Analysis of the City of Naperville Comparison Between Cell Phone and Smart Meter Exposure Levels

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Introduction

The Public Utility Commission of Texas (PUCT) issued a report [2] in December 2012 that purports to address concerns over the potential health effects of exposure to the radiofrequency emissions from the wireless technology of advanced metering. Page 43 of that report highlights the fact that the City of Naperville, Illinois, has issued a public relations flyer [3] that states:

"*...a person sitting 10 feet in front of their smart meter would have to be there for more than 100 years to receive the same RF energy that they would receive from a 3-minute cell phone call. If a person were sitting inside their home 3 feet from the back of a smart meter, they would have to be there for more than 200 years to receive the same RF energy as they would from a 3-minute cell phone call*."

Additionally, the City of Naperville documents assumptions in footnotes as follows:

1. Smart Meter Specification: duty cycle of 0.1%; 250 mW EIRP; maximum antenna gain in front of meter is 3.66; antenna gain drops by 20 times behind meter and inside the home.
2. Cell Phone Specification: duty cycle 45%; peak transmitter power after antenna is 600 mW EIRP; distance 1 cm.

The PUCT report characterizes the Naperville device comparisons as an attempt "to put RF EMF emissions from its smart meters into perspective."

It is the purpose of this document to demonstrate that the Naperville device comparisons are based upon grossly unrealistic and non-conservative assumptions and that the comparisons are likely technically meaningless in terms of evaluating potential health effects. ***Furthermore, contrary to City of Naperville claims, exposure to RF emissions from a smart meter over the course of a 24-hour period could easily exceed the exposure received from making a 3-minute cellular phone call***.

Technically Meaningless Comparisons and What Is Actually Relevant

First of all, the above Naperville comparison includes a false premise that assumes there is technical relevance in making a comparison between the "RF energy" of one type of device (a cell phone) with the "RF energy" of a totally different device such as a wireless smart meter. Such comparisons may be warranted when considering short-term thermal effects of radiofrequency (RF) exposure but are not likely of major significance when considering the possible effects of chronic exposure to pulsed RF radiation emitted from smart meters.

As explained [4] by a leading epidemiologist, Dr. Devra Davis, "It is the intermittence, the erratic nature of the signal that may be most important biologically. So, that a very weak signal … might be more damaging that one that is a steady, regular signal. … Signal characteristics may be much more important than total dose. That is to say, the total dose or the average of the dose may not be the issue so much as the characteristics of the signal - again, its erratic nature."

Additionally, as described in *The BioInitiative Report 2012* [5]: "There is increasing reason to believe that the critical factor for biologic significance is the intermittent pulse of RF, not the time-averaged SAR [specific absorption rate]. … Real-world experience is revealing worrisome evidence that … people can be adversely affected by placing new wireless pulsed RFR transmitters (utility meters on the sides or interiors of homes), even when the time-weighted average for RFR is miniscule."

Due to evidence of observed biological effects from RF radiation at extremely low levels, *The BioInitiative Report 2012* established precautionary action levels within the range of 0.0003 to 0.0006 microwatts/cm^2 for chronic exposure to pulsed RF radiation.

Finally, although one may perform an exercise in an attempt to compare possible exposures between a cell phone and a smart meter, the results of such calculations are nearly impossible to evaluate in terms of an "apples upon apples" comparison. A calculated exposure for a cell phone placed near the head is a localized exposure. The exposure calculated for a smart meter at a greater distance is more uniform in nature to the whole body. Thus, more surface area of the whole body is exposed to the RF field strength values calculated for the smart meter than is for the cell phone. For that reason, such calculations inherently underestimate the potential exposures due to wireless emissions from the smart meter (at least when plotted on the same graph with cell phone values representing localized exposures).

Naperville Device Comparison Assumptions

1. Cell Phone Power

The "cell phone specifications" used by the City Naperville in its comparison analysis are arbitrary and unreasonable. It is possible that such phone specifications were valid at some time in the past, but certainly not for all cell phones currently in use today. The City of Naperville assumes a peak cell phone transmitter power of 600 milliwatts and uses a duty cycle of 45%. Again, without any further explanation by the City, these assumptions can be concluded to be completely biased or chosen by an uninformed person.

In a submittal [6] to the Federal Communications Commission (FCC), dated September 3, 2013, the Telecommunications Industry Association (TIA) indicated that "recent analyses of actual exposure conditions demonstrate that the systems currently operate to provide exposures well below that expected by users who refer to reported SAR levels. A recent Swedish study found that after assessing output power from more than 800,000 hours of voice calls, the average level for 3G or smartphone voice calls was below 1 mW across all environments, including rural, urban, and dedicated indoor networks." This referenced study [7] is entitled "Output Power Distributions of Terminals in a 3G Mobile Communication Network," published in *Bioelectromagnetics*, May 2012. The TIA also references a French study that found that "a phone used in an urban environment typically operates at less than one percent of its maximum power."

