Before the
Federal Communications Commission
Washington, DC 20555

In the Matter of	)	
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)	ET Docket No. 03-137 (Terminated)
	)	
Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies	)	ET Docket No. 13-84 (Terminated)
	)	
Targeted Changes to the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)	ET Docket No. 19-226

To: Federal Communications Commission, Washington, DC 20554

Date: 2 June 2020

Comments on FCC 19-226 (Docket/RM 19-226)
Human Exposure to Radiofrequency Electromagnetic Fields—A Proposed Rule by the FCC

Comments by Timothy Schoechle, PhD
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QUALIFICATIONS TO COMMENT

Summary

I am an international expert in computer and communications engineering, technology, and policy. Since 1974, I have been engaged in hardware and software development and have founded successful ventures producing products employing microprocessors and both wired and wireless communication networks and protocols. Since 1984, I have been active in developing national and international standards for computers and networks, including developing technical standards, analyses, and policies on behalf of the United States, international standards bodies

(i.e., ISO/IEC)[1], and universities, in regard to network interoperability, cyber-security, privacy, and safety.

I have served on teaching faculties (including a decade on the faculty of the Interdisciplinary Telecommunications Program of the College of Engineering and Applied Science, University of Colorado, Boulder, 1995–2004) at three universities (University of Colorado, Boulder; Regis University, Denver; and Colorado State University–Global) and have undertaken teaching and policy projects for the U.S. Department of Commerce National Institute of Standards and Technology (NIST), the National Academies of Science, American National Standards Institute (ANSI), Telecommunications Industry Association (TIA), various trade and commercial organizations, and the Institute of Electrical and Electronic Engineers (IEEE). I am a Life Member of the IEEE and hold MS and PhD degrees in telecommunications engineering and in communication policy from the University of Colorado, Boulder.

Specific relevant activities

I am founder of several companies involved in the development of both wired and wireless communication systems, technologies, and networks. One of my companies, BI Incorporated was the inventor of passive radio frequency identification (RFID) that included one of the first (c. 1980) commercial[2] implementations of wireless power transfer (WPT) technology (one of the topics of this proposed rulemaking).

I have served (during the 1980s and 90s) as U.S. expert to the International Electrotechnical Commission (IEC) Technical Committee 77, Subcommittee 77B on Electromagnetic Compatibility (EMC) on behalf of the Electronic Industries Association (EIA).

I presently serve (since 1990) as the Secretary of ISO/IEC Subcommittee 25 (SC25), Working Group 1 (WG1) on *Home Electronic System*. I am also a U.S. Expert to WG1, as well as project manager for several technical standards projects involving both wired and wireless networking, signaling, and protocols, including privacy, cybersecurity, and safety[3].

I have been a participant since 2013 in several standards-setting committees related to electric vehicle charging sponsored by the Society of Automotive Engineers (SAE). Among these are J2847 *Wireless charging*.

GENERAL RESUME OF DR. TIMOTHY SCHOECHLE

Timothy Schoechle, Ph.D., CEO Smarthome Laboratories

Dr. Schoechle is an international consultant in computer and communications engineering and in technical standards development. He presently serves as Secretary of ISO/IEC SC25 Working Group 1, the international standards committee for *Home Electronic System* and is a technical co-editor of several new international standards related to the smart grid, including a new project on gateway cyber-security, privacy, and requirements for consumer electronics and Internet-of-Things (IoT) applications. He also

[1] The ISO–International Organization for Standardization and the IEC–International Electrotechnical Commission are NGOs based in Geneva, Switzerland.

[2] United States patent 4,475,841 (filed 1982/granted 1984)

[3] I serve as project manager/editor for ISO/IEC 15045-3-1 *Home Electronic System–gateway–Introduction to privacy, security, and safety*, and for ISO/IEC 15045-3-4 *Home Electronic System–gateway–safety framework.*

served as Secretariat of ISO/IEC SC32 *Data Management and Interchange,* 2006–2015, and he currently participates in a range of national and international standards bodies related to *smart grid* and to *smart cities* technology and policy issues.

As an entrepreneur, Dr. Schoechle has engineered the development of electric utility gateways and energy management systems for over 25 years and has played a major role in the development of international standards for home and building networks and for advanced metering infrastructure (AMI). He is currently an active participant of the *GridWise Architecture Council* (GWAC) hosted by the Pacific Northwest National Laboratories (PNNL), U.S. Department of Energy. He is also an active participant or liaison in several smart grid-related technical committees hosted by the ISO and the IEC (including IEC SyC Smart Cities, and IEC TC-57/WG21 (*Power System Control and Associated Communication/Interfaces and protocol profiles relevant to systems connected to the electrical grid*). He participates in the Smart Electric Power Alliance (SEPA) (formerly the *Smart Grid Interoperability Panel* (SGIP)) working groups on *Home-to-grid* (H2G) and *Cybersecurity* (CSWG) working groups, sponsored by NIST/U.S. Department of Commerce. He contributed text on electric vehicles to the NIST Internal Report *NISTIR 7628 Report: Guidelines for Smart Grid Cyber Security* that was revised and published in 2014.

He also participates in several technical working groups sponsored by the Society of Automotive Engineers (SAE) developing standards for vehicle-to-grid communications and electric vehicle charging. During 2012, Dr. Schoechle lead a smart grid SBIR phase II engineering project funded by the U.S. Department of Energy titled, *Developing an Agent-Based Distributed Smart Controller for Plug-in Electric Vehicles and Distributed Energy Resources*. He authored technical papers presented at six consecutive GWAC/Department of Energy-sponsored *Grid-Interop* technical conferences from 2007 through 2012.

