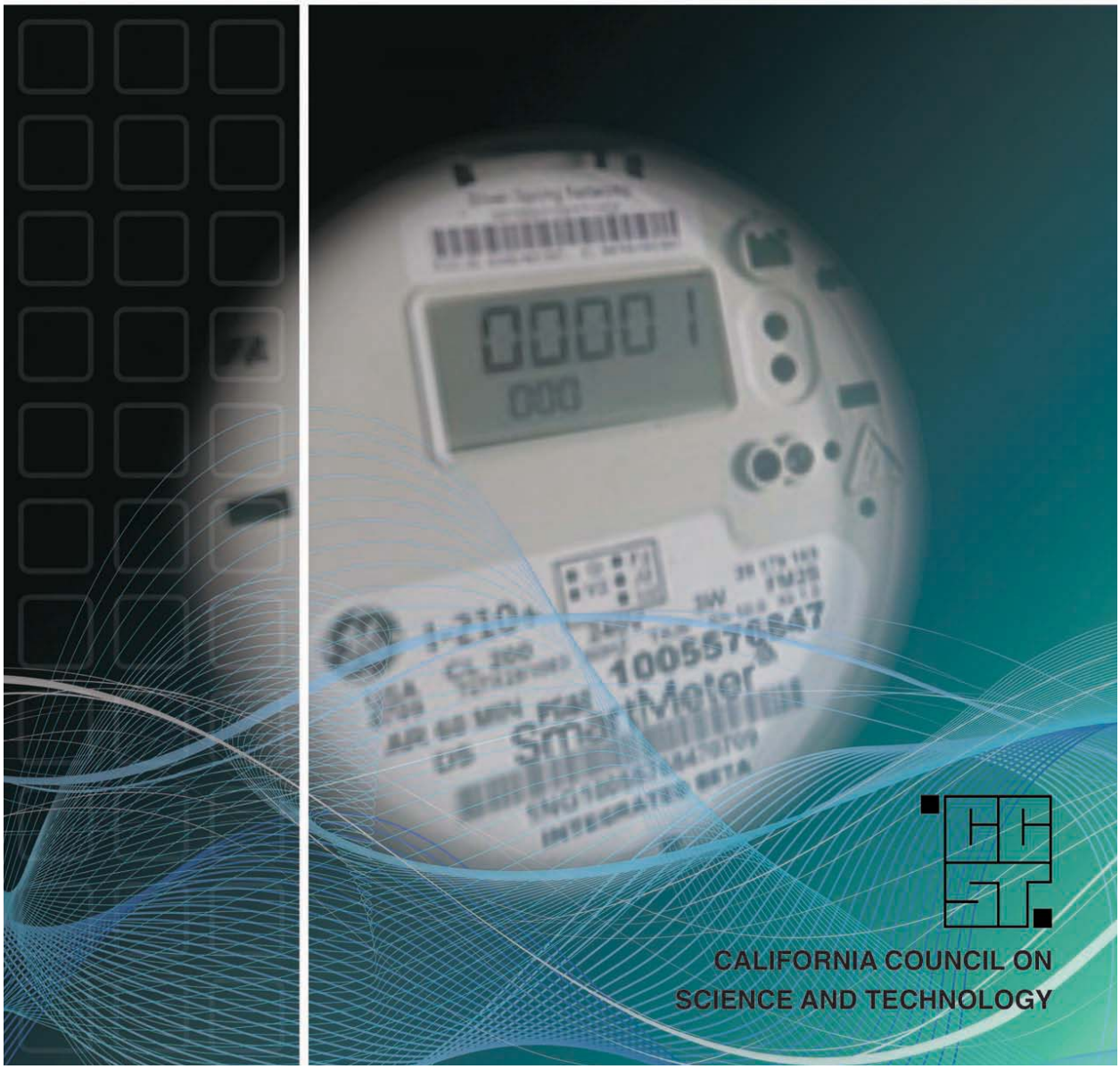
HEALTH IMPACTS OF RADIO FREQUENCY FROM SMART METERS

JANUARY 2011



CALIFORNIA COUNCIL ON
SCIENCE AND TECHNOLOGY

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Letter from CCST

With rapidly emerging and evolving technologies, lawmakers at times find themselves pressed to make policy decisions on complex technologies. Smart meters are one such technology.

Smart meters are being deployed in many places in the world in an effort to create a new generation of utility service based on the concepts of a smart grid, one that is agile, efficient and cost effective.

The electricity crisis of 2000 and 2001 helped force the issue here in California, lending significant urgency to the need for better management of power generation and distribution. In 2006, the California Public Utilities Commission authorized the Pacific Gas and Electric Company to implement a relatively new technology, smart meters, to gather much more precise information about power usage throughout the state. The process of installing the meters throughout the state is still underway.

As with any new technology, there are unknowns involved. Smart meters generally work by transmitting information wirelessly. Some people have expressed concerns about the health effects of wireless signals, particularly as they become virtually ubiquitous. These concerns have recently been brought to the attention of state legislators, with some local municipalities opting to ban further installation of the meters in their communities.

We are pleased that Assembly Members Huffman and Monning have turned to CCST for input on this issue. It is CCST's charge to offer independent expert advice to the state government and to recommend solutions to science and technology-related policy issues. In this case, we have assembled a succinct but comprehensive overview of what is known about human exposure to wireless signals and the efficacy of the FCC safety standards for these signals. To do so, we assembled a project team that consulted with over two dozen experts and sifted through over a hundred articles and reports, providing a thorough, unbiased overview in a relatively rapid manner.

In situations where public sentiment urges policy makers to make policy decisions with potentially long-term consequences, access to the best information possible is critical. This is the role that CCST was created to fulfill.

Susan Hackwood
Executive Director, CCST

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Health Impacts of Radio Frequency from Smart Meters
Response to Assembly Members Huffman and Monning

California Council on Science and Technology
January 2011

KEY REPORT FINDINGS
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 common 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 standards for such impacts

OTHER CONSIDERATIONS
Smart electricity meters are a key enabling technology for a "smart grid" that is expected to become increasingly clean, efficient, reliable, and safe at a potentially lower cost to the consumer. The CCST Smart Meter Project Team offers the following for further consideration by policy makers, regulators and the utilities. We appreciate that each of these considerations would likely require a cost/benefit analysis. However, we feel they should be considered as the overall cumulative exposure to RF emissions in our environment continues to expand. 1. As wireless technologies of all types increase in usage, it will be important to: (a) continue to quantitatively assess the levels of RF emissions from common household devices and smart meters to which the public may be exposed; and (b) continue to investigate potential thermal and non-thermal impacts of such RF emissions on human health. 2. Consumers should be provided with clearly understood information about the radiofrequency emissions of all devices that emit RF including smart meters. Such information should include intensity of output, duration and frequency of output, and, in the cases of the smart meter, pattern of sending and receiving transmissions to and from all sources. 3. The California Public Utilities Commission should consider doing an independent review of the deployment of smart meters to determine if they are installed and operating consistent with the information provided to the consumer. 4. Consideration could be given to alternative smart meter configurations (such as wired) in those cases where wireless meters continue to be concern to consumers.

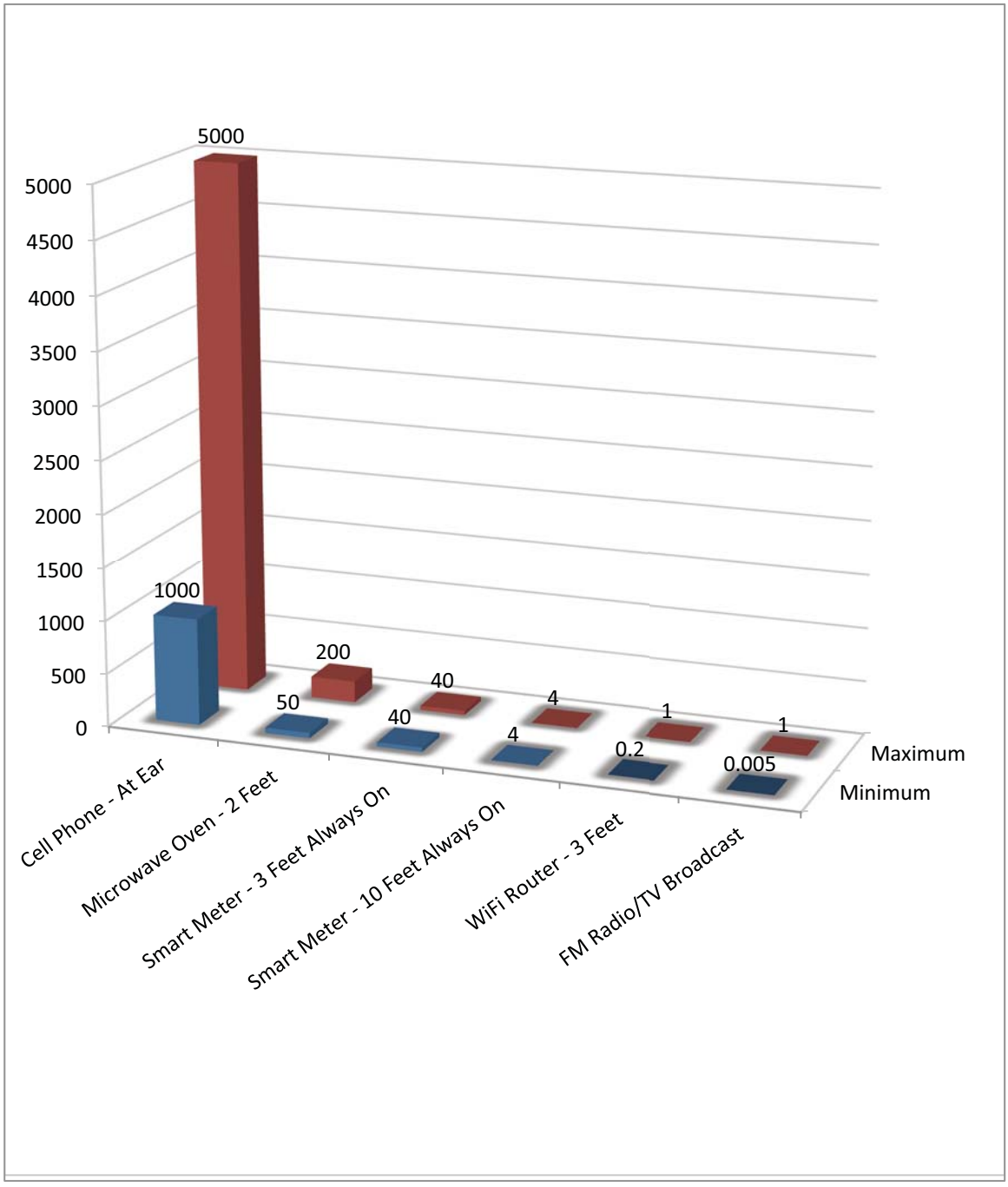

Figure 1. Comparison of Radio-Frequency Levels from Various Sources in µW /cm^2

Note: Exposure levels in µW/cm^2 obtained from Table 2 and converted from mW/cm^2. Smart meter figures represent 100% duty cycle (i.e., always on) as hypothetical maximum use case.

Legislative Request

On July 30, 2010, California Assembly Member Jared Huffman wrote to the California Council on Science and Technology (CCST) to request that the Council perform an "independent, science-based study…[that] would help policy makers and the general public resolve the debate over whether smart meters present a significant risk of adverse health effects." California Assembly Member Bill Monning signed onto the request with his own letter to CCST on September 15, 2010. The City of Mill Valley also sent a letter on September 20th supporting Assembly Member Huffman's request for the study.

Approach

Reflecting the requests of the Assembly Members, CCST agreed to compile and assess the evidence available to address:

> **1. Whether Federal Communications Commission (FCC) standards for smart meters are sufficiently protective of public health, taking into account current exposure levels to radiofrequency and electromagnetic fields.**
>
> **2. Whether additional technology-specific standards are needed for smart meters and other devices that are commonly found in and around homes, to ensure adequate protection from adverse health effects.**

CCST convened a Smart Meter Project Team composed of CCST Council and Board members supplemented with additional experts in relevant fields (see Appendix A for Project Team members). The Project Team identified and reviewed over 100 publications and postings about smart meters and other devices in the same range of emissions, including research related to cell phone RF emissions, and contacted over two dozen experts in radio and electromagnetic emissions and related fields to seek their opinion on the two identified issues.

It is important to note that CCST has not undertaken primary research of its own to address these issues. This response is limited to soliciting input from technical experts and to reviewing and evaluating available information from past and current research about health impacts of RF emitted from electric appliances generally, and smart meters specifically. A subset of those contacted provided written input on the issues to CCST. This report has been extensively reviewed by the Project Team, experts in related fields, and has been subject to the CCST peer review process (see Appendix B). It has also been made available to the public for comment.

