Mobile Phone Infrastructure Regulation in Europe: Scientific Challenges and Human Rights Protection

Claudia Roda [a] and Susan Perry [b]
The American University of Paris, 147 rue de Grenelle 75007 Paris France

[a] Computer Science Department – croda@aup.edu
[b] International Politics Department – sperry@aup.edu

Corresponding author:
Claudia Roda
The American University of Paris
147 rue de Grenelle
75007 Paris France
croda@aup.edu
+33 1 40620701

Abstract
As the progress of mobile phone technology accelerates throughout Europe, the regulatory framework necessary for its safe and extended use has been slow to develop. This article analyses the relationship between scientific knowledge and regulation concerning the heath effects of increasing emissions of electromagnetic fields (EMF). From a conservationist perspective, no other example of industrial impact on the natural environment has achieved such extended penetration so quickly. From a theoretical standpoint, stakeholders are faced with a difficult choice between comprehensive risk assessment versus immediate application of the precautionary principle. By exploring the interaction between citizens, governments, and international bodies, we first analyse the challenges faced by regulators in the presence of uncertain scientific knowledge and standards of measurement. We then highlight the inadequacy of current risk assessment parameters. Lastly, within the context of State and European regulation of EMF exposure, we expand scholarship on the human rights framework to protect vulnerable populations from environmental pollution. We conclude that, because scientific knowledge is incomplete, a precautionary approach is better suited to State obligations under international human rights law.

Keywords: EMF, Human Rights, Technology and Health, Mobile Phones

1. Introduction

The use of mobile phones is ubiquitous, and is estimated to have reached 96% penetration worldwide (ITU, 2013, 1). Mobile broadband, used for wireless access to the Internet, has more than 2 billion subscriptions worldwide, with penetration levels that reach 68% in Europe (ibid. 6). Scientific research has attempted to determine whether exposure to Electromagnetic Fields (EMF) during mobile phone use is dangerous to human health. Yet, while the public remains focused on the possible dangers of the mobile device itself, the rapidly growing infrastructure necessary for mobile communication is interfering with human physiology, as 'the antennae of broadcast stations are the most powerful continuous sources of RF energy intentionally radiated into free space' (ICNIRP, 2009, 11). From a conservationist perspective, no other example of industrial impact on the natural environment has achieved such extended penetration so quickly.

Base Transceiver Stations (BTS) – equipment normally connected to elevated structures that relay electromagnetic signals between mobile devices and a network – emit electromagnetic energy. EMF emission is widespread; the European Union, for example, requires maximal coverage for its citizens.[1] However, virtually no national legislation exists to protect the same consumers from the possible effects of prolonged EMF exposure via BTS, nor do most governments require public hearings concerning the placement and number of BTS. Such hearings are mandatory for many other potential sources of environmental pollution. The International Agency for Research on Cancer (IARC), a World Health Organization's (WHO) specialised agency, recently classified EMF as Group 2B: possibly carcinogenic to humans (IARC, 2013). The Lancet Oncology (Baan et al., 2011) reports that the IARC committee mainly focused on two types of exposures: those due to use of personal devices and those due to occupational sources. A third type of exposure, due to environmental sources, such as BTS, was not included because the committee found 'the available evidence insufficient for any conclusion' (ibid. 625). This is of obvious concern because a large part of the population is exposed to the compound effect of radiation from BTS, handsets radio transmitters, WLAN, Wi-Fi, portable computers, and other devices; more importantly, children are at higher risk according to many studies (e.g. Blank and Goodman, 2009; ICNIRP, 2009).

As scientific research on possible health effects of exposure to EMF sources continues, we aim to contribute to existing scholarship on European environmental policy by (1) explaining the current biological research on the impact of EMF on the living environment and the difficulty in establishing EMF protection standards in Europe due to a complex, controversial risk assessment procedure and measurement paradigm; (2) evaluating the extent of the resulting inadequacies in national regulatory systems (France is our example); and (3) expanding the human rights construct to 'protect, respect and remedy' vulnerable populations by including State and European regulation of EMF

[1] The Digital Agenda for Europe (DAE) required Member States to devise and make operational by 2012 national broadband plans with the objective of meeting the broadband targets for Europe by 2020.

exposure within a "due diligence" environmental pollution framework. From a theoretical standpoint, the regulator's dilemma encompasses a choice between the principle of precaution and long-term risk assessment. This article suggests that, due to the lack of scientific consensus and contradictory standards of measurement, the international and European human rights frameworks on the protection of vulnerable populations may oblige States to adopt a precautionary approach in the short and medium term, until a majority of peer-reviewed scientific publications establish the danger, or safety, of electromagnetic wave emissions.

