Received & Inspected

AUG 15 2016

FCC Mailroom

Dear FCC -

Your ECSF "upgrade" made it impossible for me to file electronically. (like I used to)
I tried to email my filing, but that option was rejected. Soo, now instead of taking 3 minutes to upload emailed files you can scan it all in, a bit ridiculous.

Perhaps you should consider a policy change?

Catherine Kleiber
ET Docket No. 16-191

Received & Inspected
AUG 15 2016
FCC Mailroom

DA 16-676

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
	)	
Office of Engineering and Technology	)	**ET Docket No. 16-191**
Technological Advisory Council (TAC)	)	
Noise Floor Technical Inquiry	)	
	)	

To: Office of the Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Comment Filed by:

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August 11, 2016

Catherine Kleiber
ET Docket No. 16-191

Thank you for opening a docket on Incidental and Unintentional Radiators, as well as Unlicensed Intentional Radiators, Industrial, Scientific, and Medical (ISM) Radiators, and Licensed Radiators. Regulation of these devices needs to be tightened substantially. Regulation was originally designed to prevent equipment from interfering with other equipment. We now know that the human body is extremely sensitive to that same interference. **Since the human body cannot be "hardened" to prevent "noise" (a source of radiofrequency (RF) exposure) from affecting it, regulations need to be tightened substantially to make technology safe.** Currently, polluting technology is causing serious health problems. Our experience which I outline below is illustrative.

It is extremely important that the regulations for "dirty" electricity from all sources be tightened. Levels of "dirty" electricity seem to be higher in certain areas on the grid, resulting in serious health problems for occupants of those buildings. Predictably at risk premises seem to include buildings with the shortest wire to a shared transformer and buildings at the end of the line.

We have first-hand experience with the devastating consequences that being at the end of the line at the wrong place on the grid can have. Our story follows, but I would first like to say that occupants of two other end of the line homes in our area are suffering from terrible health. The one started experiencing problems about the same time we did. The other seemed to as well, but is less well known to us.

Furthermore, conducted RF can radiate off the wiring in unpredictable locations within a building resulting in dangerously high exposures in those locations. Please see the attached Isotrope report for more information about some such situations, as well as the companion report - Debunking the Utility: The Antenna Effect.

No one should face disability, cancer, or death due to their home's location on the grid. So it is imperative that the FCC enact health-protective regulations governing Incidental and Unintentional Radiators, as well as frequencies that conduct on the grid from Intentional Radiators (licensed and unlicensed), Industrial, Scientific, and Medical (ISM) Radiators. In short, health-protective RF regulation should apply regardless of the source of the signal.

The existing FCC radiofrequency radiation limits are too high to protect human health. The limits need to be lowered immediately. New safety limits should be enacted using a biologically-based model.

The FCC has a duty to the public to protect the public health and safety from harm from radiofrequency radiation (H.R. Report No. 104-204, p. 94).

Earlier in 2016, the U.S. National Toxicology Program released findings that RF is carcinogenic and breaks DNA at non-thermal levels.

In May 2011, IARC classified radiofrequency radiation, including radiation from all wireless technologies, as a class 2B possible carcinogen.

In 2015, 220 scientists from 42 countries with over 2,000 peer-reviewed journal articles to their collective credit in the field of biological impacts from RF/EMF appealed to the U.N. and the WHO for greater precautions with regard to exposures from wireless technologies. This is the latest in many such alerts to the health effects of RF/EMF exposure (https://www.emfscientist.org/).

In the 2012 BioInitiative Report, the authors conclude radiofrequency radiation is a carcinogen. One mechanism responsible for the carcinogenic effect of radiofrequency radiation is its ability to initiate the

Fenton Reaction, just as ionizing radiation does. The 2012 BioInitiative Report is incorporated by reference herein in its entirety (http://www.bioinitiative.org/)

The FCC radiofrequency radiation limits are outdated and obsolete. They are based on physics, not biology and, therefore, the limits are so high that they are useless for protecting the population from harmful biological effects. *"Public safety standards are 1,000 – 10,000 or more times higher than levels now commonly reported in mobile phone base station studies to cause bioeffects."*(http://www.bioinitiative.org/conclusions/)

Since the FCC lacks the expertise to establish meaningful biologically-based safety limits, it is the duty of the FCC to advocate for allocating funding and authority to the EPA to establish biologically-based safety limits. 2012 HR6358 exists as a model of legislation to do just that.

My husband and I have lived on our farm in Waterloo, Wisconsin since 1996. Later, I provide information about the monetary costs incurred by me and my family as a direct result of the FCC's negligence in not putting into place biologically-based RF safety limits years ago. The emotional and social costs have also been very steep. None of the common uses of wireless technology comes close to justifying the monetary, physical, emotional, and social price our family has been forced to pay for it, ditto AMR electrical meters.

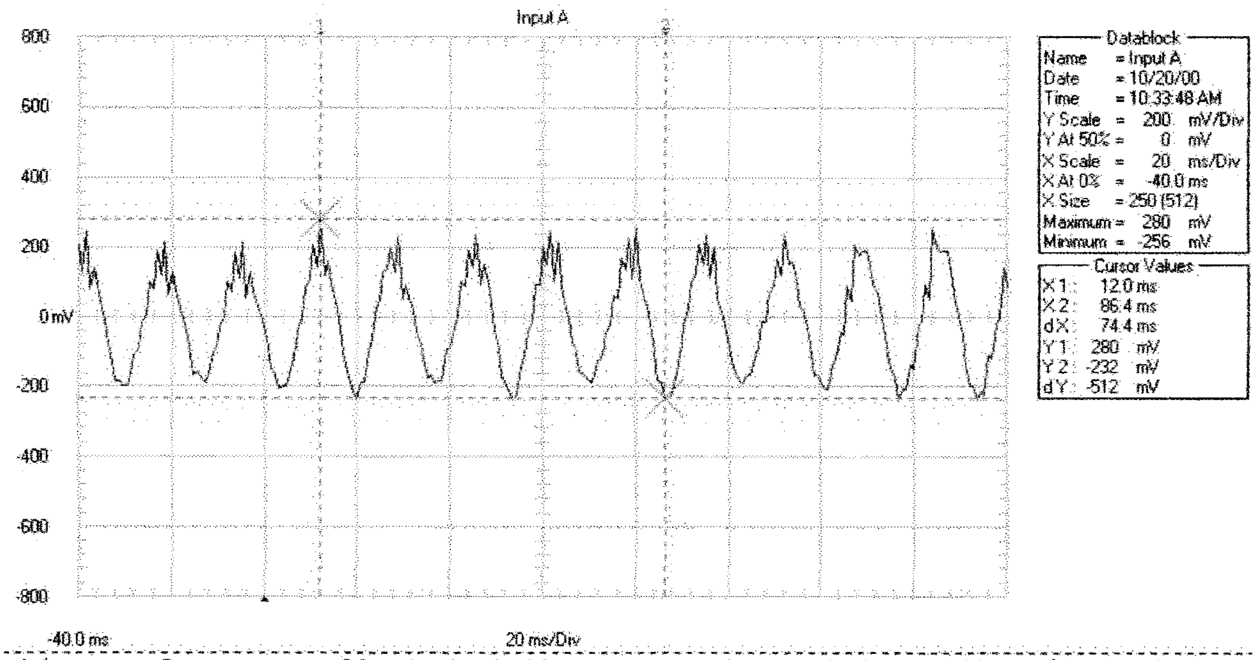
My family's on-going health nightmare, caused by the presence of biologically active levels of radiofrequencies on the electrical grid and radiofrequency radiation transmitted into the environment through use of wireless technology, is illustrative of why it is essential that the EPA finally be empowered to establish biologically-based radiofrequency radiation safety limits and why the FCC must immediately and substantially tighten the allowable levels of RF emissions from all classes of emitters.

I have radiowave sickness. (See Dodge, incorporated by reference herein in its entirety http://www.magdahavas.com/wordpress/wp-content/uploads/2010/08/Dodge_1969.pdf) It was originally misdiagnosed as chronic fatigue syndrome. However, once I found out I was being exposed to large amounts of high frequencies from electrical pollution, including "dirty" power on my wires and plumbing, and reduced that exposure as much as I was able, I began to recover almost immediately.

I am including waveforms that were collected at my house at the time that I found out about "dirty" electricity, electrical pollution, and capacitive coupling. They are not labeled with my name due to the fact that I removed it when I posted them on my website.

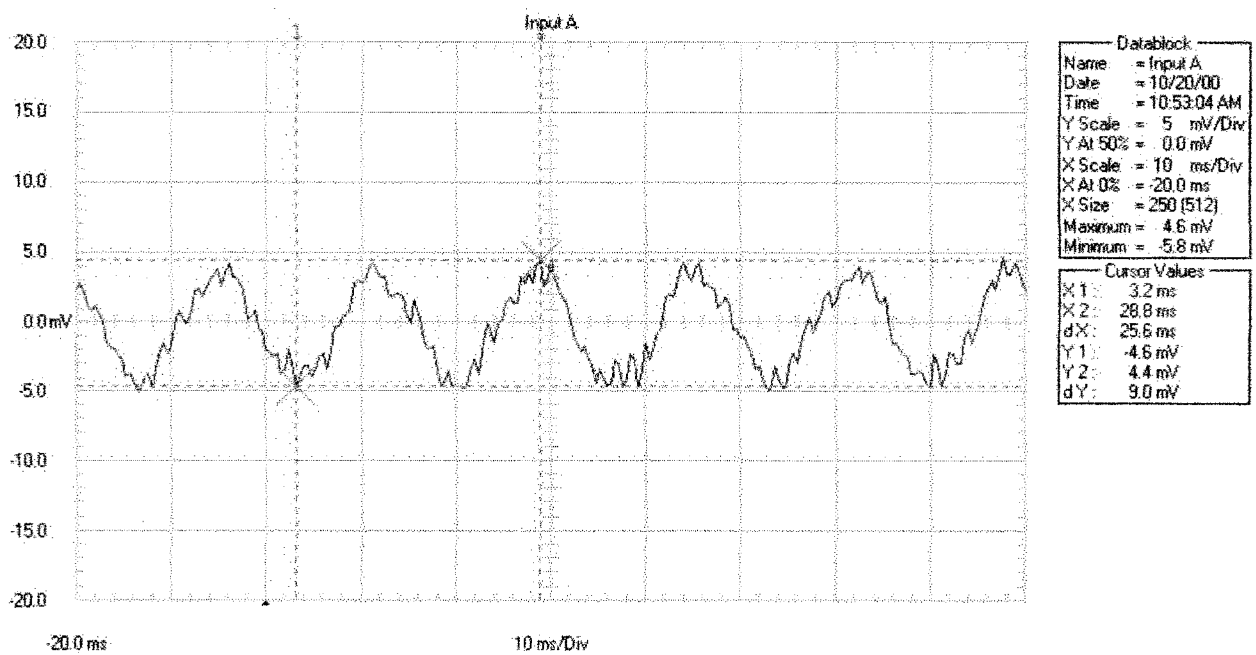
The first waveform was collected between the sink and the floor in my kitchen and illustrates how important it is that either the neutral return be adequate to return all the current, even with high frequency distortions or, preferably, that excellent device level filtering is required to prevent *Incidental* and *Unintentional* radiators from polluting the whole grid. Technology that cannot be prevented from polluting should be banned - dimmer switches may be a good example of such a technology. Three way lights - a separate filament for each level - would be a safe and reasonable substitute for those requiring adjustable lighting.

Catherine Kleiber
ET Docket No. 16-191



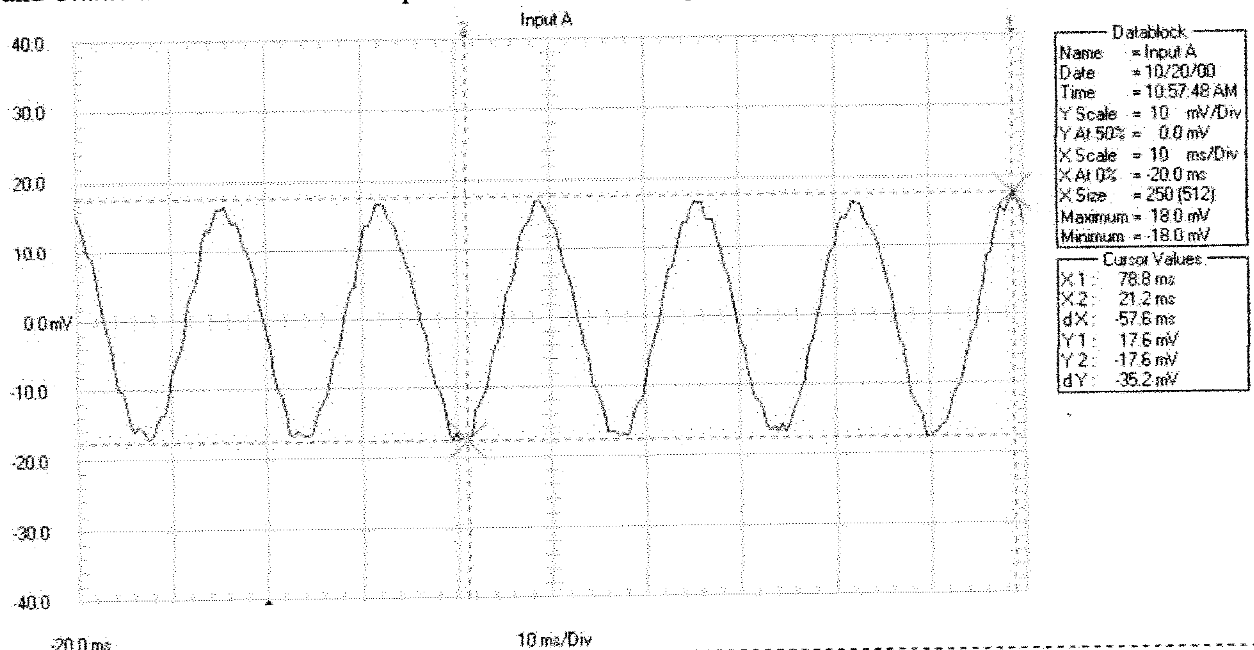
This waveform was collected at the house between the sink and an EKG placed on the kitchen floor.

The waveform below shows that the stray current caused by the inadequate return and polluting technology travels through the human body, in this case my body. However, your family members are also subject to this effect which can cause a host of health problems.



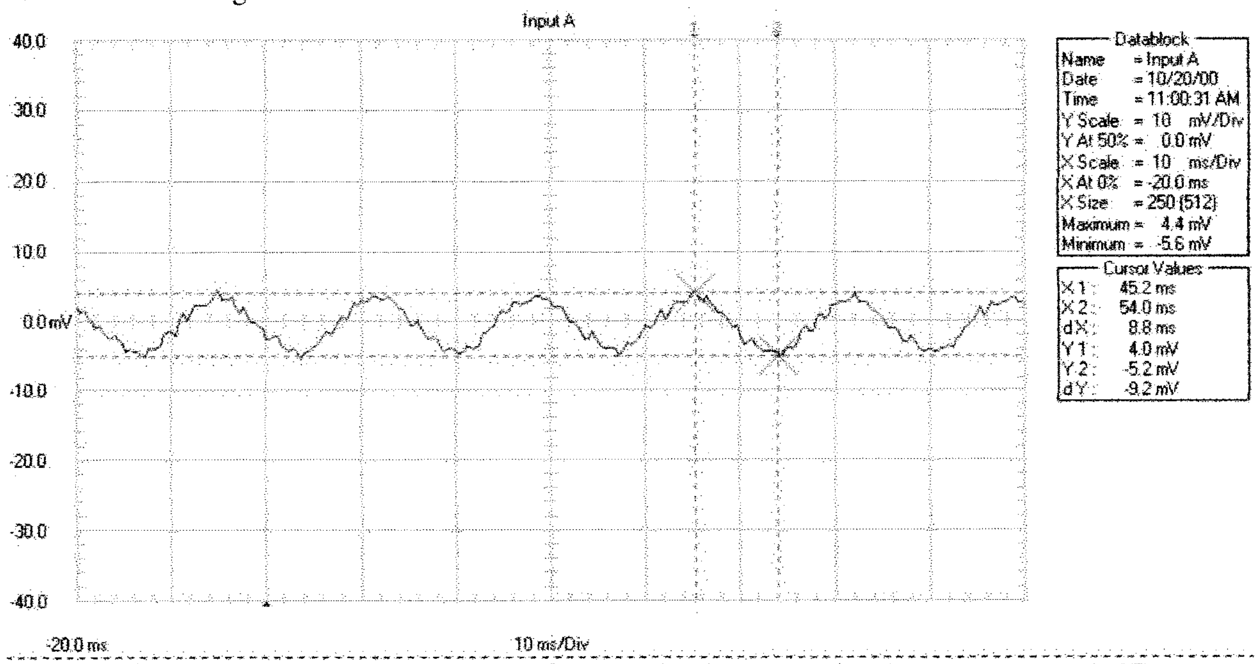
This waveform was collected at the house between 2 EKG patches placed on the ankles of while standing in front of the kitchen sink.

The waveform below shows that when I touch the kitchen sink the amplitude of the signal traveling in my body increases markedly (nearly four times). It is no wonder, then, that I used to get light-headed and dizzy while I washed fruit, vegetables, and dishes with my hands in this electrified sink. There was no "fault" causing this problem, just the electrical pollution, ground currents, and required bonding of electrical service and plumbing. Obviously, you need to dramatically tighten regulations on *Incidental* and *Unintentional* radiators to keep them from contributing to such problems.



This waveform was collected at the house between 2 EKG patches placed on ankles while she was touching the kitchen sink. NOTE THE INCREASE IN AMPLITUDE.

Finally, the waveform below shows that even while sitting on a wooden chair with my feet up on the chair seat, significant capacitive coupling to the human body occurs. The signal induced in my body is recorded below. This shows the importance of requiring good engineering to minimize any RF output onto wiring from devices. RF on wiring capacitively couples to humans (and animals) nearby. By near I mean in the building or on a sidewalk. One doesn't have to be within inches.



THE ABOVE WAVE FORM WAS BETWEEN 2 EKG PATCHES PLACE ON THE ANKLES OF WHILE SITTING ON A WOODEN CHAIR IN HER KITCHEN.

Here is a brief summary of symptoms I experienced during my high frequency related illness: heart palpitations, very pain sensitive, constant nerve pain, sluggish reactions, poor depth perception, muscle weakness, lactic acid buildup with little exertion, unrefreshing sleep, often wakeful in the night, fatigue, night sweats, poor circulation to my extremities, reflux, difficulty concentrating, difficulty thinking, inability to make decisions, low-grade fever and chills, headaches, and a dry sore throat.

We reduced our exposure as much as possible once we found out what was causing my illness both with filters and just disconnecting as much wiring as possible. I was well at home until smart meters on our neighbors' homes, worsening RF on the power lines, and 4G cell service increased our exposure enough that I began once again to experience symptoms even while in our home. We have taken additional steps to reduce our exposure to the pulse modulated microwave radiation used in wireless technology and high frequency signals on the power line.

I get sick again whenever I am around higher levels of high frequencies such as when I go into town. The degree of sickness and the exact symptoms vary depending on the duration and strength of the exposure, as well as the particular frequencies to which I am exposed.

The ambient levels of pulsed microwave radiation are now so high that I can no longer even try to go to friends' and relatives' homes, restaurants, movies, public events, or "shopping" - in the event I have to go into a store I try to arrange ahead for the item I need to be ready for me or I go in quickly, ask for assistance finding the item, buy it and leave.

I have had serious RF radiation sickness reactions to these polluted environments including cardiac arrhythmias, cognitive difficulties, short and long-term memory problems, severe neurological pain, hair loss and serious gastrointestinal effects if I try to stay longer. (See "Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system," incorporated by reference herein in its entirety http://electromagnetichealth.org/wp-content/uploads/2010/10/Havas_HRV_Ramazzini1.pdf)

One meeting, where cellphones and wifi were present, followed by what should have been a quick trip to an office supply store, which had gotten a wireless telephone headset system since my last visit, caused serious radiation poisoning symptoms. I had cardiac arrhythmias from the radiofrequency radiation at both locations. Nerve pain began toward the end of the meeting and grew worse at the store and was so bad by the time I got home that I had to limit how my children could touch me for a couple of days. Serious gastrointestinal pain and dysfunction resulting in massive diarrhea began very shortly after arriving home and finally began to subside 3 days later. The pain and diarrhea were so severe with food that I had to quit eating for a couple of days while my intestine healed. The symptoms began at the meeting and quickly escalated while I waited nearly twenty minutes for service at the store and persisted for over 3 days. The association between the exposure and the symptoms was very clear. I consumed no food at the meeting or at the store. I had no symptoms of a bacterial/viral infection. Electrical pollution levels were also high, around 2,000 G/S units at the meeting site, but had previously not caused these reactions (I always install filters to lower the electrical pollution in the room that I am in while I am there and this time was no exception.)

We have two children whom we are homeschooling so they will not be exposed to dangerous high frequency environment in our local public school (Waterloo, WI). The school has both WiFi and high electrical pollution levels - probably caused primarily at that time by the highly polluting energy efficient lights. Today computers and other technology would be heavy contributors. At the time that I measured at least eight years ago, the levels in the school were in excess of 2000 G/S units so I went back with a meter that measured higher and found levels over 5,000 G/S units. Acceptable levels in Kazakhstan are below 50 G/S units. Obviously RF pollution from *Incidental* and *Unintentional* radiators is causing serious RF pollution problems in buildings and throughout the electrical grid.

Our children both experience health problems when exposed to high frequencies. They feel sick, become hyperactive, less able to think logically and control their behavior. They also sleep poorly in bad high frequency environments. The recent increase in radiofrequency radiation exposure has given them chronic cardiac arrhythmias which worsen markedly when they are exposed to the higher levels of pulsed microwave radiation common in society within the last couple of years. (Video demonstrates finding of cardiac arrhythmia caused by DECT phones - http://www.youtube.com/watch?v=p-mw_nCJWs4&list=UUxs1UgZ6DivWUfG1dX3TELw&index=10)

The drastic measures we have taken to reduce their exposure has momentarily stabilized them at about early stage 2 radiofrequency sickness. (See Dodge) We are very concerned that any increase in the radiofrequency radiation levels could again push them over the edge toward stage 3 radiofrequency sickness. They should not be involuntarily exposed to a pollutant that has such profound detrimental effects on them.

I have maintained the website www.electricalpollution.com since 2002, shortly after I discovered that the high frequencies present on building wiring and flowing across the ground from non-linear time varying loads were making me, and others, sick. Research on the health effects of electrical pollution is available on the website on the Research Page. More technical information is available on the Technical Page.

Electrical pollution is a very potent form of exposure to high frequencies. Exposure to all forms of high frequencies, including electrical pollution, must be included in standards regulating exposure of the general public to protect the public health during continuous exposure.

Because of the serious effects exposure to high frequencies has on our health, we do not own a cellphone, cordless phones, wireless router, baby monitors, or subscribe to wireless internet.

I have read widely on the research into the health effects of exposure to high frequencies. I believe that the increased exposure to high frequencies from radiowave and microwave transmitters and from electrical pollution are behind the public health crisis that has dramatically increased utilization of our medical system for chronic conditions. The article by Halberg and Johansson in *Pathophysiology*[1] supports this contention. The comprehensive review by Dr. Cherry[2], which documents health effects and explores mechanisms, besides thermal mechanisms, through which microwave and radiowave radiation can impact health, also supports my contention that exposure to microwave and radiowave radiation is a public health threat which is probably contributing to significant public illness. A review of the Soviet literature on radiofrequency sickness by Christopher Dodge[3] of the Naval Observatory discusses radiofrequency sickness in detail. The symptoms attributed to chronic exposure to radiofrequency radiation mirror the deterioration of health being seen in the U.S. in recent years, probably due to the dramatic increase in exposure to radiofrequencies from electrical pollution and wireless technology. Papers by Dr. Milham[4], Dr. Havas[5,6,7] and Dr. Wertheimer[8] also show that exposure to electrical pollution constitutes a public health threat, as does a report by Char Sbraggia regarding health improvements experienced by teachers and students when the electrical pollution in their school was cleaned up (MelMinNurse.pdf). These are just a few of the papers I have read. However, they provide a picture which should illustrate the need for precautionary action to minimize public exposure to high frequencies until safety standards can be established to prevent health problems in the general population during continuous exposures to high frequencies, taking into account all sources of exposure.

1. Ö. Hallberg, O. Johansson, Apparent decreases in Swedish public health indicators after1997—Are they due to improved diagnostics or to environmental factors? Pathophysiology(2009)
2. Cherry, N. 2000 Criticism of the Health Assessment in the ICNIRP Guidelines for Radiofrequency and Microwave Radiation (100 kHz- 300 GHz)
3. Dodge C. Clinical and Hygienic Aspects of Exposure to Electromagnetic Fields. Biological Effects and Health Implications of Microwave Radiation, Symposium Proceedings, Richmond, Virginia, September 17-19, 1969.
4. Milham S, Morgan L. 2008 A New Electromagnetic Exposure Metric: High Frequency Voltage Transients Associated With Increased Cancer Incidence in Teachers in a California School. American Journal of Industrial Medicine.
5. Havas M, Olstad A. 2008. Power quality affects teacher wellbeing and student behavior in three Minnesota Schools, Science of the Total Environment, July.
6. Havas M. 2006. Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. Electromagnetic Biology Medicine 25(4):259-68.
7. Havas M. 2008. Dirty Electricity Elevates Blood Sugar Among Electrically Sensitive Diabetics and May Explain Brittle Diabetes. Electromagnetic Biology and Medicine, 27:135-146.
8. Wertheimer N, Savitz DA, Leeper E. 1995 Childhood Cancer in Relation to Indicators of Magnetic Fields from Ground Current Sources Bioelectromagnetics 16: 86-96.

I knew that an increase in levels of transmitted radiofrequency and microwave radiation would be very detrimental to my health and that of my family and would further impair our ability to live a normal life.

Therefore, we refused installation of the We Energies AMR meters, which transmits a spike of microwave radiation (approximately 1800 $\mu W/m^2$) every 6 seconds 24 hours a day, 7 days a week, on our two electrical services.

I asked for reasonable accommodation under the ADA because I knew that my children and I experience environmentally induced functional impairment with exposure to radiofrequency radiation, including the pulsed modulated microwave radiation utilized by the We Energies AMR meters.

My initial request was denied verbally by the PSC and in writing by We Energies.

We had to turn away at least one installer who came to install meters after we were on the record with We Energies and the PSC as not wanting an AMR meter installed.

We were concerned that we would find AMR meters installed despite our clearly expressed refusal to have AMR meters, so we padlocked our meter pedestals and installed clearly worded permanent signage.

In response to our continued refusal to allow installation of the meter, we were threatened with disconnection. (See WeEnergies9Dec2011.pdf)

My mother and father-in-law tried to refuse to take a transmitting meter so we would still be able to visit and were bullied into taking the meters by a disconnect threat. We can no longer visit. Our one try was cut short by our younger son feeling so ill that he was crying and begging to leave - in spite of it being Christmas with relatives, presents, and candy.

Both We Energies and the PSC maintained, over the phone and at the meeting with the legislators, that we had three choices and represented them as accommodation.

1. Take the AMR meters.
2. Take the AMR meters and move them anywhere on our property at our considerable expense (thousands of dollars to move them even short distances).
3. Get off-grid.

We do not consider these choices to have been any form of accommodation since we could not have moved the meters far enough to protect our health. Also, the radiofrequencies the meters produce get on the wires, essentially turning the house into a low-power microwave. This proved to be a problem even though our nearest neighbor is over half a mile away. Having two meters of our own would have worsened the effect.

We consider the refusal to accommodate us and the threat to disconnect us to have been bullying and intimidation on the part of We Energies and the Wisconsin Public Service Commission.

A group of us met with state legislators (Sen. Grothman, Rep. Jorgensen, and Connie Schulze, a staff-member of Sen. Darling's, who were supportive, but unwilling to sponsor legislation to help us.

I called numerous federal agencies - to no avail.

In March 2011, we received a letter from We Energies threatening to disconnect us within 48 hours for denying them access to the meter pedestal, which we own. This, in spite of the fact that, during a conversation about the supposed safety issue and the fact that We Energies can easily disconnect power to our farm at our transformer in case of an emergency, Tom Held (Supervising Engineer Meter Technology) concurred saying "I know. They can pull the fuse."

We had been customers in good standing.

Again we appealed to the PSC for accommodation under the ADA (PSCMarch2011WEcutoff.pdf) and asked that they address the radiation coming off of our transformer and causing cardiac arrhythmia for our son, only to be told that they would stand by and watch us disconnected, although they would make We Energies wait until after April 15. They did not address the dangerous levels of RF radiation radiating from the transformer or the high levels of RF being conducted into our home from the utility at all. The radiating energy was sufficient to cause splits in the bark on the young maples in our yard.

After consulting multiple lawyers, realizing that the sole power to provide or deny accommodation resided with the PSC, and even being told outright by one lawyer that our best bet was to get off the grid, we began making preparations -at considerable expense- in case we were forced off-grid, fighting all the while.

We got a propane refrigerator, a pilot light gas stove, installed a gravity flow hot water heating system, acquired a generator to run our commercial freezer and installed a solar photovoltaic system to run a new DC well pump and sump pumps and converted our computer to run on DC.

We felt that the PSC was in violation of its own statutes in standing by and watching customers in good standing get disconnected and that We Energies was in violation of the law, but with no one to defend us, we had no recourse other than the one easily accessible public forum - a Letter to the Editor. (We had contacted various legal organizations including the ACLU, Public Citizen, Common Cause, and NRDC. All said that they have limited funding and they had never heard of this before. News outlets were similarly uninterested - utilities and telecom companies provide substantial funding through advertising or outright ownership.) We did also reply to the PSC.

The PSC once again refused to exercise their right to stop We Energies from disconnecting us for refusing the transmitting meter.

The PSC refused to accommodate us in large part because the AMR meters were supposedly in compliance with FCC radiofrequency limits (see PSC27Apr2011reDATCP.pdf), in spite of the fact that FCC limits were never intended to protect anyone from the biological effects we experience. Compliance with FCC limits has been used to force many many people from across the country to have devices which compromise their health.

After we wrote the letter to the editor, Sue Crane, Manager Special Projects at We Energies contacted us and asked that we remove the padlock stating that she would personally guarantee in writing that the meters would not be changed for 6 months.

On October 8, 2011, we sent letters to the PSC and We Energies requesting that they remove our electrical service since they had repeatedly ignored our requests to address the problems on their system that were causing large amounts of very high frequency radiation to radiate off of our transformer and our house wiring.

We had been forced to sleep in a tent a half mile from our home site (and at least that from other electrical services) from the end of July through October 13, 2011 - the start of early deer hunting season - in order to stabilize our sons' cardiac health. (From the start of deer hunting until the secondary wires were removed on October 19, 2011 we slept in the bed of our full-sized truck parked in our metal machine shed with the openings facing the transformer electrically shielded and the bed opening away from the transformer. The electrical service to the shed was already disconnected thus preventing it from conducting the radiofrequencies in.)

Both sons were affected, although our younger son was affected more severely. After initial tachycardia incidents which we became aware of in the fall of 2010, they moved on to irregular heartbeat and heart rate which finally got quite slow and irregular, particularly during sleep. Additionally, Holter monitoring found that both boys had sinus arrhythmia. This is consistent with the descriptions of stages one and two of radiofrequency sickness in Dodge (attached). On a Holter monitor, our younger son only had a high of 242 bradycardia incidents hourly at the tent versus 1637 hourly at home. Our older son had a high of 165 bradycardia incidents hourly at home with no comparable due to a mistake on the part of the hospital. Our younger son's heart rate got so slow one night when we were forced by broken tent poles to sleep at home that he lost bladder control, wetting only his underwear because the volume of urine was so small. When I went to him in response to his call, he was agitated and upset, but his heart rate was very slow and the beats were weak and irregular. This continued for a couple of hours. We did not sleep in the house again after that until after the secondary lines were removed.

The deterioration in our health began shortly after the smart meters were installed in our area. Strong power line communication signals (likely related to broadband over power lines) in the 12.4 to 13.2 MHz and 25.5 to 26.3 MHz range along with communication signals (probably from the transmitting meters and cell/WiFi towers) radiating from our end of the line transformer and our home wiring seem to have been the final straw.

Signals in the 1 MHz to 80 MHz range used for broadband over power lines and communication signals are not supposed to cross the transformer. However, what happens when the signal hits the end of the line has not been considered as far as I know.

Our experience suggests that it radiates and does cross the transformer enough to radiate off of the wiring and plumbing throughout the house at biologically-harmful levels. The Isotrope report has documented smart meter transmitter frequencies traveling on wiring and radiating. I have attached it, along with its companion document - **DEBUNKING THE UTILITY INDUSTRY MYTH ABOUT SMART METER SAFETY:** THE ANTENNA EFFECT (http://www.stopsmartmetersny.org/debunkingutility.html). You may need to visit this link to view important video evidence. It is likely the AMR meter's transmitting frequencies and additional "dirty" electricity were the immediate precipitating factor for our health problems since they began shortly after AMR meter installation in the area. Additionally, Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters by Sage Associates (http://sagereports.com/smart-meter-rf/) found that smart meters are in likely violation of even existing FCC RF limits. I am attaching her declaration on this issue. Some remote read meter manufacturers are claiming that they don't have to have their meters FCC approved. I have attached the flyer for one system - Tantalus-Orion by Badger meter. If it is true, this is inadvisable and the loophole should be closed. This system made at least one person very sick when it was installed in her area. She never had a meter in her home.

We are now off-grid to protect our family's health.

After going completely off-grid, we had three heavenly weeks. We slept well, felt well, and had lots of energy. Our pets' health improved. Most importantly, our sons' cardiac rhythms had almost completely normalized and I was not awakened by them in the night.

Then, in early January 2012, 4G cellphone service was installed on existing towers in our area. Within a week, our sons' cardiac rhythms were again highly irregular. Our younger son was again waking us in the night crying, sweating profusely, and feeling unwell with a highly irregular cardiac rhythm. He was also clingy and fussy during the day. This suggests to us that 4G technology is particularly bioactive and dangerous. We heard similar stories from others when 4G installation occurred.

My husband screened all the windows with aluminum screen to reduce our son's exposure. Again, he slept through the night and was less clingy, but their cardiac rhythms remained irregular.

We are currently essentially housebound, unable to spend significant time in houses or businesses which have transmitting meters, which includes almost every electrical service in our area.

Due to the detrimental health effects that we experience, we are unable to visit friends and relatives who have transmitting meters.

We cannot completely escape the constant exposure from neighbors transmitting utility meters, 4G cellphones, and the power line frequencies which still radiate from the junction box down the road that terminates the line.

As 2012 passed, we had to do more and more shielding to compensate for the ever increasing levels of radiation from wireless technology. We have had to restrict the amount of time our outdoors-loving sons can be outside. They are now only able to be out an hour a day. If they are out more than that with any regularity their cardiac arrhythmias become severe enough that they become clingy and we are awakened in the night.

I have not been able to do all the animal care, yard care, and gardening that I need to do in the course of the year. The garden is overgrown. I have not even been able to keep the few potatoes I planted weed-free. Obviously, I cannot fit duties that usually took me 6-8 hours daily into the one hour they can be outside without triggering more serious cardiac arrhythmias. I have trouble performing the physical labor I always have and must do to earn our living since my heart often does not beating efficiently, due to the radiofrequency radiation levels.

Radiofrequency radiation levels have climbed high enough that even being inside most of the time is not protective enough to keep our sons from being symptomatic. We have had to shield further. Every little bit helps for awhile, then more people use their phones more, stream video more, the civil air defense radar switched to digital, etc and the levels increase further and we have to shield some more. How long before radiofrequency radiation levels climb high enough that being outside at all is dangerous? What happens when we have shielded the whole house and even so being inside does not offer enough protection? Who could take care of and protect my boys if anything happened to me and my husband?

I worry that I will run out of shielding options to protect my sons before meaningful biologically-based safety limits put an end to the insane increases in radiation exposure occurring rapidly now as usage of wireless technology increases. Radiofrequency sickness is serious and is life-threatening if it is not able to be properly treated by avoidance once it occurs.

The meters necessary to verify RF related problems cost over $1,500. Going off-grid, which was necessary to protect the lives of our sons, cost us over $70,000 dollars based on simple addition of the costs of all the separate parts and steps necessary to make that happen. The cost was that low because we were able to do much of the work ourselves. The solar installer estimated that the system we wished to put in at that time would cost us over $80,000 just for the solar system, not including the new heating system, refrigerator, well-pump, super-insulating the freezer, freezer generator, freezer/generator control switches, etc.

Shielding materials have cost us over $6,500 so far. It has cost over $7,000 to get new windows for the low E coating which helps block RF, again far less than most people would pay because we can install them. I cannot stress enough that these are only the monetary costs and do not include the physical, emotional, and social price our family has been forced to pay for the FCC's negligence in not implementing biologically-based safety limits. We are not wealthy and do not earn vast sums each year so it is a real question as to how long we can continue to pay for the continuous upgrades necessary to protect our family's health, yet how can we not? But, if we lose the farm doing it, what will happen to us?

FCC negligence in not establishing meaningful RF safety limits has caused us to pay more for my health insurance and therefore our sons' health insurance. The CFS diagnosis, which was really radiofrequency sickness from exposure to dirty power, caused me to become an automatic reject for health insurance. I was fortunate to be able to get health insurance through the Wisconsin Health Insurance Risk Sharing Plan (HIRSP), however even with the subsidy it was quite a bit more expensive than insurance I could have gotten as a healthy young woman. We had to have HIRSP policies for our sons as well, not due to their health which was great prior to the RF toxicity problems outlined above, but because you cannot insure children without at least one adult as primary on the policy. As an example of the great expense this caused us, the insurance quote we got in 2012, necessary to re-apply to HIRSP, for the whole family was $713.54/month. The premium for my insurance alone through HIRSP at that same time for the same $1.000 deductible was $729/month. HIRSP premiums at that same time and deductible level were $554/ month for Dan and $387/month for each of the boys. Up until the 2008 flood and policy changes allowed us to qualify for health insurance assistance we were paying similar large monthly premiums. Thus, FCC negligence, resulting in the absence of biologically-based RF safety limits and my CFS diagnosis, forced our family to pay significantly more for health insurance than we would otherwise have had to.

It is important to stress our experience has been that people with radiofrequency sickness react to both RF exposures from wireless technology and "dirty" electricity.

The FCC is jeopardizing the health and lives of our children, and millions of others across the country, by not having meaningful biologically-based safety limits for radiofrequency radiation for all RF sources, including *Incidental* and *Unintentional* Radiators .

Not only is the absence of biologically-based RF safety limits in violation of common sense and the principles of public health protection, but the promotion of wireless technology, a technology that so severely restricts the activities of a portion of the population, violates the ADA, including the 2008 ADA amendments. The physical, social, and emotional costs of exclusion in spite of ADA protections and previous inclusion must be weighed in the EIS when it compares costs and benefits of the existing RF limits and enacting biologically-based RF safety limits.

