SAGE Associates
ENVIRONMENTAL CONSULTANTS

An Assessment of the EPRI Technical Report

An Investigation of Radiofrequency Fields Associated With the Itron Smart Meter

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December, 2010

by

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November 11, 2011

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SUMMARY

The Electric Power Research Institute* (1) commissioned a report by Richard Tell Associates Inc. that has assessed radiofrequency (RF) emissions from an Itron 'smart meter'. The Itron meter is being installed in California by two electric utilities (SCE and SDG&E) and is similar to others being installed by other utilities. The EPRI report bases its report primarily on field measurements at the Itron meter test farms in southern California and South Carolina, two homes in Downey, CA, a drive-around street test in Downey, CA, and test results from two utilities.

The EPRI report concludes that no violations of current FCC public safety limits are predicted to occur. However, our analysis shows that this conclusion is unsupported and in error, according to the FCC OET Bulletin 65 rules for predicting public exposures.

The EPRI report does not address compliance of multiple meters, at 100% duty cycle (which is required under FCC OET 65 formulas), and our calculations show violations at 60% reflection factor (the lowest level the FCC regulations specify). Multiple meters will also violate FCC OET 65 public safety limits for calculations using 50% to 100% duty cycle at 100% reflection factor, which are reasonable, worst-case assumptions.

The EPRI report provides a generic, best-case assessment of RF emissions since it focuses on 'typical' meters rather than a broad range of conditions of location, installation and operation of Itron meters under real-world conditions. It does not provide a reasonable, worst-case analysis, nor take into account the way in which utilities are ACTUALLY locating meters in neighborhoods, nor address that the public cannot be excluded from very close proximity to meters on their own homes.

*The Electric Power Research Institute, Inc. (EPRI, www.epri.com) generation, delivery and use of electricity for the benefit of the public. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries (December 2010).

The author says that only approximations of RF exposures for '***typical***' meters, in '***common***' installations applying to '**common**' exposures of individuals, are '***likely***' to comply with FCC exposure limits. This report ignores meters that are being installed outside these highly limiting parameters, where duty cycles may be far higher, installations within or very close to occupied spaces of a home, and where there may be less shielding and more reflection of building materials that amplify exposures rather than reduce them.

METHODOLOGY

The EPRI report relied on measurements artificial 'smart meter farms' set up by utilities (7000 smart meters at one Itron Smart Meter farm on the east coast). These measurements do not realistically simulate the conditions for normal neighborhoods. The smart meter farm is an idealized test area. The 'farm' shown in Figure 9-1 is an open field with smart meters planted at regular intervals, with no intervening buildings, vegetation, topographic variations, etc. There is no comparison to the physical barriers present in normal communities, where meters are scattered at irregular distances, behind hedgerows, fences, gates and garages, facing other homes with only walk-way space, where there are impediments to transmission from buildings, cars, campers, trailers, dumpsters, and where older plaster buildings with chicken-wire reinforcement effectively block RF transmissions. The status and efficiency of the mesh network is not characterized, so whether it replicates the limitations of RF transmission effectiveness in neighborhoods across the full range of possible limitations is unknown in testing of such 'smart meter farms'.

Tell did additional surveying of meters at two homes for five-minute sessions on a single day in Downey, California is not informative due to small sample size and extremely short sampling time. There is no information about whether the mesh network in the area is fully functional. The duty cycle may or may not be 'typical' and we cannot know whether the measurement period (in hours, once only) reflects the intensive periods for beaconing, maintenance and network synchronizing.

Tell also relied on some limited SDG&E testing results of Itron meters, but meters were only tested for a five minutes on one day (December 2, 2010) and the data "*is for meters distributed across ten cells of approximately 600 meters per cell*." This is minimal information from which to draw conclusions about duty cycle.