Two Types of Radio Frequency Effects: Thermal and Non-thermal

Household electronic devices, such as cellular and cordless telephones, microwave ovens, wireless routers, and wireless smart meters produce RF emissions. Exposure to RF emissions may lead to thermal and non-thermal effects. Thermal effects on humans have been extensively studied and appear to be well understood. The Federal Communications Commission (FCC) has established guidelines to protect public health from known hazards associated with the thermal impacts of RF: tissue heating from absorbing energy associated with radiofrequency emissions. Non-thermal effects, however, including cumulative or prolonged exposure to lower levels of RF emissions, are not well understood. Some studies have suggested non-thermal effects may include fatigue, headache, irritability, or even cancer. *But these findings have not been scientifically established, and the mechanisms that might lead to non-thermal effects remain uncertain.* Additional research and monitoring is needed to better identify and understand potential non-thermal effects.

Findings

Given the body of existing, *generally accepted scientific knowledge* regarding smart meters and similar electronic devices, CCST finds that:

1. **The FCC standard provides an adequate factor of safety against known *thermally* induced health impacts of smart meters and other electronic devices in the same range of RF emissions.**
   The potential for behavioral disruption from increased body tissue temperatures is the only biological health impact that has been consistently demonstrated and scientifically proven to result from absorbing RF within the band of the electromagnetic spectrum (EMF) that smart meters use. The Federal Communications Commission (FCC) has set a limit on the Standard Absorption Rate (SAR) from electronic devices, which is well below the level that has been demonstrated to affect behavior in laboratory animals. Smart meters, including those being installed by Pacific Gas and Electric Company (PG&E) in the Assembly Members' districts, if installed according to the manufacturers instructions and consistent with the FCC certification, emit RF that is a very small fraction of the exposure level established as safe by the FCC guidelines.

   The FCC guidelines provide a significant factor of safety against thermal impacts that occur at the power levels and within the RF band used by smart meters. Given current scientific knowledge, the FCC guideline provides a more than adequate margin of safety against the known thermal effects.

2. **At this time there is no clear evidence that additional standards are needed to protect the public from smart meters or other common household electronic devices.**
   No clear causal relationship between RF emissions and non-thermal human health impacts has been scientifically established, nor have the mechanisms that might lead to such a biological impact been clearly identified. Additional research is needed to better understand and verify these potential mechanisms.

   Given the existing significant scientific uncertainty around non-thermal effects, there is currently no generally accepted definitive, evidence-based indication that additional standards are needed. Because of the lack of generally accepted evidence, there is also not an existing basis from which to understand what types of standards could be helpful or appropriate**.** Without a clearer understanding of the biological mechanisms involved identifying additional standards or evaluating the relative costs and benefits of those standards cannot be determined at this time.

   CCST notes that in some of the studies reviewed, contributors have raised emerging questions from some in the medical and biological fields about the potential for biological impacts other than the thermal impact that the FCC guidelines address. A report of the National Academies identifies research needs and gaps and recommended areas of research to be undertaken to further understanding of long-term exposure to RF emissions from communication devices, particularly from non-thermal mechanisms that are not currently addressed by the FCC guidelines.[1] In our increasingly wireless society, smart meters account for a very small portion of RF emissions to which we are exposed. Concerns about human health impacts of RF emissions from smart meters should be considered in this broader context.

   "Scientifically established", "generally accepted scientific knowledge" and other such references throughout this document are referencing information obtained through the scientific method. A scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses. These steps must be repeatable in order to predict future results. Scientific inquiry is generally intended to be as objective as possible, to reduce biased interpretations of results. Another basic expectation is to document, archive and share all data and methodology so they are available for careful scrutiny by other scientists, giving them the opportunity to verify results by attempting to reproduce them. This practice, called full disclosure, also allows statistical measures of the reliability of these data to be established.

Health concerns surrounding RF from smart meters are similar to those from many other devices that we use in our daily lives, including cordless and cellular telephones, microwave ovens, wireless routers, hair dryers, and wireless-enabled laptop computers. As detailed in the report, a comparison of electromagnetic frequencies from smart meters and other devices shows that the exposure level is very low.

[1] National Research Council (2008) *Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication,* The National Academies Press, Washington, D.C.

What are Smart Meters?

Smart meters measure attributes of electricity, natural gas, or water as delivered to consumers and transmit that information (e.g., usage) digitally to utility companies. Some smart meters are also designed to transmit real-time information to the consumer. These smart meters replace traditional, analog meters and meter readers with an automated process that is expected to reduce operating costs for utilities, and potentially, costs for customers (see Figure 2).

a. Analog Meter b. Digital Meter

Figure 2. a) An analog, conventional meter and a (b) digital smart meter (Source: PG&E)

Each of California's major electricity utilities has begun deploying smart meter infrastructure.

There are many kinds of smart meters manufactured by a variety of companies. The meter, including sensors and the housing or casing, may be manufactured by one company while the communications device (installed within the meter) is manufactured by another. Depending upon the internal communications device employed, meters are configured to operate in a wired or in wireless environment. The smart meters used by PG&E are made by General Electric and Landis + Gyr and use a wireless communications technology from Silver Spring Networks. Each of these PG&E meters has two transmitters to provide two different communications of data from these meters.[2] The first provides for the "automatic meter reading" (AMR) function of the meter (and for more detailed and real time monitoring of the characteristics of the electrical energy delivered to the consumer) and sends this data to an access point, where it is collected along with data from many other customers and transmitted to PG&E using a wireless area network (WAN) (similar to the way cell phone communication works).

[2] Tell, R. (2008) "Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of the PG&E Smart Meter Program Upgrade System," Prepared for Pacific Gas & Electric Company, Richard Tell Associates, Inc., October 27.

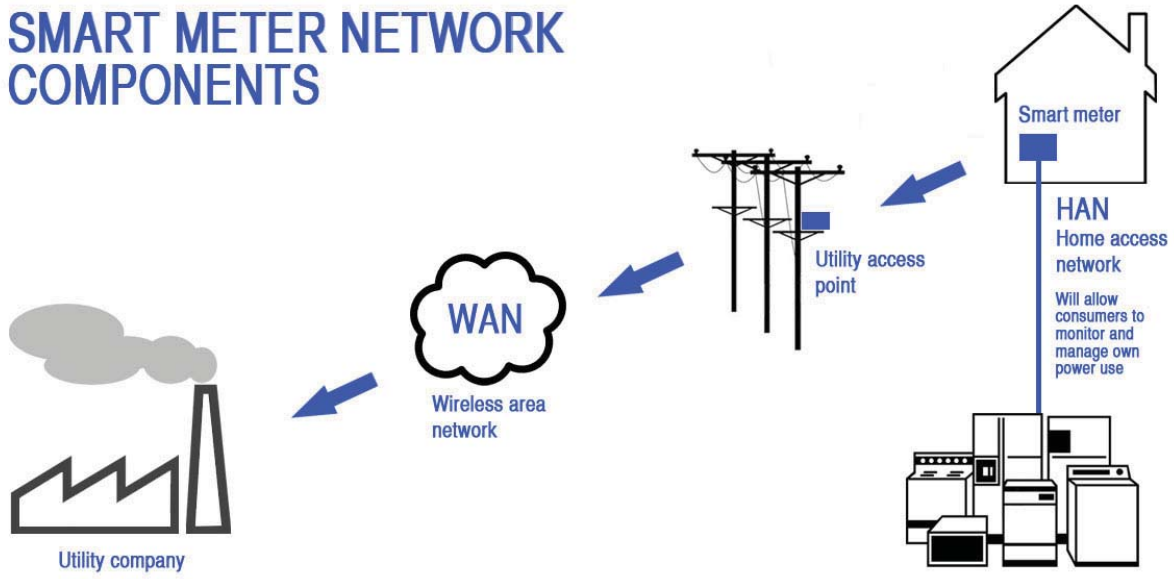

Figure 3. Simplified depiction of Smart Meter system network. Arrows show the use of radiofrequency (RF) signals for automated meter reading, communications among electric power meters, relays, access points, the company's enterprise management systems. The future home access network will operate within the house.

Smart meters have evolved from automatic meter reading (AMR; i.e., replacing meter readers) to a real time monitoring of power as delivered to the consumer by the utility company. CCST obtained from PG&E the Richard Tell Associates report, which describes the operation of the smart meter from the 2008 perspective of AMR, not a fully deployed real time smart grid. The Richard Tell Associates reports describe the use of the smart meter radios being deployed by PG&E as licensed by the FCC for a maximum power output of 1 W (watt) and within the 902-928 MHz (mega-hertz) frequency band. In its initial deployment, PG&E reports that it will configure the radios to transmit data from the meter to the access point once every four hours, for about 50 milliseconds at a time.[3] Accounting for this, the current duty cycles of the smart meter transmitter (that is, the percent of time that the meter operates) would then typically be 1 percent, or in some cases where the meter is frequently used as a relay, as much as 2-4 percent. *This means that the typical smart meter in this initial (AMR) use would not transmit any RF signal at least 96-98 percent of the time.*

It is important to note that any one smart meter is part of a broader "mesh" network and may act as a relay among other smart meters and utility access points. In addition, when the smart grid is fully functional the smart meters would be expected to be transmitting much more than once every four hours, providing data in near real-time, which will result in a much higher duty

[3] Tell, R. (2008) "Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of the PG&E Smart Meter Program Upgrade System," Prepared for Pacific Gas & Electric Company, Richard Tell Associates, Inc., October 27. http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/rfsafety/rf_fields_supplemental_report_2008.pdf)

cycle. For purposes of this report we include a hypothetical scenario where the smart meter is continually transmitting. Even in this 100% duty cycle situation the power output would be well below the FCC limits.

Smart meters are designed to transmit data to a utility access point that is usually 25 feet above ground, on utility or light poles. These access points are designed to transmit data from up to 5,000 smart meters to the utility company. Access points have a similar AMR transmitter as smart meters, as well as an additional *AirCard,* which communicates with utilities and is similar to wireless cards used in laptop computers. *AirCard*s typically operate at 0.25-1 W, in the 800-900 MHz or 1.9 GHz range.

In some cases, data is moved through the mesh network, relaying the data through other meters to the utility access point. This may occur when the topography or built environment interferes with the transmission of data from a smart meter to the access point. In these cases, the relaying of data may occur between one smart meter and another before the signal is sent to the utility access point (e.g., hops along a set of meters). Additionally, some non-meter data relays will also exist in the system to connect some smart meters to utility access points.

Many smart meters, including those from PG&E, also have a second transmitter that, at some future point in time, will allow customers to enable a home access network (HAN). The HAN will allow increased consumer monitoring of electricity use and communication among appliances and the future smart grid. This functionality is important to achieve the full potential of the smart grid. This second internal transmitter, for delivery of smart meter data to the consumer, reportedly will operate at a rated power of 0.223W, at frequency of about 2.4 GHz (again, similar to that of cell phones and wireless phones). The actual duty cycle of this transmitter will depend on the design and operation of the home area network.

Why are Smart Meters Being Installed Throughout California?

It is anticipated, when fully operational, that smart electricity meters are a key enabling technology for a "smart grid" that is expected to become increasingly clean, efficient, reliable, and safe (see Figure 3) at a potential lower cost to the consumer. (Digital meters are also being used for reading of natural gas and water consumption). Smart electrical meters allow direct two-way communication between utilities and customers, which is expected to help end users adjust their demand to price changes that reflect the condition of the electricity grid. These end user adjustments can help to protect the overall reliability of the electricity grid, cut costs for utility customers, and improve the operation and efficiency of the electricity grid. The smart grid will enable grid operators to better balance electricity supply and demand in real-time, which becomes increasingly important as more intermittent wind and solar generation resources are added to the grid.

Figure 4 depicts the potential operation of a smart grid.

