ELECTROMAGNETIC FIELDS RADIATED BY SMART POWER METERS IN RELATION TO US SAFETY GUIDELINES

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(Bill Kaune is a retired physicist whose work involved collaboration with biologists and epidemiologists investigating biological effects resulting from exposure to the electric and magnetic fields produced by the electric power system. The work reported here is his alone.)

Physical Quantities Used to Specify Exposure to Electromagnetic Fields

An incident electromagnetic field will penetrate, to some degree, into the body of an exposed human. (At 900 MHz, the frequency at which smart meters operate, 95% of the incident energy will be deposited within about 5 cm of the surface of the body.) The resulting electric and magnetic fields in the body will cause electric currents to flow and will, thus, deposit energy in the body. It is the fields inside the body that will be the cause of any biological effects that might occur. It has become customary to specify the strength of the fields produced in the body of an exposed person by the "specific absorption rate," that is the rate at which energy from the incident field is deposited in a small mass of tissue. The units of the specific absorption rate (SAR) are watts per kilogram of tissue, abbreviated W/kg. SAR is the *rate* at which energy is deposited in the tissue of interest, that is, the energy deposited in one second. The longer the exposure, the more energy is deposited.

It is generally very difficult to measure the SAR in, say, a particular organ in the body of an exposed human, so exposure needs to be specified in terms of a more easily measured quantity. The SAR is related to the strength of the incident electromagnetic field (as well as the shape of the body, the direction in which the electromagnetic field approaches the body, and the presence of other objects around the exposed person). It is easier to measure the strength of the incident electromagnetic field, so exposure is specified in terms of the strength of the incident field. At lower frequencies, the strengths of the incident field is specified by stating the strength of both the electric (E) and magnetic field (H) components that comprise the incident electromagnetic field. At higher frequencies, such as those used by smart meters, E and H are precisely related ($E = 377 \times H$) except very near the source so the strength of the incident field is specified by measuring its power density, that is, the energy carried across a unit area in one second by the field under study. Power density is equal to the product of the strengths of *E* and *H*. The units of power density are watts per square meter (W/m^2) or, more commonly, milliwatts per square centimeter (mW/cm^2; 1 mW/cm^2 = 10 W/m^2).

Engineers and physical scientists have devoted much effort to determining the relationship between the power density of an incident electromagnetic field and the resulting SAR produced in the body of an exposed human. For example, it was discovered that humans exposed to a horizontally travelling electromagnetic field with the electric field vertical experience resonant absorption of electromagnetic energy in their bodies when their heights approach one-half of the wavelength of the incident field; maximum absorption for an adult occurs at a frequency of about 70 MHz. Thus, in this region smaller incident fields will produce the same SAR as larger fields in other wavelength regions.

US Safety Guideline

The Federal Communications Commission (FCC) establishes the safety guideline in the United States for exposure to electromagnetic radiation. The FCC, in turn, relies on recommendations by several US organizations, the Institute for Electrical and Electronics Engineers (IEEE), the American National Standards Institute (ANSI), and the National Committee on Radiation Protection (NCRP). Based on their review of the recommendations of these organizations, the FCC primarily selected the NCRP's 1986 recommendations[1] (references can be found at the end of this report) on which to base the US Safety Guideline.

To set this guideline, biologists and epidemiologists first surveyed the scientific literature and selected all studies of biological effects resulting from electromagnetic radiation. They then selected those studies that they considered of adequate scientific quality, had ideally been replicated in more than one laboratory, were reporting biological effects that were thought to be potentially harmful, provided sufficient dosimetric data so that the SAR could be determined, and where there was some idea as to how the incident RF field could actually produce a biological effect. NCRP concluded that the most sensitive indicator of biological disruption was certain behavioral effects, and that potentially harmful effects began to appear at a whole-body-average SAR of about 4 W/kg. This value became the starting point of the guideline setting process.