2. The Regulator's Dilemma

Regulators may draw upon two bodies of theoretical knowledge in formulating a viable policy strategy to protect vulnerable populations from the potential health risks associated with EMF exposure. One set of theories underpins risk assessment, developed primarily in the fields of economic, financial, and behavioural theory, while the other draws from the German concept of *Vorsorge*,[2] an expansion of 19th century British law and its evolution into an obligatory due diligence framework for governments and the private sector.[3] In their work on prospect theory, Tversky and Kahneman (1981) demonstrate that human beings are hardly rational when it comes to risk assessment: the majority of respondants in one of their studies, for example, found that the certain death of 400 people is less acceptable than the two-in-three chance that 600 will die, despite the fact that the statistical risk is nearly identical. Scholarship over the course of the past ten years has attempted to address human irrationality in risk assessment by integrating due diligence and risk evaluation into a coherent paradigm that allows regulators to know when and how to favour one over the other. Economist Christian Gollier presents what he calls a "reasonable interpretation" of the precautionary principle (Gollier et al., 2001). When the basic scientific data of the decision problem are uncertain, Gollier suggests that the "learn then act" principle should be applied only when a careful costs-benefits analysis establishes that current and future preventative actions are close substitutes for one another. In all other circumstances, there is a clear benefit in acting to prevent long-term risk.

In the case of EMF exposure from BTS, preventative action would require application of the ALARA (As Low As Reasonably Achievable) principle to curb BTS emissions, an action that resembles reduction in exposure to tobacco smoke: the earlier reduction to exposure occurs, the fewer potential health problems. Thus, current and future preventative actions are not close substitutes; Gollier's normative paradigm would suggest application of the precautionary principle in these circumstances. This approach is reinforced by scholarship on the Dutch government's vigilant response to EMF generated by electric pylons (de Jong et al., 2012). Environmental history points to the importance of acting sooner, rather than later to protect vulnerable populations and ecosystems from air and

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[2] 'Foresight' in German, an idea developed in the 1930s by German social scientists.

[3] *Heaven v. Pender* (1883) 11 QBD 503, Court of Appeal, United Kingdom, introduced the 'duty of care', a wider duty to be responsible in tort to those who might be injured if 'ordinary care and skill' were not exercised.

water pollution.[4] Hence, from a theoretical point of view, the regulator's dilemma may well be resolved.

3. Contested Science and Technology

From an empirical standpoint, however, three questions underlie the debate about the safe use of mobile phones and BTS: Do EMFs generated by mobile phone technology affect human health? If so, what are the appropriate safety standards? And finally, who is responsible for BTS installation, implementation and monitoring? This section explores the controversies associated with the first two questions, while latter sections examine the third question.

In mobile telephony, electromagnetic waves of a certain frequency range are generated by a source that introduces information in the form of changes to the waves. A receiver, capable of interpreting the information, then picks up the waves. Electromagnetic waves are propagating EMF, and their strength is measured in terms of their fields (electric and magnetic). EMF of different frequencies interact with the body in different ways depending on the amount of energy associated with the electromagnetic waves. Gamma rays and x-rays have frequencies (and energies) high enough to knock an electron off its atom and break bonds between molecules; this phenomenon is called ionizing radiation. Fields at lower frequencies produce non-ionizing radiation.

All electrical devices, power supply networks, and telecommunications technology generate EMF in frequencies lower than those of ionizing radiation (unless they are purposely designed to do so). Therefore, everyone is exposed to multiple EMF radiations in the non-ionizing frequency range. For example, power grids and electrical devices are a source of Extremely Low Frequency (ELF) fields, while wireless devices and BTS are a source of Radio Frequency (RF) radiations. These exposures induce currents within the human body and cause two types of effects: either thermal or non-thermal. The WHO explains that 'the strength of these currents depends on the intensity of the outside magnetic field. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes.' (WHO, 2012).

3.1 Measuring the Biological Impact of EMF

Both the telecoms industry and the public sector have multiplied peer-reviewed scientific studies to determine whether prolonged exposure to electromagnetic waves poses a danger to human health. Biologists concede a wide range of opinion on the subject. While numerous scientific studies report that exposure to EMF has an impact on human tissues and cell development (reviews are provided in: Bioinitiative Report, 2012; Genuis, 2008; IARC 2013; Kostoff and

[4] The 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution were early attempts to protect the marine environment. It took another twenty years for Europe to ramp up regulation through the 1992 OSPAR Convention on protection of the marine environment in the North-East Atlantic, an initiative reinforced by the promulgation of REACH in 2010. Asbestos is another striking example of the lag-time between knowledge of the danger, first recognized by courts in the 1970s, protection of workers in 1983 (Council Directive 83/477/EEC) and an outright European ban on its use in 2005 (Parliamentary Directive 2003/18/EC). In both cases, one to two generations of citizens were sacrificed before definitive legislative action was taken.