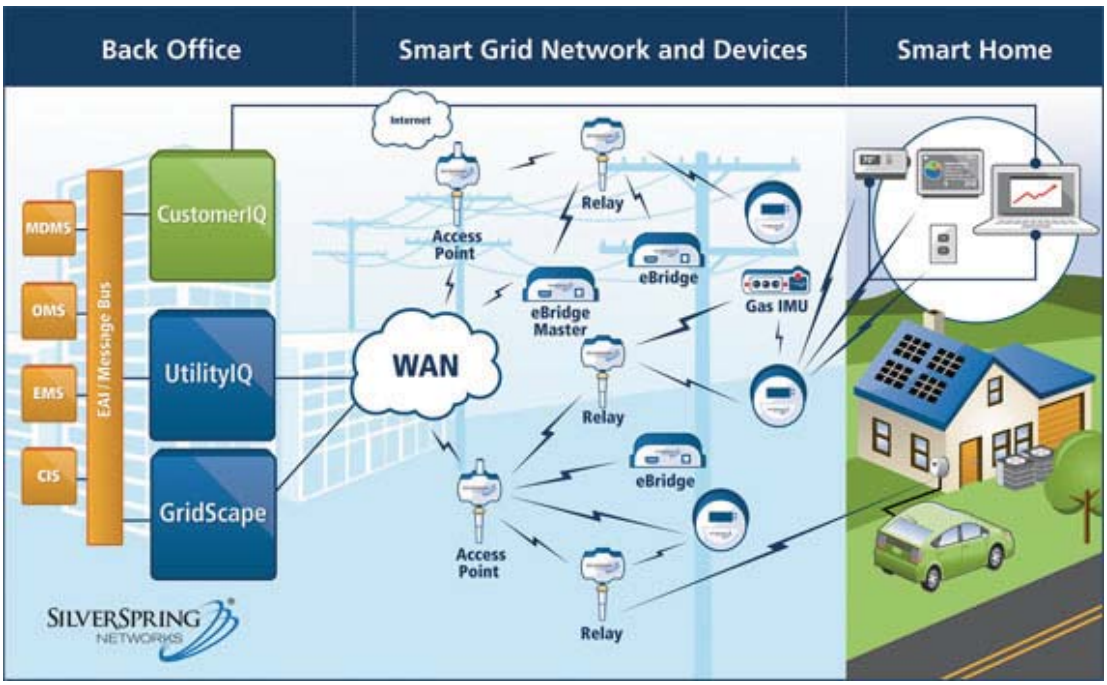

Figure 4. Illustration of components of the PG&E Smart Meter Program Upgrade showing the use of radiofrequency (RF) signals for communications among electric power meters, relays, access points and, ultimately, the company's enterprise management systems. (Source Silver Spring Network[4])

Smart meters will also allow utilities to communicate grid conditions to customers through price signals, so that consumers, via their HAN, can delay non-time sensitive demands (such as clothes drying) to a time when electricity is cheapest or has the most benefit to the reliability of the system. In some cases wireless signals interior to the structure will also be able to automatically adjust the heating and ventilation systems and to adjust heat or air conditioning units. This adaptation to price or reliability signals could reduce overall electricity costs for customers, improve the utilization of renewable and non-renewable power plants, and cut costs associated with adding intermittent wind and solar resources to the grid.

While such long-term value of smart meters will take years to fully realize, they are sufficiently promising that the federal government has required utilities to take steps to implement smart

[4] See http://www.silverspringnet.com/products/index.html for component descriptions. Network infrastructure includes the Silver Spring Access Points (APs) and Relays that forward data from endpoints across the utility's backhaul or WAN infrastructure into the back office.
The UtilityIQ application suite incorporates both utility applications such as Advanced Metering and Outage Detection as well as administrative programs for managing and upgrading the network. GridScape provides management for DA communications networks.
The CustomerIQ web portal enables utilities to directly communicate usage, pricing, and recommendations to consumers. Silver Spring works with each utility to customize the information portrayed and to import utility-specific information such as rate schedules.

grid networks, including the use of smart meters.[5] After review and authorization from the California Public Utilities Commission,[6] utilities in California have begun to install smart meters throughout the state. Some California utilities (such as Sacramento Municipal Utility District) have received significant federal funding for smart meter deployment from the American Recovery and Reinvestment Act (federal stimulus package). Many countries around the world are actively deploying smart meters as well. Digital smart meters are generally considered to be the fundamental technology required to enable widespread integration of information technology (IT) into the power grid (i.e., the smart grid). The following table (table 1) summarizes some potential societal benefits expected to result from the smart grid.

Table 1: Smart Grid Benefits

Consumers	**Environment**
1. Cost Savings Resulting from Energy Efficiency 2. Increased Consumer Choice and Convenience 3. More Transparent, Real-Time Information and Control for Consumers	1. Widespread Deployment of Renewable Energy (Solar, Wind, Biofuels) and Electric Vehicles (EVs) 2. Reduced Need to Build More Fossil Fueled Power plants 3. Reduced Carbon Footprint and Other Pollutants (via Renewables, Energy Efficiency, Electric Vehicles)
Utilities	**Economy**
1. Reduced Cost Due to Increased Efficiencies in Delivering Electricity and Reduction in Manpower to Read Meters. 2. Improved Reliability and More Timely Outage Response 3. Increased Customer Satisfaction Due to Cost Savings and Self-Control *Source: California Smart Grid Center*	1. Creates New Market for Goods and Services (i.e., New Companies, New Jobs) 2. Up-skilling Workforce to be Prepared for New Jobs 3. Reduced Dependence on Foreign Oil, Keeps Dollars at Home

What Health Concerns are Associated with Smart Meters?

Human health impacts from exposure to electromagnetic frequency (EMF) emissions vary depending on the frequency and power of the fields. Smart meters operate at low power and in the RF portion of the electromagnetic spectrum. At these levels, RF emissions from smart

[5] The federal Energy Independence and Security Act of 2007 directs states to encourage utilities to initiate smart grid programs, allows recovery of smart grid investments through utility rates, and reimburses 20% of qualifying smart grid investments. The American Recovery and Reinvestment Act of 2009 provided $4.5 billion to develop smart grid infrastructure in the U.S. For more information, see: Congressional Research Service (2007) "Energy Independence and Security Act of 2007: A Summary of Major Provisions," CRS Report for Congress, Order Code RL34l294, December 21. (http://energy.senate.gov/public/_files/RL342941.pdf)

[6] California Public Utilities Commission decision on Application 07-12-009 (March 12, 2009). Decision on Pacific Gas and Electric Company's Proposed Upgrade to the Smartmeter Program.

meters are unlikely to produce *thermal effects; however it is not scientifically confirmed whether or what the non-thermal effects* on living organisms, and potentially, human health might be. These same concerns over potential impacts should apply to all other electronic devices that operate with similar frequency and power levels, including cell phones, computers, cordless phones, televisions, and wireless routers. Any difference in health impacts from these devices is likely to be a result of differences in usage patterns among them.

Thermal Effects

Electromagnetic waves carry energy, and EMF absorbed by the body can increase the temperature of human tissue. The scientific consensus is that body temperatures must increase at least 1°C to lead to potential biological impacts from the heat. The only scientifically verified effect that has been shown to occur in the power and frequency range that smart meters are designed to occupy is a disruption in animal feeding behavior at energy exposure levels of 4 W/kg and with an accompanying increase in body temperature of 1°C or more.[7] The exposure levels from smart meters even at close range are far below this threshold. The FCC has set limits on power densities from electronic devices that are well below the level where demonstrated biological impacts occur, and the limits are tens or hundreds of times higher than likely exposure from smart meters.[8]

Non-thermal Effects

There are emerging questions in the medical and biological fields about potential harmful effects caused by non-thermal mechanisms of absorbed RF emissions. Complaints of health impacts from "electromagnetic stress" have been reported, with symptoms including fatigue, headache, and irritability. Some studies have suggested that RF absorption from mobile phones may disrupt communication between human cells, which may lead to other negatives impacts on human biology.[9,10] While concerns of brain cancer associated with mobile phone usage persist, there is currently no definitive evidence linking cell phone usage with increased incidence of cancer.[11] But due to the recent nature of the technology, impacts of long-term exposure are not known. Ongoing scientific study is being conducted to understand non-thermal effects from long-term exposure to mobile phones and smart meters, etc., especially

[7] D'Andrea, J.A., Adair, E.R., and J.O. de Lorge (2003) Behavioral and cognitive effects of microwave exposure, *Bioelectromagnetics* Suppl 6, S39-62 (2003).

[8] Tell, R. (2008) "Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of the PG&E Smart Meter Program Upgrade System," Prepared for Pacific Gas & Electric Company, Richard Tell Associates, Inc., October 27. (http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/rfsafety/rf_fields_supplemental_report_2008.pdf)

[9] Markova, E., Malmgren, L., and I.Y. Belyaev (2009) Microwaves from mobile phones inhibit 53PB1 focus formation in human stem cells stronger than in differentiated cells: Possible mechanistic link to cancer risk. Environmental Health Perspectives, doi:10.1289/ehp.0900781.

[10] Nittby, H., Grafstrom, G., Eberhardt, J.L., Malmgren, L., Brun, A., Persson B.R.R., and L.G. Salford (2008) Radiofrequency and Extremely Low-Frequency Electromagnetic Field Effects on the Blood-Brain Barrier Electromagnetic Biology and Medicine, 27: 103–126, 2008.

[11] Ahlbom, A., Feychting, M., Green, A., Kheifets, L., Savitz, D. A., and A. J. Swerdlow (2009) Epidemiologic evidence on mobile phones and tumor risk: a review. *Epidemiology* 20, 639-52 (2009).

the cumulative impact from all RF emitting devices including that of a network of smart meters operating throughout a community.[12]

There currently is no conclusive scientific evidence pointing to a non-thermal cause-and-effect between human exposure to RF emissions and negative health impacts. For this reason, regulators and policy makers may be prudent to call for more research while continuing to base acceptable human RF exposure limits on currently proven scientific and engineering findings on known thermal effects, rather than on general concerns or speculation about possible unknown and as yet unproven non-thermal effects. Such questions will likely take considerable time to resolve. The data that are available strongly suggest that if there are non-thermal effects of RF absorption on human health, such effects are not so profound as to be easily discernable.

FCC Guidelines Address Known Thermal Effects Only, not Non-thermal Effects

In 1985, the FCC first established guidelines to limit human exposure and protect against thermal effects of absorbed RF emissions. The guidelines were based on those from the American National Standards Institute (ANSI) that were issued in 1982.[13] In 1996, the FCC modified its guidelines,[14] based on a rulemaking process that began in 1993 in response to a 1992 revision of the ANSI guidelines[15, 16] and findings by the National Council on Radiation Protection and Measurements (NCRP).[17] The 1996 guidelines are still in place today.

In its rulemaking process to set SAR and MPE limits, the FCC relied on many federal health and safety agencies, including the U.S. Environmental Protection Agency and the Food and Drug Administration. While the FCC guidelines appear to provide a large factor of safety against known thermal effects of exposure to radiofrequency, they do not necessarily protect against potential non-thermal effects, nor do they claim to.[18] Without additional understanding of these effects, there is inadequate basis to develop additional guidelines at this time.

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[12] National Research Council (2008) *Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication,* The National Academies Press, Washington, D.C. (http://www.nap.edu/catalog/12036.html)

[13] American National Standards Institute (1982) "American National Standard Radio Frequency Radiation Hazard Warning Symbol," ANSI C95.2-1982, Institute of Electrical and Electronics Engineers, Inc.

[14] FCC (1997) "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," OET Bulletin 65 (Edition 97-01), Federal Communications Commission, August. (http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf)

[15] American National Standards Institute (1992) "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992 (previously issued as IEEE C95.1-1991), Institute of Electrical and Electronics Engineers, Inc.

[16] American National Standards Institute (1992) "Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave," ANSI/IEEE C95.3-1992, Institute of Electrical and Electronics Engineers, Inc.

[17] NCRP (1986) "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86 (1986), National Council on Radiation Protection Measurements.

[18] The U.S. EPA confirmed this in a letter to The Electromagnetic Radiation Policy Institute, dated March 8, 2002. (http://www.emrpolicy.org/litigation/case_law/docs/noi_epa_response.pdf)

The FCC guidelines measure exposure to RF emissions in two ways. Specific absorption rate (SAR) measures the rate of energy absorption and is measured in units of watts-per-kilogram of body weight (W/kg). It accounts for the thermal effects on human health associated with heating body tissue and is used as a limiting measurement for wireless devices, such as mobile phones, that are used in close proximity to human tissue.[19] The FCC limits, as well as the underlying ANSI and NCRP limits, are based on a SAR threshold of 4 W/kg. At the time of the FCC rulemaking, and still today, behavioral disruption in laboratory animals (including non-human primates) at this absorption rate is the only adverse health impact that has been clearly linked to RF at levels similar to those emitted by smart meters. This finding is supported in scientific literature[20, 21] and by the World Health Organization and many health agencies in Europe.[22, 23] The FCC limit of 1.6 W/kg provides a significant factor of safety against this threshold.

Limits on SAR provide the basis for another measurement of exposure, maximum permissible exposure (MPE). MPE limits average exposure over a given time period (usually 30 minutes for general exposure) from a device and is often used for exposure to stationary devices and where human exposure is likely to occur at a distance of more than 20 cm. It is measured in micro (10^6) watts-per-square-centimeter ($\mu W/cm^2$), and accounts for the fact that the human body absorbs energy more efficiently at some radiofrequencies than others. The human body absorbs energy most efficiently in the range of 30-300 MHz, and the corresponding MPE limits for RF emissions in this range are consequently the most stringent. In the frequency bands where smart meters operate, including PG&E's, namely the 902-928 MHz band and 2.4 GHz range, the human body absorbs energy less efficiently, and the MPE limits are less restrictive.