We do not want to continue to be guinea pigs for the government-sanctioned rollout of new technologies with insufficient safety standards. We do not want to continue to be part of the experiment being involuntarily carried out on the American people verifying the results of decades old research showing that the long-term health effects of these wireless signals can be profound and dangerous. (See Dodge)

The levels of radiation our family experiences on a daily basis from transmitting utility meters, wireless broadband, cellphones, cell towers, and just due to our position on the grid at the end of a line, - WITHOUT OUR PERMISSION - is already causing serious daily health problems for us.

Without conservative safety standards designed to protect the public health of our entire population during continuous exposures from all detrimental health effects and the rigorous enforcement of such standards, we fear the long-term hazards to our family's health.

We have a right to be safe in our homes and our schools and workplaces, and we have a right to current safety standards based on current science, not mistaken assumptions (the thermal model) and wishful thinking.

The existing FCC radiofrequency radiation exposure limits are way too high. Severe biological effects occur at far lower levels, as demonstrated by my family's experience, as well as in studies. If the FCC persists in ignoring this fact and does not adopt biologically-based radiofrequency radiation safety limits for all classes of RF emitters, including *Incidental* and *Unintentional* Radiators, it will be directly responsible for the ill health, even death, of millions of people. (See the 2012 BioInitiative Report - http://www.bioinitiative.org/ - for mechanisms and diseases for which links have been made in recent scientific literature and Dodge - incorporated by reference herein in its entirety http://www.magdahavas.com/wordpress/wp-content/uploads/2010/08/Dodge_1969.pdf - for connections made over 40 years ago.)

The Stetzerizer "dirty" electricity meter was evaluated in Kazakhstan and health standards were set such that no more than 50 G/S units of dirty electricity should be allowed on building wiring to protect health (www.electricalpollution.com/documents/Sanitary_Norms.pdf) and attached. Frequencies above the range of the Stetzerizer meter should also have much tighter standards. Their effect is related to capacitive coupling and energy. New standards should extend the full frequency range of existing and future *Intentional, Incidental* and *Unintentional* emitter output and be tight enough to protect human health. Special attention must be paid to instituting standards that prevent line ends from becoming hot spots for conducted and radiated RF. No one should face illness and disability because they happen to be located at the end of the line.

Sincerely,
Catherine Kleiber

Melrose-Mindoro

N181 State Rd. 108 • Melrose, WI 54642

Ron Perry, Superintendent
Del Deberg, High School Principal
Tracy Dalton, K-8 Principal

High School – (608) 488-2201 or (608) 857-3417
Fax – (608) 488-2805
Melrose Elementary – (608) 488-2311
Mindoro Elementary – (608) 857-3410

CHANGES NOTED SINCE FILTERS INSTALLED

In the years previous to the filters being installed, several children required inhalation treatments for their asthma in the spring and in the fall. Many of them required nebulizer treatments once or twice a day while at school. I have not had to administer one nebulizer treatment this past year and of the 37 students with inhalers, only three of them use the inhaler for their exercise-induced asthma before Phy Ed.

Teachers are stating they are less fatigued and tired.
The sense of smell has come back for me. I lost it for three years and the doctors said it was my allergies.
The students seem to have more energy and appear and seem less tired.
Several staff who doctored regularly for allergies have not had to take medication or see their doctor because they are having less problems.
Students whom have been diagnosed with migraine headaches have had their headaches reduced no headaches at all.
I feel that our faculty and students have had improved health overall since the filters have been installed.

Char Sbraggia R.N.
District Nurse

DEBUNKING THE UTILITY INDUSTRY MYTH ABOUT SMART METER SAFETY:

THE ANTENNA EFFECT

The utility industry's argument that smart (AMR, ERT) meters are safe must be rejected, because it relies on FCC testing for radiofrequency (RF) interference, which is not a safety testing protocol, and flawed FCC radiation exposure guidelines. The FCC testing for smart meters is done in an isolated laboratory, divorced from the context in which these meters are intended to be used, connected to the wiring in a home or business.

We present below compelling technical and empirical proof that, when these meters are used as intended, they cause an antenna effect, inflicting great harm to occupants inside their homes and businesses. **When used as intended, smart meters that appear to be safe in the testing laboratory are lethal.**

1. An RF engineer's technical report confirms that smart meters cause an antenna effect when connected to electrical distribution systems, resulting in extraordinary RF exposures that are significantly higher than those reported in isolated laboratory testing.

Stop Smart Meters New York (SSMNY) hired an RF engineering firm named Isotrope "[t]o evaluate the devices in situ" and to make "a field survey of the various emissions of concern, employing an array of electronic test equipment." Isotrope concluded, among other things, that the radiated- and conducted-emissions testing of electrical meters that was performed by the FCC "does not replicate actual conditions...." By contrast, when Isotrope tested a meter in usage as intended, connected to a home wiring grid, "the conducted emissions from the meter at 915 MHz ISM frequencies in a residence was observed to be substantial,"

This confirms what we refer to as the antenna effect of smart meters, which results in emissions that far exceed those reported when meters are tested in a laboratory setting, disconnected from wiring. The Isotrope Report goes on to state that **"if the 915 MHz conducted energy were to be held to the same standard as 30 MHz, the level of the 915 MHz conducted energy from the AMR meter would fail."**

The Isotrope report thus substantiates that smart meters cause an extraordinary RF/MW antenna effect on electrical distribution systems when they are used as intended, rather than in the isolation of a testing laboratory.

See Isotrope Report:
Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings on Hudson

2. The smart meter antenna effect results in injury to occupants of homes and business even where the meter is installed up to 150 feet away.

Many people are reporting becoming ill after smart meters, including AMR and ERT models, are installed on, in or near their homes and businesses. Reported symptoms include heart palpitations and other cardiac problems, ringing in the ears, sleep problems, anxiety, headaches, nausea, recurrence of cancer and more. These reports are too numerous and too consistent in nature to be dismissed as coincidental.

Where smart meters are installed up to 150 feet away from a home or business, the onset of these symptoms among occupants is attributable to the smart meter antenna effect.

SSMNY found evidence of the antenna effect when we visited the third floor apartment of a multi-family home in upstate New York where the residents, a mother and her daughter, have become very ill since their exposure to the RF/MW conducted then radiated emissions from a smart meter installed on the outside of the ground level of the building. On one occasion when we tested the RF/MW emissions at the meter itself, they were low. Nonetheless, our testing in a third floor bedroom confirmed the meter's antenna effect. In the bedrooms we measured levels of RF/MW emissions that exceeded the highest levels that our instruments would record, far beyond what is considered safe according to the findings in the 2012 BioInitiative Report. In the video, emissions measured zero at the meter, however, minutes later in the apartment the signal was again clearly heard and measured at high levels, disappearing when the circuit to the bedrooms was turned off. No other transmitters were plugged in on the circuit. The utility company has claimed that the meter is "non-transmitting" and no FCC identification number is visible. However, according to the meter's specifications "The kV2c meter family offers a large range of possible AMI communication technologies including RF Mesh, Cellular, Power Line Carrier, RS-232, RS-485, and Analog Phone Modem to support all of your Smart Grid applications."

The video record that we made of this testing and the smart meter antenna effect at this home can be seen here: Smart Meter Blamed For Destroying Family's Health

This video record demonstrates the importance of the conducted emissions documented in the Isotrope report and reveals how smart meters can cause illness for people sleeping in bedrooms distant from the meter. Final confirmation would require replacing the smart meter with an independently sourced analog meter and re-testing. Lacking that final proof, this video provides compelling evidence that conducted RW/MW emissions from smart meters can be extremely hazardous. A full investigation by the New York State Health Department and Centers for Disease Control is warranted.

*https://www.gedigitalenergy.com/SmartMetering/catalog/kv2c.htm

3. Smart meters have specific identifiable pulsed clicking signals.

The following video demonstrates the specific and distinct sound and RF/MW measurements of smart meters, using the identical measuring equipment that SSMNY used in the previous video. This corroborates that the signals that are audible in the prior video are attributable to the smart meter installed on the home that SSMNY visited.

The Sounds of Different RF radiation Sources with a RF Analyser

To compare:
See minute 1:38 in The Sounds of Different RF radiation Sources with a RF Analyser
See minute 3:57 in Smart Meter Blamed For Destroying Family's Health

4. Conclusion

The Isotrope report's findings concerning the antenna effect caused by smart meters, and SSMNY's observations of that effect and the injury it causes, debunk attempts by the industry to claim that these meters are safe. Those attempts depend on testing meters in the isolation of an FCC laboratory, without connecting them to wiring grids, using protocols which urgently need to be updated.

The utility industry and government regulators have presented no evidence that smart meters are safe. Moreover, the findings presented above confirm that these meters are unsafe despite the fact that they may appear to be operating within flawed FCC guidelines, in the isolation of the testing laboratory. They demonstrate that FCC testing needs to be updated from interference testing to health-based testing. In addition, the FCC should obtain assistance from the U.S. Environmental Protection Agency in establishing health-based standards and testing protocols.

The utility industry and government regulators made a dangerous mistake when they invested so heavily in smart meter technology before testing their impact on human health and safety. The industry should not be permitted to inflict the consequences of that mistake on us and our families by deploying this dangerous technology in our homes and businesses, against our will.

The FCC should acknowledge the inadequacy of its testing, remove these meters from the market and require utilities to replace non-analog meters with purely mechanical analog meters.

For additional information, please visit:

www.stopsmartmetersny.org

www.electricalpollution.com

TANTALUS — HYBRID WIRELESS NETWORK CONNECTIVITY SOLUTION

NETWORKS

technology delivered.

Tantalus

ORION® — AMR RADIO FREQUENCY (RF) SYSTEM

Catch A Rising Star In Multi-Utility RF Mobile and Fixed Network Systems

Flexibility is the key! ORION is Badger Meter's most flexible automated meter reading system for water and gas utilities. The state-of-the-art Radio Frequency (RF) system utilizes bubble-up (broadcast) technology, which eliminates the need for FCC licensing.

Built upon a mobile system platform, ORION provides features of a premier mobile AMR system plus the additional benefits of being able to integrate to the Tantalus Hybrid Wireless network. This flexibility results in seamless transition of ORION mobile AMR to a fixed network AMR solution and allows utilities to build upon their ORION system to meet their current and future needs.

The Clear Advantage. Badger has combined the latest advances in RF transmission, antenna technology and receiver sensitivity in the ORION system. In addition to the advanced technology, ORION has also been designed to provide utilities with an AMR solution that provides more than just a billing read. With the introduction of ORION's data profiling feature and Water Meter Monitor, utilities now have additional tools to provide better customer service to their water users.

ORION provides faster meter reading, greater accuracy, increased operator safety, fewer re-reads, elimination of "hard-to-read" meters, tamper detection, leak detection, and improved customer service. Selection of ORION AMR ensures that utilities will avoid stranded assets in the future when a Tantalus communications network is deployed in their city.

ORION Water Connectivity. Through the use of industry standard communication protocols, the ORION system can be installed on existing Badger® Recordall® meters with either the industry-leading Recordall Transmitter Register (RTR®) or the Absolute Digital Encoder (ADE®). Adding to ORION's flexibility, the ORION Universal 1 Transmitter can be installed on approved Neptune®, AMCO®, Hersey® or Sensus® meters and encoders.

ORION® Gas Connectivity. The ORION Integral Transmitter for Gas Meters is compatible with popular residential gas meters, including:

- American®
- Sensus, including the Rockwell®, Equimeter®, and Invensys® brands
- Actaris®, including the Metris®, Sprague® and Schlumberger® brands

ORION Network Connectivity

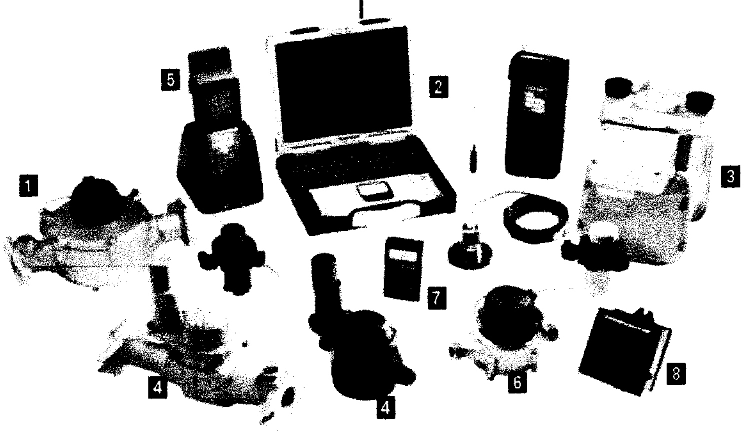
The ORION AMR system has built-in flexibility for the utility. It is upgradeable to the Tantalus Hybrid Wireless network. Working with Tantalus, Badger has expanded the options for a utility today or in the future by allowing seamless integration into the Tantalus Hybrid Wireless network.

All ORION transmitters (water and gas) are compatible with the Tantalus Hybrid Wireless network by utilizing Tantalus' 900-MHz transceivers located within the electric meters to read the ORION transmitters. The 900-MHz transceivers collect the ORION transmitter readings and sends the information back to the utility via the Tantalus Hybrid Wireless network.

This means the same ORION transmitter that is read by a mobile system can be read by the Tantalus Hybrid Wireless network - with no reprogramming of the ORION transmitter. As the Tantalus Hybrid Wireless network is deployed, the utility can simply stop mobile reading in the area.

The water and gas Utility not only gains the network readability for billing purposes but also gains the benefits of interval data transmissions. This data in turn can produce the following reports:

- Customer Profiling
- Daily Leak Detection Report
- Daily Stop Meter Report
- Daily Tamper Detection Report
- High Consumption Report
- Conservation Monitor Report
- Area Leak Report
- User-defined Reports

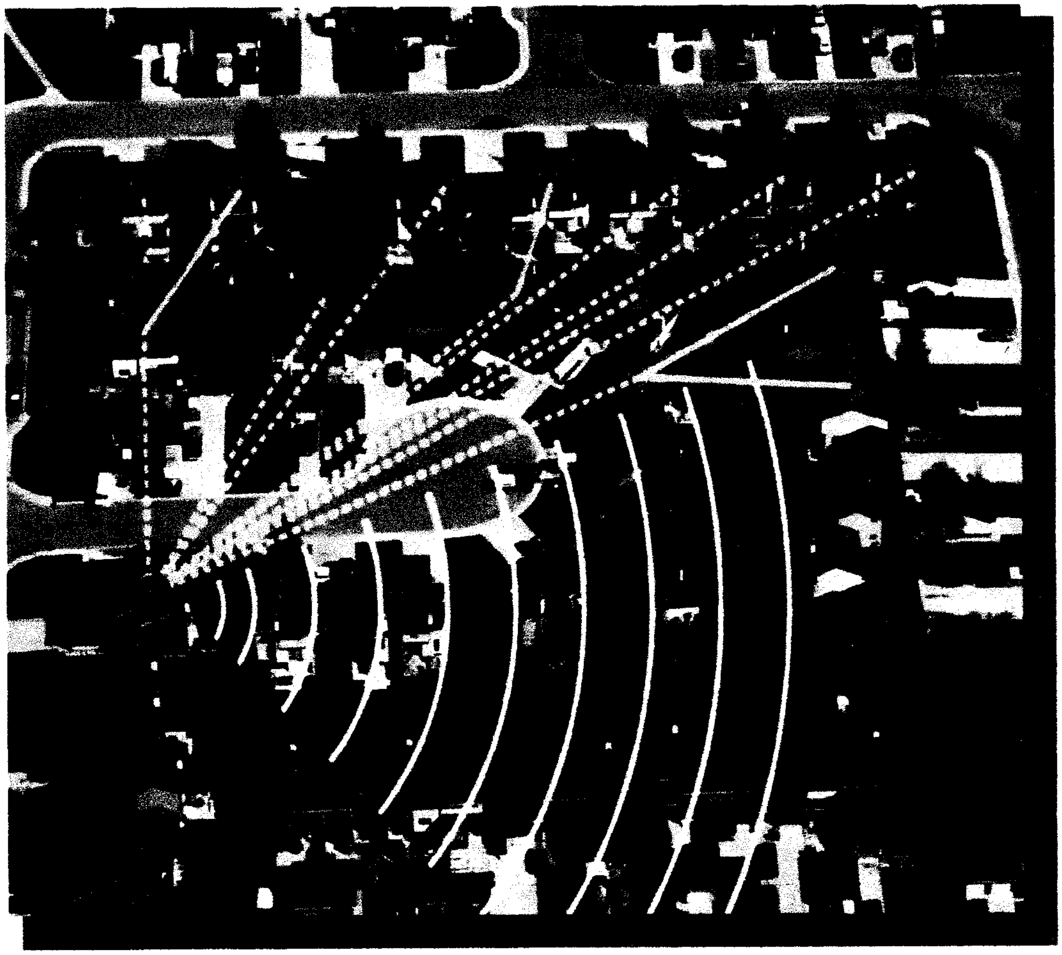


1) Pit ORION®, 2) ORION® Reading System (ORS), 3) ORION® Gas, 4) Integral ORION®, 5) Badger®-Radix®, 6) Remote ORION®, 7) ORION® Water Meter Monitor, 8) Remote Data Profiler

Hybrid Wireless Networks

The Tantalus Hybrid Wireless Network combines a 220 MHz wide area network (WAN) with a 900 MHz local area network (LAN) to create a hybrid solution that delivers efficient and affordable two-way data communications with excellent range and data throughput.

1. Endpoints transmit data over a 900 MHz LAN (yellow lines below) to a 220 MHz WAN Transceiver (blue dot below).
2. Endpoints equipped with the 200 MHz transceiver store all the data from the surrounding meters and transmit data directly to the Base Station over the WAN (white lines below).
3. The WAN Transceiver relays the data to a Network Controller at the Base Station.
4. The Network Controller stores the data and delivers it to the utility via a TCP/IP connection.



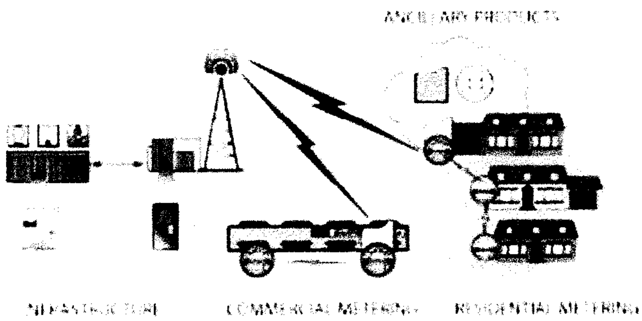
Network Solution

Badger Meter, Inc. and Tantalus Systems Corp.'s technology partnership will enable utilities to implement a wireless communications network that automates meter reading as well as enable them to remotely manage other water, gas, or electric equipment in a distribution network. The result is a single, consolidated communications system that meets the specific data and operational needs of each utility type, provides a secure communications infrastructure to protect and deliver data, and serves as the basis for outage management, demand response, load shedding and other progressive smart metering initiatives.

Tantalus transceivers listen for Badger's ORION® water and gas metering products, allowing them to communicate over the Tantalus Hybrid Wireless network back to a common network server or other host computer. This creates a practical, cost-effective system for utilities that manage multiple services or want to partner with other utilities in their service area in order to operate a common communications infrastructure. Essential consumption and operational data will be automatically channeled directly to appropriate functions within each respective utility for integration into billing, customer service, operations, or other relevant applications.

Hybrid Wireless Product Overview

Tantalus data communications products can be installed in a flexible range of configurations, creating an efficient network tailored to the specific needs of utilities.



The Tantalus Hybrid Wireless network is designed to support the following applications:

- Advanced Metering
- Outage Management
- Power Quality Monitoring
- Load Management
- Distribution Automation

How it Works

The Tantalus Hybrid Wireless network provides direct control over a distribution system.

The Tantalus Hybrid Wireless network combines a 220 MHz wide area network (WAN) with a 900 MHz local area network (LAN), to create a hybrid communications system that is effective, affordable and reaches both urban and rural customers.

The WAN provides long-range data communications between the service area and an operations center. It consists of a Network Controller installed at a radio tower and multiple WAN transceivers installed throughout the service area. The Network Controller communicates with the transceivers over the long-range 220 MHz band. The operations center communicates with the Network Controller through any available TCP/IP (Internet or Intranet) link.

The LAN collects data communications between a local service region and the WAN. Typically, more than one LAN device is associated with a single WAN transceiver in order to maximize efficiencies and minimize costs. The WAN transceiver gathers data from its associated LAN devices and relays it to the Network Controller. The WAN transceiver can also receive data from the Network Controller and send it to its LAN devices.

Electrical equipment may also be connected directly to the WAN through dedicated 220 MHz transceivers. If 220 MHz is unavailable or the utility/municipality uses fiber, Wi-Fi, or other network, then direct TCP/IP connections can be used for WAN transmission.

Installation and Maintenance

Installation and maintenance is simple. No special tools are required and no cables need to be run. When a LAN or WAN device is installed, the Tantalus Hybrid Wireless network automatically detects its presence and self-configures the system. The performance of the network and every device on it can be monitored from a web browser.

One Network Does it All

The Tantalus Hybrid Wireless network is the only data communication system needed to monitor and manage a distribution system, and it will grow with a utility as its needs expand. It provides the following functionality:

- Supports multiple applications — adds functionality, capacity, and applications as market and business needs expand
- Goes the distance — long-range communications are suitable for both rural and urban areas
- Unites the best of two wireless technologies — connects a utility to more devices more often, at a price that makes sense
- Employs unique burst-mode technology — communicates frequently and efficiently with large numbers of devices using a single narrowband radio channel
- Provides powerful tools for addressing groups of devices and executing time synchronized commands — ideal for identifying and measuring power losses on a feeder
- Designed for reliability — combines rugged hardware with a self-healing network

BadgerMeter, Inc.
4545 W. Brown Deer Road • P.O. Box 245036 • Milwaukee, WI 53224-9536
800-616-3837 • www.badgermeter.com

Tantalus
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Isotrope WIRELESS

Thinking outside the sphere

Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings-on-Hudson

November 23, 2013

www.isotrope.im Isotrope, LLC ◦ 503 Main Street ◦ Medfield, MA ◦ 02052 508 359 8833

Isotrope WIRELESS

Thinking outside the sphere

Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings-on-Hudson

November 23, 2013

Introduction

Isotrope, LLC was engaged by a group to evaluate the electromagnetic environment at several residences in Hasting-on-Hudson, New York. The clients expressed concern about human exposure to certain specific sources of electromagnetic fields. Of primary interest were the automatic meter reader (AMR) electric meters installed on local residences by Consolidated Edison. Also of interest were an electronic water meter equipped with a transmitter and cordless telephones operating with the DECT protocol. The general concerns expressed by the clients prior to the examination related to the various modes of propagation: radiated fields, conducted fields and re-radiated fields.

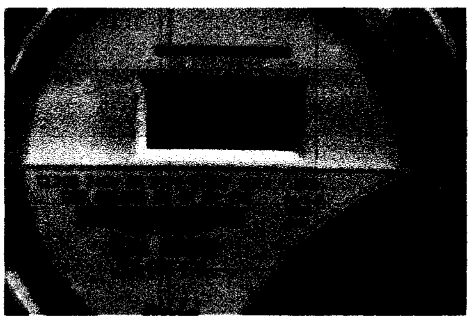
The clients sought an evaluation of the radiated and conducted emissions characteristics of these devices beyond merely comparing the emissions to applicable health and safety standards. The clients hypothesize that the emissions of some or all of the types of subject devices interact with human physiology in a manner that is not captured by conventional emissions safety guidelines. The clients' concerns relate primarily to the possible impact of these pulsed radio frequency emissions on humans in the residential environment. The examination was performed solely to characterize the nature and intensity of the emissions of concern. While the measured emissions are compared to the FCC exposure limitations, among other things, for reference, this report draws no conclusions about the risks of human exposure to these emissions.

To evaluate the devices in situ, Isotrope made a field survey of the various emissions of concern, employing an array of electronic test equipment. Conclusions in this report include the observation that Part 15 radiated- and conducted-emissions testing of electrical meters does not replicate actual conditions because a power cord is attached to the meter socket in the test chamber rather than simulating the installation of the meter on a meter socket connected to both the power grid secondary and the residence distribution panel. Moreover, while the conducted emissions from the meter at 915 MHz ISM frequencies in a residence was observed to be substantial, FCC Part 15 regulations limit conducted emissions testing to 30 MHz, ignoring the conducted emissions of the AMR radio signal.

Devices Under Test

Residential AMR Electric Meters

The AMR electric energy meters of interest are manufactured by iTron. As an intentional emitter of RF energy in the industrial, scientific and medical (ISM) band at 902-928 MHz, the model of meter has been factory tested to verify conformity with Part 15 regulations of the FCC (Title 47 of the US Code of Federal Regulations). Its test information is available from the FCC. Isotrope reviewed the test filings by referencing the FCC ID number posted on the meters.



The AMR meters were originally designed to transmit a 7 millisecond pulse of data about once every two seconds. (The meters we tested ran at about two pulses per minute.) A revision of the design is reported with a 45 ms pulse of data. The unit is designed to transmit one pulse on one radio channel and then change to another channel. This is called "frequency hopping." The hopping stays within the 915 MHz ISM radio band and is designed to minimize interference to other users of the band. The FCC reports say that radiated power levels are stated to conform to the FCC Section 15.247 interference limit for the band, which requires 1 watt or less power to the antenna.

Water Meter Transmitter

The water meter transmitter is manufactured by Neptune. Under its FCC ID number, the unit's certification filings describe a pulse is transmitted approximately once every 13 seconds. The device uses frequency hopping (see sidebar above). It is designed and tested under the same Part 15 interference regulations as the AMR meters.

DECT Phone

The cordless phone employs the DECT standard and operates in the unlicensed PCS band. DECT phones are required to comply with Part 15 interference regulations.

Test Methodology

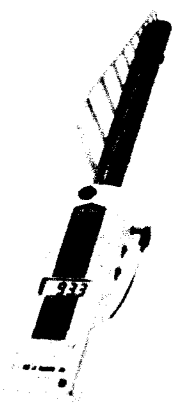
Isotrope brought an array of equipment to the site in anticipation of a variety of possible measurement needs.

Equipment	Bandwidth	Antenna Pattern	Exposure Range
Anritsu MT8222A Spectrum Analyzer with ETS model 905 probe **("Anritsu")**	1 MHz to 1 GHz probe range	Dipole-like omnidirectional	Wide dynamic range, equivalent to a minimum of less than 1 picowatt per cm^2 depending on settings (<<-90 dB mW/cm^2)
Advantest Spectrum Analyzer **("Advantest")** used with Isotrope Line Impedance Stabilization Network **("LISN")**	LISN nominally 10 kHz to 30 MHz	Conducted measurement; Not Applicable	Not an exposure measuring setup
Tektronix Oscilloscope **("Oscilloscope")**	500 MHz	Conducted measurement; Not Applicable	Not an exposure measuring setup
Gigahertz Solutions HF35-C field intensity meter (provided by others) **("HF35-C")**	800 MHz to 2.5 GHz	Log Periodic directional	Wide dynamic range, equivalent to a minimum of 10 picowatts per square centimeter (-80 dB mW/cm^2)
NARDA 8718 Meter with 8722-D Conformal Probe **("NARDA")**	300 kHz-40 GHz	3D omnidirectional	2% to 1500% of the FCC limit for general population/uncontrolled areas; equivalent to a minimum of about 10 $\mu W/cm^2$ at 1 GHz (-20 dB mW/cm^2) [1]

[1] Although the emissions under observation are at levels that are lower than the FCC safety limits, the FCC is presently inquiring "whether there is a need for reassessment of the Commission radiofrequency (RF) exposure limits and policies." (FCC 13-39). Ultimately, all radiated power densities observed were substantially below the sensitivity of the Isotrope NARDA human exposure compliance meter.

To measure radiated emissions in relative proximity to the respective sources, including in the near field and at distances typically of no more than 40 feet radially from any particular source, Isotrope employed radio frequency spectrum analyzers and a reference electric field probe commonly used in close-in electromagnetic interference (EMI) testing. The relative insensitivity of the probe was not a constraint on the measurements due to the proximity of the probe to the sources of interest. The probe was also used in close proximity to power wiring and conductive surfaces to sense any localized fields.

To examine conducted energy on the power lines, Isotrope used a line impedance stabilization network (LISN). The LISN was used to feed a spectrum analyzer, and also to feed an oscilloscope.



Finally, the client provided a Gigahertz Solutions HF35-C field intensity meter. This device employs an attached log-periodic antenna to sample the electric field between 800 MHz and 2.5 GHz. This frequency span encompasses the most common wireless telephone bands (Cellular, SMR, PCS, AWS, BRS) as well as 915 MHz ISM and 2.4 GHz WiFi, among others. The HF35-C is a relatively sensitive instrument that has plenty of dynamic range to explore the residential wireless signal environment.

> The Gigahertz Solutions HF35-C measures the electric field and converts to equivalent plane wave free space power density (reported in microwatts per square meter - $\mu W/m^2$). The unit is highly sensitive, capable of reading on the more sensitive scale to values as low as 0.1 $\mu W/m^2$ or -80 $dBmW/cm^2$. This is comparable to the received signal strength of an FM radio station broadcasting from about 10 miles away.

AMR Electric Meter

HF-35C Equivalent Power Density

At three residences AMR electric meters were observed. They consistently emitted short pulses once every thirty seconds. The HF35-C instrument was set to peak reading mode to capture as much of the pulse peak power as possible. With the HF35-C meter within about 1.5 to 2 feet of the AMR meters, the pulse would register on the high scale at levels typically between -43 and -37 $dBmW/cm^2$ (500 to 2000 $\mu W/m^{2)}$, depending on the orientation of the instrument's antenna.

Closer to the AMR meter, the HF35-C would regularly blank the display on receiving a pulse, indicating an over-range condition.[2]

Whether or not the pulse was over-range, the pulse energy would be retained by the instrument's averaging circuits and the subsequent readings would steadily decay back to the background level over the course of five seconds or so. It is important to note that only the first reading captures emitted RF energy. The subsequent readings as the meter reading decays to a baseline level are artifacts of the way the meter handles pulsed emissions and do not indicate emissions are present. The instrument manual explains this phenomenon as "charging and drooping", acknowledging that a peak reading may be "even up to a factor of ten too low." The graphic below illustrates how the instrument may capture some of the energy of the pulse and then show a decaying level after the pulse has ended.

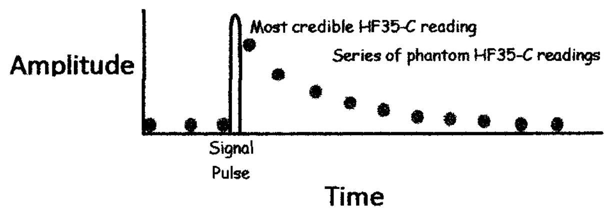


Figure 1 - Illustration of HF35-C Meter Readings over Time, in the Presence of a Single Signal Pulse

Spectrum Analysis

Using a spectrum analyzer, the AMR meter pulses were also captured in both the frequency domain and the time domain.

The pulse power levels obtained by the spectrum analyzer at the second residence were on the order of -20 dBm with the sensor approximately 6 inches from the meter's internal antenna. Recall that dBm are units of power measurement. To translate to human exposure terminology, the power received by the instrument through its antenna has to be translated to units of power per unit area, such as milliwatts per square centimeter (mW/cm^2). Based on the

[2] Note that the instantaneous power density (the pulse power density) is reported. FCC exposure specifications base public exposure on a 30 minute averaging time. In 30 minutes there would be about 60 pulses of about 50 ms duration. This totals to about 3 seconds of emissions to be averaged over 30 minutes. This way of calculating exposure reduces the FCC interpretation of exposure to 2 tenths of a percent of the measured peak.

instrumentation characteristics, this translates to an equivalent of -20 dBmW/cm^2 free space pulse power density at 6 inches from the meter.

The result on the spectrum analyzer is as much as 20 dB higher than on the HF35-C meter. This higher reading is due to two probable differences. First, the spectrum analyzer was substantially closer to the signal source than the HF35-C. Second, even if the instruments were at the same distance, it is expected that the HF35-C response to pulse inputs would artificially diminish its reading. Overall, there is enough consistency between the results of the two measurement methods to confirm the more precise measurements of the spectrum analyzer.

Away from the AMR Meter

Inside the residences, the received power levels from the AMR meters were consistent with the weakening of the signal that would be expected with increasing distance from the meter and signal absorption of residential construction. On the second floor at the opposite side of the house from the meter (in two residences tested) the AMR meter pulses were extremely diminished to the point of not being measurable on the HF35-C meter, and the pulse's clicking sound produced by the HF35-C AM detector would diminish and recede into the background noise. Similarly, attempts to capture occasional pulses on the spectrum analyzer in rooms distant from the AMR meter were often not fruitful. Measured pulse levels tended to range between -60 dBmW/cm^2 indoors nearest the meters to levels less than the sensitivity of the HF35-C instrument (< -80 dBmW/cm^2) in opposite ends of the residences. With a sensitivity of less than -90 dBmW/cm^2, the spectrum analyzer confirmed the unmeasurable levels of the AMR meter emissions were less than -90 dBmW/cm^2 in more distant parts of the houses tested.

In the basement of one residence, directly behind the cement block wall with the AMR meter on the outside, the combination of the meter's metal enclosure and the cement block construction reduced the AMR meter's signal level to -63 dBmW/cm^2 (5 μW/m^2). Outside, in front of the meter, the signal level was consistent with the power density observed near the other AMR meters (-20 to -40 dBmW/cm^2). The signal loss into the basement was about a 30 dB reduction over the free space loss that would occur outside the meter. In other words, the strength of the signal just behind the basement wall was about a thousand times weaker than the strength of the signal outside in front of the meter.

Conducted Emissions

Within the electric meter enclosure, the 915 MHz emission of the AMR meter is radiated within several inches of the power lines that pass through the meter enclosure on the way to the main service panel. Consequently, it is likely that the house electrical system conducts some of the

915 MHz signal into the residence. In the basement described above, the power cable penetrates the cement block wall, going from the meter outside to the main circuit panel mounted inside near the penetration. The nearest electrical outlet in the basement is on an interior wall approximately 12 feet away (perhaps 20 feet by wire).

A line impedance stabilization network was connected to the outlet, treating the meter/electrical panel as the device under test. A spectrum analyzer was connected and the spectrum was monitored. With the FCC regulated range below 30 MHz, the conducted emissions appeared to be compliant with the regulations. Above 30 MHz, there was a substantial conducted 915 MHz component on the power line.

The conducted 915 MHz signal level was approximately -55 dBm (about 52 dBμV RMS). The LISN is not calibrated for 915 MHz measurements; however it is reasonable to assume that if there is any error in reading a 915 MHz signal from the power line, the error is likely to cause the reading to be lower than the actual condition, due to impedance mismatch and UHF losses in the LISN. The 52 dBμV measurement is therefore conservative, erring on the side of understating the conducted 915 MHz energy.

If the 915 MHz conducted energy were held to the same standard as 30 MHz, the level of the 915 MHz conducted energy from the AMR meter would fail. FCC Part 15 conducted emissions regulations do not specify conducted emissions limits above 30 MHz. The 30 MHz limit for an appliance injecting noise into the power line is 50 dBμV at 10 ft (cable distance from the device under test).

Conducted-then-Radiated Emissions?

Emissions that are captured by house wiring and conducted around the house may ultimately be radiated from outlets and along the house wiring. When in close proximity to conductive objects (house wiring, outlets, metal lamp) the measured levels increased. This is consistent with the known behavior of objects that "re-radiate" RF energy. The apparent re-radiation of these objects created elevated fields close to them, while not materially affecting the generalized ambient field levels in the rooms tested.

The general ambient field levels in the houses followed the basic pattern of being weaker as the distance from the source (at the meter) increased. While showing elevated "hot spots" of energy near the conductive objects, these conductive objects did not appear to be major contributors to the overall ambient fields in each room.

For example, in one house, the ambient levels of the AMR signal (and a DECT phone signal emitted from the first floor) were observed to have a spatial peak value in proximity to house wiring in the wall of a second floor bedroom by a bed as well as in proximity to a metal floor lamp in another bedroom, among other locations. The spatial peaks near the electrical wire and floor lamp were, on one hand, several orders of magnitude lower than the measured radiated signals found near the electric meters and the DECT phones, yet, on the other hand, these conducted/reradiated signals were still substantially greater than the ambient emissions found generally in the same rooms as the conductive objects.

The spatial peaks that occur near conductive objects connected to the house electrical wiring could be the result of two factors. First, there could be resonant re-radiation of the over-the-air signal and/or, second, radiation of emissions conducted from the source. Resonant re-radiation occurs when a conductor is of such electrical dimensions that it acts as a passive antenna, receiving a signal from the air, resonating and reradiating the signal. Such an object may or may not be connected to a wiring network like the house electrical system. Radiation of conducted emissions occurs when conducted energy (from the house wiring) reaches conditions that cause the conductive object to radiate like an antenna.

Water Meter

The water meter of interest is located in a public park containing a tennis court. The park is approximately the size of one house lot, and is surrounded by houses on approximately ¼ acre lots. The meter is mounted on an in-ground water pipe. The water pipe is exposed below grade and is marked by a wooden post. Mounted on the wooden post is a weather-tight electronics package with a label revealing information including an FCC ID number. One low-voltage cable connects the analog meter to the electronics. There is no power connection.

Researching the FCC ID number, the unit is a transmitter that operates in the 911-924 MHz band. Like the AMR electric meters, the water meter AMR transmitter on the post is designed to transmit a burst of data at regular intervals. Operation is designed to be compliant with the Part 15 emission limit (less than 1 watt).

The HF-35C instrument detected a pulse emitted every 13 seconds, which was most apparent as an audible click on the audio detector. As is sometimes the case with direction-finding in the near field, the pulses were strongest within a 10 foot radius of the transmitter, but within that radius the signal level varied with position and sensor antenna orientation. The pulses registered on the most sensitive range of the HF-35C. It is not known what the pulse response of the instrument is, however the unit was kept on peak detection mode, which is intended to capture more realistic measurements of peaky signals. In close proximity to the water AMR transmitter power was similar to that of the electric AMR meters.

There was plenty of background noise near the water meter. Various kinds of cell site emissions appeared to be the dominant components, based on the detected audio provided by the HF35-C, in addition to the short bursts from the Neptune transmitter which were audible approximately every 13 seconds.

A scan of the radio spectrum with a spectrum analyzer resulted in an array of wireless signals and other similar signals at levels that would normally be expected in a residential area. Because the water meter transmitter frequency hops like the AMR electric meter transmitter does, its emissions were not captured on the spectrum analyzer during the short visit at the water meter. The radio frequency power of the water meter transmitter is comparable to that of the AMR meters, according to the FCC test data. The behavior of the unit observed in the park was consistent with this information.

DECT Telephone Set

Some of the residences included in the survey had cordless telephone base units and one or more cordless phones associated with them. Operating in the unlicensed PCS band at 1920-1930 MHz, these units are designed to share the spectrum with other DECT phone sets in the same neighborhood without mutually interfering and without intercepting the communications of the others. They operate by monitoring the band and selecting an available channel. Once on a channel, the base units send short bursts of data, enabling the handheld units to share the channel using time division duplexing. The base units were observed on the spectrum analyzer to be transmitting their signals at levels consistent with their unlicensed use, which are substantially below the applicable RF exposure limits.