Lau, 2013; Levitt and Lai 2010), experts do not agree on how much exposure may lead to health risks for adults or children and some research results seem to contradict previous results (e.g. Consales et al. 2012; Feychting and Forssen, 2006; Gaestel, 2010; Merhi 2012; Sommer et al. 2009). One trend is clear, however - the number of recently published, peer-reviewed scientific studies that link EMF exposure to health risks is expanding rapidly and appearing in extremely well-respected journals; see, for example, (Foliart et al. 2006; Green at al. 1999; Lowenthal et al. 2007) for ELF effects; (Aldad et al., 2012; Aslan et al. 2013; Christ et al. 2010; Gutschi et al. 2011; Hardell et al. 2005, 2013; Panagopoulos and Margaritis 2010) for RF effects caused by the use of wireless devices; and (Abdel-Rassoul et al. 2007; Khurana et al. 2010; Levitt and Lai, 2010; Otitoloju et al. 2010; Shahbazi-Gahrouei et al. 2013) for RF effects caused by exposure to BTS stations.

Effects have been reported on the reproductive system (Agarwal et al. 2009; La Vignera et al. 2012; Otitoloju et al. 2010; Panagopoulos and Margaritis 2010), on foetal and neonatal development (Aldad et al., 2012; Divan et al. 2008; Li et al., 2012), on increased risk of childhood leukaemia, adult brain tumours and acoustic neuromas (Hardell et al. 2005, 2013; Kheifets et al. 2010; Levis et al. 2011), on breast cancer (Chen et al. 2013; Erren 2001), and on neurodegenerative diseases (Hug et al. 2006); EMF exposure has also been linked to sleep disturbance (Abelin et al. 2005; Shahbazi-Gahrouei et al. 2013) headaches, memory changes, and depressive symptoms (Abdel-Rassoul et al. 2007; Hagström et al. 2013); numerous effects on plants and animals have also been reported (Cucurachi et al. 2013). Although more studies report effects on human health due to mobile phone use rather than proximity to BTS radiation, scientists indicate that 'the two kinds of radiation are very similar and effects produced by mobile phones at certain distances, can be extrapolated to represent effects from base station antennas, of the same type of radiation, at about 100 times longer distances' (Panagopoulos 2011, 12).

Scientific studies may focus on exposure to EMF with specific characteristics (e.g. frequency range; source position relative to the subject; emission duration). However, as indicated by Blank and Goodman, the same biology may occur across the range of the electromagnetic spectrum: 'While low energy EMF interacts with DNA to induce the stress response, increasing EMF energy in the RF range can lead to breaks in DNA strands. (…) The intensity of EMF interactions with DNA leads to greater effects on DNA as the energy increases with frequency' (Blank and Goodman, 2009, 71 and 76) and the effects of simultaneous exposure to several EMFs could be additive. The same authors explain that DNA has the structural characteristics of fractal antennas and therefore the same wide frequency range of interaction with EMF. This would 'contribute to greater reactivity of DNA with EMF in the environment, and the DNA damage could account for increases in cancer epidemiology' (Blank and Goodman, 2011).

In addition to the nature of EMF exposure, the characteristics of the exposed subject (e.g. age, gender, general health state) have an impact on the possible health consequences of radiation. Particularly relevant to our argument are

studies about the age-related differences in tissue response to EMF exposure and the impact on children (e.g. Byun et al. 2013; Davis et al. 2013; Divan et al. 2012; Hardell et al. 2013; Peyman et al. 2009; Sudan et al. 2012; Wiart et al. 2008). A research team led by Andreas Christ suggests that, 'in general and on average, children suffer a higher exposure of their brain regions than adults. This higher exposure is due to differences in anatomical proportions' (Christ et al., 2010, 1780). In a study where clinical and growth pattern data were collected for up to 13 years from 733 children whose mothers carried a magnetic field (MF) measuring meter during pregnancy, De-Kun Li and colleagues conclude that 'Maternal exposure to high MF during pregnancy may be a new and previously unknown factor contributing to the world-wide epidemic of childhood obesity/overweight.' (Li et al., 2012, 1). Even those scientists who believe there is no causal effect between mobile phone use and health problems for the general population have called for further studies and suggest caution with respect to childhood exposure to EMF (Aydin et al., 2011; Valentini et al., 2010).

