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, cordless phones **and microwave ovens.**

2. The current FCC standard provides ~~an adequate factor of~~for **safety** only **against known thermally induced health impacts of existing common household electronic devices and smart meters.**

3. S~~To date, s~~**cientific studies** ~~have not identified or confirmed~~produced conflicting data regarding **negative health effects** including sleep disruption, headaches, DNA damage, hearing problems, and other effects **from** ~~potential~~ **non-**thermal impacts of RF emissions such as those produced by existing common household ~~electronic~~ microwave based 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 than to minimize microwave exposure when possible.

5. Consumers and policymakers need reliable access to impartial, up to date information on benefits and risks of newer electronic devices, which is not currently easy to obtain.

OTHER CONSIDERATIONS

Smart electricity meters are a key enabling technology for a "**s**mart grid" that is expected by proponents to become increaslingly 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-lifornia 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-

Figure should be redrawn in log scale. Should include natural background and typical urban background. Could use one axis for amplitude, one for frequency.

1000

1500
2000
2500
3000
3500

4000
4500
5000
1000
50
40
4

0.2
0.005
5000
200
40
4

1

1

6

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
20th supporting Assembly Member
Huffmanard 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.

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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 RM 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~~indicated that non-thermal effects may include fatigue, headache, irritability, or even cancer. *But these findings of non-thermal effects, with the exception of the microwave hearing effect, have not been ~~scientifically established~~accepted by* *some prominent scientists, and the mechanisms that might lead to other 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 s **smart meters and similar electronic devices, CCST finds that:**

1. The FCC standard provides ~~an adequate factor of safety~~protection only **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~~one **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 conistent with the FCC certification, emit RF that is a very small fraction of the exposure level established as ~~safe~~permissible by the FCC guidelines.

The FCC guidelines provide a ~~significant~~ factor of safety of 2.5 to 50 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.~~ Although an FDA conference recently raised the question of wehther the thermal standards should be revised to take into account the differences of various body tissues in their ability to dissipate heat, it is clear that smart meters do not pose a risk from bulk thermal heating.

2. At this time there ~~is no clear~~conflicting **evidence** ~~that~~as to whether **additional standards are needed to protect the public from smart meters or other common household electronic devices.**

~~No clear causal~~The **relationship between RF emissions and non-**thermal human health impacts ~~has been scientifically established~~is not yet understood, nor have the mechanisms that might lead to such a biological impact been thoroughly analyzed~~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~~Different groups of scientists have reached different conclusions as to whether additional standards are needed. ~~Because of the lack of generally accepted evidence, there is also not an existing basis from which to understand~~Indications of a complex dose response relationship, coupled with lack of certainty of the causal relationship to human health outcomes, in the context of widespread dependence on microwave technologies, make it difficult to say 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 mechanism 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~~the typical person is now ~~are~~ exposed. However, there are also many people who choose a lifestyle with far lower levels of exposure, especially in the microwave band above 300 Mhz. Concerns about human health impacts from 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~~most people **use in** their **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** and amplitudes **from smart meters and other devices** that many people use **shows that the exposure level** from smart meters **is ~~very~~ low**er than for many of the other modern devices**.**

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 ot 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 (mainly by reducing the cost of labor for meter reading), and potentially, costs for customers (see Figure 2).

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 m**eter (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).**

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Tell, R. (2008) & Electric Company, Richard Tell Associates, Inc., October 27.

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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_2

008.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. AirCards typically operate at 0.25-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 expect 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 in principle 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. Of course, the long term reliability of the components of the smart grid, including the smart meters themselves, which could affect long term cost savings, has yet to be proven in practice**.**

Figure 4 depicts the potential operation of a smart grid.

(Source Silver Spring Network4)

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.** However, it is not clear that customers will be responsive enough to make these improvements pay off.

While the~~such~~ **long-**term value of smart meters will take years to fully ~~realize~~assess, they are sufficiently promising that the federal government has ~~required~~given financial incentives to utilities, including recovering costs through rate increases, 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.

