**Final Report**

ITU-D
Study Group 2

Question 7/2

# Strategies and policies concerning human exposure to electromagnetic fields

6th Study Period
**2014-2017**

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# Question 7/2: Strategies and policies concerning human exposure to electromagnetic fields

## Final Report

## Preface

**ITU Telecommunication Development Sector (ITU-D) study groups** provide a neutral contribution-driven platform where experts from governments, industry and academia gather to produce practical tools, useful guidelines and resources to address development issues. Through the work of the ITU-D study groups, ITU-D members study and analyse specific task-oriented telecommunication/ICT questions with an aim to accelerate progress on national development priorities.

Study groups provide an opportunity for all ITU-D members to share experiences, present ideas, exchange views and achieve consensus on appropriate strategies to address telecommunication/ICT priorities. ITU-D study groups are responsible for developing reports, guidelines and recommendations based on inputs or contributions received from the membership. Information, which is gathered through surveys, contributions and case studies, is made available for easy access by the membership using content-management and web-publication tools. Their work is linked to the various ITU-D programmes and initiatives to create synergies that benefit the membership in terms of resources and expertise. Collaboration with other groups and organizations conducting work on related topics is essential.

The topics for study by the ITU-D study groups are decided every four years at the World Telecommunication Development Conferences (WTDCs), which establish work programmes and guidelines for defining telecommunication/ICT development questions and priorities for the next four years.

The scope of work for **ITU-D Study Group 1** is to study "**Enabling environment for the development of telecommunications/ICTs**", and of **ITU-D Study Group 2** to study **"ICT applications, cybersecurity, emergency telecommunications and climate-change adaptation"**.

During the 2014-2017 study period **ITU-D Study Group 2** was led by the Chairman, Ahmad Reza Sharafat (Islamic Republic of Iran), and Vice-Chairmen representing the six regions: Aminata Kaba-Camara (Republic of Guinea), Christopher Kemei (Republic of Kenya), Celina Delgado (Nicaragua), Nasser Al Marzouqi (United Arab Emirates), Nadir Ahmed Gaylani (Republic of the Sudan), Ke Wang (People's Republic of China), Ananda Raj Khanal (Republic of Nepal), Evgeny Bondarenko (Russian Federation), Henadz Asipovich (Republic of Belarus), and Petko Kantchev (Republic of Bulgaria).

## Final report

This final report in response to **Question 7/2: "Strategies and policies concerning human exposure to electromagnetic fields"** has been developed under the leadership of its Rapporteur: Dan Liu (People's Republic of China); and two appointed Vice-Rapporteurs: Issoufi Kouma Maiga (Mali) and Dirk Oliver Von Der Emden (Switzerland). They have also been assisted by ITU-D focal points and the ITU-D Study Groups Secretariat.

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This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

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# Executive Summary

This Report collects and disseminates information concerning exposure to Radio Frequency (RF) and Electromagnetic Fields (EMF), in order to assist national administrations, particularly in developing countries, to develop appropriate national regulations. It is useful for Administrations, in order to listen and respond to the concerns of public from radiating antennas.

The EMF assessment methods depend on site and environment; calculations are suitable in many cases and have significant benefits (accurate, fast and cost effective), and measurements are required in complex environments. Field surveys can provide public reassurance, and continuous monitoring has limited long-term benefit, where electromagnetic fields levels are low and stable. Measurement surveys and continuous monitoring systems have been operating in many countries and show that the mean environmental radiofrequency levels from mobile communication systems are typically less than 0.1 $\mu W/cm^2$. The orientation of the antenna's main lobe (mainly in elevation) constitutes the main factor influencing exposure.

The maximum Specific Absorption Rate (SAR) level for different mobile phones varies according to technology and many other factors, for example, SAR is also influenced by technical parameters such as the antenna used and its placement within the device.[1]

Generally, the national legislation in many countries, including in Europe use in some way or another the international ICNIRP 1998 exposure limits in order to limit the EMF exposure of people and workers. Because of a perceived scientific uncertainty, several legislators have enacted precautionary measures for the general public or possibly vulnerable population groups against EMF exposure. Generally these national regulations recommend precautionary measures to reduce exposure to EMF, to limits below the Reference levels of ICNIRP1998. Restrictive limits result in an increased number of antennas to maintain equivalent service.

Follow the existing ICNIRP 1998 limits from stations and cellular handsets at the national level and across the country. These exposure limits are the current international scientific consensus. The tolerability of the human body to radio frequency radiation is independent of geography or political borders: there is scientific justification for different national exposure levels. Cellular networks are not local; there is no engineering reason for different exposure levels among cities inside the country; the definition of exposure limits should be national, and outside the competency of municipal or provincial councils. Global standards can help facilitate compliance with international standards, strengthen collaboration among stakeholders, ensure transparency, and enhance communication with citizens.

[1] The SAR information for a mobile phone is available from the Mobile & Wireless Forum website http://www.sartick.com/ .

# 1 CHAPTER 1 – Introduction

## 1.1 Background

The deployment of different sources of Electromagnetic Fields (EMF) to cater for the telecommunication and ICT needs of urban and rural communities has developed very rapidly. This has been due to strong competition, ongoing traffic growth, quality-of-service requirements, network coverage extension and the introduction of new technologies. It has prompted concern on the possible effects of prolonged exposure to emissions on people's health.[1]

The growing concern about electromagnetic field exposure from antenna towers has led to imposition of new legislation and/or regulations, to ensure protection of the public health. Possible health hazards due to continued exposure to EMF radiation has become a significant issue for regulators and service providers.

The regulation of non-ionizing radiations contains exposure standards and emission standards. The exposure standards are specifications that limit the exposure of people to the electromagnetic fields, and the emission standards are specifications that limit the emission of electromagnetic fields from the devices.

The EMF assessment methods depend on site and environment; calculations are suitable in many cases and have significant benefits (accurate, fast and cost effective), whereas measurements are usually only required in very complex environments. Field monitoring is effective for the safety of workers when working on towers. While, field surveys can provide public reassurance, continuous monitoring has limited long term benefit, when electromagnetic fields levels are low and stable.

The ITU[1] estimates that seven billion people (95 per cent of the global population) live in an area that is covered by a mobile-cellular network. Mobile-broadband networks (3G or above) reach 84 per cent of the global population but only 67 per cent of the rural population. The electromagnetic fields are undetectable by people, and the lack of communication and information to citizens can generate a lack of trust, which may become fear.

Global standards can help facilitate compliance with international standards, strengthen collaboration among stakeholders, ensure transparency, and promote communication with citizens.

In 2009, the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[2] reconfirmed its 1998 radio frequency "guidelines on limiting exposure to high and radiofrequency fields in the range (100 kHz – 300 GHz)." The World Health Organization (WHO) developing an update of the Environment Health Criteria (EHC) monograph on radiofrequency fields.

Above a certain threshold exposure level, the absorption of radiofrequency (RF) EMF energy by the body or a part of the body results in a rise in body temperature. The SAR limits are set with a safety margin, below the threshold level at which the body temperature starts to rise. The human body is efficient at maintaining its temperature and has sophisticated mechanisms to prevent the temperature from rising when heat is absorbed from any source, as demonstrated by our ability to live in varying climatic conditions from cold to hot all around the world.

Around the world, the use of mobile phones and other wireless systems is expanding rapidly. While this provides the opportunity for advances in public and personal safety, education, medicine and the economy, it also brings new responsibilities and challenges for local authorities. In particular, there have been concerns, that along with the benefits brought by wireless networks, there may also be risks to health.

[1] ITU, ICT Facts and Figures 2016.
[2] http://www.icnirp.org/cms/upload/publications/ICNIRPStatementEMF.pdf.

## 1.2 Scope of the Report

This report collects and disseminates information concerning exposure to EMF, in order to assist national Administrations, particularly in developing countries, to develop appropriate national regulations. It is useful for Administrations, in order to respond to the fears of public (derived also from unsupported claims of hypersensitivity and electro phobia) from radiating antennas.

# 2 CHAPTER 2 – ITU Resolutions

## 2.1 PP-14 Resolution

The Plenipotentiary Conference in 2014 (PP-14) held in Busan, Republic of Korea ("Korea" in the rest of report), approved the modified Resolution 176 on "Human exposure to and measurement of electromagnetic fields". The Resolution, among other things:

*resolves to instruct the Directors of the three Bureaux* "to collect and disseminate information concerning exposure to EMF, including on EMF measurement methodologies, in order to assist national administrations, particularly in developing countries, to develop appropriate national regulations".

*invites Member States* "to take the appropriate measures to ascertain compliance with guidelines produced by ITU and other relevant international organizations with respect to exposure to EMF".