Dr. Schoechle is the author of the 2013 published report, *Getting Smarter about the Smart Grid* published by the National Institute of Science, Law and Public Policy (NISLAPP) and was the featured speaker on smart grid policy and renewable energy by the *Commonwealth Club of San Francisco*, January 2014. More recently, he is also the author of the 2018 published 140-page report on municipal fiber, *Re-Inventing Wires: The Future of Landlines and Networks* which was sponsored by NISLAPP and initially introduced at the *Commonwealth Club of San Francisco* in February 2018. He is the Principle Investigator of the *Solar-plus-storage Demonstration Project* funded by the City of Boulder, in Boulder, Colorado.

Dr. Schoechle is a former faculty member of the University of Colorado College of Engineering and Applied Science. He is considered an expert on the international standards system, the topic of his 2009 book, *Standardization and Digital Enclosure*. He continues to lecture occasionally on telecommunications and electricity grid-related topics. Dr. Schoechle also serves as a faculty member of Colorado State University (CSU – Global) and developed two online courses during 2013-2014: *ITS460 – Information Security and Ethical Issues* (undergraduate level) and *ISM529 – Emerging Cyber Security Technology, Threats, and Defense* (graduate level).

Dr. Schoechle was a co-founder of BI Incorporated, presently a $1 billion company in Boulder, Colorado, a pioneer developer of RFID technology. He holds an M.S. in telecommunications engineering (1995) and a Ph.D. in communication policy (2004) from the University of Colorado, Boulder.

A full curriculum vita of Dr. Schoechle is attached to these comments.

INTRODUCTION

It is my understanding that the FCC does not maintain in-house expertise or competence in bio-medical or health sciences and is reliant on external agencies or other parties for expertise in the

conduct or evaluation of scientific and technical research needed for providing it timely guidance in setting appropriate radio frequency radiation (RFR) emission limits. It is also my understanding that a purpose of this rulemaking is an inquiry for gathering such research and expertise. Therefore, it is my intent to assist and inform the Commission as best I can in its search for the most current and relevant research on this topic.

The Commission has framed its inquiry with the 5 basic questions stated below[4]. I will reply to these questions through a series of Comments, each addressing one or more of the Questions below. These Comments will reference research cited in the bibliography below. My Comments are roughly in the order of the Questions, except for the first Comment, which is the most fundamental to the entire inquiry.

QUESTIONS

It is my understanding that the Commission is seeking comments on the following topics:

- **Q1** on expanding the range of frequencies for which its radiofrequency (RF) exposure limits apply;
- **Q2** on applying localized exposure limits above 6 GHz in parallel to the localized exposure limits already established below 6 GHz;
- **Q3** on specifying the conditions and methods for averaging the RF exposure, in both time and area, during evaluation for compliance with the RF exposure limits in the rules;
- **Q4** on addressing new RF exposure issues raised by wireless power transfer (WPT) devices; and
- **Q5** on the definition of a WPT device.

ANSWER/COMMENTS

Comment 1—*Exposure limits and Weak field (non-thermal) effects*

The Commission's present limits for non-ionizing RFR are based on thermal (i.e., heating) effects that relate to emission power density and are expressed in measures such as specific absorption rate (SAR) and maximum permissible exposure (MPE). The underlying assumption is that the risk to human beings posed by non-ionizing electromagnetic radiation is the heating of tissue analogous to what occurs in a microwave oven. This assumption is fundamental to this entire rulemaking and inquiry, but is now in question.

> However, over the last 20 years the evidence has become extremely strong that weaker EMF over the whole range for frequencies from static through millimeter waves can modify biological processes (Barnes and Greenebaum, 2020, p. 1).

Biological processes include health effects. Research on weak fields indicates that heating and power levels may be less important than other factors (e.g., exposure duration, signal

[4] These five questions were taken directly from the summary as stated in the *Federal Register* / Vol. 85, No. 73/ Wednesday, April 15, 2020, page 20967.

modulation, time delay between pulses, oxidative stress, etc.), relative to biological and/or health effects of RFR (Barnes & Greenebaum, 2020; Barnes & Greenebaum, 2018; Barnes & Kandala, 2018; Barnes & Greenebaum, 2016; Barnes & Greenebaum, 2014; Li & Héroux, 2019; Li & Héroux, 2014; Novikov, et al (2009); Novikov, et al (2010). Hundreds of other scientific studies and papers have accumulated that demonstrate weak field biological effects, and they increasingly challenge the dominant tissue-heating paradigm—to the point that *it can no longer be maintained*.

It is becoming increasingly clear that SAR/MPE measures, limits, or the like, must be augmented with other measures, guidelines, or policies in order to adequately protect the public health and safety. SAR is still needed, not just power density, as well as such other factors as exposure time, duration, modulation, time delay pulsation, repetition, etc., need to be allowed for, and added for accuracy to assume that this, and previous safety limits and corresponding rulemakings, actually improve safety.

Comment 2—*Extension of rules to above 6 GHz range*

The assumption that the exposure limits that have been applied below 6 GHz could also apply to higher frequency ranges is without scientific basis or experimental evidence. The same issues described above in Comment 1 apply above 6 GHz—i.e., *biological effects of (non-thermal) weak fields are not adequately dealt with in the existing exposure guidelines based only on thermal effects of RFR*.