The only generally-accepted mechanism by which adverse biological effects can be produced in an exposed human (or animal) is through the deposition of energy into the body that causes a temperature rise in the affected tissue. Biological effects resulting from temperature rise are called thermal effects. Nearly all current safety guidelines, including that of the FCC, are intended to protect against thermal effects. But, what about effects that might occur at exposure levels too low to produce a significant rise in termperature? There are a number of scientific publications that report biological effects at so-called non-thermal levels of exposure. However organizations, including the NCRP, that have made recommendations regarding exposure standards have almost invariably chosen to base their recommendations only on thermal effects. The reasons for this exclusion include:

- Reports of non-thermal effects are often inconsistent.
- Attempts to replicate reported non-thermal effects have often failed
- Reported effects at non-thermal levels of exposure do not appear to be hazardous
- There is no known mechanism by which RF fields could produce non-thermal effects

Based on these and other considerations, standards have mostly concluded that the scientific literature on non-thermal effects is not substantial enough upon which to base a safety guideline. Thus, nearly all safety guidelines have been formulated to protect against thermal effects. For example, the most recent IEEE recommendation[3], completed in 2005, reached the following conclusion about non-thermal effects of ionizing radiation:

> A review of the extensive literature on RF biological effects, consisting of well over 1300 primary peer reviewed publications published as early as 1950, reveals no adverse health effects that are not thermally related (except for electrostimulation discussed in B.2.4). This conclusion is consistent with those reached by other scientific expert groups and government agencies including the:
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> - Australian Government, Australian Radiation Protection and Nuclear Safety Agency, Committee on Electromagnetic Energy Public Health Issues
> - European Commission Expert Group
> - European Committee on Toxicology, Eco-toxicology and the Environment
> - France's Commission for Consumer Safety (the French Expert Report - 'Zmirou report' to the French Health General Directorate)
> - French Environmental Health and Safety Agency
> - Health Council of the Netherlands
> - Hong Kong-Office of the Telecommunications Authority
> - International Commission on Non-Ionizing Radiation Protection
> - Japanese Ministry of Post and Telecommunications

- New Zealand Ministry of Health and Ministry of Environment
- Royal Society of Canada Expert Panel
- Singapore Health Sciences Authority
- Swedish State Radiation Protection Authority
- U.K. Independent Expert Group on Mobile Phones (IEGMP [B73]),
- U.K. National Radiological Protection Board
- U.S. Food and Drug Administration
- World Health Organization

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has reached a similar conclusion[9]:

> Acute and long-term effects of HF exposure below the thermal threshold have been studied extensively without showing any conclusive evidence of adverse health effects.
>
> A considerable amount of research has been conducted on the relationship between HF fields and health outcomes such as headaches, concentration difficulty, sleep quality, cognitive function, cardiovascular effects, etc. This research to date has not shown any such health effects. The only consistently observed finding is a small effect on brain activity measured by electroencephalography (EEG). The biological implication of these small changes is, however, unclear. For example, they have not been shown to affect sleep quality or be associated with any other adverse effects.

The FCC safety guideline for RF radiation protection, intended to protect against thermal effects in the general public, incorporates a safety factor of 50. Thus, the threshold whole-body-averaged SAR of 4 W/kg, where adverse behavioral effects just begin to appear, is divided by 50 to yield a value of 0.08 W/kg. The guideline is intended to insure that exposures to the general public will never produce a whole-body-averaged SAR exceeding this value.

The Itron smart power meters that the PUD will use to replace our existing meters operate at a frequency of 902.4 to 927.6 MHz. The FCC safety guideline, adopted from NCRP's recommendations, for this frequency is an incident power density of 0.60 mW/cm^2 (6.0 W/m^2). The FCC guideline states that exposure, averaged over a period of 30 minutes, should not exceed this level. For example, exposure at a level of 1.20 mW/cm^2 for 15 minutes followed by 15 minutes of no exposure would also be just acceptable because the average over 30 minutes is 0.60 mW/cm^2.

Exposure Levels from Itron Power Meters

The PUD is planning to install over the next three years meters made by Itron in all residences and other facilities. The residential meters actually contain two radios, one for two-way communication with the utility, the other for two-way communication with devices inside the home. The PUD's current plan is to utilize only the first of these transmitters.