## 2.2 WTDC-14 Resolution

The sixth World Telecommunications Development Conference 2014 (WTDC-14) held in Dubai, approved the following:

- Resolution 62 on "Measurement concerns related to human exposure to electromagnetic fields".
- ITU-D Study Group 2 Question 7/2 on "Strategies and policies concerning human exposure to electromagnetic fields".

Items to be studied:

- "Compilation and analysis of the regulatory policies concerning human exposure to electromagnetic fields that are being considered or implemented for authorizing the installation of radiocommunication sites and powerline telecommunication systems."
- "Description of the strategies or methods for raising the awareness of population and increasing information to populations regarding the effects of electromagnetic fields due to radiocommunication systems."
- "Proposed guidelines and best practices on this matter."
- New item included in Resolution 62, "effect on humans of EMF from handheld devices".

## 2.3 WTSA-16 Resolution

The World Telecommunications Standardisation Assembly 2016 (WTSA-16), held in Hammamet, Tunisia, agreed on the following:

- Revision of Resolution 72 on "Measurement and assessment concerns related to human exposure to electromagnetic fields";
- ITU-T Study Group 5 Question 3/5 on "Human exposure to Electromagnetic Fields (EMFs) from information and communication technologies (ICTs)".

# 3 CHAPTER 3 – Work of other ITU Sectors

Throughout the study period, this Question has been coordinating with other ITU Sectors and groups, including: ITU-T Study Group 5, ITU-R Study Groups 1, 3, 4, 5, 6 and their relevant Working Parties.

## 3.1 ITU-T Study Groups

### 3.1.1 Question 7/5

Question 7/5 (changed to Question 3/5).[3]

New Recommendations have been developed: K.121 (ex. K.env) on "Guidance on the environmental management for compliance with radio frequency EMF limits for radiocommunication base stations" and K.122 (ex. K.emf) on "Exposure levels in the close proximity of the radiocommunication antennas". Recommendation K.52 on "Guidance on complying with limits for human exposure to electromagnetic fields" was revised.

### 3.1.2 ITU EMF Guide

Awareness is required of the different designs of mobile phone base stations that vary widely in their power and characteristics, affecting their potential for exposing people to radio frequency signals. Research has shown that at the ground level, the level of human exposure to radio signals from base stations is typically less than one thousandth of those from mobile phones.

The power from a mobile phone base station will vary depending on the number of mobile phone calls, propagation conditions and amount of data traffic being carried. In addition to the data and mobile phone calls, a pilot signal is continuously transmitted from the base station, so that relevant mobile phones can detect the network.

The objective of the ITU EMF Guide (http://emfguide.itu.int) is to answer the common questions on EMF asked by the public, and to address related concerns. The ITU EMF Guide provides education and information promotes EMF information suitable for all communities, stakeholders and governments. The EMF Guide refers to WHO and other stakeholders and clarifies some scientific uncertainties e.g., in the areas of radio frequency technology, infrastructure implementation, usage, and consequential EMF exposure. It is also available as a website and via app stores.[4]

### 3.1.3 EMF considerations in smart sustainable cities

Base stations need to be located close to users, in order to provide a coverage and capacity. Base stations and mobile devices use adaptive power control, and where the connection is good they will operate on the lowest power level needed, to maintain a quality connection.

There is an increasing trend for mobile network operators to adopt a variety of infrastructure models. This is being driven mainly by commercial and efficiency considerations, rather than by regulatory mandates. Infrastructure sharing may be passive or active: passive sharing includes site sharing, where operators use the same physical components but have different site masts, antennas, cabinets and backhaul. In active sharing, operators may share the Radio Access Network (RAN) or the core network; in addition to antennas, transmitters and receivers, operators may share also frequencies. Again there may be issues of compatibility between the technology platforms used by the operators.

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[3] Question 3/5 – Human exposure to Electromagnetic Fields (EMFs) from Information and Communication Technologies (ICTs) is the continuation of Question 7/5.

[4] https://play.google.com/store/apps/details?id=intl.itu.ituemfguide&hl=en . Apple - https://itunes.apple.com/au/app/itu-emf-guide/id990872473?mt=8 . Blackberry- https://appworld.blackberry.com/webstore/content/59972970/?countrycode=AU&lang=en .

Nearby residents may think that a higher number of antennas in the surrounding areas will lead to higher exposure levels at the ground level in publicly accessible areas. Measurements undertaken in Germany demonstrated that neither distance to the antenna nor the number of visible antennas were accurate indicators of radio frequency exposure. Instead, the orientation of the antenna's main lobe (mainly in elevation) constitutes the main factor influencing exposure.

Use of appropriate barriers or signage to restrict access is important. Guidance should be provided by the equipment manufacturer on the size of compliance zones. When locating antennas, an assessment of the safety-distances should be conducted, to determine whether the compliance zones could reach adjacent buildings. This could require a change in antenna position or reduction in transmitter power, in order to ensure compliance with the EMF limits (Recommendation ITU-T K.70). See also the examples in **Chapter 7** of this report.

### 3.1.4 ITU-T Recommendations

ITU-T K.52 – "Guidance on complying with limits for human exposure to electromagnetic fields (telecommunications installations and handsets)".It assists with compliance of telecommunication installations and mobile handsets or other radiating devices used near the head with safety limits for EMF. The assessment procedure for telecommunication installations, based on safety limits provided by ICNIRP, helps users to determine the likelihood of installation compliance based on accessibility criteria, antenna patterns and emitter power.

ITU-T K.61 – "Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations". It provides to telecommunication operators the compliance with exposure standards, promulgated by local or national authorities. It guides on measurement methods, to achieve a compliance assessment. It also guides to the select numerical methods, suitable for exposure prediction in various situations.

ITU-T K.70 – "Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations". It defines techniques which may be used by telecommunication operators to evaluate the cumulative (total) exposure ratio in the vicinity of transmitting antennas and to identify the main source of radiation. It offers guidance on mitigation methods, to reduce radiation level in order to comply with exposure limits. It also provides guidance on procedures necessary in the environment with simultaneous exposure to multiple frequencies from many different sources, belonging to many operators and emitting different radiocommunication services (e.g., cellular systems, trunking systems, broadcasting, radio relays, wireless access, etc.).

ITU-T K.83 – "Monitoring of electromagnetic field levels". It guides how to make long-term measurements and monitoring of EMF in the selected areas that are under public concern, in order to show that EMFs are under control and below the limits. It provides for the general public clear and easily available data concerning EMF levels in the form of results of continuous measurement.

ITU-T K.90 – "Evaluation techniques and working procedures for compliance with exposure limits of network operator personnel to power-frequency electromagnetic fields". It provides evaluation techniques and guidelines for compliance with safety limits for human exposure to EMF of telecommunication network personnel (e.g., outside plant craft) at power frequencies (DC, 50 Hz and 60 Hz) and provide techniques and procedures for determining the need for any precautions at the work site.

ITU-T K.91 – "Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields". It guides how to assess and monitor human exposure to EMF in areas with surrounding radiocommunication installations based on existing exposure and compliance standards in the frequency range of 9 kHz to 300 GHz. This includes procedures of evaluating exposure and how to show compliance with exposure limits with reference to existing standards. It examines the area accessible to people in the real environment of currently operated services with many different sources of radio frequency EMF, and refers to standards and Recommendations related to EMF compliance of products.

ITU-T K.100 – "Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service". It provides measurement techniques and procedures for assessing compliance with the general public EMF exposure limits when a new base station is put into service, taking into account environment and other relevant radio frequency sources present in its surrounding.

ITU-T K.113 – "Generation of radiofrequency electromagnetic field level maps". It provides guidance on how to produce EMF maps for assessing existing exposure levels over large areas of cities or territories and for an appropriate public disclosure of the results, in a simple and understandable way.

**ITU-T K.121 (ex. K.env)** – "Guidance on the Environmental Management for Compliance with Radio Frequency EMF limits for Radiocommunication Base Stations". This Recommendation gives guidance on how to manage the compliance with RF-EMF limits in areas near to radiocommunication installations and how to establish processes for responding to public concern about exposure to RF-EMF.

**ITU-T K.122 (ex. K.emf)** – "Exposure levels in the close proximity of the radiocommunication antennas". This Recommendation gives information concerning the electric field strength levels that can be expected in close proximity to the broadcasting and radiocommunication antennas so that a comparison with the exposure limits is possible. It is important for the maintenance personnel and in some cases also for the general public. In case of workers it is recommended that affected personnel should be trained by expert staff so that they are able to assess the exposure levels in the close proximity of the radiocommunication antennas.

## 3.2 ITU-R Study Groups

ITU-R Working Parties 5A, 5B, 5C and 5D share these views: "exposure limits should be established, based on scientific evidence, endorsed by the World Health Organization (WHO). The establishment of restrictive exposure limits may impact the deployment of wireless networks".

