

Review

Nils Rainer Nyberg*, Julie E. McCredden, Steven G. Weller and Lennart Hardell

The European Union prioritises economics over health in the rollout of radiofrequency technologies

<https://doi.org/10.1515/reveh-2022-0106>

Received July 5, 2022; accepted September 2, 2022;

published online September 22, 2022

Abstract: The fifth generation of radiofrequency communication, 5G, is currently being rolled out worldwide. Since September 2017, the EU 5G Appeal has been sent six times to the EU, requesting a moratorium on the rollout of 5G. This article reviews the 5G Appeal and the EU's subsequent replies, including the extensive cover letter sent to the EU in September 2021, requesting stricter guidelines for exposures to radiofrequency radiation (RFR). The Appeal notes the EU's internal conflict between its approach to a wireless technology-led future, and the need to protect the health and safety of its citizens. It critiques the reliance of the EU on the current guidelines given by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), that consider only heating and no other health relevant biological effects from RFR. To counteract the ICNIRP position, the 2021 cover letter briefly presented recent research from the EU's own expert groups, from a large collection of European and other international studies, and from previous reviews of the effects of RFR on humans and the environment. The 5G Appeal asserts that the majority of scientific evidence points to biological effects, many with the potential for harm, occurring below the ICNIRP public limits. Evidence to establish this position is drawn from studies showing changes to neurotransmitters and receptors, damage to cells, proteins, DNA, sperm,

the immune system, and human health, including cancer. The 2021 Appeal goes on to warn that 5G signals are likely to additionally alter the behaviour of oxygen and water molecules at the quantum level, unfold proteins, damage skin, and cause harm to insects, birds, frogs, plants and animals. Altogether, this evidence establishes a high priority for the European Union towards (i) replacing the current flawed guidelines with protective thresholds, and (ii) placing a moratorium on 5G deployment so as to (iii) allow industry-independent scientists the time needed to propose new health-protective guidelines. This 2021 Appeal's relevance becomes even more pressing in the context of the EU plans to roll out the sixth generation of wireless technologies, 6G, further adding to the known risks of RFR technology for humans and the environment. This all leads to an important question: Do EU decision makers have the right to ignore EU's own directives by prioritising economic gain over human and environmental health?

Keywords: 5G; appeals; electromagnetic field; EMF; environment; EU; health risks; non-ionizing radiation guidelines; radiofrequency radiation; WHO.

Introduction

On many occasions in the last century, scientists have alerted governments to the health risks associated with human economic activities. Almost just as many times, due to opposing scientific inertia, lack of political will and the prioritising of economic interests, governments have continued to ignore these warnings, to the detriment of millions of citizens and the environment. *Late Lessons from Early Warnings* [1] lists twelve key lessons from past poor decisions compiled by the European Environment Agency. If heeded, such wisdom gained in hindsight may enable governments and EU decision makers to avoid repeating the mistakes of the past. Unfortunately, in the case of biological and health effects from electromagnetic fields, the scientists who are providing the warnings to governments are observing history repeating itself. This

*Corresponding author: Nils Rainer Nyberg, EdD, MPS, Professor emeritus, Åbo Akademi University, Fredsgatan 16 A 35, 65100 Vasa, Finland, E-mail: Rainer.Nyberg@abo.fi

Julie E. McCredden, Oceania Radiofrequency Science Advisory Association (ORSAA), Kearneys Spring, QLD, Australia, E-mail: julie.mccredden@orsaa.org

Steven G. Weller, Centre of Environmental and Population Health, School of Medicine and Dentistry, Griffith University, Brisbane, QLD, Australia, E-mail: steve.weller@griffithuni.edu.au

Lennart Hardell, Environment and Cancer Research Foundation, Örebro, Sweden, E-mail: lennart.hardell@environmentandcancer.com

paper documents several unheeded Appeals, delivered to the European Commission over the last 4 years so as to warn the Union and the Commission regarding the risks associated with wireless technologies. The rationales that have been given, the calls to invoke the Precautionary Principle, and the lack of political will to act are recorded here. This document thus bears witness to an unfolding global health tragedy which may yet be prevented, but only if the EU and governments can untangle themselves from corporate binds [2] and only if wisdom can prevail over the current worldwide, deep-seated, naive faith in technology to save mankind from all its ailments in the 21st century [3].

The EU 5G Appeal [4] has now been endorsed by more than 400 scientists and medical doctors from all over the world and has been sent six times to the EU. It requests stricter guidelines on exposure to radiofrequency radiation (RFR) and a moratorium on 5G deployment until international guidelines for RFR exposures are adequate to protect health and the environment. It raises grave concerns for the future well-being of humans and the environment. The Appeal urges the EU to allow time for truly industry-independent scientists to propose new health-protective guidelines that can replace those of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The 5G Appeal, including an extensive cover letter (henceforth together termed “the Appeal”) was again sent to the EU Commissioners for Health, for the Environment, and to several other Commissioners and members of the Consilium¹ on 2-6 September, 2021.

The sections below review the Appeal, describing the arguments made to the EU regarding its conflicting goals, with updates on the latest scientific evidence, and a request to the EU for further responses from Commissioners to be based on a consideration of this evidence rather than providing scripted responses from subordinates. The 2021 Appeal presented new research from the EU’s expert groups and from a large compilation of European and international studies. This collective evidence, presented in the review below, undermines any reassurances that current guidelines would protect health, and demonstrates that the heating-only evidence used to justify industry-serving guidelines for decades is short-sighted and potentially harmful. Subsequent calls made by the Appeal for the EU to act by employing the Precautionary Principle, establishing protective thresholds, and placing a moratorium on 5G deployment are then summarised below.

Great plans, great promises but false claims

In 2016, the European Parliament and the Council were asked by the European Commission to endorse the *5G for Europe: An Action Plan* [5]. While this plan predicted a great future, it considered only the technical and economic aspects of the deployment of 5G. The EU appears to be conflicted by actions taken towards an RFR technology-led future because decisions to enact these plans compromise the EU obligation to first of all, ensure the health and safety of citizens, regardless of economic loss.

On the one hand, the potential health and safety risks associated with RFR have been exposed in a recent EU-commissioned review of the currently available scientific evidence, the 2021 European Parliamentary Research Service’s EPRS/STOA *Health impact of 5G* report [6]. The conclusions of the comprehensive review declared sufficient evidence for cancer from RFR in animals, sufficient evidence for adverse effects from RFR on the fertility of men, male rats and mice, and that RFR is probably carcinogenic to humans. In short, the EPRS/STOA report shows that RFR is harmful for health. The report subsequently calls for measures to *incentivise the reduction of RF-EMF exposures* (p. 153), such as lowering the limit for allowed exposures and the preferential use of wired connections.

Similarly, the EU’s own (ITRE committee) 2019 in-depth analysis, *5G Deployment: State of Play in Europe, USA and Asia* [7] warned that, when added to 2G, 3G, 4G, WiFi, WIMAX, DECT, radar etc., 5G will cumulatively lead to dramatically more total radiation: *not only from the use of much higher frequencies in 5G but also from the potential for the aggregation of different signals, their dynamic nature, and the complex interference effects that may result, especially in dense urban areas* (p 11). These concerns are based on the complexity of communications signals and the unknowns of their interactions. Electromagnetic signals transmitted by manmade communication devices are not regular waves; rather, they are a complex combination of ultra-high frequency carrier waves, and modulations that encode the messages using extremely-low and ultra-low frequencies [8]. In addition, the signals are pulsed at ultra-low frequencies (sent in short on-off bursts). This means that although the RFR carrier waves may sit in the high frequency GHz range, their modulations and pulse rates are much closer to brain-wave frequencies; e.g., the 217 Hz pulsing of a GSM phone signal [9]. Pulsed or modulated RFR signals have been shown to be more bio-active than simple continuous waves of the same intensity and exposure duration [8]. This is of significant concern in relation to public health and is not limited to just the higher 5G

¹ Kyriakides, Timmermans, Sinkevicius, Sefcovic, Goulard, Ferreira, Dalli, Schmit, Schinas.

frequencies. Furthermore, as the report noted [7], the effects of these new complex beam formed signals have *unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation* (p. 6) but are yet to be mapped reliably for real situations, outside the laboratory (p. 11).

Conflicting interests within the EU

In conflict with the recommendations and warnings from the aforementioned reports, the EU Council 2020 conclusions to the 2020 *Shaping Europe's Digital Future* report [10] recommends that the Commission *incentivise* the development of 5G and 6G capacities; i.e.: *CALLS on the Commission to put forward a revised Action Plan for 5G and 6G supported with adequate financing measures ... to enable all stakeholders to invest in the most advanced 5G network and service solutions, in line with competition law principles, and to incentivise European companies to start developing and building technology capacities in 6G* (paragraph 35).

As a result, the more recent Connecting Europe Facility (CEF Digital) proposal [11] recommends 5G/6G expansion, thereby significantly increasing radiation exposures of the public and environment.

Comment: On the one hand, the recommendation of the EU is to *incentivise reduction* of RFR exposures and on the other hand, the EU is planning to *incentivise an increase*. These two contradictory positions cannot coexist, and the EU is therefore internally conflicted. In order to resolve such a conflict, European Case Law provides direction, where the Court of Justice of the European Union has ruled in several instances that the protection of public health must take precedence over economic considerations, based on the following reasoning: *It must be stressed that Article 3(o) of the EC Treaty provides that the objectives of the Community include 'a contribution to a high level of health protection'. That objective is reiterated in the first subparagraph of Article 129(1) of the EC Treaty, under which the Community is to contribute towards ensuring a high level of human health protection. The third subparagraph of Article 129(1) further specifies that health protection requirements are to form a constituent part of the Community's other policies. Finally, the Court has already held that efforts to achieve the objectives of the common agricultural policy cannot disregard requirements of public interest, such as the protection of consumers or of the health and life of humans and animals, which the Community institutions must take into account in exercising their powers (Case 68/86 United Kingdom v Council [1988] ECR 855, paragraph 12) (excerpt from case 180/96 R, paragraph 63).*

This EC Treaty directive, which prioritises public health over economic considerations, has been applied in several landmark cases.² It is therefore incumbent on the creators of any institutional policy to ensure adherence to this principle.