Summary Conclusions

The following observations result from the survey.

Interference Compliant. The radio transmitters of interest appeared to be functioning within the FCC radiated interference limits imposed in Part 15.

Interference Specifications are Not Exposure Specifications. Part 15 exists to enable compatible use of the radio spectrum by myriad devices that use radio frequencies without requiring licensing of the use. It is not a safety specification.

Strongest Fields are Found Near the Sources. The greatest potential whole body exposure to the AMR meter energy would occur near the meter and would be less than 1 mW/m^2 (-40 $dBmW/cm^2$).

Range of In-Home Exposure to EMR Meter Emissions: Regardless of the previous conclusion, the emissions of the AMR meters are well above ambient RF levels and measured in occupied space from below -90 $dBmW/cm^2$ at more distant rooms to about -60 $dBmW/cm^2$ inside the exterior walls nearest the meters.

AMR Conducted Emissions Are Strong, but Not Regulated. The conducted emissions of the AMR electric meters at the 915 MHz band are substantial, but are not regulated by Part 15 (which cuts off above 30 MHz). If the 30 MHz limit were applied to 915 MHz, it is probable that the meter would fail a lab test, subject to the following observation.

AMR Meter Lab Testing Fails to Simulate in Situ Wiring. The lab testing of the AMR meters employed a simple power cord temporarily attached to the meter mounted in a panel. The meter does not normally employ a power cord. This approach does not simulate the manner in which the house wiring feeds through the electric meter. The meter has two power connections: one entering the meter typically from the top to deliver power to the meter and another exiting the bottom of rear of the meter panel to supply power to the main breaker panel. Using a power cord instead of setting up the power wiring the way the device is actually used may not reveal how the house circuit wiring through the meter may act. The actual in situ wiring may be more like an antenna that may pick up unwanted RF energy and noise within the meter and conduct it into the residence. See photo appended to this report.

Reradiation and Incidental Radiation Exists as Expected. House wiring (and other metallic objects and cables) act as concentrators or reradiators of RF energy that produce spatial peaks of RF energy near the conductors. This is a well-known phenomenon (particularly at AM broadcast frequencies, where the effect near high power AM stations is substantial – the effect exists on all frequencies to some degree, depending on the frequency and radiated power level and dimensions of the conductor); the appearance of conducted RF energy and localized RF fields around conducting objects at AMR and DECT frequencies is consistent with experience.

Reradiation and Incidental Radiation Appears Near Conductive Objects. Reradiated energy from in-house conductors (such as electrical wiring) is lower than the emissions in the vicinity of the radiating antenna. The nature of passive reradiation is that the reradiating object or material cannot increase the power it receives. Therefore, the amount of energy emitted by the reradiator cannot be greater than that which is emitted by the source that excites the reradiator. Also, as the distance from the source to the reradiator increases, the field intercepted by the reradiator diminishes.

Table 1, below, Summarizes Ambient Levels of the AMR Meters Tested.

Table 1 - Comparison of Exposure Levels from Emissions of the AMR Meter under Test

Location of Measurement	Equivalent Plan Wave Free Space Power Density†	Device
Approximately 6 inches away	-20 dBmW/cm^2 *	Spectrum Analyzer
1 – 2 feet away	-37 to -43	HF35-C ††
Inside occupied spaces	-60 to less than -90**	Spectrum Analyzer
Inside occupied spaces	-60 to less than -80**	HF35-C

†The general practice is to convert measured field (volts per meter) to power density assuming the measurement was of a signal radiating in free space. In proximity to objects or to the radiating element, this conversion may overstate the actual power density.

††Note that HF35-C readings may be artificially low due to meter design with respect to short pulses.

*The use of decibels makes it easier to present data over a wide numerical range. The more negative the number of dB, the weaker the signal.

-20 dBmW/cm^2 is one one-hundredth of a milliwatt per square centimeter (0.01).

-60 dBmW/cm^2 is one millionth of a milliwatt per square centimeter (0.000001).

-90 dBmW/cm^2 is one billionth of a milliwatt per square centimeter (0.000000001).

** The lower figures (-90 and -80) represent the approximate sensitivity of the instruments. When signals are not measured, it is because they are below the sensitivity of the instrument.

Remediation

Removal

If the AMR meter emissions at a particular residence are to be minimized, the most effective method is to remove the meter. Of course, this must be done in coordination with the electric power supplier.

Reduce Duty Cycle (to about once a month)

If the meter can be replaced with one that only responds when polled, then there would only be a brief emission during monthly meter readings when a meter reader passes the location of the meter with a radio that interrogates the meter and receives its reply. However, as AMR meters give way to so-called smart meters that communicate with devices in the house, the rate of transmissions will increase to provide data communication between the meter and smart appliances.

Retrofit with Protection

If neither of the above can be accomplished to eliminate or minimize the meter emissions, shielding the meter so that its emissions are diminished or are focused away from the residence could be considered. One vendor of a meter shield product made a demonstration that obtained what was apparently about 40 dB of attenuation of the meter's radiated emission (a reduction to one ten thousandth of the power density without the shield.)

Also, based on our conducted emission test, if shielding is employed, then it may be desirable to place filtration on the power lines entering/exiting the meter panel to reduce conducted emissions. A search for "power line EMI filter" will yield a variety of sources. A party experienced in EMI suppression should be involved in working with the electrician.

Conclusion

This report summarizes the results of a field survey of the ambient emissions of AMR meters at three residences in Hasting on Hudson, New York. Measurements were taken near the outdoor meters and within the residences to which they are attached, including radiated emissions testing in three homes and conducted emissions testing on the electrical wiring in one home. Radiated emissions measurements were compared between two primary measuring devices. Measurements were also compared to applicable interference and exposure standards for reference.

Appendix 1

Photograph of Test Configuration of AMR Meter,

with substitute power cord installed in lieu of typical house mains wiring configuration

Source:

FCC Part 15.247 Certification
Test Report

FCC ID: SK9C1A-3

FCC Rule Part: 15.247

ACS Report Number: 05-0122-15C

Manufacturer: Itron Electricity Metering, Inc.
Equipment Type: Electricity Meter With FHSS Transmitter
Trade Name: CENTRON ™ ICARe
Model: C1A-3

Test Setup Photographs

Isotrope Note:

Power cord installed for testing. Not consistent with field applications of device.

No House Mains wiring installed for simulation (on radiated and conducted emissions tests).

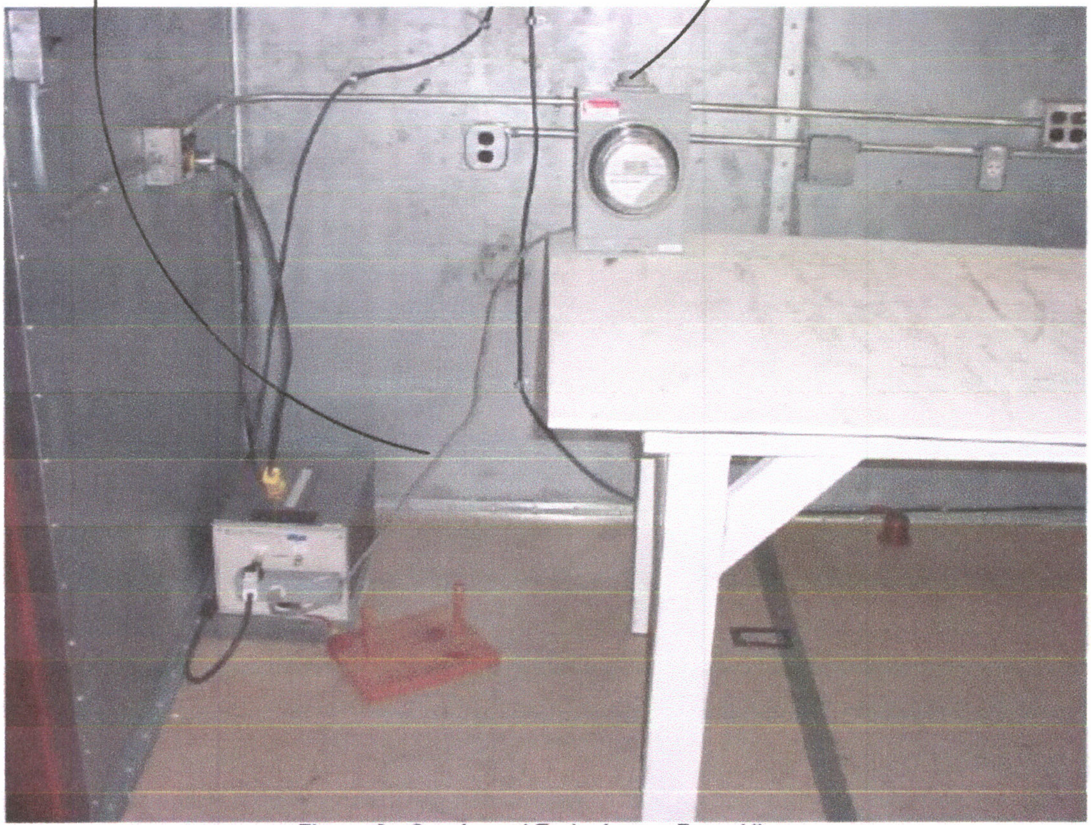


Figure 3: Conducted Emissions – Front View

Declaration of Cynthia Sage, Sage Associates

January 4, 2011

My name is Cynthia Sage. I am the owner of Sage Associates, an environmental consulting firm. My business address is 1396 Danielson Road, Montecito, California, 93108. I am providing a declaration in support of A.10-04-018.

I have been a professional environmental consultant since 1972. I hold an M.A. degree in Geology, and a B.A. in Biology (Zoology) from the University of California, Santa Barbara. I am a Senior Fellow, Department of Oncology, School of Health and Medical Sciences, Orebro University, Orebro, Sweden (2008-2011).

I served as a member of the California Public Utilities Commission EMF Consensus Group (1990-1991), the Keystone Center Dialogue for Transmission Line Siting (a national group developing EMF Policy 1991-1992), and of the International Electric Transmission Perception Project. Between 1977 and 1981, I served as a member of the California Board of Registration for Professional Engineers (Department of Consumer Affairs). I am a full member of the Bioelectromagnetics Society. I am the co-editor of the BioInitiative Report, and a founding member of the BioInitiative Working Group, an international scientific and public health research collabortion. I was a Lecturer in the Environmental Studies Program, University of California, Santa Barbara and a founding member of that program, and developed and taught classes in environmental impact assessment from 1972 – 1981. My publications are attached.

My professional involvement in this area includes constraint analysis, environmental planning, and impact assessment on EMF and radiofrequency radiation siting issues for more than 30 years. My company has provided professional consulting services to city and county planners, private developers, state and federal agencies and schools with respect to measurement and assessment of EMF as a part of land planning and environmental constraints analysis since 1972. I have been an expert witness who testifies on EMF computer modeling, impacts on people and property, EMF policy, public perception, visual impairment and land use issues, and have qualified both in state and in federal court proceedings as an expert witness in this area.

1. Sage Associates has prepared the ***Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters*** [1] to document radiofrequency radiation (RF) levels

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[1] http://sagereports.com/smart-meter-rf/

associated with wireless smart meters in various scenarios depicting common ways in which they are installed and operated.

5. The Report includes computer modeling of the range of possible smart meter RF levels that are occurring in the typical installation and operation of a single smart meter, and also multiple meters in California.

6. FCC compliance violations are likely to occur under normal conditions of installation and operation of smart meters and collector meters in California, because the public has access to smart meters installed on their homes.

7. In addition to exceeding FCC public safety limits under some conditions of installation and operation, smart meters can produce excessively elevated RF exposures, depending on where they are installed. RF levels are predicted to be substantially elevated within a few feet to within a few tens of feet from the meter(s).

9. RF levels associated with smart meters under some conditions of installation and operation will produce RF power density levels that exceed those reported in some scientific studies to result in adverse health impacts, including headache, sleep disruption, restlessness, tremor, cognitive impairment, tinnitus, increased cancer risk, and cardiac problems at distances less than 500 meters from cell antennas, or at levels over 0.1 microwatts per centimeter squared. [1,2,3,4,5,6]

10. Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

11. People who are afforded special protection under the federal Americans with Disabilities Act are not sufficiently acknowledged nor protected. People who have medical and/or metal implants or other conditions rendering them vulnerable to health risks at lower levels than FCC RF limits may be particularly at risk.

12. Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

13. Consumers, for whatever personal reason, choice or necessity who have already

eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters on a 24-hour basis. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

14. In summary, no positive assertion of safety can be made by the FCC, nor relied upon by the CPUC, with respect to pulsed RF when exposures are chronic and occur in the general population. [3,5,6] Indiscriminate exposure to environmentally ubiquitous pulsed RF from the rollout of millions of new RF sources (smart meters) will mean far greater general population exposures, and potential health consequences. Uncertainties about the existing RF environment (how much RF exposure already exists), what kind of interior reflective environments exist (reflection factor), how interior space is utilized near walls), and other characteristics of residents (age, medical condition, medical implants, relative health, reliance on critical care equipment that may be subject to electronic interference, etc) and unrestrained access to areas of property where meter is located all argue for caution.

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Under penalty of perjury, I declare that the facts set forth above are true and correct to the best of my knowledge.

Dated January 4, 2011, at Santa Barbara, California.

/s/

Cynthia Sage

A New Electromagnetic Exposure Metric: High Frequency Voltage Transients Associated With Increased Cancer Incidence in Teachers in a California School

Samuel Milham, MD, MPH*,† **and L. Lloyd Morgan,** BS‡

Background *In 2003 the teachers at La Quinta, California middle school complained that they had more cancers than would be expected. A consultant for the school district denied that there was a problem.*
Objectives *To investigate the cancer incidence in the teachers, and its cause.*
Method *We conducted a retrospective study of cancer incidence in the teachers' cohort in relationship to the school's electrical environment.*
Results *Sixteen school teachers in a cohort of 137 teachers hired in 1988 through 2005 were diagnosed with 18 cancers. The observed to expected (O/E) risk ratio for all cancers was 2.78 ($P = 0.000098$), while the O/E risk ratio for malignant melanoma was 9.8 ($P = 0.0008$). Thyroid cancer had a risk ratio of 13.3 ($P = 0.0098$), and uterine cancer had a risk ratio of 9.2 ($P = 0.019$). Sixty Hertz magnetic fields showed no association with cancer incidence. A new exposure metric, high frequency voltage transients, did show a positive correlation to cancer incidence. A cohort cancer incidence analysis of the teacher population showed a positive trend ($P = 7.1 \times 10^{-10}$) of increasing cancer risk with increasing cumulative exposure to high frequency voltage transients on the classroom's electrical wiring measured with a Graham/Stetzer (G/S) meter. The attributable risk of cancer associated with this exposure was 64%. A single year of employment at this school increased a teacher's cancer risk by 21%.*
Conclusion *The cancer incidence in the teachers at this school is unusually high and is strongly associated with high frequency voltage transients, which may be a universal carcinogen, similar to ionizing radiation.* Am. J. Ind. Med. 2008. *© 2008 Wiley-Liss, Inc.*

KEY WORDS: high frequency voltage transients; electricity; dirty power; cancer; school teachers; carcinogen

BACKGROUND

Since the 1979 Wertheimer–Leeper study [Wertheimer and Leeper, 1979] there has been concern that exposure to power frequency (50/60 Hz) EMFs, especially magnetic fields, may contribute to adverse health effects including cancer. Until now, the most commonly used exposure metric has been the time-weighted average of the power-frequency magnetic field. However, the low risk ratios in most studies suggest that magnetic fields might be a surrogate for a more important metric. In this paper we present evidence that a

Abbreviations: EMF, electromagnetic fields; O, observed cases; E, expected cases; O/E, risk ratio; p, probability; Hz, Hertz or cycles per second; OSHA, Occupational Safety and Health Administration; OCMAP, occupational mortality analysis program; AM, amplitude modulation; GS units, Graham/Stetzer units; G/S meter, Graham/Stetzer meter; MS II, Microsurge II meter; mG, milligauss; EKG, electrocardiogram; LQMS, La Quinta Middle School.

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new exposure metric, high frequency voltage transients existing on electrical power wiring, is an important predictor of cancer incidence in an exposed population.

The new metric, GS units, used in this investigation is measured with a Graham/Stetzer meter (G/S meter) also known as a Microsurge II meter (MS II meter), which is plugged into electric outlets [Graham, 2005]. This meter displays the average rate of change of these high frequency voltage transients that exist everywhere on electric power wiring. High frequency voltage transients found on electrical wiring both inside and outside of buildings are caused by an interruption of electrical current flow. The electrical utility industry has referred to these transients as "dirty power."

There are many sources of "dirty power" in today's electrical equipment. Examples of electrical equipment designed to operate with interrupted current flow are light dimmer switches that interrupt the current twice per cycle (120 times/s), power saving compact fluorescent lights that interrupt the current at least 20,000 times/s, halogen lamps, electronic transformers and most electronic equipment manufactured since the mid-1980s that use switching power supplies. Dirty power generated by electrical equipment in a building is distributed throughout the building on the electric wiring. Dirty power generated outside the building enters the building on electric wiring and through ground rods and conductive plumbing, while within buildings, it is usually the result of interrupted current generated by electrical appliances and equipment.

Each interruption of current flow results in a voltage spike described by the equation $V = L \times di/dt$, where V is the voltage, L is the inductance of the electrical wiring circuit and di/dt is the rate of change of the interrupted current. The voltage spike decays in an oscillatory manner. The oscillation frequency is the resonant frequency of the electrical circuit. The G/S meter measures the average magnitude of the rate of change of voltage as a function of time (dV/dT). This preferentially measures the higher frequency transients. The measurements of dV/dT read by the meter are defined as GS (Graham/Stetzer) units.

The bandwidth of the G/S meter is in the frequency range of these decaying oscillations. Figure 1 shows a two-channel oscilloscope display. One channel displays the 60 Hz voltage on an electrical outlet while the other channel with a 10 kHz hi-pass filter between the oscilloscope and the electrical outlet, displays the high frequency voltage transients on the same electrical outlet [Havas and Stetzer, 2004, reproduced with permission].

Although no other published studies have measured high frequency voltage transients and risk of cancer, one study of electric utility workers exposed to transients from pulsed

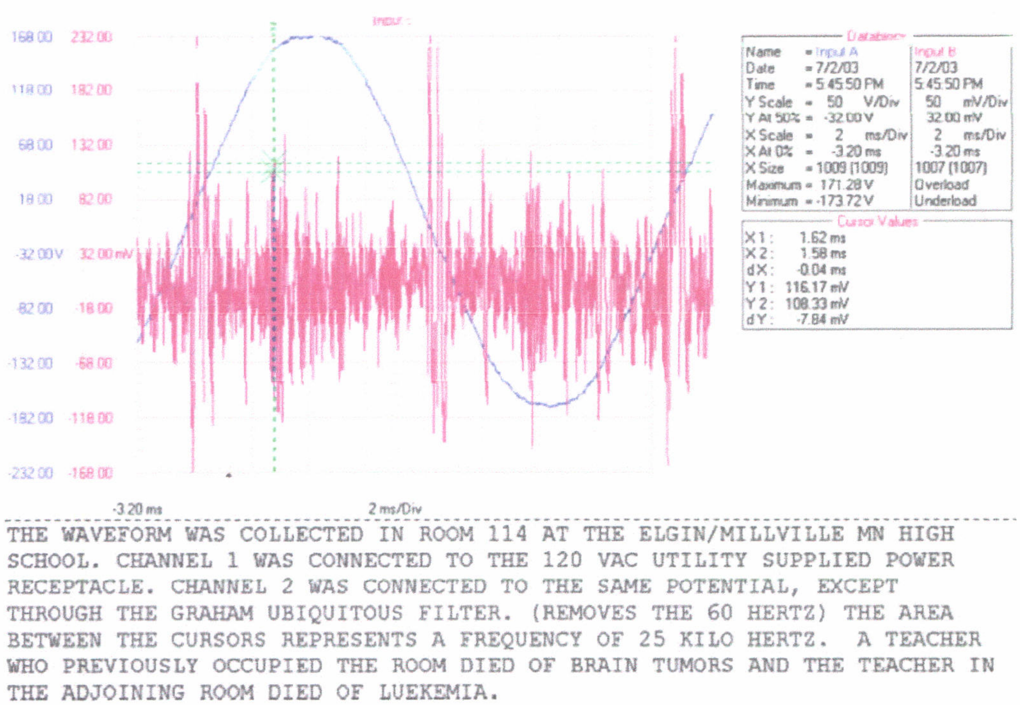


FIGURE 1. Oscilloscope display of dirty power: 60 Hz electrical power (channel 1) with concurrent high frequency voltage transients (channel 2). A 10 kHz hi-pass filter was used on channel 2 in order to filter out the 60 Hz voltage and its harmonics. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

electromagnetic fields found an increased incidence of lung cancer among exposed workers [Armstrong et al., 1994].

INTRODUCTION

In February 2004, a Palm Springs, California newspaper, The Desert Sun, printed an article titled, "Specialist discounts cancer cluster at school," in which a local tumor registry epidemiologist claimed that there was no cancer cluster or increased cancer incidence at the school [Perrault, 2004]. An Internet search revealed that the teacher population at La Quinta Middle School (LQMS) was too small to generate the 11 teachers with cancer who were reported in the article. The school was opened in 1988 with 20 teachers hired that year. For the first 2 years, the school operated in three temporary buildings, one of which remains. In 1990, a newly constructed school opened. In 2003, the teachers complained to school district management that they believed that they had too many cancers. Repeated requests to the school administration for physical access to the school and for teachers' information were denied. We contacted the teachers, and with their help, the cancers in the group were characterized. One teacher suggested using yearbooks to develop population-at-risk counts for calculating expected cancers. We were anxious to assess the electrical environment at the school, since elevated power frequency magnetic field exposure with a positive correlation between duration of exposure and cancer incidence had been reported in first floor office workers who worked in strong magnetic fields above three basement-mounted 12,000 V transformers [Milham, 1996]. We also wanted to use a new electrical measurement tool, the Graham/Stetzer meter, which measures high frequency voltage transients.

The Graham/Stetzer Microsurge II meter measures the average rate of change of the transients in Graham/Stetzer units (GS units). Anecdotal reports had linked dirty power exposure with a number of illnesses [Havas and Stetzer, 2004]. We decided to investigate whether power frequency magnetic field exposure or dirty power exposure could explain the cancer increase in the school teachers.

METHODS

After the school administration (Desert Sands Unified School District) had refused a number of requests to assist in helping us evaluate the cancers reported by the teachers, we were invited by a teacher to visit the school after hours to make magnetic field and dirty power measurements. During that visit, we noted that, with the exception of one classroom near the electrical service room, the classroom magnetic field levels were uniformly low, but the dirty power levels were very high, giving many overload readings. When we reported this to Dr. Doris Wilson, then the superintendent of schools (retired December, 2007), one of us (SM) was threatened with prosecution for "unlawful.. trespass," and the teacher who had invited us into the school received a letter of reprimand. The teachers then filed a California OSHA complaint which ultimately lead to a thorough measurement of magnetic fields and dirty power levels at the school by the California Department of Health Services which provided the exposure data for this study. They also provided comparison dirty power data from residences and an office building, and expedited tumor registry confirmation of cancer cases.

Classrooms were measured at different times using 3 meters: an FW Bell model 4080 tri-axial Gaussmeter, a Dexsil 310 Gaussmeter, and a Graham-Stetzer (G/S) meter. The Bell meter measures magnetic fields between 25 and 1,000 Hz. The Dexsil meter measures magnetic fields between 30 and 300 Hz. The G/S meter measures the average rate of change of the high frequency voltage transients between 4 and 150 KHz.

All measurements of high frequency voltage transients were made with the G/S meter. This meter was plugged into outlets, and a liquid crystal display was read. All measurements reported were in GS units. The average value was reported where more than one measurement was made in a classroom.

We measured seven classrooms in February 2005 using the Bell meter and the G/S meter. Later in 2005, the teachers measured 37 rooms using the same meters. On June 8, 2006, electrical consultants for the school district and the California Department of Health Services (Dr. Raymond Neutra) repeated the survey using the G/S meter and a Dexsil 320 Gaussmeter, measuring 51 rooms. We used results of this June 8, 2006 sampling in our exposure calculations, since all classrooms were sampled, multiple outlets per room were sampled, and an experienced team did the sampling. Additionally, GS readings were taken at Griffin Elementary school near Olympia, Washington, and Dr. Raymond Neutra provided GS readings for his Richmond California office building and 125 private California residences measured in another Northern California study.

All the cancer case information was developed by personal, telephone, and E-mail contact with the teachers or their families without any assistance from the school district. The local tumor registry verified all the cancer cases with the exception of one case diagnosed out of state and the two cases reported in 2007. The out-of state case was verified by pathologic information provided by the treating hospital. The teachers gathered population-at-risk information (age at hire, year of hire, vital status, date of diagnosis, date of death, and termination year) from yearbooks and from personal contact. The teachers also provided a history of classroom assignments for all teachers from annual classroom assignment rosters (academic years 1990–1991 to 2006–2007) generated by the school administration. The school administration provided a listing of school employees, including the teachers, to the regional tumor registry after the teachers involved the state health agency by submitting an OSHA complaint. The information we obtained anecdotally from the teachers, yearbooks, and classroom assignment rosters was nearly identical to that given to the tumor registry. None of the cancer cases were ascertained initially through the cancer registry search.

Published cancer incidence rates by age, sex, and race for all cancers, as well as for malignant melanoma, thyroid, uterine, breast, colon, ovarian cancers, and non-Hodgkin's lymphoma (NHL) were obtained from a California Cancer Registry publication [Kwong et al., 2001]. We estimated the expected cancer rate for each teacher by applying year, age, sex, and race-specific cancer incidence rates from hire date until June 2007, or until death. We then summed each teacher's expected cancer rate for the total cohort.

Using the California cancer incidence data, the school teacher data, and the GS exposure data, we calculated cancer incidence and risks. A replicate data set was sent to Dr. Gary Marsh and to Mike Cunningham at the University of Pittsburgh School of Public Health for independent analysis using OCMAP software. We calculated cancer risk ratios by duration of employment and by cumulative GS unit-years of exposure. We calculated an attributable risk percent using the frequencies of total observed and expected cancers, and performed trend tests [Breslow and Day, 1987] for cancer risk versus duration of employment and cumulative GS unit-years of exposure. Poisson P values were calculated using the Stat Trek website (Stat Trek, 2007). We also performed a linear regression of cancer risk by duration of employment in years and by time-weighted exposure in GS unit-years.

Since neither author had a current institutional affiliation, institutional review board approval was not possible. The teachers requested the study, and their participation in the study was both voluntary and complete. All the active teachers at the school signed the Cal OSHA request. The authors fully explained the nature of the study to study participants and offered no remuneration to the teachers for participation in the study. The authors maintained strict confidentiality of all medical and personal information provided to us by the teachers, and removed personal identifiers from the data set which was analyzed by the University of Pittsburgh. Possession of personal medical information was limited to the two authors. No patient-specific information was obtained from the tumor registry. With the individual's permission we provided the registry with case information for a teacher with malignant melanoma diagnosed out of state. The exposure information was provided by the California Department of Health Services. The basic findings of the study were presented to the Desert Sands Unified School District School Board and at a public meeting arranged by the teachers.

RESULTS

Electrical Measurements

In our seven-room survey of the school in 2005, magnetic field readings were as high as 177 mG in a classroom adjacent to the electrical service room. A number of outlets had overload readings with the G/S meter. Magnetic fields were not elevated (>3.0 mG) in the interior space of any of the classrooms except in the classroom adjacent to the electrical service room, and near classroom electrical appliances such as overhead transparency projectors. There was no association between the risk of cancer and 60 Hz magnetic field exposures in this cohort, since the classroom magnetic field exposures were the same for teachers with and without cancer (results not shown).

This school had very high GS readings and an association between high frequency voltage transient exposure in the teachers and risk of cancer. The G/S meter gives readings in the range from 0 to 1,999 GS units. The case school had 13 of 51 measured rooms with at least one electrical outlet measuring "overload" (≥2,000 GS units). These readings were high compared to another school near Olympia Washington, a Richmond California office building, and private residences in Northern California (Table I). Altogether, 631 rooms were surveyed for this study. Only 17 (2.69%) of the 631 rooms had an "overload" (maximum, ≥2,000 GS units) reading. Applying this percentage to the 51 rooms surveyed at the case school, we would expect 1.4 rooms at the school to have overload GS readings ($0.0269 \times 51 = 1.37$). However, thirteen rooms (25%) measured at the case school had "overload" measurements above the highest value (1,999 GS units) that the G/S meter can

TABLE I. Graham/Stetzer Meter Readings: Median Values in Schools, Homes and an Office Building

Place	Homes	Office bldg	Olympia WA School	LQMS	Total
No. of rooms surveyed	500	39	41	51	531
Median GS units	159	210	160	750	<270[a]
Rooms with overload GS units (≥2,000)	4	0	0	13*	17

[a]Excludes homes as specific room data was not available.
*$P = 3.14 \times 10^{-9}$.

TABLE II. Risk of Cancer by Type Among Teachers at La Quinta Middle School

Cancer	Observed	Expected	Risk ratio (O/E)	P-value
All cancers	18	6.51	2.78*	0.000098
Malignant melanoma	4	0.41	9.76*	0.0008
Thyroid cancer	2	0.15	13.3*	0.011
Uterus cancer	2	0.22	9.19*	0.019
Female breast cancer	2	1.5	1.34	0.24
All cancers less melanoma	14	6.10	2.30*	0.0025

*$P \leq 0.05$.

measure. This is a highly statistically significant excess over expectation (Poisson $P = 3.14 \times 10^{-9}$).

We noticed AM radio interference in the vicinity of the school. A teacher also reported similar radio interference in his classroom and in the field near his ground floor classroom. In May 2007, he reported that 11 of 15 outlets in his classroom overloaded the G/S meter. An AM radio tuned off station is a sensitive detector of dirty power, giving a loud buzzing noise in the presence of dirty power sources even though the AM band is beyond the bandwidth of the G/S meter.

Cancer Incidence

Three more teachers were diagnosed with cancer in 2005 after the first 11 cancer diagnoses were reported, and another former teacher (diagnosed out-of-state in 2000) was reported by a family member employed in the school system. One cancer was diagnosed in 2006 and two more in 2007. In the years 1988–2005, 137 teachers were employed at the school. The 18 cancers in the 16 teachers were: 4 malignant melanomas, 2 female breast cancers, 2 cancers of the thyroid, 2 uterine cancers and one each of Burkitt's lymphoma (a type of non-Hodgkins lymphoma), polycythemia vera, multiple myeloma, leiomyosarcoma and cancer of the colon, pancreas, ovary and larynx. Two teachers had two primary cancers each: malignant melanoma and multiple myeloma, and colon and pancreatic cancer. Four teachers had died of cancer through August 2007. There have been no non-cancer deaths to date.

The teachers' cohort accumulated 1,576 teacher-years of risk between September 1988 and June 2007 based on a 12-month academic year. Average age at hire was 36 years. In 2007, the average age of the cohort was 47.5 years.

When we applied total cancer and specific cancer incidence rates by year, age, sex, race, and adjusted for cohort ageing, we found an estimate of 6.5 expected cancers, 0.41 melanomas, 0.15 thyroid cancers, 0.22 uterine cancers, and 1.5 female breast cancers (Table II). For all cancers, the risk ratio (Observed/Expected = 18/6.5) was 2.78 ($P = 0.000098$, Poisson test); for melanoma, (O/E = 4/0.41) was 9.8 ($P = 0.0008$, Poisson test); for thyroid cancer (O/E = 2/0.15) was 13.3 ($P = 0.0011$, Poisson test); for uterine cancer (O/E = 2/0.22), was 9.19 ($P = 0.019$, Poisson test).

Table III shows the cancer risk among the teachers by duration of employment. Half the teachers worked at the school for less than 3 years (average 1.52 years). The cancer risk increases with duration of employment, as is expected when there is exposure to an occupational carcinogen. The cancer risk ratio rose from 1.7 for less than 3 years, to 2.9 for 3–14 years, to 4.2 for 15+ years of employment. There was a positive trend of increasing cancer incidence with increasing duration of employment ($P = 4.6 \times 10^{-10}$). A single year of employment at this school increases a teacher's risk of cancer by 21%.

Using the June 8, 2006 survey data (Table IV), the cancer risk of a teacher having ever worked in a room with at least one outlet with an overload GS reading (≥2000 GS units) and employed for 10 years or more, was 7.1 ($P = 0.00007$, Poisson test). In this group, there were six teachers diagnosed

TABLE III. Cancer Risk by Duration of Employment

Time at school	Average time	Teachers	% of teachers	Cancer observed	Cancer expected	Risk ratio (O/E)	Poisson p
<3 years	1.52 years	68	49.6	4	2.34	1.72	0.12
3–14 years	7.48 years	56	40.9	9	3.14	2.87*	0.0037
15+ years	16.77 years	12	8.8	5	1.02	4.89*	0.0034
Total		137	100	18	6.51	2.78*	0.000098

Positive trend test (Chi square with one degree of freedom = 38.8, $P = 4.61 \times 10^{-10}$).
*$P \leq 0.05$.

TABLE IV. Cancer in Teachers Who Ever Taught in Classrooms With at Least One Overload GS Reading (≥2000 GS Units) by Duration of Employment

Ever in a room >2,000 GS units	Employed 10+ years	Total teachers	Cancers observed	Cancers expected	Risk ratio (O/E)	Poisson p
Yes	Yes	10	7[a]	0.988	7.1*	0.00007
Yes	No	30	3[a]	0.939	3.2	0.054
Total		40	10	1.93	5.1*	0.00003
No	Yes	19	2	1.28	1.6	0.23
No	No	78	6	3.25	1.8	0.063
Total		97	8	4.56	1.8*	0.047
Grand total		137	18	6.49	2.8*	0.000098

[a]One teacher had two primary cancers.
*$P < 0.05$.

with a total of seven cancers, and four teachers without a cancer diagnosis, who were employed for 10 or more years and who ever worked in one of these rooms. Five teachers had one primary cancer and one teacher had two primary cancers. *These teachers made up 7.3% of the teachers' population (10/*137) but had 7 cancers or 39% (7/18) of the total cancers. The 10 teachers who worked in an overload classroom for 10 years or more had 7 cancers when 0.99 would have been expected ($P = 6.8 \times 10^{-5}$ Poisson test). The risk ratio for the 8 teachers with cancer and 32 teachers without cancer, who ever worked in a room with an overload GS reading, regardless of the time at the school, was 5.1 ($P = 0.00003$, Poisson test). The risk ratio for 8 teachers with cancer and 89 teachers without cancer who never worked in a room with an overload G-S reading was 1.8 ($P = 0.047$, Poisson test). Teachers who never worked in an overload classroom also had a statistically significantly increased risk of cancer.

A positive dose-response was seen between the risk of cancer and the cumulative GS exposure (Table V). Three categories of cumulative GS unit-years of exposure were selected: <5,000, 5,000 to 10,000, and more than 10,000 cumulative GS unit-years. We found elevated risk ratios of 2.0, 5.0, and 4.2, respectively, all statistically significant, for each category. There was a positive trend of increasing cancer incidence with increasing cumulative GS unit-years of exposure ($P = 7.1 \times 10^{-10}$). An exposure of 1,000 GS unit-years increased a teacher's cancer risk by 13%. Working in a room with a GS overload (≥2,000 GS units) for 1 year *increased cancer risk by 26%.*

An attributable risk percentage was calculated: (observed cancers-expected cancers)/observed cancers = (18−6.51)/18 = 63.8%.

The fact that these cancer incidence findings were generated by a single day of G/S meter readings made on June 8, 2006 suggests that the readings were fairly constant over time since the school was built in 1990. For example, if the 13 classrooms which overloaded the meter on June 8, 2006 were not the same since the start of the study and constant throughout, the cancer risk of teachers who ever worked in the overload rooms would have been the same as the teachers who never worked in an overload room.

Although teachers with melanoma and cancers of the thyroid, and uterus, had very high, statistically significant risk ratios, there was nothing exceptional about their age at hire, duration of employment, or cumulative GS exposure. However, thyroid cancer and melanoma had relatively short latency times compared to the average latency time for all 18 cancers. The average latency time between start of

TABLE V. Observed and Expected Cancers by Cumulative GS Exposure (GS Unit-Years)

Exposure group	<5,000 GS unit-years	5,000 to 10,000	>10,000 GS unit-years	Total
Average GS unit-years	914	7,007	15,483	
Cancers obs.	9	4	5	18
Cancers exp.	4.507	0.799	1.20	6.49
Risk ratio (O/E)	2.01*	5.00*	4.17*	2.78*
Poisson p	0.0229	0.0076	0.0062	0.000098

Positive trend test (Chi square with one degree of freedom = 38.0, $P = 7.1 \times 10^{-10}$).
*$P < 0.05$.

employment at the school and diagnosis for all cancers was 9.7 years. The average latency time for thyroid cancer was 3.0 years and for melanoma it was 7.3 years (with three of the four cases diagnosed at 2, 5, and 5 years).

An independent analysis of this data set by the University of Pittsburgh School of Public Health using OCMAP software supported our findings.

DISCUSSION

Because of access denial, we have no information about the source, or characterization of the high frequency voltage transients. We can assume, because the school uses metal conduit to contain the electrical wiring, that any resultant radiated electric fields from these high frequency voltage transients would radiate mainly from the power cords and from electrical equipment using the power cords within a classroom.

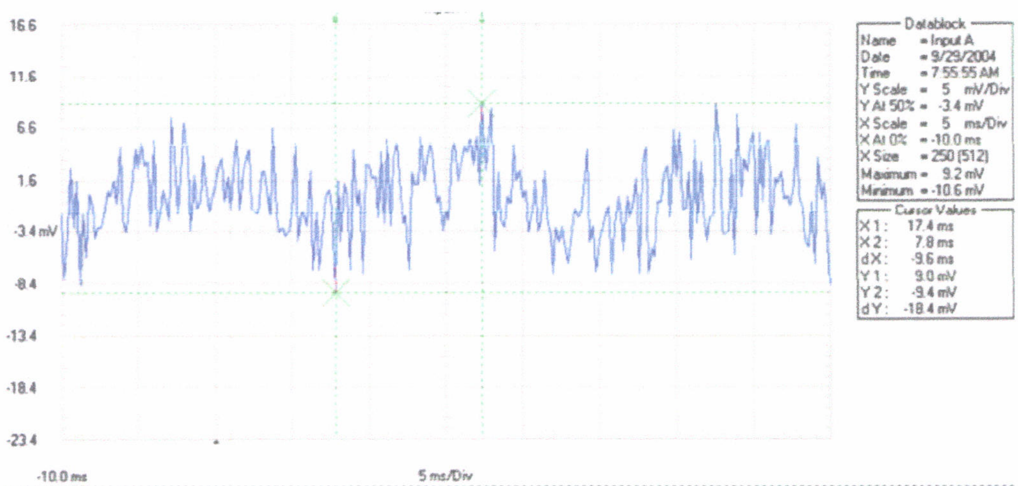
The school's GS readings of high frequency voltage transients are much higher than in other tested places (Table I). Also, teachers in the case school who were employed for over 10 years and who had ever worked in a room with an overload GS reading had a much higher rate of cancer. They made up 7.3% of the cohort but experienced 39% of all cancers.