> There is now solid experimental evidence and supporting theory showing that weak fields, especially but not exclusively at low frequencies, can modify reactive free radical concentrations and that changes in radical concentration and that of other signaling molecules, such as hydrogen peroxide and calcium, can modify biological processes [Batchelor et al., 1993; Bingham, 1996; Timmel et al., 1998; Woodward et al., 2001; De Iuliis et al., 2009; Castello et al., 2014; Li and Heroux, 2014; Usselman et al., 2014; Barnes and Greenebaum, 2015]. Static and low‐frequency magnetic fields have shown both acceleration and inhibition of cancer cell growth rates in the culture [Bingham, 1996; De Iuliis et al., 2009; Castello et al., 2014; Li and Heroux, 2014; Gurhan et al., 2020]. Both the acceleration and inhibition of growth rates of planarian [Van Huizen et al., 2019] have been demonstrated with static magnetic fields in the range from 0.5 to 600 μT (Barnes and Greenebaum, 2020, p. 1-2).

The introduction of 5G cellular technology anticipates frequency use above 6 GHz up to 100 GHz or higher. While data exist on current levels of exposure from 3G and 4G frequencies, very limited data on 5G millimeter wave frequencies is available.

> …we currently have only very limited good data on 5G. One important research need is to measure these exposure levels under various actual conditions. It is currently not clear that, with focused beams and higher data rates leading to shorter-on times, whether the personal exposures will increase or decrease with the increased number of lower-power base stations ((Barnes and Greenebaum, 2020, p. 3).

Also, use patterns have changed dramatically with the proliferation of smartphones and other mobile devices. The widespread deployment of small cell base stations, antenna densification, reduction in radiated power, and increased usage over time have generally increased overall exposure to weak field (non-thermal) RFR.

> The spreading use of RF technology and the application of it to new uses and higher frequencies have fed suspicion that the health of the public is at risk from extended, low-level exposure. Fear is heightened since some diseases, including autoimmune diseases, are on the rise
>
> …At present, the current standards are saying that there is no evidence that fields are harmful, and the attention of the regulators, funding agencies, and others is directed elsewhere. But there is also a growing collection of scientific results from laboratories in the United States, Europe, Japan, China, and elsewhere that says that EMF do have effects, as well as a small but vocal group of people inside and outside of science who are positively convinced that we are harming ourselves with the growing use of RF technology (Barnes and Greenebaum, 2020, p. 3).

The extension of rules to the above 6 GHz range cannot be justified without a scientific basis backed by experimental evidence and safety testing.

Comment 3—*Assumptions about localized exposure limits*

Here again, the assumptions about localized exposure limits implicit in the current limits below 6 GHz (i.e., that heating is the only or primary risk of RFR) and its proposed extension above 6 GHz is without scientific basis or experimental evidence, and lacks validity. The same issues described in Comment 1 apply above 6 GHz—i.e., biological effects of (non-thermal) weak fields are not adequately dealt with in the existing rules based only on thermal effects of RFR.

For example, the removal of minimum evaluation distance (FCC, 2019, paragraph 73, page 36) seems particularly arbitrary and without scientific basis or experimental justification.

Comment 4—*Assumptions about exposure averaging*

What may make sense with conventional SAR/MPE thermal exposure limits may not apply at all to weak field (non-thermal) effects resulting from entirely different biological mechanisms. Average or cumulative exposure energy may have little or no meaning, while other factors such as signal frequency, duration, repetition, modulation, time delay, or feedback can be important. Complex multiple feedback mechanisms operate in cellular biological systems.

> These multiple feedback loops lead to a wide variety of responses including oscillations, bi-stability, and system stabilization. The multiple feedback loops often make it hard to separate cause and effect. For example, when we exercise, the metabolic rate is increased, which in turn increases the generation of reactive oxygen species (ROS), such as O2 and H2O2. The increased concentration of these molecules signals the generation of antioxidants that in normal circumstances return the concentration levels back to their normal resting values (Barnes and Kandala, 2018).

Thus, exposure level and duration can become more important than average energy absorption and periodic recovery from oxidative stress can be important to re-stabilization of cellular metabolism.

> Increased emphasis on long-term exposures may require refining the concept of dose to more flexibly combine exposure time and field intensity or energy absorbed (Barnes and Greenebaum, 2020, p 4).

Also, averaging masks peak power, modulation, and the role of intervals between doses.

Section B in FCC 19-126 beginning on page 61 deals with time averaging of exposure and proposes generally that the higher millimeter wave RFR would have lower penetration characteristics, with radiation effects and concerns occurring primarily at or near the skin surface. For example footnote 351 (page 61) focuses on warmth sensations in the skin, and

paragraph 136 (page 56) takes the approach of calculating limits based on time-averaging and limiting temperature rise, taking in to account skin dryness, frequency, etc., based on standards proposed by ICNIRP and IEEE. All of this, however is based on the same flawed assumption that thermal effects are all that matters, and weak field non-thermal effects play no significant role.

The thermal assumption in the skin case is also contradicted by research into the risks of carcinogenisis and skin aging in the case of optical radiation, including IR frequencies adjacent above the GHz range. Alaya, et al show that "Epidemiologic and clinical data suggest that IR radiation is involved in the process of premature skin aging and carcinogenesis. Indicationg that IR exposure is not entirely safe" (Alaya et al, 2013).

> Unlike ionizing radiations, the energy of non-ionizing ones is not sufficient to ionize atoms and molecules by modifying bonds. However they can break chemical bonds by means of photochemcal reactions (p. 2).

There is no reason to assume that the same might not apply to millimeter waves. According to Alaya et al, "…excessive cumulative solar exposure (total lifetime hours) is well proven as the main causal factor in the pathogenesis of melanoma."