Unfortunately, adherence to the EC directive to prioritise public health has not been achieved in the case of the latest version of the EU plan, which includes a Declaration on digital rights and principles [12] stating that it aims for *safe technology for everyone*. The Declaration claims that it is built on [inter alia] *the Treaty on the European Union (TEU), the case-law of the Court of Justice of the European Union, and the EU Charter of Fundamental Rights*. However, the application of these foundational principles in the EU plan is unclear. The declaration does not mention human health or protection thereof (except for the potential applications of digitalisation in healthcare). Instead, the declaration defines human rights merely as *data protection rules and equal treatment* (p. 1). While it states that the aim is to put *people at the centre of the digital transition* (p. 1), the emphasis is not on people's health, but on people's rights regarding access to *artificial intelligence, data analytics, robotics, the Internet of Things and the integration of these into business models* (p. 2). Therefore, it appears that technology and its promoters are at the centre of the transition, while human health and well-being have been disregarded.

The Commission's latest moves to prioritise industry interests over human health leave it internally conflicted between its plans for a supposed golden future and its core values. Rather than deal with the enormity of the problem that the known health risks from RFR present, the Council of the EU has instead chosen a path of denial; i.e. in *Shaping Europe's Digital Future* [10] paragraph 36, the Council of the EU labelled statements regarding health risks associated with 5G networks as "false claims"; i.e.: *STRESSES that the roll out of new technologies such as 5G/6G should preserve the abilities of law enforcement*

² This principle was applied by the European Court of Justice in the "Mad Cow Disease" case, where judgements were made even though there was scientific uncertainty; i.e. in Case 157/96, *National Farmers Union*, the finding was that *public health requirements are indivisible and universal* (paragraph 22) and in Case 180/96 R *United Kingdom v Commission* [1996] ECR 1–3,903 that *Whilst acknowledging the economic and social difficulties caused by the Commission's decision in the United Kingdom, the Court cannot but recognize the paramount importance to be accorded to the protection of health* (paragraph 93). These precedent cases were then used by the Court of Justice to make its ruling in Case 183/95 *Affish* that *the protection of public health which the contested decision is intended to guarantee must take precedence over economic considerations* (paragraph 43). Subsequently, an Order of the Court of First Instance in Case 136/95 *Industria del Frio Auxiliar Conservera* based its ruling on the same principle that *the protection of public health which the disputed decision is intended to guarantee must take precedence over economic considerations* (paragraph 58).

authorities, security authorities and the judiciary to perform their legitimate functions effectively; TAKES into account the international guidelines concerning the health impact of electromagnetic fields; and EXPRESSES the importance of fighting against the spread of misinformation related to 5G networks, with special regard to false claims that such networks constitute a health threat ...

Comment: The real false claim in this statement is the insinuation that there is no health threat from 5G/6G networks. However, this claim, created and perpetuated by two industry-linked advisory bodies, ICNIRP and SCEHNIR (see below) is now being repeated by the EU Commission as fact. The false sense of security provided by this claim has permitted the EU to give the green light to a fully digital future built on 5G/6G infrastructure. For example, the European electronic communication code [13] clarifies that the Commission uses the guidelines issued by the International Commission on Non-Ionizing Radiation Protection [14] and calls on all member states to do likewise. The Commission's 5G policy communication [15] ignores the voices of independent scientists and moreover, muddies their reputation by linking them with Covid conspiracies. This clever dismissal of alternative viewpoints allows the communication to untruthfully conclude that *the deployment of 5G networks will not have a negative effect on people's health.*

This claim is false because it is not established in science. Indeed, any claim of no harm is undermined by a large pool of evidence revealing that existing wireless networks do cause health threats at RFR exposure levels far below the current permitted public exposure limits set within international (ICNIRP) guidelines. This evidence is given in the conclusions of the EPRS/STOA report [6] described above and through a wealth of evidence, summarised below.

Health risks demonstrated over 50 years

The Appeal summarises past and recent scientific evidence showing that there are very real risks to human and planetary health from existing signals, with the likelihood of even greater harm from adding 5G frequencies into the mix. The research presented in the Appeal is summarised in the sections below.

All human and planetary systems are built from moving charges, frequencies and vibrations. Scientific understanding of the role played by these physical properties in protein folding, cell signaling, the brain and the human sensory system is still in its infancy. Meanwhile, Telecom

engineers, with little understanding of biophysics or the likelihood of harm, are blindly developing more and more devices, thereby altering the natural frequency patterns throughout earth, and affecting fundamental biological processes.

The Appeal has informed the EU Commission of the very real risks to humans and the environment from RFR that are revealed in thousands of independent studies, summarised in a series of reviews spanning several decades, and confirmed in the recent follow-up work of current international expert groups. Adverse health effects from microwave radiation were well recorded by the US Naval Medical Research Institute back in the 1970s [16] when Glaser and his colleagues compiled two extensive bibliographies referencing more than 3,700 scientific studies and publications [17, 18]. Since that time, RF radiation from billions of devices and antennas for e.g., 2G, 3G, 4G, WIMAX, Wi-Fi and DECT have been introduced.

The BioInitiative Reports [19–21] have reviewed the evidence for an array of biological and health related effects linked to RFR exposures, including reduced fertility, neurological and behavioural effects, effects on gene expression, and effects on the immune system. The most recent version (2020 update) [21] has found that between 65 and 91% of 1,299 studies reported biological effects (depending on the bio-effect endpoints being studied). Similarly, the Oceania Radiofrequency Science Advisory Association (ORSAA) who maintains the world's largest categorized database on electromagnetic fields (ODEB), has stated that approximately 69% of 2,065 relevant peer reviewed studies in ODEB show statistically significant biological effects. These include effects on sleep [22], cardiovascular disease [23], free radicals and oxidative stress [21], cancer [24] and DNA damage [25], which can endanger future generations [26, 27]. Overall, the scientific evidence from these two major compilations of the publications in this field reveals that biological effects are occurring far below public limits (see review by ORSAA [28]). These effects can lead to adverse health outcomes such as cancer, sleep disorders, anxiety and depression, chronic fatigue, respiratory issues, autoimmune disease, heart disease, neurodegeneration and issues with reproduction. All of these aforementioned diseases and disorders match many of the major health issues currently being faced by people all over the world, including those who live in Europe.

The interdisciplinary Swiss expert group for electromagnetic fields and non-ionising radiation (BERENIS) comprising both scientists and doctors, has recently published a special issue [29] reviewing the effects of electromagnetic fields on oxidative stress in animals and cells. BERENIS found that overall, there is evidence that RFR

causes increased oxidative stress (excessive oxidative stress is an underlying factor in cancer, diabetes, and neurodegenerative diseases). *EMF exposure, even in the low dose range, can lead to changes in oxidative balance ... Pre-existing conditions, such as immune deficiencies or diseases (diabetes, neurodegenerative diseases), compromise the body's defence mechanisms, including antioxidative protection, and it is therefore possible that individuals with these conditions experience more severe health effects* (p. 8).

The work of Panagopoulos et al. [30, 31] has shown that weak electromagnetic fields can open calcium channels in the cell membranes. This is suggested to be one of the main mechanisms by which RFR causes damage to biological systems, even at low signal strengths. Separately, recent medical research has shown that some viruses upregulate intracellular ionic calcium (Ca^{2+}) concentrations via calcium channels thereby promoting viral replication [32]. The same research suggests Ca^{2+} acts as an important intracellular secondary messenger that is associated with cellular physiological and pathological processes. These results, together with recent epidemiological data [33] suggest that RFR exposures might make cells more susceptible to viruses. This possibility must be investigated, because significant increases in exposures are occurring with the 5G rollout, while at the same time, each person is trying to minimize all factors that promote viral infections.

The Panagopoulos model has been further applied and promoted by Pall [34], who has reviewed and summarised the main biological effects from RFR into seven distinct types: nervous system effects, hormonal system effects, oxidative stress damage, DNA damage, elevated levels of programmed cell death, lowered fertility, and calcium overload [35]. Pall has concluded that *Each of these 7 repeatedly found Wi-Fi effects should, therefore, be considered established Wi-Fi effects* (p. 406). This evidence has been used by Pall [36] to direct a communication towards the EU and other leading nations warning that these effects ... *become much deeper and become existential threats when one considers that several of these effects are both cumulative and eventually irreversible* (p. 2).

DNA damage, leading to cancer is one of the most well-researched RFR biological effects. Many future generations could be harmed if DNA is damaged, particularly if this occurs in the germline (i.e., the reproductive cells that pass genetic material from one generation onto the next). DNA damage induced by radiofrequency exposure was revealed in the 2004 REFLEX study [37] conducted on behalf of the EU by 12 institutions with a total budget of 3 million Euros. The results showed that significant biological damage is caused in human cells and DNA at a SAR value of 1.3 W/kg which is lower than the official limit yet representative of many

mobile phones [25]. This is of great concern for foetuses and children who are undergoing growth with rapid cell division, and are therefore vulnerable to RFR genotoxic effects.

More recently, cancer effects in animals from RFR exposures have been investigated by two major international institutions: the US \$30 Million National Toxicology Program (NTP) and the renowned Ramazzini Institute in Italy. The technical reports of the NTP study [38, 39] describing the final results were subjected to a rigorous peer review process with a panel of experts [24], who concluded that the studies were well designed, and that there was clear evidence for heart schwannomas, some evidence for brain gliomas and increased cancerous activity (neoplasia) in male rats exposed to modulated GSM or CDMA signals. The Ramazzini study [40] found similar schwannoma effects in the hearts of male rats subjected to lifelong exposures (representing cell tower RFR exposures experienced by the human population).