The relatively short latency time of melanoma and thyroid cancers suggests that these cancers may be more sensitive to the effects of high frequency voltage transients than the other cancers seen in this population.

In occupational cohort studies, it is very unusual to have a number of different cancers with an increased risk. An exception to this is that cohorts exposed to ionizing radiation show an increased incidence of a number of different cancers. The three cancers in this cohort with significantly elevated incidence, malignant melanoma, thyroid cancer and uterine cancer, also have significantly elevated incidence in the large California school employees cohort [Reynolds et al., 1999].

These cancer risk estimates are probably low because 23 of the 137 members of the cohort remain untraced. Since exposure was calculated based on 7 days a week for a year, this will overstate the actual teachers' exposure of 5 days a week for 9 months a year.

We could not study field exposures in the classrooms since we were denied access to the school. We postulate that the dirty power in the classroom wiring exerted its effect by capacitive coupling which induced electrical currents in the



The waveform was recorded between 2 EKG patches placed on the ankles of XXXXXX XXXXXXXXX standing in front of his kitchen sink at his home near Bright Ontario. It shows a distorted 60 cycle sine wave containing high frequencies applied to each foot, allowing high frequency current to freely oscillate up one leg and down the other. XXXXXX has been diagnosed with prostrate cancer since moving to the house in less than a year. He was standing with feet shoulder width apart, wearing shoes, at the time of the readings. The amplitude increased as the feet were placed farther apart.

FIGURE 2. Oscilliscope display of 60 Hz current distorted with high frequencies taken between EKG patches applied to the ankles of a man standing with shoes on at a kitchen sink. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

teachers' bodies. The energy that is capacitively coupled to the teachers' bodies is proportional to the frequency. It is this characteristic that highlights the usefulness of the G/S meter. High frequency dirty power travels along the electrical distribution system in and between buildings and through the ground. Humans and conducting objects in contact with the ground become part of the circuit. Figure 2 [Havas and Stetzer, 2004, reproduced with permission] shows an oscilloscope tracing taken between EKG patches on the ankles of a man wearing shoes, standing at a kitchen sink. The 60 Hz sine wave is distorted by high frequencies, which allows high frequency currents to oscillate up one leg and down the other between the EKG patches.

Although not demonstrated in this data set, dirty power levels are usually higher in environments with high levels of 60 Hz magnetic fields. Many of the electronic devices which generate magnetic fields also inject dirty power into the utility wiring. Magnetic fields may, therefore, be a surrogate for dirty power exposures. In future studies of the EMF-cancer association, dirty power levels should be studied along with magnetic fields.

The question of cancer incidence in students who attended La Quinta Middle School for 3 years has not been addressed.

CONCLUSION

The cancer incidence in the teachers at this school is unusually high and is strongly associated with exposure to high frequency voltage transients. In the 28 years since electromagnetic fields (EMFs) were first associated with cancer, a number of exposure metrics have been suggested. If our findings are substantiated, high frequency voltage transients are a new and important exposure metric and a possible universal human carcinogen similar to ionizing radiation.

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Dirty Electricity Elevates Blood Sugar Among Electrically Sensitive Diabetics and May Explain Brittle Diabetes

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Transient electromagnetic fields (dirty electricity), in the kilohertz range on electrical wiring, may be contributing to elevated blood sugar levels among diabetics and pre-diabetics. By closely following plasma glucose levels in four Type 1 and Type 2 diabetics, we find that they responded directly to the amount of dirty electricity in their environment. In an electromagnetically clean environment, Type 1 diabetics require less insulin and Type 2 diabetics have lower levels of plasma glucose. Dirty electricity, generated by electronic equipment and wireless devices, is ubiquitous in the environment. Exercise on a treadmill, which produces dirty electricity, increases plasma glucose. These findings may explain why brittle diabetics have difficulty regulating blood sugar. Based on estimates of people who suffer from symptoms of electrical hypersensitivity (3–35%), as many as 5–60 million diabetics worldwide may be affected. Exposure to electromagnetic pollution in its various forms may account for higher plasma glucose levels and may contribute to the misdiagnosis of diabetes. Reducing exposure to electromagnetic pollution by avoidance or with specially designed GS filters may enable some diabetics to better regulate their blood sugar with less medication and borderline or pre-diabetics to remain non diabetic longer.

Keywords Radio frequency; Transients; Dirty electricity; Power quality; Plasma glucose; Blood sugar; Insulin; GS filters; Electrohypersensitivity; Brittle diabetes; Type 3 diabetes; Type 2 diabetes; Type 1 diabetes.

Introduction

Diabetes mellitus is increasing globally. According to the World Health Organization, in 1985 the global population of diabetics was 30 million (0.6% of the world population). This increased to 171 million (2.8% of the global population) by 2000, and it is expected to more than double to 366 million (4.5% of the global population) by 2030 (Wild et al., 2004; U.S. Census Bureau, 2005). Doctors attribute this rise in diabetes to poor diet and limited exercise, resulting in obesity, and seldom look for causes other than lifestyle and genetics.

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This article presents a paradigm shift in the way we think about diabetes. In addition to Type 1 diabetics, who produce insufficient insulin, and Type 2 diabetics, who are unable to effectively use the insulin they produce, a third type of diabetes may be environmentally exacerbated or induced by exposure to electromagnetic frequencies.

Our increasing reliance on electronic devices and wireless technology is contributing to an unprecedented increase in our exposure to a broad range of electromagnetic frequencies, in urban and rural environments and in both developed and developing countries. This energy is generated within the home by computers, plasma televisions, energy efficient lighting and appliances, dimmer switches, cordless phones, and wireless routers, and it can enter the home and work environment from nearby cell phone and broadcast antennas as well as through ground current.

Although the position of most international health authorities, including the World Health Organization, is that this form of energy is benign as long as levels remain below guidelines, an increasing number of scientific studies report biological and health effects associated with electromagnetic pollution well below these guidelines (Sage and Carpenter, 2007). Epidemiological studies have documented increased risks for childhood leukemia associated with residential magnetic fields exposure (Ahlbom et al., 2000), greater risk for various cancers with occupational exposure to low-frequency electric and magnetic fields (Havas, 2000), miscarriages (Li et al., 2002), Lou Gehrig's disease (Neutra et al., 2002), brain tumors associated with cell phone use (Kundi et al., 2004), as well as cancers and symptoms of electrical hypersensitivity (EHS) for people living near cell phone and broadcast antennas (Altpeter et al., 1995; Michelozzi et al., 2002). Laboratory studies report increased proliferation of human breast cancer cells (Liburdy et al., 1993), single- and double-strand DNA breaks (Lai and Singh, 2005), increased permeability of the blood brain barrier (Royal Society of Canada, 1999), changes in calcium flux (Blackman et al., 1985), and changes in ornithine decarboxylase activity (Salford et al., 1994).

In this article, changes in plasma glucose, in response to electromagnetic pollution, for numerous measurements on four subjects—two with Type 1 diabetes taking insulin and two non medicated with Type 2 diabetes—are described. They include men and women, ranging in age from 12–80, as well as individuals recently diagnosed and those living with the disease for decades.

Case 1: 51-Year Old Male with Type 2 Diabetes

A 51-year old male with Type 2 diabetes, taking no medication, monitored his plasma glucose levels from April 24 to May 30, 2003. He also monitored the dirty electricity in his home using a Protek 506 Digital Multimeter connected to a ubiquitous filter (Graham, 2000) to remove the 60-Hz signal and its harmonics. Measurements were taken in the morning and randomly throughout the day. Low or no readings of dirty electricity were taken in an electromagnetic clean environment far from power lines and cell phone antennas (Fig. 1 upper graph). Three years later, the microsurge meter became available and Case 1 monitored his blood sugar levels once more (Fig. 1 lower graph). This meter provides a digital readout of the absolute changing voltage as a function of time ($|dv/dt|$, expressed as GS units) for the frequency range 4–100 kHz and with an accuracy of $\pm$ 5% (Graham, 2003).

Figure 1 shows a positive correlation between dirty electricity and plasma glucose levels taken randomly during the day (upper graph) and first thing in the morning (lower graph). His elevated plasma glucose is unrelated to eating. Working

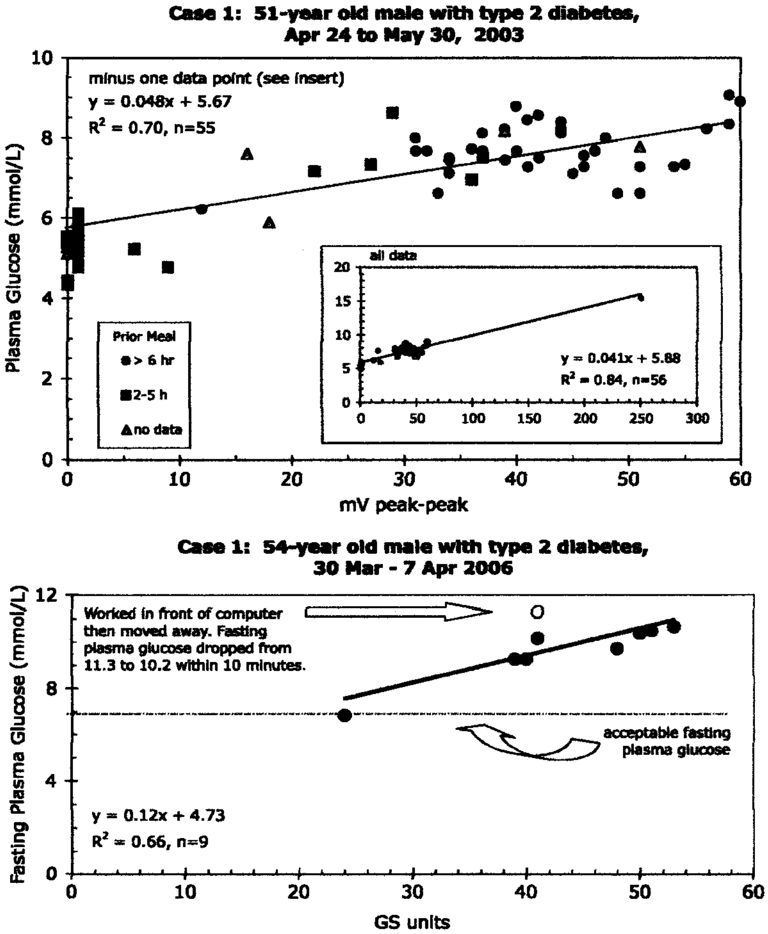

Figure 1. Case 1: *Upper chart*: Plasma glucose levels of a 51-year old male with Type 2 diabetes exposed to different levels of power quality. Insert shows the entire data set with one very high plasma glucose reading that was recorded during a period of high exposure to dirty electricity. *Lower chart*: Three years later, fasting plasma glucose levels correspond to power quality measured in GS units. Time spent in front of computer resulted in higher plasma glucose levels that dropped 1.1 mmol/L [19.8 mg/dL] 10 min after moving away from computer. Note that we have scaled both plots the say way in Fig. 1.

on a computer increases blood sugar, but these values decrease as much as 0.11 mmol/L* [2 mg/dL] per minute after moving away from the computer. Blood viscosity decreased as his plasma glucose levels dropped.

Case 1 also documented rapid changes in blood sugar as he moved from a medical clinic (environment with dirty electricity), to his parked vehicle (no dirty electricity), and back to the medical clinic. His blood sugar levels changed significantly within 20 min. His endocrinologist classified him as *pre-diabetic* when his blood sugar was tested immediately upon entering the medical clinic and as a *Type 2 diabetic* after a 20-min wait in the medical clinic. Measurement of blood sugar needs

*Multiply by 18 to convert to mg/dL.

to be done in an electromagnetically clean environment to prevent misdiagnosis and to accurately determine the severity of the disease.

Case 2: 57-Year Old Female with Type 2 Diabetes

A 57-year old female with Type 2 diabetes takes no medication and controls her plasma glucose with exercise and a hypoglycemic diet. When she exercised by walking for 20–30 min at a mall after hours, her blood sugar levels dropped from a mean of 11.8 to 7.2 mmol/L [212 to 130 mg/dL] ($p = 0.045$). When she walked on a treadmill, her blood sugar levels increased from 10 to 11.7 mmol/L [180 to 211 mg/dL] ($p = 0.058$) (Fig. 2). Treadmills have variable speed motors and produce dirty electricity.

Doctors recommend exercise for patients with diabetes. However, if that exercise is done in an electromagnetically dirty environment, and if the patient is sensitive to this form of energy, it may increase stress on the body and elevate levels of plasma glucose, as in Case 2.

This subject also measured her plasma glucose as she moved from an environment with dirty electricity to one that was clean, and back again. Her blood sugar in the dirty environment was 12.5 mmol/L [225 mg/dL] and within 20 min in the clean environment dropped to 10.6 mmol/L [191 mg/dL]. Within 5 min after returning to the dirty environment, her blood sugar rose to 10.8 mmol/L [194 mg/dL] and 15 min later to 12.6 mmol/L [227 mg/dL]. She did not eat or exercise during this period. Her elevated plasma glucose levels were associated with headaches, nausea, and joint pain in her home, where she was exposed to both dirty electricity and radio frequency radiation from nearby cell phone antennas. These exposures and symptoms were absent in the clean environment.

Case 3: 80-Year Old Female with Type 1 Diabetes

An 80-year old female with Type 1 diabetes, who takes insulin (Humlin® 70/30) twice daily, documented her blood sugar levels before breakfast and before dinner

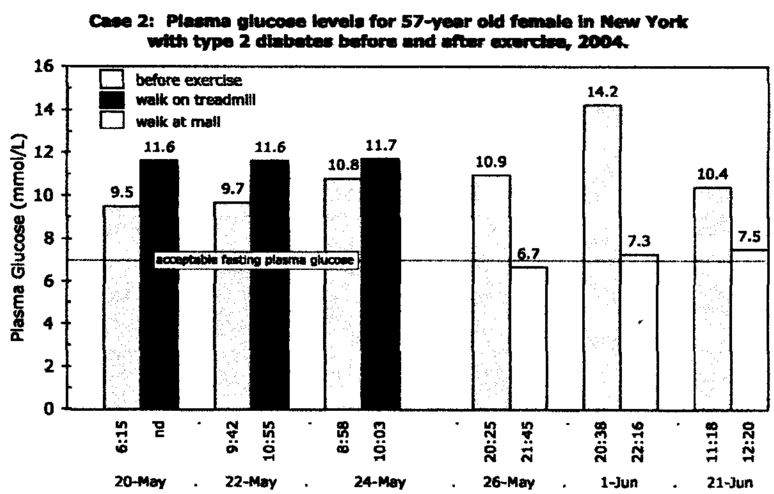

Figure 2. Case 2: Plasma glucose levels for a 57-year old female in New York with Type 2 diabetes, before and after walking for 20–30 min on a treadmill in her home and after hours at a mall.

for one week. On June 12, 2004, the dirty electricity in her home was reduced from an average of 1,550 GS units (range: 600 to >2,000) to 13 GS units (range 11 to 22) with Graham/Stetzer filters (GS filters). These filters provide a short to high frequency, and, thus, reduce transients on electrical wiring with an optimal filtering capacity between 4 and 100 kHz (Graham, 2000, 2002, 2003). They are similar to capacitors installed by industry to protect sensitive electronic equipment from power surges and to adjust the power factor. GS units measure the energy associated with dirty electricity (amplitude and frequency) and are a function of changing voltage with time (dv/dt). Dirty electricity can be measured using an oscilloscope or multimeter set for peak-to-peak voltage or a Microsurge meter that provides a digital readout (GS units) and is easily used by non professionals.

Case 3 had mean fasting plasma glucose of 9.5 mmol/L [171 mg/dL] without the GS filters and 6.6 mmol/L [119 mg/dL] with the GS filters ($p = 0.02$) (Table 1). Her evening blood sugar did not change appreciable during this period, although it did differ on days she was away from home. She was able to more than halve her insulin intake ($p = 0.03$) once the GS filters reduced the dirty electricity in her home (Table 1).

Table 1

Case 3: Plasma glucose levels and daily insulin injections (Humulin® 70/30) for an 80-year old woman with Type 1 diabetes before and while GS filters were installed in her home in Arizona

	Plasma Glucose (mg/dL)		
Date 2004	Morning (7 am)	Evening (5 pm)	Daily Insulin (units)
Without GS Filters: Dirty Electricity 1,550 GS units			
June 5	158	239●	56
June 6	158	167	56
June 7	160	113●	56
June 8	180	104	0
June 9	180	144	56
June 10	151	76	56
June 11	116	229	28
Mean (sd)	171 (20)	153 (63)	44 (22)
With GS Filters: Dirty Electricity 13 GS units (installed June 12)			
June 13	86	194	0
June 14	140	94	25
June 15	115	178	0
June 16	112	135	15
June 17	131	175	20
June 18	167	250●	50
June 19	70	169	22
June 20	133	126	22
Mean (sd)	119 (31)	166 (49)	19 (16)
2-tailed t-test	$p = 0.002$**	$p = 0.69$	$p = 0.03$*

●Subject was away from home during the day.

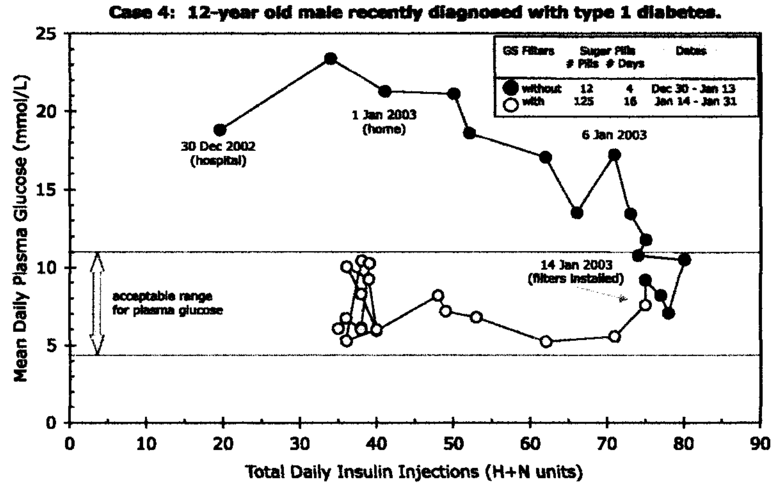

Figure 3. Case 4: Sequence of mean daily plasma glucose levels and total daily insulin injections for 12-year old male with Type 1 diabetes who was admitted to hospital in December 2002 and returned home on January 1, 2003. On January 14, 2003, GS filters were installed in his home to improve power quality.

Case 4: 12-Year Old Male with Type 1 Diabetes

A mother and her 5 children, who were all home schooled, began to develop intermittent, excruciating headaches during the fall of 2002 in rural Wisconsin, shortly after they had a new septic system installed. The headaches continued and a power quality expert measured high levels of dirty electricity and ground current, possibly attributable to the septic system installation.

In December 2002, one child, a 12-year old male, was hospitalized and diagnosed with Type 1 diabetes. His younger sister had been living with diabetes since the age of 3 months and was one of the youngest children diagnosed with diabetes in the United States.

On January 14, 2003, the family installed GS filters to help alleviate their symptoms of electrical hypersensitivity. The headaches disappeared and the family's health began to improve. Shortly after the GS filters were installed, the mother had great difficulty controlling her son's blood sugar. She couldn't reduce the amount of insulin fast enough to keep it within an acceptable range and needed to give him sugar pills to prevent hypoglycemia (Fig. 3). He was taking a combination of Humalog® (H-insulin, a short-acting insulin) and Humulin® NRT (N-insulin, a long-lasting insulin).[1] During this period, her daughter's blood sugar levels began to drop as well.

Doctors attribute the short-term improvement in blood sugar to the "honeymoon period", which is observed among some diabetics shortly after diagnosis and lasts from weeks to months and occasionally for years (Bernstein, 2003). The honeymoon period cannot explain the response of the subject's sister, who had been living with Type 1 diabetes for years, and who also had lower plasma glucose levels

[1]Both the short-acting Humalog® (H-insulin) and the long-lasting Humulin® NPH (N-insulin) are produced by Eli Lilly.

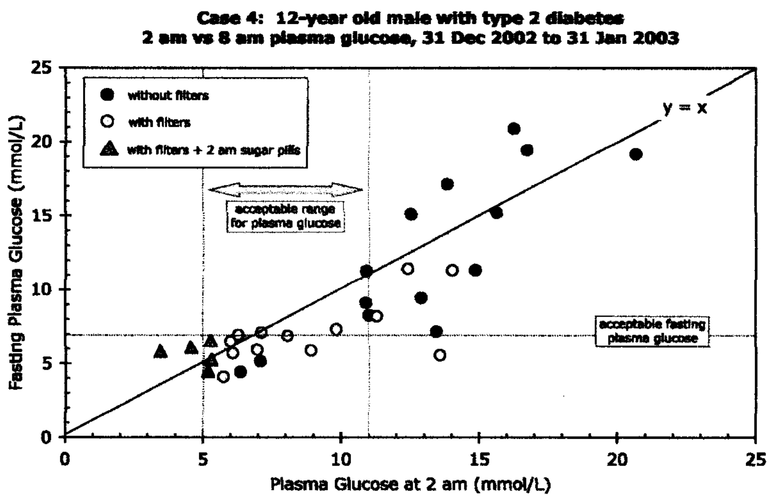

Figure 4. Case 4: Fasting (8 am) and 2 am plasma glucose levels for 12-year old male with Type 1 diabetes with and without GS filters. NOTE: Sugar pills were administered at 2 am for 5 d to prevent hypoglycemia while filters were installed.

and difficulty regulating her insulin within an acceptable range after the GS filters were installed and the dirty electricity was reduced.

Case 4 had higher levels of plasma glucose at 8 am (fasting) than at 2 am on some days before the GS filters were installed. This was not observed with the filters, except when sugar pills were taken at 2 am to deliberately increase blood sugar (Fig. 4). In Wisconsin, dirty electricity often increases in the middle of the night, beginning at 2–3 am and lasting from minutes to hours, as the electric utility makes changes in its system.

Discussion

These results show that plasma glucose levels, in the Type 1 and Type 2 diabetic cases reported, respond to electromagnetic pollution in the form of radio frequencies in the kHz range associated with indoor wiring (dirty electricity). Type 1 diabetics require less insulin in an electromagnetically clean environment and blood sugar levels for Type 2 diabetics increase with increasing exposure to dirty electricity.

In May 2006, a long-term health care facility in Ontario, Canada installed GS filters to reduce dirty electricity. Of the five diabetic residents, for whom data were available, two (aged 87 and 88) were insulin-dependent Type 1 diabetics. Both had significantly lower fasting plasma glucose levels ($p < 0.01$) after the GS filters were installed. Their insulin intake did not change during this period and nursing staff had to give them orange juice on several occasions to prevent hypoglycemia. The levels of plasma glucose of the remaining three, who were Type 2 diabetics, did not change during this period.

The GS filters, used in this study have been tested at the Yoyogi Natural Clinic in Japan (Sogabe, 2006). Three people participated in the study. Three hours after eating, their blood sugar was 6.3, 7.7, 17.9 mmol/L [113, 139, and 322 mg/dL] in an environment with more than 2,000 GS units of dirty electricity. GS filters reduced the dirty electricity to 30–35 GS units and, within 30 min, their plasma became less viscous and their blood sugar dropped to 5.6, 6.1, 16.1 mmol/L [101, 110, 290 mg/dL], respectively.

The person with the highest plasma glucose levels was a 28-year old male with Type 2 diabetes and fasting plasma glucose levels of 16.7 mmol/L [300 mg/dL]. Despite taking 250 mg of Glycoran®, 3 times a day, and 12 mg of Amaryl®, spread throughout the day, he still had difficultly regulating his blood sugar. Three days after installing 4 GS filters in his home, his blood sugar dropped to 6.9 mmol/L [124 mg/dL] and he was feeling well. He had been unable to achieve such low values with medication alone.

In this study, we classify diabetics whose blood sugar responds to electromagnetic pollution as Type 3 diabetics. In contrast to true Type 1 diabetics who produce insufficient insulin and true Type 2 diabetics who are unable to effectively use the insulin they produce, Type 3 diabetics are responding to environmental triggers that affect blood sugar readings and blood viscosity. These individuals may be better able to regulate plasma glucose by controlling their exposure to frequencies in the low RF range, and thus differ from true Type 1 and Type 2 diabetics whose blood sugar is not affected by this type of electromagnetic exposure.

The increase in blood viscosity with increasing exposure to dirty electricity is a critical observation. If this turns out to be the case among electrosensitive individuals, it may explain the symptoms of headaches, chest pain, higher blood pressure, blurred vision, and fatigue.

The percentage of diabetics who are likely to be affected by electromagnetic energy is unknown, but if the values are similar to those suffering from symptoms of electromagnetic hypersensitivity (EHS), 3–35% of the population (Philips and Philips, 2006), then globally between 5 and 60 million existing diabetics may have Type 3 diabetes as described in this study.

There is a growing body of *in vivo*, *in vitro*, and epidemiological evidence, which suggests a relationship between plasma glucose levels, insulin secretion, and exposure to electromagnetic energy at frequencies both lower and higher than the ones we tested in this study.

Altpeter et al. (1995) reported that for people living within a 2 km radius of a short-wave transmitter, in Schwarzenburg, Switzerland, the odds ratio (OR) for diabetes was 1.93 when compared with a population further away. There was a significant linear correlation ($R^2 = 0.99$) between daily median RF exposure and incidence of diabetes. The highest RF readings, recorded in the nearest zone (51 mA/m), were well below the International Radiation Protection Agency's 1988 guidelines of 73 mA/m. Those living near the transmitter also had difficulty falling and staying asleep, were restless, experienced weakness and fatigue, and had both limb and joint pain with statistically significant odds ratios between 2.5 and 3.5. These symptoms are typical of radio wave sickness or electrical hypersensitivity (Firstenberg, 2001). Failure of the transmitter for a 3-d period was associated with improved sleep and, hence, these reactions are biological not psychological.

Beale et al. (2001) reported that the prevalence of chronic illness, asthma, and Type 2 diabetes was linearly related to 50-Hz magnetic field exposure for adults living near transmission lines. For Type 2 diabetes, the crude OR was 8.3 (95% CI 1 to 177), but the OR adjusted for possible confounders (age and ethnicity) was reduced to 6.5 and was not statistically significant ($p > 0.05$). Epidemiological studies of power lines tend to focus on cancers, rather than diabetes, and, hence, limited information of this type is available.

Litovitz et al. (1994) exposed diabetic subjects to 60-Hz magnetic fields between 0.2–1 μT (2–10 mG) and noticed that blood glucose levels increased above 0.6 μT. No statistical tests were reported and no attempt was made to measure frequencies other than 60 Hz. Magnetic flux densities above 0.6 μT are realistic near transmission lines and overlap with the range documented in the Beale study (2001).

Jolley et al. (1982) exposed islets of Langerhans from rabbits to low-frequency pulsed magnetic fields and noted a reduction in insulin release during glucose stimulation compared with controls ($p < 0.002$). Similarly, Navakatikyan et al. (1994) exposed rats to 50-Hz magnetic fields for 23 h per day for 11 days at 10, 50, and 250 μT. Serum insulin levels decreased at the middle- and high-flux densities, which the authors associated with stress.

Sakurai et al. (2004) measured insulin secretion from an islet derived insulinoma cell line, RIN-m, exposed to low-frequency magnetic fields of 5 mT compared with sham exposure of less than 0.5 μT. Insulin secretion was reduced by approximately 30% when exposed to low-frequency magnetic fields compared to sham exposure. The authors conclude: "it might be desirable for diabetic patients who have insufficient insulin secretion from pancreatic islets to avoid exposure to ELFMF". The magnetic flux density was exceptionally high in this experiment and is unlikely to be encountered in normal daily life. Studies of the incipient level of electromagnetic exposure, at which insulin secretion is reduced, would be useful.

Li et al. (2005) exposed hepatocytes *in vitro* to 50 Hz pulsed electric fields (0.7 V/m) and noted a conformation change in the insulin molecule and an 87% reduction in the binding capacity of insulin to its receptors compared with controls.

Stress often increases plasma glucose levels in diabetics (Hinkle and Wolf, 1950; Jolley et al., 1982). Studies with laboratory animals and *in vitro* studies with human cells show both low-frequency electromagnetic fields and non thermal RF radiation stimulates production of stress proteins, and that the biochemical reactions are the same over a range of frequencies and intensities (Blank and Goodman, 2004). Release of insulin is strongly inhibited by the stress hormone norepinephrine, which leads to increased blood glucose levels during stress. Rajendra et al. (2004) found elevated levels of norepinephrine in the brain of fertilized chick eggs on day 15 following exposure to 5, 50, and 100 μT. The "stress response" to electromagnetic energy may provide, yet, another mechanism that could explain Type 3 diabetes.

Reduced insulin secretion and reduced binding capacity of insulin to its receptors may explain the elevated levels of plasma glucose in Type 3 diabetics exposed to electromagnetic fields. More research on mechanisms is needed.

Conclusions

In addition to lifestyle and genetics, the environment appears to be another factor contributing to high levels of blood sugar. This concept presents a possible paradigm shift in the way we think about diabetes and the consequences may be far reaching. As a result, we have labeled environmental diabetes as Type 3 diabetes.

We recognize that there is, as yet, no accepted definition of Type 3 diabetes and that our definition may be in conflict with others that have been suggested including a combination of Type 1 and Type 2, gestational diabetes, and that Alzheimer's Disease is a form of diabetes (Steen et al., 2005; de la Monte et al., 2006).

What we describe here is a totally different type in the sense it has an environmental trigger. Doctors have long suspected an environmental component but it has not been until now that one has been found.

The increasing exposure and ubiquitous nature of electromagnetic pollution may be contributing to the increasing incidence of this disease and the escalating cost of medical care. Diagnosis of diabetes needs to be done in an electromagnetically clean environment to prevent misdiagnosis, and to properly assess the severity of this disorder. Most medical centers have electronic equipment and use fluorescent lights that produce dirty electricity, which is likely to cause abnormally high blood sugar readings for those with a combination of diabetes and electrohypersensitivity (Type 3 diabetes). Dirty electricity may also explain why brittle diabetics have difficulty controlling their blood sugar levels.

Type 3 diabetes, as described in this study, is an emerging disease. Unlike true Type 1 and Type 2 diabetics whose blood sugar is not affected by dirty electricity, Type 3 diabetics may be better able to regulate their blood sugar with less medication, and those diagnosed as borderline or pre-diabetic may remain non diabetic longer by reducing their exposure to electromagnetic energy. The GS filters and the microsurge meter provide the tools needed for scientific investigation of dirty electricity and may help diabetics regulate their blood sugar by improving power quality in their home, school, and work environment. Minimizing exposure to radio frequencies (kHz to GHz), flowing along the ground or through the air, also needs to be addressed. Large-scale studies are needed in controlled settings to determine the percentage of the population with Type 3 diabetes.

These results are dramatic and warrant further investigation. If they are representative of what is happening worldwide, then electromagnetic pollution is adversely affecting the lives of millions of people.

Conflict of Interest

Please note that the author has no vested interest, financial or otherwise, in the commercial devices mentioned in this article.

Acknowledgments

The author thanks the people who participated in this study; Dave Stetzer and Martin Graham for information about power quality; and reviewers for their critical comments and suggestions.

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Electromagnetic Hypersensitivity: Biological Effects of Dirty Electricity with Emphasis on Diabetes and Multiple Sclerosis

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Dirty electricity is a ubiquitous pollutant. It flows along wires and radiates from them and involves both extremely low frequency electromagnetic fields and radio frequency radiation. Until recently, dirty electricity has been largely ignored by the scientific community. Recent inventions of metering and filter equipment provide scientists with the tools to measure and reduce dirty electricity on electrical wires. Several case studies and anecdotal reports are presented. Graham/Stetzer (GS) filters have been installed in schools with sick building syndrome and both staff and students reported improved health and more energy. The number of students needing inhalers for asthma was reduced in one school and student behavior associated with ADD/ADHD improved in another school. Blood sugar levels for some diabetics respond to the amount of dirty electricity in their environment. Type 1 diabetics require less insulin and Type 2 diabetics have lower blood sugar levels in an electromagnetically clean environment. Individuals diagnosed with multiple sclerosis have better balance and fewer tremors. Those requiring a cane walked unassisted within a few days to weeks after GS filters were installed in their home. Several disorders, including asthma, ADD/ADHD, diabetes, multiple sclerosis, chronic fatigue, fibromyalgia, are increasing at an alarming rate, as is electromagnetic pollution in the form of dirty electricity, ground current, and radio frequency radiation from wireless devices. The connection between electromagnetic pollution and these disorders needs to be investigated and the percentage of people sensitive to this form of energy needs to be determined.

Keywords Diabetes; Dirty electricity; Electromagnetic hypersensitivity; Multiple sclerosis; Power quality; Radio frequency.

Introduction

Most of the research on the biological effects of nonionizing radiation is done at one of two frequency ranges: extremely low frequency (ELF) associated with electricity (50/60 Hz) and radio frequency (RF) associated with wireless telecommunication

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devices (800 MHz to 2.5 GHz range). An intermediate frequency range, at the low end of the RF spectrum (kHz), flows along and radiates from wires (dirty electricity) and thus has characteristics of the two major types of electromagnetic pollution mentioned above. Scientists doing research on the biological effects of power line frequencies seldom measure this frequency range and thus ignore the effects it might have on health.

Recent advances in filtering technology (Graham/Stetzer or GS filters) and measuring equipment (microsurge meter) enable scientists to test for dirty electricity and to reduce it on indoor wires. In this article, case studies are presented of individuals who have benefited after the dirty electricity in their environment was reduced. This technology provides scientists with the tools to monitor, reduce, and experiment with a frequency range that, until now, has been largely ignored and it may help those who suffer from symptoms of electromagnetic hypersensitivity (EHS).

Dirty Electricity

Poor power quality, also known as dirty electricity, has been a concern for the electric utility for decades. Dirty electricity refers to electromagnetic energy that flows along a conductor and deviates from a pure 60-Hz sine wave (Figure 1). It has both harmonic and non harmonic (transient) components and emerged as a problem in the late 1970s with the increasing use of electronic devices that produce nonlinear loads. Karl Stahlkopf, a vice president of the Electric Power Research Institute (EPRI), estimates that dirty power costs U.S. industry between $4 and $6 billion a year, and that it is likely to get worse before it can be mitigated. EPRI expects that 70% of all electricity produced within the U.S. will flow through electronic devices by 2002, compared with 30% in 1999 (Fortune, 1999).

Dirty electricity is ubiquitous. It is generated by electronic equipment such as computers, plasma televisions, energy efficient appliances, dimmer switches, as

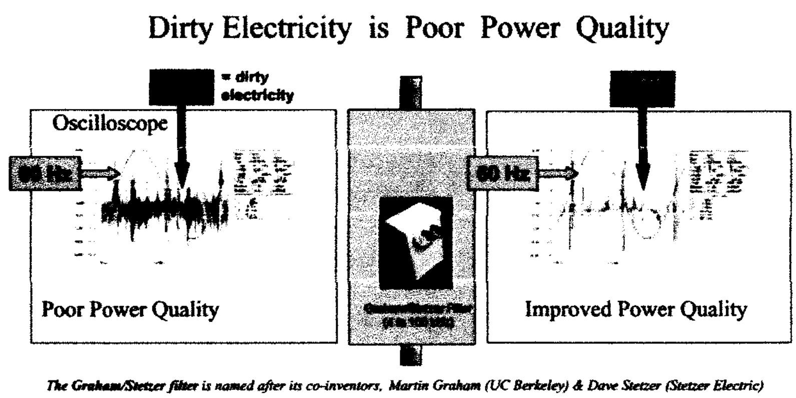

Figure 1. Visual display of dirty electricity (kHz range) and 60 Hz power frequency without (left) and with (right) Graham/Stetzer filters. A 2-channel Fluke 199 Scopemeter was attached to a ubiquitous filter to separate the 60 Hz frequency from the dirty electricity (Graham, 2000). The improved power quality has fewer spikes and smaller amplitude for the high frequency transients. The GS filters have no effect on the 60 Hz sine wave.

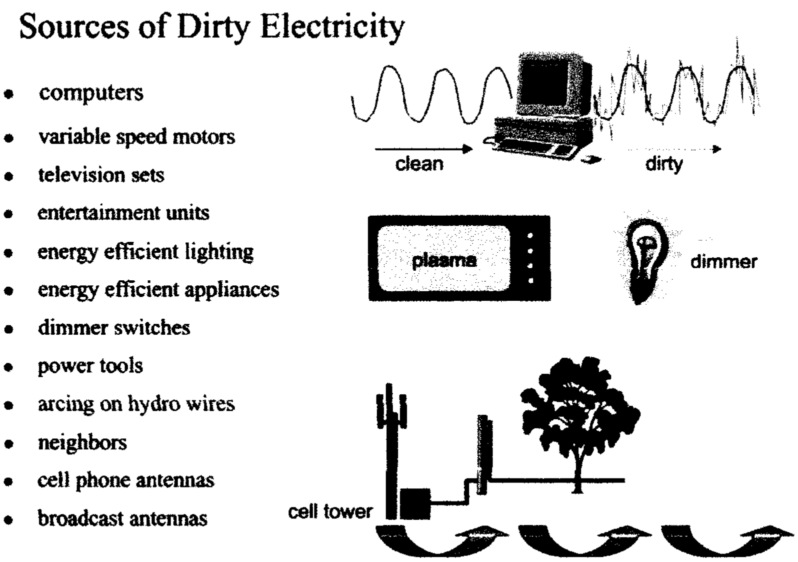

Figure 2. Sources of dirty electricity include electronic equipment and appliances, arcing on wires, and unfiltered cell phone and broadcast frequencies from nearby antennas.

well as arcing on electrical conductors caused by loose wires or contact with trees (Figure 2). Dirty electricity is thus produced within buildings but can also enter buildings from neighbors who share the same transformer. Mobile or broadcast antennas, if not properly filtered, can also contribute to high frequencies on electrical wires in nearby buildings.

The IEEE 519-1992 recommends installing filters to control harmonic distortions on power lines. With 5 kV and higher voltage distribution lines the IEEE identifies voltage notching, which produces both harmonic and nonharmonic frequencies in the radio frequency (RF) range and, as such, can introduce harmful effects associated with spurious RF. Industry uses large capacitors to protect sensitive equipment from power surges, especially in production line work, where malfunctions and down time are costly. Until now filters have not been available for in home use.

Professor Martin Graham from UC Berkeley and power quality expert, Dave Stetzer, President of Stetzer Electric in Wisconsin, have designed a filter that can be used inside buildings to clean the power that enters the building as well as the dirty electricity generated within the building. The Graham/Stetzer (GS) filter is a compact unit that plugs into an electrical outlet (Figure 3). It contains an electrical capacitor that shorts-out the high frequency transients on the circuit and is most effective when placed close to the appliance generating the dirty electricity. The GS filter has optimum filtering capacity between 4 and 100 kHz (Graham, 2000, 2002).