A new computer-assisted RF program called WI-SPY is used to display and capture RF emissions characteristics in this study. However, Tell discounts its utility in predicting duty cycles for either typical or full-range transmission possibilities. The WI-SPY measurement interval is long (0.37 seconds) in comparison to the very short 0.002 second to 0.02 second RF pulses of a smart meter). Tell indicates that "*it is not clear that all transmissions from the meter are captured due to sweep time and display update produced by the Chanalyzer software*." (Page 12-6).

San Diego Gas & Electric (SDG&E) recently provided testimony to the CPUC Administrative Law Judge on the Itron meter indicating the type, frequency and variability of RF emissions. (2) In total, SDG&E estimates for the Itron meter that nearly 26,000 RF transmissions per day may occur, and it is not specified if this is 'typical' or a maximum. SDG&E and SCE say routine network communication with the mesh network may contribute 90% of the RF pulses, and the data transmission only 10% (from filings with the CPUC on November 1, 2011). It cannot be determined whether this EPRI report takes into account the unusual pattern of more frequent RF emissions reported by SDG&E that will occur during the initial set-up time, periodic maintenance and software upgrades, etc. There is no breakout in the EPRI report computations to show intermittent (unintentional) periods of RF pulses for beaconing to establish electronic hand-shakes with neighboring meters. This process of repetitive RF transmissions from a new meter takes place until a connection of the new meter to the network is established. It can be on the order of days or more than a week of one-per-second RF transmissions, according to SDG&E. The EPRI report is uninformative on whether such data was being transmitted during the testing times. These time periods have heavier RF transmissions and last significant periods of time. They are not 'typical'.   Further, it cannot be determined whether the Tell report relied on testing that included part or all of normal network maintenance, which can account for 90% of RF transmissions that include normal synchronization, security, data integrity and dynamic network resiliency, and other network system checks, and outage checks, according to SDG&E. Since it is only the electrical use (the 10% intentional data transmissions) that gives the information to consumers for energy conservation, the constant 'network chatter' is unnecessary RF exposure that could be avoided with a wired solution or by retaining analog meters. Thus, it cannot be determined if the report includes all relevant information on duty cycles related both intentional (data transmission RF) and unintentional RF transmissions (mesh network, system network maintenance, updates, synchronization, etc).

In the Discussion of Results and Insights, Section 16, "(*A) time-averaged duty cycle of 5%"* was based on limited SCE data for the 900 MHz antenna, and "*a 1% upper range duty cycle for the 2.4 GHz Zigbee antenna was based on limited Itron data*" (page 16-1) If duty cycles (or RF traffic on the meter, including all kinds of signals from the meter, the mesh network and the power transmitters on appliances inside the home) cannot be validated in real-world systems.   Using artificially-low duty cycles can greatly underestimate the amount of radiofrequency radiation to which the public may be exposed.

Limitations of the Testing Program

Section 12 of the EPRI report discusses serious limiting factors that decrease confidence in predictions about duty cycles of smart meters today and in the future, a key determinant in predicting RF exposures for ratepayers.   If there was any doubt about the dismal state of prediction of smart meter emissions, this paragraph captures the myriad problems, and the fact that we will not have answers before full deployment (when it is too late).   It lays to rest the idea that 'post-installation' testing by a ratepayer to check for FCC compliance is technologically and economically possible, even if it were an equitable burden for ratepayers, which it is not.