The NTP lead designer, Melnick, in a commentary on these studies [41] concluded that: *the overall results from the NTP studies indicate that cell phone RFR is potentially carcinogenic to multiple organs of exposed people* (p 5). The confirmatory results from these two major studies indicate that cancer is caused by exposure to low levels of man-made radiation, highlighting the great need for updated health-based exposure guidelines that take into account the results of these studies, including the effects of total, cumulative long-term exposure to radiation [42]. As Melnick [41] has pointed out, *Even a small increase in cancer risk could have a serious health impact due to the widespread use of cell phones (~300 million in the US and 5 billion worldwide)* (p 5.).

In addition to the scientific evidence above, there is mounting anecdotal evidence coming from people claiming to have been injured by RFR. These claims along with the related supporting scientific evidence, are being accepted in legal and legislative domains; e.g. in Italy in 2020, the Court of Appeal of Turin confirmed the claim that RFR from a mobile phone used for occupational purposes caused an acoustic neuroma [43]. In Spain, electromagnetic harm to a worker from continual exposure to RFR at work was confirmed by The Superior Court of Justice of Aragon in 2019 [44]. With concerns for health and biodiversity, the Canton of Geneva has adopted a precautionary approach and placed a three-year moratorium on any further roll out of 4G+ and 5G [45].

Predictable risks from adding 5G frequencies

The 5G rollout will bring a dramatic increase in network infrastructure and signaling, as described in the *5G for Europe: An Action Plan* [5], Section 3.3: *The planned 5G*

networks are expected to serve up to one million connected devices per square kilometer, about a one-thousand-fold increase as compared to today. This dramatic surge in the number of devices will also increase traffic per network access point, which will require increasingly smaller cells to deliver the planned connectivity performance and an increase in the density of antennae deployed.

That is, there will be many more devices and antennas and much more traffic on the network. Therefore, 5G will substantially increase the total radiation, bringing:

- a) Billions of new connections within the “Internet of Things” [46];
- b) Thirty times more antennas [47], to be situated at lower positions (about the height of the 2nd or 3rd floor of buildings), and much closer to people in homes and offices than current masts.
- c) At least 800 base stations per square kilometre (and more in densely populated areas) [46];
- d) Radiation from 100,000 5G satellites will increase man-made electromagnetic radiation at unprecedented levels with little to no concern for the safety and wellbeing of the humans who will be exposed to it [48]. An EU Parliamentary Briefing of March 2020, *Effects of 5G Wireless Communication on Human Health* [46] warns of this increase: *The aim to cover all urban areas, railways and major roads with uninterrupted fifth generation wireless communication can only be achieved by creating a very dense network of antennas and transmitters. In other words, the number of higher frequency base stations and other devices will increase significantly. This raises the question as to whether there is a negative impact on human health and environment from higher frequencies [nanosecond pulses] and billions of additional connections* (p. 1).

When considering the limited research into the higher 5G millimetre wave frequencies, the European Parliamentary Research Service (EPRS/STOA) report [6] noted that there are insufficient experiments on which to base any conclusions. The report warned that: *Implementing MMW 5G technology without further preventive studies would mean conducting an ‘experiment’ on the human population in complete uncertainty as to the consequences* (p. VII). However, the report notes that harm from 5G millimetre wave frequencies can be extrapolated from evidence of harm at the existing lower frequencies, such as adverse effects on male fertility from exposures between 450 and 6,000 MHz (this range includes the current 5G Phase 1 frequencies which sit below 6 GHz).

A recent review [49] has determined that even though the results are preliminary, potential harm from the higher 5G frequencies exists: *Preliminary observations showed that MMW [millimetre waves] increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, affect neuro-muscular dynamics* (p. 367).

A recent book, easily read by policy makers [50], describes adverse effects from low doses of radiation exposure and explains why the new 5G standard holds dangerous risks.

Environmental effects need urgent attention

Recent reviews of relevant research on flora and fauna [51] and birds, insects and wildlife [52] reveal how susceptible wildlife are to harm from man-made background electromagnetic fields. For example, honey bees maximally absorb the higher 5G frequencies because the millimetre wavelengths resonate with their body size [53]. Adverse RFR effects also occur for other pollinating insects [54], plants [55], trees [56], birds, frogs, animals [57] and humans [58].

A recent review on insects by Balmori [59] reminds us that *Insects are at the structural and functional base of many of the world’s ecosystems* (p. 1) and warns of the adverse effects of radiation:

... evidence for the effects of non-thermal microwave radiation on insects has been known for at least 50 years. The review carried out in this study shows that electromagnetic radiation should be considered seriously as a complementary driver for the dramatic decline in insects, acting in synergy with agricultural intensification, pesticides, invasive species and climate change ... taking into account the benefits they provide to nature and humankind, the precautionary principle should be applied before any new deployment [such as 5G] is considered (p. 1).

A recent comprehensive review of the effects of electromagnetic fields on flora and fauna [51] summarizes the last several decades of research: *Biological effects have been seen broadly across all taxa and frequencies at vanishingly low intensities comparable to today’s ambient exposures. Broad wildlife effects have been seen on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and longevity and survivorship. Cyto- and geno-toxic effects have been observed* (p. 81).

All of the above effects were well established a) before the current intensively modulated 5G frequencies were

added to the total radiation and b) before ICNIRP released new guidelines [14] allowing still higher radiation levels for beams of high 5G frequencies.

Fundamental planetary systems are being disrupted

RFR has known effects on fundamental planetary systems, such as alterations to oxygen and water molecules. The engineering literature is clear that the high frequency 5G millimetre waves will create quantum level changes in the rotational energy of water (at 22.3 GHz, 33 GHz, and 323 GHz) and oxygen molecules (at 60 GHz) [60]. Meteorologists have expressed serious concerns about the subsequent interference of 5G satellites with weather stations [61]. However, the ramifications are much more serious, in that forced changes to the fundamental building blocks of life are likely to affect all lifeforms on earth in unpredictable and potentially devastating ways.

Wireless energy consumption will have a greater than tenfold increase

While all other sectors in society are trying to reduce energy consumption, the wireless industry plans to increase it significantly. Already, wireless connections to "the cloud" consume 10 times more energy than wired internet [62]. An IEEE article [47], has clarified that with 5G, energy consumption will increase still more, because 30 times more antennas and more complex waveforms are required. However, while the IEEE article admits that *5G is going to come with a price, and that price is battery consumption*, this statement is a distraction from the significant increase in energy consumption which will be required for supporting the infrastructure, such as powering of masts and accessing of information from the cloud [62]. Consistent with this prediction, a 2019 survey of more than 100 telecommunications decision makers found that by 2026, 5G technology will likely increase total network energy consumption by 150–170 per cent [63].

On the basis of the existing evidence and logical reasoning, it can be anticipated that with higher frequencies (5G/6G) added with much higher exposure limits [14, p. 490], the situation will be worse still for humans, animals, insects and plants. However, despite the publication of *The EU 5G Appeal* in 2017 and the most recent update to the Appeal, permission for all of these technology additions have been approved by the US Federal Communications Commission. Similarly, the potential environmental and

health risks associated with the 5G expansion have been totally neglected in the *5G for Europe: An Action Plan* [5].

Greenwashed digital future

With complete disregard for the above warnings, the *Connecting Europe Facility Regulation* [64] is entirely and unquestioningly based on the premise that total interconnectivity of transport, energy and digital communications is essential to rescue Europe from Global Warming and to reduce greenhouse gases. There has been no rational case made to support such a hypothesis, nor an admission of the significant increases in energy consumption. Rather, the industries involved have managed to greenwash their interests; e.g., by tying the valued concept of renewable energy to the need for a smart grid.

A smart grid requires massive communications and cloud-based infrastructure which will consume much more energy than the requirements of the existing power grid. A smart grid is not necessary for renewable energy, and is only one of the several options available for monitoring consumption. Optical fiber and hard-wired networks provide a far more sensible solution by delivering (a) higher speed, (b) lower electricity consumption, (c) precaution, by reducing radiation in society, and (d) protection of human and environmental health [65]. In spite of superior alternatives, the greenwashed rhetoric promoting wireless and satellite communications is subsequently being promulgated through EU Commission reports and press releases [66]. The underlying message is that Europe needs digital everything to save her from global warming and to ensure the financial recovery of a single European market. Clearly, the EU Commission has not heeded the lessons presented in *Late lessons from early warnings* [1] or the well documented risks of RFR presented in the 5G Appeal, sent six times since 2017 with cover letters summarising updated research.

The current guidelines are compromised and unscientific

All of the current plans of the Council and the Commission are based on the assumption that wireless technologies are harmless. This is the message declared by two main advisory bodies that the EU has endorsed regarding the health risks of non-ionising radiation, ICNIRP and SCENIHR. In 1999 the council adopted the *International Commission on Non-Ionizing Radiation Protection (ICNIRP)* guidelines [67]. The

authority of these guidelines was reiterated by The Council of the EU, in its 2020 conclusions on shaping Europe's digital future when it requested that the *Commission takes into account the international guidelines concerning the health impact of electromagnetic fields* [10, para 36.] In addition to ICNIRP, the Commission established its own advisory body in 2008, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) [68].

Advisory bodies are compromised

Unfortunately, these two main advisory bodies, ICNIRP and SCENIHR, are compromised. Their members comprise a handful of like-minded industry-linked researchers, very few of whom have expertise in the biophysics of RFR, a crucial area of expertise that is required for this field. In spite of credentials that are not task-appropriate, these individuals have been able to use their positions in ICNIRP and SCENIHR to promote the industry-favourable claim within the halls of government that the ICNIRP international guidelines are protecting health. While giving the appearance of being scientific, the roles of these bodies are actually political and aimed at protecting the telecom industries and operators.

SCENIHR misrepresentations

In 2015, SCENIHR submitted an opinion report to the EU [69], which not only misrepresented the science and used incorrect evaluation criteria, but also failed in its fundamental obligation to warn the European Commission that *EMF is a new and emerging problem that may pose an actual or potential threat* [70, p. 192]. Through this strategy the members of SCENIHR, who have been shown to be supportive of industry and biased [71], were able to give the telecom industry a clean bill of health, allowing operators and equipment producers to expose EU citizens to levels and pulses of radiation that are far too high to guarantee human health and wellbeing in the long term.