WP 5B (Maritime mobile service including the Global Maritime Distress and Safety System (GMDSS); the aeronautical mobile service and the radiodetermination service) does not have any documentation regarding this subject matter, and is of the view that administrations address in their own way human exposure to non-ionizing radiation.

ITU-R Study Group 5 Working Party 5C is of the view that fixed point to point wireless systems are directive and line of sight links do not radiate towards people, living near the antennas, which transmit point to point. Any human exposure from point to point links is derived only from the antenna side lobes.

ITU-R Study Group 1 Working Party 1C working on "Spectrum monitoring" views that administrations conducting monitoring tasks may place more emphasis on measurements from cellular, broadcasting and amateur radio stations, relative to the voluntary personal handsets and terminals. WP1C is pleased to continue collaboration with ITU-D and ITU-T on this matter.

New Question 1/239 on "Electromagnetic field measurements to assess human exposure" is studying:

a) What are the measurements techniques to assess the human exposure from wireless installations of all types?

b) How can measurement results be presented?

### 3.2.1 ITU-R Recommendation and Handbook

ITU-R BS.1698 – "Evaluating fields from terrestrial BC transmitting systems operating in any frequency band for assessing exposure to non-ionizing radiation". This Recommendation derives and estimates the values of EMF around a broadcasting station that occurs at particular distances from the transmitter site. Using such information, organizations can then develop appropriate measures,

to protect humans from undesirable exposure to harmful radiation. The actual values to be applied in any administration depend on national exposure levels.

ITU-R Handbook on Spectrum Monitoring, Revision 2011 section 5.6, details “Non-ionizing radiation measurements”.

# 4 CHAPTER 4 – International EMF activities and exposure limits

## 4.1 World Health Organization (WHO)

Dr Emilie van Deventer (WHO[5], Department of Public Health and Environment, Geneva, Switzerland) presented "WHO: Electromagnetic Radiofrequency Fields National Management and Regulatory Approaches" to the meeting on 22 April 2016. She underlined that: studies are on-going to assess potential long-term effects of wireless technologies. To date, no specific adverse health effects have been established from environmental exposures to radio frequency fields. She thanked the three ITU Sectors who have assisted in reviewing the recent WHO publications: Environment Health Criteria (EHC) monograph, Fundamental Safety Principles and Fact Sheet. WHO has published a database of EMF policies.[6] She also identified: several challenges for governments, including the fact that rapidly evolving radio frequency technologies are launched on the market before any health evaluation, and the disparities in risk management measures and regulations around the world which compound concerns from the public. Governments may wish to delineate clear roles and responsibilities on this topic, adopt health-based standards and ensure their compliance. They may also promote public information programmes and dialogue with stakeholders, and where feasible, enable further research to reduce scientific uncertainty.

## 4.2 ICNIRP 1998 Guidelines – Reference levels

### 4.2.1 ICNIRP 1998 limits applicable to fixed transmitters

Quoting the ICNIRP exposure guidelines[7](1998, p. 495): "Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary". The ICNIRP 1998 reference levels are accepted by a number of countries and countries' threshold are compared to these reference levels. ICNIRP 1998 (p.511 tables 6 and 7) define the exposure thresholds. The following tables and figures specify the ICNIRP reference levels at different frequencies; the exposure limits in the figures are general public and occupational exposure. Below 10 MHz (wavelength 30 meters), effects on human body are due to mostly near-field conditions; the reference levels are provided mainly for the electric field-strength (V/m). Between 10 MHz and 300 GHz the basic restrictions are also provided on the basis of power-density ($W/m^2$), to prevent excessive heating in tissue at or near the body surface. The power-density limit of the general public exposure is five times lower than the occupational exposure limit.[8]

[5] http://www.who.int/peh-emf/en/.
[6] http://www.who.int/gho/phe/emf/legislation/en/.
[7] http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf.
[8] See Wiley's, Mazar Book 'Radio Spectrum Management: Policies, Regulations, Standards and Techniques', Chapter 9.

Table 1: **ICNIRP 1998** reference levels for occupational and general public exposure

| Frequency range | Electric field-strength (V/m) | | Equivalent plane wave power-density $S_{eq}$ ($W/m^{2(}$) | |
|---|---|---|---|---|
| | General public | Occupational | General public | Occupational |
| 1-25 Hz | 10,000 | 20,000 | Power-Density limits not applicable | |
| 0.025-0.82 kHz | 250/f(kHz) | 500/f(kHz) | | |
| 0.82-3 kHz | 250/f(kHz) | 610 | | |
| 3-1,000 kHz | 87 | 610 | | |
| 1-10 MHz | $87/f^{1/2}$ (MHz) | 610/f (MHz) | | |
| 10-400 MHz | 28 | 61 | 2 | 10 |
| 400-2,000 MHz | $1.375f^{1/2}$ (MHz) | $3f^{1/2}$ (MHz) | f/200 | f/40 |
| 2-300 GHz | 61 | 137 | 10 | 50 |

Figure 1: **ICNIRP 1998** electric field-strength for occupational and general public exposure

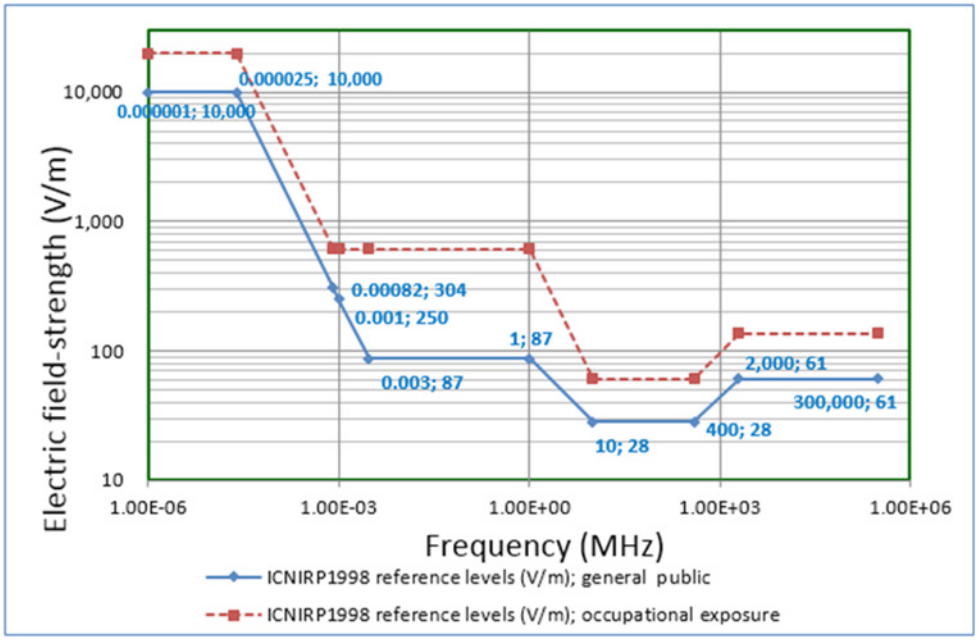
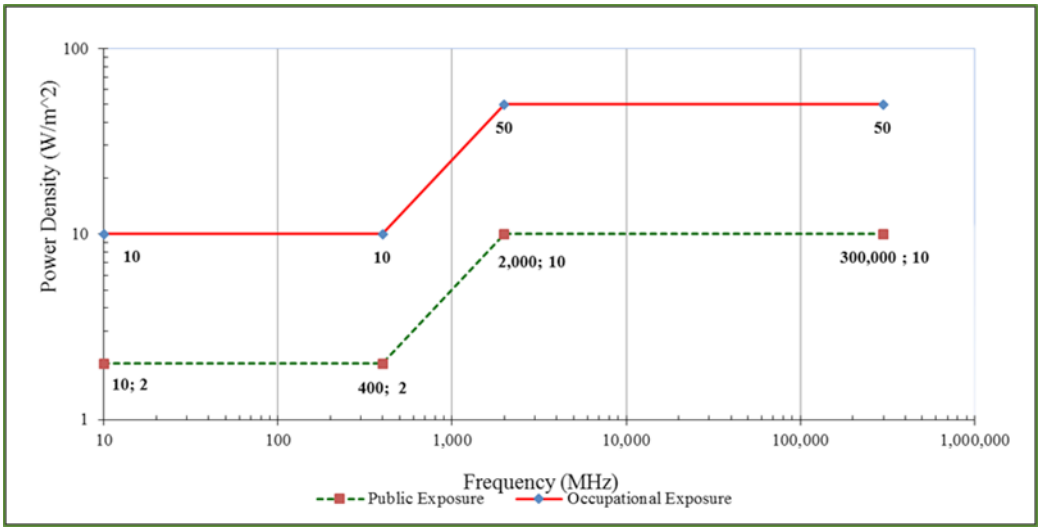