Rather than using a fictitious number for cell phone power output, let's use the results of a peer-reviewed study, namely a representative "average output power" of 1 milliwatt. [8]

2. Cell Phone Duty Cycle

Smart grid industry "experts" apparently are not familiar with current cell phone technology. Depending on the technology, cell phones incorporate a number of features that reduce the average power output as compared to the peak power output, including adaptive power control, time-slotted modulation, discontinuous transmission (DTX), and power control (PWC). These features contribute to an effective device duty cycle which is typically less

than 1%, consistent with the above statements from the Telecommunications Industry Association. In addition to the average power output of a cell phone being much less than its maximum, the true duty cycle should be calculated based upon the duration of time that the device is used over a period 24 hours. In the Naperville device comparison, the cell phone is used for a period of 3 minutes. Thus, the maximum "duty cycle" based upon time-of-use would be 3 minutes divided by 1440 minutes/day, or 0.2%.

3. Cell Phone Distance from Head

Another area where the Naperville cell phone calculation is not necessarily representative of actual phone use conditions is where it is assumed that a person holds the phone 1 cm from the body. This assumption is arbitrary. If you were performing calculations regarding maximum possible exposure scenarios for voluntary phone use, this value could be used, but that is not the purpose of these calculations. The EPRI field strength values [9] typically quoted in smart grid industry documents that range from 1000 to 5000 microwatts/cm^2 involve exposure to an "imaginary" cell phone with a continuous power output of 250 milliwatts and where the phone is held at a distance from head or ear ranging from 1 cm to 2 inches. Just to pick a distance in the middle of that range, let us use 1 inch for model calculations. These selected distance values are somewhat arbitrary, and as will be later demonstrated, another possible arrangement would be to use a hands-free phone using a distance of about a foot or so. Please remember it is not the phone itself that is the source of radiation, but the antenna which either extends outward from the phone or is embedded within the device itself. In addition, as a person uses a cell phone, it is not "locked" in place, and the person would likely adjust orientation of the phone periodically such that the same localized areas are not constantly exposed to the maximum possible exposure level.

4. Smart Meter Duty Cycle

The next major unreasonable and biased assumption by the City of Naperville is with regard to the assumed smart meter duty cycle of 0.1%. This value is likely a design specification value for one meter operating in isolation, not as part of a mesh network. As part of a network, the duty cycle of a smart meter can dramatically increase due to performing several functions, such as network management, time synchronization, and activities related to forwarding routed messages for <u>other</u> customers.

For a person with a concern about wireless smart meter emissions, the concern is over (involuntary) potential exposure for oneself and family, ***<u>not</u>*** an exposure calculated based upon a meter design specification. In fact, several smart meter measurement test studies show that at least some smart meters involved with each study have duty cycles in the range of 3% to 4% to 5%, depending on the study. [10] Since the average person does not possess the equipment necessary to measure the actual RF emissions from a wireless smart meter located on his or her property, at a minimum, it ***must*** be assumed that the duty cycle is the maximum value measured in the field.

One of the smart grid industry's most touted reports [11] is called, "Health Impacts of Radiofrequency from Smart Meters," Final Report, dated April 2011, published by the California Council on Science and Technology (CCST). Even in the CCST report, it is stated that: "The PG&E commissioned report by Richard Tell Associates is based only on [a] duty cycle of transmitting data once every four hours. … To truly be a smart grid, the data will be transmitted at a much more frequent rate than this. In this report we look at the worst – case scenario, a meter that is stuck in the "on" position, constantly relaying, at a 100% duty cycle."

"Each smart meter is part of a broader 'mesh' network and may act as a relay between other smart meters and utility access points. The transmitter at each smart meter will be idle some of the time, with the percent of time idle (not transmitting) depending on the amount and schedule of data transmissions made from each meter, the relaying of data from other meters that an individual meter does, and the networking protocol (algorithm) that manages control and use of the communications paths in the mesh network. Theoretically the transmit time could increase substantially beyond today's actual operation level if new applications and functionality are added to the meter's communication module in the future. For a hypothetical illustration (i.e., the meter transmits half the time and receives half the time), an upper end duty cycle would be 50%."

The table below (extracted from the CCST report) shows two possible smart meter duty cycles. **Note that the 5% duty cycle is listed under the column of "Typical Smart Meter Operation with Repeater Activity."**

Typical Smart Meter Operation With Repeater Activity	Scaled Hypothetical Maximum Use Case (i.e., always on)
5% Duty Cycle	50% Duty Cycle
72 minutes/day	12 hours/day

