by the explosion and loss of life and property in San Bruno, CA, or
    - By not taking actions against PG&E's spying on groups opposing wireless smart meters,[17] or
    - By not taking action against PG&E's public release of private emails from people who are opposed to wireless smart meters, and
    - For not requiring PG&E to document why particular smart meters malfunctioned.
  - for not investigating smart meter EMI reports of interference with garage door openers, cordless telephones, baby monitors and heart pace makers, as well as for not filing reports to the FCC of such EMI reports,
  - for not requiring its subcontractor, Structure™, to test the accuracy of smart meter under real-world conditions of potential EMI resulting from high frequency voltage transients[18] conducted into the smart meters that co-exist with 60 Hz power, and where large RF radiation fields[19] create potential EMI from radiated fields into smart meters,
  - For not having medical doctors investigate the health effects reported to them by citizens, nor even asking citizens making these reports to provide medical documentation of their reported health problems by their physicians.

References, partial list (all reported results are statistically significant unless otherwise noted)

Brain cancer

A 160% increased risk was found for ≥10 years of digital cellphone use [1). When cellphone use began as a teenager or younger, a 680% increased risk was found for ipsilateral[20] use of a cellphone, compared to when cellphone use began between ages 20-49 where a 110% increased risk was found [2]. A 118% increased risk was found for >10 years of cellphone use compared to short-term use (1.0 –1.9 years) [3].

1. Lennart Hardell, Michael Carlberg, Kjell Hansson Mild. Pooled analysis of two case–control studies on use of cellular and cordless telephones and the risk for malignant

[17] William Devereaux, Senior Director of Pacific Gas and Electric's 'Smart' Meter program has been caught falsifying his identity in a covert attempt to access information from a group of citizens opposing the new meters.,

[18] Voltage transients are created whenever the electrical current flow is changed. The highest levels of these transients can be found immediately adjacent to cellphone base stations that conduct high frequency voltage transients back onto the electrical grid.

[19] These fields are particular high in close proximity to radio and TV broadcast antennae as well in close proximity to aircraft and weather radar facilities.

[20] Ipsilateral: tumor on same side of head as where cellphone was held.

brain tumours diagnosed in 1997–2003. Int Arch Occup Environ Health. 2006 Sep;79(8):630-9. Epub 2006 Mar 16.
2. Lennart Hardell & Michael Carlberg. Mobile phones, cordless phones and the risk for brain tumours. International Journal of Oncology 35: 5-17, 2009.
3. The Interphone Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study. Int J Epidemiol. 2010 Jun;39(3):675-94. Epub 2010 May 17.

Acoustic Neuroma

A 70% increased risk was found from ipsilateral use of a cellphone [4]. A 400% increased risk was found for use for >20 minutes per day, both for 1 and 5 years before diagnosis [5]. A 290% increased risk was found for ≥10 years of ipsilateral use [6].

4. Lennart Hardell, Michael Carlberg, Kjell Hansson Mild. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003. International Journal of Oncology 28: 509-5181, 2006.
5. Yasuto Sato, Suminori Akiba, Osami Kubo, and NaohitoYamaguchi. A Case-Case Study of Mobile Phone Use and Acoustic Neuroma Risk in Japan. Bioelectromagnetics. 2011 Feb;32(2):85-93.
6. Stefan Lönn, Anders Ahlbom, Per Hall, and Maria Feychting. Mobile Phone Use and the Risk of Acoustic Neuroma. Epidemiology 2004;15: 653–659)

Meningioma

A 40% increased risk was found from ipsilateral use of a cellphone [7]. A 380% increased risk was found for ≥1,640 cumulative hours with cellphone use for 1-4 years [8]. A 202% increased risk was found for occupational exposure to ELF EMF [9].

7. Lennart Hardell, Michael Carlberg, Kjell Hansson Mild. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003. International Journal of Oncology 28: 509-5181, 2006
8. The Interphone Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study. Int J Epidemiol. 2010 Jun;39(3):675-94. Epub 2010 May 17.
9. Isabelle Baldi, Gaëlle Coureau, Anne Jaffré, Anne Gruber, Stéphane Ducamp, Dorothée Provost, Pierre Lebailly, Anne Vital, Hugues Loiseau, and Roger Salamon. Occupational and Residential Exposure to Electromagnetic Fields and Risk of Brain Tumours in adults: a Case-Control Study in Gironde, France. Int J Cancer. 2010 Nov 12. [Epub ahead of print]

Salivary (parotid) gland tumors

A 96% increased risk was found for >1,035 cumulative hours of cellphone use [10]. A borderline significant 160% increased risk (p=0.078) was found for ≥10 years since first use [11]. In Israel, parotid gland cancers averaged 37 cases per year from 1977-2001, and averaged 61 cases per year from 2001-2006 [12]

10. Siegal Sadetzki, Angela Chetrit, Avital Jarus-Hakak, Elisabeth Cardis, Yonit Deutch, Shay Duvdevani, Ahuva Zultan, Ilya Novikov, Laurence Freedman, and Michael

Wolf. Cellular Phone Use and Risk of Benign and Malignant Parotid Gland Tumors—A Nationwide Case-Control Study. Am J Epidemiol. 2008 Feb 15;167(4):457-67. Epub 2007 Dec 6.