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 costs and **benefits expected to result from the smart grid.**

Table 1: Smart Grid Costs and **Benefits**
Consumers

Add costs to each section of table: Consumers: increased rates to pay for new meters. Possible erroneous meter readings. Potential privacy invasion/security vulnerability (data transmitted on when no electricity is being used). May feel flat rate billing is more convenient.

Utilities: possible lawsuits. Possible premature equipment failure. Consumers may demand return to analog meters.

Environment: RF/dirty power effects on birds, trees, insects. Possible waste of resources if smart grid is abandoned.

Economy: Costs jobs. Wasted expense if smart grid is abandoned or if equipment needs to be recalled.

Possible benefits

Consumers

1. Cost Savings ~~Resulting from Energy Efficiency~~For Off-Peak Usage

2. ~~Increased Consumer Choice and Convenience~~ Possibly Fewer Blackouts If Peak Use Reduced

3. More Transparent, Real-Time Information and Control for Consumers (but this benefit can be achieved by Kill-o-Watt devices and other means in which the consumer has full control).

Utilities
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

Environment
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)~~ (same as 1.)

Economy
1. Creates New Market for Goods and Services (i.e., ~~New Companies, New Jobs~~New Meters, Meter Installation)
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~~ similar power and frequency as cell phones, both of which use ~~in~~ the ~~RF~~microwave portion of the RF electromagnetic spectrum. At these levels, RF emissions from smart

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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 RL34|294, December 21. (http://energy.senate.gov/public/_files/RL342941.pdf)

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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 consumers choose to 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, and the prior health of people who choose to use 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 degree C (1.8 degrees F) to lead to potential short-term **biological impacts from the heat.** ~~The only~~One **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 1oC 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~~thermal **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 dating back to the 1960's and '70's in the medical and biological fields about potential harmful
effects caused by non-thermal mechanisms of absorbed RF emissions, particularly in the microwave frequencies (cite e.g. Zapping of America). Complaints of health
impacts from "electromagnetic stress" have been repoted, 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~~a division in the scientific community as to whether **cell phone usage** is convincingly linked **with increased incidence of cancer.**(cite Hardell review) **11** ~~But~~ D~~d~~**ue to the recent nature of the technology, impacts of long-**term
exposure are not known. ~~Ongoing~~More scientific study ~~is being conducted~~has been called for to understand non-
thermal effects from long-term exposure to mobile phones and smart meters, etc., especially

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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.

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.

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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 c**ulative impact from all RF emitting devices including that of a network of smart meters operating throughout a community.12**

~~There~~ ~~c~~Currently, the most **conclusive scientific evidence pointing to a non-**thermal cause-and-effect between human exposure to RF emissions and ~~negative health impacts~~biological effect is the microwave hearing effect, in which subjects have the illusion of sound perception when exposed to pulsed microwaves. This effect has not been shown to occur at exposre levels caused by smart meters, but the threshold has never been fully characterized, and disputes over the mechanism have never been resolved. 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~~ ~~q~~Questions about other non-thermal effectswill likely take considerable **time to**
resolve. ~~The data that are available strongly~~Everyday experience **suggest**s **that the**~~re are~~ **non-**thermal effects of RF
absorption on human health~~, such effects~~ are not so profound as to be easily discernable in most people over a short period of time.

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
guidelines15, 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-2) Inc.
16

American National Standards Institute (1992) sorption rate
(SAR) measures the rate of energy absorption and is measured in units of watts-aking, and still today, behavioral disruption in laboratory animals (including non-erage 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
(106) watts- others.
The
human
body

absorbs energy most efficiently in the range of 30-

FCC (2001) of microwave exposure,
Bioelectromagnetics Suppl 6, S39-equency electromagnetic fields and comments on The Bioinitiative Report,ents/bulletins/oet65/oet65.pdf)
25

FCC (1999) gher, 1000
s
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 ours which results in this very low estimated peak power.
However, we are not aware of the justification for using averaging over a four-

26

Tell, R. (2008) mated maximum exposure from a 1-

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 e from smart meter HAN
transmier at 5%, 50% and 100% duty cycle
FCC Limit
100% if always on
Max exposure from smart meter AMR
transmier at 5% duty cycle

19

Figure 6. Power density from a sample smart meter versus distance;29 1-a.

