Mobile & Wireless Forum

ENVIRONMENTAL HEALTH TRUST

FCC-MWF MTG

September 17, 2020

Overview of MWF Research Efforts

Online link to document
https://ecfsapi.fcc.gov/file/1092165897816/FCC%20Mtg%20Sept%2017Final.pdf

MWF-Sponsored 5G Research Project Publications

1. Foster, Ziskin and Balzano, "Thermal response of human skin to microwave energy: a critical review", Health Physics Journal, 2016
2. Foster and Colombi, "Thermal response of tissue to RF exposure from canonical dipoles at frequencies for future mobile communication system, Electronic Letters, 2017
3. Foster, Ziskin and Balzano, "Thermal modeling for the next generation of radiofrequency exposure limits: commentary", Health Physics Journal, 2017
4. Ziskin, Alekseev, Foster and Balzano, "Tissue models for RF exposure evaluation at frequencies above 6 GHz", Bioelectromagnetics, 2018
5. Christ, Colombi and Joyner, "Thermal Modeling of the Near-Field Exposure from Wireless 5G Devices", EuCap 2018
6. Carrasco, Colombi, Foster, Ziskin and Balzano, "Exposure Assessment of Portable Wireless Devices above 6 GHz", Radiat Prot Dosimetry, 2018
7. Foster, Ziskin, Balzano and Bit-Babik, "Modeling Tissue Heating From Exposure to Radiofrequency Energy and Relevance of Tissue Heating to Exposure Limits: Heating Factor", Health Physics Journal, 2018
8. Pfeifer, Carrasco, Crespo-Valero, Neufeld, Kuhn, Samaras, Christ, Capstick and Kuster, "Total Field Reconstruction in the Near Field Using Pseudo-Vector E-Field Measurements", IEEE EMC, 2018
9. Lundgren, Helander, Gustafsson, Sjöberg, Xu and Colombi, Near Field Reconstruction for Electromagnetic Exposure of 5G Communication Devices, Annual Meeting and Symposium of the Antenna Measurement Techniques Association, 2018
10. Colombi, Xu, Törnevik, Christ, Foster, Ziskin and Balzano, "Comparison between numerically and experimentally assessed skin temperature elevations for localized RF exposure at frequencies above 6 GHz", BioEM 2018
11. Christ, Samaras, Neufeld and Kuster, "RF-Induced temperature increase in a stratified model of the skin for plane-wave exposure at 6-100 GHz" Radiation Protection Dosimetry, 2020
12. Foster, Ziskin, Balzano and Hirata, "Thermal Analysis of Averaging Times in Radio-Frequency Exposure Limits Above 1 GHz", IEEE Access, 2019
13. Lundgren, Helander, Gustafsson, Sjöberg, Xu, and Colombi, "Near-Field Measurement and Calibration Technique for RF EMF Exposure Assessment of mm-wave 5G Devices", in publication on the IEEE Antennas and Propagation Society Magazine.
14. Aerts, Verloock,Van den Bossche, Colombi, Martens, Törnevik, Joseph,"In-Situ Measurement Methodology for the Assessment of 5G NR Base Station Exposure at Sub-6 GHz Frequencies", IEEE Access, 2019

Mobile & Wireless Forum

Health Physics 105, no. 6 (2013)

ENVIRONMENTAL HEALTH TRUST

WI-FI AND HEALTH: REVIEW OF CURRENT STATUS OF RESEARCH

Kenneth R. Foster* and John E. Moulder†

Abstract—This review summarizes the current state of research on possible health effects of Wi-Fi (a commercial name for IEEE 802.11-compliant wireless networking). In response to public concerns about health effects of Wi-Fi and wireless networks and calls by government agencies for research on possible health and safety issues with the technology, a considerable amount of technology-specific research has been completed. A series of high quality engineering studies have provided a good, but not complete, understanding of the levels of radiofrequency (RF) exposure to individuals from Wi-Fi. The limited number of technology-specific bioeffects studies done to date are very mixed in terms of quality and outcome. Unequivocally, the RF exposures from Wi-Fi and wireless networks are far below U.S. and international exposure limits for RF energy. While several studies report biological effects due to Wi-Fi-type exposures, technical limitations prevent drawing conclusions from them about possible health risks of the technology. The review concludes with suggestions for future research on the topic.
Health Phys. 105(6):561–575; 2013

Key words: e…
protecti…, ra…

to the Internet by laptop computers, although IEEE 802.11 protocols are used for other communications devices, including some electric utility meters.