Exposure calculations

The strength of the electromagnetic fields from a source depend on a number of factors, including the distance and direction from the source, the output power, in watts, sent to the source's antenna, the gain of the antenna, and the presence of objects around the source, including the ground, that will modify its radiation pattern. It would be difficult to account for all these influences through calculations, so calculations are useful only for distances close to the meter.

Appendix A describes briefly how the maximum radiated power density from an isolated smart meter can be calculated. There it is shown that the maximum radiated power density, D_{max}, from an isolated Itron meter is approximately

$$D_{\text{max}} = \frac{0.132}{R^2},$$

where R is the distance from the meter measured in feet and D_{max} has units of mW/cm^2. D_{max} is the maximum power density at a distance R in the direction of maximum radiation (generally directly in front of the meter). The radiated power density will be less in all other directions.

Table 1 lists the maximum power density for various distances from the power meter. If one were to stand 3 feet directly in front of the power meter, calculated exposure would be about 2.4% of the FCC safety guideline of 0.60 mW/cm^2.

The data in Table 1 assume that the power meter is continually transmitting, that is, has a 100% duty cycle. However, this is not the way power meters operate. Instead, they periodically emit data. Generally, the duty cycle is not much more than about 1% (more on this later). The FCC safety guideline states that exposure should be averaged over a period of 30 minutes. Doing this reduces exposure by a factor of 100. The last column compares average exposure levels to the

Table 1. Maximum power density emitted by Itron meters at various distances. The FCC safety guideline is 0.60 mW/cm^2.

Distance from Meter	Maximum power density	% of FCC safety guideline: 100% duty cycle	% of FCC safety guideline: 1% duty cycle
1 ft	0.13 mW/cm^2	22%	0.22%
3 ft	0.015 mW/cm^2	2.4%	0.024%
5 ft	0.0053 mW/cm^2	0.87%	0.0087%
7.5 ft	0.0023 mW/cm^2	0.39%	0.0039%
10 ft	0.0013 mW/cm^2	0.22%	0.0022%

FCC guideline. At 3 feet from the meter, maximum exposure is only about 0.024% of the FCC safety guideline, that is, exposure is about 4000 times less than the safety guideline.

Actually, the fields from the power meter will be stronger near the face of a person standing 3 feet away than at lower locations of the body, because the distance, *R*, from the meter will be greater (assuming the power meter is located at a height of about 6 feet). The FCC safety guideline says in a case where the field is not uniform, an average over the projected area of the body should be determined. In this case, the average can be estimated to be a reduction of exposure by at least 45%. Thus, the time-averaged exposure that should be compared against the FCC safety guideline for a distance of 3 feet is actually about 0.013% of the FCC guideline.

Calculations may be useful for a subject standing directly in front of and close to a power meter, but for other locations, the accuracy of such calculations is highly doubtful because of 1) the presence of the frame in which the power meter is mounted, which will attenuate the field emitted in back of the meter, 2) circuit breaker panels that are often located close to power meters, 3) materials such as the walls of a house, 4) the presence of additional power meters on nearby homes, 4) the location of the power meter relative to the station that receives by radio its data, and 5) uncertainties of the duty cycles of power meters. Because of all these reasons, I think the best way to estimate exposures that people will actually receive in their homes from power meters is to examine measurements of the actual fields emitted by power meters and the duty cycles of these meters.

Measured exposures from smart meters

I have found two substantial measurement studies of the radio frequency fields emitted by power meters, both performed by a Washington Company, Richard Tell Associates, Inc. The first[4] was performed in 2012 for the Benton PUD in southeastern Washington State. (Benton County includes the cities of Richland, Kennewick, and Prosser.) The second[5] was performed in 2013 for the Vermont Department of Public Service and involved meters operated by two utilities, Green Mountain Power and Burlington Electric Power. Both studies included measurements of the strength of radiated radio frequency fields near power meters, near banks of power meters as might be encountered in apartment buildings, and in the interiors of residences. In addition, both studies included measurements of the duty cycles of selected meters.