In Russia, the safety guidelines for electric and magnetic field exposure are frequency specific. For frequencies between 5 Hz and 2 kHz, the guideline is 25 V/m for electric fields and 0.25 μT (2.5 mG) for magnetic fields. For frequencies between 2 and 400 kHz, the guidelines are lower by a factor of 10. Since energy is proportional to frequency, the energy is 1,000 times higher at 60 kHz than it is at 60 Hz.

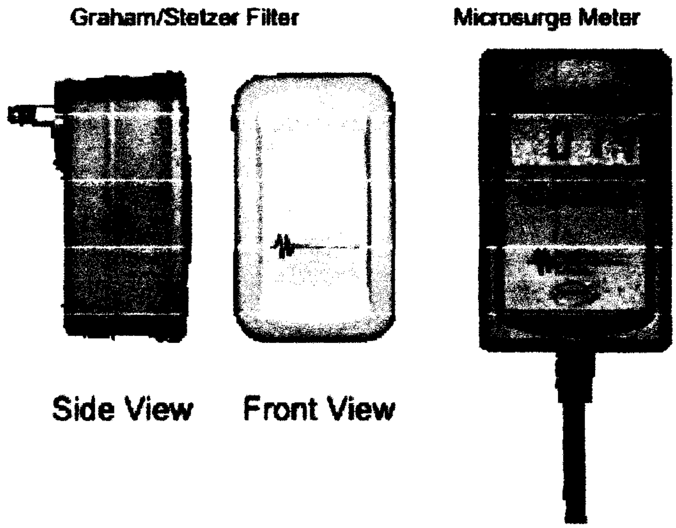

Figure 3. Equipment used to reduce and monitor dirty electricity inside buildings: the Graham/Stetzer filter and the microsurge meter.

The microsurge meter (Figure 3), also designed by Graham and Stetzer, measures the energy associated with dirty electricity in GS units with a range from 1 to 1999 and an accuracy of ±5% (Graham, 2003). The Health Department of the Republic of Kazakhstan (2003) has stated that any reading on the microsurge meter exceeding 50 is unacceptable and steps must be taken to lower such readings. Experience with this meter suggests that values below 30 GS units are undesirable and that extremely sensitive individuals may not see any benefits until the values are at or below 20 GS units. In some extremely dirty environments it is not possible to achieve such low values.

In the following, a number of case studies are presented.

Case Studies

GS filters have been placed in homes, offices, and schools. People report having better sleep, more energy, and less pain. They document cognitive improvements in memory and concentration. Symptoms of radio wave sickness or electrical hypersensitivity (Table 1) are often reduced or eliminated in the filtered environment.

GS filters placed in one Wisconsin school that had sick building syndrome, significantly improved power quality. Shortly after the filters were installed, the health and energy level of staff and students began to improve. According to the District Nurse, of the 37 students in the school who used inhalers on a daily basis, only 3 required inhalers and only for exercise-induced asthma after the filters were in place (Sbraggia, 2002).

GS filters were placed in a Toronto school and approximately 50% of the teachers documented improvements in energy, performance, mood, and/or health in a single blind study (Havas et al., 2004). Student behavior, especially at the elementary level, also improved. The symptoms that changed were ones we associate

Table 1
Symptoms of radio wave sickness first documented among radar workers during the Second World War resemble those now associated with electromagnetic hypersensitivity

Symptoms of radio wave sickness* (Firstenberg, 2001)
Neurological: Headaches, dizziness, nausea, difficulty concentrating, memory loss, irritability, depression, anxiety, insomnia, fatigue, weakness, tremors, muscle spasms, numbness, tingling, altered reflexes, muscle and joint paint, leg/foot pain, "flu-like" symptoms, fever. More severe reactions can include seizures, paralysis, psychosis, and stroke.
Cardiac: Palpitations, arrhythmias, pain or pressure in the chest, low or high blood pressure, slow or fast heart rate, shortness of breath.
Respiratory: Sinusitis, bronchitis, pneumonia, asthma.
Dermatological: Skin rash, itching, burning, facial flushing.
Ophthalmologic: Pain or burning in the eyes, pressure in/behind the eyes, deteriorating vision, floaters, cataracts.
Others: Digestive problems, abdominal pain, enlarged thyroid, testicular/ovarian pain, dryness of lips, tongue, mouth, eyes, great thirst, dehydration, nosebleeds, internal bleeding, altered sugar metabolism, immune abnormalities, redistribution of metals within the body, hair loss, pain in the teeth, deteriorating fillings, impaired sense of smell, ringing in the ears.

**Note:* These symptoms resemble symptoms associated with electrical hypersensitivity.

with attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD). This begs the question, "How much of the increase in ADD/ADHD among young people is due to electromagnetic pollution and poor electromagnetic hygiene?"

People with situational tinnitus (ringing in the ears that is present only in certain environments, often where RF is present) have documented improvements as well after the filters were installed in their home, as have those individuals who are otherwise healthy (Havas and Stetzer, 2004). Two diseases we seldom associate with electromagnetic hypersensitivity are diabetes and multiple sclerosis (MS). What follows are case studies that document the response to dirty electricity of diabetics and those with MS.

Diabetes

Two case studies are presented. (1) A 51-year old male with Type 2 diabetes who does not take medication and (2) an 80-year old female with Type 1 diabetes who takes insulin twice a day. A 51-year old male with Type 2 diabetes monitored dirty electricity in his environment and his blood sugar levels randomly throughout the day for approximately one month in 2003. The microsurge meter was not yet available to measure dirty electricity so he used a Protek 506 Digital Multimeter and measured the peak-to-peak voltage. His blood sugar levels were positively correlated with the amount of dirty electricity in his environment (Figure 4). One day he was

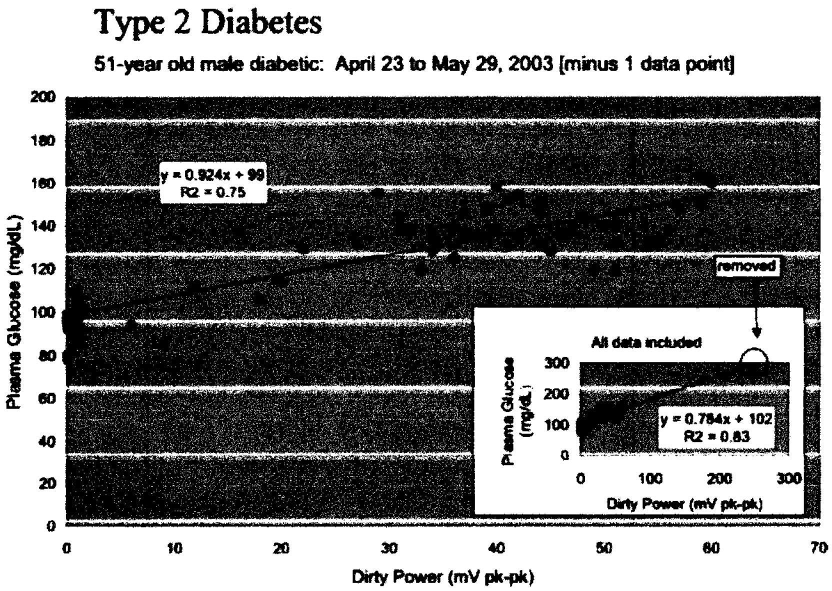

Figure 4. Fifty-one year old male with Type 2 diabetes. His plasma glucose levels correlate with the dirty electricity in his environment. Insert shows exposure on one day to a very high level of dirty electricity and this is reflected in elevated blood sugar.

exposed to very high levels of dirty electricity and this was reflected in exceptionally high levels of blood sugar. He noticed that his blood sugar levels remained low when he was in his truck away from power lines and antennas and when he was in a wilderness setting. In an electromagnetically dirty environment his blood sugar levels would increase within minutes.

An 80-year old female with Type 1 diabetes, who monitors her blood sugar twice daily—once in the morning upon awakening (fasting plasma glucose) and once in the evening before supper—had her home in Arizona filtered by an electrician. He was able to reduce the dirty electricity in her home from an average of 800 GS units to 13 GS units. As soon as the dirty electricity in her home was reduced, her blood sugar began to drop. Her average fasting plasma glucose levels without the filters was 171 mg/dL and this dropped to an average of 119 with the filters (Figure 5). During this period her insulin injections were reduced from a daily average of 36 units to 9 units.

Her evening plasma glucose did not change after the filters were installed in her home but they did change on days she spent away from home. Levels were particularly high after spending time in a casino. Casinos are likely to have high levels of dirty electricity but stress may also have contributed to higher levels of blood sugar (Hinkle and Wolf, 1950).

Multiple Sclerosis

One teacher in the Wisconsin school that was filtered had been diagnosed with multiple sclerosis (MS). She was extremely tired, had double vision, had cognitive

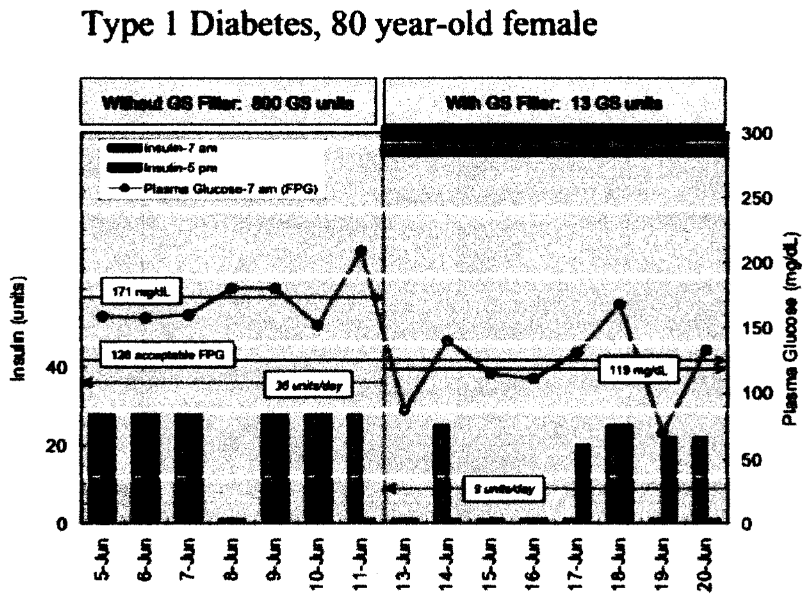

Figure 5. Eighty-year old female with Type 1 diabetes, who takes insulin twice daily. Fasting plasma glucose levels and insulin injections with and without Graham/Stetzer filters are shown.

difficulties and could not remember the names of the students in her 4th grade class. Her health would improve during the summer but her symptoms returned in September. She assumed her problems were mold-related but her symptoms did not improve after the mold was removed from the school. Once the school was filtered her symptoms disappeared. Similar stories prompted studies with people who had MS.

Havas began to work with people diagnosed with MS, who had difficulty walking and who used canes or walkers. The first person she worked with noticed improvements within 24 h. At that stage Havas assumed this was a powerful placebo effect but the subject's symptoms continued to improve weekly and regressed only during wet weather, which had always been a problem for this subject. Several other people with MS were able to walk unassisted after a few days to weeks with the GS filters and Havas began to videotape those who gave her permission to do so.

One of those individuals is a 27-year old male who had been diagnosed with primary progressive MS two years earlier. He walked with a cane or did "wall walking" at home (holding onto the wall or furniture for balance). He had tremors, was exceptionally tired, and was beginning to have difficulty swallowing. Three days after 16 GS filters were placed in his home his symptoms began to disappear. The dirty electricity in his home was reduced from 135–410 GS units to 32–38 GS units. He assumed his body was recovering spontaneously but he had been diagnosed with progressive MS and not relapsing/remitting MS, so spontaneous recovery was unlikely in his case.

A week after the filters were installed in his home he had enough energy to go shopping with his father. He did not take his cane because he had not needed it, but

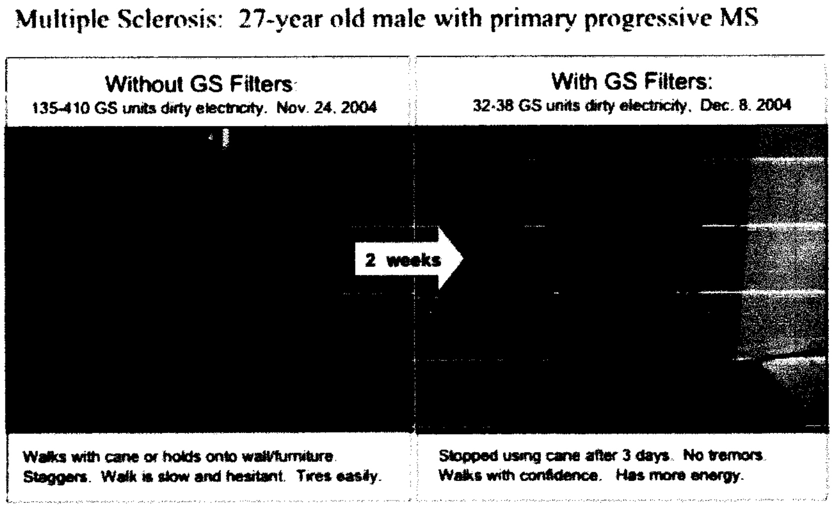

Figure 6. Video-clip of 27-year old male with primary progressive multiple sclerosis, diagnosed two years earlier. In the video on left (without Graham/Stetzer filters), he walks slowly and is hesitant. In the video on the right (two weeks after Graham/Stetzer filters were installed in his home), he walks with confidence and is well coordinated.

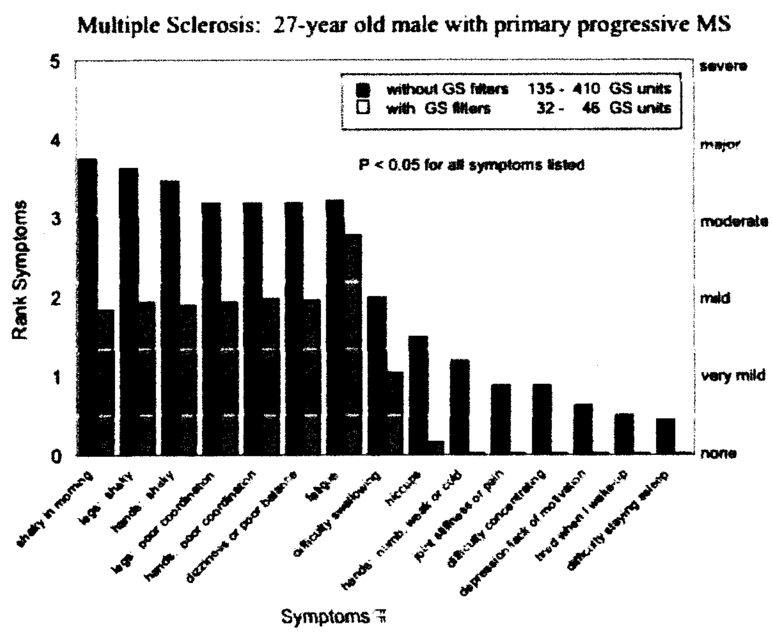

Figure 7. Symptoms of 27-year old male with primary progressive multiple sclerosis with and without Graham/Stetzer filters in his home.

after a couple of hours in the store his symptoms reappeared and he had difficulty walking to the car. His tremors began to subside three hours after arriving home. This experience has been repeated on several occasions and he now knows that if he goes into an environment with dirty electricity his MS symptoms reappear.

Figure 6 is taken from a video before the filters were installed in his home and two weeks later. Prior to the filters his walk was stilted and slow. He staggered and resembled the gait of someone who was intoxicated. Two weeks after the filters were installed his walk was normal with no signs of MS. During this period he began to put on weight, was sleeping better, and had fewer tremors and more energy (Figure 7).

Some other observations that are notable is that his mother had been suffering from hot flashes at night associated with menopause and these came to an end after the filters were installed and his father experienced several episodes of vertigo weekly and these became less frequent.

Conclusions

These case studies and anecdotal reports suggest that dirty electricity is biologically active. Once dirty electricity is reduced, people's health improves. For some it is reflected in more normal blood sugar levels, for others symptoms of MS are reduced, and for still others tinnitus disappears and behavior resembling ADD/ADHD improves. Since dirty electricity is becoming ubiquitous large fractions of the population are being exposed to this pollutant and some are being adversely affected.

Diabetes, multiple sclerosis, ADD/ADHD, asthma chronic fatigue, and fibromyalgia are all increasing in the population and the reasons for this increase are poorly understood. Dirty electricity may be one of the contributors to these illnesses.

According to Philips and Philips (2006) 3% of the population has electromagnetic hypersensitivity (EHS) and 35% have symptoms of EHS. If these percentages apply to diabetics then as many as 5–60 million diabetics worldwide may be responding to the poor power quality in their environment (Wild et al., 2004). Evidence from laboratory studies documents that insulin release and insulin-binding capacity to receptors cells is reduced by electromagnetic fields (Li et al., 2005; Sakurai et al., 2004). It is further known that stress increases blood sugar levels in diabetics and that exposure to electromagnetic energy induces stress proteins at various frequencies (Blank and Goodman, 2004; Hinkle and Wolf, 1950).

Dirty electricity can now be monitored with meters and reduced with filters, providing scientists with the tools needed for research. What is presented here is a handful of studies, many preliminary, with dramatic results. This area warrants further investigation to determine the mechanisms involved and the percentage of the population affected.

Conflict of Interest

Please note that the author has no vested interest, financial or otherwise, in the commercial devices discussed in this article.

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Power quality affects teacher wellbeing and student behavior in three Minnesota Schools

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ABSTRACT

BackgroundPoor power quality (dirty electricity) is ubiquitous especially in schools with fluorescent lights and computers. Previous studies have shown a relationship between power quality and student behavior/teacher health.

ObjectivesThe purpose of this study is to determine the ability of power line filters to reduce dirty electricity in a school environment and to document changes in health and behavior among teachers and students.

MethodWe installed Graham Stetzer filters and dummy filters and measured power quality in three Minnesota Schools. Teachers completed a daily questionnaire regarding their health and the behavior of their students for an 8-week period. Teachers were unaware of which filters were installed at any one time (single blind study).

ResultsDirty electricity was reduced by more than 90% in the three schools and during this period teacher health improved as did student behavior in the middle/elementary schools. Headaches, general weakness, dry eyes/mouth, facial flushing, asthma, skin irritations, overall mood including depression and anxiety improved significantly among staff. Of the 44 teachers who participated 64% were better, 30% were worse, and 6% did not change. Behavior of high school students did not improve but elementary/middle school students were more active in class; more responsive, more focused; had fewer health complaints; and had a better overall learning experience.

ConclusionsDirty electricity in schools may be adversely affecting wellbeing of teachers and behavior of their students, especially younger students in middle and elementary school. Power line filters improve power quality and may also protect those who are sensitive to this energy. Work on electric and magnetic field metrics with and without Stetzer filters urgently needs to be carried out to determine just what characteristics of the dirty electricity may be interacting with the people.

1. Introduction

Poor power quality, commonly referred to as dirty electricity, is a growing concern for the electrical utility as it interferes with sensitive electronic equipment leading to malfunctions and costly repairs. Schools with fluorescent lights and electronic equipment in the form of computers; those near high voltage transmission lines and near antennas for wireless communication are prime candidates for poor power quality (Havas 2006b; Vignati and Giuliani 1997).

Another, less well understood, consequence of dirty electricity is ill health for those who have become electrically hypersensitive (EHS). Diabetics with EHS have higher plasma glucose levels and require more medication, when exposed to

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this energy, and people with multiple sclerosis have a worsening of their symptoms (Havas 2006b). The most common complaints among self-proclaimed EHS include chronic fatigue, chronic pain, difficulty sleeping, mood disorders such as anxiety or depression, concentration and memory problems, dizziness, skin irritation, visual disturbances and ringing in the ears (Firstenberg 2001; Havas and Stetzer 2004; Schooneveld and Kuiper 2007).

A study of dirty electricity, in a Toronto school, documented improved health among teachers and improved behavior among students when the dirty electricity was reduced with Graham/Stetzer filters (GS filters) plugged into outlets throughout the school (Havas et al., 2004). These filters short out high frequency transients and harmonics that contribute to poor power quality.

We repeated the study at three schools in Minnesota: an elementary and middle school, in the same building, and a nearby high school.

2. Materials and method

This research was approved by Trent University Ethics Committee and complies with local, state, and national regulations. Teacher participation was voluntary and those who participated could opt out during the study. Teachers provided written consent for us to use the information they provided with the understanding that their identify would not be revealed.

Three schools in Minnesota, an elementary, middle and high school, agreed to participate in a study that monitored and improved power quality and assessed teacher health and student behavior. The middle and elementary schools were in the same building. We did spot measurements of magnetic fields in randomly selected classrooms (using a trifield meter) and found the values to be low (less than 2 mG). Two power quality exposures were tested in each school. One test was with dummy filters that have no effect on power quality and the other was with GS filters that improve power quality. These filters are identical except the dummy filters are internally disconnected. A total of 541 GS filters or 285 dummy filters were installed in the three schools during testing. The protocol was as follows: first two weeks (Jan 31 to Feb 11 2005) with dummy filters, four weeks with GS filters (Feb 14 to Mar 11), and two weeks (Mar 14–25) with dummy filters to minimize seasonal effects on health and behavior. This was a single blind study as teachers were unaware of which filters were installed at any time during the study. While we did not use exactly the same number of real and placebo filters during this study, whether teachers counted the number of filters in their classrooms, along the hallway, in the library, etc. is questionable. We are confident this was a blinded study.

Power quality was monitored with a Microsurge meter that measures high frequency transients and harmonics between 4 to 100 kHz. This meter provides a digital reading from 1 to 1999 of $|dv/dt|$ expressed as GS units with +/−5% accuracy (Graham, 2003). The power quality was measured during the weekend when the dummy and real filters were first installed. Lights were turned on in each room and some computers may have been on but were not in use. Readings obtained are likely to be lower than readings during regular school hours. While this is less than ideal we did not want teachers to know when the filters were exchanged.

Teachers answered a questionnaire related to their health and the behavior of their students at the end of each school day for an 8-week period between January 31 and March 25 2005. For ethical reasons information on the health and behavior of individual students was unavailable and we confined our questionnaire to classroom behavior. Internal checks were used to determine reliability of the responses to the questionnaire with similar questions asked in different ways.

A total of 44 teachers responded frequently enough to the questionnaire to enable statistical analysis providing 685 teacher-days of data. Two-tailed t-tests (dummy vs. GS filters or poor vs. improved power quality) were used for each teacher and for each symptom at the 5% probability level for significant effects and at the 10% level for slight effects. Classroom behavior was assessed the same way. Middle and elementary schools were in the same building and data were combined for analysis. We analyzed data for 14 classes in the middle and elementary school and 17 classes in the high school.

3. Results and discussion

GS filters improved power quality in all three Minnesota schools by more than 90% in the frequency range of 4 to 100 kHz (Table 1). Dirty electricity for all three schools averaged 574 GS units and ranged from 90 to greater than 2000 with dummy filters installed. With GS filters the values ranged from 16 to 150 with an average of 37 GS units. Based on previous studies, values below 50 and ideally below 40 GS units are associated with health benefits for those who are electrically sensitive (Havas, 2006a).

3.1. *Teacher wellbeing*

Teacher health and sense of well being improved with enhanced power quality (Fig. 1). Of the 38 symptoms 79% were better, 13% were worse, and 8% were the same while the GS filters were installed. Headaches, general weakness, dry eye/mouth, facial flushing, depression, mood, dizziness, asthma, pain, skin irritations, clarity of thought, and energy were among the net improvements documented by teachers. Elementary and middle school teachers reported greater improvement (68% of net symptoms) than high school teachers (24% of net symptoms).

A similar study to the one in Minnesota was conducted in a Toronto school for students with learning disabilities from grade 1 to 12 (Havas et al., 2004). Net improvements in teacher wellness were documented for 14 of the 16 symptoms (88%).

In the present study asthma, among teachers, was one of the symptoms that improved as did other respiratory ailments such as runny noise and sinus congestion. Installation of GS filters in a Wisconsin school, experiencing sick-building syndrome, resulted in students with asthma no longer requiring daily use of their inhalers as documented by the school nurse (Havas, 2006a).

Many of the teachers' symptoms that improved are common among people who have developed electrohypersensitivity

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Table 1 – Power quality with real and dummy filters installed in three Minnesota schools

School	Power quality	#rooms	#filters	Dirty electricity (GS units)			Power
				Minimum	Mean	Maximum	% improvement
Elementary	Poor	35	62 (dummy)	147	722	>2000	
	Improved	35	131 (real)	29	41	60	94%
Middle	Poor	30	87 (dummy)	200	563	>2000	
	Improved	28	139 (real)	28	46	150*	92%
High	Poor	36	136 (dummy)	90	438	>2000	
	Improved	37	271 (real)	16	23	40	95%
All	Poor	101	285 (dummy)	90	574	>2000	
	Improved	100	541 (real)	16	37	150*	94%

*Boiler room, large copy machine.

(EHS) (Firstenberg, 2001; Schooneveld and Kuiper, 2007). The symptoms of electrohypersensitivity resemble radiowave sickness, first described among radar workers following World War 2 (Firstenberg, 2001). Electrosensitivity may be severely affecting 3% of the population, who would be unable to work in a school environment with computers and fluorescent lighting and with wireless technology associated with phones and computers (Johansson, 2006). Another 35% of the populations have some of the symptoms of EHS (Philips and Philips, 2006), such as headaches, body aches and pains, fatigue and poor sleep and simply associate these symptoms with either aging or living a stressful lifestyle.

Teachers in this study were ranked based on the amount their symptoms improved (Fig. 1). During the period of enhanced power quality, 64% of the teachers were better, 30% were worse, and 7% were the same resulting in a net improvement among 34% of the teachers overall. This corresponds to the 35% with moderate symptoms of EHS according to Philips and Philips (2006) and is just below the 40% in the Toronto School study (Havas et al., 2004).

Several teachers showed marked improvements ranging from 10% of their symptoms to more than 70%. We believe this relates to the degree of electrosensitivity of the individuals involved.

The teacher who benefited the most is an elementary school teacher. Levels of dirty electricity in her classroom were reduced from 406 to 40 GS units and 27 (71%) of her symptoms improved. She noted that her psoriasis, which had been bothering her for years, completed cleared-up during the study and she did not change any of her medication or skin lotions. Skin irritations following exposure to computer screens, commonly referred to as screen dermatitis, have been extensively studied in Sweden

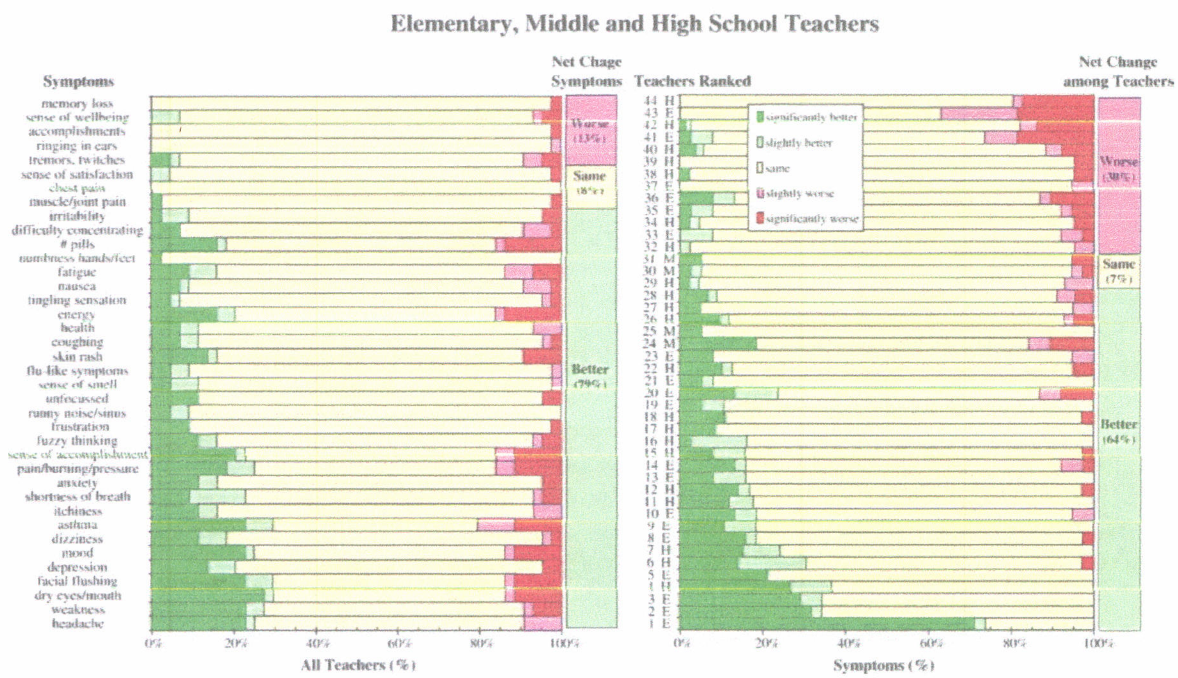

Fig. 1 – Changes in health and wellness symptoms, associated with improved power quality, among teachers in three Minnesota Schools. Note: letter after teacher ranking is for elementary (E), middle (M), and high school (H).

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(Johansson, 2006). Production of mast cells and histamine may be the underlying mechanism for the skin irritations and this seems to differ among people with EHS.

We were unable to lower the dirty electricity in each classroom below the recommended 40 GS units and found that teacher response related to both the original levels of dirty electricity and the values after cleanup. The greater the improvement in power quality the greater was the improvement among teachers (Fig. 2).

The dummy filters, in Fig. 2, represent the ambient levels of dirty electricity and the real filters indicate how much the dirty electricity was reduced in any one classroom. Since we know which teachers taught in which classrooms, we were able to compare their "recovery" with the before and after filter values for power quality.

In classrooms that had values of dirty electricity above 300 GS units and that were reduced to less than 50 GS units with the filters, all the teachers improved. In classrooms where the filters reduced the dirty electricity to above 50 GS units fewer teachers improved (59–82%). In classrooms with the lowest levels of dirty electricity (less than 300), the levels needed to be reduced to less than 30 GS units before all the teachers improved. This demonstrates that the teacher's response was influenced by the original levels of dirty electricity and the values after cleanup.

Other studies have examined the relationship between poor power quality and cancers. Milham and Morgan (submitted for publication) reported a cancer cluster among teachers at La Quinta Middle School in California. Of the 137 teachers, 18 cancers were observed and 6.5 were expected. This 3-fold increase in cancer cases has a 1 in 10,000 possibility of being due to chance. Monitoring of the rooms showed that 13 rooms had high levels of dirty

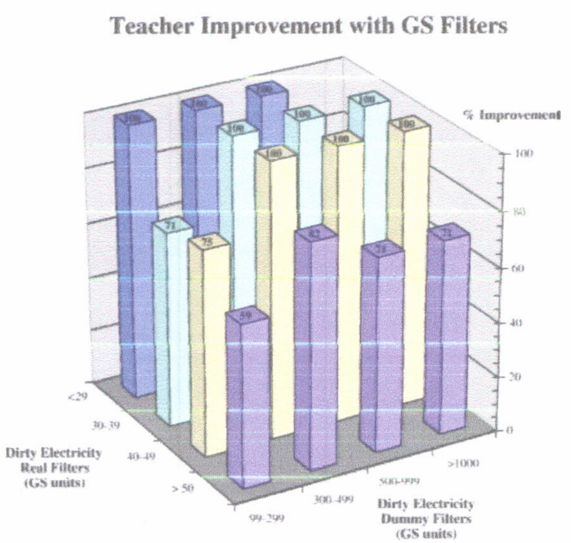

Fig. 2 – Net improvement in the health and wellness of teachers in three Minnesota Schools associated with power quality. The real GS filters improved power quality, while the "dummy" filters represented ambient levels.

electricity (>2000 GS units) and the teachers who taught in those rooms had a greater risk of developing cancer. Cancer risk for teachers was 1.8 fold if they never taught in those rooms; 5.1 fold if they ever taught in those rooms; and 7.1 fold if they taught in those rooms and had been at the school for more than 10 years. Cancers included melanoma, thyroid, uterine, breast, colon, pancreas, ovary, larynx, lymphoma, and multiple myeloma. In the present study we did not inquire about cancers among staff, but if the conclusions of Milham and Morgan are correct then levels in at least three rooms, with values above 2000 GS units, should be reduced.

Interestingly, cancers (Eger et al., 2004; Kundi et al., 2004; Wolf and Wolf, 2004) and symptoms of EHS (Zwamborn et al., 2003; Oberfeld et al., 2004) are the two most common associations with RF exposure from wireless technology including their base stations and antennas.

3.2. *Student behavior*

During this study, the behavior of high schools students did not improve whereas elementary and middle school students did.

3.3. *High school*

Thirty-eight percent of the behavioral traits and 18% of the high school classes were worse overall during the period of enhanced power quality (Fig. 3). One exception was the computer room where student behavior improved for more than 60% of the behavioral traits tested. Interestingly, the results for the Toronto school showed that improvements among high schools students were marginal compared with middle and elementary school students (Havas et al., 2004). This may be due to cell phone use, which is another form of radio frequency exposure that was not controlled in this study, or to the fact that high school students change rooms for their classes and hence a 60-minute exposure in any one class may not be sufficiently long to assess changes in behavior. According to the Principal, 50% of the high school students carry cell phones to class, although they are allowed to use them only in between classes.

In a study of 250 self-proclaimed EHS sufferers, 26% claimed to be bothered by cell phones (Schooneveld and Kuiper, 2007). According to the Stewart Report (2000), children may be more vulnerable to cell phone radiation and should be discouraged from using them for non-essential calls. Here the concern was for developing brain tumors rather than for other less severe but chronic symptoms of EHS.

3.4. *Elementary and middle school*

Behavioral traits among elementary and middle school students were better for 70% of the traits and for 42% of the classrooms overall (Fig. 4). The improvements were not nearly as dramatic as for the Toronto school for learning-disabled students (Havas et al., 2004). Perhaps students with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD) are inherently more sensitive to electromagnetic energies.

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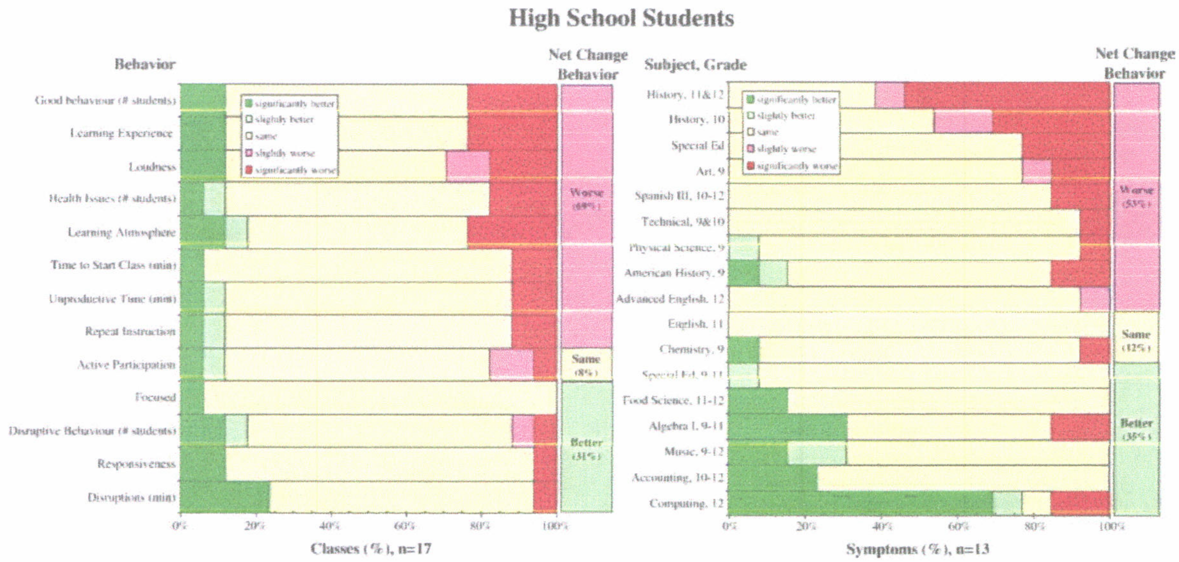
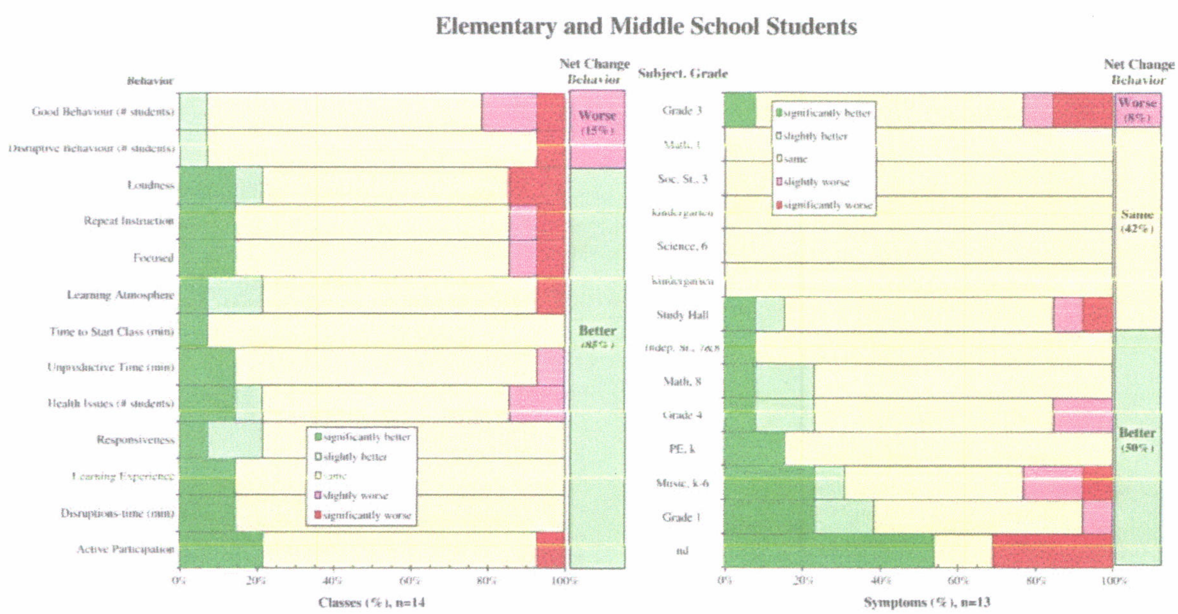


Fig. 3 – Behavioral changes in high school students in Minnesota associated with improved power quality.

Teachers reported that students were more actively involved and more responsive during classes. The amount of time it took to start the class and to deal with disruptions was reduced. Students were more focused and required fewer repetitions of instructions and had fewer health complaints. Overall this resulted in an improved learning environment and a better learning experience.

3.5. *High school vs. elementary/middle school*

This different response among the teachers and students in the high school and those in the elementary/middle school may be due to natural variability or, possibly, to other sources of radio frequencies radiation that were not monitored such as wireless computing, within the school, or telecommunication



nd = do data

Fig. 4 – Behavioral changes in elementary and middle school students in Minnesota associated with improved power quality. nd = no data.