Initially developed as a wireless replacement for Ether-

May 25, 2016 UNITED STATES DISTRICT COURT DISTRICT OF MASSACHUSETTS
Kenneth Foster stated regarding the support by the wireless companies for this paper, "I think the total contract was in the order of $40,000. As I recall we split the amount. It was a small contract. That's how these things go."

tion: bathroom scales, gaming devices, audio equipment, household thermostats, and running shoes. While numerous wireless networking technologies are available, virtually all of the WLANs with which an ordinary citizen would be

Acknowledgments—This work was funded by the Wi-Fi Alliance, Washington, DC, and Mobile Manufacturers Forum, Brussels, Belgium. Neither organization had any role in the research for, or preparation of, the manuscript; and they had no knowledge of the contents or conclusions of this review prior to submission for publication. The opinions in this review are those of the present authors only.

Health Physics 92(3):280-9 · April 2007

RADIOFREQUENCY EXPOSURE FROM WIRELESS LANS UTILIZING WI-FI TECHNOLOGY

ENVIRONMENTAL HEALTH TRUST

Kenneth R. Foster*

Abstract—**This survey measured radiofrequency (RF) fields from wireless local area networks (WLANs) using Wi-Fi technology against a background of RF fields in the environment over the frequency range 75 MHz–3 GHz. A total of 356 measurements were conducted at 55 sites (including private residences, commercial spaces, health care and educational institutions, and other public spaces) in four countries (U.S., France, Germany, Sweden). Measurements were conducted under conditions that would result in the higher end of exposures from such systems. Where possible, measurements were conducted in public spaces as close as practical to the Wi-Fi access points. Additional measurements were conducted at a distance of approximately 1 m from a laptop while it was uploading and downloading large files to the WLAN. This distance was chosen to allow a useful comparison of fields in the far-field of the antenna in the laptop, and give a representative measure of the exposure that a bystander might receive from the laptop. The exposure to the user, particularly if the antenna of the client card were placed against his or her body, would require different measurement techniques beyond the scope of this study. In all cases, the measured Wi-Fi signal levels were very far below international exposure limits (IEEE C95.1-2005 and ICNIRP) and in nearly all cases far below other RF signals in the same environments. An Appendix discusses technical aspects of the IEEE 802.11 standard on which WLANs operate that are relevant to determining the levels of RF energy exposure from WLANs...**

wireless local-area network "hot spots" in operation around the world.[†] This study concerns WLANs that based on the widely utilized Wi-Fi technology; other technologies such as WiMAX are not considered. The technology has occasionally prompted questions from the public about health and safety issues related to exposure to RF energy, and in U.K. schools, WLANs have been removed due to health concerns (Bale 2006).

While WLANs clearly operate at low power, little quantitativ... health phys... of exposu... technical r... al. 2005), ... the conven... survey of R... and other ... variety of l... accessible ... more detailed considerations related to RF exposure from WLANs.

May 25, 2016 UNITED STATES DISTRICT COURT DISTRICT OF MASSACHUSETTS
Lawyer "How much did they pay on that contract, do you remember?"
Kenneth Foster PhD response "It was probably $50,000 of which easily half of that was travel cost."

Almost all WLANs are based on the IEEE 802.11

Acknowledgments— This work was supported by the Wi-Fi Alliance.

IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received May 23, 2020, accepted June 14, 2020, date of publication July 9, 2020, date of current version July 27, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3008322

Transient Thermal Responses of Skin to Pulsed Millimeter Waves

KENNETH R. FOSTER[1], (Life Fellow, IEEE), MARVIN C. ZISKIN[2], (Life Fellow, IEEE), QUIRINO BALZANO[3], (Life Fellow, IEEE), AND AKIMASA HIRATA[4], (Fellow, IEEE)

[1]Department of Bioengineering, University of Pennsylvania, Philadelphia, PA 19104, USA
[2]Department of Radiology, Temple University Medical School, Philadelphia, PA 19140, USA
[3]Department of Electrical and Computer Engineering, University of Maryland, College Park, MD 20742, USA
[4]Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan

Corresponding author Kenneth R. Foster (kfoster@seas.upenn.edu)

The work of Kenneth R. Foster, Marvin C. Ziskin, and Quirino Balzano was supported in part by the Mobile & Wireless Forum.