The first study was performed for the Benton County PUD. The meters used by this utility were manufactured by Icon Sensus and are, in many respects similar to the meters our PUD will install because their maximum output RF power (1 watt) and frequency of operation (940 MHz) are similar. At 3 feet from face of a meter, the maximum measured exposure level across three houses was 1.9% of the FCC safety guideline, a little less than the calculated value of 2.4% in Table 1. This comparison assumes that the field is constant across the body of the exposed person and assumes that the field is constantly present, neither actually the case. Thus, time- and spatially-averaged exposure will be much less.

The investigators also measured the fields near banks of power meters. They found that the peak fields were similar to the value measured near single meters, because on average only one meter was transmitting at any one time. However, the presence of multiple meters will increase the duty cycle, that is, the fraction of time where at least one meter is transmitting and will thus increase exposure averaged over time.

Measurements in the rooms of three homes yielded in general much lower values. The largest exposure level measured in a garage, close to the back of a power meter that was transmitting data, was 0.16% of the FCC guideline. In rooms in homes, the largest value was measured in one bedroom while a nearby meter was transmitting was 0.022% of the FCC guideline. The average field measured in all rooms of the three homes (excluding garages) was 0.0015% of the FCC guideline.

The investigators developed an interesting method for determining the duty cycle of the meters. Through measurement, they determined that the average duration of an individual transmission from a meter was 0.157 seconds. (Message length for the meters Jefferson PUD will install is specified by the manufacturer as 0.150 seconds maximum.) They then obtained from the Benton County PUD a log of all messages received from about 46,000 homes during a seven-day period. From these two sets of data, they could compute the duty cycles of each meter (for this period of time). They found that 50% of meters had duty cycles less than 0.00128%, 99% had duty cycles less than 0.0124%, and 99.999% had duty cycles less than 0.0465%. The largest recorded duty cycle was 0.047%. The total time the meter with the largest value was transmitting during a 24-hour period was 41 seconds, consisting of about 260 individual messages.

As an estimate of the worst-case time-average exposure measured in homes by this study, combine the maximum exposure level, measured with the meter transmitting, of 0.16% with the largest measured duty cycle of 0.0465% to yield a time averaged exposure of 0.000074% of the FCC exposure guideline. The average for all measurements was 0.0033% of the FCC guideline.

The second study was performed in two areas in Vermont. The meters used in these two areas were manufactured by Elster and Itron and had output RF powers of 0.182 and 0.304 watts, respectively, and operated in the frequency range 902 to 928 MHz. Radio frequency exposure levels measured 3 feet from 17 meters varied from 0.036% to 0.586% of the FCC guideline while the meters were transmitting. The average for all 17 meters was 0.265% of the FCC guideline.

RF field measurements were made at 141 locations in 15 homes while they home's meter was transmitting. The largest exposure value was measured in the garage of one home and was 0.08% of the FCC guideline. The largest exposure measured in rooms of the 15 homes, excluding garages, was 0.070% of the FCC guideline. The average for all measurements, including garages, was 0.0033% of the FCC guideline.

The meters in the Vermont areas were deployed in a "mesh" configuration. This means that meters will transmit their data to other meters which will then pass it on to other meters until the data reaches a central collection point. Meters remote from the collection point will only need to transmit their own data while meters near the collection point will be transmitting not only their own data but the data from other more-remote meters. Duty cycles were measured for meters located close to and remote from the collection point. The duty cycle of one meter located close to its collection point was measured to be 3.6%; this was the largest duty cycle measured in the study. The duty cycle measured for meters remote from the collection point was 0.14% or less.

As a worst case estimate for the Vermont study, take the maximum measured exposure level with the meter transmitting of 0.08% and time average it with the largest measured duty cycle of 3.5%. The result is a time-average exposure of 0.0028% of the FCC guideline.

This study also measured exposures behind three power meters to be about 6-8% of the measured values in front of the meter.