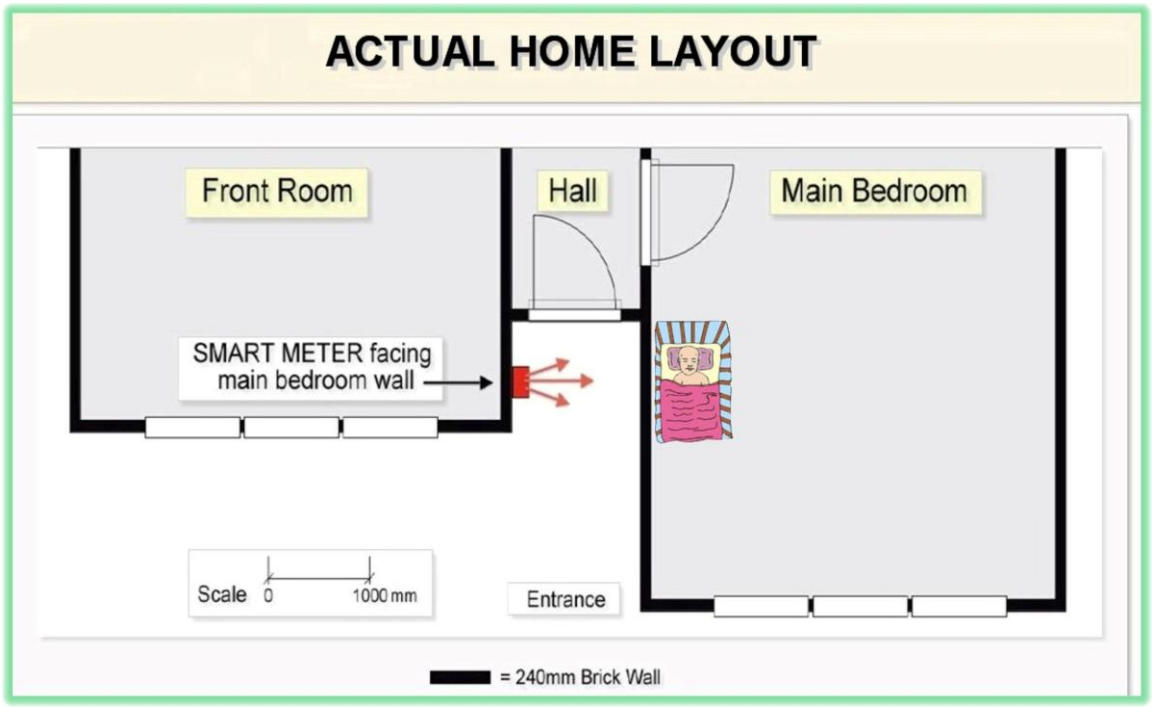
To use a duty cycle value of 0.1% in model calculations is totally inappropriate and non-conservative since it represents a meter design specification value that is not reflective of actual values that ***may*** occur in the field. Based upon the above CCST information, one ***could*** justify either using a smart meter duty cycle of 50% or possibly even 100% as the absolute worst case, stuck "on" position, especially since the typical member of the public has no way to measure or otherwise know whether his or her smart meter is the one that may be transmitting with the hypothetical maximum duty cycle. These are hypothetical numbers that could occur although at this time the 5% duty factor is probably the most likely maximum value to be measured in the field.

Finally, duty cycles are sometimes measured or assigned for purposes of calculating the average RF field strength of a wireless device over time. Although such calculations are relevant for evaluating possible adverse biological effects caused by a thermal mechanism, they are of little use in evaluating possible effects that would be due to chronic exposure to pulsed or modulated RF emissions where a non-thermal mechanism may be involved. Thus, although an exercise may be performed to calculate average RF field intensity values, they would not be used to evaluate chronic exposure to RF emissions from smart meters. In those instances, instantaneous RF field intensity values for a transmitting smart meter should be compared to the precautionary action levels of documents such as *The BioInitiative Report 2012*.

5. Antenna Gain Assumptions

Another Naperville assumption that can be challenged as non-conservative for model calculation purposes is the antenna gain dropping by 20 times behind the meter and inside the home. This assumption is used to characterize a somewhat typical arrangement where the smart meter only faces away from other building walls and where there are no reflective wave conditions that might actually increase exposure with distance away from the smart meter. This is not always the case and again, the concern is regarding (involuntary) potential exposure for oneself and family, *not* an exposure calculated based upon a non-conservative model. What you see below is the layout for an *actual home* where the smart

meter faces directly towards the main bedroom. In this case, a baby's crib, for example, may be positioned as close as 3 to 4 feet from the smart meter. There would likely be some attenuation by the bedroom wall but this could be countered by reflective wave conditions as well as construction materials or windows in some bedroom walls offering little if any attenuation to RF emissions. Furthermore, there is recent evidence that RF radiation emitted from a wireless digital electric meter in the 900 MHz range enters the home through a conductive mechanism and reradiates into rooms through conductive objects such as wiring and table lamps. [12] It is therefore unwise to make any assumptions regarding an attenuation that may or may not be applicable for being "behind" a smart meter.



Revised Comparison Calculations

Based upon the above analysis, we have shown that Naperville assumptions for cell phone and smart meter comparisons were either erroneous or inappropriately non-conservative. More appropriate values that should be used in technically valid operational scenario calculations are summarized below:

Parameter	Value
Cell Phone Average Power Output:	1.0 milliwatt, based upon TIA correspondence to the FCC and published study
Distance from Cell Phone Antenna to Head	One (1) inch or 2.54 cm
Smart Meter Duty Cycle:	5 %, based upon consideration as "Typical Smart Meter Operation with Repeater Activity," per CCST
Antenna Gain:	3.66 regardless of direction, with no credit for possible attenuation through walls

Regarding calculations for field intensity values for cell phones over short distances, there are wave size and geometry considerations that make such calculations inappropriate even though the smart grid industry insists on making them. The problems associated with making such calculations and associated measurements are why cell phone exposure

limit values are expressed in units of SAR or specific absorption rate rather than in terms of units such as microwatts/cm^2.