The FCC limits on MPE are summarized in Figure 5.[24, 25] At 902 MHz, appropriate for operation of the AMR transmitter of the smart meter, the FCC limit is 601 $\mu W/cm^2$. At higher frequencies,

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[19] FCC (2001) "Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions," Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), Federal Communications Commission, June. (http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65c.pdf)

[20] D'Andrea, J.A., Adair, E.R., and J.O. de Lorge (2003) Behavioral and cognitive effects of microwave exposure, *Bioelectromagnetics* Suppl 6, S39-62 (2003).

[21] Sheppard, A.R, Swicord, M. L., and Q. Balzano (2008) Quantitative evaluations of mechanisms of radiofrequency interactions with biological molecules and processes, *Health Phys* 95, 365-96 (2008).

[22] The World Health Organization has reviewed international guidelines for limiting radiofrequency exposure and scientific studies related to human health impacts and concludes that exposure below guideline limits don't appear to have health consequences. (http://www.who.int/peh-emf/standards/en/)

[23] Committee on Man and Radiation (COMAR) (2009) "Technical Information Statement: Expert reviews on potential health effects of radiofrequency electromagnetic fields and comments on The Bioinitiative Report," Health Physics 97(4):348-356 (2009).

[24] FCC (1997) "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," OET Bulletin 65 (Edition 97-01), Federal Communications Commission, August. (http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf)

[25] FCC (1999) "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields," OET Bulletin 56 (Fourth Edition), Federal Communications Commission, August. (http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf)

the human body absorbs even less energy, and the threshold for the 2.4 GHz transmitter for home area network communications is consequently higher, 1000 $\mu W/cm^2$.

PG&E commissioned a 2008 study by Richard Tell Associates, "Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of the PG&E Smart Meter Program Upgrade System." In this study of PG&E's proposed smart meter network it is noted that the FCC limits on MPE include a factor of safety, and the perceived hazardous exposure level is 50 times higher than the FCC limits.[26] The study estimates that the highest exposure from smart meters, if an individual were standing directly in front of and next to the meter, would be 8.8 $\mu W/cm^2$ transmitting at 2 to 4% of the time. The study notes that this is almost 70 times less than the FCC limit and 3,500 times less than the demonstrated hazard level. In all likelihood, individuals will be much farther away from smart meters and likely behind them, (within a structure) where power density will be much lower. The highest exposure from the entire smart meter system would occur immediately adjacent to an access point. It is very unlikely that an individual would be immediately adjacent to an access point, as they are normally located 25 feet above the ground on a telephone or electrical pole or other structure. The peak power density from an access point is estimated to be 24.4 $\mu W/cm^2$, or about 25 times less than the FCC limit. From the ground, exposure to power density from access points is estimated to be 15,000 times less than the FCC limit in great part due to the distance from the device.

The PG&E commissioned report by Richard Tell Associates is based only on an AMR duty cycle of transmitting data once every four hours which results in this very low estimated peak power. However, we are not aware of the justification for using averaging over a four-hour period. We do know the FCC[27] allows averaging of exposure over a designated period (30 minutes). 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. Even in this 100% scenario the RF emissions would be measurably below the FCC limits for thermal effects.

[26] Tell, R. (2008) "Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of the PG&E Smart Meter Program Upgrade System," Prepared for Pacific Gas & Electric Company, Richard Tell Associates, Inc., October 27. (http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/rfsafety/rf_fields_supplemental_report_2008.pdf)

[27] http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf

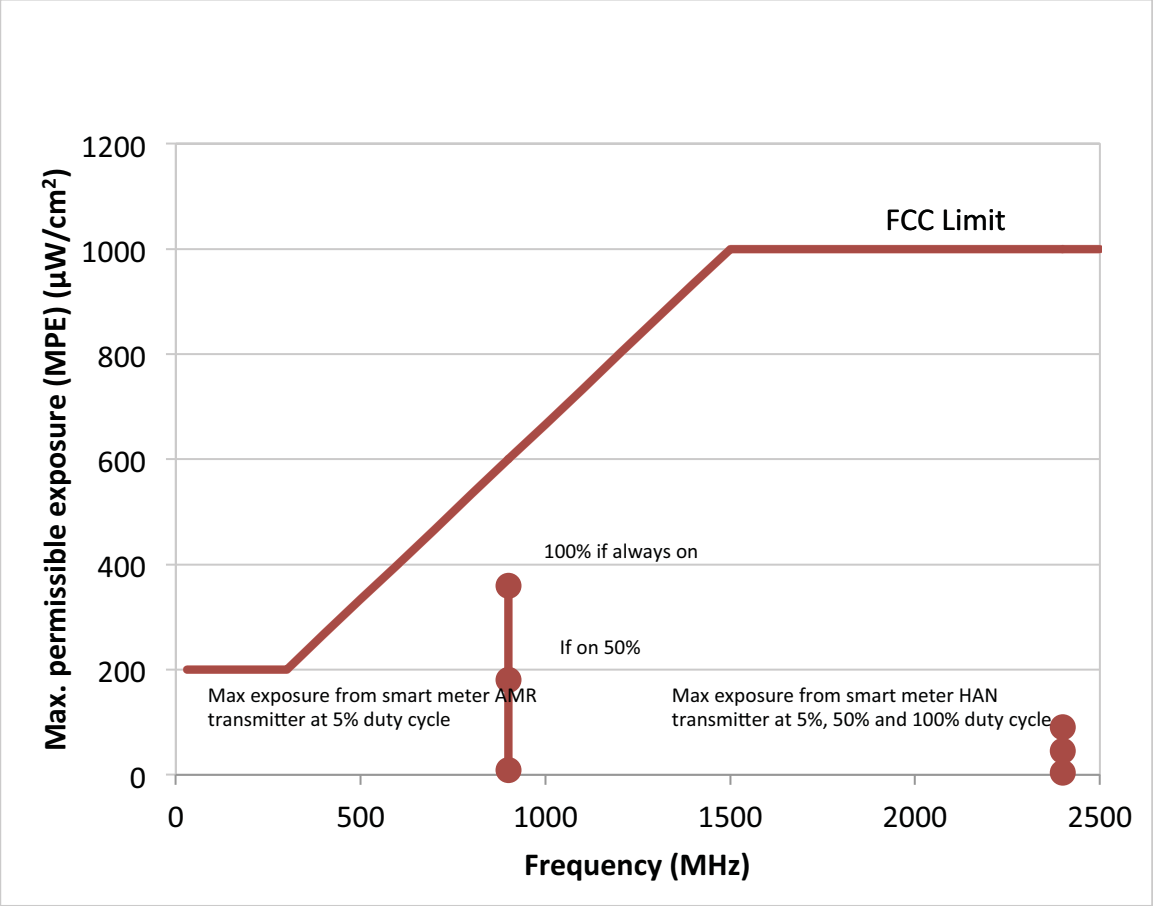

Figure 5. FCC maximum permissible exposure limits on power density rise with frequency because the human body can safely absorb more energy at higher frequencies. The estimated maximum exposure from a 1-Watt AMR transmitter at 5% duty cycle (i.e., 72 minutes/day) and one-foot distance is 18 µW/cm^2, or 3% of the FCC limit. Even if a meter malfunctioned and was stuck in the always-on transmit mode (i.e., 100% duty cycle), exposure levels would be 60% of the FCC limit for an AMR transmitter. For a 250mW HAN transmitter at a 5% duty cycle, the level would be .45% of the FCC limit and 9% of the FCC limit if the transmitter were on 100%. Exposure figures derived from November 2010 Electric Power Research Institute (EPRI) field measurement study entitled "Radio Frequency Exposure Levels from Smart Meters".[28]

Power Density (and Exposure Level) Declines Rapidly with Distance

The power density from smart meters, or other devices that emit RF, falls off dramatically with distance. Figure 6 illustrates this affect for an example smart meter. While the estimated maximum exposure level at 1 foot from the meter with a duty cycle of 50% is 180 µW/cm^2 (far below the FCC guidelines), at a distance of about 10 feet, the power-density exposure approaches zero.

[28] EPRI (2010) "Radio Frequency Exposure Levels from Smart Meters," Electric Power Research Institute, November 2010.

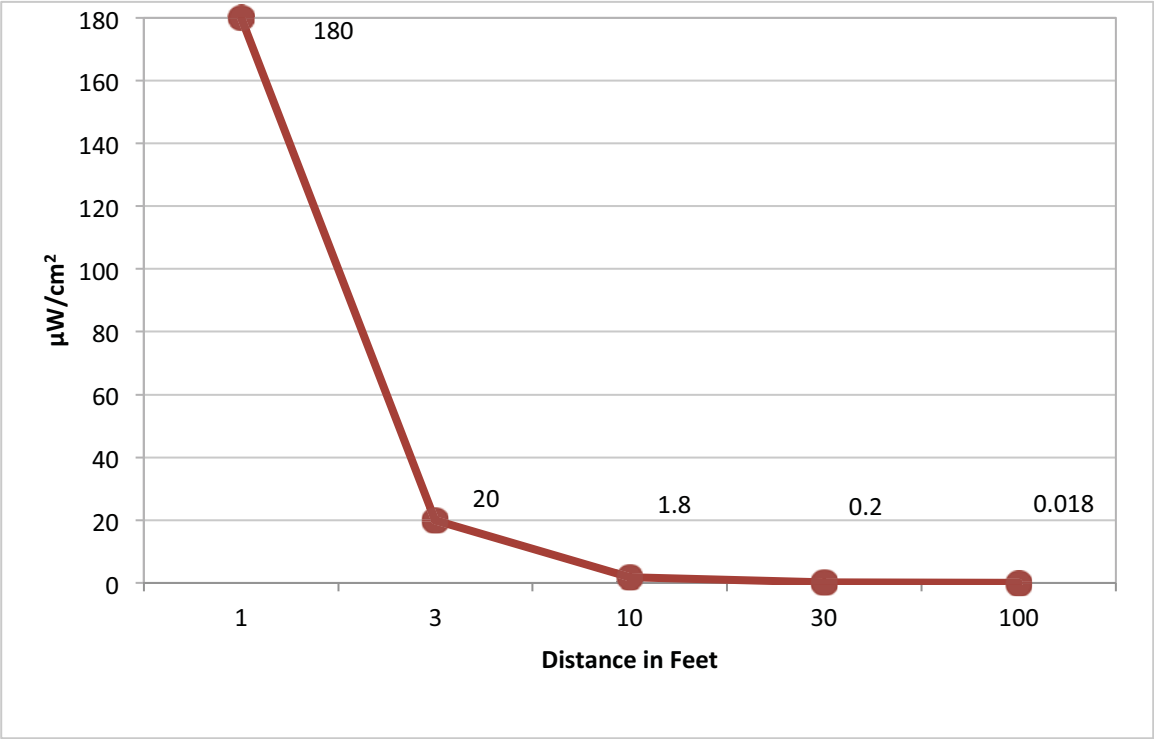

Figure 6. Power density from a sample smart meter versus distance;[29] 1-Watt emitter at 50% duty cycle. Typical smart meter AMR transmitter power density declines rapidly with distance. The rapid drop of power density with distance (inverse-square law) is similar for various duty cycles and different sets of source data.

Comparison of Electromagnetic Frequencies from Smart Meters and Other Devices

Health concerns surrounding RF from smart meters are similar to those from many other devices that we use in our daily lives, including cordless and mobile telephones, microwave ovens, wireless routers, hair dryers, and wireless-enabled laptop computers.

In addition to slight differences in frequency and power levels, which affect human absorption of RF from these devices, the primary difference among them is how they are used. Cell phones, for example, are often used for many minutes at a time, several times over the course of a day, and held directly next to one's head.

For perspective, microwave ovens operate at a similar frequency as the HAN transmitter of smart meters (2.45 GHz), and the U.S. Food and Drug Administration has set limits on leakage levels that are five times higher (5,000 µW /cm^2) than the FCC limit for smart meters and other devices operating at 2.4 GHz.[30] Wireless routers and Wi-Fi equipment produce radiofrequency

[29] EPRI (2010) "Radio Frequency Exposure Levels from Smart Meters," Electric Power Research Institute, November 2010.