"*A preliminary investigation was made to examine the potential utility of the SCE Smart Meter Network Management software for remotely determining the operational duty cycle of specific Smart Meters. Acquiring measurement data at specific meters from which an assessment of transmitter duty cycle can be made is technically demanding because of the highly intermittent nature of the Smart Meter signals, the pseudorandom frequencies of the signals across the spectrum and the general variability of Smart Meter mesh network activity throughout a day, week, month or year. Because of the self-healing character of mesh networks, wherein alternative data transmission paths can be invoked on a moment-to-moment basis, Smart Meter transmission activity is more meaningfully defined through a statistical description. A Smart Meter's transmitter activity on one day may not be the same as on another day despite the periodic transmission of beacon signals to alert other meters of its presence in the network or of regularly scheduled data dumps of electrical energy consumption; activity during a particular hour of the day may not be replicated during the same hour on another day. Further, depending on the topology of the mesh network the duty cycle of more distant meters within a given mesh network could be expected to be less than that of meters closer to the associated cell relay meter. Smart Meter duty cycles are, therefore, not fixed and can be dissimilar from one another and vary over time. Consequently, a full characterizatin of a particular Smart Meter duty cycle requires collection of transmitter activity over a prolonged period of days if not weeks and months. Added to this complexity is the fact that the network consists of a large number of meters and a full understanding of duty cycle means that a relatively long-term data collection effort across many meters is necessary. The advantages of exploiting automated software based methods for obtaining such data are obvious. Finally, once the HAN function is implemented, the cumulative RF field caused by both the RF LAN and HAN transmitters and their effective duty cycles for a particular Smart Meter location may change.*" This is a significant admission that total smart meter system operation has not been characterized in this report. The addition of multiple, additional power transmitters that create in-home RF exposures to signal the smart meter about energy usage of each appliance is entirely ignored. These devices have high, localized RF pulsed emissions.

Utilities are already promoting this technology (RF power transmitters inside household appliances) and it is an integral part they envision.

Section 17 (Conclusions) contains at least seven (7) references in less than two pages of text that there is uncertainty about exposures. Time-averaged fields cannot be measured easily because of the highly variable nature of RF transmissions. The RF signals of wireless electric meters vary in length, and the frequencies change constantly. The duty cycle (number of RF transmissions or 'traffic' through the meter and the larger system including the mesh network and the power transmitters on appliances that report through the meter) requires long-term statistical study of mature systems. Actual long-term emissions data is entirely lacking. Estimates from the utilities and vendors for smart meters vary enormously. Few, if any, actual systems are fully up and running so testing is very limited.

> *"Given the nature of mesh networks, hundreds of meters are interacting with one another in a way to form connections between various meters and, ultimately a cell relay meter. The activity of this interaction leads to variability in activity of each of the RF LAN transmitters and, hence, measurements at any particular time are not expected to necessarily be indicative of the same transmitter's activity during another time of the day or on another day."*

> *"Thorough examining meter data throughputs, over many meters within a Smart Meter deployed region, and over an extended period of time, good statistical representation of meter RF activity should be achievable."*

> *"(u)nless conducted over an extended period, are unlikely to yield meaningful measures of maximum average duty cycles.*

RF exposures for the public are dependent on "*highly intermittent emissions'* and exposures are dependent on "*the activity of the mesh network itself*". Tell says

"(M)easurements of Smart Meter fields present a challenge due to their highly intermittent nature and frequency hopping characteristic".

ASSESSMENT OF EPRI 2010 TECHNICAL REPORT

The EPRI report concludes that no violations of current FCC public safety limits are predicted to occur. However, our analysis shows that this conclusion is unsupported and in error, according to the FCC OET Bulletin 65 rules for predicting public exposures.

The EPRI report does not address compliance of <u>multiple meters</u>, at 100% duty cycle (which is required under FCC OET 65 formulas, and our calculations show violations at 60% reflection factor (the lowest level the FCC regulations specify). Multiple meters will also violate FCC OET 65 rules for calculations using 50% to 100% duty cycle at 100% reflection factor, which are reasonable, worst-case assumptions.

The report does not provide specific compliance verification for <u>collector meters</u> at all, in the case of one collector alone or one collector in combination with multiple smart meters. Collector meters produce higher RF exposures than smart meters.

A systemic deficiency in this report is its reliance on SCE and other utility and vendor estimates that give low duty cycles that are inherently unpredictable, uncertain and largely unrelated to 'real-life' performance of wireless electric meters. In the Discussion of Results and Insights, Section 16, "(*A) time-averaged duty cycle of 5%"* was based on limited SCE data for the 900 MHz antenna, and "*a 1% upper range duty cycle for the 2.4 GHz Zigbee antenna was based on limited Itron data*". (page 16-1) If duty cycles (or RF traffic on the meter, including all kinds of signals from the meter, the mesh network and the power transmitters on appliances inside the home) cannot be validated in real-world systems, then these assurances are based on untestable assumptions. This can greatly minimize the calculated amount of radiofrequency radiation people to be subjected to 24-hours per day, every day.