Levitt and Lai conducted an extensive literature review of studies related to the biological effects from exposure to EMF radiated by BTS and other RF antennae. They reported that children are impacted differently than adults by electromagnetic wave emissions from mobile phones and BTS:

> *Children absorb energy differently than adults because of differences in their anatomies and tissue composition.. … For instance, radiation from a cell phone penetrates deeper into the head of children … The same can be presumed for proximity to towers, even though exposure will be lower from towers under most circumstances than from cell phones. This is because of the distance from the source. The transmitter is placed directly against the head during cell phone use whereas proximity to a cell tower will be an ambient exposure at a distance (Levitt and Lai, 2010, 373).*

Determining the risks of ambient exposure at a distance highlights a key issue in the regulatory framework discussed in greater detail below. In mobile phone communication, BTS distribute a signal, received by a landline, and send it to a receiver (mobile phone) within a certain area using the available frequency spectrum (bandwidth). The broader the available bandwidth, the more information can be transmitted in a given unit of time. This means that increasing download speed, increases emission[5]. Accessing an online movie or playing an online game, for example, requires more bandwidth than accessing a web site with still images and text. Users employ their smartphones to access services requiring high data transmission rates and they expect their connection to be maintained in a variety of locations including indoor and on public transport. Consequently, as demands for bandwidth and connectivity coverage have increased, telecom companies have responded by augmenting the number of BTS to partition each area into smaller coverage areas so that the available bandwidth is reused, the capacity is increased and more people can be served at the same time within the original area.

[5] As the download speed increases, the number of bits per second increases. Since the energy per bit must remain the same in order to maintain the same quality of service, there is an increased energy per second, which is an increased radiated power.

Thus, as the number of BTS increases, more people are living in close proximity to a mobile phone tower than ever before.[6] The only way to reduce the biological impact of exposure to electromagnetic fields is either to reduce the number of BTS or their transmission power. This means that either fewer customers will be served at the same time, which could be a problem in densely populated European cities, or that these same customers will be served, but with a lower data transmission rate.[7] A lower data rate may imply, for example, that access to Web sites and emails is available, but video download is not. Consequently, the application of the ALARA principle regarding health risks needs to be weighed against the benefits of accessibility required by the Digital Agenda for Europe (see footnote 1). On the one hand, regulators will need to evaluate which technologies are safe to use for delivering the desired accessibility, and on the other hand, where, when, how much and what type of information or services need to be made available to citizens. Protection measures may include: reducing exposure limits, prohibiting specific "windows" of exposure (Belyaev, 2010; Blackman, 2009; Kostoff and Lau 2013), establishing age limits for the use of mobile communication devices, barring installations from sensitive areas such as schools and hospitals, requiring maximisation of wired rather than wireless networks, and establishing procedures for citizens' exposure measurements. In order to define which measures should be implemented, regulators need accurate and comprehensible information allowing them to weigh the trade-offs between large data services availability and the protection of human health. When the health risk cannot be determined with sufficient certainty, the precautionary principle should be applied as recommended by Council of Europe Resolution 1815.

3.2 Setting Standards

In order to establish regulations and recommendations, several national and international bodies have used guidelines made available by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[8] ICNIRP offers two types of guidelines: *basic restrictions* on 'exposure to time-varying electric, magnetic, and electromagnetic fields' (ICNIRP, 1998, 495) and *reference levels* 'provided for practical exposure assessment purposes […] Compliance with the reference level will ensure compliance with the relevant basic restriction' (ibid. 495).

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[6] France's Agence Nationale des Fréquences (ANFR, 2013a) reports that in January 2012, 157,000 installations had been authorized – this number includes installations on French territories overseas, but it does not include installations of the defence, civil aviation or interior ministries. Of the 157000 installations, the ones dedicates to mobile communication include 52600 for GSM 900 or GSM 1800, 47600 for UMTS and 1300 for WIMAX. For example, according to ANFR data (ANFR, 2013b), the first arrondissement of Paris, which only extends over 1.83Km^2, hosts 107 GSM 900, 173 GSM 1800, and 355 UMTS antenna units. The map, available on the Web site in the reference, shows that no location in the arrondissement is more than 500 meters away from a BTS, with most installations hosting more than one antenna. In the period November 2012 – August 2013 the approved installations for 4G communication in France have increased from 507 to 6931 (ANFR 2013c)

[7] Although alternative technical solutions are being explored (Ezri and Shilo, 2009).

[8] The IEEE also provides similar guidelines (IEEE, 1999; IEEE, 2005).

As summarized in Table 1, which only covers the frequency range typical of BTS operation, *basic restrictions* for human exposure are expressed in terms of Specific Absorption Rate (SAR), and power density (S). SAR defines the rate of energy absorption per unit mass (how much energy the body absorbs), is expressed in Watts per Kilogram (W/kg), and is not directly measurable. Power density represents the rate of energy flow through a given surface area and is measured in watts per square meter (W/m2). For practical purposes however, the values used to establish regulations are those in the *reference levels* column of table 1. Emission limits are frequently indicated in terms of the electric field strength in Volts per meters (V/m).