Figure 2: **ICNIRP 1998** power-density reference levels; above 10MHz only




### 4.2.2 ICNIRP 1998 limits applicable to cellular handsets

The general public receives the highest exposure from handheld devices such as mobile phones, which deposit most of the radio frequency energy in the brain and surrounding tissues. Typical exposures to the brain from handsets are several orders of magnitude higher than those from mobile-phone base stations on rooftops or from terrestrial television and radio stations. As far as exposure levels are concerned, a distinction is made between the fixed radiating transmitters of the base stations and the portable handsets. The exposure from fixed transmitters refer to the field-strength and power-density generated, whereas handset exposures are assessed by the Specific Absorption Rate (SAR) value from 10 MHz to 10 GHz and by power density[9] from 10 to 300 GHz. The reason for the two different approaches is that the far-field[10] exposure from fixed wireless stations is practical to analyse (easily simulated and measured) relative to power density limits. The handset, which is used in proximity to the user's body, meaning that the body in conjunction with the handset design have a strong impact on the EMF in the near-field.[11] The SAR, related to the internal electric field and by extension the temperature rise due to the EMF, defines the threshold limits for sources used close to the body, including handsets. In terms of exact definition, the SAR is 'the time derivative of the incremental power absorbed by (dissipated in) an incremental mass; it is expressed in W/kg.

**Table 2** compares the SAR limits in ICNIRP 1998, European Community (EC)[12], United States of America, Canada[13] and the Republic of Korea in uncontrolled environments and specifies the exposure limits for the partial body limit for mobile devices.

[9] The public exposure limit in this frequency range given by ICNIRP (1998) is 10 W/m$^2$.

[10] Recommendations ITU-T K.91 p.7 and K.61 p.2 define far-field 'That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In the far-field region, the field has predominantly plane-wave character, i.e., locally uniform distribution of electric field-strength and magnetic field-strength in planes transverse to the direction of propagation'.

[11] ITU-T K.91 p. 8 defines near-field 'The near-field region exists in the proximity to an antenna or other radiating structure in which the electric and magnetic fields do not have a substantially plane-wave character but vary considerably from point to point'.

[12] References: ICNIRP 1998p.509 Table 4; 1999/519/EC Annex III, Table 1 and IEC 62209-1; IEEE 1999 p. 29.

[13] FCC 1997 OET Bulletin 65p. 75 (FCC 2012 CFR 47 FCC § 2.1093) and 1999 Canada Safety Code 6. NOI FCC 13-39 or R&O FCC 03-137 2013 keeps the SAR levels unchanged.

Table 2: Maximal power from handsets: Specific Absorption Rate (SAR) (W/kg)

| ICNIRP 1998 | European Community | Canada, Republic of Korea and United States of America |
|---|---|---|
| From 10 MHz to 10 GHz; localized SAR (head and trunk) | From 10 MHz to 10 GHz; localized SAR (head and trunk) | portable devices;<br>general public / uncontrolled |
| 2.0; averaged over 10 g tissue (it is also IEEE C95.1-2005 level) | 2.0; averaged over 10 g tissue (it is also IEEE C95.1-2005 level) | 1.6; averaged over 1g tissue |

Manufacturers follow international compliance testing standards to ensure that when tested the device operating at maximum power will comply with relevant international or national limits. The handset is working in full output power in the worst connection conditions (obstacles or long distance to base station), and in minimum output power in the best connection conditions (line of sight and close to the base station).

The maximum SAR level for different mobile phones varies according to technology and many other factors, for example, SAR is also influenced by technical parameters such as the antenna used and its placement within the device. The SAR information for a mobile phone is available from the Mobile & Wireless Forum website at: http://www.sartick.com.

## 4.3 Regional, national and comparative exposure limits

### 4.3.1 EMF regulations in Europe

Europe addresses radio exposure limits for workers in Directive 2013/35/EU. There is a difference in the public exposure limits among European countries, as there is no legal basis for the European Commission, to establish public exposure limits for base stations. However, the EC recommends adoption of ICNIRP (1998) limits in Council Recommendation 1999/519/EC. In general, Northern Europe is more aligned with 1999/519/EC than Southern Europe. There are no clear distinctions between Western and Eastern European countries. See bibliography EMC-2016; EMF.

There is large variation from among European countries on the regulations and the specific implementation measure for the protection of the general public, against exposure from EMF originating from transmitters. Monitoring activities are quite widely undertaken in Europe; however, the scale and scope of the monitoring activities seem also to be very diverse.

#### 4.3.1.1 Legally binding measures

Most European countries follow officially the non-mandatory EU Council Recommendation 1999/519/EC, 'limiting the public exposure to electromagnetic fields (0 Hz to 300 GHz)'; the same exposures of human-hazards as the ICNIRP 1998 levels. Some EU countries adopt more restrictive reference levels. The European Commission (EC) has procuded "Report from the Commission on the application of Council Recommendation of 12 July 1999", that provides details on the implementation.[14]

#### 4.3.1.2 Exposure limits

Generally the national legislation in Europe use in some way or another the international ICNIRP 1998 exposure limits in order to limit the EMF exposure of people.

[14] http://ec.europa.eu/health/ph_risk/documents/risk_rd03_en.pdf.

#### 4.3.1.3 Precaution

Because of the perceived existing uncertainty, several legislators in Europe and in other countries enacted precautionary measures for the general public or possibly vulnerable population groups against EMF exposure. Generally these national regulations recommend precautionary measures to reduce exposure to EMF, to limits below the Reference levels of ICNIRP1998. Measurements show that typical exposure levels in public areas are not reduced by adopting lower limit[15],[16]. A survey[17] for the European Commission found that restrictive limits and other precautionary measures are associated with higher levels of public concern. In addition, restrictive limits result in an increased number of antennas to maintain equivalent service.[18]

#### 4.3.1.4 Compliance verification

It has a competent authority. Local planning authority and town councils may be responsible for the process (may be the same national authority assigning frequencies, environment protection or public health authorities). In order to demonstrate compliance, the applicant should provide relevant information. Usually the authority adopts predictive modeling, to calculate the exposure-ranges around the transmitter.

#### 4.3.1.5 Enforcement following start of operation of transmitter

In some cases, regular and systematic (once a year, as an example) measurement (occasionally permanent radio frequency radiation monitoring systems) monitor the installations around the transmitter, especially in sensitive areas (schools, hospitals, etc.), at the initiative of the authorities, or on request subsequently to concerns by general public.

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15 Comparative international analysis of radiofrequency exposure surveys of mobile communication radio base stations. Rowley et al. *Journal of Exposure Science and Environmental Epidemiology*. 22(3):304–315, May/June 2012.

16 Radio-frequency electromagnetic field (RF-EMF) exposure levels in different European outdoor urban environments in comparison with regulatory limits. Urbinello et al. *Environment International*. 68(0):49-54, July 2014.

17 Special Eurobarometer 347: Electromagnetic Fields, Conducted by TNS Opinion & Social at the request of the Directorate General for Health and Consumer Affairs. Survey coordinated by Directorate General Communication. June 2010.

18 The impact of EMF exposure limits reduction on an existing UMTS network, Niţu, *University Politehnica of Bucharest Scientific Bulletin., Series C*, 77(3):123-134, 2015.

# 5 CHAPTER 5 – Case studies based on responses received to survey

At the September 2015 meetings of ITU-D Study Group 2 and its Working Party 1/2, it was agreed to issue a joint survey in order to collect the latest information on the status of strategies and policies concerning human exposure to electromagnetic fields (study Question 7/2) and other study Questions, to request input from the Membership on these specific topics. By the end of the deadline, study Question 7/2 received 24 responses from ITU Member States and ITU-D Sector Members. Through the analysis of the inputs, findings will help to assist countries in building and strengthening their capacity in human exposure to EMF. Detailed information can be found in **Annex 1** to this report.