In summary, averaging the RFR exposure may be of little or no value with regard to weak field (non-thermal) biological and/or health effects. This thermal rationale for RFR limits is without sound basis.

Comment 5—*Assumptions about SAR-based exemption and MPE-exemption*

The SAR-based exemption (paragraph 42, page 22) and MPE-based exemption (paragraph 48, page 25) suffer from the same basic flaw as was discussed in Comment 1 (i.e., that they assume that only thermal effects are important and *do not take into account weak-field non-thermal effects*). Both exemptions are inappropriate because they do not consider weak field (non-thermal) effects.

In regard to the SAR-based exemption, the footnotes in paragraph 42 that should appear at the bottom of page 23 are missing (i.e., footnotes 126–130 are missing). This may have to do with an editorial formatting error associated with the table 1 pasted in on page 23. The missing footnotes appear to relate to effective radiated power (ERP) and time averaging. *In any case, the exemption is inappropriate because it does not consider weak field effects*.

Comment 6—*Assumptions about "inconsistent" experimental results*

The recurring theme described in the 19-126 document regarding RFR health studies and expert opinions is "no harm found". In part this non-finding finding is attributed because the studies show inconsistent results, weak harms, or none. However, experimental research results that superficially appear to be anomalous, inconsistent, or non-replicable, may actually reflect the masking, obscuring, or confusing of the complexity of the cellular or metabolic processes involved, *while still indicating the presence of biological effects*. In other words, positive effects may be balancing out negative effects—resulting in net zero effects—but this does not mean zero effects—and there may actually be a lot of activity at the cellular level. Such activity may have health consequences. In addition, the apparent experimental variability/inconsistency may simply be a demonstration of the limitations of the thermal paradigm, and the lack of consideration of critical variables such as pulsation, modulation, frequency, time delay, etc,. which evidence has shown to be in play.

The NTP study

Such effects and their mechanisms need to be understood in order to predict behavior and conditions in order to establish meaningful and effective exposure limits in regard to weak fields. But, typically these results tend to be dismissed as inconsistent, weak or no harm, unreliable, or not replicable. For example, such is the tone of the ICNIRP evaluation of the NTP study cited by the 19-226 document (FCC, 2019, footnote 34, page 9).

> ICNIRP discussing both the NTP Animal Studies and the Ramazzini Study concluded that "these studies do not provide a reliable basis for revising the existing radiofrequency exposure guidelines" and noted various inconsistencies, limitations, and further need to review the application of animal studies to human carcinogenicity research that affect the usefulness of the studies in setting exposure guidelines.

However, the key point being missed here by ICNIRP is that *there are effects*, although not yet predictable. The important issue is that *there are effects that are not fully understood and that they could affect public health and safety*. We need to know why—could they be a "time bomb"? Until we understand what is actually happening, a big experiment is being conducted—with the public as the guinea pig. In regard to the NTP and Ramazzini studies,

> The results of these papers have not been considered convincing or relevant by the reviewing organization's panels due to methodological issues, because they did not relate closely enough to human health, and because the experimental results are mixed, showing increases, decreases, or no change in similar situations. However, taken as a group *they do provide strong evidence that weak EMF can be sensed by biological systems, as well as suggestive evidence that fields may affect human health* (Barnes and Greenebaum, 2020, p. 2). [emphasis added]

Another view of the NTP study

An evaluation of several recent animal studies (including the NTP study) of RFR oncogenicity was conducted by the IIT Research Institute[5]. The evaluation found a mixture of negative, but also of positive effects across the studies (McCormick, 2019). Most importantly, the evaluation showed biological activity. In other words, buried in "inconsistent" results was clear evidence that *weak field RFR is biologically active*, and under some yet-to-be-understood conditions can have carcinogenic and/or other health effects.

The IIT evaluation study is particularly troubling because of the size of the risk and the potentially long latency for the emergence of toxicities or other adverse effects. According to the GSM Association, over two thirds of the world's population has access to a mobile communications device with now 5 to 6 billion wireless devices in use, while also "…some cancers may not be generated for twenty years or more." (McCormick, 2019, p. 6). The IIT study goes on to observe that,

> …the need for adverse health outcomes to have occurred prior to hazard identification, thus delaying the possible identification of a true human hazard for years, if not decades. This is considered to be perhaps the most important limitation of RFR epidemiology. Given the potentially long latency of RFR-induced health effects, identification of such effects through epidemiology alone may require years (or decades) of exposure. Should epidemiology identify

[5] IITRI is an independent applied research laboratory that operates collaboratively with the Illinois Institute of Technology and the U.S. Government.

> significant adverse health effects of RFR exposure, billions of people will have already been exposed to RFR for extended periods and will therefore be at risk of those health effects. Given the truly massive population exposure to RFR from wireless devices, avoidance of a potentially major public health crisis mandates that risks be identified more quickly than can be accomplished through epidemiology alone (McCormick, 2019, p. 6).

Many researchers already consider weak field (non-thermal) cellular phone RFR to be *causal* for cancer or a class 1 human carcinogen (Carlberg and Hardell 2017; Miller, et al, 2018).

> In the interpretation of epidemiological studies on cancer there may be no explanation about how the strength of a link between a cause and an effect can vary from a "scientific suspicion of risk" to a "strong association" through "reasonably certainty" and to "causality" which requires the strongest evidence. This continuum in strengths of evidence, which was illustrated in Bradford Hill's paper, written at the height of the tobacco and lung cancer controversy, is not always explained. This means that the media and the public may assume that "not causal" means "no link," with mobile phone use and brain tumour risk as one example (Carlberg & Hardell, 2017, p. 1).