Nevertheless, rough estimates can be made and the value calculated [13] by SkyVision Solutions for a cell phone held one (1) inch from the head and with a power output of 1 milliwatt is about 10 microwatts/cm^2. If one corrects this exposure value for a duty cycle of 0.2% (for a 3-minute phone call in a day), the resultant exposure to the user's head over the course of a 24-hour day is 0.02 microwatts/cm^2.

Moving on to smart meters, using the Naperville smart meter with a design specification power output of 250 milliwatts and an antenna gain of 3.66, both the instantaneous RF power density values during signal transmission **and** the average exposure levels for a smart meter with a duty cycle of 5% are shown below [14].

Comparison Between Various Smart Meter and Cell Phone RF Exposure Scenarios	
Exposure Type	Exposure Level
Cell Phone held at one (1) inch; average localized exposure ***while phone is used by consumer*** for a 3 minute cell phone call. *	10 microwatts/cm^2
Cell Phone held at one (1) inch; average localized exposure over the course of 24 hours ***using a duty cycle of 0.2% based upon a 3 minute phone call***. *	0.02 microwatts/cm^2
Smart Meter at a distance of 10 feet; average exposure using a duty cycle of 5%. **	0.04 microwatts/cm^2
Smart Meter at a distance of 3 feet; average exposure using a duty cycle of 5%. **	0.4 microwatts/cm^2
Smart Meter at a distance of 10 feet; instantaneous exposure values. **	0.8 microwatts/cm^2
Smart Meter at a distance of 3 feet; instantaneous exposure values. **	8.8 microwatts/cm^2
BioInitiative Report 2012 precautionary action levels for chronic exposure to pulsed RF radiation.	0.0003 to 0.0006 microwatts/cm^2
* Note that the peak exposure is generally unknown for any individual cell phone user; the hypothetical peak output is typically brief and is normally encountered when a cell phone user initially powers on a cell phone or experiences a handoff from one cell phone tower to another.	
** Chronic (24/7) smart meter exposure is appropriately assumed for an infant child or a vulnerable member of the population who has restricted mobility.	

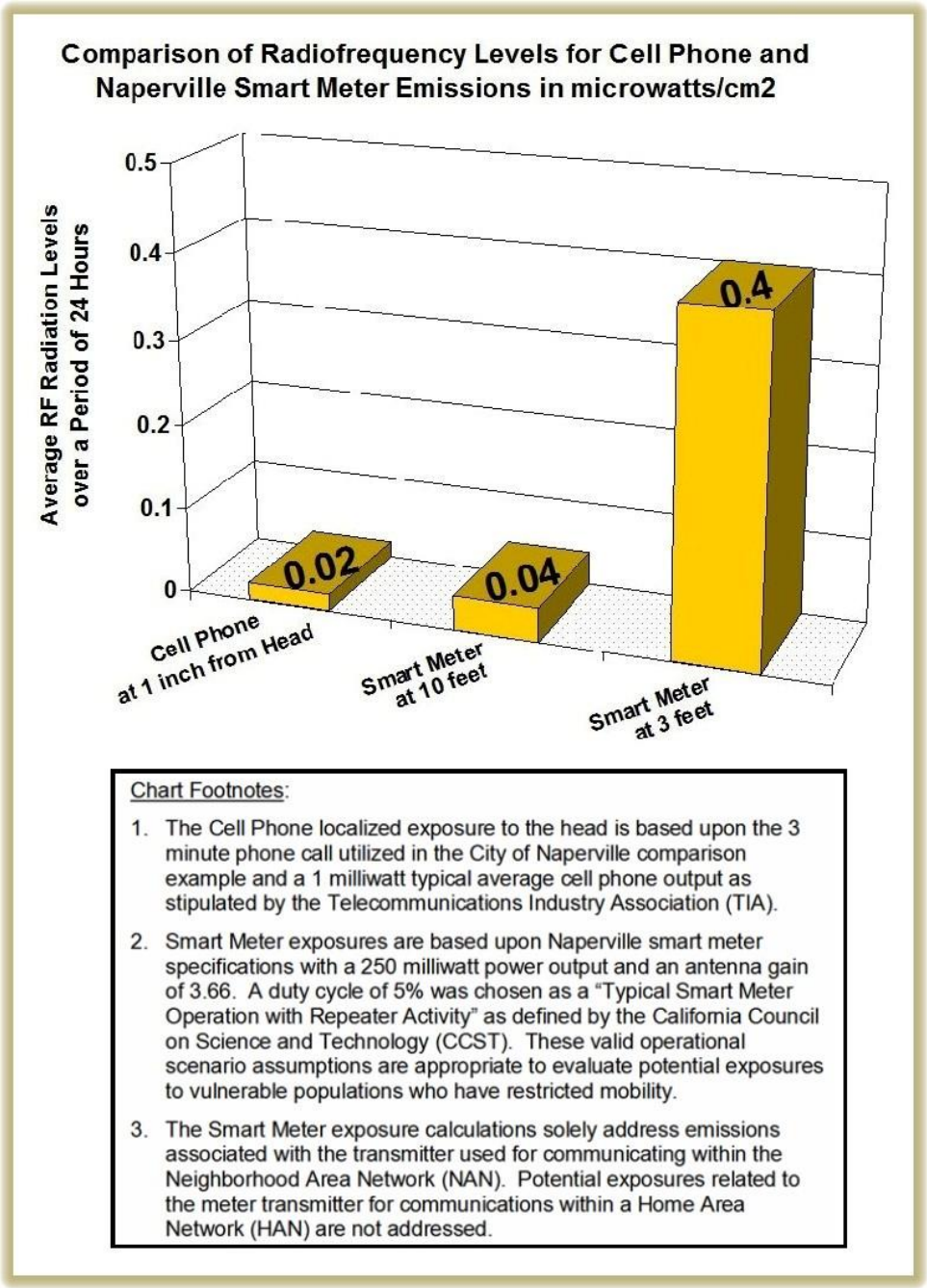
As can be seen from the information summarized in the above table, it is absurd for the City of Naperville to state that one would need to be exposed to a smart meter for 100 to 200 years to receive the same RF energy as a 3 minute cell phone.