Table 3: Extract of responses to survey

| Questions | Answers |
|---|---|
| 1. Does your country have a standard or specification that determines the exposure limits? | 81% countries follow the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines; 13% countries have own national standard or specification, that differ from ICNIRP guidelines; 1% countries are in the process of formulating the country standard or specification; 5% countries have no standard or specification that determines the exposure limits. (23 responses) |
| 2. Which type of legislation and/or regulation exists in your country? | 17 countries have laws, 9 countries have Decrees, 9 countries have Norms, and 4 countries have other legislation and/or regulation. (23 responses, more than one answer possible) |
| 3. What kind of organizational structure of responsible authorities exists in your country? | 17 countries have agency/department responsible for standards/specification setting; 17 countries have agency/department responsible for monitoring; 9 countries have agency/department responsible for health related impact assessment; 18 countries have agency/department responsible for enforcement; 8 countries have agency/department responsible for test and approval of the construction of infrastructures; 5 countries have other authorities. (24 responses, more than one answer possible) |
| 4. What kind of measures are taken with consideration to possible sensitive areas (schools, hospitals, etc.) and vulnerable populations (pregnant women, children, etc.)? | 12 countries have restrictions on erecting towers in sensitive areas; 9 countries have continuous proactive measurements (etc.); 13 countries have measurements on request (etc.); 10 countries have information shared on websites or other media; 7 countries have other measures. (21 responses, more than one answer possible) |
| 5. What is the approximate timeframe to assess a radiocommunication site? | 59% countries take less than 30 days; 25% countries take 30-60 days; 15% countries take 60-180 days; 1% countries take more than 180 days. 94% of these time frame is specified in a law/decree/norm/guidelines, etc. (21 responses) |
| 6. What is the approximate expense of assessing a conventional (used in populated areas) radiocommunication site? | 79% countries charge less than 5,000 USD; 16% countries charge 10,000-15,000 USD; 5% countries charge more than 15,000 USD and no country charges 5,000-10,000 USD. 11% of these are specified in a law/decree/norm/guidelines, etc. (19 responses) |
| 7. Who will pay for the assessment of a radiocommunication site? | Monitoring agency measures in 12 countries, radiocommunication site owner pays for it in 13 countries; requesting person or agency who allowed the site to be established in his private property pay for it in 8 countries; others will pay for it in 3 countries. (28 responses, more than one answer possible) |

| Questions | Answers |
|---|---|
| 8. What's the Specific Absorption Ratio (SAR) limit for mobile terminals in your country? | 90% countries follow ICNIRP guidelines; 10% countries have own national SAR limits. (21 responses) |
| 9. Is there any special legislation and/or regulation for the deployment of radiocommunication infrastructures in your country? | 83% countries do have special legislation and/or regulation for the deployment of radiocommunication infrastructures. (23 responses) |
| 10. What constitute some good practices on how to raise the awareness in the population/country on issues concerning human exposure to electromagnetic fields? | 20 countries introduce relevant knowledge in the special area on the website or other media; 11 countries hold regular or irregular seminars; 5 countries use bulk SMS through the mobile operator; 10 countries create a dedicated website and share information through social media; 6 countries provide information through mobile apps; 3 countries have others. (22 responses, more than one answer possible) |
| 11. What constitute some good practices on how to bring the exposure information to the attention of the population? | 17 countries introduce relevant measurement results in the special area on the website or other media (broadcasting included); 14 countries introduce relevant measurement results in the special area of relevant agencies; 6 countries show violation of regulations on the website; 7 countries use bulk SMS through the mobile operator; 8 countries create a dedicated website and share information through social media; 10 countries provide information through mobile apps; 3 countries have others. (25 responses, more than one answer possible) |
| 12. Does your country enforce obligations for radiocommunication site owners? | 17% countries measure and disseminate on a regular basis; 11% countries disseminate awareness information on a regular basis; 71% countries have others; 1% countries have no enforcement. (23 responses) |

# 6 CHAPTER 6 – Comparison of exposure limits

Countries in Europe, Japan and the People's Republic of China ("China" in the rest of the Report) all use 2 W/kg in 10g SAR, for the partial body limit for mobile devices; however, in the Republic of Korea, the United States of America and Canada the limit is 1.6 W/kg in 1g. In the far-field, at 400-1,500 MHz (which includes cellular transmission and UHF TV bands), the maximum allowed Power Density level (PD) of ICNIRP, Europe and the Republic of Korea for the general public exposure is *f* (MHz)/200 W/m$^2$. At the 300-1,500 MHz range, the United States' and Japanese threshold is *f* (MHz)/150 W/m$^2$, which is higher by 4/3 (200/150), compared to the ICNIRP 1998 threshold. Like Japan, the United States of America allows higher limits for radio frequency exposure from base stations.[19]

It is important to underline that the United States', Canadian and Korean regulations are more restrictive than 1999/519/EC and IEEE C95.1-2005 in the allowed SAR from the cellular terminal. It should be noted that the FCC limits are based an older IEEE standard (C95.1-1991) that has since been updated[20] to align with ICNIRP. The ICNIRP 1998 threshold, adopted by the European Community and IEEE is **2.0** W/kg, while the limit in the Republic of Korea, the FCC § 2.1093 and Canada Safety Code SC6 is **1.6** W/kg for the partial body. This position seems more rational (at least compared to countries, dividing ICNIRP 1998 power levels up to 100), as the radio frequency energy absorbed from the handset and notebook is much stronger, being much nearer to the user's body, compared to the received signal from the base stations. The United States of America and Japan are the most tolerant in regulating uncertain risks around fixed transmitters.

**Table 4** provides overall comparison: France, United Kingdom, United States of America, People's Republic of China, Japan and Republic of Korea limits relative to the general public ICNIRP 1998 reference levels (adopted by EC and IEEE): PD 5 W/m$^2$ at 1,000 MHz, and SAR 2 W/kg. Reference levels are calculated at *f* 1,000 MHz, and indicate the partial body limit for mobile devices average SAR. **Table 4** assorts the rows by PD, descending percentage of ICNIRP level; indicating that the People's Republic of China (0.08 ICNIRP level) is the most restrictive.

Table 4: Overall comparison of power density and SAR

| Country | PD 1,000 MHz (W/m$^2$) | SAR (W/kg) |
|---|---|---|
| United States of America | f/150 =6.67; 133/% | 1.6, averaged over 1g tissue |
| Japan | | 2.0, over 10 g |
| France and United Kingdom | f/200 =5; 100% | |
| Republic of Korea | | 1.6, averaged over 1g tissue |
| Canada | 0.02619f 0.6834 =2.94; 59% | |
| People's Republic of China | 0.4; 8% | 2.0 W/kg, over 10 g |

Note: [a] it is also ICNIRP and IEEE 2006 reference levels.

[19] See Mazar: Human Radio Frequency Exposure Limits: an update of reference levels in Europe, USA, Canada, People's Republic of China, Japan and Republic of Korea; EMC Europe Wroclaw, 2016.

[20] The International Committee on Electromagnetic Safety (ICES) that maintains the C95 series standards has explained that the 1991 SAR limits were based on early dosimetry considerations alone, whereas the 2005 limits are based on a significantly improved understanding of the RF and thermal dosimetry and biological/health effects considerations. (See C.2.2.2.1.1 in C95.1-2006).

The following figures depict exposure-ranges around terrestrial transmitters.[21] For transparency, figures around base stations, depicting field-strength or power-density relative to the national reference-level may be published, for the public living near the terrestrial stations. The following calculations take into account terrain map and buildings, and use Recommendation ITU-R P.526-13 (Propagation by Diffraction; Deygout 1994). The calculated distances are lower than the free-space model. Assuming free-space propagation loss, the field-strength *e* around the terrestrial station $e = \frac{\sqrt{30 \times eirp}}{d}$, i.e. disregarding buildings and obstacles, the exposure-distance is easily calculated by inserting the field-strength reference-level, ICNIRP 1998 limit for general public as *e*: the safety distance *d* around the station is $d = \frac{\sqrt{30 \times eirp}}{e}$.

[21] The figures were prepared by Eng. Hervé Napoletano.

# 7 CHAPTER 7 – Field-strength around transmitters

## 7.1 Field-strength around FM transmitters

The following analysis refers to Omni antenna FM 100 MHz transmitter of 60,000 Watts eirp, 60 m above ground level.[22] The propagation model takes into account the attenuation due to buildings. Even they are significant, in order to simplify the view, the calculation disregards the **elevation-pattern** of the antenna and **near-field effects**.