< insert Table 1 >

There is a good deal of controversy over the reliability of the ICNIRP guidelines (as well as other, less referenced, guidelines), which are questioned on several grounds:

1) A possible conflict of interest exists between the ICNIRP and the telecoms industry and has been raised in the report to the Council of Europe (Huss, 2011) that eventually led to the adoption of Resolution 1815 [9]
2) It has been argued that ICNIRP's *reference levels* don't actually ensure that corresponding *basic restrictions* are met. In particular, Georgiou explains that using the electric field strength reference level for expressing EMF radiation exposure limits, as several countries do and the Council of Europe recommends (Council of Europe, 2011), may misrepresent the SAR basic restrictions[10] (Georgiou, 2010).
3) The measures used to define *basic restrictions* are contested. Some scientists argue that both SAR and power density measures have several limitations, including the fact that 'the existing standardized phantom is not optimal for SAR measurements of large base station antennas' (Hansson et al., 2011, 664), that current SAR recommendations do not take into account 'the smaller size and greater physiological vulnerability and increased absorption to the heads of children and females' (Han et al., 2010, 301), and that SAR needs to be integrated with other measures in order to be a useful tool for the evaluation of health risks associated with EMF exposure (Belyaev, 2010; Fragopoulou et al., 2010).
4) Most contentious, the ICNIRP guidelines do not offer protection against non-thermal effects of EMFs, particularly with respect to prolonged

[9] In his report to the council Rapporteur Jean Huss states 'it is most curious, to say the least, that the applicable official threshold values for limiting the health impact of extremely low frequency electromagnetic fields and high frequency waves were drawn up and proposed to international political institutions (WHO, European Commission, governments) by the ICNIRP, an NGO whose origin and structure are none too clear and which is furthermore suspected of having rather close links with the industries whose expansion is shaped by recommendations for maximum threshold values for the different frequencies of electromagnetic fields'. (Huss 2011: Section B Explanatory Memorandum by Mr Huss, Rapporteur, point 29)

[10] 'For a 250-fold exposure increase from 0.01 to 2.5 mW/m2, the corresponding exposure increase in mV/m (from 61 to 955) is only 16 fold. Radiation exposure misrepresentation using V/m gets even worst at lower exposure values' (ibid. 79).

> exposure (Belyaev, 2010; Bioinitiative Report, 2007, 2012; Blackman 2009). In fact, current restrictions are based only on short-term thermal health effects, because the ICNIRP committee concluded that 'Whilst it is in principle impossible to disprove the possible existence of non-thermal interactions, the plausibility of various non-thermal mechanisms that have been proposed is very low'. (ICNIRP 2009, 260)

Thus, the fundamental question of what constitutes sufficient evidence for setting restrictions is still open. Some scientists argue that current standards for risk assessment are inappropriate (Bioinitiative Report, 2007, 2012; Fragopoulou et al., 2010) and that long-term effects on citizens' health are due to a heightening, over time, of exposure to several EMF sources, a phenomenon normally more difficult to measure than acute effects (Belyaev, 2010; Kostoff and Lau, 2013). So, while certain experts deem the epidemiological studies on long-term effects of EMF exposure inconclusive on the basis of their potentially biased results or an unconvincing demonstration of risk, other scientists argue that studies of this type should be considered more carefully (Axelson, 2004; Blair et al., 2007; Georgiou, 2010). This is similar to the IARC assessment of environmental risk mentioned above, which found 'the available evidence insufficient for any conclusion' (Baan et al., 2011, 625) and highlights the current paucity of studies addressing the complex problem of interaction amongst effects of multiple agents (Kostoff and Lau, 2013). We are facing a conflict of epistemic cultures of non-knowledge (Böschen et al., 2010) with some scientists placing a higher value on more controlled experiments, but disregarding 'contextual factors or persisting real-world uncertainties' (ibid. 792) - such as exposure to multiple EMFs and long-term effects – and others who attempt to address the complexity and context of the problem, but at the cost of scientific reproducibility and predictability.

Regulatory bodies that are tasked with appropriate protective actions for EMF exposure are in a difficult situation: research aimed at assessing its potential danger has so far produced mixed results (especially for long-term exposure), and controversies are not limited to the magnitude of values that would limit health hazards, but also extend to the definition of what should actually be measured. The difficulty in establishing measurement standards, as well as the scarcity of long-term impact studies of EMF on the living environment, may explain why the WHO has only recently recognized the danger related to radiofrequency fields and maintains a classification of 'possibly' carcinogenic to humans (IARC-WHO, 2011). And yet, issues remain, such as which policy framework should be applied when evidence of risk is inconclusive, and whether the burden of proof should be on demonstrating risk or on demonstrating the safety of the technology (the latter being regularly applied to medical products). In section 4, we examine how European bodies and States have addressed the former issue, albeit with non-binding norms, and in 5 we propose that the latter, infrequently addressed issue be resolved on the basis of State compliance with binding international human rights law.