> The nine Bradford Hill viewpoints on association or causation regarding RF radiation and glioma risk seem to be fulfilled in this review. Based on that we conclude that glioma is caused by RF radiation. Revision of current guidelines for exposure to RF radiation is needed (Carlberg & Hardell, 2017, p. 14).

By setting exposure limits of any kind, and effectively legitimating the further proliferation of wireless devices and technologies—thus making universal public exposure to cell site radiation involuntary—and essentially mandatory—the FCC is undertaking a prodigious responsibility for potential future negative consequences.

Comment 7—*Problematic Reliance on "opinions" from industry-biased bodies like ICNIRP.*

Due to the high financial stakes, the market power of industry leaders and political influences can bear on regulatory processes. The FCC relies on and refers to IEEE and ICNIRP. The IEEE membership is highly invested in wireless technology development. ICNIRP is a self appointed group with deep ties to the industries dependent on wireless technology and does not disclose its funding sources. There is a need for an independent and objective scientific basis for public policy and it is not likely to come from these organizations.

The case of AGNIR

A detailed analysis of the technical bias and the dependency of the Advisory Group on Non-Ionizing Radiation (AGNIR), the U.K. agency responsible for providing official advice on the safety of RFR, it was found that "Independence is needed from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the group that set [in 1998] the exposure guidelines being assessed [now] " (Starkey, 2016, p. 493). The analysis revealed conflicts of interest and much cross-membership and a revolving door between AGNIR and ICNIRP. The analysis also revealed various methods found in reports and publications that obscure or distract from scientific evidence that should raise concerns. For example, in reference to a specific AGNIR/ICNIRP report, "Studies [were] omitted, included in other sections but without any conclusions, or conclusions left out" (p. 494-495).

> Only 7 studies were included in the section on reactive oxygen species [ROS; page 94 (2); Figure 1]. These were summarised by "production of reactive oxygen species (ROS) were increased in some studies, but not others" [page 106 (2)]. At least a further 30 studies relevant to ROS or the

> possible resulting damaging state of oxidative stress were included throughout the report, but with no reference to ROS or oxidative stress within the main text for 16 of these (listed in Supplementary Information, SI) and no mention of this subject in any other summaries or conclusions. At least a further 30 studies relevant to ROS or the possible resulting damaging state of oxidative stress were included throughout the report, but with no reference to ROS or oxidative stress within the main text for 16 of these (listed in Supplementary Information, SI) and no mention of this subject in any other summaries or conclusions. At least 40 studies were omitted (using AGNIR restriction to the English language; identified from PubMed and EMF-Portal databases or references within the papers; SI). If these had been included, 79% of studies (61 out of 77) would have demonstrated evidence of significantly increased ROS or oxidative stress in response toRF fields (Figure 1; SI). By only including a few of the available studies, not referring to many scattered throughout the report and not mentioning ROS or oxidative stress in any conclusions or the executive summary, this important area of research was misrepresented. Oxidative stress is a toxic state which can lead to cellular DNA, RNA, protein or lipid damage (7, 8), is accepted as a major cause of cancer (7), as well as being implicated in many reproductive, central nervous system, cardiovascular, immune and metabolic disorders (7–14).

The analysis further notes that "ICNIRP only accept thermal effects of RF fields and focus on average energy absorbed" (p. 495), and points out the shortcomings of this approach.

> Highly controlled, simulated signals with descriptions of overall specific absorption rates (SARs) are suited to the assessment of temperature rises in cells or tissues. Real signals make it more difficult to measure average energy, but have characteristics which controlled, simulated signals lack. The complex field patterns, with variable peak field strengths and intervals between transmissions, may influence biology in ways that controlled, simulated patterns cannot, but they are not represented by time-averaged, duty factor reductions of described energy absorption.

Finally the analysis, noting the recurring "inconsistency" argument used to dismiss evidence of biological activity, quotes directly from the AGNIR report (p. 496):

> "However, the effects reported are *varied* and, although the majority find effects, neither is this unanimous nor does it necessarily provide supporting evidence of a *consistent effect*. The variety of cellular systems and exposures makes *comparisons of the effects* on the cell membrane *problematic* and without independent replication it is *difficult to assess* the robustness or even the *validity* of the findings." [emphasis added]

Although the FCC describes "international standards like IEEE or INCIRP" as "less restrictive" than its own limits, the entire 19-126 document (FCC, 2019) repeatedly refers to and relies on ICNIRP and IEEE limits and methods as a guide in a number of ways.

Repudiation of ICNIRP's NTP analysis

The largest and most important animal study to date for cellphone RFR has been the 2018 NTP $28 million study funded by the U.S. government. A principal leader and designer of this study was Ronald Melnick, a senior scientist and toxicologist with a 28-year history at the National Institute of Environmental Sciences (NIEHS) and the National Toxicology Program (NTP) under the National Institutes of Health (NIH). In 2018, the NTP reported its findings, and the data revealed a "weak", but clear and positive link to cancer and certain other health problems. A similar study by the Ramazzini Institute in Italy produced similar results. The ICNIRP promptly issued a Note containing an evaluation of the NTP study (ICNIRP, 2018), claiming methodological shortcomings, inconsistencies, and limitations, and "ICNIRP concludes that these studies do not provide a reliable basis" for revising the existing decades-old ICNIRP RFR

exposure guidelines. Melnick repudiated the ICNIRP evaluation for containing "numerous false and misleading statements" (Melnick, 2019).