ICNIRP compromised

In 2020, two EU parliamentarians, Buchner & Rivasi, commissioned an in-depth investigation into the makeup and functioning of ICNIRP. Their final report [72] concluded that ICNIRP has been *captured by industry* and is therefore unable to give a trustworthy appraisal of the current science. Furthermore, such conflict of interest has enabled ICNIRP to

formulate a set of “safety” guidelines that are designed to protect industry profits over the health of the public and the environment [73]. Unfortunately, as ICNIRP decrees, so SCENIHR echoes and the EU complies without questioning. Most national radiation safety agencies in European states make exactly the same mistake, because the EU has endorsed SCENIHR and ICNIRP members as authorized scientists.

A very recent investigation into the breadth and variation of the scientific opinions used by ICNIRP [74] discovered that the contributors belong to a core group of 17 authors, and that *literature reviews presented by ICNIRP 2020 as being from independent committees, are in fact products of this same informal network of collaborating authors, all committees having ICNIRP 2020 authors as members. This shows that the ICNIRP 2020 Guidelines fail to meet fundamental scientific quality requirements and are therefore not suited as the basis on which to set RF EMF exposure limits for the protection of human health.*

Dismissal of important science

In the service of industry interests, ICNIRP and SCENIHR have dismissed most of the above studies showing adverse biological effects of radiation, and have justified ignoring clearly observed effects because they claim that science does not yet fully understand the underlying causal biophysical mechanisms. Each of these actions is a poor example of scientific process and judgment, which have together enabled ICNIRP and SCENIHR to formulate an opinion for the EU and governments that the evidence for harm is ‘not established’.

Such dismissal of relevant science suggesting harm has also excused ICNIRP from addressing risk in an effective manner. Rather than considering the array of observed biological effects, ICNIRP has narrowed the focus for harm down to temperature rises in human tissue caused by energy transfer from the EMF signal to body tissue, thereby keeping the outdated view that RFR only has heating effects [75]. Consistent with this narrow focus, ICNIRP sets its limits for exposure to ensure that the energy (heat) from one single source of RFR does not cause an increase of 2 or 5 degrees Celsius (depending on the specific area of the body and depth of penetration). ICNIRP and SCENIHR then claim that the current levels of RFR in the built environment are safe because they are much lower than these microwave oven-like heating thresholds set by ICNIRP. These ICNIRP safety thresholds are designed to protect people only from heating of tissue when exposed to short-term exposures (6 or 30 min). Thus, they do not provide protection for most European citizens who are being subject to RFR exposures 24×7 , continuously for

decades, and now coming from an increasing number of radiating objects, which may be as high as one million transmitters in just one square kilometre [5, Section 3.3].

Simple modelling of complex systems

ICNIRP calculations use only simple heating models that are not considering the complexities of the many interacting and aggregated signals that occur in the built environment, an important issue that the *5G Deployment: State of Play in Europe, USA and Asia* report [7] has raised (described above). The many new and complex exposure-patterns that are now being used are addressed by a directive of the EU [76] regarding exposure of workers to the risks from electromagnetic fields, that *exposure limitation systems need to be exposure-pattern and frequency dependent in order to adequately protect workers exposed to electromagnetic fields*. However, the ICNIRP calculations ignore this directive. They only use average values for heating of tissue, and simplistic modelling that does not include the effect of several important physical characteristics of telecommunication signals such as low frequency modulations, pulsing, polarisation [77] and the constant variability in intensity that occurs with real world signals used in many laboratory experiments [78]. These complexities, together with *the aggregation of different signals* [7, p. 11] from ongoing intermittent spikes of energy, *which can be hundreds of thousands times higher than mean values* [79, p. 458] causing harm to biological tissues irrespective of the average absorbed energy. An ICNIRP literature review admits that pulsed signals *are generally more effective in producing a biological response* [14, p. 506] than continuous signals with same average energy levels. However, the ICNIRP method for calculating risk neglects those characteristics of telecommunication signals that are the most harmful to human and planetary health.

In truth, the exposure patterns caused by beam formed signals from 5G base stations and 5G cell phones are still not fully understood by physicists and engineers [80]. For example, rapid trains of pulsed millimetre waves may create intense hotspots within the skin, causing permanent damage [79, 81]. Furthermore, at millimetre wave frequencies, sweat ducts in the skin both become more conductive and act as spiral antennas [82], thereby increasing their energy absorption from 5G and leading to unforeseen non-thermal biological effects at the higher 5G frequencies [83].

The ICNIRP position has been deemed to be flawed by many reviewers, such as Cherry [84], Favre [85], Hansson-Mild & Hardell [86], ORSAA [87] and Redmayne [88]. The overall state of play has been summarized by Pall: *the*

ICNIRP ... guidelines are completely unscientific and cannot be relied upon to protect our safety [36, p. 17].

Inadequate safety testing

As well as neglecting harmful patterns, aggregations and components of signals, industry and national radiation safety agencies use inadequate testing methods [89] to test only for thermal changes in body tissue. In order to test mobile phones for compliance, heating of brain tissue is estimated by encasing simulant fluids [90] within a large plastic phantom head [91]. Such testing can only validate thermal changes, but does not address the well documented biological interference effects and aggregations of radio-frequency fields on cell integrity and function (described above). Moreover, during measurements, the phones are not pressed against the head, but held 2–3 cm from the phantom head, which leads to underestimates of real exposure levels. If held at 0 mm from the body (by the ear, in a shirt pocket etc.) many cell phones exceed the current “safety limits”. Cell phone tests should be made more realistic with 0 mm distance to the body [92, 93].

These findings have been the basis for recent action against mobile phone companies [93] as well as leading to the French ministries of Health, Ecology and Economy asking the European Commission to ensure that more accurate tests be carried out in contact mode, and consumers be given adequate warnings [94]. The tests carried out consider only heating and from only one cell phone or one tablet during only 6 or 30 min. They do not consider the stronger and extended exposures of real-world environments. For example, a typical school classroom may have 20 simultaneously active tablets, cell phones in many students’ pockets, and a Wi-Fi router in the ceiling, all radiating continuously for at least 5 h a day over many years. The current testing is completely inadequate to ensure safety in such real-world scenarios, where radiation can be life-long and emanating from a large number of sources; e.g., see [95].

Exposure of captured agencies

The deficits of industry-biased bodies are now beginning to be exposed. In 2021, the US Federal Communications Commission (FCC) was deemed by a US Court of Appeals for the D.C. Circuit ruling as having been negligent for two decades in its role as protector of public health, in that when it decided that its 1996 emission guidelines protected public health, it neglected to consider (a) impacts of long term

wireless exposure, (b) unique impacts to children, (c) testimony of people injured by wireless radiation, (d) impacts to wildlife and the environment and (e) impacts to the developing brain and reproduction [96]. The book *Captured Agency* describes the compromised position of the FCC in its role as public protector [97]. The compromised actions of ICNIRP since their inception, including inviting industry representatives to the table, are described by Maisch [98, Chapter 4]. As noted by the Turin Court of Appeal [43], opinions from such conflicted advisory bodies as ICNIRP are not reliable.

New guidelines are needed

After reviewing the above issues of negligence, the Appeal recommends that ICNIRP and SCENIHR be replaced by two new groups of truly industry-independent EMF-health scientists, and that the ICNIRP guidelines be replaced, as described below.

Since the first ICNIRP guidelines were written, the science has evolved and greater understanding has developed. The results of more recent research described above clearly show that the ICNIRP guidelines are out of step with the levels at which harm has been shown to occur and therefore are unable to protect the health of the public. For the reasons given above, the ICNIRP guidelines [14], which consider only heating must be discarded and replaced with guidelines considering all biological effects that have health implications while also utilising principles of safety and precaution.

Citizens' rights to live in peace

Within the new guidelines, all citizens' private and family life must be respected according to the European Convention on Human Rights [99] Article 8:

- (1) *Everyone has the right to respect for his private and family life, his home and his correspondence.*
- (2) *There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.*

Protecting private and family life means that potentially harmful telecommunications signals must not be beaming

into citizens homes or having any effects on their well-being. This fundamental right is currently being violated by the telecommunications industry with the permission of the politicians, and matters are only getting worse as the 5G rollout continues unquestioned in most cities of Europe; e.g., see also [100].

Safety-first

Alternative guidelines to protect citizens have been created by four groups of industry-independent scientists, based on *best available scientific evidence*; i.e., setting exposure levels lower than where biological effects with health implications have been found. As described in [101] these four groups recommend the following limits for human exposures to RF-EMR:

- 1) Building biologists [102] suggest a very low radiation level of no more than $0.1 \mu\text{W}/\text{m}^2$ (in sleeping areas);
- 2) EuropaEM-EMF Environmental Medicine researchers [103] suggest $1 \mu\text{W}/\text{m}^2$ during the night and $10 \mu\text{W}/\text{m}^2$ during the day time;
- 3) The BioInitiative-group conclusions (2012 update) [20], made by 29 prominent researchers, and based on 2,200+ scientific reports, suggest $3\text{--}6 \mu\text{W}/\text{m}^2$ as the upper limit for exposures;
- 4) The Council of Europe (CoE) Resolution 1815 [104] Section 8.2.1 says *set preventative thresholds for levels of long-term exposure to microwaves in all indoor areas, in accordance with the precautionary principle, not exceeding 0.6 V per metre [$1,000 \mu\text{W}/\text{m}^2$], and in the medium term to reduce it to 0.2 V per metre [$100 \mu\text{W}/\text{m}^2$].*

While there is some variation in the above recommendations, they are all far lower than the ICNIRP 2020 guidelines [14] which, for all frequencies from 2–300 GHz, allow a 30 min average whole body exposure of $10,000,000 \mu\text{W}/\text{m}^2$ ($10 \text{ W}/\text{m}^2$; Table 5, p.495). For the more recent, higher 5G frequencies of 6–300 GHz, the ICNIRP guidelines allow an average 6 min local exposure over a 4-cm^2 region of $200,000,000 \mu\text{W}/\text{m}^2$ ($200 \text{ W}/\text{m}^2$; p. 490). Furthermore, *An additional specification of 400 W m^{-2} has been set for spatial averages of square 1-cm^2 regions, for frequencies $>30 \text{ GHz}$* ([14], p. 490). These ICNIRP specification mean that future 5G cell phones may send narrow directional beams that impact small regions of body tissue with intensities of $200,000,000\text{--}400,000,000 \mu\text{W}/\text{m}^2$. However, the maximum intensity should be no higher than $1\text{--}10 \mu\text{W}/\text{m}^2$, according to recommendations 1), 2), 3) above that are aimed at protecting human health.