Studies that assume low duty cycle, low reflection factors, and very effective first-time first-signal RF transmission are not looking at actual operational conditions of fully built-out systems. They will arrive at best-case conclusions only. Duty cycle, or how often an RF signal is transmitted, is the major controller of RF exposures for people. It is also the hardest factor to properly predict. Utilities have reported that there are periods of time where the wireless systems will need maintenance. New software upgrades will need to be installed wirelessly. Each of these events can increase duty cycle over 'typical' levels.

Comparisons to the Sage Report (2011) at one foot show that multiple meters produce 887 microwatts/centimeter squared at one foot, where the FCC limit is 655 uW/cm2 using Tell's 60% reflection factor and 100% duty cycle required as by FCC OET 65. (3)

This should have been disclosed. Violations also occur in predictions using 80% and 90% duty cycles with the 60% reflection factor (the lowest reflection factor of the FCC equations). Using the FCC's next higher reflection factor of 100%, multiple meters at 50%, 60%, and 70% duty cycle also violate FCC safety limits at one foot distance.*

Thus, the EPRI report fails to identify FCC violations of public safety limits that are possible, at a distance considered by Tell but not disclosed for multiple meters on one wall. More instances of violations of public safety limits can occur if distances closer than one foot are disclosed, or the higher reflection factor allowed by FCC OET 65 are used, or where a collector meter is considered, either alone or in combination with multiple smart meters.

The minimum distance that Tell's work addresses is one foot from the meter. The compliance distance for FCC testing of the meters is 20 centimeters (or 8 inches), which is a distance that is possible for public exposure since uncontrolled public access must be

- It *should be noted that the PG&E Silver Springs OWS-NIC514 has about 4.5 times the power output of the Itron SK9AMI-4 so resulting RF exposure predictions will be larger, and FCC compliance distances will be greater.*

assumed on private property. Even where the EPRI report indicates compliance with FCC public safety limits is achieved, it reports on distances no closer than at one (1) foot from the faceplate. At the duty cycles and reflection factor used by Tell in figures in Section 14, there are likely to be FCC violations using his power density estimates for distances less than one (1) foot. What is most concerning is that these meters can be accessible directly at and near the face plate of the meter, so that the public cannot be restricted (these are on private property and all areas around the meter are private property that can be assumed to be accessible by both children and adults). Such access virtually guarantees that violations will occur. Access is not a controllable situation since these meters are on private property of every ratepayer, and accessible to the general public, including children playing in their backyards, side yards, or inside their home. Signage, protective RF clothing, and other methods that are used to protect workers cannot be implemented for the general public. Since warnings cannot be read by children, and may not be seen or readable by adults, the FCC has no way to prevent harmful exposures (those which exceed federal safety limits as defined by the FCC).

Measurements at the Itron ‘smart meter farm’ are not sufficiently related to real-life neighborhood smart meter systems. Numerous differences may exist due to physical barriers present in normal communities, where meters are scattered at irregular distances, behind hedgerows, fences, gates and garages, facing other homes with only walk-way space, where there are impediments to transmission from buildings, cars, campers, trailers, dumpsters, and where older plaster buildings with chicken-wire reinforcement effectively block RF transmissions.

The status and efficiency of the mesh network is not characterized, so whether it replicates the limitations of RF transmission effectiveness in neighborhoods across the full range of possible limitations is unknown in testing of such ‘smart meter farms’. It cannot be determined if the report includes all relevant information on duty cycles related both intentional (data transmission RF) and unintentional RF transmissions (mesh network, system network maintenance, updates, synchronization, etc) as discussed in the

SCE and SDG&E data submitted to the California Public Utilities Commission in November 2011.