4. Legislative Dearth

As mobile-phone technology has progressed from first to fourth generation, requiring ever more powerful antennae, the Council of Europe responded in 2011 with Resolution 1815 (Council of Europe, 2011), a set of non-binding norms defining an emissions limit of .6V/m for wireless devices, along with recommendations to reduce 'threshold values for relay antennae in accordance with the ALARA principle and install systems for comprehensive and continuous monitoring of all antennae' (ibid. section 8.4.3). Resolution 1815 also articulates strategies for better protection of children. But, these guidelines do not have the power of law. The Council must thus rely on its 47 members to regulate electromagnetic emission levels at the national or municipal level.

Moving from recommendations on standards of measurement to legislation is a slow process[11]. Throughout Europe, no new national legislation on BTS emissions has been established since national governments aligned their norms (e.g. Direction Générale de la Santé, 2002) with recommendations fixed by the European Union at 41-61 V/m (Council of Europe, 1999).[12] These recommendations were based on the ICNIRP guidelines discussed above. Given the controversies surrounding the guidelines, grassroots organizations have demanded more protective regulation from their national and local governments. Government responses have often been contradictory, since public officials are guided by the conflicting needs of protecting citizens' health, responding to the commercial logic of the telecom companies (frequently major employers within their jurisdictions), and meeting the obligations of information accessibility under the Digital Agenda for Europe. The analysis of the case of Paris, presented below, clearly illustrates these competing demands and the inadequacy of current regulation.

4.1 French law and jurisprudence

The principle of precaution, inscribed in the French Constitution in 2005, functions as a guiding standard when determining how to evaluate environmental risk, especially with respect to the most vulnerable members of society, such as children. Unfortunately, the precautionary principle has been substantively weakened by a series of court rulings over the course of 2011-2012. In October 2011, the Conseil d'Etat, the highest court overseeing French administrative matters, handed down a decision that circumscribed the role of mayors in determining whether a BTS installation was appropriate in their commune or municipality. Instead, the Council indicated that responsibility for BTS installation was in the hands of the Autorité de Régulation des Communications Electroniques et des Postes (ARCEP) and the Agence nationale des fréquences (ANFR), two national bodies that regulate the emission of electromagnetic waves and the placement of mobile phone towers, with a mandate to assure full coverage throughout France (Conseil d'État, 2011). The decision would have garnered less national attention had the rapporteur of the Council's decision not been a former affiliate of a leading French telecom

[11] The authors of one of the major studies that prompted the IARC carcinogenic classification recently remarked that the measure 'does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.' (Hardell et al. 2013, 85)

[12] Limits are set at 41V/m for GSM 900; 58V/m for GSM 1800; and 61V/m for UMTS.

company (Thénard, 2012), and had the state not just pocketed 968 million euros in licensing fees[13] for fourth generation bandwidth for mobile phone towers (Chicheportiche, 2011; ARCEP, 2011).

Another example is a series of rulings in May 2012 by the French Jurisdictional Court, a hybrid super-court that is called upon to decide whether France's civil or administrative courts have jurisdiction in the event of a dispute. After losing a seminal Court of Appeals decision in 2009 that required a telecom company to pay minor damages and dismantle a contested mobile phone tower,[14] the company decided to challenge the jurisdiction of the First Instance Court and its appellate court to adjudicate the installation of BTS. Claiming that the authority to dismantle was under the jurisdiction of the administrative, rather than the civil court system, the plaintiff brought a suit that rightly emphasized the lack of pertinent national legislation on this issue. The Tribunal rendered an odd decision, declaring that the civil court was competent to determine financial damages for health risks incurred due to exposure to emissions from a BTS, whereas only the administrative court could order the dismantling of a mobile phone tower, concluding that it is the administrative court that has policing jurisdiction in this domain under French law (Tribunal des conflits de la cour de cassation, 2012). With these two decisions - the first of which places the obligation to protect in the hands of a national body mandated to provide full coverage, and the second of which provides the administrative court with the power to adjudicate what is essentially a civil matter – the French judicial system appears to have rendered jurisprudence that is at odds with the constitutional principle of precaution.

4.2 Regulation in Paris

Paris has been considered a leader in calling for extremely low levels of electromagnetic wave emission from BTS, with a ten-year norm of 2 V/m from 2003-2011 (Ville de Paris, 2003). This Charter of Voluntary Compliance was suspended in Fall 2011 as the City moved to decrease emissions in accordance with the Council of Europe Resolution 1815 cited above, while the operators hoped to increase their emissions to accommodate fourth generation (4G) mobile phone technology (Maussion, 2011). In October 2012, despite the determined opposition of local NGOs and the Green Party, the Mayor's Office ceded to the demands of the telecom companies, and raised emission limits to 5-7 V/m (Ville de Paris, 2012). A 2013 report from the French government has indicated that citizen exposure to EMF is expected to rise 50% due to 4G emissions from BTS (DGRP, 2013, 95).[15]

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[13] A further, significantly larger, licensing fee has been collected recently with the attribution of frequencies in the 800MHz range (ARCEP, 2012).