[30] FDA, "Summary of the Electronic Product Radiation Control Provisions of the Federal Food, Drug, and Cosmetic Act," U.S. Food and Drug Administration. (http://www.fda.gov/Radiation-EmittingProducts/ElectronicProductRadiationControlProgram/LawsandRegulations/ucm118156.htm)

fields of about 0.2 – 1.0 µW /cm^2.[31, 32,33] People in metropolitan areas are exposed to radiofrequency from radio and television antennas, as well, although for most of the population, exposure is quite low, around 0.005 µW /cm^2.[34]

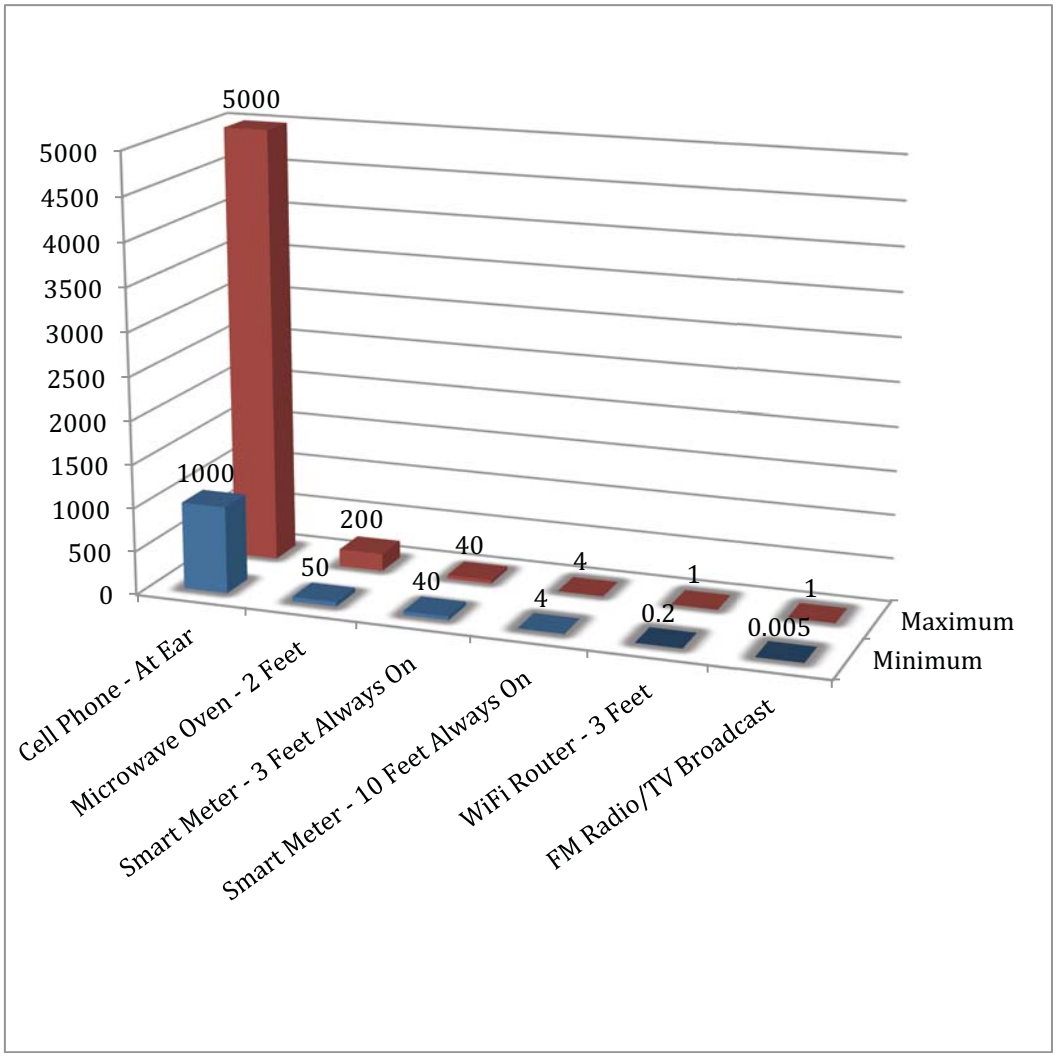

Figure 7. Comparison of Radio-Frequency Levels from Various Sources in µW /cm^2

Note: Exposure levels in µW/cm^2 obtained from Table 2 and converted from mW/cm^2. Smart meter figures represent 100% duty cycle (i.e., always on) as hypothetical maximum use case.

[31] "Radio-Frequency Exposure Levels from Smart Meters", *white paper by Rob Kavet and Gabor Mezei of the Electric Power Research Institute (EPRI).* November 2010.
[32] Foster, K.R. (2007) Radiofrequency exposure from wireless LANS utilizing WI-FFI technology. *Health Physics*, Vol. 92, No. 3, March, pp. 280-282.
[33] Schmidt, G. et al. (2007) Exposure of the general public due to wireless LAN applications in public Places, *Radiation Protection Dosimetry*, Vol. 123, No. 1, Epub June 11, pp. 48-52.
[34] EPA (1986) The Radiofrequency Radiation Environment: Environmental Exposure Levels and RF Radiation Emitting Sources, EPA 520/1-85-014, U.S. Environmental Protection Agency, July.

Table 2: Radio-Frequency Levels from Various Sources

Source	Frequency	Exposure Level (mW/cm^2)	Distance	Time	Spatial Characteristic
Mobile phone	900 MHz, 1800 MHz	1—5	At ear	During call	Highly localized
Mobile phone base station	900 MHz, 1800 MHz	0.000005—0.002	10s to a few thousand feet	Constant	Relatively uniform
Microwave oven	2450 MHz	~50.05-0.2	2 inches2 feet	During use	Localized, non-uniform
Local area networks	2.4—5 GHz	0.0002—0.001 0.000005—0.0002	3 feet	Constant when nearby	Localized, non-uniform
Radio/TV broadcast	Wide spectrum	0.001 (highest 1% of population) 0.000005 (50% of population)	Far from source (in most cases)	Constant	Relatively uniform
Smart meter	900 MHz, 2400 MHz	0.0001 (250 mW, 1% duty cycle) 0.002 (1 W, 5% duty cycle) 0.000009 (250 mW, 1% duty cycle) 0.0002 (1 W, 5% duty cycle)	3 feet 10 feet	When in proximity during transmission	Localized, non-uniform

Source: Electric Power Research Institute (EPRI), Radio Frequency Exposure Levels from Smart Meters (November 2010)

What is Duty Cycle and How Does it Affect Human Health?

Duty cycle refers to the fraction of time a device is transmitting. For instance, a duty cycle of 1% means the device transmits RF energy 1% of a given time period. One percent of the time in a day is equivalent to 14.4 minutes per day. *The duty cycle, or signal duration is an often-overlooked factor when comparing exposures from different kinds of devices (e.g., mobile phones, Wi-Fi routers, smart meters, microwave ovens, FM radio/TV broadcast signals).*

Duty cycles of various devices vary considerably. The duty cycle of AM/FM radio/TV broadcasts, are 100%; in other words, they are transmitting continuously. Mobile phones usage varies widely from user to user, of course. However, the national average use is about 450 minutes per month. This usage equates to a 1% duty cycle for the "average" user.

From information that CCST was able to obtain we understand that the smart meter transmitter being used by PG&E operates with a maximum power output of 1 W (watt) and within the 902-928 MHz (mega-hertz) frequency band. 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 "worst case" illustration (i.e., if the meter malfunctioned and was stuck in the transmit mode), an absolute upper end duty cycle would be 100%, where the transmitter is always on. The table below compares the effect of different duty cycles against the FCC guidelines for human exposure limits.

Typical Smart Meter Operation With Repeater Activity	**Scaled Hypothetical Maximum Use Case (i.e., always on)**
5% Duty Cycle	100% Duty Cycle
72 minutes/day	24 hours/day
3% of FCC limit	60% of FCC limit

Source data on operating duty cycles (i.e., first column) from Electric Power Research Institute (EPRI) actual field testing of smart meters, as reported in *Radio Frequency Exposure Levels from Smart Meters*, November 2010. Second column hypothetical maximum case derived through extrapolation of first column data. Both exposure levels at 1 foot distance.

In summary, the duty cycles of smart meters in typical meter-read operation and added maximum-case repeater operation result in exposures that are 3% of the FCC exposure guidelines. Even in a hypothetical always-on scenario the maximum exposure would be about 60% of the FCC limit, which provides a wide safety margin from known thermal effects of RF emissions.

What About Exposure Levels from a Bank of Meters and from Just Behind the Wall of a Single Meter?

In a November 2010 study Electric Power Research Institute (EPRI)[35] field tested exposure levels from a bank of 10 meters of 250 mW power level at one foot distance in order to simulate a bank of smart meters located at a multifamily building, such as an apartment house. The exposure level was equivalent to 8% of the FCC standard.

In the same study EPRI measured exposure of one meter from eight inches *behind* the meter panel box in order to simulate proximity on the opposite site of the meter wall. At 5% duty cycle it yielded an exposure of only 0.03% of the FCC standard. Even at 100% duty cycle (i.e., always transmitting), exposure at eight inches behind the meter was 0.6% of the FCC limit.

Is the FCC Standard Sufficient to Protect Public Health?

The FCC guidelines do provide a significant factor of safety against thermal impacts the only currently understood human health impact that occurs at the power level and within the frequency band that smart meters use. In addition to the factor of safety built into the guidelines, at worst, human exposure to RF from smart meter infrastructure operating at even 50% duty cycle will be significantly lower than the guidelines. While additional study is needed to understand potential non-thermal effects of exposure to RF and effects of cumulative and prolonged exposure to several devices emitting RF, given current scientific knowledge the FCC guideline provides an adequate margin of safety against known thermal effects.

Are Additional Technology-specific Standards Needed?

The FCC guidelines protect against thermal effects of RF exposure. Many non-thermal effects have been suggested, and additional research is needed to better understand and scientifically validate them.

Given the scientific uncertainty around non-thermal effects of all RF emitting equipment, at this time there is no clear indication of what, if any, additional standards might be needed. Neither is there a basis from which to understand what types of standards could be helpful or appropriate**.** Without a clear understanding of the biological mechanisms at play, the costs and benefits of additional standards for RF emitting devices including smart meters, cannot be determined at this time.

[35] EPRI (2010) "A perspective on radio-frequency exposure associated with residential automatic meter reading technology," Electric Power Research Institute, February.

Public Information and Education

It is important that consumers have clear and easily understood information about smart meter emissions as well as readily available access to clear, factual information and education on known effects of RF emissions at various field strengths and distances from an array of devices commonly found in our world.

Equipped with this information, people can make knowledgeable judgments about how to prudently minimize possible risks to themselves and their families by utilizing standards-compliant devices at known safe distances. Also, people will be better able to gauge relative field strengths of various RF sources in our everyday environment (e.g., mobile phones, electric blankets, clock radios, TV and radio, computers, smart meters, power lines, microwave ovens, etc.). An ongoing regularly updated source of unbiased information on the state of scientific research, both proven and as-yet-unproven causal effects being studied, if presented by an independent entity, would provide consumers a credible and transparent source from which to obtain facts about RF in our environment.

CCST is not currently aware of a single website with up-to-date consumer information which we are able to endorse as impartial.

Alternatives to Wireless?

Assembly Member Huffman has inquired about potential alternatives to wireless communication with smart meters. There are currently several other methods of transmitting data from some smart meters to the utility company. These methods include transmitting over a power line or wired through phone lines, fiber-optic or coaxial cable. Each method has tradeoffs among cost and performance (e.g., how much data can be carried, how far, how fast). The ability to have a transmission protocol alternative to wireless depends upon the type and configuration of the meter used. Some existing smart meters can be hard-wired, while others would have to be modified or replaced. The communications board plugs into a digital meter. The current PG&E meters use a SilverSpring communications board that only supports wireless protocol. SilverSpring or another vendor could provide an alternative communications means if such were warranted and cost effective. The related costs of an alternative approach would need to be factored into the decision making process related to different options.

If future research were to establish a causal relationship between RF emissions and negative human health impacts, industries and governments worldwide may be faced with difficult choices about practical alternatives to avoid and mitigate such effects. This would greatly affect the widespread use of mobile phones, cordless phones, Wi-Fi devices, smart meters, walkie-talkies, microwave ovens, and many other everyday appliances and devices emitting RF. If such a hypothetical scenario were to occur, smart meters could conceivably be adapted to non-wireless transmission of data. However, retrofitting millions of smart meters with hard-wired technology could be difficult and costly. Perhaps more importantly, retrofitting smart

meters would not address the significantly greater challenge presented by the billions of mobile phones in use globally.