11. Stefan Lönn, Anders Ahlbom, Helle C. Christensen, Christoffer Johansen, Joachim Schüz, Staffan Edström, Gert Henriksson4, Jan Lundgren, Johan Wennerberg, and Maria Feychting. Mobile Phone Use and Risk of Parotid Gland Tumor. Am J Epidemiol. 2006 Oct 1;164(7):637-43. Epub 2006 Jul 3
12. Czerninski, Rakefet; Zini, Avi; Sgan-Cohen, Harold D. Risk of Parotid Malignant Tumors in Israel (1970–2006). Epidemiology: January 2011 - Volume 22 - Issue 1 - pp 130-131.

Eye cancer

A 320% increased risk was found for "probable/certain exposure to mobile phones" [13].

13. Andreas Stang, Gerasimos Anastassiou, Wolfgang Ahrens, Katja Bromen, Norbert Bornfeld, and Karl-Heinz Jöckel. The Possible Role of Radiofrequency Radiation in the Development of Uveal Melanoma. Epidemiology 2001;12:7–12).

Human testicular cancer and damaged sperm

A borderline significant (p=0.061), 80% ipsilateral risk was found when the cellphone is kept in trouser pockets [14]. "Use of cell phones decrease the semen quality …by decreasing the sperm count, motility, viability, and normal morphology" [15]. "The prolonged use of cell phones may have negative effects on the sperm motility characteristics" [16].

14. L. Hardell, M. Carlberg, C.-G. Ohlson, H. Westberg, M. Eriksson§ and K. Hansson Mild. Use of cellular and cordless telephones and risk of testicular cancer. Int J Androl. 2007 Apr;30(2):115-22. Epub 2006 Dec 20.
15. A. Agarwal, F. Deepinder, R.K. Sharma, G. Ranga, J. Li, Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study, Fertil. Steril. 89 (2008) 124–128.
16. I. Fejes, Z. Závaczki, J. Szöllősi, S. Koloszár, J. Daru, L. Kovács, A. Pál, Is there a relationship between cell phone use and semen quality? Arch. Androl. 51 (2005) 385–393.

Leukemia

A 200% increased risk was found for exclusive use of a GSM cellphone [17]. A borderline significant (p=0.051) 108% increased risk was found for AML[21] from ≥15 years of cellphone use [18].

17. David W. Kaufman, Theresa E. Anderson & Surapol Issaragrisil. Risk factors for leukemia in Thailand. Ann Hematol. 2009 Nov;88(11):1079-88. Epub 2009 Mar 18.
18. R Cooke, S Laingand AJ Swerdlow. A case–control study of risk of leukaemia in relation to mobile phone use. British Journal of Cancer (2010) 103, 1729 – 1735.

In-vivo Studies: brain DNA damage

"[R]eviews studies that have investigated DNA strand breaks and other changes in DNA structure" [19]. "[T]he safe limit for general public exposure by the Non-Ionizing

[21] AM: Acute Myeloid Leukemia

Radiation Committee of the International Radiation Protection Association, may imply a need for (re)evaluation of the mutagenic potential of microwaves at the prescribed safe limit for the personnel and people who are being exposed" [20]. "Exposure to a 60-Hz magnetic field at 0.01 mT for 24 hr caused a significant increase in DNA single- and double-strand breaks" [21] "[A] dose rate-dependent 0.6 and 1.2 W/kg whole body specific absorption rate (SAR)] increase in DNA single-strand breaks was found in brain cells of rats at 4 h post exposure" [22]. "Single- and double-strand DNA breaks in individual brain cells were measured at 4h post-exposure" [23].

19. J.L. Phillips, N.P. Singh, H. Lai. Electromagnetic fields and DNA damage. Pathophysiology. 2009 Aug;16(2-3):79-88. Epub 2009 Mar 4.
20. S. Sarkar, S. Ali, J. Behari, Effect of low power microwave on the mouse genome: a direct DNA analysis, Mutat. Res. 320 (1994) 141–147.
21. H. Lai, N.P. Singh, Magnetic-field-induced DNA strand breaks in brain cells of the rat, Environ. Health Perspect. 112 (2004) 687–694.
22. H. Lai, N.P. Singh, Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells, Bioelectromagnetics 16 (1995) 207–210.
23. H. Lai, N.P. Singh, Single and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation, Int. J. Radiat. Biol. 69 (1996) 513–521.