The above comparisons reveal that ICNIRP and most European states allow incident power densities at least a million times higher than the first three independent advisory bodies mentioned above. This is because the ICNIRP guidelines consider only temperature rises in “tissue simulants” in plastic “heads” but no other risks, like biological effects on living glial cells, blood or DNA, which have been well documented in EU’s sponsored research and reviews [1, 3, 4, 6, 7].

The 5G Appeal asks EU to invoke the precautionary principle

The future health of European children was the focus of a ministerial conference 2004 attended by the European Commissioners for Health and the Environment, European Member States, and the WHO regional director for Europe. The conference declaration [105] noted that *the burden of disease due to environmental hazards is continuing to have serious impacts on public health. We recognize that preventing ill health and injury is infinitely more desirable and cost-effective than trying to address the diseases* (p. 14). The declaration concluded that the Precautionary Principle ... *should be applied where the possibility of serious or irreversible damage to health or the environment has been identified and where scientific evaluation, based on available data, proves inconclusive for assessing the existence of risk and its level but is deemed to be sufficient to warrant passing from inactivity to policy alternatives* (p. 19).

Article 168 of the EU Treaty on the Functioning of the European Union [106] declares that health protection must be ensured (art 168): *A high level of human health protection shall be ensured in the definition and implementation of all Union policies and activities. Union action, which shall complement national policies, shall be directed towards improving public health, preventing physical and mental illness and diseases, and obviating sources of danger to physical and mental health.*

Article 191 of the EU Treaty endorses the Precautionary Principle for protection of the environment (art. 191.2): *Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay.* [107]

The meaning of the Precautionary Principle and how it is to be applied was clarified in a EU Commission

communication [108], summary [109] and associated press release [110] which states:

The Communication underlines that the precautionary principle forms part of a structured approach to the analysis of risk, as well as being relevant to risk management. It covers cases where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU ... and should thus be maintained as long as the scientific data remain incomplete, imprecise or inconclusive and as long as the risk is considered too high to be imposed on society.

The communication from the Commission [108] states that: *Recourse to the precautionary principle presupposes that potentially dangerous effects deriving from a phenomenon ... identified [in this case, electromagnetic fields and radiation], and that scientific evaluation does not allow the risk to be determined with sufficient certainty. ... The implementation of an approach based on the precautionary principle should start with a scientific evaluation, as complete as possible* (p. 3).

Such a scientific evaluation has been conducted, in the EPRS/STOA report [6] and the myriad of reports listed above. These evaluations reveal that there are reasonable grounds for concern, as established above. The risk to human health [58], as well as the risks for insects, birds and plants [52] from all forms of man-made microwave signaling, including 5G [49] must now be deemed by world leaders as too high for society.

The European Commission claims in a press release [110] concerning the Precautionary principle: *The Commission has consistently striven to achieve a high level of protection, inter alia in the environmental and human, animal and plant health fields. It is the Commission’s policy to take decisions aimed to achieve this high level of protection on a sound and sufficient scientific basis.*

Directly addressing this claim is the EU’s own commissioned expert report [6], which maintains that it is now time to invoke the Precautionary Principle. The 5G Appeal therefore asks: *Will the EU Council and Commission conform to the EU Treaty on the Functioning of the European Union, and invoke the precautionary principle as both warranted and urgent?*

The precautionary principle in practice

The European Parliamentary Research Service’s EPRS/STOA report [6] gives guidance for how the

Precautionary Principle may be implemented: The option of lowering RF-EMF exposure as much as possible ... still applies whatever the frequencies, from 1G to 5G (p. vi) ... adopting stricter limits in the EU for mobile phone devices will be simultaneously a sustainable and a precautionary approach. ... Using the lowest frequencies of 5G and adopting precautionary exposure limits ... significantly lower than those recommended by ICNIRP, could help achieve these European sustainability objectives (p. 152).

The EPRS/STOA report goes to great lengths to show how protective solutions may not hinder industry. For example, Italy has a ten-time lower exposure limit with no detrimental effects for industry. The report also nominates fibre-optics as a viable alternative to 5G wireless in schools, libraries, workplaces, houses, public buildings, all new buildings etc. (p 153) and suggests the creation of ‘no RF-EMF’ areas in public gathering places.

The EU has failed to act on warnings

Until now, the EU Health Commission has not acted to protect European citizens from the adverse effects of significantly increased radiation exposure. This is in spite of:

- a. The EU 5G Appeal, which is endorsed now by more than 400 scientists and doctors [4], with more information and research updates in each new cover letter, having during four years been sent six times to the EU for a considered response.
- b. Thousands of research reports [17–21] indicating harmful effects from radiofrequency radiation, described above and summarised in the ORSAA Review [28] and in EMF-data [111] concluding that: *The commonly made claim that there would be no relevant biological effects below the current exposure limits must be considered proven false*
- c. EU expert reports such as the EPRS/STOA report [6], the EU’s in-depth-analysis requested by the ITRE committee, in the EU Parliamentary Briefing ([7], described above).
- d. The detailed critique of the ICNIRP guidelines sent to the EU: *Response to 2018 ICNIRP Draft Guidelines and Appendices on Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields* [112].
- e. The extensive documentation regarding harm sent to the EU: *5G: Great risk for EU, U.S. and International Health! Compelling Evidence for Eight Distinct Types of Great Harm Caused by Electromagnetic Field (EMF) Exposures and the Mechanism that Causes Them* [36].
- f. Viable alternatives available (described above).

Great denials continue

In spite of the above extensive advice since 2017, the EU Health Commission, through their subordinates, have been denying the scientific facts presented to them by the EU’s own commissioned expert reports, and by the Appeal. The Appeal is now endorsed by 400+ independent scientists and medical doctors, of whom 80 are professors, and who base their conclusions on more than 8,000 scientific reports [16–21] and over 100 research reviews [113].

A 2020 article entitled *Appeals That Matter Or Not* [73] describes the series of five back and forth responses from the EU and our subsequent rebuttals reiterating the main points of the Appeal. The article describes how in each case, the EU response was based on denials of scientific facts, and written by a subordinate within the EU Health Commission, contrary to the conduct required of EU Commissioners by the EU Treaty. All responses from the EU Health Commissioners’ subordinates have failed to pay attention to the extensive scientific literature that has been accumulated on harmful non-thermal radiofrequency field effects on health and the environment.

For example, when we asked for a reply to the first version of the Appeal, director John Ryan replied that Commissioner Andriukaitis had tasked him to respond. Ryan’s reply was a canned response [114, p.30] based on the opinions of ICNIRP and SCENIHR, and not based on an evaluation of the evidence presented to the Commission in the Appeal. Ryan replied: *There is consistent evidence that exposure to electromagnetic fields does not represent a health risk ... if it remains below the limits set by Council Recommendation 1999/519/EC.*

Furthermore, in reply to our warnings in a second cover letter 2017 to the EU Health Commissioner that the radiation from several simultaneous sources of 3G, 4G and 5G will pose a high risk for health, the Commissioner subordinate, Arunas Vincinunas, replied that: *The recourse to the EU’s precautionary principle to stop distribution of 5G products appears too drastic a measure. We need first to see how this technology will be applied and how the scientific evidence will evolve* [115].

The most recent Appeal specifically requested that the Commissioners for Health and for the Environment, Kyriakides and Sinkevičius, as well as other EU representatives, refrain from making the same mistake in office, and to instead make an honest and considered reply, based on the *best available scientific evidence*. However, the response to the recent Appeal has been similar to responses of the past. The subordinates of the EU health Commissioner have

several times responded to us that the EU prefers to trust in ICNIRP and SCENIHR. This trust remains even though the two bodies have repeatedly been shown to be compromised by links with industry, as stressed in the 5G Appeal text (in footnote 1): *Avoid similar mistakes as when the Commission (2008/721/EC) [116] appointed industry supportive members for SCENIHR [71], who submitted to EU a misleading SCENIHR report on health risks giving telecom industry a clean bill to irradiate EU-citizens [117]. The report is now quoted by radiation safety agencies in EU.*

After four years and six submission versions of the 5G Appeal sent to the EU Health Commissioner, several other Commissioners and members of the Council, including new cover letters with research updates since 2017, the authors of the Appeal have not yet received any relevant and trustworthy replies, but only dismissive phrases and assertions such as the quotations provided above. It is now time to for the EU Commission to take stock, listen to warnings from 400+ scientists and physicians to start following the requirements specified in European Case Law presented above.

Conclusions for EU policy

The Appeal asks the Commissioners: *what measures you will take to protect the EU-inhabitants against RF-EMF and especially 5G radiation?* To assist the Commission to answer to this question, the Appeal informs the EU that in order to protect EU citizens and the environment it is now time to:

- Accept that ICNIRP and SCENIHR have been misrepresenting the scientific evidence due to industry influences.
- Replace SCENIHR and ICNIRP members, who are industry supportive (as well proven above) with truly industry-independent and knowledgeable biological and medical researchers; e.g., from groups such as Building Biologists, EuropaEM-EMF, the BioInitiative group, and other respected independent researchers.
- Comply with European law and thus no longer give precedence to industry's plans for 5G on the basis of mainly economic considerations.
- Follow the EU treaty mandate to protect human health and the total environment [106] by creating new guidelines that:
 - i. Reduce the exposure limits (The EU's own EPRS/STOA report [6] suggests that EU should *revise residential and public exposure maxima*) and
 - ii. Address the man-made pulsations, their aggregations and complexity of signals that cause the high risks (as described above).