Key Factors to Consider When Evaluating Exposure to Radiofrequency from Smart Meters

1. Signal Frequency	Compare to devices in the 900 MHz band and 2.4 GHz band	Frequency similar to mobile phones, Wi-Fi, laptop computers, walkie-talkies, baby monitors, microwave ovens
2. Signal Strength (or Power Density)	Microwatts/square centimeter ($\mu W/cm^2$)	Meter signal strength very small compared to other devices listed above
3. Distance from Signal	Signal strength drops rapidly (doubling distance cuts power density by four)	Example: 1 ft. – 8.8 $\mu W/cm^2$ 3 ft. – 1.0 $\mu W/cm^2$ 10 ft. – 0.1 $\mu W/cm^2$
4. Signal Duration	- Extremely short amount of time (2.0-5.0%, max.) - No RF signal 95-98% of the time (over 23 hours/day)	- Often overlooked factor when comparing devices. - Short duration combined with weak signal strength yields tiny exposures
5. Thermal Effects	- Scientific consensus on proven effects from heat at high RF levels	- FCC "margin-of-safety" limits 50 times lower than hazardous exposure level - Typical meter operates at 70 times less than FCC limit and 3,500 times less than the demonstrated hazard level
6. Non-thermal Effects	- Inconclusive research to date - No established cause-and-effect pointing to negative health impacts	Continuing research needed

Conclusion

The CCST Project Team, after carefully reviewing the available literature on the current state of science on health impacts of radiofrequency from smart meters and input from a wide array of subject matter experts, concludes that:

1. **The FCC standard provides a currently accepted factor of safety against known thermally induced health impacts of smart meters and other electronic devices in the same range of RF emissions. Exposure levels from smart meters are well below the thresholds for such effects.**

2. **There is no evidence that additional standards are needed to protect the public from smart meters.**

The topic of potential health impacts from RF exposure in general, including the small RF exposure levels of smart meters, continues to be of concern. This report has been developed to provide readers and consumers with factual, relevant information about the:

- Scientific basis underpinning current RF limits
- Need for further research into RF effects
- Relative nature of RF emissions from a wide array of devices commonly used throughout world (e.g., cellular and cordless phones, Wi-Fi devices, laptop computers, baby monitors, microwave ovens).

CCST encourages the ongoing development of unbiased sources of readily available and clear facts for public information and education. A web-based repository of written reports, frequently asked questions and answers, graphics, and video demonstrations would provide consumers with factual, relevant information with which to better understand RF effects in our environment.

Appendix A – Letters Requesting CCST

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Assembly
California Legislature

JARED HUFFMAN
ASSEMBLYMEMBER, SIXTH DISTRICT

COMMITTEES
CHAIR, WATER, PARKS AND WILDLIFE
NATURAL RESOURCES
UTILITIES AND COMMERCE

SUBCOMMITTEE NO.3
ON RESOURCES

July 30, 2010

Karl Pister, Chair
Susan Hackwood, Executive Director
California Council on Science and Technology
1130 K Street, Suite 280
Sacramento, CA 95814-3965

Dear Chair Pister and Ms. Hackwood:

I am writing to request a study by the California Council on Science and Technology in response to the many concerns and questions that have been raised by constituents in my Assembly District including the Marin County Board of Supervisors, City of Sebastopol, City of Fairfax, and Marin Association of Realtors relating to potential negative health effects from SmartMeters, the electronic monitoring devices that Pacific Gas and Electric Company (PG&E) is installing statewide to continuously measure the electricity output from each household and business.

SmartMeters are currently being installed throughout the state under the authority of the California Public Utilities Commission (CPUC) pursuant to a series of decisions that span from 2006 through 2009. The authority for PG&E to deploy SmartMeters in its territory is embodied in two decisions: D.06-07-027 (the initial deployment) and D.09-03-026 (the upgrade). On the question of health effects of radiation from the devises, PG&E and CPUC maintain that electromagnetic fields emitted from these SmartMeters and the radio frequency power associated with the wireless radios fall within the Federal Communications Commission's (FCC) regulations, pointing out that SmartMeters emit fewer radio frequencies than the amount allowable for cellular telephones, microwave ovens, and wireless Internet Services.

Critics claim, among other things, that FCC standards are not sufficiently protective of public health and do not take into account the cumulative effect of radiation exposure from a growing number of sources and devices, including continuous exposure from some sources. For example, they cite a letter from the Radiation Protection Division of the Environmental Protection Agency (attached), they argue, ..."these standards were thermally based and do not apply to chronic, nonthermal exposure situations, ... and that … the current exposure guidelines are based on the effects resulting from whole-body heating, not exposure of and effect on critical organs including the brain and the eyes." Therefore, they argue the "safety" standards were not designed to protect the public from health problems under the circumstances which the meters are being used.

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An independent, science-based study by the California Council on Science and Technology would help policy makers and the general public resolve the debate over whether SmartMeters present a significant risk of adverse health effects. Toward that end, I request that the Council specifically determine whether FCC standards for SmartMeters are sufficiently protective of public health taking into account current exposure levels to radiofrequency and electromagnetic fields, and further to assess whether additional technology specific standards are needed for SmartMeters and other devises that are commonly found in and around homes, to ensure adequate protection from adverse health effects.

Thank you for your serious consideration of this important and time-sensitive request. Please do not hesitate to contact me if I can be of assistance going forward

Sincerely,

JARED HUFFMAN
Assemblymember, 6th District

COMMITTEES
CHAIR, HEALTH
ARTS, ENTERTAINMENT, SPORTS, TOURISM & INTERNET MEDIA
ENVIRONMENTAL SAFETY & TOXIC MATERIALS
JOINT LEGISLATIVE AUDIT COMMITTEE
JUDICIARY
LABOR AND EMPLOYMENT
WEBSITE: www.assembly.ca.gov/monning

Assembly
California Legislature

WILLIAM W. MONNING
ASSEMBLYMEMBER, TWENTY-SEVENTH DISTRICT

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(831) 649-2935

SANTA CLARA COUNTY DIRECT LINE
(408) 782-0647

September 15, 2010

Karl Pister, Chair
California Council on Science and Technology
1130 K Street, Suite 280
Sacramento, CA 95814-3965

Dear Chair Pister:

This letter is to formally request that I be included in the response from the California Council on Science and Technology (CCST) regarding the health safety evaluation of the new electronic metering devices, otherwise known as Smart Meters, currently being installed by Pacific Gas and Electric Company (PG&E) which will be available by October 15, 2010.

Numerous concerns and questions have been raised by PG&E customers throughout the state, as well as local government entities such as the County of Santa Cruz, the City of Capitola, City of Santa Cruz, City of Scotts Valley, and the City of Watsonville, relating to potential health effects of the radio frequency (RF) emitted from Smart Meters.

As you know, the federal Energy Independence and Security Act of 2007 required each state to initiate a smart grid system. In response to this federal mandate, the State of California enacted Senate Bill 17, Chapter 327, Statutes of 2009, granting the California Public Utilities Commission (CPUC) smart grid oversight authority. While the CPUC has authorized PG&E to install their current Smart Meter system, CPUC has not addressed the question of whether the RF emissions from Smart Meter devices have potential health impacts.

While PG&E maintains that Smart Meters comply with the Federal Communications Commission (FCC) safety standards, there is still public concern that the FCC standards do not sufficiently protect the public's health and do not take into account the cumulative effect of radiation exposure from the growing number of sources and devices emitting RF.

The scientific evaluation by the California Council on Science and Technology will help to inform both elected officials and the public about the safety of PG&E's Smart Meters and I appreciate the Council taking the time to assess this very important issue.

Thank you for your time and assistance on this issue.

Sincerely,

WILLIAM W. MONNING
Assemblymember, 27th District

WWM:rog

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Stephanie Moulton-Peters
Mayor
Ken Wachtel
Vice-Mayor
Garry Lion
Councilmember

MILL VALLEY

Shawn Marshall
Councilmember
Andrew Berman
Councilmember
James C. McCann
City Manager

September 20, 2010

Karl Pister, Chair
Susan Hackwood, Executive Director
California Council on Science and Technology
1130 K Street, Suite 280
Sacramento, CA 95814-3965

Dear Chair Pister and Ms. Hackwood:

On behalf of the Mill Valley City Council, I am writing to support Assemblymember Jared Huffman's request for a study by the California Council on Science and Technology (CCST) to specifically determine whether Federal Communications Commission (FCC) standards for Pacific Gas and Electric (PG&E) SmartMeters are sufficiently protective of public health.

This request is in response to the many concerns and questions that have been raised by Mill Valley residents relating to potential negative health effects from SmartMeters. Mill Valley residents have expressed their concerns that these devices, which are regulated by the California Public Utilities Commission (CPUC), emit levels of radiation that may be harmful to public health, especially with consideration to the long-term and cumulative impacts of the devices. The CPUC maintains that SmartMeters emit radiation well below the FCC-established safety standards, and have therefore not ordered PG&E to halt the installation of the advanced metering devices.

Critics argue that the safety standards determined by the FCC are not sufficient and specifically not designed to protect the public from health problems under the circumstances which the meters will be used. The FCC standards, they claim, do not take into consideration long-term and cumulative exposures to these devices.

The City of Mill Valley City Council therefore join Assemblymember Huffman in requesting the CCST undertake a study to specifically determine whether FCC standards for SmartMeters are sufficiently protective of public health, taking into account current exposure levels to radiofrequency and electromagnetic fields, and further to assess whether additional technology

City of Mill Valley, 26 Corte Madera Avenue, Mill Valley, California 94941 • 415-388-4033

specific standards are needed for SmartMeters and other devices that are commonly found in and around homes, to ensure adequate protection from adverse health effects.

Thank you for your consideration.

Sincerely,

Stephanie Moulton-Peters

Stephanie Moulton-Peters, Mayor
City of Mill Valley

Cc: Mill Valley City Council
Assemblymember Jared Huffman
Joshua Townsend, PG&E Public Affairs Manager
Marzia Zafar, CPUC Business and Community Outreach Division Manager

Appendix B – Project Process

CCST Smart Meter Project Approach

Assembly Member Huffman (Marin) (July 30, 2010 letter) and Assembly Member Monning (Santa Cruz) (September 17, 2010 letter) requested CCST's assistance in determining if there are health safety issues regarding the new SMART meters being installed by the utilities. In addition, the City of Mill Valley sent a letter to CCST (September, 2010) in support of Mr. Huffman's request. (Appendix A - letters)

The CCST Executive Committee appointed a Smart Meter Project Team that oversaw the development of a response on the issue (Appendix C):

- Rollin Richmond (Chair), President Humboldt State University, CSU
- Jane Long, Associate Director at Large, Global Security Directorate Fellow, Center for Global Security Research Lawrence Livermore National Laboratory
- Emir Macari, Dean of Engineering and Computer Science, California State University, Sacramento and Director of the California Smart Grid Center
- Patrick Mantey, Director, CITRIS @ Santa Cruz
- Ryan McCarthy, 2009 CCST Science and Technology Policy Fellow
- Larry Papay, CEO, PQR, LLC, mgmt consulting firm
- David Winickoff, Assistant Professor of Bioethics and Society, Department of Environmental Science, Policy and Management, UC Berkeley
- Paul Wright, Director, UC Center for Information Technology Research in the Interest of Society (CITRIS)

In addition to those on the project team, CCST approached over two dozen technical experts to contribute their opinion to inform CCST's response. The experts were referred from a variety of sources and were vetted by the Smart Meter Project Team. Efforts were made to include both biological and physical scientists and engineers to help provide broad context and perspective to the response. Many of the experts approached indicated they did not time to provide a written response however they provided references to additional experts and/or literature for review. A few experts identified were not asked to contribute due to affiliations that were felt to be a conflict of interest. Experts were asked to provide written comment on two issues, to provide referral to other experts, and to suggest literature that should be reviewed. Appendix D provides a list of those experts who provided written comment.

Smart Meter Project Team members and the experts providing written technical input completed a conflict of interest disclosure form to reveal any activities that could create the potential perception of a conflict.

In addition to written and oral input from technical experts, CCST identified relevant reports and other sources of information to inform the final report. This material can be found listed in Appendix E and on a CCST website: http://ccst.us/projects/smart/.

Peer Review: After the draft report was vetted in great detail by the Smart Meter Project Team, it was forwarded to the CCST Board and Council for peer review.

Public Comment: The report is being posted to the CCST website that will allow the general public to comment.

Appendix C – Project Team

The California Council on Science and Technology adheres to the highest standards to provide independent, objective, and respected work. Board and Council Members review all work that bears CCST's name. In addition, CCST seeks peer review from external technical experts. The request for rigorous peer review results in a protocol that ensures the specific issue being addressed is done so in a targeted way with results that are clear and sound.

In all, this report reflects the input and expertise of nearly 30 people in addition to the project team. Reviewers include experts from academia, industry, national laboratories, and non-profit organizations.

We wish to extend our sincere appreciation to the project team members who have helped produce this report. Their expertise and diligence has been invaluable, both in rigorously honing the accuracy and focus of the work and in ensuring that the perspectives of their respective areas of expertise and institutions were taken into account. Without the insightful feedback that these experts generously provided, this report could not have been completed.

Rollin Richmond, Smart Meter Project Chair, CCST Board Member
President Humboldt State University, CSU

Prior to Richmond's appointment at Humboldt State University in 2002, he had a distinguished career as a faculty member, researcher in evolutionary biology and academic administrator. Richmond received a Ph.D. in genetics from the Rockefeller University and a bachelor's degree in zoology from San Diego State University. Dr. Richmond's career has included: Chairperson of biology at Indiana University, founding Dean of the College of Arts and Sciences at the University of South Florida, Provost at the State University of New York at Stony Brook, and Provost and Professor of Zoology and Genetics at Iowa State University. He was named the sixth President of Humboldt State University in July of 2002. Dr. Richmond is a fellow of the American Association for the Advancement of Science and a member of Phi Beta Kappa. His research interests are in evolutionary genetics.