ICNIRP responded in a *Health Physics* "correspondence" with a new note defending their previous methodological complaints. Interestingly, the new ICNIRP Note included a telling acknowledgement (ICNIRP, 2020, p. 527).

> If the [NTP] claims were accurate, and if the research was shown to have relevance to humans, this would represent a crucial issue for ICNIRP to incorporate into the advice and guidance that it provides to the community through a range of formats, such as its RF EMF exposure guidelines.

With this remark, ICNIRP defends its position by relying on the suggestion that health effects in rodents might not have relevance to health effects in humans. Melnick subsequently challenges this reliance (see Melnick quote below, with emphasis). More significantly, however, animal and human cellular biology work so similarly at the molecular and cellular levels, the connection with cancer (or some other specific pathology) is less important than the fact that *there are clearly biological effects being demonstrated directly resulting from wireless cellphone weak field (non-thermal) RFR*. This observable fact bypasses the basic ICNIRP argument quarreling over purported NTP/Ramazzini methodological issues and animal-to-human relevance.

In a recent in *Health Physics* correspondence replying to the ICNIRP Note, Melnick re-asserted that

> ICNIRP's misrepresentation of the methodology and interpretation of the NTP studies on cell phone RF radiation does not support their conclusion that "limitations preclude drawing conclusions about carcinogenicity in relation to RF EMFs." …the dosimetry issue raised in the ICNIRP note falsely portrays the relevance and utility of the NTP cancer data for assessing human cancer risks. *After all, it was the US Food and Drug Administration that requested the NTP studies of cell phone radiation in experimental animals to provide the basis to assess the risk to human health.* The NTP studies show that the assumption that RF radiation is incapable of causing cancer or other adverse health effects other than by tissue heating is wrong (Melnick, 2020). [emphasis added]

Importance of the NTP and Ramazzini studies

The basic importance and value of the NTP and Ramazzini animal studies, as well as of some of the current cellular biology lab research, lies in the difference between long term and short term exposures, and that because of the adaptive characteristics of biology, simple changes can have big consequences. Results can switch from gain to loss by changing the frequency, modulation, or the time delay between pulses, as well as reactive oxygen. This kind of research can ultimately tell us how to understand exposures and risks.

If ICNIRP were to open the door to consideration of non-thermal weak field RFR effects, it could have far reaching consequences. It could make unavoidably obvious the need for more bio-medical research (such as proposed by Barnes and Greenebaum). But, such research could possibly destabilize the decades-old regulatory and wireless subsidization paradigm—just as the telecom carriers are fitfully attempting to gain a foothold with widespread small cell deployment by touting a new generation cellular wireless technology—the much-hyped 5G rollout. The consequences could be unacceptable to the industry.

And the case of the BioInitiative report—careful what you ask for

The FCC 19-126 document's authors complain in paragraph 12 (FCC, 2019, p. 7) that

> Commenters that provided scientific articles did not answer our request for a specific, quantitative goal but many provided descriptive references to the BioInitiative Report and Building Biology, which specify extremely low limits (0.3-0.6 nW/m2 and 0.1 μW/m2, respectively) for RF energy exposure—limits that are millions to billions times more restrictive than FCC limits. *No device could reliably transmit any usable level of energy by today's technological standards while meeting those limits*. [emphasis added]

It seems that the FCC's focus above is not on why the BioInitiative's proposed limits are lower than the FCC's, but rather on the business considerations involved in establishing the limit.

In any case, the FCC cannot and should not rely on ICNIRP for guidance on RFR emission limits, because of ICNIRP's clear bias, narrow and inaccurate view of the issue, and failure to consider all of the evidence.

Comment 8—*Risk of failing to establish adequate exposure limits*

As has been the case with asbestos, lead, tobacco, DDT, glyphosate herbicide, and other environmental pollutants, there is a need for an objective scientific basis for sound public policy. Experience shows that the consequences could be huge costs, lawsuits, disabilities, lost market opportunities, public backlash, and regulatory mandates.

> Both governmental and private entities that emit RF signals would be well advised to fund research to elucidate and define threshold signal levels for the generation of long-term biological effects. Given the way the current product liability law works, an able lawyer might well convince a jury that exposures within the current limits have caused cancer, cognitive disabilities in children, etc., which could cost billions of dollars (Barnes and Greenebaum, 2020, p. 4).

The lack of adequate exposure standards may put the entire industry at risk of a public backlash as health issues become more evident.

> Funding for research into the effects of EMF in the United States is close to nonexistent…We believe a carefully targeted program of federal research funds is called for, supplemented by communications system operators and corporations that manufacture equipment, under independent scientific management. Both governmental and private entities that emit RF signals would be well advised to fund research to elucidate and define threshold signal levels for the generation of long-term biological effects (Barnes and Greenebaum, 2020, p. 4).

The safest way to support this kind of research where the outcome entails both high financial stakes for industry and high potential health risks to the public, is through an entirely government funded and managed program, as was done with the NTP study. For example, such funding could be funded by some of the proceeds from the spectrum auctions.

Comment 9—*Wireless power transfer (WPT)*

Generally speaking, WPT can be defined as supplying power to devices by means of electromagnetic fields rather than through metal wires. This definition is insufficient to define industries and safety limits. For example, WPT can be either near-field or far-field (including directed beam), and either persistent or transient. WPT uses are highly application-specific and they present different exposure limit challenges. Setting limits on RFR from WPT is not a straightforward matter and will certainly require more study and input from a variety of industries and consumers. Limits will inevitably be highly application-specific.