- Accept that the health risks are real because around 70% of all research in the area shows biological effects with the potential to cause harm occurring within the ICNIRP guidelines (as shown above). Therefore, invoke the Precautionary Principle in the roll-out of this new technology. According to the European Commission [107] *the precautionary principle may be invoked when a phenomenon, product or process may have a dangerous effect, identified by a scientific and objective evaluation, if this evaluation does not allow the risk to be determined with sufficient certainty.* (Article 191)

Invoking the Precautionary principle means re-establishing guidelines to be environmental-centered, and with consideration for the wellbeing of sensitive populations, animals and insects, and to choose safety as the first priority.

In a *Lancet Planetary Health* article, Bandara and Carpenter [118] illustrate how planetary man-made radio frequency electromagnetic pollution has increased a billion-fold during the past four decades, with exposure sustained from conception to death. Thus, humans and the environment have not had sufficient time to adapt to current radiation levels. They conclude: *A genuine evidence-based approach to the risk assessment and regulation of anthropogenic electromagnetic fields will help the health of us all, as well as that of our planetary home.*

This review of the Appeal and the EU responses thus leads to the request to the EU to take all necessary measures to dissolve ICNIRP and SCENIHR and rescind their guidelines of 10,000,000–400,000,000 $\mu\text{W}/\text{m}^2$, replacing them instead with the available alternative, safety-first guidelines with a total maximum of 100 $\mu\text{W}/\text{m}^2$ [0.2 V/m] as proposed in 2011 by the Council of Europe [104].

The Appeal maintains that it is necessary to adopt a moratorium on 5G deployment until a new international group of truly industry-independent experts with no conflicts of interest has summarised the research in the area and suggested guidelines which protect against all adverse health effects, not only heating [119]. Therefore, the first suggestion in The Appeal is for a moratorium; i.e.,

We urge EU: 1) To take all reasonable measures to halt the 5G RF-EMF expansion until independent scientists can assure that 5G and the total radiation levels caused by RF-EMF (5G together with 2G, 3G, 4G, and WiFi) will not be harmful for EU citizens, especially infants, children and pregnant women, as well as the environment [4].

The Appeal also asks the Commission to disseminate the information, health warnings and cited sources contained in The Appeal to all stakeholders and 5G/6G decision makers within the EU, in order to ensure that they act

in accordance with the EU treaty, EU laws and international agreements and the EU's Precautionary Principle.

Concluding remarks

At the current juncture, millions of EU citizens are relying on the EU to address the issues raised in the EU 5G Appeal. The EU decision makers need to put aside their industry-fuelled fantasies of a digital saviour for mankind and instead, ensure that industry acts according to EU laws, made to prioritise humans and planetary health above industry profit or science fiction futures. *Any economic benefits from 5G are likely to be outweighed by the risk of harm to the health of billions of people around the world* [33].

If the EU continues to fail to act on these warnings, Europe may end up being faced with a non-reversible burgeoning health impact on humans, especially children and the environment.

To allow the levels and frequencies of exposures to continue unfettered is to put the world population and the environment at great risk, especially young people [28].

Research funding: No funding was received.

Author contributions: All authors participated in the conception, design and writing of the manuscript, and have read and approved the final version

Competing interests: The authors declare that they have no competing interests.

Informed consent: Not applicable.

Ethics approval and consent to participate: Not applicable.

Patient consent for publication: Not applicable.

Availability of data and materials: The information generated and analysed during the current study is available from the corresponding author on reasonable request.

References

- Gee D, Grandjean P, Foss Hansen S, van den Hove S, MacGarvin M, Martin J, et al. editors. Late lessons from early warnings: science, precaution, innovation. Luxembourg: European Environment Agency. Publications Office of the European Union; 2013. Available from: <https://www.eea.europa.eu/publications/late-lessons-2>.
- Walker MJ. Corporate ties that bind: an examination of corporate manipulation and vested interest in public health. New York, NY, USA: Skyhorse Publishing Inc; 2017.
- Hardell L, Carlberg M. Lost opportunities for cancer prevention: historical evidence on early warnings with emphasis on radiofrequency radiation. *Rev Environ Health* 2021;36:585–97.
- Nyberg R, Hardell L. European 5G appeal; 2017. Available from: <http://www.5gappeal.eu/>.
- European Commission. Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions. 5G for Europe: an action plan. Brussels: European Commission; 2016. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0588>.
- Belpoggi F. Health impact of 5G, study for the panel for the future of science and technology, panel for the future of science and technology. In: European parliamentary research service, scientific foresight unit. Brussels; 2021. Available from: [https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690012/EPRS_STU\(2021\)690012_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690012/EPRS_STU(2021)690012_EN.pdf).
- Blackman C, Forge S. 5G deployment: state of play in Europe, USA and Asia, study for the committee on industry, research and energy, policy. Luxembourg: Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament; 2019. [https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL_IDA\(2019\)631060_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL_IDA(2019)631060_EN.pdf).
- Panagopoulos DJ, Karabarounis A, Yakymenko I, Chrousos GP. Human-made electromagnetic fields: ion forced-oscillation and voltage-gated ion channel dysfunction, oxidative stress and DNA damage. *Int J Oncol* 2021;59:1–16.
- Hyland GJ. Physics and biology of mobile telephony. *Lancet* 2000;356:1833–6.
- The Council of the European Union. Council conclusions on shaping Europe's digital future. Brussels; 2020. Available from: <https://www.consilium.europa.eu/media/44389/st08711-en20.pdf>.
- Connecting Europe Facility — CEF Digital. Digital program 2021–2017. Brussels: European Commission; 2021. [press release] Available from: <https://digital-strategy.ec.europa.eu/en/news/launch-new-calls-worth-eu258-million-support-digital-connectivity-infrastructures>.
- European Commission. European declaration on digital rights and principles for the digital decade. Brussels: European Commission; 2022. Available from: <https://digital-strategy.ec.europa.eu/en/library/declaration-european-digital-rights-and-principles>.
- European Parliament and the Council. Directive (EU) 2018/1972 European parliament and of the council of 11 December 2018 establishing the European electronic communications code. *Eur-Lex*; 2018. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L1972&from=EN>.
- International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). *Health Phys* 2020;118:483–524.
- European Commission. 5G and electromagnetic fields [press release]. Brussels: European Commission; 2021. Available from: <https://digital-strategy.ec.europa.eu/en/policies/5g-and-electromagnetic-fields>.
- Tachover D. Archive of 4,000 documents reveals government knew decades ago about health impact of wireless technology. *Aust Natl Rev (ANR News)* 2021;19. <https://www.australiannationalreview.com/state-of-affairs/archive-of-4000-documents-reveals-government-knew-decades-ago-about-health-impact-of-wireless-technology/>.
- Glaser ZR. Bibliography of reported biological phenomena ('effects') and clinical manifestations attributed to microwave and radio-frequency radiation. Inst Bethesda MD: Naval Medical

- Research; 1972. Available from: <https://apps.dtic.mil/sti/pdfs/AD0750271.pdf>.
18. Glaser ZR, Brown PF, Brown MS. Bibliography of reported biological phenomena ('effects') and clinical manifestations attributed to microwave and radio-frequency radiation: Compilation and integration of report and seven supplements. Bethesda MD: Naval Medical Research Institute Detachment at Naval Surface Weapons Centre; 1976. Available from: <https://ehtrust.org/wp-content/uploads/Naval-MRI-Glaser-Report-1976.pdf>.
 19. Bio Initiative Working Group. BioInitiative report: A rationale for a biologically-based public exposure standard for electromagnetic fields (ELF and RF). Sage C, Carpenter DO, editors; 2007. Available from: <https://www.centerforadvancedmed.com/wp-content/uploads/2018/10/bioInitiativeReport2012.pdf>.
 20. Bio Initiative Working Group. BioInitiative report: A rationale for a biologically-based public exposure standard for electromagnetic radiation. Sage C, Carpenter DO, editors; 2012. Available from: <https://bioinitiative.org/>.
 21. Bio Initiative Working Group. BioInitiative report: 2020 updated research summaries. Sage C, Carpenter DO, editors; 2020. Available from: <https://bioinitiative.org/research-summaries/>.
 22. Lustenberger C, Murbach M, Dürr R, Schmid MR, Kuster N, Achermann P, et al. Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement. *Brain Stimul* 2013;6:805–11.
 23. Bandara P, Weller S. Cardiovascular disease: time to identify emerging environmental risk factors. *Eur J Prev Cardiol* 2017;24: 1819–23.
 24. National Toxicology Program. Peer review of the draft NTP technical reports on cell phone radiofrequency radiation. Research Triangle Park, NC: National Institute of Environmental Health Sciences; 2018. Available from: https://ntp.niehs.nih.gov/ntp/about_ntp/trpanel/2018/march/peerreview20180328_508.pdf.
 25. Lai H. Genetic effects of non-ionizing electromagnetic fields. *Electromagn Biol Med* 2021;40:264–73.
 26. Vriens L. Summary of REFLEX study: jrs eco wireless; 2011. Available from: <https://www.jrseco.com/eu-reflex-study-shows-dna-damage-caused-by-radiation-from-wireless-devices-and-mobile-phones/>.
 27. Adlkofer F, Belyaev IY, Richter K, Shiroff VM. How susceptible are genes to mobile phone radiation. Effect of wireless communication technology. In: State of the research endorsements of safety and controversies– self help recommendations; 2009, vol 3, 3–24 pp. Available from: <https://www.jrseco.com/wp-content/uploads/how-susceptible-are-genes-to-mobile-phone-radiation-adlkofer-kompetenz.pdf>.
 28. Oceania Radiofrequency Scientific Advisory Association. Statement regarding harmful biological effects of communication radiofrequencies; 2021. Available from: <https://www.orsaa.org/uploads/6/7/7/9/67791943/eu-attachment1-orsaa.pdf>.
 29. Mevissen M, Schürmann D. Is there evidence for oxidative stress caused by electromagnetic fields? In: BERENIS–the swiss expert group on electromagnetic fields and non-ionising radiation newsletter–special issue January; 2021:1–10 pp. Available from: <https://www.bafu.admin.ch/bafu/en/home/topics/electrosmog/publications-studies.html>.
 30. Panagopoulos DJ, Karabarbounis A, Margaritis LH. Mechanism for action of electromagnetic fields on cells. *Biochem Biophys Res Commun* 2002;298:95–02.
 31. Panagopoulos DJ, Messini N, Karabarbounis A, Philippetis AL, Margaritis LH. A mechanism for action of oscillating electric fields on cells. *Biochem Biophys Res Commun* 2000;272: 634–40.
 32. Bai D, Fang L, Xia S, Ke W, Wang J, Wu X, et al. Porcine deltacoronavirus (PDCoV) modulates calcium influx to favor viral replication. *Virology* 2020;539:38–48.
 33. Tsiang A, Havas M. COVID-19 attributed cases and deaths are statistically higher in states and counties with 5th generation millimeter wave wireless telecommunications in the United States. *Med Res Arch* 2021;9. <https://doi.org/10.18103/mra.v9i4.2371>.
 34. Pall ML. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. *J Cell Mol Med* 2013;17:958–65.
 35. Pall ML. Wi-Fi is an important threat to human health. *Environ Res* 2018;164:405–16.
 36. Pall ML. 5G: great risk for EU, US and international health: compelling evidence for eight distinct types of great harm caused by electromagnetic field (EMF) exposures and the mechanism that causes them. 2018. Available from: https://www.5gappeal.eu/wp-content/uploads/2018/06/pall_2018.pdf.
 37. Adlkofer F. Risk evaluation of potential environmental hazards from low energy electromagnetic field exposure using sensitive in vitro methods. In: Bioelectromagnetics current concepts. Springer; 2006:331–54 pp. Available from: https://link.springer.com/chapter/10.1007/1-4020-4278-7_22.
 38. National Toxicology Program. NTP technical report on the toxicology and carcinogenesis studies in sprague Dawley rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones. Technical Report 2018;NTP TR-595. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr595_508.pdf.
 39. National Toxicology Program. NTP technical report on the toxicology and carcinogenesis studies in B6C3F1/N mice exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones. Technical Report 2018;TR-596. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr596_508.pdf.
 40. Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. *Environ Res* 2018;165:496–503.
 41. Melnick RL. Commentary on the utility of the National Toxicology Program Study on cell phone radiofrequency radiation data for assessing human health risks despite unfounded criticisms aimed at minimizing the findings of adverse health effects. *Environ Res* 2019;168:1–6.
 42. Uche UI, Naidenko OV. Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach. *Environ Health* 2021;20:1–14.