[14] Cour d'Appel de Versailles, *S.A Bouygues Telecom v. Eric Lagouge*, R.G. N° 08/08775, 4 February 2009.

[15] According to the report, the average simulated exposure for the cities under study was increased by approximately 50% with the addition of 4G (LTE) antennas. For example, in the 14th arrondissement of Paris, the simulated ground exposure levels rose from approximately .6 V/m to 0.9 V/m (DGRP 2013,95, authors' translation)

France has four telecom companies that compete for installation sites on Parisian rooftops. The city was home to nearly 2053 base transceiver stations in 2012 (Ville de Paris, 2012, 2). Zoning regulations are extremely strict and focus on aesthetics, or what the French call l'aspect.[16] Thus, mobile phone towers are virtually invisible, hidden by camouflage structures resembling chimneys or brick walls. Equally invisible is the type of public information sharing that citizens have come to expect for the installation of high-impact structures, such as wind-parks or power plants.[17] Public property rights allow building cooperatives to approve rooftop installations in exchange for an annual fee, without prior consultation with their neighbours, many of whom live on the upper floors in surrounding buildings and will be exposed to stronger EMF than those who actually approved the installation. Once the project has been endorsed by a home-owners' cooperative, the ANFR must vet the level of emissions and the technical capacity of the BTS, while the aesthetic aspect is scrutinized by the Monuments Nationaux de France. Once approved at the national level, the project is examined at the municipal level, where a Preliminary Declaration is filed with the Département d'urbanisme. Only once the Preliminary Declaration has been approved, does the first indication of a BTS installation appear in the public domain. A small white sign posted on the building door informs passers-by that a construction project will take place, in this case the installation of a new BTS. In several instances, especially when the white sign has appeared near schools or day-care centres, citizens have mobilized to insist on the removal of the installation to a different location.[18] The fact remains, however, that the State safeguards the aesthetic beauty of Paris and obliges the telecom companies to provide maximal coverage to consumers, while providing no regulation to protect children from the potentially harmful effects of EMF exposure from BTS.

5. Extending the Regulatory Framework

International human rights law constitutes a possible means to address the current regulatory impasse. The painstaking work after the end of the Second World War to build an edifice of binding international treaties, ranging from the international bill of human rights to more specific protection for women, children and minorities, culminated with the entry into force of the Convention on the Rights of the Child in November 1989. Recent international instruments, such as the OECD Guidelines for Multinational Enterprises or the Ruggie Report, oblige State parties to 'protect, respect and remedy' human rights violations by businesses against individuals or groups, bringing corporations into the international human rights paradigm through State compliance with binding treaty law.

In this section, we argue that (1) because protection of children is a high threshold norm in HR law and (2) the binding language of the Convention on the Rights of the Child obliges States Parties to provide a higher standard of protection for children than adults, any widespread or systematic form of

[16] Historic zoning is especially strict. See Art. R111-21, amended by decree no. 2007-18 of 5 January 2007, *Code de l'Urbanisme*.

[17] Commissariat Générale au Développement Durable 2009, 73/1 and 84/1.

[18] See, for example, the *Collectif Rue Lobineau*: www.ruelobineau.org

environmental pollution that poses a long-term threat to a child's rights to life, development or health may constitute an international human rights violation. Thus, when EMF exposure is too high, the State must legislate to implement the 'protect, respect and remedy' framework.

5.1 BTS Installations and Children Rights

Articles 3, 6 and 24 of the UN Convention of the Rights of the Child (United Nations High Commissioner for Human Rights, 1989) constitute a legally binding responsibility on the part of States Parties to protect children from verified and potential threats to health and safety. We have argued, in a submission to the UN Committee on the Rights of the Child, that electromagnetic pollution poses a critical threat to the 'highest attainable standards of health' for children, as articulated in article 24 of the Convention on the Rights of the Child, and can be analysed using constructs similar to those employed to assess trafficking and forced labour violations involving minors (Perry et al., 2012). Scientists from both industry and the academy recognize that children's physiology places them at greater risk to electromagnetic pollution from mobile phones and BTS (see Section 3.1 above), triggering stricter legal thresholds and precautions under articles 2 and 3 of the Convention. Regular testing of emission limits by an independent body of experts, with 'appropriate sanctions' for widespread or systematic pollution under article 32 of the Convention, coupled with regular monitoring of both voluntary and legally binding compliance by the telecoms industry, constitutes a minimum level of protection as required by the Convention (ibid.). According to the Convention, decisions on where to place BTS and on what constitutes safe levels of EMF exposure for children should be made by competent health specialists guided by viable national legislation that requires public consultation and the lowest emissions possible in proximity to day-care and schools. The principle of precaution thus functions as a guiding standard when determining how to evaluate environmental risk with respect to children.