As has been noted above, there is a considerable body of research showing that magnetic and electromagnetic fields, both static and of all frequencies, have biological effects. To evaluate

any related health risks, it is necessary to have biological or biomedical, as well as engineering expertise involved. This has not been adequately taken into account by regulators or industry standards.

WPT was the original dream of Nicola Tesla.[6] He apparently invented radio communication (c. 1894) on his way to attempt to invent WPT. He was not successful with WPT for some good reasons.[7] Although WPT has and is being used today for some small scale specialized applications,[8] it has some serious drawbacks, including inefficiency, cost, and unintended side effects. *Before any emission exposure limits can be set for WPT, the biological effects of weak field non-thermal biological effects must be better understood.*

Alternatives to wireless

Meanwhile, advances in wired technologies have provided attractive alternatives to wireless for both communication and on-premises power delivery (Schoechle, 2018). Among these are optical fiber and Ethernet. New versions of Ethernet are being standardized[9] and planned for market introduction in the near future for application in homes, buildings, and automobiles. For example, a twisted pair Ethernet has been developed for the auto industry (and homes) that includes DC power delivery (over the same pair) and enables "multidrop" taps allowing a true "bus" network topology. This arrangement would allow consumers to plug in their computers and fixed or portable devices to receive low voltage DC power and/or charging along with 10 megabit data over the same simple wire pair (such as a conventional phone pair).

Such standards could obviate much of the need for wireless charging and possibly for much on-premises wireless device use. Wired alternatives to wireless have advantages in cost, performance, safety, quality-of-service, durability, and many other benefits. Wireless should be primarily for things that move (Schoechle, 2018). Enabling DC power distribution in homes and buildings offers to also greatly improve the energy efficiency of these portable devices by avoiding the need for wall plug power supplies, and could greatly reduce or eliminate the chronic electrical and electromagnetic "noise" that such power supplies emit.

In summary, WPT is not recommended because it suffers from the same dearth of knowledge about weak field (non-thermal) effects as wireless communications, except that it is likely to be even worse because it requires even higher levels of RFR signal power to be effective. In any case, any application of WPT should require the shortest possible transient usage for considerations of health, safety, and energy waste. As for wireless car charging, or any other charging, it would be prudent to ask, "what is the need for wireless charging when we can simply charge with a wire more simply, safely, and efficiently?"

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[6] Wireless power transmission was the main purpose of Tesla's Wardenclyffe tower and laboratory on Long Island, (c. 1901) (now being restored as a memorial to Tesla), and of his earlier tower and laboratory near Colorado Springs (c. 1899).

[7] Among these reasons was that wires proved good enough for electric power delivery—and the same continues to be true today, except for some specialized applications (Schoechle, 2018, ch 5). Tesla was a visionary who was far ahead of his time—so far ahead that he essentially skipped over his own invention of radio communications.

[8] Examples include passive RFID devices, electric toothbrushes, battery charging of small portable devices, (possibly) EV charging, etc.

[9] Ethernet is standardized as the IEEE 802.3 series and internationally as the ISO/IEC 11801 series

Comment 10—*The FCC should devolve or delegate setting of RFR exposure limit standards to a competent party*

If the FCC does not maintain the medical or health sciences expertise needed to fully, fairly and objectively assess the current research, it should not maintain control, evaluate, or determine the appropriate exposure limits and compliance assessment processes. If this role is outside its expertise, the FCC should devolve this role to another agency with such competence, and/or to a properly constituted and accredited consensus technical standards body that can balance the interests of all, including industry, operators, and consumers.

The FCC has assumed a rather passive role—waiting for evidence or emission limits to "show up", meanwhile defaulting to essentially arbitrary limits adopted from elsewhere. The FCC does not do its own research or actively search the literature, but rather simply initiates an inquiry and sees what shows up. This is called "building a record" as indicated in paragraph 12 (FCC, 2019, page 7).

> In the inquiry, we sought comment to determine whether our general rules and regulations limiting RF exposure are still appropriately drawn. Over 1,000 comments or ex parte presentations were filed in the proceeding. The vast majority of filings were unscientific, and even the filings that sought to present scientific evidence failed to make a persuasive case for revisiting our existing RF limits. While the record includes some research information, there is no persuasive case in the record to evaluate the quality and significance of that research. Nor do cases advocating alternatives in the record provide sufficient scientific evidence or explanation justifying why the proposed reductions are the appropriate value(s), or how they might affect the viability or performance of wireless services and devices. In other words, while the record includes scientific papers of variable quality and significance that allude to more restrictive RF exposure limits under certain circumstances, they fail to provide any specific, pragmatic recommendation for how our RF exposure limits could be adjusted as a result of this research.

This approach is less than adequate, given the size of the industry, its role in society, and the consequences of getting it wrong. Some means must be found to inform the process of setting emission safety standards with active objective scientific research that keeps pace with the technology being commercialized.

It should be clearly understood that what we have now is not a *standard*, but rather a simple *limit guideline* that has been somewhat arbitrarily chosen in the past by the FCC without an independent scientific basis. As the science and the research literature has developed, the FCC lacks the internal competence to understand and evaluate this research. For example, the FCC 19-226/126 document (FCC, 2019, p. 2) states on the first page, in paragraph 2,

> "We take to heart the findings of the Food & Drug Administration (FDA), an expert agency regarding the health impacts of consumer products, that "[t]he weight of scientific evidence has not linked cell phones with any health problems." The accompanying footnote reads: "U.S. Food and Drug Administration, Do cell phones pose a health hazard?" https://www.fda.gov/RadiationEmittingProducts/RadiationEmittingProducts andProcedures/HomeBusinessandEntertainment/CellPhones/ucm116282.htm (last updated Dec. 4, 2017).