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antennas, outside the school. Neither building had wireless computing at the time of this study. However, within a radius of 400 m, the Elementary/Middle school had 1 antenna and the high school had 4 (www.antennasearch.com). Monitoring of RF radiation at these schools is advised to confirm or rule out this exposure to RF radiation.

Studies showing increased symptoms of EHS and/or cancers near cell phone antennas cite a critical distance of 300 to 400 m and exposure values far below the existing Federal Communication Commission (FCC) and international guidelines (Oberfeld et al., 2004; Wolf and Wolf, 2004; Zwamborn et al., 2003).

4. Conclusions

Poor power quality or dirty electricity has been implicated with poor health in schools in Ontario, Wisconsin, California, and now Minnesota. Fluorescent lighting and computers are the primary sources of poor power quality but external sources cannot be ruled out. Improving power quality, with GS filters, is accompanied with enhanced teacher wellbeing and improved student behavior in middle and elementary school resulting in a better overall learning experience. The effect of poor power quality on health is a relatively new area of research but one that needs attention, especially in schools where the health and wellbeing of teachers and students are at stake. Work on electric and magnetic field metrics with and without Stetzer filters urgently needs to be carried out to determine just what characteristics of the dirty electricity may be interacting with the people.

Boards of Education have long considered the health effects of air quality, mold, and asbestos and have reduced these in school buildings. Many schools restrict wearing of perfume, to protect those with chemical sensitivities, and have nut-free environments, for those with peanut allergies. School Superintendents and School Boards need to recognize that some people are sensitive to electromagnetic energy and that schools need to be monitored for power quality and for other forms of radio frequency radiation. If levels are high they need to be reduced to ensure a safe environment for both students and staff. More research is required into the health effects of dirty electricity but in the meantime, based on the evidence to date, steps should be taken to reduce dirty electricity exposure in schools.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.scitotenv.2008.04.046.

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Radiofrequency exposure near high-voltage lines
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ABSTRACT

Many epidemiologic studies suggest a relationship between incidence of diseases like cancer and leukemia and exposure to 50/60 Hz magnetic fields. Some studies suggest a relationship between leukemia incidence in populations residing near high-voltage lines and the distance to these lines. Other epidemiologic studies suggest a relationship between leukemia incidence and exposure to 50/60 Hz magnetic fields (measured or estimated) and distance from the main system (220 or 120 V). The present work does not question these results but is intended to draw attention to a possible concurrent cause that might also increase the incidence of this disease; the presence on an electric grid of radiofrequency currents used for communications and remote control. These currents have been detected on high- and medium-voltage lines. In some cases they are even used on the main system for remote reading of electric meters. This implies that radiofrequency (RF) magnetic fields are present near the electric network in addition to the 50/60 Hz fields. The intensity of these RF fields is low but the intensity of currents induced in the human body by exposure to magnetic fields increases with frequency. Because scientific research has not yet clarified whether the risk is related to the value of magnetic induction or to the currents this kind of exposure produces in the human body, it is reasonable to suggest that the presence of the RF magnetic fields must be considered in the context of epidemiologic studies.

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Low-frequency transient electric and magnetic fields coupling to child body
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ABSTRACT

Much of the research related to residential electric and magnetic field exposure focuses on cancer risk for children. But until now only little knowledge about coupling of external transient electric and magnetic fields with the child's body at low frequency transients existed. In this study, current densities, in the frequency range from 50 Hz up to 100 kHz, induced by external electric and magnetic fields to child and adult human body, were investigated, as in residential areas, electric and magnetic fields become denser in this frequency band. For the calculations of induced fields and current density, the ellipsoidal body models are used. Current density induced by the external magnetic field (1 μT) and external electric field (1 V/m) is estimated. The results of this study show that the transient electric and magnetic fields would induce higher current density in the child body than power frequency fields with similar field strength.

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CLINICAL AND HYGIENIC ASPECTS OF EXPOSURE TO ELECTROMAGNETIC FIELDS

(*A Review of the Soviet and Eastern European Literature*)[1]

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INTRODUCTION

It has long been apparent that electromagnetic fields impose a health hazard, especially at field intensities greater than approximately 15 mW/cm², which cause thermal (heating) responses in the organism. Only quite recently it is suspected, from the Soviet and East European literature, that these fields might also elicit certain functional or so-called "specific" responses, especially in the nervous system, at field intensities less than 10–15 mW/cm², which do not cause heating.

Prior to 1964, no comprehensive effort had been attempted in this country to review the world (especially the Soviet and East European) literature on the general biological effects of microwaves. Soviet literature was in most cases scattered, quite difficult to locate, and consequently had never come to the attention of the U.S. scientific community. When in 1964, one of the first reviews on this subject was attempted by the writer, then affiliated with the Library of Congress, it was speculated by some authorities on the subject that an extremely low yield of literature would result from the attempt. It was therefore quite surprising that a search of the Soviet and Eastern European literature on the biological effects of microwaves revealed a large and virtually unexploited body of information which had never come to the attention of the U.S. scientific community. The first review (1) contained 132 references to Soviet and East European work on this subject. Subsequent reviews by the author (2-4) and a number of others (5-9) revealed that some of the most active research in the world was being conducted in the Soviet Union and some of the Eastern European countries.

It is the purpose of this paper to review Soviet and Eastern European studies of the effects of radio-frequency fields on the human organism. An attempt will be made to summarize the more noteworthy findings of some of the literally hundreds of published works devoted to this subject and to underscore the need for a more critical and systematic treatment of this subject. This review will concentrate nearly exclusively on human clinical studies and occupational hygiene surveys and will not consider the more theoretical or experimental aspects of the biological effects of microwaves.

BACKGROUND

As early as 1933, certain Soviet scientists had already recognized that electromagnetic fields affected the human nervous system. In 1937, Turlygin (10) published one of the first comprehensive Soviet accounts of the effects of centimeter waves on the human central nervous system. He found that CNS excitability was increased by 100% of the control level when a crude spark oscillator in the vicinity of the head of a subject was switched on. In a lengthy review article, Livshits (11) cited no fewer than 28 Soviet publications on the general subject of clinical and biological microwave effects which had been published by the end of the 1930's.

During the 1940's and early 1950's, there was an understandable lull in research on this subject due to World War II. By the middle and late 1950's, there appeared a veritable deluge of Soviet literature dealing, in the main, with the clinical and hygienic aspects of microwave exposure which has continued unabated to this day. By the early 1960's, the Eastern European countries of Czechoslovakia and Poland had also become extremely active in the area of microwave exposure effects. In a cursory

[1] The views expressed by the author do not necessarily represent those of the U.S. Navy.

search of the Soviet and Eastern European literature on this subject alone, a total of about 100 publications authored by 75 researchers was found and this figure is probably a conservative reflection of the available works which are estimated to be several hundred.

In an attempt to summarize the prolific Soviet and Eastern European work on clinical and hygienic aspects of exposure to microwaves, it became apparent that a number of human systems and functions had been documented to be affected by this factor (Table 1). By far the most frequently and repeatedly reported human responses to microwaves involve the central nervous system. These responses have been noted for a wide range of frequencies (~30–300,000 MHz) at both thermogenic (>10 mW/cm²) and nonthermogenic (microwatts to milliwatts/cm²) intensities.

An often disappointing facet of the Soviet and East European literature on the subject of clinical manifestations of microwave exposure is the lack of pertinent data on the circumstances of irradiation; frequency, effective area of irradiation, orientation of the body with respect to the source, waveform (continuous or pulsed, modulation factors) exposure schedule and duration, natural shielding factors, and a whole plethora of important environmental factors (heat, humidity, light, etc.) In addition, the physiological and psychological status of human subjects such as health, previous or concomitant medication, and mental status is also more often than not omitted. These variables, both individually and combined, affect the human response to microwave radiation. Despite these omissions, however, the reviewer cannot help but be impressed both by the consistency of the findings and the large size of Soviet and East European clinical and hygienic surveys which have involved literally thousands of people over the past 20 or more years.

CLINICAL MANIFESTATIONS OF EXPOSURE TO RADIOFREQUENCY FIELDS

General Clinical Syndromes

Many Soviet clinical workers have attempted to categorize the chronological stages of human responses to microwaves. Panov et al. (12) proposed three categories or stages of responses to microwaves (Table 2). These were listed as the asthenic syndrome, characterized by fatigue, depression, and a number of other changes. This first stage is not marked by severe episodes such as fainting or dramatic changes in pulse or blood pressure and the subject responds to outpatient treatment. The second category is called the "syndrome of autonomic and vascular dystonia". The essential feature of this stage is pulse lability (brady- and tachycardia), blood pressure lability (hypo- or hypertension), EKG changes, and general neurocirculatory asthenia. Severe episodes such as fainting spells may occur and the subject requires hospitalization of unspecified nature or duration. The third stage is referred to as the diencephalic syndrome in which visceral dysfunctions and crises are observed. Typical episodes during this stage are listed as "apathic ambulic" disorders, hypersomnia, hypokinesis, hypothalamo-pituitary-suprarenal weakness, and inhibition of sexual and digestive reflexes. Panov claims that these changes are not always reversible and that subjects require hospitalization. It should be noted that Panov did not specify the nature or duration of outpatient or hospital treatment, nor did he relate these symptoms to specific irradiation parameters.

TABLE 1

Effects of electromagnetic radiation on the human organism

I. Central Nervous System
II. Autonomic Nervous System
III. Neurohumoral Systems
IV. Endocrine Glands and Functions
V. Eye and Ocular Functions
VI. Blood and Hematopoietic Systems
VII. Miscellaneous Organs

General Subjective Complaints (Indirect Effects on the CNS)

A large number of East European and especially Soviet clinical and hygienic workers (13–22) have consistently and repeatedly documented an astonishing number of subjective complaints which are usually referred to as evidence of the direct or indirect effect of microwaves on the central nervous system (Table 3). These responses have been reported for a wide range of wavelengths (30–300,000 MHz) and field intensities (microwatts to several milliwatts/cm²). Unfortunately, it is often difficult to attach any significance to Soviet clinical findings in the absence of pertinent data on exposures and on patient backgrounds. Typical, for instance, was a survey conducted by Sadchikova (21) in which three groups of occupational personnel (technicians, assemblers, and maintenance workers around centi-

TABLE 2

Soviet classification of general clinical syndromes of exposure to electromagnetic radiation EMF's

A. The Asthenic Syndrome (reversible; outpatient treatment)
   1. fatigability and emotional changes
   2. acrocyanosis
   3. increased perspiration of extremities
   4. increased pilomotor reflex
   5. dermographism
   6. pulse lability
   7. blood pressure lability
B. Autonomic Dystonia (reversible; hospitalization)
   1. hyper- or hypotension
   2. bradycardia and tachycardia
   3. changes in EKG signs
   4. fainting spells
C. Diencephalic Syndrome (usually reversible; hospitalization)
   1. insomnia
   2. adynamia
   3. hypothalamo-pituitary-suprarenal inhibition
   4. inhibition of sexual function and digestive reflexes

meter wave generators) were exposed to: (1) periodic intense radiation (3–4 mW/cm²); (2) moderate radiation (tenths of mW/cm²); and (3) weak radiation (hundredths-tenths of mW/cm²). As can be seen in Table 4, the group exposed to the weakest radiation was shown to display the highest incidence of complaints. This finding and lack of pertinent exposure data such as duration and affected body area make these data difficult to accept on face value. On the other hand, Edelwejn (14) has conducted interesting and comprehensive neurological examinations and interviews of Polish personnel exposed for up to six hours/day to microwave field intensities of 10 microwatts to several milliwatts/cm². He found that many of the subjective complaints listed in Table 3 (headaches, dizzy spells, fatigue, perspiration, etc.) depended upon the length of employment and degree of exposure. Only subjects exposed to high (mW/cm²) intensities exhibited EEG changes. Edelwejn was of the opinion that there is a dramatic response to microwave exposure occurring during the first three years which are accompanied by neurotic symptoms. This three year period is followed by a phase of gradual adaptation. The reappearance of neurologic symptoms occurs after a long period (many years) of exposure to microwaves, even after adaptation has occurred.

Osipov (1965) (20) in a review of neurologic responses to microwave exposure concluded that most subjective symptoms were reversible and that pathological damage to neural structures was insignificant. Only rarely were microwaves found to cause hallucinations, syncope, adynamia and other manifestations of the so-called "diencephalic" syndrome.

Soviet workers have also documented subjective complaints identical to those in Table 3 as a result of exposure to electric and magnetic fields. Vyalov et al. (23) reported characteristic microwave symptoms such as headache, fatigue etc., in workers exposed to 150–1500 oersted magnetic fields. Asanova (24) reported analagous findings for workers exposed to 115–125 microampere fields around hydroelectric stations.

Functional Changes in the CNS

Many Soviet and Eastern European workers have attempted to identify specific CNS functional responses to microwave exposure. Most Soviet workers are of the opinion that the CNS is the most sensitive of all systems to the effects of microwaves, both at thermogenic and nonthermogenic field intensities. Based primarily upon experimental research, Presman (9) is of the opinion that the hypothalamus is the most sensitive CNS structure to microwave effects which would explain, in his view, the high incidence of blood and humoral changes noted in human subjects exposed to this factor.

Changes in human CNS function have been evaluated on the basis of EEG surveys, reflex tests, and general neurological examinations (Table 5). These changes are reported for a wide range of frequencies and field intensities (thermal and nonthermal). However, functional CNS responses appear to be de-

TABLE 3

General subjective complaints resulting from exposure to electromagnetic radiation

1. Pain in head and eyes
2. Lacrimation
3. Weakness, weariness and dizziness
4. Depression, antisocial tendencies, general irritability
5. Hypochondria, sense of fear, and general tension
6. Impairment of memory and general mental function
7. Adynamia and inability to make decisions
8. Inhibition of sex life (male)
9. Scalp sensations and loss of hair
10. Chest pain and heart palpitation
11. Dyspepsia, epigastric pain, and loss of appetite
12. Trembling of eyelids, tongue, and fingers
13. Asthma
14. Brittle fingernails
15. Sensitivity of mechanical stimulation and dermographism

TABLE 4

Changes in the nervous system as a result of exposure to microwaves

		Changes observed (in % of subjects studied)							
Group	No. examined	Headache	Increased fatigue	Increased irritability	Sleepiness	Delayed der-morgraphism	Slowed orthostatic reflex	Wrist hyperdrosis	Thyroid hypertrophy
1	184	12	20	8	2	16	19	6	15
2	129	39	31	12	14	7	21	37	—
3	78	36	31	15	19	14	11	26	52
Control	100	8	10	8	2	—	—	4	14

pendent upon wavelength; direct effects on the brain were reported by Gordon (1964) (25) and Presman (9) to intensify with increase in wavelength. However, when reactions are due to a combination of peripheral and direct stimulation, it is impossible to correlate response with wavelength.

A number of workers have reported changes in EEG patterns as a result of exposure to microwaves. Klimkova-Deutschova (26), a Czechoslovakian researcher, reported that both clinical and EEG findings suggested a predominance of an inhibition process. EEG's showed a predominance of sleep rhythms. In this connection, the interesting (if rather curious) work of Ivanov-Muromskiy (27), a Soviet expert on electrosleep and electroanesthesia

TABLE 5

Functional CNS changes resulting from exposure to electromagnetic radiation

1. Changes in EEG patterns
   a. "asthenic" signs
   b. predominance of inhibition process
   c. increased incidence of slow, high amplitude waves
   d. decreased incidence of alpha rhythms and waves
   e. predominance of "sleep" rhythms
2. Perceptual changes
   a. hallucinations (visual)
   b. decrease in ocular blind spot area
   c. shortening of optic chronaxie and reduction of rheobase
   d. auditory sensitivity changes
   e. decreased olfactory sensitivity
   f. increased olfactory activity
   g. parapsychologic phenomena
3. Alternating arousal and drowsiness
4. Stimulation of motor functions
5. Depression of mental functions
6. Involuntary motor reactions

deserves comment. His research on human subjects suggested that pulsed (10–1000 Hz) UHF fields of nonthermal intensity directed from bitemporal electrodes a few inches from the subject's head could induce inhibition similar to that produced by pulsed electrical currents (electrosleep). Unfortunately, this research was not described in detail by Ivanov-Muromskiy.

Drogichina (13) reported that CNS damage is characterized by the "asthenic syndrome" which can be detected from EEG and neurological findings. Presman (9), in reviewing Soviet, Czechoslovakian, and Polish work, reports that the EEG's of subjects exposed to weak (nonthermal) microwave field intensities show an increased incidence of slow, high amplitude waves. In Poland, Edelwejn and Baranski (14) reported a decreased incidence of alpha rhythms and a decreased percentage of alpha waves in subjects exposed to "high" (mW/cm²) intensities of microwave fields. All subjects examined in this study over-reacted to the administration of cardiozol, a respiratory and cardiac stimulant. In general, because of the rather primitive state-of-the-art of EEG analysis, these findings should be viewed with extreme caution.

Perceptual changes as a result of exposure to microwaves have also been frequently reported. Livshits (28) reported that "high intensity" microwaves had been found by Soviet workers to cause hallucinations. He also reported that high frequency, high intensity fields had been demonstrated to cause involuntary motor reactions in one healthy individual. Matuzov (29) noted visual perception changes after a 10 minute exposure to 10 cm microwaves of nonthermal (1.1 mW/cm²) intensity. He found a considerable decrease in blind spot area,

TABLE 6

Autonomic and cardiovascular effects of electromagnetic radiation

1. Changes in cardiac function (EKG)
   a. decreased spike amplitude
   b. lengthened QRS interval
   c. slowed auricular and ventricular conductivity
2. Bradycardia and tachycardia
3. Hyper- and hypotension
4. Increased precapillary resistance
5. Increased vascular elasticity

shortening of optic chronaxie, and reduction of rheobase in two subjects. These effects were judged to be nonthermal (specific) and were found to be reversible. Sheyvekhman (30) noted changes in auditory sensitivity (5–10 dB) in response to 6 meter waves pulse modulated at 300, 1000, or 4000 Hz applied for five minutes to the heads of human subjects. He did not clarify whether sensitivity was increased or decreased. Lobanova and Gordon (31) noted a decrease in olfactory sensitivity after exposure to microwaves and suggested that this response might be a good index for identifying harmful microwave effects. These authors also found an increase in olfactory excitability (decreased threshold) after a single dose of caffeine. This was suggested as evidence of functional olfactory changes caused by microwaves.

In the realm of parapsychology, it is interesting to note that leading Soviet researchers who strongly believe in the nonthermal CNS effects of microwaves are involved in the electromagnetic (centimeter wave) theory of extrasensory perception (3). This work, initiated in 1966, is being conducted for a special Bioinformation Section of the Scientific and Technical Society of Radiotechnology in Moscow. The results of Soviet ESP research have thus far been interesting but statistically inconclusive.

Both the stimulatory and inhibitory effects of microwaves on CNS function have been frequently documented by Soviet workers. Subbota (32) reported alternating arousal and drowsiness in response to microwaves in working with dogs. As mentioned earlier, the Soviet electrosleep expert, Ivanov-Muromskiy (27) concluded from his studies of human subjects that pulsed UHF fields could be used as a form of contactless electrosleep which he calls "radiosleep". Depression of mental function, inability to concentrate, and general sluggishness is frequently documented by Soviet and Eastern European researchers as a subjective response to microwave exposure.

Autonomic and Cardiovascular Responses

Reports of human autonomic and cardiovascular responses to microwaves are nearly as numerous as those documenting CNS responses to this factor (Table 6). Responses are noted for a wide range of frequencies at thermal and nonthermal field intensities and during acute and chronic exposure. Decreased EKG spike amplitudes have been noted by Drogichina (33) in subjects working around radiofrequency fields. Sadchikova (34) reported on various cardiovascular shifts in workers exposed to different field intensities (Table 7). Figar (15) and Smurova (35) have noted decreased coronary conductivity, sinusoidal arrythmia, brady- and tachycardia, and oscillating hypo- and hypertension. Monayenkova et al. (36) studied minute blood volume, peripheral resistance, average arterial pressure, and smooth muscle tonus using a mechanocardiograph. She found that a tendency toward hypertension, increased elasticity of myogenous vessels, increased precapillary resistance, sinus bradycardia, and changes in intracardiac conductivity were more often noted in exposed than in unexposed subjects. All of these changes were found to be reversible with one or two questionable exceptions.

There is some evidence that certain enzymes implicated in CNS function might be affected by exposure to microwaves (Table 8). Revuts'kyy et al. (37) found a change in the specific cholinesterase activity of erythrocytes in human whole blood with 13.56 and 23.75 MHz microwaves. The 13.56 MHz radiation was found to decrease blood histamine content while not altering cholinesterase activity. The 23.75 MHz radiation did not change blood histamine content but increased cholinesterase activity. Bartonicek et al. (38) surveyed the blood biochemistry of workers exposed to centimeter waves. Of a total of 27 blood sugar curves, 7 were flat, 7 were prediabetic, and four indicated slight glycosuria. The distribution of pyruvic and lactic acid and creatinine are shown in Table 9. Lactic acid was found to be decreased 2.5 times more than it was found to be increased. Roughly 75% of the subjects exposed to microwaves and examined by Bartonicek were reported to have prediabetic blood sugar curves. These metabolic shifts were attributed to autonomic dysregulation, possibly indicative to diencephalic lesions resulting from early exposure to centimeter

TABLE 7

Cardiovascular changes in subjects exposed to electromagnetic radiation (Sadchikova, 1964).

EMF parameters		Exposure/control ratio		
Range	Field intensity	hypertonia	bradycardia	increase of QRS interval (up to 0.1 sec)
SHF	1-several mW/cm²	1.85	24.0	11.5
	1 mW/cm²	2.0	16.0	12.5
UHF	nonthermal	1.2	8.0	21.0
LF	tens to hundreds V/M	9.21	12.0	—
	hundreds to 1000 V/M	1.2	5.0	—
Percent incidence in controls		14%	3%	2%

waves. Gel'fon and Sadchikova (39) noted increased blood globulins in 50% of a group exposed to microwaves which indicated a shift in the albuminglobulin coefficient. Haski (40) noted slight changes in the levels of blood sugar, cholesterol, and lipids of healthy subjects exposed to microwaves. However, there was a pronounced decrease in all three categories when diabetics were exposed.

Hematopoietic and Biochemical Responses

Numerous human hematopoietic changes have been reported to result from exposure to microwave fields (Table 10). The severity of these changes range from minimal to significant. Sokolov (41) noted reticulocytosis in radar workers. Baranski (42) observed that a small drop in erythrocytes occurs in all people exposed to microwaves and that the phenomenon is related to the duration and severity of exposure. About 50% of the subjects examined by Baranski showed a moderate decrease in platelet count. Lysina (43) noted basophilic granularity of erythrocytes and was of the opinion that this index should be taken as an initial sign of microwave effects on the human organism. Presman et al. (44) found that the osmotic resistance of erythrocytes was negatively affected by microwaves. Smurova (22) and others found that the shape and volume of erythrocytes changes as a result of exposure to microwave fields. Prolonged exposure was occasionally noted to result in hemolytic processes. An increase in the RNA level of lymphocytes was also noted by Smurova in workers chronically exposed to microwaves; this finding corresponded to a concomitant increase in monocytes (young cells) which contain the greatest quantity RNA. Baranski (42) detected various leukocyte shifts in workers exposed for one year to microwaves. Normalization of this index was found to occur after prolonged exposure to this factor. He also found a tendency towards lymphocytosis with accompanying eosinophilia in subjects exposed for more than five years to low and moderate microwave intensities.

Soviet workers have also found biochemical changes to occur in other sites (8). A drop in RNA content was noted in the spleen, liver, and brain in animals chronically exposed to microwaves while DNA content was found to remain constant.

TABLE 8

Neurohumoral responses to radiofrequency electromagnetic radiation

1. Altered cholinesterase activity in human whole blood (erythrocytes)
2. Decrease in blood histamine content
3. Increase in blood proteins
4. Altered carbohydrate metabolism
5. Changes in blood sugar, cholesterol, and lipids (pronounced in diabetics)
6. Decreased hemoglobin

Ocular Responses

Changes in human ocular function and eye pathology are widely documented and occur primarily

TABLE 9

Distribution of pyruvic and lactic acid and creatinine excretions in workers exposed to microwaves

	Pyruvic acid		Lactic acid		Creatinine	
	number	%	number	%	number	%
No. of measurements	40	100.0	35	100.0	34	100.0
Normal	28	70.0	14	40.0	14	41.2
Increased	4	10.0	6	17.2	6	17.6
Lowered	8	20.0	15	42.8	14	41.2
Averages	0.77 mg%		14 mg%		1.33 mg%	
Controls	0.65 mg%		17 mg%		1.30 mg%	
Established standard	0.5—1.0		10—20		1.2—1.9	

after acute or chronic exposure to thermogenic microwave intensities (Table 11). As mentioned earlier, one Soviet worker (28) has reported that exposure to intense microwave fields was noted to cause hallucinations. Matuzov (29) found the area of the blind spot to decrease after exposure to nonthermogenic (10 cm; 1.1 mW/cm²) microwave field intensities. Other Soviet workers, as reported by Marha (8), have found that microwave radiation (a few mW/cm²) can cause a decrease in sensitivity to color (blue) and difficulty in detecting white objects. Changes in intraocular pressure have also been noted by Soviet workers as have altered sensitivity to light stimuli during exposure to pulsed and nonpulsed fields. General ocular pain, eye strain and fatigue, eyelid tremor, and lacrimation are also common symptoms noted by Soviet workers.

Pathological changes in the eye (cataracts) occur primarily as a result of exposure to thermogenic (greater than 10 mW/cm²) microwave intensities. Sadchikova (45) and other Soviet workers (6) have noted unilateral and bilateral cataracts to occur in subjects exposed to several mW/cm² field intensities. Presman (44) noted a drop in vitamin C content in the lens and anterior chamber fluid at nonthermogenic intensities. In the event of acute cataract development a decrease in ATP and pyrophosphatase activity of the lens was noted. In addition, it is suspected that damage to tissue respiration and oxidation mechanisms as a result of exposure to microwaves can lead to cataract formation.

There is some evidence that ocular responses to microwaves are frequency dependent. Pol (46) noted that 10 GHz fields caused anterior lens opacity while 2.45 GHz cause posterior opacity.

Belova (47) noted that in 370 microwave generator workers exposed to mW/cm², lacrimation, ocular fatigue, and frequent conjunctival irritation would occur at the end of each working day. Zydecki (48) suggested that all candidates for occupation around microwave sources receive comprehensive ophthalmological examinations. This suggests that certain ophthalomological profiles might be more vulnerable to microwave radiation than others.

TABLE 10

Hematopoietic and biochemical responses to electromagnetic radiation

1. Blood
   a. reticulocytosis
   b. basophilic granularity of erythrocytes
   c. decrease in erythrocytes, platelets and hemoglobin
   d. altered osmotic resistance of erythrocytes
   e. neutrophilic leukocytosis
   f. lymphocytosis, monocytosis, and eosinophilia
   g. increased RNA in lymphocytes
2. Organs
   a. Decreased RNA content in brain, liver, and spleen

Endocrine Responses

Damage to sex glands and functions have frequently been documented to occur after chronic exposure to primarily thermal microwave fields (Table 12). Marha (8) in reviewing Soviet and East European findings noted decreased spermatogenesis, altered sex ratio of births, changes in menstruation, retarded fetal development, congential effects in newborn babies, decreased lactation in nursing mothers, and other related responses to occur as a result of exposure to thermal (i.e., greater than 10 mW/cm²) microwave intensities. Microwaves were also implicated in an increase in the percentage of miscarriages in both humans and animals. Some of these findings reported by Marha are consistent with subjective complaints reported by Soviet researchers such as decreased sex activity, mentioned earlier. Specific genetic changes resulting from exposure to either thermal or nonthermal microwave fields have yet to be demonstrated.

TABLE 11

Effects of electromagnetic radiation on the eye

1. Perceptual and function changes
   a. hallucinations
   b. decrease in size of blind spot
   c. decreased sensitivity to color (blue)
   d. difficulty in detection of white objects
   e. decreased sensitivity to light stimuli in dark adapted eye
   f. change in intraocular pressure
   g. lacrimation, ocular fatigue, and ocular pain
   h. trembling of the eyelids
   i. altered tissue respiration and oxidation-reduction processes
2. Pathological changes
   a. lens coagulation (cataracts)
   b. decrease in vitamin C content of lens and vitreous humor
   c. decrease in ATP and pyrophosphinatase activity
   d. anterior and posterior lens opacity
   e. conjunctival irritation

Soviet sources have reported pituitary and other endocrine responses to microwave exposure. Kolesnik (49) suggested that pituitary-hypophyseal-adrenal changes were primarily due to CNS influences on the hypophysis after exposure to microwaves. Drogichina (33, 50), Sadchikova (21, 34), and Smirnova (51) have reported thyroid gland enlargement and increased iodine-131 uptake. These changes suggest an increase in thyroid stimulating hormone (6). Hasik (40) and Presman (44) noted increased activity of the adrenal cortex to occur after microwave exposure. Murashov (52) studied 20 subjects occupationally exposed to UHF fields. He noted a reduction in plasma corticosteroid content which was attributed to lowered adrenal, or possibly sex gland androgenic activity.

TABLE 12

Endocrine responses to radiofrequency radiations

1. Sex organs and ontogenesis
   a. thermal trauma (tissue damage) to male reproductive tissues
   b. decreased spermatogenesis (sterility)
   c. altered sex ratio of births (more girls)
   d. altered menstrual activity
   e. altered fetal development
   f. decreased lactation in nursing mothers
2. Endocrine glands
   a. altered pituitary and pituitary-hypophyseal function (CNS)
   b. hyperthyroidism
   c. thyroid enlargement
   d. increased iodine-131 uptake
   e. increased adrenal cortex activity
   f. decreased corticosteroids in blood
   g. decreased glucocorticoidal activity

Miscellaneous Responses

Loshak (53) reported that various human responses, such as subjective complaints as a result of chronic microwave exposure, appeared to vary slightly with climate (Table 13). In general, responses to microwave fields were more pronounced in hot, dry climates. It was found that the electrical resistance of the skin of exposed workers was lower than in unexposed workers in a hot climate. Decreased resistance was attributed both to CNS stimulation or increased sympathetic tonus due to skin receptor reactions. These findings, while not dramatic, led Loshak to speculate that special hygienic considerations for workers exposed to microwaves in a hot climate should be exercised (improved ventilation etc.).

TABLE 13

Miscellaneous effects on electromagnetic radiation

1. Climatic effects
   a. responses to electromagnetic radiation more pronounced in hot climate
   b. decreased electrical resistance of skin in hot climate due to electromagnetic radiation
2. Internal Organs
   a. dyspepsia and epigastric pain
   b. decreased appetite
   c. liver enlargement

[illegible]

TABLE 12

NON-THERMAL EFFECTS AND MECHANISMS OF INTERACTION BETWEEN ELECTROMAGNETIC FIELDS AND LIVING MATTER

An ICEMS Monograph

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Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system

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Abstract

Aim: **The effect of pulsed (100 Hz) microwave (MW) radiation on heart rate variability (HRV) was tested in a double blind study.** ***Materials and Methods:*** **Twenty-five subjects in Colorado between the ages of 37 to 79 completed an electrohypersensitivity (EHS) questionnaire. After recording their orthostatic HRV, we did continuous real-time monitoring of HRV in a provocation study, where supine subjects were exposed for 3-minute intervals to radiation generated by a cordless phone at 2.4 GHz or to sham exposure.** ***Results:*** **Questionnaire: Based on self-assessments, participants classified themselves as extremely electrically sensitive (24%), moderately (16%), slightly (16%), not sensitive (8%) or with no opinion (36%) about their sensitivity. The top 10 symptoms experienced by those claiming to be sensitive include memory problems, difficulty concentrating, eye problems, sleep disorder, feeling unwell, headache, dizziness, tinnitus, chronic fatigue, and heart palpitations. The five most common objects allegedly causing sensitivity were fluorescent lights, antennas, cell phones, Wi-Fi, and cordless phones. Provocation Experiment: Forty percent of the subjects experienced some changes in their HRV attributable to digitally pulsed (100 Hz) MW radiation. For some the response was extreme (tachycardia), for others moderate to mild (changes in sympathetic nervous system and/or parasympathetic nervous system). and for some there was no observable reaction either because of high adaptive capacity or because of systemic neurovegetative exhaustion.** ***Conclusions:*** **Orthostatic HRV combined with provocation testing may provide a diagnostic test for some EHS sufferers when they are exposed to electromagnetic emitting devices. This is the** ***first study that documents immediate and dramatic changes in both*** **Hearth Rate (HR) and HR variability (HRV) associated with MW exposure at levels**

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well below (0.5%) federal guidelines in Canada and the United States (1000 microW/cm^2).

***Key Words*: heart rate variability, microwave radiation, DECT phone, autonomic nervous system, provocation study, sympathetic, parasympathetic, cordless phone, 2.4 GHz, electrohypersensitivity**

Introduction

A growing population claims to be sensitive to devices emitting electromagnetic energy. Hallberg and Oberfeld[1] report a prevalence of electrohypersensitivity (EHS) that has increased from less than 2% prior to 1997 to approximately 10% by 2004 and is expected to affect 50% of the population by 2017. Whether this is due to a real increase in EHS or to greater media attention, is not known. However, to label EHS as a psychological disorder or to attribute the symptoms to aging and/or stress does not resolve the issue that a growing population, especially those under the age of 60, are suffering from some combination of fatigue, sleep disturbance, chronic pain, skin, eye, hearing, cardiovascular and balance problems, mood disorders as well as cognitive dysfunction and that these symptoms appear to worsen when people are exposed to electromagnetic emitting devices[2-7].

The World Health Organization (WHO) organized an international seminar and working group meeting in Prague on EMF Hypersensitivity in 2004, and at that meeting they defined EHS as follows[8]:

". . . a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields (EMFs) . . . Whatever its cause, EHS is a real and sometimes a debilitating problem for the affected persons . . . Their exposures are generally several orders of magnitude under the limits in internationally accepted standards."

The WHO goes on to state that:

"EHS is characterized by a variety of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation and digestive disturbances). The collection of symptoms is not part of any recognized syndrome."

Both provocation studies (where individuals are exposed to some form of electromagnetic energy and their symptoms are documented) and amelioration studies (where exposure is reduced) can shed light on the offending energy source and the type and rate of reaction.

Several amelioration studies have documented improvements in the behavior of students and the health and wellbeing of teachers[9], among asthmatics[10], and in both diabetics and those with multiple sclerosis[11,12] when their exposure to dirty electricity is reduced. Dirty electricity refers to microsurges flowing along electrical wires in the kHz range that can damage sensitive electronic equipment and, it appears, affect the health of those exposed.

In contrast to amelioration studies, provocation studies, examining the response of people with self-diagnosed EHS, have generated mixed results.

Rea *et al.*[13] were one of the first to show that sensitive individuals responded repeatedly to several frequencies between 0.1 Hz and 5 MHz but not to blank challenges. Reactions were mostly neurological and included tingling, sleepiness, headache, dizziness, and - in severe cases - unconsciousness, although other symptoms were also observed including pain of various sorts, muscle tightness particularly in the chest, spasm, palpitation, flushing, tachycardia, etc. In addition to the clinical symptoms, instrument recordings of pupil dilation, respiration, and heart activity were also included in the study using a double-blind approach. Results showed a 20% decrease in pulmonary function and a 40% increase in heart rate. These objective instrumental recordings, in combination with the clinical symptoms, demonstrate that EMF sensitive individuals respond physiologically to certain EMF frequencies although responses were robust for only 16 of the 100 potentially sensitive individuals tested.

In a more recent review, Rubin *et al.*[14] concluded that there was no robust evidence to support the existence of a biophysical hypersensitivity to EMF. This was based on 31 double-blind experiments that tested 725 EHS subjects. Twenty-four studies found no difference between exposure and sham conditions and of the seven studies that did find some evidence that exposure affected EHS participants, the research group failed to replicate the results (two studies) or the results appeared to be statistical artifacts (three studies).

Those who live near antennas and those who suffer from EHS often complain of cardiovascular problems such as rapid heart rate, arrhythmia, chest pain, and/or changes in blood pressure[3,7,15,16].

Indeed, the doctors who signed the Freiburger Appeal[17] stated the following:

> *"We have observed, in recent years, a dramatic rise in severe and chronic disease among our patients especially . . . extreme fluctuations in blood pressure, ever harder to influence with medications; heart rhythm disorders; heart attacks and strokes among an increasingly younger population . . ."*

Based on these findings we decided to study the affect of microwave (MW) radiation generated by a digital cordless phone on the cardiovascular system by monitoring heart rate variability (HRV). Unlike cell phones that radiate microwaves only when they are either transmitting or receiving information, the cordless phone we used radiates constantly as long as the base of the phone is plugged into an electrical outlet. The phone we used was an AT&T digitalally pulsed (100 Hz) cordless telephone that operates at 2.4 GHz or frequencies commonly used for microwave ovens and Wi-Fi. It resembles its European version know as a Digital Enhanced Cordless Telecommunications (DECT) phone that operates at 1.9 GHz[18].

HRV is increasingly used for screening cardiovascular and neurological disorders[19-24]. We wanted to determine whether HRV could be used as a tool to diagnose EHS and whether it could be used to predict probability and/or intensity of the reaction to a MW provocation. The HRV analysis, using NervExpress software[25,26], provides information about the functioning of the sympathetic and parasympathetic nervous system with real time monitoring and provides additional information including a pre-exposure fitness score based on the orthostatic test.

Materials and methods

Background electromagnetic environment

Testing was done in two locations, one in Golden and the other in Boulder, Colorado, on three separate weekdays during a 6-day period (Table 1). Background levels of low frequency magnetic fields, intermediate frequency radiation on electrical wires, and radio frequency radiation were monitored at each location and the values are provided in Table 1. All testing of the electromagnetic environment was done in the area where volunteers were tested for their heart rate variability during the provocation study.

The extremely low frequency **magnetic field** was measured with an omni-directional Trifield meter. This meter is calibrated at 60 Hz with a frequency-weighted response from 30 to 500 Hz and a flat response from 500 to 1000 Hz. Accuracy is ± 20%.

Power quality was measured with a Microsurge Meter that measures high frequency transients and harmonics between 4 and 150 kHz (intermediate frequency range). This meter provides a digital reading from 1 to 1999 of dv/dt expressed as GS units with a +/-5% accuracy[27]. Since we were trying to ensure low background exposure, we installed GS filters to improve power quality. The results recorded are with GS filters installed.

Within at least 100 m of the testing area, all wireless devices (cell phones, cordless phones, wireless routers) were turned off. **Radio frequency radiation** from outside the testing area was measured with an Electrosmog Meter, which has an accuracy of ±2.4 dB within the frequency range of 50 MHz to 3.5 GHz. Measurements were conducted using the omni-directional mode and were repeated during the testing. This meter was also used to determine the exposure of test subjects during provocation with a digital cordless phone. This **cordless phone** emits radio frequency radiation when the base station is plugged into an electrical outlet. This happens even when the phone is not in use. We used the base station of an AT&T 2.4 GHz phone (digitally pulsed at 100 Hz) to expose subjects to MW radiation[18]. The emission of MWs at different distances from the front of the base station is provided in fig. 1.