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-

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 of the Electronic Product Radiation Control Provisions of the Federal Food, Drug, and Cosmetic

Act,Sources in g WI- 11, pp. 48- 3500 4000 4500
5000
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50 40 4
0.2 0.005
5000
200 40
4
1 1

21

Table 2: Radio-W, 5%
duty cycle)
3
feet

10 feet
When in proximity
during transmission Localized, non- Power Research Institute (EPRI), Radio Frequency Exposure Levels from Smart Meters (November 2010)

22

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-ces 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
een 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 todayion (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- 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-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-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)
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-

etc.). An ongoing regularly updated source of unbiased information on the state of scientific research, both proven and as- meters to the utility company. These methods include transmitting over a
power line or wired through phone lines, fiber-ould 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-such a hypothetical scenario were to occur, smart meters could conceivably be adapted to
non-crowave ovens
2. Signal Strength
(or Power Density) Microwatts/square centimeter (-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:

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-
(September 17, 2010 letter) requested CCSTcari, Dean of Engineering and Computer Science, California State
University, Sacramento and Director of the California Smart Grid Center
f
Society (CITRIS)

In addition to those on the project team, CCST approached over two dozen technical experts to contribute their opinion to inform CCSTto 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
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- 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 Richmondf 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, CCSTr. 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-I 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-wnsville. 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 mastergineering geomechanics from the University of Colorado. He has a bachelorhysics 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- and Society at UC Berkeley, where he co- 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-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 energy use and emissions in the state.

Appendix D gy, University Hospital, Orebro, Sweden and Co-ommittee on Electromagnetic Energy Public Health Issues
(Fact Sheet)
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (May 2010)
Chronicle (September 26, 2010)

Children and Safe Cell Phone Use
Toronto Public Health (July 2008)

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Effects of Wireless Communication
National Academies Press (nts (April 5, 2005)
Provided by Raymond Neutra
the Precautionary Principal to
Low and High Frequency Electromagnetic Fields?
Raymond Richard Neutra
Society for Risk Analysis
EMF Standards
for Consideration by Alexander Blink 1
o Public Health Implications of Wireless Technologies, Cindy Sage
o Memory and Behavior, By Henry Lai, Bioelectromagnetics Research
Laboratory, University of Washington
Sage Consulting
o Assessment of Radiofrequency Microwave Radiation Emissions from
Smart Meters
Sage Associates (January 2011)
o Cindy Sage Letter to Julius Knapp (FCC)
(September 22, 2010)
o Response Letter to Cindy Sage from Julius Knapp (FCC)
(August 6, 2010)
o Cindy Sage Letter to Edwin D. Mantiply (FCC)
(March 15, 2010)
o Bioinitiative Report: A Rational for a Biologically- Report: Steps
to
the
Clinic
with
ELF
EMF

(1.0MB
PDF)

o Mobile Phone Base on Clearinghouse (SGIC)

for
wireless connectivity via a WAN to the Internet or a particular computer facility.

Duty cycle fixed way that can convey electromagnetic energy. Antennas
produce electromagnetic fields when they are used to transmit signals.

Federal Communications Commission (FCC) - as set by the FCC are
contained in the Office of Engineering and Technology (OET) Bulletin 65, Edition 97-iding 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
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 -urement to a utility company. Automated meter
reading (AMR) meters send information one-n, or city. Commonly, WANs are implemented via a wireless
connection using radio signals. High-cs, 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-h 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 The University of Hawai
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

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Appendix I

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)

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CCST Staff:
Donna King, Executive Assistant and Accountant
Sandra Vargas-Stations -

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