Further, this report does not include any RF exposure information that takes power transmitters (the RF-pulsing devices in appliances that 'talk' to the smart meter). This is a key part of the overall system. If there are multiple power transmitters inside the kitchen, laundry, or other rooms where energy use information is collected, then this represents an additional RF burden that should be profiled.

This report also makes no allowance for unrelated RF interference sources that may cause meters to send weak signals or for data packets to be unsuccessful in transmission, causing resending of RF transmissions until they are successfully sent. Peyman et al (2011) discuss how the RF emissions from a laptop computer on wireless transmission mode can increase duty cycle. "*Retransmission of the signal due to weak or lost packets are among the parameters that affect the duty cycle*." (Page 602) "*Quality and strength of the radio signals has a direct effect on the data transmission rate and duty factor*" (Page 605) Public complaints about smart meters triggering non-stop operation of motion-sensing lights has been reported to the CPUC. Smart meter wireless RF emissions can cause interference with household electronic appliances and devices, so can the operation of these devices interfere with the efficient RF transmissions of the smart meter to the mesh network? RF transmissions that occur in any common wireless devices (cell phone, cordless phone and WI-FI and wireless laptop) that share common RF transmission frequencies might cause interference with 'smart meter' transmissions (causing repeat transmissions, increasing duty cycle and thus RF emissions); or whether wireless meters operating at these frequencies in close proximity to wireless devices in the home will cause dropped calls, cause interference and thus cause unnecessary RF exposures from repeated signal transmissions, cell phone calls that are dropped and have to be redialed, etc.

Only '*very rough approximations*' of directionality of the RF emission pattern that can show '*generally*' how RF signals radiate away from the meter are provided. The RF exposure of a person standing immediately adjacent to a Smart Meter '*will be predominantly*' of the portion of the body nearest the meter. Only spatial averaging of the RF allows the maximum permissible FCC RF exposure limit to be met within this test, at these unvalidated duty cycles (in real-life operation) and at reflection factors which may be artificially low in many situations, and at distances which may not be achieved in many homes due to meter location in relation to occupied space.

Another significant deficiency in the EPRI report is that there is no information on existing (baseline) RF levels from other environmental sources that may tip an individuals' RF exposure over allowable safety limits. This is a factor that Richard Tell has previously considered important in determining whether and when FCC safety violations may occur.

Section 12 of the EPRI report discusses serious limiting factors that decrease confidence in predictions about duty cycles of smart meters today and in the future, a key determinant in predicting RF exposures for ratepayers. If there was any doubt about the dismal state of prediction of smart meter emissions, this paragraph captures the myriad problems, and the fact that we will not have answers before full deployment (when it is too late). It lays to rest the idea that 'post-installation' testing by a ratepayer to check for FCC compliance is technologically and economically possible, even if it were an equitable burden for ratepayers, which it is not. Section 17 (Conclusions) contains at least seven (7) references in less than two pages of text that there is uncertainty about exposures. Such emphasis on the inadequacies of the measurements and lack of full disclosure of potential FCC public safety limit violations that are likely to occur undermine the reliability of this document to be held up as a vindication of the safety or FCC compliance of meters in the manner utilties are actually installing and operating them.

As a consequence, no positive assertion of safety can be made by the parties involved in this issue, nor are any solid answers provided by this EPRI report.

Richard Tell is a recognized expert in the field of RF exposure assessment. He has handled the prediction uncertainties in a relatively straight forward way in this report. Where his conclusions find no apparent violation of FCC safety limits, he also qualifies his conclusions on safety with so many limitations that a reasonable reader can conclude "we just don't know" about applying this all-clear to smart meters which don't fit the study's very narrow profiling and limited test conditions. This report fails to account for realistic conditions of location and operation that cover the range of possible RF exposures to ratepayers and to utility personnel who service these wireless meters in the field.