Jane Long, CCST's California's Energy Future Project Co-Chair and CCST Sr. Fellow
Associate Director at Large, Global Security Directorate Fellow, Center for Global Security Research Lawrence Livermore National Laboratory

Dr. Long is the Principal Associate Director at Large for Lawrence Livermore National Laboratory working on energy and climate. She is also a Fellow in the LLNL Center for Global Strategic Research. Her current interests are in reinvention of the energy system in light of climate change, national security issues, economic stress, and ecological breakdown. She holds a bachelor's degree in engineering from Brown University and Masters and Ph.D. from UC Berkeley.

Patrick Mantey

Director, UC Center for Information Technology Research in the Interest of Society (CITRIS) @ Santa Cruz, University of California, Santa Cruz

Mantey holds the Jack Baskin Chair in Computer Engineering and was the founding Dean of the Jack Baskin School of Engineering. He is now the director of CITRIS at UC Santa Cruz and of ITI, the Information Technologies Institute in the Baskin School of Engineering. In 1984, he joined the UCSC faculty to start the engineering programs, coming from IBM where he was a senior manager at IBM Almaden Research. His research interests include system architecture, design, and performance, simulation and modeling of complex systems, computer networks and multimedia, real-time data acquisition, and control systems. Mantey is a Fellow of the Institute of Electrical and Electronics Engineers. His current projects at CITRIS include the Residential Load Monitoring Project and work on power distribution system monitoring and reliability. Mantey received his B.S. (magna cum laude) from the University of Notre Dame, his M.S. from the University of Wisconsin-Madison, and his Ph.D. from Stanford University, all in electrical engineering. He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE).

Emir José Macari

Dean of Engineering and Computer Science, California State University, Sacramento and Director of the California Smart Grid Center

Prior to his appointment as dean at CSU Sacramento, Macari was dean of the College of Science, Mathematics and Technology at the University of Texas at Brownsville. Prior to that, he served as the program director for the Centers of Research Excellence in Science and Technology at the National Science Foundation. He spent five years as the Chair and Bingham C. Stewart Distinguished Professor in the Department of Civil and Environmental Engineering at Louisiana State University. At the Georgia Institute of Technology he taught both engineering and public policy and at the University of Puerto Rico he was a professor and director of Civil Infrastructure Research Center. He has also worked as a civil engineer in private industry and has been a fellow at NASA. Macari holds both a doctorate and a master's degree in civil engineering geomechanics from the University of Colorado. He has a bachelor's degree in civil engineering geomechanics from Virginia Tech University.

Larry Papay CCST Board Member

CEO, PQR, LLC, mgmt consulting firm

Papay is currently CEO and Principal of PQR, LLC, a management consulting firm specializing in managerial, financial, and technical strategies for a variety of clients in electric power and other energy areas. His previous positions include Sector Vice President for the Integrated Solutions Sector, SAIC; Senior Vice President and General Manager of Bechtel Technology & Consulting; and Senior

Vice President at Southern California Edison. Papay received a B.S. in Physics from Fordham University, a M.S. in Nuclear Engineering from MIT, and a Sc.D. in Nuclear Engineering from MIT. He is a member of the National Academy of Engineering and served on its Board of Councilors from 2004-2010. He served as CCST Council Chair from 2005 through 2008, after which he was appointed to the Board.

David E Winickoff

Associate Professor of Bioethics and Society, Department of Environmental Science, Policy and Management, UC Berkeley

David Winickoff (JD, MA) is Associate Professor of Bioethics and Society at UC Berkeley, where he co-directs the UC Berkeley Science, Technology and Society Center. Trained at Yale, Harvard Law School, and Cambridge University, he has published over 30 articles in leading bioethics, biomedical, legal and science studies journals such as The New England Journal of Medicine, the Yale Journal of International Law, and Science, Technology & Human Values. His academic and policy work spans topics of biotechnology, intellectual property, geo-engineering, risk-based regulation, and human subjects research.

Paul Wright

Director, UC Center for Information Technology Research in the Interest of Society (CITRIS)

As Director of CITRIS Wright oversees projects on large societal problems such as energy and the environment; IT for healthcare; and intelligent infrastructures such as: public safety, water management and sustainability. Wright is a professor in the mechanical engineering department, and holds the A. Martin Berlin Chair. He is also a co-director of the Berkeley Manufacturing Institute (BMI) and co-director of the Berkeley Wireless Research Center (BWRC). Born in London, he obtained his degrees from the University of Birmingham, England and came to the United States in 1979 following appointments at the University of Auckland, New Zealand and Cambridge University England. He is also a member of the National Academy of Engineering.

Ryan McCarthy

Science and Technology Policy Fellow, California Council on Science and Technology

McCarthy recently completed the CCST Science and Technology Policy Fellowship in the office of California Assembly Member Wilmer Amina Carter, where he advised on issues associated with energy, utilities, and the environment, among others. McCarthy holds a master and doctorate degree in civil and environmental engineering from UC Davis, and a bachelor's degree in structural engineering from UC San Diego. His expertise lies in transportation and energy systems analysis, specifically regarding the electricity grid in California and impacts of electric vehicles on energy use and emissions in the state.

Appendix D – Written Submission Authors

Written Input Received from:

Physical Sciences/Engineers

Kenneth Foster, Professor, Department of Bioengineering, University of Pennsylvania

Rob Kavet, Physiologist/Engineer, Electric Power Research Institute (EPRI)

Biologists/medical

De-Kun Li, MD, Ph.D., Senior Reproductive and Perinatal Epidemiologist, Division of Research, Kaiser Foundation Research Institute, Kaiser Permanente

Asher Sheppard, Ph.D., Asher Sheppard Consulting, trained in physics, environmental medicine, and neuroscience

Magda Havas, B.Sc., Ph.D., Environmental & Resource Studies, Trent University, Peterborough, Canada

Cindy Sage, MA, Department of Oncology, University Hospital, Orebro, Sweden and Co-Editor, BioInitiative Report

Ray Neutra, MD, Ph.D., Epidemiologist, retired Chief of the Division of Environmental and Occupational Disease Control, California Department of Public Health (CDPH)

Appendix E – Additional Materials Consulted

All sources can be accessed through the CCST website at http://ccst.us

American Academy of Pediatrics

- The Sensitivity of Children to Electromagnetic Fields American Academy of Pediatrics (August 3, 2005)

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

- www.arpansa.gov.au Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
- Radiation Protection - Committee on Electromagnetic Energy Public Health Issues (Fact Sheet)
  Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (May 2010)
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  Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (June 25, 2010)

Documents From the California Department of Public Health (CDPH)

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  The Chronicle (September 26, 2010)
- Summary of the Literature: What do we Know About Cell Phones and Health?
  (July 20, 2010)
- Brain Tumor Risk in Relation to Mobile Telephone Use: Results of the INTERPHONE International Case - Control Study
  Oxford University Press (March 8, 2010)
- Mobile Phones and Health
  U.K. Department of Health
- Late Lessons from Early Warnings: Towards Realism and Precaution with EMF?
  David Gee, European Environment Agency, (January 30, 2009)
- Statement of Finnish Radiation and Nuclear Safety Authority (STUK) Concerning Mobile Phones and Health
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- Fact Sheet: Children and Safe Cell Phone Use
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- Children and Mobile phones: The Health of the Following Generations in Danger
  Russian National Committee on Non-Ionizing Radiation Protection (April 14, 2008)
- AFSSE Statement on Mobile Phones and Health
  French Environmental Health and Safety Agency - AFSSE (April 16, 2003)

Committee on Man and Radiation (COMAR)

- IEEE Engineering in Medicine and Biology Society Committee on Man and Radiation (COMAR)
- COMAR Technical Information Statement the IEEE Exposure Limits for

Radiofrequency and Microwave Energy
IEEE Engineering in Medicine and Biology Magazine (April 2005)

Commonwealth Club of California

- Commonwealth Club of California - The Health Effects of Electromagnetic Fields (Video) (November 18, 2010)

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- emf.epri.com EMF/RF Program at EPRI
- Radio-Frequency Exposure Levels from SmartMeters
  Electric Power Research Institute (November 2010) - accessed via the Internet December 2010
- Perspective on Radio-Frequency Exposure Associated With Residential Automatic Meter Reading Technology
  Electric Power Research Institute (EPRI) (February 22, 2010)
- Testing and Performance Assessment for Field Applications of Advanced Meters
  Electric Power Research Institute (EPRI) (December 4, 2009)
- Overview of Personal Radio Frequency Communication Technologies
  Electric Power Research Institute (EPRI) (September 9, 2008)
- Characterizing and Quantifying the Societal Benefits Attributable to Smart Metering Investments
  Electric Power Research Institute (EPRI) (July 2008)
- Metering Technology
  Electric Power Research Institute (June 20, 2008)
- The BioInitiative Working Group Report
  Electric Power Research Institute (EPRI) (November 23, 2007)
- An Overview of Common Sources of Environmental Levels of Radio Frequency Fields
  Electric Power Research Institute (EPRI) (September 2002)

Environmental Protection Agency

- United States Environmental Protection Agency's Response to Janet Newton (March 8, 2002)
- United States Environmental Protection Agency's Response to Jo-Anne Basile (September 16, 2002)

Epidemiology

- Prenatal and Postnatal Exposure to Cell Phone Use and Behavioral Problems in Children
  Epidemiology July 2008 - Volume 19 - Issue 4 - pp 523-529

European Journal of Oncology - Ramazzini Institute

- Non-Thermal Effects and Mechanisms of Interaction between Electromagnetic Fields and Living Matter
  (2010)

Federal Communications Commission

- Radio Frequency Safety FAQ's
- RF Safety Page
- Federal Communications Commission Response to Cindy Sage
  (August 6, 2010)
- FCC Certifications
  - FCC Certification for the Silver Spring Networks Devices - September 28, 2009
  - FCC Certification for the Silver Spring Networks Devices - September 28, 2009
  - FCC Certification for the Silver Spring Networks Devices - September 4, 2007
  - FCC Certification for the Silver Spring Networks Devices - July 6, 2007
- Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields
  Federal Communications Commission Office of Engineering & Technology (August 1999)
- Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
  Federal Communications Commission Office of Engineering & Technology (August 1997)

Food and Drug Administration

- No Evidence Linking Cell Phone Use to Risk of Brain Tumors
  U.S. Food and Drug Administration (May 2010)

Health Protection Agency

- Wi-Fi
  Health Protection Agency (Last reviewed: October 26, 2009)
- Cordless Telephones - Digital Enhanced Cordless Telecommunications (DECT) and other Cordless Phones
  Health Protection Agency (Last reviewed: September 4, 2008)

International Commission on Non-Ionizing Radiation Protection (ICNIRP)

- www.icnirp.de International Commission on Non-Ionizing Radiation Protection (ICNIRP)
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) on the Interphone Publication
  International Commission on Non-Ionizing Radiation Protection (May 18, 2010)
- ICNIRP Statement on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)"
  International Commission on Non-Ionizing Radiation Protection (September 2009)
- Epidemiologic Evidence on Mobile Phones and Tumor Risk
  International Commission on Non-Ionizing Radiation Protection (September 2009)
- Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz - 300 GHz)

International Commission on Non-Ionizing Radiation Protection (2009)

National Academies Press

- Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication
  National Academies Press (2008)
- An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy (9.9MB PDF)
  National Academies Press (2005)

National Cancer Institute

- Cell Phones and Cancer Risk (Fact Sheet)
  National Cancer Institute
- Cell Phones and Brain Cancer: What We Know (and Don't Know)
  National Cancer Institute (September 23, 2008)

National Institute of Environmental Health Sciences

- Electric and Magnetic Fields
  National Institute of Environmental Health Sciences

PG&E

- Understanding Radio Frequency (RF)
  PG&E
- Supplemental Report on An Analysis of Radiofrequency Fields Associated with Operation of PG&E SmartMeter Program Upgrade System
  Richard A. Tell, Richard Tell Associates, Inc. (October 27, 2008)
- Smart Grid: Utility Challenges in the 21st Century (7.4MB PDF)
  Andrew Tang, Smart Energy Web, Pacific Gas and Electric Company (September 18, 2009)
- Summary Discussion of RF Fields and the PG&E SmartMeter System
  Richard A. Tell, Richard Tell Associates, Inc. (2005 Report and 2008 Supplemental Report)
- Analysis of RF Fields Associated with Operation of PG&E Automatic Meter Reading Systems
  Richard A. Tell, Richard Tell Associates, Inc. and J. Michael Silva, P.E. Enertech Consultants (April 5, 2005)