In actuality, based upon the appropriate and reasonable assumptions made as part of this analysis, one can conclude the following:

*A person can receive **twice as much** RF energy from exposure to a Naperville smart meter over the course of a day at a distance of 10 feet as compared to the localized exposure received from making a 3-minute cellular phone call*.

*A person can receive **20 times more** RF energy from exposure to a Naperville smart meter over the course of a day at a distance of 3 feet as compared to the localized exposure received from making a 3-minute cellular phone call*.

Refer to the chart below to more easily conceptualize how the *average* smart meter exposures can *exceed* the localized cell phone call exposure over the course of a 24 hour period.



It is not asserted that the above calculated smart meter exposures will be typical for everyone. However, it is claimed that the above calculated exposures are valid scenarios that should be considered when assessing potential exposures to consumers who may have specific living arrangements within their homes that would make these scenarios applicable to their situations. This would be particularly true for vulnerable members of our population who have restricted mobility and spend most or all of their time in one room of a home.

More importantly, beyond the discussion of exposure to RF emissions based upon *averaging* over a 24-hour period, the relevant parameter for evaluating potential adverse health effects is the chronic exposure to frequent and pulsed signals from a smart meter. The instantaneous power density values for a smart meter during signal transmission of 0.8 and 8.8 microwatts/cm^2 for 10 feet and 3 feet respectively are those of interest in comparison to *The BioInitiative Report 2012* precautionary action levels. With action levels being in the range of 0.0003 to 0.0006 microWatts/cm^2 for *chronic exposure to pulsed RF radiation*, it is evident that smart meter instantaneous exposure levels are over a thousand times higher than those expected to be able to cause observed negative health effects.

Also note that the 3-minute cell phone call exposure is not considered chronic, and thus *The BioInitiative Report* action levels are *not* as relevant for that exposure type.

Other Considerations Not Addressed by the City of Naperville

Another complicating issue is that Naperville smart meters contain two separate transmitters. One transmitter operates in the frequency range of 900 MHz and functions within the Neighborhood Area Network (NAN), communicating with the utility and with other smart meters in the area. The second transmitter operates in the frequency of range of 2.4 GHz and exists to function within a Home Area Network (HAN), communicating with "smart" appliances within an individual residence and with an In-Home Display (IHD) unit. In its public relations flyer, the City of Naperville has only attempted to address the transmissions related to the NAN communications.

From a City of Naperville, smart meter testing plan document [15], dated September 22, 2011, it contains the following statements:

"Note that the 2.4 GHz ZigBee radio in the Elster residential REX2 meter is programmed to transmit beacon signals periodically, even if a ZigBee HAN device is not being used with the REX2 meter. These beacon signals, which are part of the ZigBee protocol, let other ZigBee devices know they are within communication range."

In addition, from a document [16] entitled, "An Evaluation of Radio Frequency Fields Produced by Smart Meters Deployed in Vermont," by Richard Tell Associates, Inc., dated January 14, 2013, it contains the following statements:

"Despite the fact that the Elster meters were not generally 'activated' to interact with In-Home Displays (IHDs), the HAN radios in the smart meters periodically issue a brief signal lasting approximately 1.75 ms once every 15 seconds plus a group of four closely spaced signals once per minute for a total of eight pulse emissions per minute. These signals are presumably related to the HAN radio searching for IHDs in the vicinity to wirelessly connect to the meter."

So even if a customer does not have a smart appliance or In-Home Display unit, the smart meter will emit, at least for some models, a total of eight (8) HAN-related pulses per minute. Over a period of 24 hours, that is 11,520 pulses. And what if you do have an In-Home Display unit or smart appliances with which the smart meter would communicate? Logically, the potential for increased exposure is great, particularly as

one increases the number of indoor smart appliances and other devices that may communicate with an In-Home Display unit or the smart meter itself.

The ZigBee radio in the Naperville residential smart meter has a rated power output of 100 milliwatts, less than the 250 milliwatts of the transmitter used for NAN communications. These signals operate at different frequencies and likely do not transmit simultaneously, so there should not necessarily be an additive effect in terms of peak power density values. However, what is most important is that the HAN-related communications represent another source of chronic exposure within the home to pulsed RF emissions that would still exceed the precautionary action levels of *The BioInitiative Report 2012*.