ENVIRONMENTAL HEALTH TRUST

The work of Kenneth R. Foster, Marvin C. Ziskin, and Quirino Balzano was supported in part by the Mobile & Wireless Forum.

the s... and intense pulse... extended to lower frequencies as well. The study employs a simple one-dimensional baseline thermal model for skin and Pennes' bioheat equation (BHTE), together with a baseline model for thermal damage to skin based on a standard model. The predicted temperature increases produced by 3-sec pulses at 94 GHz are consistent with previous experimental results with no adjustable parameters in the model. The few reported data on thermal damage to the skin from pulsed 94 GHz energy are insufficient to enable a conventional analysis of damage thresholds and the data may be affected by errors in dosimetry. The baseline model suggests that the implicit limits on pulse fluence in the present FCC guidelines might allow, in extreme (but in practice unrealistic) cases, transient increases in skin temperature that approach thresholds for thermal pain but which remain well below levels anticipated to cause thermal damage. Limits on pulse fluence in the current IEEE and ICNIRP

Tissue Models for RF Exposure Evaluation at Frequencies above 6 GHz

Marvin C. Ziskin,[1]* Stanislav I. Alekseev,[2] Kenneth R. Foster,[3] and Quirino Balzano[4]

[1]Department of Radiology, Temple University School of Medicine, Philadelphia, Pennsylvania
[2]Institute of Cell Biophysics, Russian Academy of Sciences, Pushchino, Russia
[3]Department of Bioengineering, University of Pennsylvania, Philadelphia, Pennsylvania
[4]Department of Electrical Engineering, University of Maryland, College Park, Maryland

Exposures to radiofrequency (RF) energy above 6 GHz are characterized by shallow energy penetration, typically limited to the skin, but the subsequent increase in skin temperature is largely determined by heat transport in subcutaneous layers. A detailed analysis of the energy reflection, absorption, and power density distribution requires a knowledge of the properties of the skin layers and their variations. We consider an anatomically detailed model consisting of 3 or 4 layers (stratum corneum, viable epidermis plus dermis, subcutaneous fat, and muscle). The distribution of absorbed power in the different tissue layers is estimated based on electrical properties of the tissue layers inferred from measurements of reflected millimeter wavelength energy from skin, and literature data for the electrical properties of fat and muscle. In addition, the thermal response of the model is obtained using Pennes bioheat equation as well as a modified version incorporating blood flow rate-dependent thermal conductivity that provides a good fit to experimentally-found temperature elevations. A greatly simplified 3-layer model (Dermis, Fat, and Muscle) that assumes surface heating in only the skin layer clarifies the contribution of different tissue layers to the increase in surface skin temperature. The model shows that the increase in surface temperature is, under many circumstances, determined by the thermal resistance of subcutaneous tissues even though the RF energy may be deposited almost entirely in the skin layer. The limits of validity of the models and their relevance to setting safety standards are briefly discussed. Bioelectromagnetics. 39:173–189, 2018.

Keywords: skin; radiofrequency; permittivity; reflectivity; temperature elevation

INTRODUCTION

Humans are increasingly exposed to radiofrequency (RF) electromag... from many different sou... [Bains, 1993], automotive... airport scanners [Scheen... wave therapy [..ojavin... developed 5G mobile c... significantly add to this... exposure to RF energy are ... by major international health and safety organizations such as

[IEEE C95.1-2006, 2005]. To achieve and maintain these goals, the limits are constantly being reviewed to determine if any need to be updated.

Grant sponsor: Mobile and Wireless Forum (MWF).

Conflicts of interest: None.