Provided by Raymond Neutra

- www.ehib.org/emf The California Electric and Magnetic Fields (EMF) Program
- Should the World Health Organization (WHO) Apply the Precautionary Principal to Low and High Frequency Electromagnetic Fields?
  Raymond Richard Neutra

Society for Risk Analysis

- Risk Governance for Mobile Phones, Power Lines and Other EMF Technologies
  Society for Risk Analysis (2010)

Swedish State Radiation Protection Authority (SSI)

- The Nordic Radiation Safety Authorities See no Need to Reduce Public Exposure Generated by Mobile Bas Stations and Wireless Networks
  Swedish State Radiation Protection Authority (SSI) (2009)

University of Ottawa

- Wireless Communication and Health - Electromagnetic Energy and Radiofrequency Radiation FAQ's
  University of Ottawa, RFcom

World Health Organization

- Database of Worldwide EMF Standards
- WHO - Electromagnetic Fields
- Electromagnetic Fields and Public Health - Base Stations and Wireless Networks (Fact Sheet N°304)
  World Health Organization (May 2006)
- Electromagnetic Fields and Public Health - Electromagnetic Hypersensitivity (Fact Sheet N°296)
  World Health Organization (December 2005)
- Electromagnetic Fields and Public Health - Mobile phones (Fact Sheet N°193)
  World Health Organization (May 2010)

Unsolicited Submissions

Documents Provided by Alexander Blink, Executive Director of the DE-Toxics Institute, Fairfax CA

- Points and Sources Submitted for Consideration by Alexander Blink 2
- Points and Sources Submitted for Consideration by Alexander Blink 1
- Public Health Implications of Wireless Technologies, Cindy Sage
- Memory and Behavior, By Henry Lai, Bioelectromagnetics Research Laboratory, University of Washington

Sage Consulting

- Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters
  Sage Associates (January 2011)
- Cindy Sage Letter to Julius Knapp (FCC)
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- Response Letter to Cindy Sage from Julius Knapp (FCC)
  (August 6, 2010)
- Cindy Sage Letter to Edwin D. Mantiply (FCC)
  (March 15, 2010)
- Bioinitiative Report: A Rational for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF) (3.1MB PDF)
- Bioinitiative Report: What is the BioInitiative Report?
- Bioinitiative Report: Myocardial Function Improved by Electromagnetic Field Induction of Stress Protein hsp70 (1.1MB PDF)

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  Cindy Sage, Editorial Perspective
- Bioinitiative Report: Steps to the Clinic with ELF EMF (1.0MB PDF)
- Mobile Phone Base Stations - Effects on Wellbeing and Health
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- Increased Blood-Brain Barrier Permeability in Mammalian Brain 7 Days after Exposure to the Radiation from a GSM-900 Mobile Phone
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- Public Health Implications of Wireless Technologies
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- Genotoxic Effects of Radiofrequency Electromagnetic Fields
  Pathophysiology (August 2009)
- Epidemiological Evidence for an Association Between Use of Wireless Phones and Tumor Diseases
  Pathophysiology (August 2009)
- Public Health Risks from Wireless Technologies: The Critical Need for Biologically-based Public Exposure Standards for Electromagnetic Fields (2.9MB PDF)
  BioInitiative Briefing for President-Elect Obama Transition Team
- The BioInitiative Report: A Rationale for A Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF) (3.6MB PDF)
  Cindy Sage PowerPoint Presentation (November 2007)

Wilner & Associates

- SmartMeters and Existing Electromagnetic Pollution
  Wilner & Associates (January 2011) **- This report was not commissioned by CCST**
- Application for Modification Before the California Public Utilities Commission (3.5MB PDF)

Other Documents

- Health Canada Safety Code 6 and City of Toronto's Proposed Prudent Avoidance Policy
  (2010)
- Transmitting Smart Meters Pose A Serious Threat To Public Health
  (2010)
- RF Safety and WiMax FAQ's: Addressing Concerns About Perceived Health Effects
  (April 2008)

Relevant Websites

- EMF - Portal
- emfacts.com
- emfsafetynetwork.org
- lbagroup.com

- NIOSH Program Portfolio Centers for Disease Control and Prevention (CDC)
- Radio Frequency RF Safety and Antenna FAQs
- Smart Grid Information Clearinghouse (SGIC)
- stopsmartmeters.org

Appendix F – Glossary

Access point - A term typically used to describe an electronic device that provides for wireless connectivity via a WAN to the Internet or a particular computer facility.

Duty cycle – A measure of the percentage or fraction of time that an RF device is in operation. A duty cycle of 100% corresponds to continuous operation (e.g., 24 hours/day). A duty cycle of 1% corresponds to a transmitter operating on average 1% of the time (e.g., 14.4 minutes/day).

Electromagnetic field (EMF) - A composition of both an electric field and a magnetic field that are related in a fixed way that can convey electromagnetic energy. Antennas produce electromagnetic fields when they are used to transmit signals.

Federal Communications Commission (FCC) - The Federal Communications Commission (FCC) is an independent agency of the US Federal Government and is directly responsible to Congress. The FCC was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite, and cable. The FCC also allocates bands of frequencies for non-government communications services (the NTIA allocates government frequencies). The guidelines for human exposure to radio frequency electromagnetic fields as set by the FCC are contained in the Office of Engineering and Technology (OET) Bulletin 65, Edition 97-01 (August 1997). Additional information is contained in OET Bulletin 65 Supplement A (radio and television broadcast stations), Supplement B (amateur radio stations), and Supplement C (mobile and portable devices).

Gigahertz (GHz) - One billion Hertz, or one billion cycles per second, a measure of frequency.

Hertz - The unit for expressing frequency, one Hertz (Hz) equals one cycle per second.

Megahertz (MHz) - One million Hertz, or one million cycles per second, a unit for expressing frequency.

Mesh network - A network providing a means for routing data, voice and instructions between nodes. A mesh network allows for continuous connections and reconfiguration around broken or blocked data paths by “hopping” from node to node until the destination is reached.

Milliwatt per square centimeter (mW/cm^2) - A measure of the power density flowing through an area of space, one thousandth (10^{-3}) of a watt passing through a square centimeter.

Microwatt per square centimeter ($\mu W/cm^2$) - A measure of the power density flowing through an area of space, one millionth (10^{-6}) of a watt passing through a square centimeter.

Radiofrequency (RF) - The RF spectrum is formally defined in terms of frequency as extending from 0 to 3000 GHz, the frequency range of interest is 3 kHz to 300 GHz.

Repeater unit - A device that can simultaneously receive a radio signal and retransmit the signal. Repeater units are used to extend the range of low power transmitters in a geographical area.

Router - An electronic computer device that is used to route and forward information, typically between various computers within a local area network or between different local area networks.

Smart meter - A digital device for measuring consumption, such as for electricity and natural gas, and sending the measurement to a utility company. Automated meter reading (AMR) meters send information one-way only. Automated meter infrastructure (AMI) meters are capable of two-way communications.

Specific absorption rate (SAR) - The incremental energy absorbed by a mass of a given density. SAR is expressed in units of watts per kilogram (or milliwatts per gram, mW/g).

Transmitter - An electronic device that produces RF energy that can be transmitted by an antenna. The transmitted energy is typically referred to a radio signal or RF field.

Wide area network (WAN) - A computer network that covers a broad area such as a whole community, town, or city. Commonly, WANs are implemented via a wireless connection using radio signals. High-speed Internet connections can be provided to customers by wireless WANs.

Wi-Fi - An name given to the wireless technology used in home networks, mobile phones, and other wireless electronic devices that employ the IEEE 802.11 technologies (a standard that defines specific characteristics of wireless local area networks).

Appendix G – CCST 2011 BOARD MEMBERS

Karl S. Pister, ***Board Chair****; Chancellor Emeritus, UC Santa Cruz; and Dean and Roy W. Carlson Professor of Engineering Emeritus, UC Berkeley*

Bruce M. Alberts, *Professor, Department of Biochemistry & Biophysics, UC San Francisco*

Ann Arvin, *Vice Provost and Dean of Research, Lucile Salter Packard Professor of Pediatrics and Professor of Microbiology and Immunology, Stanford University*

Warren J. Baker, *Emeritus, President*, *California Polytechnic State University, San Luis Obispo*

Peter Cowhey, *Council Vice-Chair and Dean, School of International Relations and Pacific Studies, UC San Diego*

Bruce B. Darling, *Executive Vice President, University of California*

Susan Hackwood, *Executive Director, California Council on Science and Technology*

Randolph Hall, *Vice Provost for Research Advancement, University of Southern California*

Charles E. Harper, *Executive Chairman, Sierra Monolithics, Inc.*

Miriam E. John, *Council Chair and Emeritus Vice President, Sandia National Laboratories, California*

Mory Gharib, *Vice Provost, California Institute of Technology*

Bruce Margon, *Vice Chancellor of Research*, University of California, Santa Cruz

Tina Nova, *President, CEO, and Director, Genoptix, Inc.*

Lawrence T. Papay, *CEO and Principal, PQR, LLC*

Patrick Perry, *Vice Chancellor of Technology, Research and Information Systems, California Community Colleges*

Rollin Richmond, *President, Humboldt State University*

Sam Traina, *Vice Chancellor of Research*, University of California, Merced

Appendix H – CCST 2011 COUNCIL MEMBERS

Miriam E. John, ***Council Chair*** *and Emeritus Vice President, Sandia National Laboratories, California*

Peter Cowhey, ***Council Vice Chair*** and *Dean, School of International Relations and Pacific Studies, UC San Diego*

Wanda Austin, *President and CEO, The Aerospace Corporation*

Julian Betts, *Professor of Economics, UC San Diego*

George Blumenthal, *Chancellor, UC Santa Cruz*

Susan Bryant, *Former Vice Chancellor for Research, UC Irvine*

Charles Elachi, *Director, Jet Propulsion Laboratory*

David Gollaher, *President and CEO, California Healthcare Institute*

Corey Goodman, *Former President, Biotherapeutics and Bioinnovation Center, Pfizer*

M.R.C. Greenwood, *President, The University of Hawai'i System*

Susan Hackwood, *Executive Director, California Council on Science and Technology*

Bryan Hannegan, *Vice President of Environment and Renewables, Electric Power Research Institute*

Sung-Mo "Steve" Kang, *Chancellor, University of California, Merced*

Charles Kennedy, *Vice President for Health Information Technology, WellPoint, Inc.*

Jude Laspa, *Deputy Chief Operating Officer, Bechtel Group, Inc.*

William Madia, *Former Senior Executive Vice President of Laboratory Operations, Battelle*

David W. Martin, Jr., M.D., *Chairman & CEO, AvidBiotics Corporation*

Fariborz Maseeh, *Founder and Managing Principal, Picoco LLC*

George H. Miller, *Director, Lawrence Livermore National Laboratory*

Michael Nacht*, Dean, Goldman School of Public Policy, UC Berkeley*

Stephen D. Rockwood, *Executive Vice President, Science Applications International Corporation*

Jeffrey Rudolph, *President and CEO, California Science Center*

Shankar Sastry, *Dean, College of Engineering, University of California, Berkeley*

Soroosh Sorooshian, *Distinguished Professor and Director, Center for Hydrometeorology & Remote Sensing (CHRS), UC Irvine*

James L. Sweeney, *Director, Precourt Institute for Energy Efficiency, and Professor of Management Science and Engineering, Stanford University*

S. Pete Worden, *Director, NASA Ames Research Center*

Julie Meier Wright, *President and CEO, San Diego Economic Development Corporation*

Kathy Yelick, *Director, National Energy Research Scientific Computing Center (NERSC), Lawrence Berkeley National Laboratory*

Appendix I – Report Credits

CCST Smart Meters Project Team:
Rollin Richmond (Chair), *President Humboldt State University, CSU*
Jane Long, *Associate Director at Large, Global Security Directorate Fellow, Center for Global Security Research Lawrence Livermore National Laboratory*
Emir Macari, *Dean of Engineering and Computer Science, California State University, Sacramento and Director of the California Smart Grid Center*
Patrick Mantey, *Director, CITRIS @ Santa Cruz*
Ryan McCarthy, *2009 CCST Science and Technology Policy Fellow*
Larry Papay, *CEO, PQR, LLC*, mgmt consulting firm
David Winickoff, *Assistant Professor of Bioethics and Society, Department of Environmental Science, Policy and Management, UC Berkeley*
Paul Wright, *Director, UC Center for Information Technology Research in the Interest of Society (CITRIS)*

With Additional Assistance From:
JD Stack, *Administrator, California Smart Grid Center, College of Engineering and Computer Science, California State University, Sacramento*

CCST Executive Director:
Susan Hackwood

Project Manager:
Lora Lee Martin, Director, S&T Policy Fellows

CCST Staff:
Donna King, Executive Assistant and Accountant
Sandra Vargas-De La Torre, Project Coordinator, Layout