A look at the website link reveals the statement, "The available scientific data on exposure to radio frequency energy show no *categorical proof* of any adverse biological effects other than tissue heating" [emphasis added]. Neither the reliance on a public website, the *categorical proof* proviso, nor the 3-year-old reference indicate a diligent science-based pursuit or interest on the

part of the FCC. This approach might be referred to colloquially as "kicking the can down the road."

Similar references are found elsewhere in the FCC 19-126 document, such as in paragraph 121 (page 56) supported by a footnote that references a personal comment from an FDA official. Footnote 320 reads,

> [320] U.S. Food and Drug Administration, Children and Cell Phones, https://www.fda.gov/radiation-emittingproducts/cell-phones/children-and-cell-phones; see also Statement from Jeffrey Shuren, M.D., J.D., director of the FDA's Center for Devices and Radiological Health on the recent National Toxicology Program draft report on radiofrequency energy exposure (Feb. 2, 2018), https://www.fda.gov/news-events/press-announcements/statementjeffrey-shuren-md-jd-director-fdas-center-devices-and-radiological-health-recent-national ("I want to underscore that based on our ongoing evaluation of this issue and taking into account all available scientific evidence we have received, we have not found sufficient evidence that there are adverse health effects in humans caused by exposures at or under the current radiofrequency energy exposure limits. Even with frequent daily use by the vast majority of adults, we have not seen an increase in events like brain tumors. Based on this current information, we believe the current safety limits for cell phones are acceptable for protecting the public health.") (FCC, 2019, p. 56).

The above brief statement by Dr. Shuren falls short of what we might expect to see in a rigorous and sincere scientific investigation in support of RFR emission limits. He seems to dismiss the findings and implications of the NTP study, and to have taken a rather passive role in relying on "scientific evidence we have received" rather than actively seeking or developing his agency's own scientific evidence. The FCC should avoid reliance on such anemic and unsupported testimony.

RECENT RESEARCH

A list of 25 recent papers is attached (with abstracts, synopsis, and conclusions). This list is only the latest in a growing library of scientific and policy papers on wireless issues provided by Dr. Joel Moskowitz of the School of Public Health at the University of California, Berkeley.

CONCLUSIONS AND RECOMMENDATIONS

Final Comments:

1. The existing limits are inadequate because they do not consider *weak field* (non-thermal) effects on biological systems and processes. This entire FCC inquiry has a problem from the get-go—it is based on a fallacious and obsolete assumption that thermal effects are sole risk.
2. Well below the threshold of thermal RFR effects, the inquiry needs to consider weak field (non-thermal) effects, including the difference between long term and short term exposures, and that because of the adaptive characteristics of biological systems, one can switch from gain to loss by changing the modulation, the frequency, or the time delay between pulses as well as the presence of reactive oxygen—all of which have not been adequately taken into consideration by the FCC.

3. If existing limits are not adequate for weak field (non-thermal) effects, it makes little sense to simply extend these limits to frequency ranges above 6 GHz.
4. It makes little sense to further weaken thermal limits by relying on effective power alone. Dropping SAR-based limits excludes consideration of absorption into the body that should be accounted for by SAR with the additional consideration of duration of exposure as well as more sophisticated measures of impact on bodies and cells.
5. Averaging power over time is inadequate and deceptive because it does not deal with peak power, is still based on the assumption that the only mode of potential harm is heating (e.g., SAR or MPE), does not consider weak field (non-thermal) effects on biological systems and processes, and does not deal with effects over time, or with long term exposure effects.
6. The 19-126 inquiry and the FCC exposure guidelines are largely based on assumptions and theoretical models rather than on experimental evidence or testing. Exposure limits should be based on empirical science (i.e., verifiable by observation or experience rather than theory or pure logic). "Increased emphasis on long‐term exposures may require refining the concept of dose to more flexibly combine exposure time and field intensity or energy absorbed." (Barnes and Greenebaum, 2020, p. 4). "What is missing in the current guidelines or regulations are guidelines for long-term exposure to weak EMF" (p. 5).
7. The Commission should request the FDA and/or other agencies with appropriate health science competence to pursue or undertake establishment of actual safety standards based on actual animal or human safety testing, recommendations, or guidelines for both short term and long term RFR exposures and emissions as proposed by Barnes & Greenebaum, 2020, p. 4-5). The FCC should recuse themselves from the process of setting human RFR exposure guidelines due lack of expertise.
8. "Limits on the time for operations of base stations and exposures in adjacent living spaces are not controlled by the user and must be set by competent authorities, based on scientific evidence. It is likely to be difficult to specify times when exposures to RF signals are zero or below some limit. What will be needed is being able to say with some certainty that exposure below a given level has not been shown to cause changes in body chemistry above some level" (p. 5).
9. "A starting point might be current levels from TV and radio stations that are large enough to give signal‐to‐noise ratios around 20 dB (100‐fold) with typical receiving systems. Currently, mean values for the population's exposure to these systems are estimated to be around 0.1 V/m and peak exposures range up to 2 V/m, which exceed current exposure limits for a small fraction of the population" (p. 5).
10. Consumers are entitled to informed consent to risk. The public should be educated about the real risks involved in using cellphones and being near cell antennas big or small as well as the risks of being exposed to RF radiation in general. It is the responsibility of the FCC to inform the public openly and accurately. The FCC has not done so in this proposed rulemaking.

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ATTACHMENTS

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Novikov, 2010
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