*Correspondence to: Marvin C. Ziskin, Department of Radiology, ... University School of Medicine, 3420 N. Broad Street

MODELING TISSUE HEATING FROM EXPOSURE TO RADIOFREQUENCY ENERGY AND RELEVANCE OF TISSUE HEATING TO EXPOSURE LIMITS: HEATING FACTOR

Kenneth R. Foster,[1] Marvin C. Ziskin,[2] Quirino Balzano,[3] and Giorgi Bit-Babik[4]

Abstract—This review/commentary addresses recent thermal and electromagnetic modeling studies that use image-based anthropomorphic human models to establish the local absorption of radiofrequency energy and the resulting increase in temperature in the body. The frequency range of present interest is from 100 MHz through the transition frequency (where the basic restrictions i... exposure guidelines change from specific ab...ption rate to incident power density, which occurs ... 10 GHz depending on the ... in thickness of tissue layers, the effects of normal physiological variation in tissue blood flow have been relatively unexplored.
Health Phys. 115(2):295–307; 2018

Key words: exposure; radiofrequency; radiation; nonionizing; radiofrequency; safety standards

INTRODUCTION

Q.B., K.R.F, and M.Z. were supported in this project by Mobile and Wireless Forum, which did not review and had no control over preparation of this manuscript. The authors thank A. Hirata, Nagoya Institute of Technology, Japan, for providing results used to prepare Fig. 3, and Dr. Vitas Anderson

and Dr. C-K Chou for helpful discussion of earlier drafts of this paper. The views and opinions expressed herein are solely those of the authors and are not to be attributed to Motorola Solutions or any of its operating companies.

Health Physics July 2017, Volume 113, Number 1

THERMAL MODELING FOR THE NEXT GENERATION OF RADIOFREQUENCY EXPOSURE LIMITS: COMMENTARY

Kenneth R. Foster,* Marvin C. Ziskin,† and Quirino Balzano‡

Abstract—**This commentary evaluates two sets of guidelines for human exposure to radiofrequency (RF) energy, focusing on the frequency range above the "transition" frequency at 3–10 GHz where the guidelines change their basic restrictions from specific absorption rate to incident power density, through the end of the RF band at 300 GHz. The analysis is based on a simple thermal model based on Pennes' bioheat equation (BHTE) (Pennes 1948) assuming purely surface heating; an Appendix provides more details about the model and its range of applicability. This analysis suggests that present limits are highly conservative relative to their stated goals of limiting temperature increase in tissue. As applied to transmitting devices used against the body, they are much more conservative than product safety standards for touch temperature for personal electronics equipment that are used in contact with the body. Provisions in the current guidelines for "averaging time" and "averaging area" are not consistent with scaling characteristics of the bioheat equation and should be refined. The authors suggest the need for additional limits on fluence for protection against brief, high intensity pulses at millimeter wave frequencies. This commentary considers only thermal hazards, which form the basis of the current guidelines, and excludes considerations of reported "non-thermal" effects of exposure that would have to be evaluated in the process of updating the guidelines.**

Health Phys. 113(1):41–53; 2017

Key words: exposure, radiofrequency radiation, nonionizing

of Electrical and Electronics Engineers (IEEE) (IEEE 2005). Most national limits [in the U.S., the limits of the Federal Communications Commission (FCC 2010)] are generally similar to IEEE and ICNIRP limits. All three sets of limits are in the process of revision and updating.

The frequency range above 3–10 GHz through the top of the RF band (300 GHz) has heretofore received relatively little attention by the committees that develop the guidelines, despite a large number of (generally low-powered) devices that already operate in this wide band (Fig. 1). Largely, this is because most devices operating in this frequency range have little potential for high-level exposure to humans, and partly because few consumer devices operate at present in this frequency range and there has been little controversy about the safety of such devices. However, this broad frequency band is about to gain much wider use with the introduction of a new generation (5 G) of wireless communications (Andrews et al. 2014) and the development of high-powered millimeter wave devices (30–300 GHz) for industrial and military applications.

The authors consider the current IEEE and ICNIRP

Acknowledgments—This work was sponsored by Mobile Manufacturers Forum, which had no control over the contents of this paper. The authors thank Dr. C-K Chou for helpful suggestions on this work.

IEEE Access

Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

Received August 31, 2018, accepted November 13, 2018, date of publication November 23, 2018, date of current version December 27, 2018.