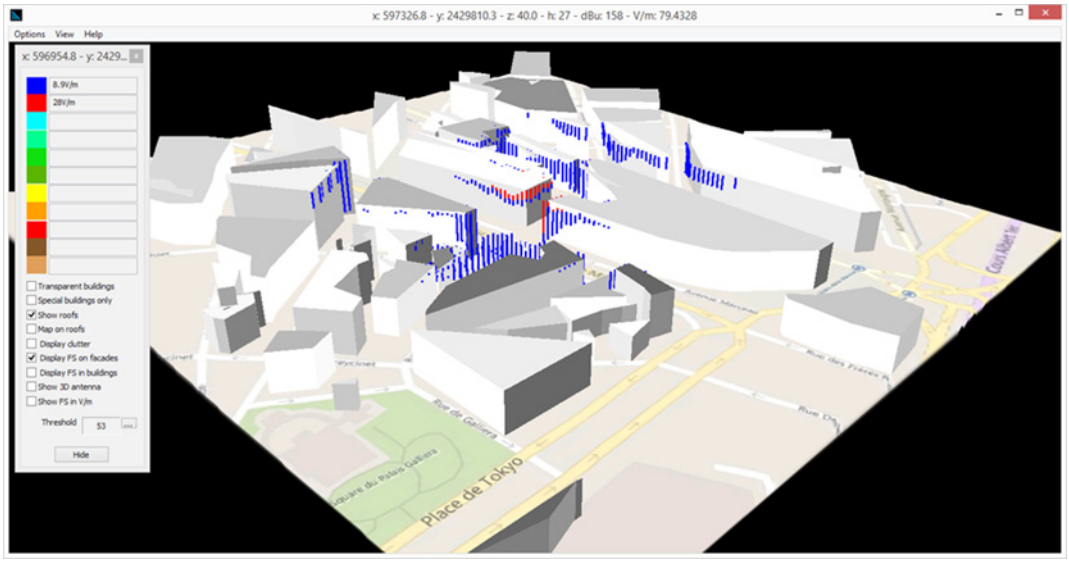
At 100 MHz the electric field-strength (V/m) ICNIRP general-public reference-level is 28 V/m. As some countries divide the ICNIRP power-density by 10, the following figures refer also to 8.9 V/M (28 divided by $\sqrt{10}$ ).

Assuming free-space propagation loss, $e = \frac{\sqrt{30 \times eirp}}{d}$, i.e. disregarding any buildings and other obstacles, the safety-distance is easily calculated by $d = \frac{\sqrt{30 \times eirp}}{e}$

For eirp 60 kW, the free-space propagation loss safety-contours are 48 m for 28 V/m and 151 m for 8.9 V/M.

Taking into account terrain map and buildings, non-free space propagation loss, the calculated distances are lower; as shown in **Figure 3** and **Figure 4**.

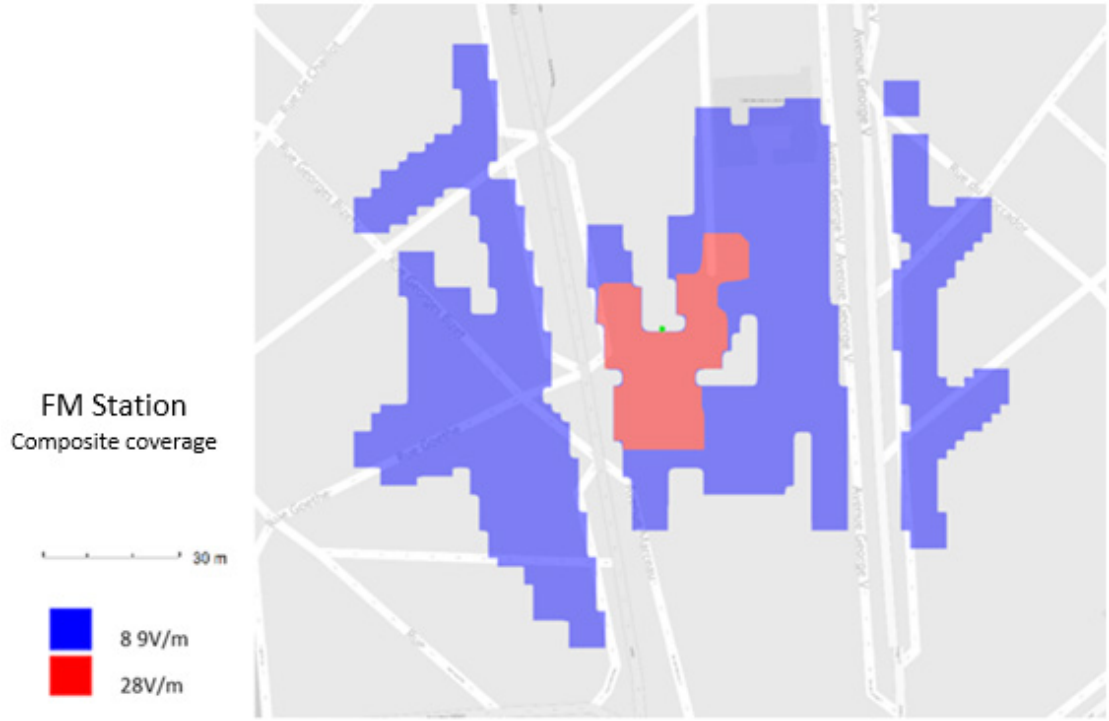
Figure 3: Three dimensions FM exposure-contours




Source: ATDI, France

[22] See ATDI's ITU-R6/395, 6 July 2015.

Figure 4: Two dimensions FM exposure-contours



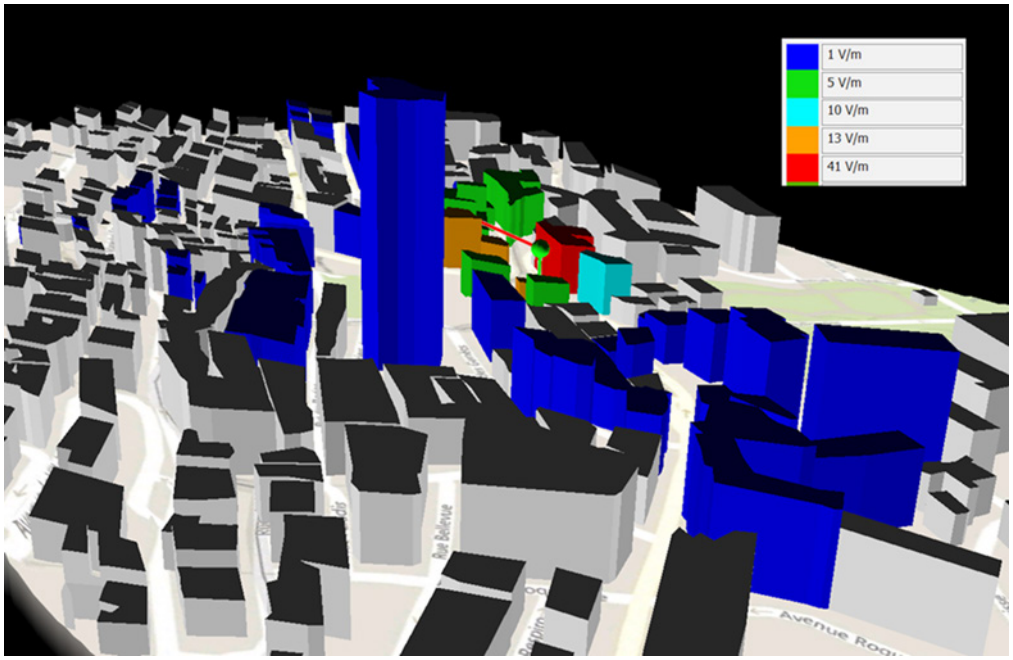

Source: ATDI, France

## 7.2 Field-strength around cellular transmitters

Even they are significant, in order to simplify the view, the calculation disregards the elevation-pattern of the antenna and the effect of reduced gain in the near-field.[23] Actually for cellular base stations, below the transmitter, the antenna gain is very low. Two dimensional view, taking into account the elevation pattern will confuse the viewer. At 900 MHz the electric field-strength (V/m) ICNIRP general-public reference-level is 41 ($1.375f^{1/2}$ = 1.375 × 30) V/m. As some countries divide the ICNIRP power-density by 10, the 3 dimensions **Figure 5** refers also to 13 V/M (41 divided by $\sqrt{10}$, as the field-strength is related to the square root of the power). For maximal downlink power of 100 W and antenna gain (including losses) 17 dBi, eirp is 5 kW; the free-space outdoor propagation loss safety-contours are 9.5 m for 41 V/m and 30 m for 13 V/M.

[23] See ATDI ITU-R 5A/8 of 25 January 16.