The question of accountability is complicated by the problem of multiple sources of environmental pollution, a reality which means that a business may bear no legal responsibility as a corporate entity because the impact is cumulative. The rapid increase in all sorts of environmental pollutions, ranging from diesel particle emissions to multiple sources of EMF, renders it difficult to isolate the precise cause of a particular environmental cancer or disease. But, what if EMF exposure constitutes one environmental pollutant too many for the infants and toddlers exposed to a disputed installation? While the main difficulty in legislating to protect has to do with the science - both the complex measurement paradigm for EMF emissions and the on-going biological research on EMF impacts on the living environment – theory and practice suggest that the lack of agreement on scientific knowledge can only be addressed through the principle of precaution. Moreover, Council of Europe Resolution 1815 and the Convention on the Rights of the Child ratified by all EU members oblige Member States to protect the most vulnerable from this relatively new form of environmental pollution.

6. Conclusions

We have explored the difficulties inherent to EMF emission regulation and argued that they are due to a lack of scientific knowledge on long-term impact, along with a contested understanding of what constitutes appropriate assessment of risk. We have demonstrated how inadequate regulation on BTS emissions has generated contradictory policies at the national and local level, and has failed to reassure citizens that their health and the health of their children is sufficiently protected. Given this situation we have posited that the human rights framework to 'protect, respect and remedy' vulnerable populations from corporate violations of international law should also apply to State and European regulation of EMF exposure. In particular we have explained how the dearth of legislation to regulate the installation of BTS in close proximity to children's facilities and schools clearly constitutes a human rights concern according to the language of the Convention on the Rights of the Child, a treaty that has been ratified by all European States.

If we are to deliver on the promise of digital technology to enhance democratic dialogue and facilitate human lifestyles, then we have to make sure it is environmentally safe to use – particularly for the generations to come.

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Biographies

Professor Claudia Roda's research focuses on the impact of digital technology on human behavior and social structure. She recently published the book "Human Attention in Digital Environments" with Cambridge University Press. Claudia holds a bachelor degree in Computer Science from the University of Pisa, and a PhD from the University of London.

Professor Susan Perry, a specialist in international human rights law, holds degrees from Yale, Oxford and the Ecole des Hautes Etudes en Sciences Sociales (Paris). She recently served as a child rights expert and US Delegation member in Chad for the drafting of the N'djamena Declaration to End the Recruitment of Child Soldiers.

Table 1 – Guidelines for the frequency range of BTS

<table>
<tr><th>Frequency</th><th>Basic Restrictions (ICNIRP 1998)</th><th colspan="5">Reference Levels[a] (ICNIRP 1998)</th></tr>
<tr><td>100 kHz–10 GHz</td><td>Restrictions on Specific energy absorption rate (SAR) prevent whole-body heat stress and excessive localized tissue heating

0.08 W/kg</td><td colspan="5"><table>
<tr><th rowspan="2">Frequency range</th><th rowspan="2">Electric field strength (V/m)</th><th colspan="2">Magnetic field strength</th><th>Electrom. field strength</th></tr>
<tr><th>H-field (A/m)</th><th>B-field (μT)</th><th>power density (W/m²)</th></tr>
<tr><td>3–150 kHz</td><td>87</td><td>5</td><td>6.25</td><td></td></tr>
<tr><td>0.15–1 MHz</td><td>87</td><td>0.73/f</td><td>0.92/f</td><td></td></tr>
<tr><td>1–10 MHz</td><td>87/f^1/2</td><td>0.73/f</td><td>0.92/f</td><td></td></tr>
<tr><td>10–400 MHz</td><td>28</td><td>0.073</td><td>0.092</td><td>2</td></tr>
<tr><td>400–2000 MHz[b]</td><td>1.375f^1/2</td><td>0.0037f^1/2</td><td>0.0046f^1/2</td><td>f/200</td></tr>
<tr><td>2–300 GHz</td><td>61</td><td>0.16</td><td>0.20</td><td>10</td></tr>
</table></td></tr>
<tr><td>10–300 GHz</td><td>Restrictions on power density (S) prevent excessive heating in body tissue
10 W/m²</td><td colspan="5">Same as 2-300 GHz range above</td></tr>
</table>

[a] The limits reported are those for public exposure; different (higher) limits are specified for occupational exposure.
[b] If calculated, the E-field strength level ranges between 27.5 and 61.5 V/m (sqrt(400) * 1.375 = 27.5 and sqrt(2000) * 1.375 = 61.49).