Digital Object Identifier 10.1109/ACCESS.2018.2883175

ENVIRONMENTAL HEALTH TRUST

Thermal Analysis of Averaging Times in Radio-Frequency Exposure Limits Above 1 GHz

KENNETH R. FOSTER[1], (Life Fellow, IEEE), MARVIN C. ZISKIN[2], (Life Fellow, IEEE), QUIRINO BALZANO[3], (Life Fellow, IEEE), AND AKIMASA HIRATA[4], (Fellow IEEE)

[1]Department of Bioengineering, University of Pennsylvania, Philadelphia, PA 19104 USA
[2]Temple University School of Medicine, Philadelphia, PA 19140 USA
[3]Department of Electrical and Computer Engineering, University of Maryland at College Park, College Park, MD 20742 USA
[4]Department of Electrical and Mechanical Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan

Corresponding author Kenneth R. Foster (kfoster@seas.upenn.edu)

The work of K. R. Foster, M. C. Ziskin, and Q. Balzano was supported in part by Mobile and Wireless Forum.

ABSTRACT This paper considers the problem of choosing an appropriate "averaging time" in radiofrequency (RF) exposure limit... RF frequency range above 3–10 ...

The work of K. R. Foster, M. C. Ziskin, and Q. Balzano was supported in part by Mobile and Wireless Forum.

a layered ... ying

Radiation Protection Dosimetry (2019), Vol. 183, No. 4, pp. 489–496
Advance Access publication 10 May 2018
doi:10.1093/rpd/ncy177

EXPOSURE ASSESSMENT OF PORTABLE WIRELESS DEVICES ABOVE 6 GHZ

Eduardo Carrasco[1], Davide Colombi[2], Kenneth R. Foster[3], Marvin Ziskin[4] and Quirino Balzano[5,*]
[1]Universidad Politécnica de Madrid, 28040 Madrid, Spain
[2]Ericsson AB, Torshamnsgatan 21, 164 83 Stockholm, Sweden
[3]Department of Bioengineering, University of Pennsylvania, Philadelphia
[4]Department of Radiology, Temple University School of M
[5]Department of Electrical and Computer Engineerin
USA

*Corresponding author: qbfree01@aol.com

ENVIRONMENTAL HEALTH TRUST

FUNDING

This work was sponsored by Mobile & Wireless Forum.

Received 22 July 2018; revised 7 September 2018; editorial deci
accepted 12 September 2018

The emerging 5 G wireless devices working at frequencies above 6 GHz are expected to have antenna arrays formed by dipoles, slots, patches or their combination. At lower frequencies, the accepted criteria for exposure compliance is stated in terms of specific absorption rate. IEEE and ICNIRP are adopting epithelial or transmitted power density (PD through body surface) as the dosimetric reference for frequencies above 6 GHz, which entails the measurement of free space PD. Theoretical and numerical results presented in this article show that it is possible to perform meaningful free space PD assessments at half wave ($\lambda/2$) distance from arrays and, with the proper instrumentation, as close as $\lambda/(2\pi)$. However, if a dissipative body is placed very close ($<\lambda/2\pi$) to the arrays, its reflection and absorption of RF energy can change the electric currents and charges over the antenna. The relevance of such an effect should be further investigated, for instance by means of experimental analysis including measurements of tissue heating when in the presence of a strong reactive near field.

INTRODUCTION

With the launch of 5 G technology and its integration in mobile devices, new exposure dosimetric requirements will appear. This article is motivated by the ongoing revisions of IEEE standard and ICNIRP guidelines that will replace SAR with other measures of absorbed power above 6 GHz for devices placed in close proximity to the human body.

6 GHz. For such frequencies, energy is absorbed in a very thin layer (e.g. ~4 mm at 10 GHz), and the evaluation of transmit PD by means of measurements is not feasible. For practical difficulties in assessing epithelial or transmitted PD in the superficial tissue, exposure standards provide limits on reference levels also in terms of incident PD in free-space. For the foreseeable future, it is expected that

Link to paper

Thermal response of tissue to RF exposure from canonical dipoles at frequencies for future mobile communication systems

K. Foster and D. Colombi✉

The level of protection against thermal hazard of the current RF EM field (EMF) exposure limits is estimated at the transition frequency where the basic restrictions change from specific absorption rate to power density. It is shown that the calculated steady-state temperature increase in the skin generated by a nearby dipole transmitting at maximum power to meet compliance with the EMF limits presents a significant discontinuity at this frequency. The results suggest that for exposure to limited areas of the body at frequencies where basic restrictions are provided in terms of power density, the currently existing exposure guidelines need to be revised. These findings might have large implications on the development of future radio access technologies operating at the millimetre wave.