Testing of subjects

Subjects were **recruited** by word-of–mouth based on their availability during a short period of testing. Of the 27 people who volunteered to be tested, two were excluded, one based on age (less than 16 years old) and another based on a serious heart condition.

Subjects were asked to complete a wellness and EHS **questionnaire**. They were then asked questions about their age, height, weight, blood type, time of last meal, and occupation (in the event of occupational exposure to electromagnetic fields/radiation).

Table 1 - Measurements of the electromagnetic environment at each testing location

Location Colorado	*Date*	*Magnetic Field* 30 - 1000 Hz mG	*Power Quality* 4 - 150 kHz GS units	*Radio Frequency Radiation* 50 MHz – 3.5 GHz microW/cm^2
Golden	10/16/08	3 – 15	140	0.8
Boulder	10/20/08	0.4	37	<0.01
Boulder	10/21/08	0.4	80	<0.01

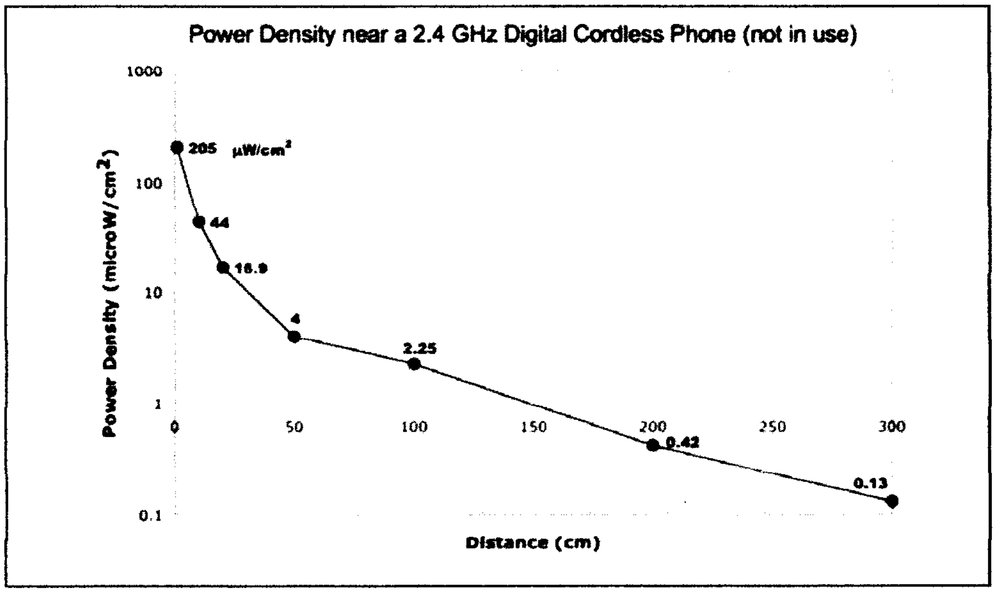

Fig. 1. Radiation near a 2.4 GHz AT&T digital cordless phone when the base station of the phone is plugged into an electrical outlet and the phone is not in use

We measured resting heart rate and blood pressure using a Life Source UA-767 Plus digital blood pressure monitor; saliva pH with pH ion test strips designed for urine and saliva (pH range 4.5-9.0), and blood sugar with ACCU-CHEK Compact Plus.

In an attempt to address the question: "Is there a simple test that relates EHS with the electrical environment of the human body?", we measured galvanic skin response (GSR), body voltage, and the high and low frequency electric and magnetic field of each subject.

Wrist-to-wrist galvanic skin response was measured as an indicator of stress using a Nexxtech voltmeter (Cat. No. 2200810) set at 20 volts DC and attached to the inner wrist with a Medi Trace 535 ECG Conducive Adhesive Electrodes Foam used for ECG monitoring. Capacitively coupled "body voltage" was measured with a MSI Multimeter connected to a BV-1 body voltage adaptor. The subject's thumb was placed on one connector and the other connector was plugged into the electrical ground, which served as the reference electrode. High frequency (HF) and low frequency (LF) electric and magnetic fields were measured with a Multidetektor II Profi Meter held at approximately 30 cm from the subject's body, while the subject was seated.

HRV testing

Two types of HRV testing were conducted. The first was an *orthostatic* test and the second was *continuous monitoring* of heart rate variability with and without provocation (exposure to MW frequencies from a digital cordless phone). NervExpress software was used for HRV testing[25]. NervExpress has both CE and EU approval and is a Class Two Medical Device in Canada and in the European Union. An electrode belt with transmitter was placed on the person's chest near the heart, against the skin. A wired HRV cable with receiver was clipped to the clothing near the transmitter and connected to the COM port of the computer for acoustical-wired transmission (not wireless). This provided continuous monitoring of the interval between heartbeats (R-R interval).

For the *orthostatic* testing subject laid down on his/her back and remained in this position for 192 R-R intervals or heartbeats (approximately 3 minutes), at which time a beep from the computer indicated that the person stand up and remain standing until the end of the testing period, which was 448 intervals (approximately 7 minutes depending on heart rate).

For the *provocation* testing, subject remained in a lying down position for the duration of the testing. A digital cordless phone base station, placed approximately 30 to 50 cm from subject's head, was then connected randomly to either a live (real exposure) or dead (sham exposure) extension cord. It was not possible for the subject to know if the cordless phone was on or off at any one time. Continuous real-time monitoring recorded the interval between each heartbeat. Data were analyzed by timed stages consisting of 192 R-R intervals (heartbeats).

The sham exposures are referred to as either pre-MW exposure or post-MW exposure to differentiate the order of testing. Since type of exposure was done randomly in some instances either the pre-MW or the post-MW is missing. Subjects who reacted immediately to the cordless phone were retested with more real/sham exposures. When subject was exposed multiple times, only the first exposure was used for comparison. Provocation testing took between 9 to 30 minutes per subject.

After the initial testing, treatments (deep breathing, laser acupuncture, Clean Sweep) that might alleviate symptoms were tried on a few subjects but these results will be reported elsewhere.

Interpretation of HRV results

The results for the orthostatic testing and provocation testing were sent to one of the authors (JM) for interpretation. An example of the type of information send is provided in fig. 2 (orthostatic) and fig. 3 (provocation). No information was provided about the subject's self-proclaimed EHS and the information about exposure was blinded. JM did not examine the provocation results until he reviewed the orthostatic results. No attempt was made to relate the two during this initial stage of interpretation.

Predicting response and health based on orthostatic test

For the orthostatic testing JM provided a ranking for cardiovascular tone (CVT), which is based on the blood pressure and heart rate (sum of systolic and diastolic blood pressure times heart rate) and provides information on whether the cardiovascular system is hypotonic (<12,500) or hypertonic (>16,500). We used a 5-point ranking scale as follows: Rank 1: < 12,500, hypotonic; Rank 2: 12,500 to 14,000; Rank 3: 14,000 to 15,500; Rank 4: 15,500 to 16,500; Rank 5: > 16,500, hypertonic.

Non-Adaptive Capacity (NAC)[a] was ranked on a 5-point scale with 1 indicating highly adaptive and 5 indicating highly non-adaptive. This was based on a balanced sympathetic (SNS) and parasympathetic (PSNS) nervous system (average orthostatic response within ±1 standard deviation from center on graph) and on the overall fitness

[a] Later Adaptive Capacity (AC) was used, which is the inverse of NAC.

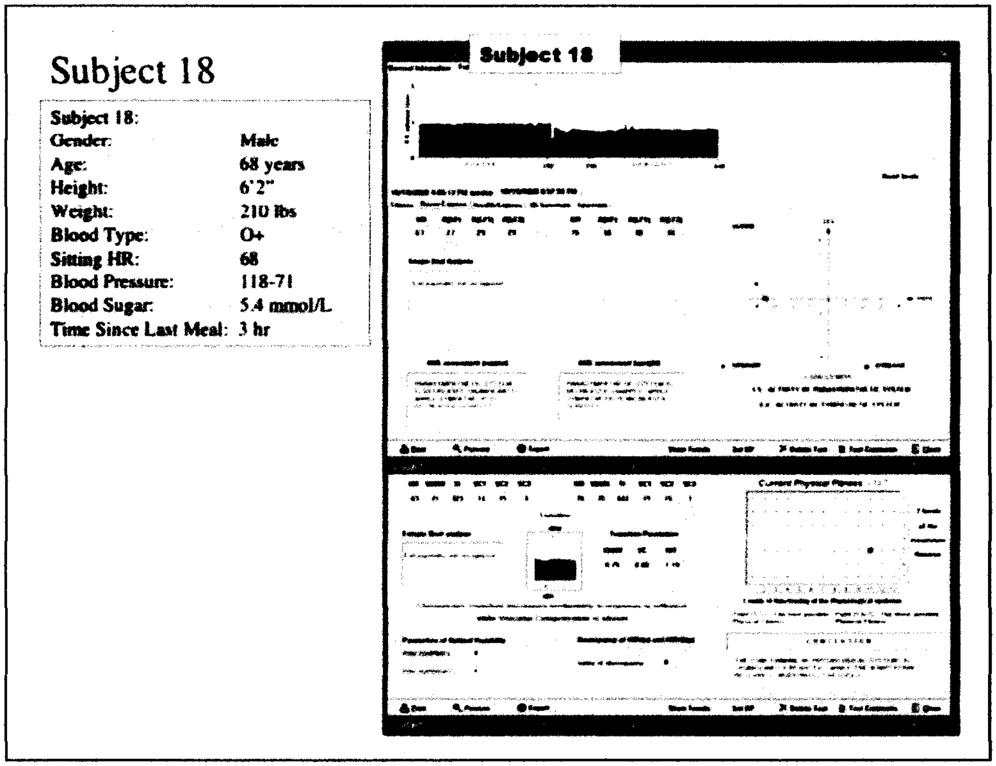

Fig. 2. Orthostatic HRV information provided for blinded analysis of Subject 18

score. The closer to normal value of the autonomic nervous system (ANS) in a given subject, the less likely they are to react, since their adaptive capacity is high. "Normal" refers to the balanced SNS/PSNS and the appropriate direction of movement under stress, in this case when person stood up. Direction of movement is shown in the NervExpress graph (fig. 2). Appropriate direction of movement would be either up 1 standard deviation (small increase in SNS and no change in PSNS); up and to the left 1 standard deviation each (small increase in SNS and small decrease in PSNS); or to left (no change in SNS and slight decrease in PSNS). For those who move further to the left (greater down regulation of PSNS) or further up and to the left (greater up regulation of SNS combined with a greater down regulation of PSNS), the less likely they are to adapt and the more likely they are to react. Likewise, if the fitness score is high or adequate, the individual would be capable of resisting the stressor. An adequate physical fitness score is between 1:1 and 10:6. The first number refers to the functioning of the physiological system and the second is the adaptation reserve. The lower the numbers the greater the level of fitness in each category. Note, if a subject with good or adequate fitness was to be a reactor to MW stress, his/her reaction would be both rapid and strong.

Probability of Reaction (POR) was ranked on a 5-point scale with "1" indicating low probability of a reaction and "5" indicating high probability of a reaction to stress of any kind. Criteria were similar to the NAC. However, greater consideration was given to the Chronotropic Myocardial Reaction Index (ChMR) value and the dysautonomic

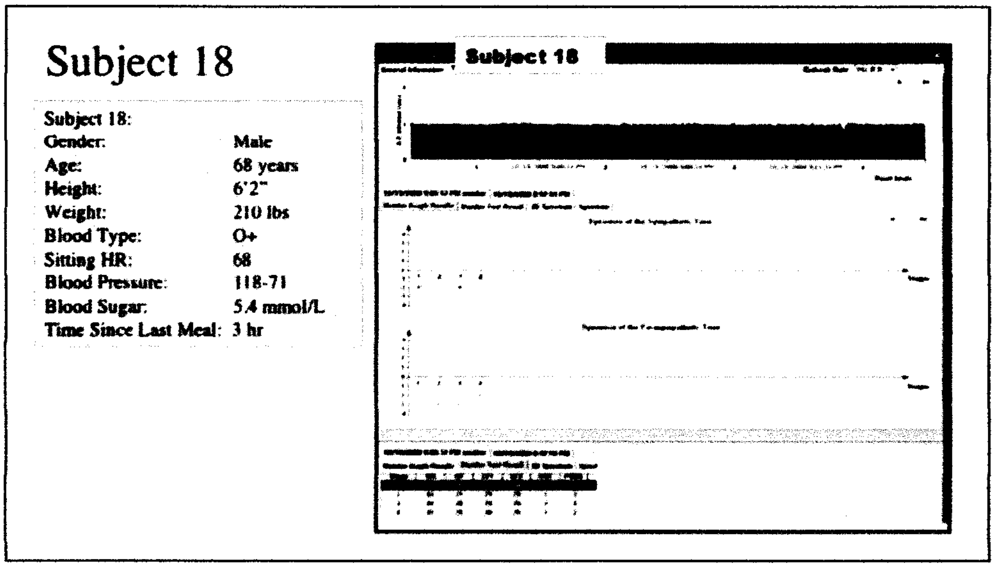

Fig. 3. Continuous monitoring of HRV with real and sham exposure to MW radiation from a digital cordless phone. Information provided for blinded analysis of Subject 18

status (average of orthostatic test is more than two standard deviations from center or up to the right) of the subject, whereby individuals with compromised ANS and a poor ChMR ranking (outside the range of 0.53 to 0.69) would be most likely to react and *vice versa*.

A potential non-responding reactor is someone with low energy, average orthostatic response in lower left quadrate, and a physical fitness score between 10:6 and 13:7. Subject 18 in fig. 2 is a borderline non-responding reactor. Note, this does not necessarily imply that this person is hypersensitive, only that he probably does not have enough energy to mount a reaction even if he was EHS.

JM also provided his comments on the health status of the subject based on the rhythmogram, autonomic nervous system assessment (changes in the SNS and PSNS), Fitness Score, Vascular Compensation Reaction (VC), ChMR, Compensation Response (CR), Ortho Test Ratio (OTR), Parameters of Optimal Variability (POV), Index of Discrepancy (ID); and Tension Index (TI). The interpretation of the HRV parameters is dependant to a certain degree on the integration of all the data provided as a whole with value being given to the total ANS picture presented. Those skilled in the art and science of HRV analysis should reach similar interpretive assessment of the data presented here[26].

Blinded analysis of provocation results

The blinded data for the continuous monitoring of heart rate variability with real and sham exposure were sent to JM for analysis (fig. 3). JM attempted to identify the stage during which exposure took place, stage during which the subject reacted, and then ranked symptom probability (5-point scale) and intensity (non-reactive, mild, moderate, intense). The assessment is provided in Appendix A.

Wellness and EHS Questionnaire

Prior to any testing, each subject was asked to complete a wellness and EHS questionnaire. This was designed on surveymonkey (www.surveymonkey.com) and was administered in paper format. This questionnaire was analyzed separately from the HRV data.

Results

Background electromagnetic environment

The two environments, where we conducted the testing, differed in their background levels of EMF and electromagnetic radiation (EMR). The Golden site had high magnetic fields (3-15 mG), high levels of dirty electricity (140 GS units) despite the GS filters being installed, and elevated levels of radio frequency (RF) radiation (0.8 microW/cm^2) coming from 27 TV transmitters on Lookout Mountain within 4 km of our testing environment. Despite RF reflecting film on windows the RF levels inside the home were elevated. The Boulder environment was relatively pristine and differed only with respect to power quality on the two days of testing (Table 1).

The cordless phone, used for provocation, produced radiation that was maximal at the subject's head (3 to 5 microW/cm^2) and minimal at the subject's feet (0.2 to 0.8 microW/cm^2) depending on height of subject and the environment. The cordless phone did not alter magnetic field or power quality.

Participants

A total of 25 subjects were included in this pilot study, ranging in age from 37 to 79 with most (40%) of the subjects in their 50s (Table 2). Eighty percent were females. Approximately half of the participants had normal body mass index and the other half were either overweight (28%) or obese (16%)[28]. Mean resting heart rate for this group was 70 (beats per minute) and ranged from 53 to 81. Blood pressure fell within a normal range for 40% of participants and fell within stage 1 of high blood pressure for 16% of the subjects[29]. None of the subjects had pacemakers, a prerequisite for the study. Forty percent had mercury amalgam fillings and 28% had metal (artificial joints, braces, etc.) in their body. This is relevant as metal implants and mercury fillings may relate to EHS[30].

Questionnaire

Self-perceived Electrosensitivity

One third of participants did not know if they were or were not electrically sensitive, 40% believed they were moderately to extremely sensitive, 16% stated that they had a little sensitivity, and 8% claimed they were not at all sensitive. Their sensitivity was slightly debilitating for 24% and moderately debilitating for 20% of participants (fig. 4).

Reaction time for symptoms to appear after exposure ranged from immediately (12%) to within 2 hours (4%) and was within 10 minutes for the majority of those who believe they react (28%) (fig. 5). Recovery time ranged from immediately to within 1 day with

Table 2 - Information about participants

		#	%
Gender	Male	5	20%
	Female	20	80%
Age	Mean and Range	60 years	37-79 years
Age Class	20s	1	4%
	30s	1	4%
	40s	2	8%
	50s	10	40%
	60s	5	20%
	70s	7	28%
BMI[a]	obese	4	16%
	overweight	7	28%
	normal	13	52%
	underweight	1	4%
Resting Heart Rate	Mean and Range	70 bpm	53-81 bpm
Blood Pressure[b]	Normal	10	40%
	Pre-hypertension	11	44%
	High Blood Pressure	4	16%
Metal in Body	Pace maker	0	0%
	Mercury fillings	10	40%
	Other metal	7	28%

[a] BMI = Body Mass Index based on height and weight[28]
[b] Blood Pressure (BP) according to National Heart Lung and Blood Institute (nd)[29]

only 4% claiming to recover immediately. Several participants noted that the rate of reaction and recovery is a function of the severity of their exposure and their state of health. The more intense the exposure the more rapid their response and the slower their rate of recovery. These results may have a bearing on the provocation study as we are testing an immediate reaction/recovery response (~3 minutes) to a moderate intensity exposure (3 to 5 $\mu W/cm^2$) and the percent that claims to respond quickly is low among this group.

Symptoms

The most common symptoms of exposure to electrosmog, as identified by this group of participants, included poor short-term memory, difficulty concentrating, eye problems, sleep disorder, feeling unwell, headache, dizziness, tinnitus, chronic fatigue and heart palpitations (fig. 6, upper graph). Of the symptoms commonly associated with EHS, heart palpitations (10th), rapid heartbeat (18th), arrhythmia (21st), and slower heartbeat (23rd) are the only ones we would be able to identify with HRV testing. For most participants who claim to react, reactions are mild to moderate.

All of the symptoms, except high blood pressure, arrhythmia, and slower heartbeat, were experienced several times per day (daily) or several times per week (weekly) by at least one or more participants. The patterns for symptom severity and frequency are similar (fig. 6, upper *vs* lower graph). Some of the symptoms (feeling unwell, pain, chronic fatigue, gas/bloat, skin problems) were experienced several times each month (monthly) may relate to menses in pre-menopausal or peri-menopausal women (16 women).

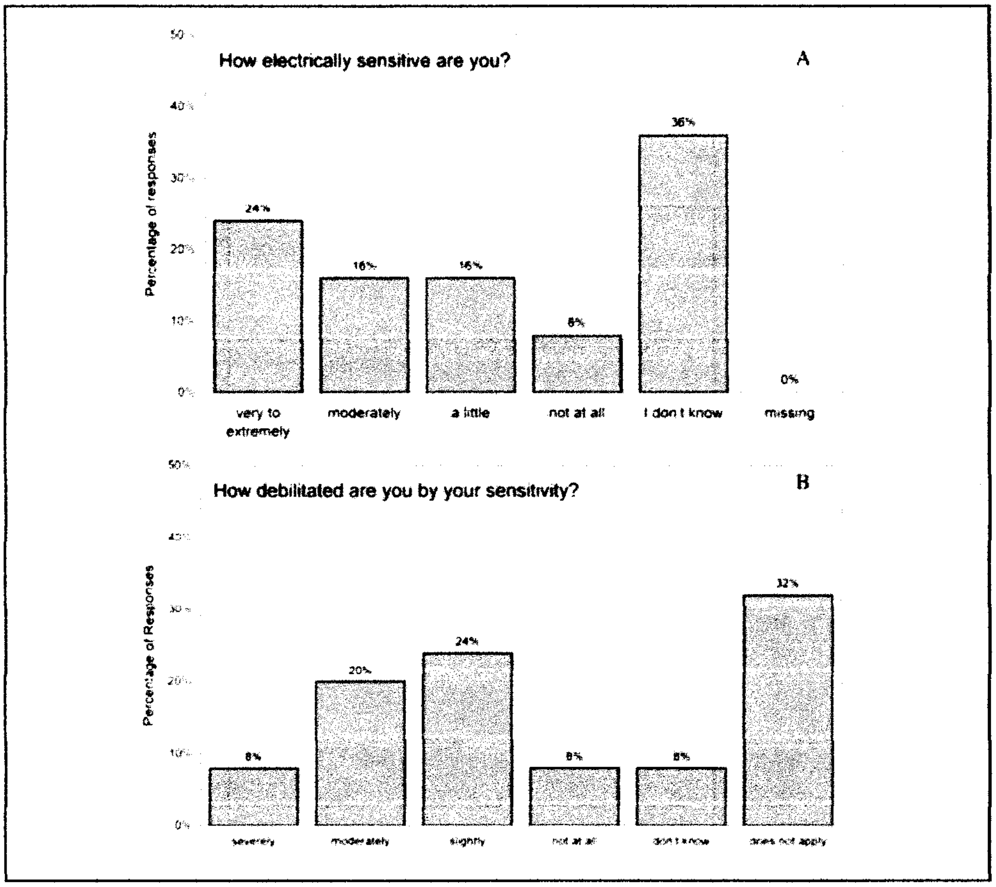

Fig. 4. Self-proclaimed electrosensitivity of participants (n=25)

A large percentage of participants had food allergies (64%), mold/pollen/dust allergies (48%), pet allergies (20%), and were chemically sensitive (36%) (fig. 7).

Some also had pre-existing health/medical conditions (fig. 8). The top five were anxiety (28%); hypo-thyroidism (24%); autoimmune disorder (20%), depression (16%) and high blood pressure (16%). Note these may be self-diagnosed rather than medically diagnosed conditions.

Objects contributing or associated with adverse health symptoms

Among the objects identified as contributing to adverse health symptoms, tube fluorescent lights were at the top of the list with more than 40% of participants reacting *often* or *always* (fig. 9). The next 4 items on the list (antennas, cell phones, Wi-Fi, cordless phones) all emit microwave radiation. According to this figure 16% of subjects respond to cordless phones *often* or *always* and their responses may include headaches, dizziness, depression, which we are unable to monitor with HRV.

Fifty-two percent stated they are debilitated by their sensitivity, 24% slightly, 20% moderately, and 8% severely. Some have difficult shopping, which may relate to

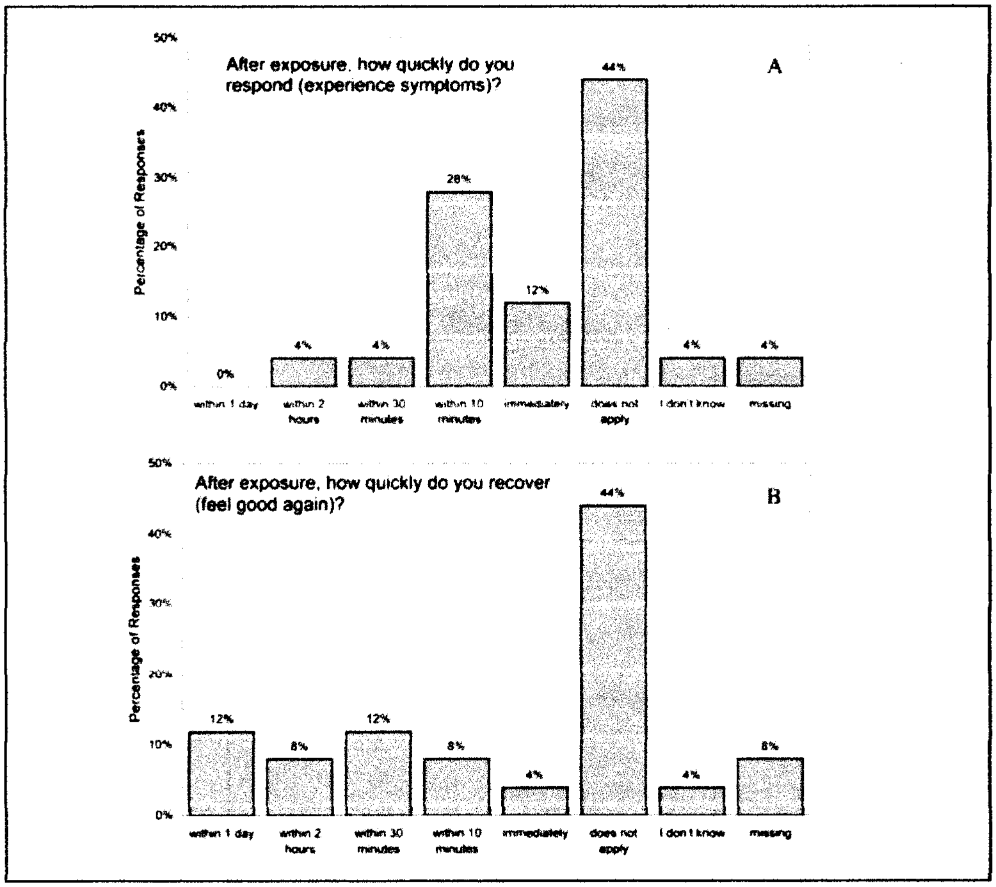

Fig. 5. Self-proclaimed response time of participants to electro-stress and recovery (n=25)

lighting in stores. Others have difficulty flying or traveling by car, perhaps due to microwave exposure on highways and in airplanes. A few subjects are unable to use mobile phones and computers and are unable to watch television. Some are unable to wear jewelry because it irritates the skin and/or watches because they often malfunction (fig. 7).

EHS and person's EMF

The body voltage, as measured by the potential difference between the subject and the electrical ground, differed at the two sites. Subjects at Golden had much higher values than those at Boulder. This was also the case for the high and low frequency electric field and for the HF and LF magnetic field (Table 3). Galvanic skin response was highly variable among subjects prior to testing and did not relate to either sensitivity or the environment. There was no association between any of the EMF measurements (body voltage, GSR, electric field or magnetic field) that we conducted prior to testing and EHS of the subjects tested. In a follow-up study it would be useful to monitor each person's EMF before, during, and after exposure.

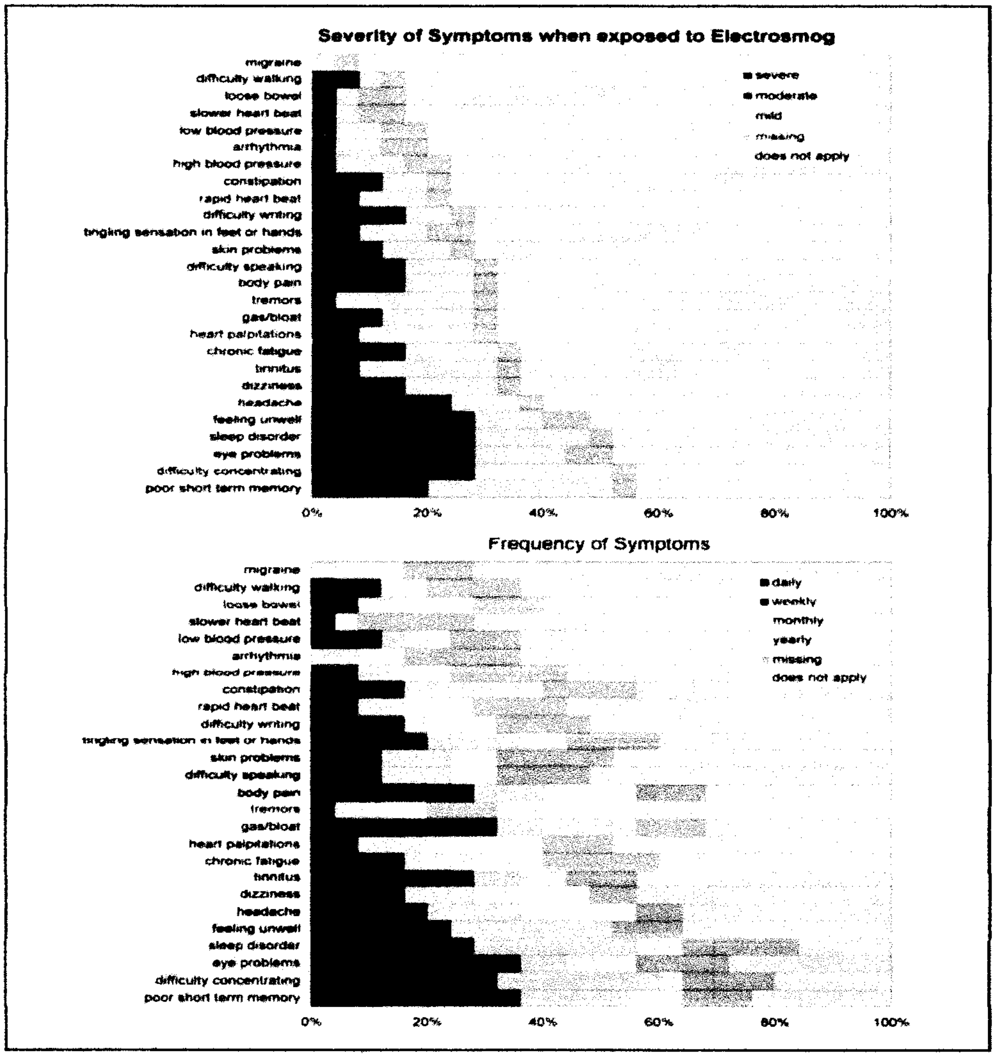

Fig. 6. Severity and frequency of symptoms associated with electrosmog exposure (n=25)

Blind assessment of responses: orthostatic HRV provocation HRV

The Orthostatic HRV provided us with the state of the ANS and the relative fitness score of the individual prior to exposure, which is important for predicting the intensity outcome of exposure.

A summary of the orthostatic HRV (blinded analysis) along with the self-assessment and the provocation HRV (blinded and unblinded) are provide in Appendix A for each subject. For those individuals who had either a moderate or intense response, the blinded predictions show good agreement for stage of exposure and for intensity of exposure.

Based on the orthostatic test, those with high adaptive capacity had a lower probability of reacting to stress, but if they did react, their reaction would be moderate to

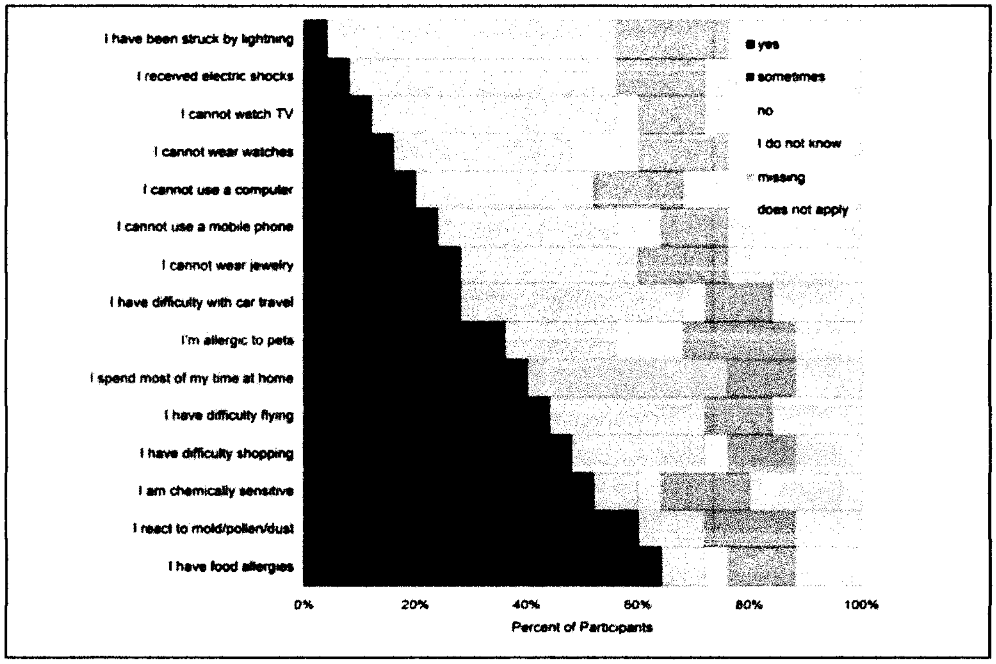

Fig. 7. Response to specific questions that may contribute to or be associated with electrical sensitivity (n=25)

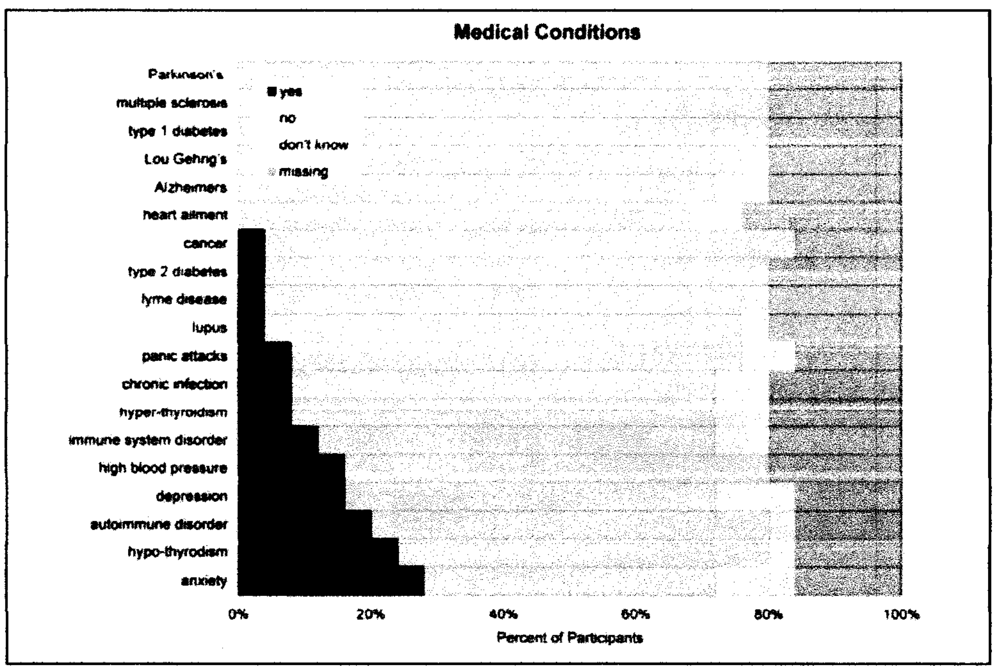

Fig. 8. Existing medical conditions of participants (n=25)

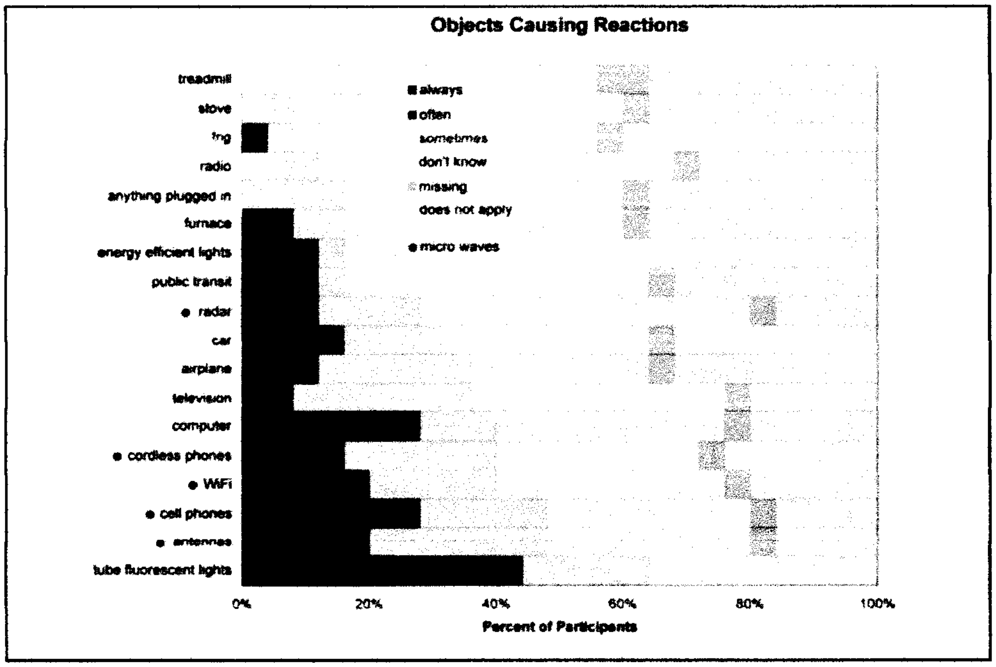

Fig. 9. Objects contributing to adverse health symptoms. Those marked with a dot generate microwave frequencies (n=25)

Table 3 - Personal electromagnetic environment (mean ± standard deviation) of subjects tested including galvanic skin response (GSR), body voltage, electric (E-field) and magnetic fields (M-field) at both high and low frequency (HF and LF) [* P ≤0.05].

Location	Date	GSR mV	Body Voltage mV	E-field HF mV	E-field LF mV	M-field HF mG	M-field LF mG
Golden	10/16/08	3.5 ± 1.8	3.4 ± 0.5*	88 ± 85*	333 ± 71*	4.6 ± 5.7*	17 ± 14*
Boulder	10/20/08	3.2 ± 2.5	0.5 ± 0.5	13 ± 33	63 ± 94	0.2 ± 0.6	2.7 ± 0.7*
Boulder	10/21/08	4.1 ± 1.3	0.2 ± 0.1	2 ± 0.8	57 ± 50	0.1 ± 0.4	1.7 ± 0.6*

intense. Conversely, those with low adaptive capacity had a higher probability of reacting but they didn't always have the energy to react and hence their reactions would be mild.

Provocation HRV

Most of the subjects (15/25, 60%) did not respond appreciable to the MW radiation generated by the cordless phone when it was plugged into a live outlet. The rhythmogram was unchanged and the heart rate, parasympathetic and sympathetic tone remained constant (figs. 3, 10, 12).