Relevant Information from Another Industry Document

There is additional revealing information in the report mentioned earlier entitled, "An Evaluation of Radio Frequency Fields Produced by Smart Meters Deployed in Vermont," by Richard Tell Associates, Inc. In that report, measurements were made of RF fields produced by a cellular phone, a Samsung Model Blackjack II, "to provide perspective on potential exposure to cell phones and smart meters." It was noted that "there [were] abrupt changes in the signal level (RF field) at different times during the test call suggesting that the phone is dynamically changing its power in response to the mobile phone base station to which it is connected at the time."

Furthermore, according to Richard Tell Associates:

"Cell phones make use of transceivers that, in terms of power and frequencies used, are not very different from the transceivers in smart meters. Thus, one would not expect that there would be very much difference in exposure between the two devices except for the fact that cell phones are intended to be used against the body while smart meters are not. In a measurement of the spatially averaged RF field over a six-foot vertical dimension, with the phone positioned at five feet above the floor, the field was found to be equivalent to 0.070% of the MPE. Interestingly, this is in quite close agreement with the value obtained for the maximum field smart meter in terms of time-averaged field, including spatial averaging of 0.068% of the MPE." [17] [emphasis added]

The above language is a bit technical, but do you realize what this means? The Richard Tell Associates' time averaged RF measurement results for a smart meter were almost ***identical*** to those of the cellular phone, measured in the same configuration. This configuration was such that when the measurement device was placed at a height of five feet, that it was located one (1) foot away from the smart meter/cell phone being measured. For the cell phone measurement at one foot, the exposure is similar to that experienced while using a hands-free kit.

The counter argument by detractors to the above professionally documented test evidence is that people are not normally located at a distance one (1) foot away from a smart meter. With the above information as background, however, it is possible to now provide perspective and make an "apples upon apples" comparison based upon actual test data, not just theoretical calculations. The Tell study provides a credible mechanism to compare cell phone and smart meter power density levels in a way that was based upon the same spatial configuration. These spatially averaged test results help account for the difficulties mentioned earlier in this paper that result from calculations made for a localized cell phone exposure to the head as compared to a more uniform exposure resulting from a smart meter at some distance away in feet.

In addition, the Tell test results help dispel misleading and erroneous statements made by the smart grid industry that "RF signals used by smart meters are *much weaker* than

the RF signals from cell phones." [18] … and of course the absurd statement made by the City of Naperville that: "a person sitting 10 feet in front of their smart meter would have to be there for more than 100 years to receive the same RF energy that they would receive from a 3-minute cell phone call."

Something to emphasize is that based upon testing performed by one of the smart grid industry's most respected testing companies, one can say that: "You can stand in front of a smart meter and get the same amount of radiation as you would get from a 'hands-free' cell phone call, minute for minute, during the call." Why would the City of Naperville or other smart grid-related organizations not want to advertise this device comparison based upon actual testing, at least as one example? Could there be bias involved?

Summary

It has been shown that the statements made by the City of Naperville regarding smart meter exposures and cell phones are based upon erroneous and inappropriate assumptions. Correcting those assumptions, the actual calculated field strength values in microwatts/cm^2 can be shown to be quite similar for the two types of devices. In fact, ***it has been demonstrated that the RF field strength values for a smart meter averaged over a period of 24 hours can well <u>exceed</u> the localized exposure received from intermittent cell phone use for that same 24 hour period***. Beyond that, however, the comparisons are of little technical relevance since field strength intensity is only part of the information necessary to evaluate potential effects. Biological effects likely vary based upon frequency and modulation of a signal such that a very weak signal may have a significant biological effect.

Finally, it must be considered that mandated smart meter exposure is chronic and involuntary in nature. The smart meter field intensity values calculated in this paper exceed *The BioInitiative 2012 Report* action levels based upon the fact that they are pulsed and chronic in nature. It is one thing for an adult to engage in a voluntary 3-minute cell phone call. It is quite another to allow an infant child to sleep in a crib or live in a room located a few feet from a wireless smart meter.

The above sentiment regarding chronic and involuntary exposure to smart meters was well summarized by Dr. De-Kun Li in testimony [19] filed before the Maine Public Utility Commission in December 2012 regarding wireless smart meter safety:

a. "Cell phone use is usually for short duration. However, a smart meter, if installed near or outside the location within a residence that people are frequently occupying (such as bedrooms, living rooms, nurseries, etc.,) creates exposure to RF EMF that last many hours.

b. Use of cell phones is voluntary. One can choose not to use a cell phone. Vulnerable populations like infants and young children are not exposed to cell phone RF EMF in most cases. However, every resident, including infants, pregnant women and the fetus, in the household will be exposed to RF EMF from smart meters if installed nearby. Given that installation of smart meters is mandatory in most places, RF EMF exposure from smart meters is an "*<u>involuntary</u>*" exposure. Based upon the principle of risk assessment, involuntary exposures require more stringent safety standards.

c. Because of the nature of involuntary exposure, many susceptible populations including pregnant women, young children, and those who are sensitive to RF EMF are being equally exposed. Susceptible populations usually have much lower thresholds [for being affected by] exposure."