Acknowledgment: This work was supported in part by the Mobile Manufacturers Forum.

IEEE Access
The journal for rapid open access publishing

Are Children More Exposed to Radio Frequency Energy From Mobile Phones Than Adults?

KENNETH R. FOSTER[1], (Life Fellow, IEEE), AND CHUNG-KWANG CHOU[2], (Life Fellow, IEEE)
[1]Department of Bioengineering, University of Pennsylvania, Philadelphia, PA 19104, USA
[2]C-K. Chou Consulting, Fort Lauderdale, FL 33322, USA
Corresponding author: K. R. Foster (kfoster@seas.upenn.edu)

ABSTRACT There has been long-standing controversy, both among scientists and in the public, about whether children absorb more radio frequency (RF) energy in their heads than adults when using a mobile telephone. This review summarizes the current understanding of this issue, and some of the complexities in comparing the absorption of RF energy in different individuals from use of mobile phones. The discussion is limited to dosimetric issues, i.e., possible age-related differences in absorption of RF energy in the heads of mobile phone users. For most metrics of exposure, in particular those relevant to assessing the compliance of handsets with regulatory limits, there is no clear evidence for age-related differences in exposure. For two metrics of exposure, there is a clear evidence that age can play a factor: 1) the local specific absorption rate (SAR), in particular anatomically defined locations within the brain, will vary with head size and hence with age and 2) the SAR, in particular tissues
age-related differences in the dielectric properties
that are below the 1-g or 10-g peak spatial SAR
significance for compliance assessment. Age-relat
presently considered are difficult to generalize to
due to many variables that determine SAR during

ACKNOWLEDGMENT

Publication costs of this paper were supported by Mobile Manufacturers Forum, who did not review the contents of this paper before publication. The same organization supported travel costs of one of the authors (Foster) to the BioEM 2013 meeting (Thessaloniki Greece, June 2013) to co-chair a Workshop session together with the second author on the subject of this paper. C-K. Chou was the Chief EME Scientist of Motorola Solutions at the time of the Workshop, and is presently retired.

RADIOFREQUENCY ENERGY EXPOSURE FROM THE TRILLIANT SMART METER

Kenneth R. Foster* and Richard A. Tell†

Abstract—**This paper reviews radiofrequency (RF) field levels produced by electric utility meters equipped with RF transceivers (so-called Smart Meters), focusing on meters from one manufacturer (Trilliant, Redwood City, CA, USA, and Granby, QC, Canada). The RF transmission levels are summarized based on publicly available data submitted to the U.S. Federal Communications Commission supplemented by limited independent measurements. As with other Smart Meters, this meter incorporates a low powered radiofrequency transceiver used for a neighborhood mesh network, in the present case using ZigBee-compliant physical and medium access layers, operating in the 2.45 GHz unlicensed band but with a proprietary network architecture. Simple calculations based on a free space propagation model indicate that peak RF field intensities are in the range of 10 mW m^{-2} or less at a distance of more than 1–2 m from the meters. However, the duty cycle of transmission from the meters is very low (< 1%). Limited measurements identified pulses from the meter that were consistent with data reported by the vendor to the U.S. Federal Communications Commission. Limited measurements conducted in two houses with the meters were unable to clearly distinguish emissions from the meters from the considerable electromagnetic clutter in the same frequency range from other sources, including Wi-Fi routers and, when it was activated, a microwave oven. These preliminary measurements disclosed the difficulties that would be encountered in characterizing the RF exposures from these meters in homes in the face of background signals from other household devices in the same frequency range. An appendix provides an introduction to Smart Meter technology. The RF transmitters in wireless-equipped Smart Meters operate at similar power levels and in similar frequency ranges as many other digital communications devices in common use, and their exposure levels are very far below U.S. and international exposure limits.**

Health Phys. 105(2):177–186; 2013

INTRODUCTION

Throughout the world, electric utilities are installing advanced utility meters, called Smart Meters, on customers' houses that enable frequent (hourly or more) reading of meters, prompted in part by government incentives to move to time-of use pricing to promote a more efficient use of the power grid. While the design of Smart Meter systems varies with the vendor, most systems incorporate low-powered radiofrequency (RF) transceivers that link neighboring meters into a network (called a neighborhood area network or NAN) to enable reliable communication with the utility. In addition, the meters may include separate transceivers to support a second network (a Home Area Network or HAN) that links the meter with household appliances. In part because of citizens' concerns about RF exposure, Smart Meters have become controversial in many areas, and there is considerable discussion (often inaccurate) on the Internet about levels of exposure to RF energy that they produce.