Discussion and Conclusions

I estimated for each of the two studies the maximum time-averaged exposure in the home by combining the maximum observed peak exposure in the garages of homes with meters transmitting with the maximum duty cycle measured in each study. The results for the Benton PUD and Vermont studies were 0.000074% and 0.0028%, respectively. I believe the meters in the Vermont study were operated in a manner nearer to that of our PUD's new meters. Therefore, I will start with a worst-case estimate of 0.0028%.

The meters in the Vermont study had output RF powers of 0.182 and 0.304 watts. The new meters our PUD will install have a maximum RF power of 0.972 watts, which means that, everything else being equal, the strengths of the RF emissions from our PUD's meters will be 3.2 to 5.3 times stronger. Thus, for our PUD, an estimate of the worst-case exposure in a home from its own power meter will be 5.3 times the Vermont worst-case exposure, or about 0.014%. In other words, the maximum estimate exposure in a home in Jefferson County resulting from its own power meter will be about 1/7,000 of the FCC safety guideline. Furthermore, as mentioned earlier, the safety guideline already incorporates a safety factor of 50, so the total safety factor is about 350,000.

Of course, it may be that the Jefferson PUD operates their meters in a manner such that their duty cycles are larger (or smaller) than the duty cycles measured in the Vermont study. Itron indicates that the maximum duty cycle for their meters is 10%. If we use this value instead of the maximum value of 3.4% measured in Vermont, estimated maximum exposure levels rise to about 0.040% of the FCC safety guideline. This exposure would be 2500 times less than the FCC guideline and would incorporate a safety factor of 125,000.

Do these results indicate that one should not be concerned about the electromagnetic radiation from smart meters? In our country, safety guidelines are set to eliminate risks from known hazards. There is, of course, always the possibility that there are hazards that have not yet been identified. In fact, safety guidelines do tend to become more stringent over time as new research identifies new potential hazards. The safety guideline in 1975 was about 15 times larger than now. So, it is certainly possible that future safety guidelines will be lowered, but it seems to me very unlikely that these guidelines will ever be lowered to the point that they even begin to approach levels that measurements indicate that people are exposed to in their homes arising from the operation of smart power meters. These results convince me that the likelihood of EMR from power meters ever being a health risk is small.

Comparison with Cell Phones

Exposure to the electromagnetic fields produced by cell phones occurs in a very different way than from smart meters because cell phones are normally held very close to the head. The fact that a cell phone is very close to the head means that exposure from it cannot accurately be determined by specifying the strength of the incident field, as is done with smart meters. This is because the distance between the phone and the head of the exposed person is small relative to the wavelength of the incident radiation. In this "near field" region, the relationship between the electric and magnetic field strengths is complex. Instead, exposure has to be characterized by the actual specific absorption rate (SAR), that is, the power actually deposited in a small volume of tissue. The FCC requires that all manufacturers of cell phones characterize the maximum SAR their phone can produce in an exposed head phantom, which is constructed to simulate the human head. These maximum SAR data are available online[10] and vary from about 0.18 W/kg (watts per kilogram) to about 1.5 W/kg. (These maximum values probably occur in the lobe of the ear.)

What SAR's are produced by smart meters? In the previous section, a worst-case exposure of 0.04% of the FCC guideline was estimated for the smart meters that Jefferson PUD plans to install. The FCC guideline is intended to limit SAR's to about 0.08 W/kg. Thus, an exposure of 0.04% of this guideline would limit SAR's to about 0.000032 W/kg, much less than that from a cell phone.

Other Risk Assessments of Smart Meter

California Council on Science and Technology

The California Council on Science and Technology (CCST) is a non-profit organization established in 1988 at the request of the California State Government. CCST' mission is to improve science and technology policy by proposing programs, conducting analyses, and recommending public policies and initiatives that will maintain California's technological leadership and a vigorous economy.