In-vivo Studies: Damaged Sperm

"This study suggests …a significant genotoxic effect on epididymal spermatozoa is evident" [24]. "Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats. In addition, abnormal clumping of sperm cells was present in rats exposed to cellular phone emissions and was not present in control group rats. These results suggest that carrying cell phones near reproductive organs could negatively affect male fertility" [25].

24. R.J. Aitken, L.E. Bennetts, D. Sawyer, A.M. Wiklendt, B.V. King, Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline, Int. J. Androl. 28 (2005) 171–179.
25. J.G. Yan, M. Agresti, T. Bruce, Y.H. Yan, A. Granlund, H.S. Matloub, Effects of cellular phone emissions on sperm motility in rats, Fertil. Steril. 88 (2007) 957–964.

In-vivo Studies: Blood-Brain-Barrier (BBB) Leakage

A study of rats exposed to GSM cellphone radiation at SAR levels of 0.012 to 0.120 W/kg showed BBB leakage resulting in dead neurons [26]. A 2 hour exposure to GSM cellphone radiation created BBB leakage with neuronal damage in the cortex, hippocampus and basal gaglia of rat brains [27]. "GSM exposed rats had impaired memory for objects and their temporal order of presentation, compared to sham exposed controls ($P = 0.02$)" [28].

26. Jacco L. Eberhardt, Bertil R. R. Persson, Arne E. Brun, Leif G. Salford, and Lars O. G. Malmgren. Blood-Brain Barrier Permeability and Nerve Cell Damage in Rat Brain 14 and 28 Days After Exposure to Microwaves from GSM Mobile Phones. Electromagnetic Biology and Medicine, 27: 215–229, 2008
27. Leif G. Salford, Arne E. Brun, Jacob L. Eberhardt, Lars Malmgren, and Bertil R. R. Persson. Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves

from GSM Mobile Phones. Environmental Health Perspectives ,Vol. 111 (7), June 2003.

28. Nittby H, Grafström G, Tian DP, Malmgren L, Brun A, Persson BR, Salford LG, Eberhardt J. Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation. Bioelectromagnetics. 2008 Apr;29(3):219-32.

Modulation differences induced 6-fold difference in threshold of genetic damage to cells

Human fibroblast cells exposed to GSM cellphone radiation found the detection threshold for genetic damage at SAR=0.3 W/kg [29]. Human fibroblast cells exposed to UMTS cellphone radiation found the detection threshold for genetic damage at SAR=0.05 W/kg [30].

29. Adlkofer, F. 2004 Final Report, Risk Evaluation of Potential Environmental Hazards From Low Frequency Electromagnetic Field Exposure Using Sensitive in vitro Methods, Figure 94. EU Contract number QLK4-CT-1999-01574.
30. Schwarz C, Kratoclivil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW 2008. Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health May;81(6):755-67.

In-vitro Studies: Genetic damage to cells including human sperm cells

"RF-EMF exposure (1800 MHz; SAR 1.2 or 2 W/kg; different modulations; during 4, 16 and 24h; intermittent 5 min on/10 min off or continuous wave) induced DNA single- and double-strand breaks [31]. "These data suggest that EMR[22] emitted by cellular phone influences human sperm motility. In addition to these acute adverse effects of EMR on sperm motility, long-term EMR exposure may lead to behavioral or structural changes of the male germ cell" [32].

31. E. Diem, C. Schwarz, F. Adlkofer, O. Jahn, H. Rudiger, Non-thermal DNA breakage by mobile-phone radiation (1800-MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro, Mutat. Res. 583 (2005) 178–183.
32. O. Erogul, E. Oztas, I. Yildirim, T. Kir, E. Aydur, G. Komesli, H.C. Irkilata, M.K. Irmak, A.F. Peker, Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study, Arch. Med. Res. 37 (2006) 840–843.

33. Richard Tell Associates. Analysis of RF Field Associated with Operation of PG&E Automatic Reading Systems (April 6, 2005).
34. Richard Tell Associates. Supplemental Report on An Analysis of Radio Frequency Fields Associated with Operation of the PG&E SmartMeter Program Upgrade System (October 27, 2008).
35. FCC 01-158, FURTHER NOTICE OF PROPOSED RULE MAKING AND ORDER, Adopted: May 10, 2001, Released: May 11, 2001, page 2.

[22] EMR: Electromagnetic Radiation