Figure 5: Three dimensions cellular exposure-contours, showing buildings impacted




Source: ATDI, France

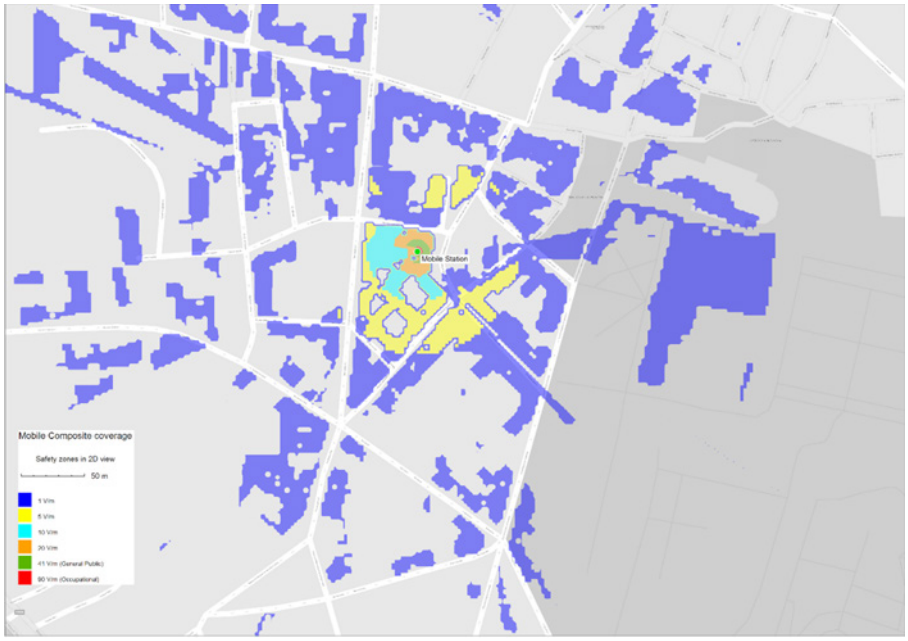
For the same cellular transmitter, the following two dimensions figure depicts downlink safety-zones for a receiving antenna height of 1.5m above ground level or above rooftop. Taking into account wall attenuation, with 1.5m AGL mobile receiver, the coverage indoor is very poor. Modelling for the French authorities has shown that restrictive limits lead to reductions in the quality of indoor coverage.[24] **Figure 6** depicts also safety distance for occupational exposure. The ICNIRP (see Table 1) general-public reference-level is 41 (1.375f 1/2 = 1.375 × 30) V/m and the occupational reference-level is 90 V/M: 3f 1/2 (MHz); the field-strength scales are 1, 5, 10, 20, 41 (general-public) and 90 (occupational) V/M. The following figure depicts buildings impacted in 3D view.

Measurement surveys and continuous monitoring systems have been operating in many countries and show[25] that the mean environmental radiofrequency levels from mobile communication systems are typically less than 0.1 μW/cm$^2$.

[24] Concertation et information locales dans le cadre de l'implantation d'antennes relais. Diminution de l'exposition aux ondes électromagnétiques émises par les antennes relais de téléphonie mobile. Rapport de la première phase par François Brottes, 30 August 2011.

[25] Observations from national Italian fixed radiofrequency monitoring network. Rowley et al. *Bioelectromagnetics*. 37(2):136–139, February 2016.

Figure 6: Two dimensions cellular exposure-distances



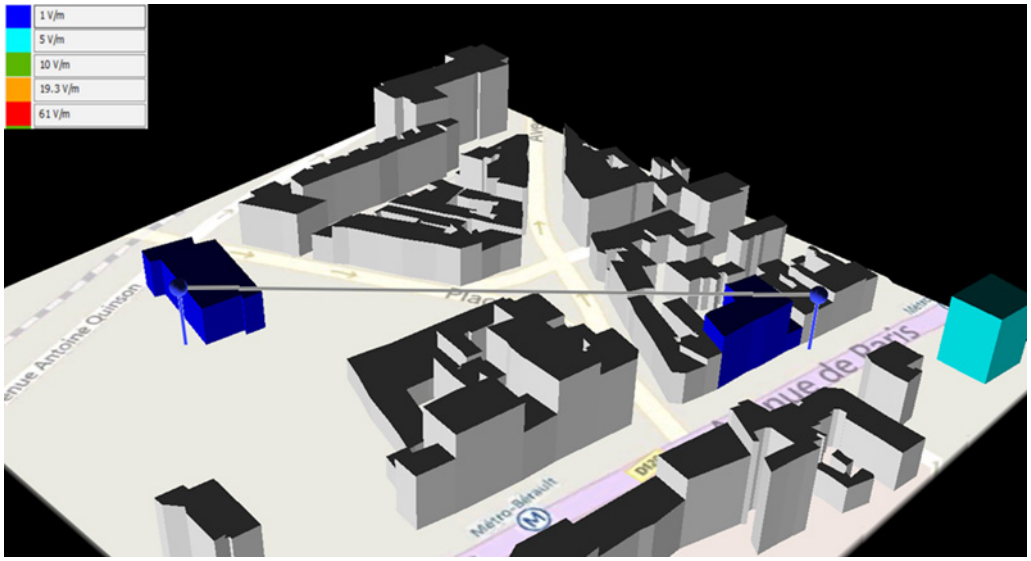

Source: ATDI, France

## 7.3 Field-strength around point-to-point transmitters

The antenna patterns are retrieved from Recommendation ITU-R F.699-7 in elevation and azimuth (similar patterns as the antenna is circular). At 10 GHz the electric field-strength (V/m) ICNIRP 1998 general-public reference-level is 61 V/m. As some countries divide the ICNIRP power-density by 10 and even more, the following 3D Figures refer also to 19.3 V/M (61 divided by $\sqrt{10}$ ) and less field-strength level.[26] For maximum power of 2W and antenna gain (including losses) 43 dBi, eirp equals 40 kW; the free-space propagation loss exposure-contours are 18 m for 61 V/m and 57 m for 19.3 V/M. The following figures depict the field-strength derived from two point to point transmitters 40 kW eirp, using isotropic (the case where the directive antennas may accidently change azimuth or elevation) or directional antennas.

[26] See ATDI ITU-R 5C/17of 29 March 2016.

Figure 7: Three dimensions exposure, with ITU-R F.699 antenna patterns; 40 kW eirp




Source: ATDI, France

Figure 8: Two dimensions exposure-distances with ITU-R F.699 antenna patterns

Figure 1A: Does


Source: ATDI, France

# 8 CHAPTER 8 – Stakeholder responsibilities and national practices

## 8.1 Roles for national authorities

The roles and responsibilities within national authorities may vary widely from one country to another, depending on the legislative framework in place.

**The possible responsibilities for planning authority or regulator:**

- Protect public health;
- Authorize siting of transmitters;
- Establish planning rules for transmitters;
- Approve land use near transmitters;
- Coordinate with other stakeholders.

**The possible responsibilities for landowner of site housing a transmitter, or which a network operator would like to use for a transmitter:**

- Decide whether to lease site;
- Act as a good neighbor;
- Use position as landowner to encourage or promote local priorities.

**The possible responsibilities for network operator:**

- Operate radio telemetry network to monitor status of local infrastructure;
- Operate private mobile radio network to communicate with staff;
- Operate Wi-Fi network for public use;
- Comply with regulatory requirement.

**The possible responsibilities for employer:**

- Meeting occupational health and safety responsibilities for staff working near wireless network transmitters.

**The possible responsibilities for source of information:**

- Lead public communications about health issues;
- Respond to questions about wireless networks from local residents, elected representatives, etc.;
- Forward position of national health authorities.

## 8.2 National practices in some countries

Table 5: National practices

| Policy category | Implementation plan | Countries |
|---|---|---|
| Safety limits of human exposure to electro-magnetic fields | Follow in general the ICNIRP guidelines | Brazil, Republic of Korea, Israel, Benin, People's Republic of China |
| | To set their own standards | Côte d'Ivoire, Uzbekistan |

| Policy category | Implementation plan | Countries |
|---|---|---|
| Legislative and regulatory mode | Publish laws to supervise the influence to human health and surrounding environment of base station | Uzbekistan, Benin, People's Republic of China |
| | Have specialized agencies responsible for assessment and approval of the base station installation or relocation | Côte d'Ivoire, Hungary, People's Republic of China, Brazil, Republic of Korea |
| | Take protective measures to sensitive area and Vulnerable populations | Côte d'Ivoire, Benin |
| | According to relevant laws, regulations and social demands, etc., measure the stations on a regular basis at the national level | Côte d'Ivoire, Brazil, Israel, Hungary, Benin |
| | To determine obligations of the base station owners | Côte d'Ivoire |
| Information disclosure | Introduce relevant knowledge and measurement results in the website of regulatory agencies | Côte d'Ivoire Brazil, Republic of Korea, Israel, Hungary, People's Republic of China |
| | Monitoring software and violation of EMF limits are shown on the website of regulatory agency | Israel |

## 8.3 Policies to limit human exposure to radiofrequency fields

Field-strength, monitoring and theoretical assessments of human exposure of cellular sites around the world[27] reveal that the exposure levels are very low, relative to ICNIRP 1998 reference levels; so, these questions may be raised:

- As there are millions of cellular base stations, approximately one station per thousand subscribers, do we need to enforce post-installation measurements for any base station at ground level for compliance purposes? and
- Why to monitor ex-ante nationally, if measurements can be made ex-post, after specific demand of worried citizens?