What is lacking in this and other EPRI reports (5, 6, 7, 8) on smart meters is recognition that many tens or hundreds of thousands of meters are installed at very close proximity to occupied space within homes. It is unrealistic to assume that electric meters are installed on a garage wall, or at sufficient distance from occupied spaces that RF emissions will fall off to negligible levels compared to where people actually spend their time at home. Some electric meters are installed INSIDE homes, facing people directly. In other cases, electric meters are installed on a common wall with a kitchen or bedroom, or other heavily used home space. Others are flush-mounted at or within the residential wall, so that they are much closer to the interior space of the home. In each case, the installation is not 'typical', and this report addresses only 'typical' situations.

Where multiple meters are located on a single wall (could be a bedroom or kitchen) of a multi-family apartment or condominium project, these testing deficiences compound the uncertainties in predicting RF exposures to the public. Where a collector meter is present, with far higher RF emissions, there is essentially no analysis or verification of compliance with FCC public safety limits, where the collector meter is considered by itself, or in combination with multiple smart meters.

The case where a single-family home or a multi-family residential building also has the third collector meter that relays RF signals to the network from hundreds of other meters in the area. These meters have a third internal antenna that contributes a significant RF load along with the existing 900 MHz and 2.4 GHz antennas. All of the deficiencies noted in this report that combine to underestimate RF exposures in other than ‘typical’ conditions also make this report a best case assessment. SCE originally predicted that one collector meter for every 500 to 5000 homes would be needed. The ‘tsunami of data’ that is actually resulting (primarily from the real-world operation of the mesh network functions) may mean that only 1 in 50 homes can be served by a single collector meter, thus necessitating many thousands of additional collector meters with their larger RF footprint. This ‘figure-it-out-as-you-go’ approach underscores that substantial uncertainties still exist about how the systems will work in practice. It will likely result in over-optimistic assessments of wireless meter performance. It underscores the likelihood that the reliability of studies of RF duty cycle, RF emissions, FCC compliance distances and impact on public health are tenuous at best.

CONCLUSIONS

The EPRI report lays a foundation of doubt about whether and when a specific smart meter may or may not place a family home at risk of violations of FCC safety limits. The report chronicles the many problems in full and proper characterization of RF emissions.

Tell discusses many problems with predicting RF emissions and the need for long-term statistical monitoring of matured (read fully deployed and operational) smart meter networks across regions. He says this testing cannot be done today. So, utilities are hoping for the best, and deploying at full speed, regardless of the clear ‘between-the-lines’ warnings, from their own highly regarded expert.

Wisely, the author cautions EPRI and other readers that only approximations of RF exposures for ‘***typical***’ meters, in ‘***common***’ installations applying to ‘**common**’ exposures of individuals’, are ‘***likely***’ to comply with FCC exposure limits. This report ignores meters that are being installed outside these highly limiting parameters, where duty cycles may be far higher, installations within or very close to occupied spaces of a home, and where there may be less shielding and more reflection of building materials that amplify exposures rather than reduce them.

No positive assertion of safety can be made by the parties involved in this issue, nor are any solid answers provided by this EPRI report. What is clear is that the information on RF emissions is highly uncertain, and may not be known unless and until the entire system is up and running, and subjected to long-term testing. What is also clear is that the conclusions of this report cannot be applied to the tens to hundreds of thousands of electric meters in California that do not fit this limited, best-case profile. The EPRI study does not address electric utility meters that are located so that occupants have direct, unshielded exposures in occupied space within the home and property. Continued deployment of wireless utility meters means taking real risks to health, privacy and security of ratepayers without any defensible basis for judging the actual costs and negative impacts to society.

Deploying millions of wireless utility meters on such limited testing and questionable assertions of safety is unwise. Given that RF has recently been classified as a Possible Human Carcinogen, and this wireless utility meter initiative imposes the most extensive RF blanket yet created over every living resident that is electrified, ratepayers and the decision-makers will not know what irretrievable commitments of health and resources have been made until it is too late. Where even the best industry study cannot give more reliable and defensible evidence of compliance with FCC safety limits, public utility commissions should halt the rollout, pending demonstration that RF emissions meet FCC public safety limits under a reasonable worst-case assessment as determined by FCC OET 65 formulas.

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