So far, only one study has appeared in the scientific literature on RF exposure from Smart Meters, based on measurements of meters from one vendor (Itron, West Union SC) that had been modified to transmit at 100% duty cycle (Tell et al. 2012). This present study considers exposure characteristics of a different meter (by Trilliant, 1100 Island Dr., #201, Redwood City, CA USA and Granby, QC, Canada), using numerical calculations based on design data and limited measurements from meters in homes

Acknowledgments: This work was supported by the Electric Power Research Institute (EPRI) with technical support from Hydro One and Hydro One Brampton.

MWF's Position

- MWF's response to the NPRM urges:
  - MWF advocates specifically that the power density averaging time allowed under the FCC's time-averaging regulations be aligned with the ICNIRP and IEEE standards -- and that its proposed approach (as reflected in Table 5 of the NPRM) be withdrawn.
- MWF's approach is supported by the latest research by Dr. Foster:
  - Dr. Foster notes that the extreme cases being guarded against by the FCC do not occur in telecom signals. We therefore propose that extreme cases be carved out and telecom signals aligned with the IEEE and ICNIRP standards.
  - Dr. Foster advises that if the goal is to protect against excessive thermal transients from extreme high-fluence mm-wave pulses, however unrealistic such exposures may be, **a scientifically accurate approach would be to limit pulse fluence directly**, as an add-on to existing limits and averaging times. This is the approach taken in the latest revisions of IEEE C95.1 (2019) and ICNIRP (2020). A separate NPRM on this approach for extreme cases would be appropriate.

MWF
Mobile & Wireless Forum

Dr. Foster's Big-Bang Pulse Analysis [12]

"Big Bang Pulse": We consider the response to a single pulse of duration $\Delta\tau$ and fluence ($I_o \tau_{avg}$), which is the maximum fluence pulse permitted under the limit I_o subject to averaging time τ_{avg} (here assumed to be 6 min). This is the most extreme exposure scenario that would be permitted under the constraints of the limits on time-averaged power density and averaging time.

The thermal transients produced by the "big bang" pulses (Fig. 3) at mm-wave frequencies are as much as 20 times higher than the temperature increases from CW exposure in the steady state. Such "big bang" exposures represent extreme cases that would hardy ever or never be encountered in the real world but are considered as a limiting case. One exception is a military nonlethal weapons system [6].

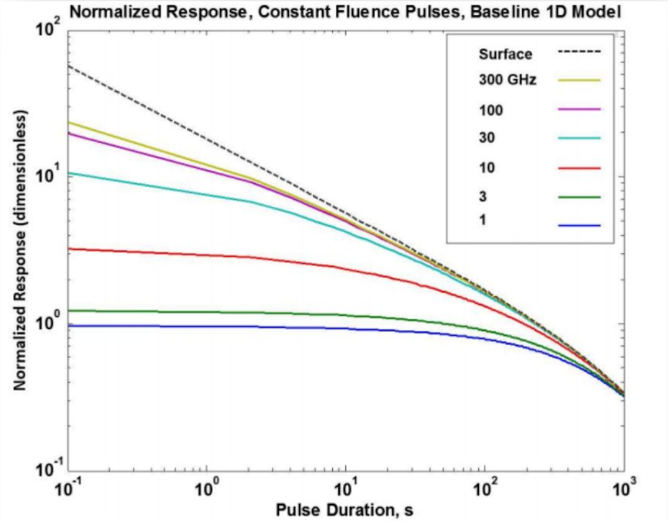

FIGURE 3. Peak transient increase in surface temperature in 1D baseline model produced by a single "big bang" pulse of constant fluence ($I_o\tau_{avg}$) vs. pulse duration. Results are normalized by the steady-state temperature increase for CW exposures at power density I_o Averaging time τ_{avg} is 6 min.

Back

Mobile & Wireless