CCST has published a report[6], dated April 2011, dealing with the health impacts of radio-frequency exposure from smart meters. Their key report findings are:

1. Wireless smart meters, when installed and properly maintained, result in much smaller levels of radio frequency (RF) exposure than many existing common household electronic devices, particularly cell phones and microwave ovens.
2. The current FCC standard provides an adequate factor of safety against known thermally induced health impacts of existing household electronic devices and smart meters
3. To date, scientific studies have not identified or confirmed negative health effects from potential non-thermal impacts of RF emissions such as those produced by existing common household electronic devices and smart meters.
4. Not enough is currently known about potential non-thermal impacts of radio frequency emissions to identify or recommend additional guidelines for such impacts.

<u>Arizona Department of Health Services</u>

The Arizona Corporation Commission voted on August 5, 2013, to request the Arizona Department of Health Services to conduct a study on the potential health effects of exposure to radio frequencies emitted from Smart Meters. The Office of Environmental Health of the Arizona Department of Health Services (ADHS) performed this study and published their results in report form[6] on October 31, 2014. ADHS reached the following conclusions:

1. The measured RF radiation emissions (in power density) from electronic meters are below the FCC guideline of 0.6 watts per square centimeter.
2. In general, the measured RF radiation emissions are higher from AMI and AMR smart meters. The measured RF radiation emission from analog and PLC (power line carrier) meters are similar to the background levels.
3. In general, for electronic meters, the measured RF radiation emissions are higher for apartment complexes when they are compared to single family homes.

4. In general, for electronic meters, the measured RF radiation emission is higher from urban area when they are compared to those from rural area.
5. Exposure to electric meters (AMI and AMR) is not likely to harm the health of the public. This conclusion was reached because (1) none of the detected power densities exceeded the FCC guideline of 0.6 mW/cm^2. This guideline was determined based on thermal effects, and was set to prevent whole-body heat stress and excessive localized tissue heating; (2) available government assessments and scientific literature indicated that there is no consistent or convincing evidences to support a cause-and-effect relationship related to the exposures to the RF frequency (900-930 MHz) used by the smart meters; (3) none of the detected power density exceeded the lowest available guideline of 0.01 mW/cm^2 (determined by Russia). This value was determined to ensure that no exposure would cause any possible biological consequences among the exposed population.

Public Utility Commission of Texas

Because of concerns expressed by some citizens to Texas regarding the safety of smart meters, PUC staff were directed to investigate the health concerns expressed by citizens and other interested parties. The results of this investigation are presented in a 84-page document. This document provided background on radiation and science, reviewed recent studies and expert opinion, and reached the following conclusion:

> Decades of scientific research have not provided any proven or unambiguous biological effects from exposure to low-level radio frequency signals. Further, after performing a review of all available material, Staff found no credible evidence to suggest that smart meters emit harmful amounts of RF EMF.

County of Santa Cruz Health Services Agency

In a memorandum[8] prepared by a Santa Cruz health officer, it is argued that smart meter usage conveys substantial health risks. The argument is partially based on the author's conclusion that exposure to smart meters is a little over 50 times greater than from cell phone usage, which is a conclusion very different from those arrived at by most other observers. To arrive at this conclusion, the author assumed that the duty cycle of smart meters was always 100% and that the radiation from cell phones should be averaged over the whole body. Neither of these assumptions seem tenable to me. Duty cycles measured for actual smart meters in southeastern Washington State and Vermont were much less than 100%, with the largest measured value being 3.5%. In reference 4, it is noted that the duty cycles of the Sensus Icon meters in this study were limited to about 3.4% by the design of the transmitter's power supply. Itron states that the maximum duty cycle of their instruments is 10%. (I don't know if this is a hardware limitation.)

The author also argues that the cell phone signal should be averaged over the entire body of the user. But, the major health concern from cell phone usage has been brain tumors, and it seems highly unlikely that the exposure level at one's foot or even waist would be a pertinent to this exposure. Cell phone exposure is higher than from smart meters because the phone is normally held flush with the ear of the user and is, thus, located much closer to the body than a smart meter. The duty cycles of cell phones are, apparently, substantially less than 100% but still more than measured smart-meter duty cycles.