References and Notes

1. SkyVision Solutions operates a website at http://smartgridawareness.org/ dedicated to raising public awareness about the benefits, costs, and risks associated with smart grid systems as well as the potential hazards related to radiofrequency (RF) radiation emissions from all wireless devices, including smart meters. The website moderator earned a B.S. in Engineering Physics and an M.S. in Nuclear Engineering with a specialty in radiation protection, both degrees received from the University of Illinois at Urbana-Champaign. The moderator was employed by a leading electric utility for over 25 years, serving in various positions, including Station Health Physicist, Senior Health Physicist, Corporate Health Physics Supervisor, and corporate Senior Technical Expert for Radiobiological Effects. The website moderator is an emeritus plenary member of the Health Physics Society.

2. "Health and RF EMF from Advanced Meters: An Overview of Recent Investigations and Analyses," prepared by Alan Rivaldo for the Public Utility Commission of Texas (PUCT), December 2012. The document preparation was supported by the Department of Energy under award numbers DE-OE0000092 and DE-OE0000180. Refer to link at: http://wp.me/a3nav9-1sY.

3. Naperville Smart Grid Initiative (NSGI) public relations flyer, "Smart Meters and Radio Frequency Communications," available at: http://www.naperville.il.us/emplibrary/Smart_Grid/SmartMeterandRFCommunications.pdf.

4. The statements quoted from Dr. Devra Davis are part of the transcript for a presentation made by Dr. Davis on April 4, 2012, entitled "Cell Phone Exposure, Toxicology and Epidemiology - An Update." The transcript is available at the following link: http://wp.me/a3nav9-3H.

5. *The BioInitiative Report 2012* is available at http://www.bioinitiative.org/. The quoted statements are from pages 23 and 24 of Section 1, "Summary for the Public." The precautionary action levels in the range of 0.0003 to 0.0006 microwatts/cm^2 are summarized on page 25 of Section 1 of the same document.

6. "Comments of the Telecommunications Industry Association," dated September 3, 2013, submitted to the Federal Communications Commission (FCC); ET Docket Numbers 13-84 and 03-137; refer to page 20 of the correspondence for the reference to the average power output of mobile phones.

7. Persson, T., Törnevik, C., Larsson, L.-E. and Lovén, J. (2012), "Output Power Distributions of Terminals in a 3G Mobile Communication Network," *Bioelectromagnetics*, 33: 320–325; abstract available at http://www.ncbi.nlm.nih.gov/pubmed/22012866.

8. To supplement the evidence presented by References [6] and [7] above, a review of "US Wireless Carrier Metrics," for the fourth quarter of 2012 revealed that nearly 60% of US cellular phones operate with CDMA (Code Division Multiple Access) technology. In an article published in 2011 [citation below], power output values for CDMA phones and other phone types were reported under various conditions, i.e., rural, suburban, and urban. In this study, there were 92 uses or trips for phones that

employed CDMA technology. The study was conducted within the state of California. For the 92 trials, the overall average RF power output was -0.38 dBm or 0.92 milliwatts (approximately 1 milliwatt). Thus, the average power output of 1 milliwatt from an additional published study for phones using CDMA technology in the United States is further supportive of using this power output value in model calculations as a valid operational scenario for cellular phone use in the United States. [Citation: "Measured Radiofrequency Exposure during Various Mobile-Phone Use Scenarios," by Kelsh MA, Shum M, Sheppard AR, et al., *Journal of Exposure Science and Environmental Epidemiology*, 2011 Jul-Aug;21(4):343-54; abstract available at http://www.ncbi.nlm.nih.gov/pubmed/20551994.]

9. The source of most smart grid information related to typical RF emissions of various wireless devices, including cell phones is Table 1 of EPRI Document # 1022270, "Radio-Frequency Exposure Levels from Smart Meters: A Case Study of One Model," February 2011. EPRI stands for the Electric Power Research Institute.

10. Supporting documentation for the assertion that at least some smart meters involved with smart meter studies have found duty cycles in the range of 3% to 4% to 5% include:

    - From page 5 of Reference [9]: "When deployed at residences during actual conditions, these units [smart meters] typically operate with a maximum duty cycle of about 5% (*duty cycle* refers to the fraction of time a meter is transmitting)."

    - From page 3 of the "Vermont report" by Richard Tell Associates and more fully described and listed in this analysis document as Reference [16]: "Maximum duty cycles were in the 3 -- 4% range and were comparable to duty cycles found in earlier studies."

    - From a published article by Tell, R.A., R. Kavet and G. Mezei (2012), "Characterization of Radiofrequency Field Emissions from Smart Meters," *Journal of Exposure Science and Environmental Epidemiology* 23, 549-553, December 2012: "99.99% of meters had duty cycles < 4.53%. … Duty cycles were > 5% for 0.02% of the sample with a maximum value of 13.9% for one smart meter."

    - From a published article by Tell R.A., Sias G.G., *et al.*, "Radiofrequency Fields Associated with the Itron Smart Meter," *Radiation Protection Dosimetry,* (2012) 151 (1): 17-29: [For Southern California Edison (SCE)], "The maximum duty cycle for the RF LAN transmitters was 4.74%."

    - A 5% duty cycle is listed in the CCST report [11] as the duty cycle for "Typical Smart Meter Operation with Repeater Activity."

11. "Health Impacts of Radio Frequency Exposure from Smart Meters," California Council for Science and Technology (CCST), Final Report, dated April 2011. The document is available at the following link: www.ccst.us/publications/2011/2011smart-final.pdf.