43. Romeo V. INAIL the decision of the tribunal of Ivrea of 2017, 904/2019 of 3.12.2019; 2020. Available from: <https://phonegatealert.org/en/the-court-of-appeal-of-turin-confirms-the-link-between-a-head-tumour-and-mobile-phone-us>.
44. el Periodico de Aragon. TSJA links electrosensitivity to workplace accidents; 2019. Available from: <https://www.theguardian.com/technology/2017/apr/21/italian-court-rules-mobile-phone-use-caused-brain-tumour>.
45. Radio television Switzerland, three-year moratorium on 4G+ and 5G in Geneva. 2020, The Swiss Broadcasting and Television Society. Available from: <https://www.rts.ch/info/regions/geneve/11125794-moratoire-de-trois-ans-sur-la-4g-et-la-5g-a-geneve.html>.
46. Karaboytcheva M. Effects of 5G wireless communication on human health. European Parliamentary Research Service; 2020. Available from: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/646172/EPRS_BRI\(2020\)646172_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/646172/EPRS_BRI(2020)646172_EN.pdf).
47. Koziol M. 5G's Waveform is a battery vampire. IEEE Spectrum; 2019. Available from: <https://spectrum.ieee.org/5gs-waveform-is-a-battery-vampire>.
48. Broomhall R. Global deployment of 100,000 5G satellites continues, What are the health effects? Green planet FM. New Zealand. 2021. Available from: <https://www.ourplanet.org/greenplanetfm/ray-broomhall-global-deployment-of-100000-5g-satellites-continues-what-are-the-health-effects>.
49. Di Ciaula A. Towards 5G communication systems: are there health implications? Int J Hyg Environ Health 2018;221:367–75.
50. Buchner K, Krout M. 5G-Wahn[sinn] (5G Madness). Murnau a. Staffelsee, Germany: Mankau Verlag; 2021:255 p.
51. Levitt BB, Lai HC, Manville AM. Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment. Rev Environ Health 2021;37:81–122.
52. Physicians for Safe Technology. Environment and wildlife effects; 2016. Available from: <https://mdsafetech.org/environmental-and-wildlife-effects/>.
53. Thielens A, Bell D, Mortimore DB, Greco MK, Martens L, Joseph W. Exposure of insects to radio-frequency electromagnetic fields from 2 to 120 GHz. Sci Rep 2018;8:3924.
54. Thill A. Biological effects of electromagnetic fields on insects, Review. Published in: Umwelt · Medizin · Gesellschaft 2020; 33(Suppl. 3):1–27. https://ehtrust.org/wp-content/uploads/Thill_Review_Insects_2020_Engl.pdf.
55. Halgamuge MN. Review: weak radiofrequency radiation exposure from mobile phone radiation on plants. Electromagn Biol Med 2017;36:213–35.
56. Waldmann-Selsam C, Balmori-de la Puente A, Breunig H, Balmori A. Radiofrequency radiation injures trees around mobile phone base stations. Sci Total Environ 2016;572:554–69.
57. Balmori A. Electromagnetic pollution from phone masts. effects on wildlife. Pathophys 2009;16:191–9.
58. Miller AB, Sears ME, Morgan LL, Davis DL, Hardell L, Oremus M, et al. Risks to health and well-being from radio-frequency radiation emitted by cell phones and other wireless devices. Front Public Health 2019;7(Article 223):1–10.
59. Balmori A. Electromagnetic radiation as an emerging driver factor for the decline of insects. Sci Total Environ 2021;767: 144913.
60. Ippolito LJ, Jr. Satellite communications systems engineering: atmospheric effects, satellite link design and system performance. John Wiley & Sons; 2017. Available from: <https://ieeexplore.ieee.org/book/8040455>.
61. Witze A. Global 5G wireless deal threatens weather forecasts. Nature 2019;575:577–8.
62. Centre for Energy Efficient Communications. The power of wireless cloud. Bell Labs and University of Melbourne; 2015. Available from: <https://ceet.unimelb.edu.au/publications/ceet-white-paper-wireless-cloud.pdf>.
63. Vertiv 5G. The risks and rewards for operators. In: Vertiv and 451 research; 2019. Available from: <https://www.vertiv.com/en-emea/about/news-and-insights/articles/white-papers/5g-the-risks-and-rewards-for-operators/>.
64. European Parliament and The Council. Regulation (EU) 2021/1153 of the European parliament and of the council of 7 July 2021 establishing the connecting Europe facility and repealing regulations (EU) No 1316/2013 and (EU) No 283/2014. Eur-Lex; 2021. (Document 32021R1153). Available from: <https://digital-strategy.ec.europa.eu/en/news/connecting-europe-facility-regulation-adopted-support-connectivity-across-eu>.
65. Schoechele T. Re-Inventing wires: the future of landlines and networks, Washington, DC: National Institute for Science, Law & Public Policy; 2018, vol 69. Available from: <http://www.emrsa.co.za/wp-content/uploads/2018/02/ReInventing-Wires-1-25-18.pdf>.
66. European Commission. New approach to enable global leadership of EU standards promoting values and a resilient, green and digital single market. Brussels: European Commission; 2022. Available from: <https://digital-strategy.ec.europa.eu/en/news/new-approach-enable-global-leadership-eu-standards-promoting-values-and-resilient-green-and-digital>.
67. The Council of the European Union. Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC). Official Journal of the European Communities; 1999. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999H0519&from=EN>.
68. The Commission of the European Communities. 2008/721/EC: commission decision of 5 August 2008 setting up an advisory structure of scientific committees and experts in the field of consumer safety, public health and the environment and repealing decision 2004/210/EC. (Text with EEA relevance), O.J.o.t.E. Union, Editor. 2008. Available from: <https://eur-lex.europa.eu/eli/dec/2004/210/oj>.
69. Scientific Committee on Emerging Newly Identified Health Risks. Opinion on potential health effects of exposure to electromagnetic fields. Bioelectromagnetics 2015;36:480–4.
70. Sage C, Carpenter DO, Hardell L. Comments on SCENIHR: opinion on potential health effects of exposure to electromagnetic fields. Bioelectromagnetics 2015;36:480–4.
71. Swedish Radiation Protection Foundation and Priartem. Complaint SCENIHR opinion on health effects from electromagnetic fields 2015: annex 1. SCENIHR members' history (bias and conflicts of interest). Sweden and France; 2015. Available from: http://www.stralskyddsstiftelsen.se/wp-content/uploads/2015/09/Annex_1_SCENIHR_Experts_2015.pdf.
72. van Scharen H. The International commission on non-ionizing radiation protection: conflicts of interest, corporate capture and the push for 5G. members of the European Parliament – Michèle Rivasi (Europe Écologie) and Klaus Buchner (Ökologisch-Demokratische Partei); 2020. Available from:

- <https://kompetenzinitiative.com/wp-content/uploads/2020/07/ICNIRP-report-FINAL-19-JUNE-2020.pdf>.
73. Hardell L, Nyberg R. [Comment] Appeals that matter or not on a moratorium on the deployment of the fifth generation, 5G, for microwave radiation. *Mol Clin Oncol* 2020;12:247–57.
 74. Nordhagen EK, Flydal E. Self-referencing authorships behind the ICNIRP 2020 radiation protection guidelines. *Rev Environ Health* 2022. <https://doi.org/10.1515/reveh-2022-0037>. In press.
 75. Carlo GL, Schram M. *Cell Phones: invisible Hazards in the wireless age*. New York: Carroll & Graf Publishers Inc; 2001.
 76. European Parliament and the Council. Directive 2013/35/EU of the European parliament and of the council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields): *Eur-Lex*; 2013. Available from: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013L0035>.
 77. Panagopoulos DJ, Johansson O, Carlo GL. Polarization: a key difference between man-made and natural electromagnetic fields, in regard to biological activity. *Sci Rep* 2015;5:1–10.
 78. Panagopoulos DJ. Comparing DNA damage induced by mobile telephony and other types of man-made electromagnetic fields. *Rev Mutat Res* 2019;781:53–62.
 79. Puranen L. Altistumisen mittaus ja laskentamallit (Finnish: exposure measurement and calculation models) in Sähkömagneettiset kentät. In: Nyberg H, Jokela K, editors. *Karisto, Hämeenlinna: Säteily- ja ydinturvallisuus-sarja, osa, vol 6*; 2006:455–99 pp. Available from: https://www.stuk.fi/documents/12547/494524/6_10.pdf/588055cc-7672-446a-a12a-570df87b3599.
 80. Keller H. On the assessment of human exposure to electromagnetic fields transmitted by 5G NR base stations. *Health Phys* 2019;117:541–5.
 81. Neufeld E, Samaras T, Kuster N. Discussion on spatial and time averaging restrictions within the electromagnetic exposure safety framework in the frequency range above 6 GHz for pulsed and localized exposures. *Bioelectromagnetics* 2020;41:164–8.
 82. Hayut I, Putzenko A, Ben Ishai P, Polsman A, Agranat AJ, Puzenko FY. The helical structure of sweat ducts: their influence on the electromagnetic reflection spectrum of the skin. *IEEE Trans Terahertz Sci Techn* 2012;3:207–15.
 83. Betzalel N, Ishai PB, Feldman Y. The human skin as a sub-THz receiver—does 5G pose a danger to it or not? *Environ Res* 2018; 163:208–16.
 84. Cherry NJ. Criticism of the health assessment in the ICNIRP guidelines for radiofrequency and microwave radiation (100 kHz–300 GHz); 2002. Available from: <https://core.ac.uk/download/pdf/35464854.pdf>.
 85. Favre D. Comments on the ICNIRP draft RF guidelines. Environment and Cancer Research Foundation; 2018. Available from: <https://environmentandcancer.com/comments-icnirp-hansson-mild-hardell/>.
 86. Hanson-Mild K, Hardell L. Comments on the ICNIRP draft RF guidelines. Environment and Cancer Research Foundation; 2018. Available from: <https://environmentandcancer.com/comments-icnirp-hansson-mild-hardell/>.
 87. Oceania Radiofrequency Scientific Advisory Association. Comments on the ICNIRP draft RF guidelines. ICNIRP; 2018. Available from: https://www.icnirp.org/cms/upload/consultation_upload/Respondent4.
 88. Redmayne M. Comments on the ICNIRP draft RF guidelines. Environment and Cancer Research Foundation; 2018. Available from: <https://environmentandcancer.com/comments-icnirp-redmayne/>.
 89. Environmental Health Trust. *The SAR Test Is Inadequate*; 2017. Available from: <https://ehtrust.org/sar-test-inadequate/>.
 90. Indexsar. *SAR test systems and human body phantoms for wireless testing: tissue simulant fluids horsham*. West Sussex; 2022. Available from: <https://indexsar.com/product-category/phantoms/tissue-simulant-fluids-phantoms/fluids-tissue-simulant-fluids-phantoms/>.
 91. Lazer Sam. *Comrel Technologies*; 2019. Available from: https://comreltec.com/wp-content/uploads/2019/03/lazer-sam-compv1_orig-1024x769.jpg.
 92. Gandhi OP. Microwave emissions from cell phones exceed safety limits in Europe and the US when touching the body. *IEEE Access* 2019;7:47050–2.
 93. Arazi M, Davis DL. Background and facts documenting phone gate and our call for congressional action. In: *Phonagate and the environmental health trust*; 2020. Available from: <https://www.phonagatealert.org/wp-content/uploads/2020/01/Background-and-Facts-on-PhoneGate-with-links.pdf>.
 94. Arazi M. (Eng. translation by Regan Kramer). *Phonagate. Overexposed and deceived: what the cell phone industry doesn't want you to know*. France: Massot Editions; 2020.
 95. Leach V, Weller S, Redmayne M. Letter to the Editor. Comments on Karipidis, KK, Henderson, AS, Wijayasinghe, D, Tjong, L. and Tinker, R. Exposure to radiofrequency electromagnetic fields from WiFi in Australian schools. *Radiat Protect Dosim* 2017;177: 356–8.
 96. Children's Health Defense Team. 'Historic Win': CHD wins case against FCC on safety guidelines for 5G and wireless: The Defender Children's health defense news and views; 2021. Available from: <https://childrenshealthdefense.org/defender/chd-wins-case-fcc-safety-guidelines-5g-wireless/>.
 97. Alster N. *Captured Agency. How the federal communications commission is dominated by the industries it presumably regulates*. Cambridge, MA: Edmond J. Safra Center for Ethics Harvard University; 2021. Available from: <https://www.alumni.columbia.edu/content/captured-agency-how-federal-communications-commission-dominated-industries-it-presumably>.
 98. Maisch DR. The procrustean approach: setting exposure standards for telecommunications frequency electromagnetic radiation. An examination of the manipulation of telecommunications standards by political, military, and industrial vested interests at the expense of public health protection. New South Wales, Australia: University of Wollongong; 2009. Available from: <https://ro.uow.edu.au/cgi/viewcontent.cgi?article=4148&context=theses>.
 99. Council of Europe. *European convention on human rights*. Strasbourg, France; 2021. Available from: https://www.echr.coe.int/Documents/Convention_ENG.pdf.
 100. Koppel T, Hardell L. Measurements of radiofrequency electromagnetic fields, including 5G, in the city of Columbia, SC, USA. *World Acad Sci J* 2022;4:23.
 101. Hardell L, Nilsson M, Koppel T, Carlberg M. Aspects on the international commission on non-ionizing radiation protection (ICNIRP) 2020 guidelines on radiofrequency radiation. *J Cancer Sci Clin Ther* 2021;5:250–85.

102. Institut für Baubiologie+Ökologie IBN. Building biology evaluation guidelines for sleeping area. In: Supplement to the standard of building biology testing methods SBM; 2008. Available from: <https://www.baubiologie.de/downloads/building-biology-guidelines-english.pdf>.
103. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, et al. Europa EMF guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. *Rev Environ Health* 2016;31:363–97.
104. Council of Europe Parliamentary Assembly. The potential dangers of electromagnetic fields and their effect on the environment; 2011. Available from: <https://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994>.
105. Fourth ministerial conference on environment and health declaration. Budapest, Hungary: World Health Organisation Europe; 2004. Available from: https://www.euro.who.int/__data/assets/pdf_file/0004/88222/RC54_edoc10annexes.pdf.
106. European Union. Consolidated version of the treaty on the functioning of the European Union. Official Journal of the European Union; 2008, 51. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2008:115:FULL&from=EN>.
107. European Union. Consolidated version of the treaty on the functioning of the European Union, part three - Union policies and internal actions; 2008. Title xx - Environment Article 191 Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:12016E191>.
108. Commission of the European Communities. Communication from the commission on The precautionary principle. Brussels: European Commission; 2000. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52000DC0001&from=EN>.
109. European Union. Summary of communication (COM(2000) 1 final) on the precautionary principle. Brussels; 2000. Available from: <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l32042>.
110. European Commission. Commission adopts communication on precautionary principle. Brussels: Press Release; 2000. Available from: https://ec.europa.eu/commission/presscorner/detail/en/IP_00_96.
111. Diagnose:Funk. EMF-Data: 514 studies about electromagnetic fields. Germany; 2015. Available from: <https://www.emfdata.org/en/study-overview>.
112. Pall ML. Response to 2018 ICNIRP draft guidelines and appendices on limiting Exposure to time-varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz); 2018. Available from: https://www.icnirp.org/cms/upload/consultation_upload/Respondent76.
113. Diagnose:Funk. Liste EMF-reviews (112 reviews). Germany; 2022. Available from: <https://www.emfdata.org/en/study-overview?&studycategory=3>.
114. European Commission. Directorate-general health and food safety. Reply from director John F. Ryan. Luxembourg. Ares(2017) 5015409 - 13/10/2017; 2017. Available from: https://www.5gappeal.eu/wp-content/uploads/2018/06/reply_ryan.pdf.
115. Vinciunas A. Head of Cabinet. Second reply to the EU Appeal from the European Commission, Cabinet of Commissioner Vytenis Andriukaitis. Ref. Ares(2017) 5844097 (29.11.2027). Available from: https://www.stralskyddsstiftelsen.se/wp-content/uploads/2018/01/2nd_reply_EU_to_RN_LH.pdf.
116. The Commission of the European Communities. 2008/721/EC: Commission decision of 5 August 2008 setting up an advisory structure of scientific committees and experts in the field of consumer safety, public health and the environment and repealing decision 2004/210/EC (Text with EEA relevance). Brussels; 2008. Available from: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008D0721>.
117. Scientific committee on emerging and newly identified health risks (SCENIHR). opinion on potential health effects of exposure to electromagnetic fields (EMF). Luxembourg: European Commission; 2015. Available from: https://ec.europa.eu/health/scientific_committees/emerging/docs/scenih_r_o_041.pdf.
118. Bandara P, Carpenter DO. Planetary electromagnetic pollution: it is time to assess its impact. *Lancet Planet Health* 2018;2: e512–e4.
119. Hardell L, Carlberg M. [Comment] Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest. *Oncol Lett* 2020;29: 1–11.