However, 10 subjects (40%) did respond to the MW challenge. Fig. 13 shows the response for six of those 10. Response and the recovery were immediate. MW provoca-

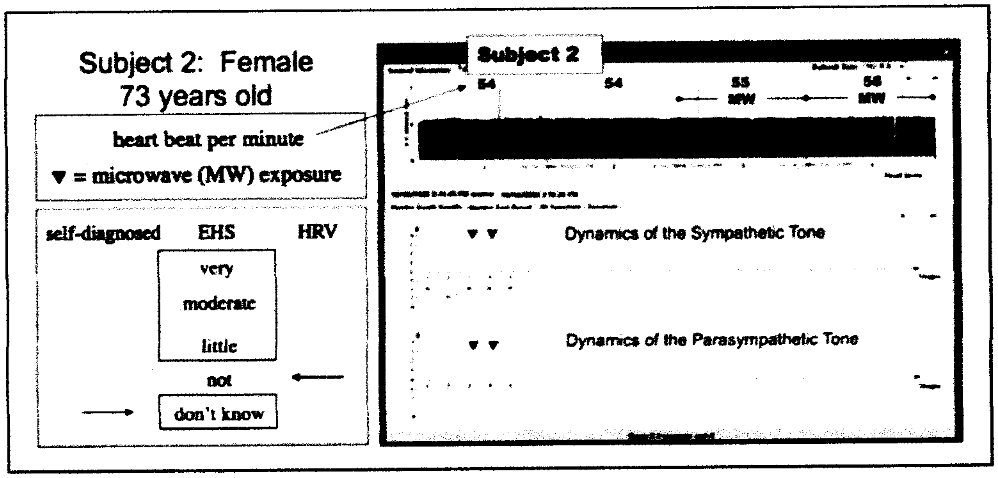

Fig. 10. Continuous monitoring of HRV during provocation part of this study for one subject who was non-reactive

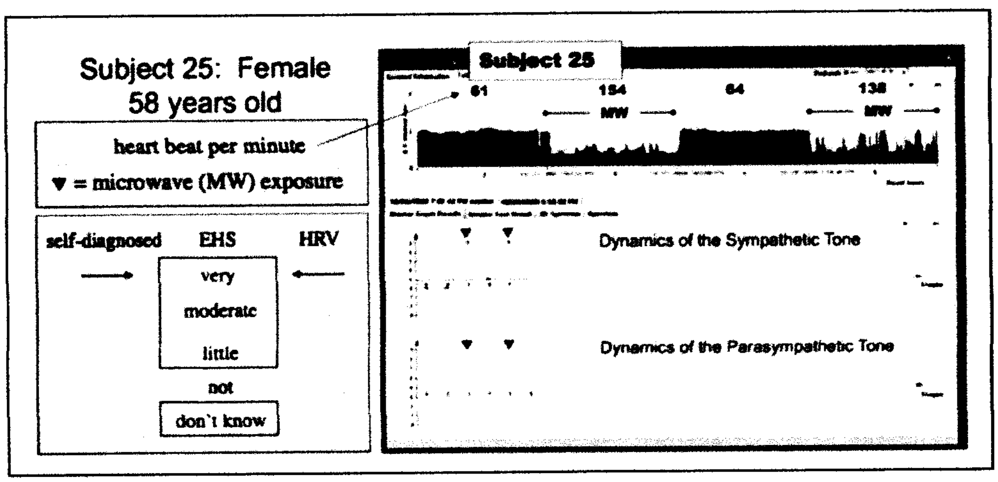

Fig. 11. Continuous monitoring of HRV during provocation part of this study for one subject who reacted to the MW radiation from a digital cordless 2.4 GHz phone

tion differed noticeably compared with sham exposure. Heart rate increased significantly for four of the subjects, resulting in tachycardia for three. The heart rate for subject 25 jumped from 61 bpm to 154 bpm (with real provocation) and returned to 64 bpm (with sham provocation) (fig. 11). The increase in heart rate was accompanied by up regulation of the SNS and down regulation of the PSNS during cordless phone exposure for four subjects in Table 4 (fig. 13). Response of the one subject (Subject 27) was paradoxical in that the heart rate increased from 72 to 82 bpm during which time the parasympathetic tone increased and the sympathetic tone remained constant.

Fig. 14 shows the range of responses of some non- or slightly reactive subjects to provocation.

Table 4 - Real-time monitoring of heart rate, sympathetic and parasympathetic tone before, during, and after exposure to a 2.4 GHz digital cordless phone radiating 3-5 microW/cm²

EHS	Subject Code	EHS Ranked	Heart Rate (bpm) bgrnd	pre	MW	post	Sympathetic Response bgrnd	pre	MW	post	Parasympathetic Response bgrnd	pre	MW	post
Intense	25	1	61	61	154	64	-1	-1	4	0	0	0	-4	-1
	17	2	66	68	122	66	0	0	4	0	0	-2	-3	0
	26	3	59	61	106	61	-1	-1	3	0	1	2	-3	1
	27	4	72	nd	82	69	0	nd	0	0	-3	nd	2	-2
Moderate	5	5	66	66	66	65	1	1	3	0	-1	-1	-3	-1
	9	6	77	75	75	73	1	1	0	1	-2	0	-3	-1
	3	7	48	50	53	nd	2	-2	0	nd	2	0	0	nd
	16	8	61	nd	62	63	0	nd	-2	0	-2	nd	-2	-2
	8	9	81	nd	81	80	1	nd	1	1	0	nd	-2	-1
	10	10	69	68	70	70	0	0	0	0	-2	-2	-3	-1
Mild	2	11	54	54	55	56	-2	-3	-2	-2	-3	-3	-3	-3
	23	12	59	nd	58	60	-1	nd	0	-2	-2	nd	-2	-3
	12	13	71	nd	69	74	0	nd	1	0	-1	nd	-1	-1
	18	14	60	61	61	61	-2	-1	-2	-1	-3	-3	-3	-2
	19	15	63	62	62	61	-1	0	-1	-1	-3	-3	-3	-2
	6	16	65	66	66	65	0	0	0	0	-3	-3	-4	-3
	4	17	61	62	61	61	-2	-1	-1	-2	-3	-2	-3	-2
	24	18	71	72	71	69	0	0	0	0	-3	-2	-1	-2
None	1	19	71	70	71	71	0	0	0	1	-3	-1	-1	-1
	11	20	57	nd	57	58	0	nd	0	0	3	nd	3	2
	21	21	78	78	78	nd	1	1	1	nd	-2	-3	-3	nd
	7	22	70	71	70	69	0	0	0	0	-3	-3	-3	-3
	14	23	69	68	67	66	0	0	0	0	-1	-2	-2	-1
	20	24	67	nd	66	66	0	nd	0	0	-1	nd	-1	-1
	13	25	80	78	76	nd	1	1	1	nd	-3	-2	-2	nd

Response	Mean Heart Rate (bmp)				Mean Sympathetic Response				Mean Parasympathetic Response			
Intense	65	63	116	65	-0.5	-0.7	2.8	0.0	-0.5	0.0	-2.0	-0.5
Moderate	67	65	68	70	0.8	0.0	0.3	0.4	-0.8	-0.8	-2.2	-1.2
Mild	63	63	63	63	-1.0	-0.8	-0.6	-1.0	-2.6	-2.7	-2.5	-2.3
None	70	73	69	66	0.3	0.4	0.3	0.2	-1.4	-2.2	-1.3	-0.8
All	66	66	74	66	-0.1	-0.3	0.4	-0.2	-1.5	-1.7	-2.0	-1.4

Note:
EHS categories described in text: bgrnd = background; pre=sham exposure before real exposure; MW=microwave exposure; post=sham exposure after real exposure; nd=no data

The pre- and post-MW cordless phone response (SNS & PSNS) differed significantly for this group (fig. 15) with up regulation of the SNS and down regulation of the PSNS with MW exposure and the reverse for post-MW exposure suggesting a recovery phase.

The severe and moderate responders had a much higher LF/HF ratio than those who either did not respond or had a mild reaction to the MW exposure from the cordless phone (fig. 16B). This indicates, yet again, a stimulation of the SNS (LF) and a down-

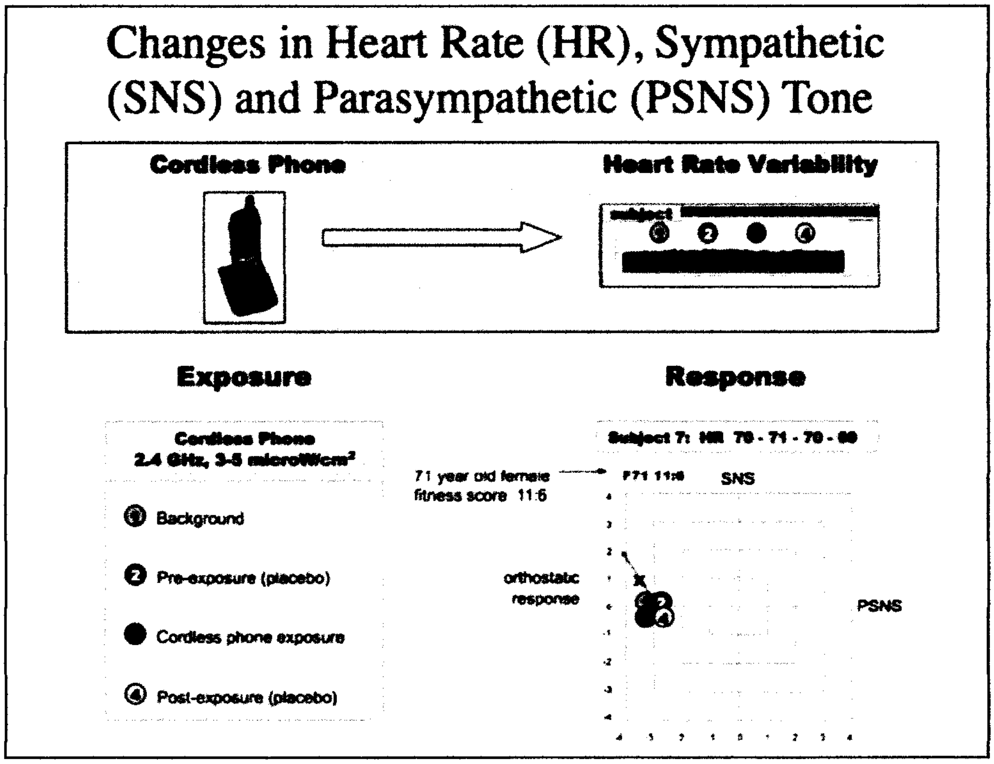

Fig. 12. Subject 7: no changes in heart rate, sympathetic, and parasympathetic tone before, during, and after blind provocation with a 2.4 GHz cordless phone generating exposure of 3 to 5 microW/cm^2

regulation of the PSNS (HF). The up regulation was greater for LF2 than for LF1 (fig. 16A).

Based on self-assessment and the results from the provocation study, 2 subjects (8%) underestimated their sensitivity and 5 subjects (20%) overestimated their sensitivity to the cordless phone provocation. However, only two of the 5 claim to experience mild heart palpitations and only one of those responds "sometimes" to cordless phones.

Discussion

The most intriguing result in this study is that a small group of subjects responded immediately and dramatically to MW exposure generated by a digital cordless DECT phone with blinded exposure. Heart rate (HR) increased significantly for 4 subjects (16%) (10 to 93 beats per minute) and the sympathetic/parasympathetic balance changed for an additional 6 subjects (24%) while they remained in a supine position. This is the first study documenting such a dramatic change brought about immediately and lasting as long as the subject was exposed and is in sharp contrast to the provocation studies reviewed by Levallois[5], Rubin *et al.*[14], and Bergqvist *et al.*[31]. Authors of these reviews generally conclude that they were unable to establish a relationship between low or high frequency fields and electromagnetic hypersensitivity (EHS) or with symptoms typically occurring

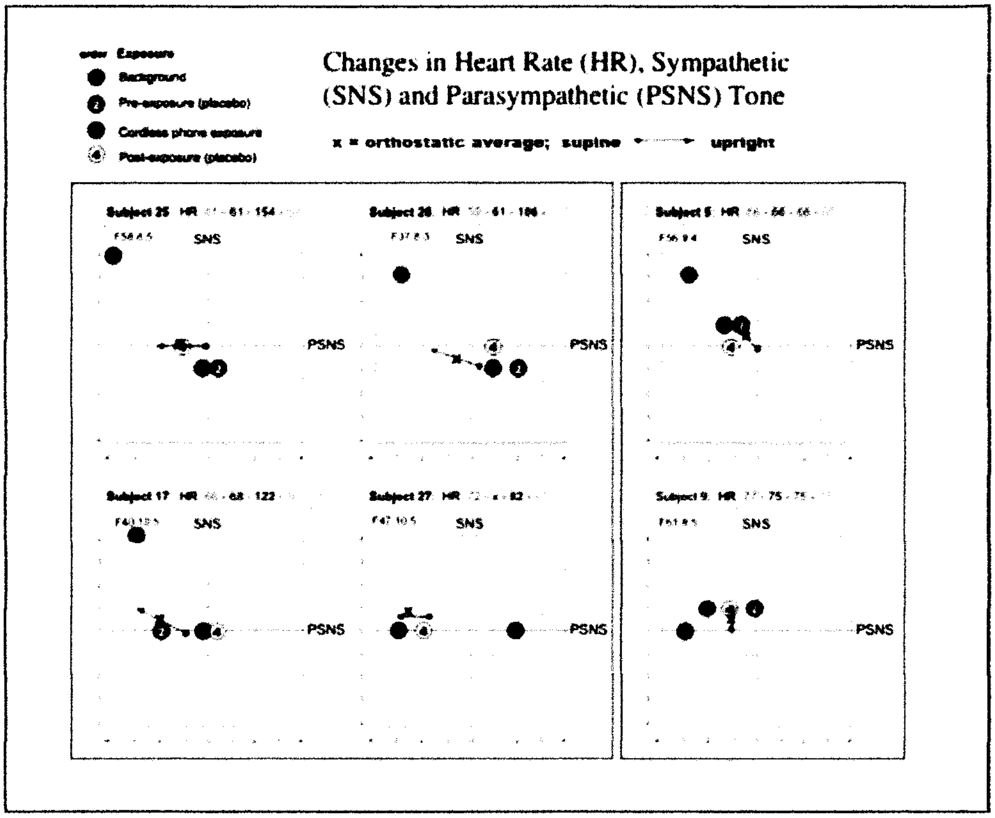

Fig. 13. Reactive Subjects: changes in heart rate, sympathetic, and parasympathetic tone before, during, and after blind provocation with a 2.4 GHz cordless phone that generates exposure of 3 to 5 microW/cm²

among such afflicted individuals. Furthermore, several studies report no effect of mobile phones (various exposure conditions) on human HRV-parameters[32-39].

Our results clearly show a causal relationship between pulsed 100 Hz MW exposure and changes in the ANS that is physiological rather than psychological and that may explain at least some of the symptoms experienced by those sensitive to electromagnetic frequencies. Dysfunction of the ANS can lead to heart irregularities (arrhythmia, palpitations, flutter), altered blood pressure, dizziness, nausea, fatigue, sleep disturbances, profuse sweating and fainting spells, which are some of the symptoms of EHS.

When the SNS (fight or flight response) is stimulated and the PSNS (rest and digest) is suppressed the body is in a state of arousal and uses more energy. If this is a constant state of affairs, the subject may become tired and may have difficulty sleeping (unable to relax because of a down regulated PSNS and/or up regulated SNS). Interestingly, Sandstrom[40] found a disturbed pattern of circadian rhythms of HRV and the absence of the expected HF (parasympathetic) power-spectrum component during sleep in persons who perceived themselves as being electrically hypersensitive.

If the dysfunction of the ANS is intermittent it may be experienced as anxiety and/or panic attacks, and if the vagus nerve is affected it may lead to dizziness and/or nausea.

Our results show that the SNS is up regulated (increase in LF) and the PSNS is down regulated (decrease in HF) for some of the subjects during provocation. The greatest

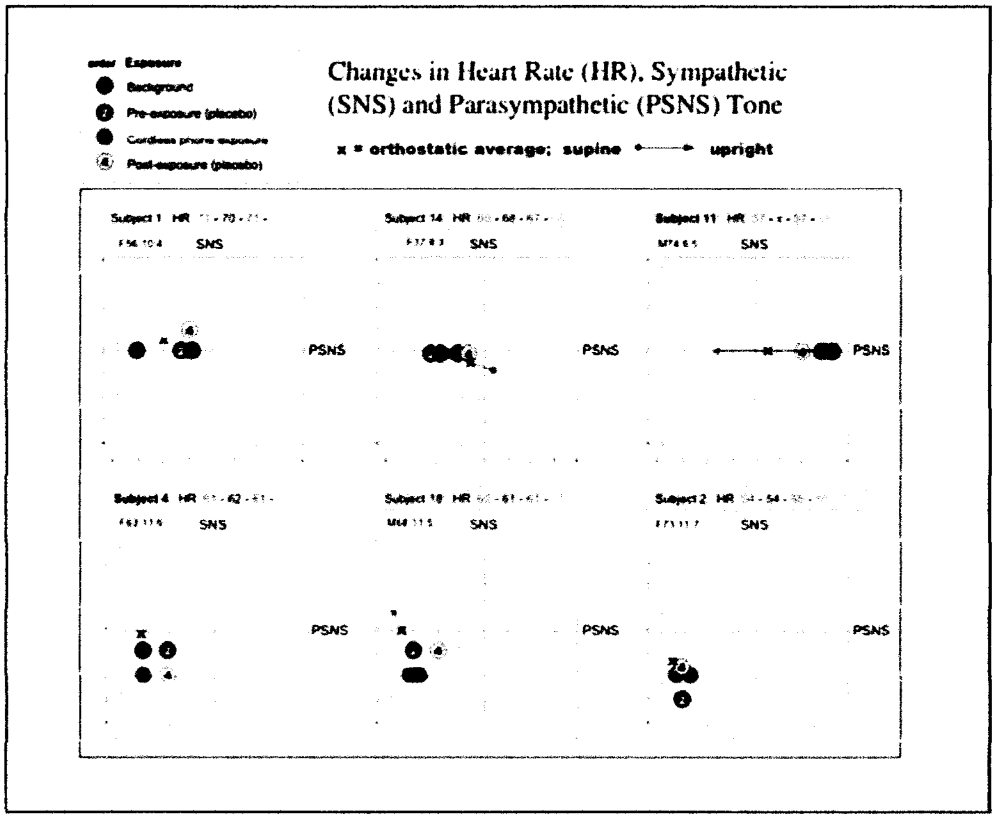

Fig. 14. Non or slightly reactive subjects: patterns of response for before, during, and after blind provocation with a 2.4 GHz cordless phone that generates exposure of 3 to 5 microW/cm^2

increase is in LF2, which is the adrenal stress response, although LF1 also increases. We not know the degree to which this is due to the 100 Hz pulse, the MW carrier, or their combination.

Several studies lend support to our results.

Lyskov *et al.*[41] monitored baseline neurophysiological characteristics of 20 patients with EHS and compared them to a group of controls. They found that the observed group of patients had a trend to hypersympathotone, hyper-responsiveness to sensor stimulation and heightened arousal. The EHS group at rest had on average lower HR and HRV and higher LF/HF ratio than controls. We found that subjects with intense and moderate reactions to the MW provocation also had higher LF/HF ratios than those who did not respond.

Kolesnyk *et al.*[42] describes an "adverse influence of mobile phone on HRV" and Rezk *et al.* [43] reports an increase of fetal and neonatal HR and a decrease in cardiac output after exposure of pregnant women to mobile phones.

Andrzejak *et al.*[44] reports an increased parasympathetic tone and a decreased sympathetic tone after a 20-minute telephone-call. While these results are contrary to our findings, the effect of speaking cannot be ruled out in Andrzejak's study. In our study the subject remained in a supine position, silent and still during the testing.

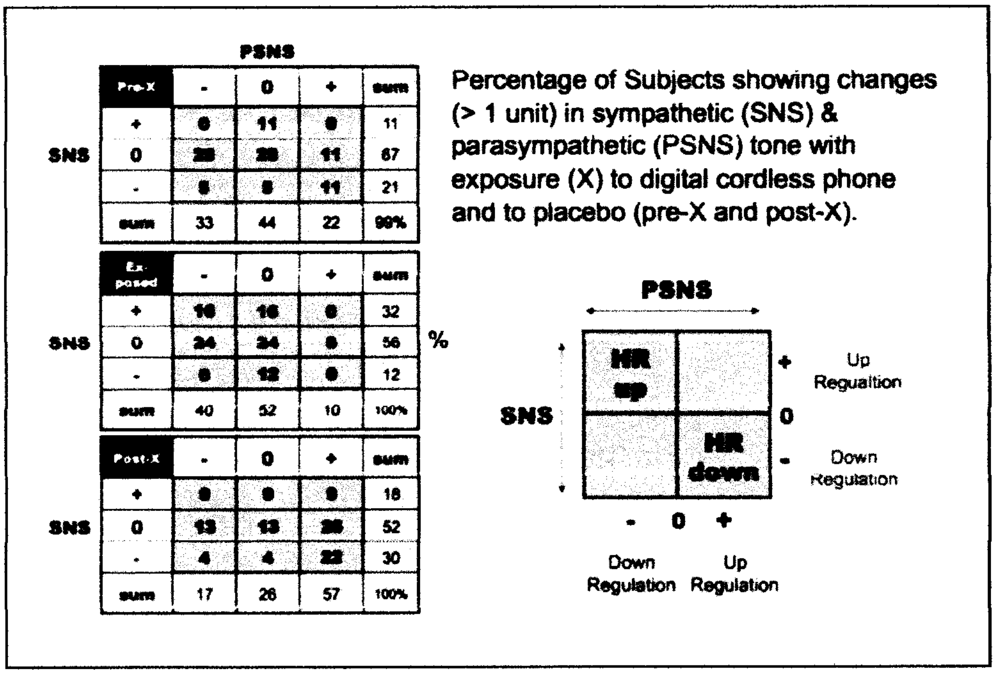

Fig. 15. Response of 25 subjects to blind provocation by a 2.4 GHz digital cordless phone that generates exposure of 3 to 5 microW/cm²

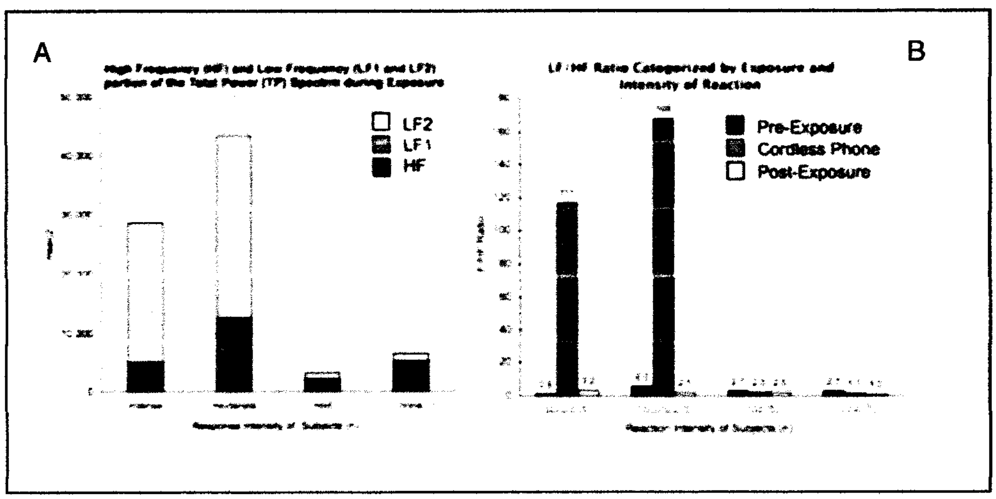

Fig. 16. A. Mean high frequency (parasympathetic) and low frequency (sympathetic) spectral distribution as a function of response intensity of 25 subjects exposed to a 2.4 GHz cordless phone. B. Low frequency (LF1 + LF2) to high frequency (HF) ratio for different exposures

Workers of radio broadcasting stations have an increased risk of disturbances in blood pressure and heart rhythm. They have a lower daily heart rate, a decreased HR variability, higher incidences of increased blood pressure and disturbances in parameters of diurnal rhythms of blood pressure and HR-all of no clinical significance, but showing a certain dysregulation of autonomic cardiac control[45-48].

Bortkiewicz *et al.*[49] reported that exposure to AM radio frequency EMF within hygienic standards affects the functions of the ANS of workers. Workers had higher frequency of abnormalities in resting and 24-h ECG than controls and an increased number of heart rhythm disturbances (ventricular premature beats). As in our study, RF exposure was associated with a reduced HF power spectrum suggesting that the EMF field reduce the influence of the PSNS on circulatory function.

Several studies report changes in blood pressure with electromagnetic exposure[50, 51]. Others show an increase of oxidative stress and a decrease of antioxidative defense-systems in heart-tissue irradiated with 2.45 GHz and 900 MHz respectively[52, 53]. Still others show a stress-response reaction following exposure to radio frequency radiation either in the form of heat shock proteins (hsp) or changes in enzymatic activity. Irradiation of rats with a low-intensity-field (0.2-20 MHz) resulted in an increase of myocardial hsp70[54]. Similarly 1.71 GHz MW exposure increased hsp70 in p53-deficient embryonic stem cells[55]. Abramov and Merkulova[56] report pulsed EMFs increase the enzymatic activity of acetylcholinesterase in the animal heart, which suppresses the parasympathetic and allows the sympathetic to dominate.

Most of the studies on humans, that did not show any effects of MW radiation in some of the studies mentioned above, were conducted with young, healthy subjects, giving rise to the question whether the experiments would have yielded different results with subjects with a "higher level of pathologic pre-load" and thus fewer possibilities to acutely compensate the possible stressor of radiation.

The studies on work-exposure to MW radiation were able to show different levels of effects on the cardiovascular system, and this could be interpreted as the necessity to remain regularly, repeatedly, and for a longer time under the influence of a certain EMF exposure, hence pointing out the great importance of the electromagnetic exposures in the work and home environment. Perhaps only chronic exposure to MW-EMF can influence various rhythms (e.g. cardiovascular biorhythms) sufficiently to cause detectable effects. Perhaps it is these individuals who become EHS and then respond to stressors if they have sufficient energy to mount a reaction.

In our study, half of those tested claimed to be moderately to extremely sensitive to electromagnetic energy and they ranged in age from 37 to 79 years old. The symptoms they identified are similar to those reported elsewhere and include poor short-term memory, difficulty concentrating, eye problems, sleep disorder, feeling unwell, headache, dizziness, tinnitus, chronic fatigue, and heart palpitations[2, 7, 57].

The common devices attributed to stress generation included fluorescent lights, antennas, cell phones, Wi-Fi, and cordless phones. The last 4 items all emit MW radiation.

Many of those claiming to have EHS also had food allergies, mold/pollen/dust allergies and were chemically sensitive. With so many other sensitivities it is difficult to determine whether the sensitivity to electromagnetic energy is a primary disorder attributable to high and/or prolonged EM exposures or a secondary disorder brought about by an impaired immune system attributable to other stressors.

Interestingly, the younger participants (37 to 58) displayed the most intense responses presumably because they were healthy enough to mount a response to a stressor. Those who did not respond to the MW exposure were either not sensitive, or they had a low adaptive capacity coupled with a poor fitness score and did not have enough energy to mount a reaction. Orthostatic HRV combined with provocation monitoring may help distinguish these three types of responses (sensitive, not sensitive, non-responsive reactors).

The term EHS was deemed to imply that a causal relationship has been established between the reported symptoms and EMF exposure and for that reason the WHO[8] has labeled EHS as *Idiopathic Environmental Intolerance* (IEI) to indicate that it is an acquired disorder with multiple recurrent symptoms, associated with diverse environmental factors tolerated by the majority of people, and not explained by any known medical, psychiatric or psychological disorder. We think this labeling needs to be changed especially in light of this study.

Conclusions

The orthostatic HRV provides information about the adaptive capacity of an individual based on fitness score and on the state of the SNS and PSNS. A person with high adaptive capacity is unlikely to respond to a stressor (because they are highly adaptive) but if they do respond the response is likely to be intense. Orthostatic HRV was able to predict the intensity of the response much better than the probability of a response to a stressor, which in this case was a 2.4 GHz digital cordless phone that generated a power density of 3 to 5 microW/cm^2.

Forty percent of those tested responded to the HRV provocation. Some experienced tachycardia, which corresponded to an up regulation of their SNS and a down regulation of their PSNS (increase in LF/HF ratio). This was deemed a severe response when the HR in supine subjects increased by 10 to 93 beats per minute during blinded exposure. HR returned to normal during sham exposure for all subjects tested. In total, 16% had a severe response, 24% had a moderate response (changes in SNS and/or PSNS but no change in HR); 32% had a slight response; and 28% were non-responders. Some of the non-responders were either highly adaptive (not sensitive) or non-responding reactors (not enough energy to mount a reaction). A few reactors had a potentiated reaction, such that their reaction increased with repeated exposure, while others showed re-regulation with repeated exposure.

These data show that HRV can be used to demonstrate a physiological response to a pulsed 100 Hz MW stressor. For some the response is extreme (tachycardia), for others moderate to mild (changes in SNS and/or PSNS), and for some there is no observable reaction because of high adaptive capacity or because of systemic neurovegetative exhaustion. Our results show that MW radiation affects the ANS and may put some individuals with pre-existing heart conditions at risk when exposed to electromagnetic radiation to which they are sensitive.

This study provides scientific evidence that some individuals may experience arrhythmia, heart palpitations, heart flutter, or rapid heartbeat and/or vasovagal symptoms such as dizziness, nausea, profuse sweating and syncope when exposed to electromagnetic devices. It is the first study to demonstrate such a dramatic response to pulsed MW radiation at 0.5% of existing federal guidelines (1000 microW/cm^2) in both Canada and the US.

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APPENDIX A: Summary of data based on blind assessment.

1		2	3	4	5			6				7				Notes
					Orthostatic HRV			Actual	Changes in			Blind Assessment				
EHS	Subject Code	EHS Ranked	EHS Self	CV Tone	IOR	AC	POR	Stages Exposed	HR	SNS	PSNS	Stages Exposed	Stages Showing	POR	IOR	
intense	25	1	very	3	3.5	4.5	1.5	3, 5 (6, 7, 9)	93	5	4	**3, 5**	3, 5	5	high to extreme	8
	17	2	very	3	3.5	3.5	3.0	3, 5 (8)	54	4	1	**3, 5, 6**	3, 5, 6	4.5	moderate	9
	26	3	moderate	1	5.0	5.0	1.5	3, 5, 6 (7, 8)	45	4	5	**3, 5, 6, 7**	3, 5, 6, 7	5	moderate to intense	10
	27	4	little	3	3.0	5.0	3.5	2, 4 (5, 6)	70	0	3	**2, 4, 5**	2, 4, 5	5	mild	11
moderate	5	5	moderate	2	4.0	3.5	3.5	3, 5	0	2	3	**3, 5**	3, 5	5	moderate to high	12
	9	6	don't know	2	3.5	4.5	2.0	3, 5, 6, 8	0	1	3	**3, 5, 6**	3, 5, 6	4	high	13
	[illegible]	7	don't know	[illegible]	[illegible]	4.0	[illegible]	3, 4	[illegible]	[illegible]	[illegible]	**3**	3, 4	4	moderate	14
	16	8	very	1	4.0	4.0	3.5	2, 4, 6	1	-2	0	**2**	2	1	mild	15
	8	9	not	5	2.5	1.5	4.5	2, 3	0	0	2	**2, 4**	2, 4	1	mild	16
	10	10	don't know	2	3.5	3.0	3.0	3 (7, 8, 9)	2	0	1	**3, 7, 8, 9**	3 mild, 7, 8, 9 intense	5	intense	17
mild	2	11	don't know	2	2.0	1.0	3.5	3, 4	1	1	0	unknown	none	1.75	mild	18
	23	12	little	1	5.0	1.5	4.5	2, 4 (5, 6)	1	1	0	**2, 5**	2, 5	2	mild to moderate	19
	12	13	little	3	4.0	4.0	2.5	2, 3 (5)	2	1	0	**3**	3, 4, 5	3	mild to moderate	20
	18	14	don't know	2	2.5	2.5	4.5	3	0	1	0	**3**	3	1.5	mild	21
	19	15	don't know	4	2.0	2.5	3.0	3	0	1	0	2, 4	2, 4	3	mild to moderate	22
	6	16	very	2	3.5	2.0	4.5	3, 4	0	0	1	2	2	2	mild	23
	[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3, 4	[illegible]	[illegible]	[illegible]	24
	24	18	little	2	3.0	4.0	3.0	3, 5	1	0	1	2, 4, **5**	2, 4, 5	2.5	mild	25
none	1	19	don't know	5	3.5	3.5	3.5	3, 4	1	0	0	**3, 4**	4, 5	1	mild	26
	11	20	not	1	1.0	5.0	1.5	2, 4, 5	0	0	0	3	3	1	mild or non-symptomatic	27
	21	21	little	1	2.5	2.0	3.5	3 (4, 5)	0	0	0	2, **5**	2, 5	1.5	none to mild	28
	7	22	very	2	2.5	1.5	4.0	3, 4	1	0	0	unknown	unknown	1.5	mild	29
	14	23	don't know	5	2.5	3.5	3.0	3, 4	1	0	0	2	2, 3, 4	1.75	mild	30
	20	24	little	3	3.5	4.0	4.5	2	1	0	0	possibly 5?	6	1	mild	31
	[illegible]	25	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	32

code	code	code	code	code	code	code
5	hypo	intense	high	high	high	intense
4		strong				strong
3	normal	moderate	moderate	moderate	moderate	moderate
2		mild				mild
1	hyper	don't know	low	low	low	don't know

Notes:

1 Electrohypersensitivity (EHS) response categories are based on HR = heart rate; SNS = sympathetic nervous system; PSNS = parasympathetic nervous system.

2 EHS was ranked based on changes in HR and changes in the SNS and PSNS during exposure to microwave (MW) radiation.

3 Self-assessment of sensitivity based on questionnaire response.

4 Cardiovascular (CV) Tone is based on the HR times the sum of the systolic and diastolic blood pressure; values at 1 or lower are hypotonic and values at 5 are hypertonic.

5 Intensity of reaction (IOR); adaptive capacity (AC), which is 6 - non adaptive capacity (NAC); and probability of reaction (POR) are based on the orthostatic heart rate variability (HRV) results and are described in the text.

6 Subjects were exposed to MW radiation at different stages. Stages in parentheses were not used in the study as they reflect multiple exposures with interference from other agents.

7 Blind assessment was based on the HRV during continuous monitoring with real and sham exposure to MW radiation from a 2.4 GHz digital cordless phone radiating and at a power density between 3 and 5 microW/cm².

8 Excellent subject.

9 Symptomatic at stage 3, parasympathetic rally begins to recovery but feels anxiety, stage 3 faint or dizziness predicted. Decent Chronotropic Myocardial Reaction Index (ChMR) and vascular compensation reaction (VC). Middle of bell curve.

10 The healthier a subject the more likely the reaction. This person has the energy to become symptomatic.

11 Mildly inflamed. Mildly fatigued but highly adaptive. ChMR and VC good. Has ability to react.

12 Adaptive person. Could use Mg and/or K based on high standing HR.

13 Has plenty of energy. Moderate response due to weakening. Stage 7 body re-regulating from exposure.

14 Shows a weakening reaction (down regulation of SNS). Positive reactor. Very healthy for age. Highly adaptive geriatric.

15 Lot of adaptive capacity. If she is exposed her reaction would be a fairly strong reaction.

16 Has diminished energy capacity (11:6). This person doesn't have enough energy to have a robust response.
17 Potentiated reactor, time sensitive, couldn't tolerate re-exposure. If she reacts it will be moderately strong because of ChMR. Needs minerals for VC factor slowed her down.
18 May be on heart medication. Cardiac rate and rhythm non-adaptive. CV tone hypertonic.
19 Any neurological insult will be met with a hard reaction since she has inverted response when she stands up.
20 If reactor, it will be strong because of ChMR strong. Highly adaptive capability and reserve. Slow VC could be mineral or vitamin D deficiency.
21 Don't have a strong PSNS resistance. Reactivity is based on inability to go parasympathetic, and then they will go more sympathetic if they have the energy to do so. No energy. Either a delayed reaction or a weak reaction.
22 Afibrillation, palpitations of heart probable. Strong girl. 11:6 fitness is OK for a person this age.
23 May have dental problems based on S/P response. Neurologically compromised.
24 Neurologically compromised. May be overmedicated on CV drug.
25 Strong gal. Decent reserve capacity but temporary fatigue. Doesn't feel bad but poor health for her age.
26 Normal reaction to stress, mild non-toxic reaction. Potential for reaction: moderately high because of the 10.4 but may tolerate an amount of exposure before they react because of the reserve capabilities.
27 Ridiculously healthy. Poster boy for his age. He can take a lot based on fitness of 6:5.
28 Lower end of bell curve. Doesn't have energy to react although may be symptomatic.
29 Either highly adaptive or non-reactive. Orthostatic response indicates that person doesn't have enough energy to have a robust response.
30 Normal CV tone for age, Decent Tension Index (TI). Good geriatric pattern. If she reacts it would be moderate to mild.
31 Strong girl. Has strong adrenal capacity. If she reacts it will be strong. May have chronic fatigue.
32 Moderate inflammation. Tired and has low adaptive reserve. If stressor comes along it will produce more stress. If reacting it would be medium.

CONFIRMED:
The order of the Head State Sanitary Physician of the Republic of Kazakhstan
« 28 » November 2003 г. № 69

Permissible levels
of high-frequency electromagnetic pollutions' voltage in a wires of industrial frequency alternating current

Sanitary-epidemiologic norms

1 General provisions

1. Sanitary-and-epidemiologic norms «Permissible levels of high-frequency electromagnetic pollutions' voltage in a wires of industrial frequency alternating current» (further - norms) define levels electromagnetic pollutions in electric wires of power supply of an industrial electric equipment, office techniques, electrical household appliances in a range 1 kiloHertz – 400 kiloHertz (further – kHz).

2. The present norms are directed on improvement and optimization of a sanitary-epidemiologic situation and prevention of environmental contamination by electromagnetic radiation, and also management of corresponding risk, in addition to existing norms.

3. Heads of the organizations and physical persons which activity is connected to operation of the industrial organizations using the equipment and devices, being sources of electromagnetic radiation, provide maintenance of requirements of the present norms.

4. In the present norms the following terms and definitions are used:

1) electromagnetic pollution – parasitic (casual) frequencies in a network of an alternating current of industrial frequency of 50 Hertz (further – Hz) which source is not determined;

2) electromagnetic pollutions – one of kinds of electromagnetic pollution in a range of frequencies 1 kHz – 400 kHz, arising in networks of an alternating current of industrial frequency.

2 Permissible level of electromagnetic pollutions' voltage

5. The permissible level of a high-frequency electromagnetic pollutions' voltage in a range of frequencies 1-400 kHz in a wires of an alternating current of industrial frequency of 50 Hz should not exceed 0,05 volts (further – V) 50 millivolts (further – mV).

3 Choice of points of the control

6. Control points get out in the socket of wires of an alternating current of industrial frequency (50 Hz), taking place near to a plug (socket) of a cable of the connected equipment. The number of control points depends on number of workplaces. In each control point one measurement is carried out.

4 Recommended devices for the control

7. For the control high-frequency electromagnetic pollutions in a range of frequencies (1-400) kHz in a wires of an alternating current of industrial frequency of 50 Hz are recommended to be used millivoltmeter, having corresponding characteristics and registered in the State Register of Republic of Kazakhstan.

5 Requirements to carrying out of measurement

8. The device is plugged into socket of an alternating current in a control point.

9. Tap switch of ranges necessary to put in position of 1-2 V.

10. If indications are not fixed or are small, tap switch put in position 100-999 mV or in position 1,1-99,9 mV, depending on a registered level of a voltage.

Results are registered and compared to the norms specified in item 5 of the present norms.