12. There is recent evidence that RF radiation emitted from a wireless digital electrical energy usage meter in the 900 MHz range enters the home through a conductive mechanism and reradiates into rooms through wiring and other conductive objectives.

Based upon a "Report on Examination of Selected Sources of EMF at Selected Residences in Hastings-on-Hudson" by Isotrope Wireless, dated November 23, 2013:

- "[T]here was a substantial conducted 915 MHz component on the power line."
- "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 concentrated close to the objects."
- "The spatial peaks near the electrical wire and table 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." [emphasis added]

The above information suggests that one cannot be assured that RF levels emitted from a smart meter will decrease inside a building with the inverse square of the distance or be fully shielded by walls as much as utilities likely claim. There will be elevated "hot spots" of RF energy concentrated near conductive objects.

13. For estimating near-field RF power densities, an approach similar to that use by EPRI in Reference [9] is normally used where the antenna is approximated as a line source. The equation is $S=P/2\pi RH$, where is the P would be 1 milliwatt in this case; R is the 2.54 cm distance from the head; H is the length of the antenna, assigned a value of 3 inches or 7.6 cm. Solving for S, the power density is 0.008 milliwatts/cm^2. Rounding up and changing units, the RF exposure level 1 inch from the antenna is approximately 10 microwatts/cm^2.

14. For the smart meter exposures, they are treated as a point sources using the equation of $P_D=gP/4\pi r^2$, where P is the smart meter power output of 250 milliwatts; g is the antenna gain of 3.66; r is the distance from the smart meter. The 3 foot distance is 91 cm, and the 10 foot distance is 305 cm. Substituting values will result in instantaneous power density levels during smart meter signal transmission of about 8.8 microwatts/cm^2 at 3 feet and 0.8 microwatts/cm^2 at 10 feet.

15. City of Naperville, Naperville Smart Grid Initiative (NSGI), Pilot 2 RF Emissions Testing – Plan and Results – V2.0, "Smart Meters, Household Equipment, and the General Environment," September 22, 2011. The reference to the ZigBee radio beacon signals is on page 9 of the document available at the following link: http://www.naperville.il.us/emplibrary/Smart_Grid/Pilot2RFEmissionsTesting-Final.pdf.

16. "An Evaluation of Radio Frequency Fields Produced by Smart Meters Deployed in Vermont," by Richard Tell Associates, Inc., dated January 14, 2013, available at the following link: http://wp.me/a3nav9-1t2.

17. MPE refers to the maximum permissible exposure values established by the Federal Communications Commission (FCC). It is acknowledged that RF field intensity values at distances a foot or greater from either a cell phone or wireless smart meter would likely meet FCC guidelines under all possible model scenarios. Unfortunately, FCC exposure guidelines were never formulated to fully protect human health. In fact, they are only believed to protect against injury that may be caused by acute

exposures that result in tissue heating or electric shock and burn. FCC exposure guidelines have no biological relevance to protect humans from chronic exposure to pulsed radiofrequency radiation emitted by devices such as smart meters.

To support the above assertion regarding the FCC exposure guidelines, the following quotations from governmental agencies are presented:

- **"**The FCC's current [radiofrequency/microwave] exposure guidelines, as well as those of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection, are thermally based, and do not apply to chronic, nonthermal exposure situations. .... the generalization by many that the guidelines protect human beings from harm by any or all mechanisms is not justified." Letter from Norbert Hankin of the U.S. EPA's Office of Air and Radiation, Center for Science and Risk Assessment, Radiation Protection Division, July 16, 2002.

- "[T]he electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today." [emphasis added] Letter from Willie R. Taylor of the U.S. Department of Interior, Director, Office of Environmental Policy and Compliance, February 7, 2014.

18. The specific reference to the statement "RF signals used by smart meters are *much weaker* than the RF signals from cell phones," is from a Delmarva Power Fact Sheet. Several smart grid-related organizations make similar statements, such as:

    - "This [RF] energy is all around and the energy associated with smart meters is far less than those of other common services and equipment." [Utilities Telecom Council, "No Health Threat from Smart Meters."]

    - "[Smart meters] give off a fraction of RF emissions compared to cell phones or other common household devices. … Experts Agree – Smart meters emit far less RF than many existing household devices." [Reference: FPL Fact Sheet on Smart Meters.]

    - "It is important to know that Smart Meters communicate using low-power, radio signals that are much weaker in strength than those created by cell phones, microwaves or even exposure from sitting in a coffee shop with internet access." [Glendale Water & Power, OpEd in Glendale News Press.]

    - "A health risk assessment expert asserts that radio frequency signals from smart meters are significantly weaker and more infrequent than those emitted by common devices such as cell phones and microwave ovens, and do not pose a health hazard to electric utility customer." [As reported on smartmeters.com at http://www.smartmeters.com/the-news/2885-radio-frequency-signals-in-smart-meters-not-a-health-risk.html.]

    - "It is important to understand that the RF signals used by smart meters are much weaker and less frequent than exposure from cell phones and other home electronic devices." [Reference: Lakeland Electric, PlugIntoSMART.com, "Smart Meters and Radio Frequency Fields."]

19. A summary of the testimony by Dr. De-Kun Li filed before the Maine Public Utility Commission in December 2012 is available at the following link: http://wp.me/P3nav9-4B.