Finally, the author assumes that "numerous situations" exist in which the distance between a smart meter and an exposed person is less than 3 feet, as for example a smart meter mounted on the exterior wall of a bedroom with the bed placed adjacent to the mounting next to the wall. I agree that this could happen in Jefferson County, but I do not think it would happen in numerous situations. Most power meters in our area are mounted on garages. But, assume that the meter is mounted on the exterior wall of a bedroom with a bed next to the wall. The author then estimates that the distance from the meter to a person sleeping in the bed would be 1 foot. This seems unlikely to me because the wall has a thickness of a minimum of 4 inches (modern homes have 6-inch walls), so in order to sleep within 1 foot of the meter the person would have to lying right against the wall.

But, assume the author's 1 foot is correct. According to measurement in both the Benton County and Vermont studies, the field behind a power meter is attenuated by at least a factor of 10 relative to the field in front. From Table 1, the estimated field from a 1-watt power meter at 1 foot in front of the meter is about 22% of the FCC safety guideline. Taking into account the attenuation mentioned above, the field 1 foot in back of the meter would be about 2.2%. And, assuming a duty cycle of 10%, the estimated time-averaged exposure level is about 0.22% of the FCC guideline, that is the estimated exposure is about 450 times less than the FCC guideline. Taking into account the safety factor of 50 present in the FCC guidelines, the overall safety factor for exposure at 1 foot is about 22,000.

As I said before, it is certainly possible that some new hazard will be conclusively identified resulting from exposure to RF fields at levels below the current FCC guidelines, but it seems to me extremely unlikely that the safety guidelines will have to be reduced by a factor of 450 to protect against this new hazard.

World Health Organization Conference on Electromagnetic Hypersensitivity

Some argue that perhaps 1-3% of humans are particularly sensitive to very low-level electromagnetic fields; this phenomenon is often referred to as electromagnetic hypersensitivity (EHS). In response to these concerns, the World Health Organization (WHO) organized an International Workshop of EHS[11] that was held in Prague, Czech Republic, October 25-27, 2004. Some of the conclusions from the workshop included:

> EHS is characterized by a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. For some individuals the symptoms can change their lifestyle.
>
> The term "Idiopathic Environmental Intolerance (IEI) with attribution to EMF" was proposed by the working group to replace EHS since the latter implies that a causal relationship has been established between the reported symptoms and EMF….
>
> IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people and cause disruptions in their occupational, social, and personal functioning.
>
> The majority of studies indicate that IEI individuals cannot detect EMF exposure any more accurately than non-IEI individuals. By and large well controlled and conducted double-blind studies have shown that symptoms do not seem to be correlated with EMF exposure.

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Appendix A: Calculation of Power Density from a Point Source

The simplest ideal radiator, called an isotropic radiator, would send its output power equally in all directions. Thus, if you placed an imaginary sphere around the source, with the source at the sphere's center, the output power would be distributed equally over the area of the sphere, which is $4\pi R^2$, where R is the radius of the sphere. Thus, the power density, D, of the radiation from this source at a distance R from it would be

$$D = \frac{P}{4\pi R^2}, \tag{1}$$

where P is the output power of the source.

But, actual sources do not radiate equally in all directions but, instead, radiate stronger in some directions than others. The direction of strongest radiation is called the main lobe of the radiation pattern of the source. Antenna gain is the ratio of the power density of the radiated field in the main lobe divided by the power density that would be present if the source were an isotropic radiator. Denote antenna gain by the symbol G. Then the strongest field emitted by a source with an antenna gain of G would be

$$D_{max} = G\frac{P}{4\pi R^2}. \tag{2}$$

Using this equation we can estimate the strongest field produced near an Itron meter.

According to Itron, the maximum power sent to the antenna of the meter is P = 0.972 watts (W) and the antenna gain is G = 1.58 (2.0 dBi). Consequently, the maximum power density radiated by the meter is

$$D_{max} = \frac{0.132}{R^2}, \tag{3}$$

where R is measured in feet and the units of D_{max} are mW/cm^2 (milliwatts per square centimeter). This equation was used to calculate the maximum power density values in Table 1 in the main body of this report.