As measurements on the ground in public areas typically show very low exposure levels some administrations have considered that the ICNIRP 1998 reference levels too high and have considered that they could be reduced. The ICNIRP levels are based on established health hazards and subject to continuous review. The limits are not based on technology. In addition, such a rational ignores the fact that reduction in exposure limits means larger antenna compliance zones that must be managed.

At the moment of writing this report ICNIRP is preparing an update to the 1998 guidelines for frequency 100 KHz to 300 GHz and a draft is expected at the end of 2017.

### 8.3.1 Policies to reduce human exposure

Derived from the precautionary-principle, these are policies to reduce human exposure:

- Follow the existing ICNIRP 1998 limits from stations and cellular handsets at the national level and across the country. These exposure limits are the current international scientific consensus.

[27] See Wiley's, Mazar Book 'Radio Spectrum Management: Policies, Regulations, Standards and Techniques', Chapter 9.

The tolerability of the human body to radio frequency radiation is independent of geography or political borders: there is no technical justification for different national exposure levels. Cellular networks are not local; there is no engineering reason for different exposure levels among cities inside the country; the definition of exposure limits should be national, and outside the competency of municipal or provincial councils;

- Introduce clear labelling indicating the presence of microwaves or electromagnetic fields exceeding limit values, the transmitting power or the SAR of the device and any established health risks connected with its use;
- Where it is feasible from competition, cost, capacity, and coverage consideration, Consider the alternative mediums that potentially have lower exposure;
- Promote cellular sites' co-location passive (same site, mast and antenna) and even active sharing (same transceivers and frequencies) among operators, in order to reduce the number of the cellular base stations;
- Do not limit construction of masts near sensitive places, as the individual exposure from the handsets increases, with fewer base station antenna, due to handset power growth [ITU-T K.91 2012];
- Inform the public transparently about existing and expected exposure values, by performing simulations. For the cell phones: provide good visible publication of the SAR values; and,
- Theoretically assess every base station to assure that general public exposure is lower than ICNIRP 1998 reference levels; measure upon request; try to software monitor the exposure and emitted power 24 hour a day 365 days a year.

### 8.3.2 Mitigation techniques to decrease the radiofrequency exposure level

The following approaches can be applied to reduce human exposure:

- Restrict access to areas where the exposure limits are exceeded. Physical barriers, lockout procedures and adequate signs are essential; workers can use protective clothing (Recommendation ITU-T K.52);
- Increase the antenna height. The distances to all points of investigation are increased and the radiation level is reduced. Moreover, additional attenuation to the radiation is achieved due to the increase of off-boresight elevation angle and decrease of transmitting antenna side lobe (ITU-T K.70);
- Increase the antenna gain (mainly by reducing the elevation beam width), and consequently decrease the radiation in the direction accessible to people. The vertical beam width may be used to reduce the radiation level in close proximity to the antenna. Moreover, the same value of the eirp can be achieved by a low power transmitter feeding high gain antenna or by high power transmitter feeding low gain antenna. As far as the protection against radiation is concerned, a much better choice is to use the low power transmitter feeding the high gain antenna. (ITU-T K.70); and
- Minimize the base station transmission to the minimum needed to maintain the quality of the service, as quality criterion. Decrease the transmitter power and consequently decrease linearly the power-density in all the observation points. As this mitigation technique reduces the coverage area, it is used only if other methods cannot be applied (ITU-T K.70).

## Abbreviations and acronyms

Various abbreviations and acronyms are used through the document, they are provided here.

| Abbreviation/acronym | Description |
|---|---|
| **3G** | Third Generation |
| **ANSI** | American National Standards Institute (United States of America) |
| **BBC** | British Broadcasting Corporation |
| **BDT** | Telecommunications Development Bureau |
| **EC** | European Commission (executive body of the European Union) |
| **EHC** | WHO Environment Health Criteria |
| **ELF** | Extremely Low Frequency |
| **EMF** | Electromagnetic Fields |
| **ETRI** | Electronics and Telecommunications Research Institute (Republic of Korea) |
| **EU** | European Union and European Commission |
| **FCC** | Federal Communications Commission (United States of America) |
| **FG** | Focus Group |
| **GHz** | Gigahertz |
| **GMDSS** | Global Maritime Distress and Safety System |
| **HF** | High Frequency (3-30 MHz) |
| **Hz** | Hertz (the base unit of frequency) |
| **IARC** | International Agency for Research on Cancer |
| **ICES** | International Committee on Electromagnetic Safety |
| **ICNIRP** | International Commission on Non-Ionizing Radiation Protection |
| **ICT** | Information and Communication Technologies |
| **IEC** | International Electrotechnical Commission |
| **IEEE – SA** | Institute of Electrical and Electronics Engineer – Standards Association |
| **ITU** | International Telecommunication Union |
| **ITU-D** | ITU Telecommunication Development Sector |
| **ITU-R** | ITU Radiocommunication Sector |
| **ITU-T** | ITU Telecommunication Standardization Sector |
| **KEPCO** | Korea Electric Power Corporation (Republic of Korea) |
| **kHz** | Kilohertz |
| **MF** | Medium Frequency |

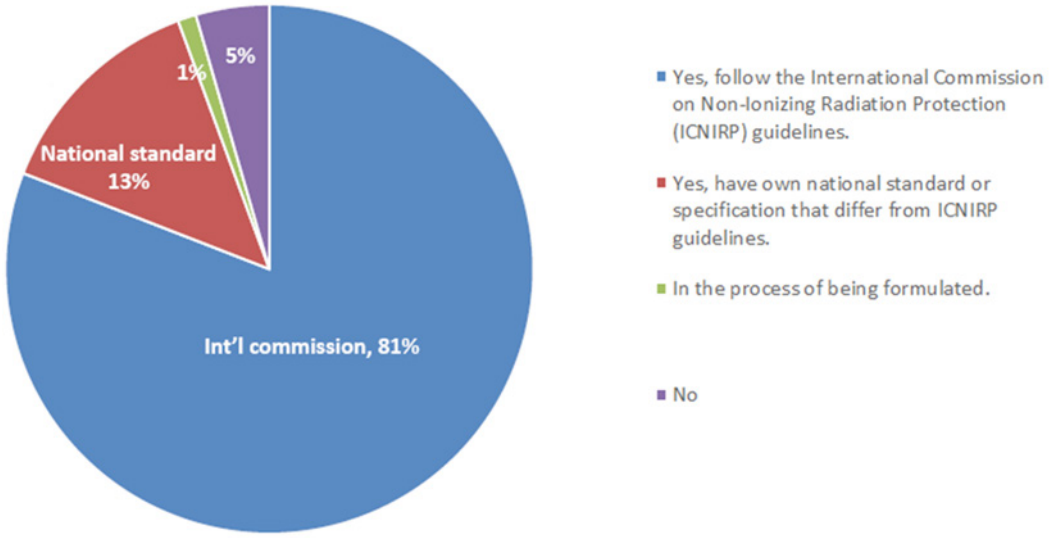
| Abbreviation/acronym | Description |
|---|---|
| **MFN** | Multi Frequency Network |
| **MOTIE** | Ministry of Trade, Industry and Energy (Republic of Korea) |
| **MSIP** | The Ministry of Science, ICT and Future Planning (Republic of Korea) |
| **NIR** | Non-Ionizing Radiation |
| **NMIAH** | National Media and Infocommunications Authority of Hungary |
| **NRIRR** | National Research Institute for Radiobiology and Radiohygiene |
| **PD** | Power Density |
| **P-MP** | Point to Multi Point |
| **PP** | Plenipotentiary Conference (ITU) |
| **RAN** | Radio Access Network |
| **RF** | Radio Frequency |
| **RRA** | Radio Research Agency (Republic of Korea) |
| **SAR** | Specific Absorption Rate |
| **SC** | Safety Code (Health-Canada) |
| **SCENIHR** | Scientific Committee on Emerging and Newly Identified Health Risks |
| **SCHEER** | Scientific Committee on Health, Environmental and Emerging Risks |
| **SDO** | Standard Development Organization |
| **SSC** | Smart Sustainable Cities |
| **UHF** | Ultra High Frequency (300-3,000 MHz) |
| **UMTS** | Universal Mobile Telecommunication System |
| **USD** | US Dollar |
| **VHF** | Very High Frequency (30-300 MHz) |
| **WHO** | World Health Organisation |
| **Wi-Fi** | Wireless Fidelity (IEEE) |
| **WLAN** | Wireless Local Area Networks |
| **WTDC** | World Telecommunications Development Conference (ITU-D) |
| **WTSA** | World Telecommunications Standardisation Assembly (ITU-T) |

# Annexes

## Annex 1: Survey on strategies and policies concerning human exposure to EMF

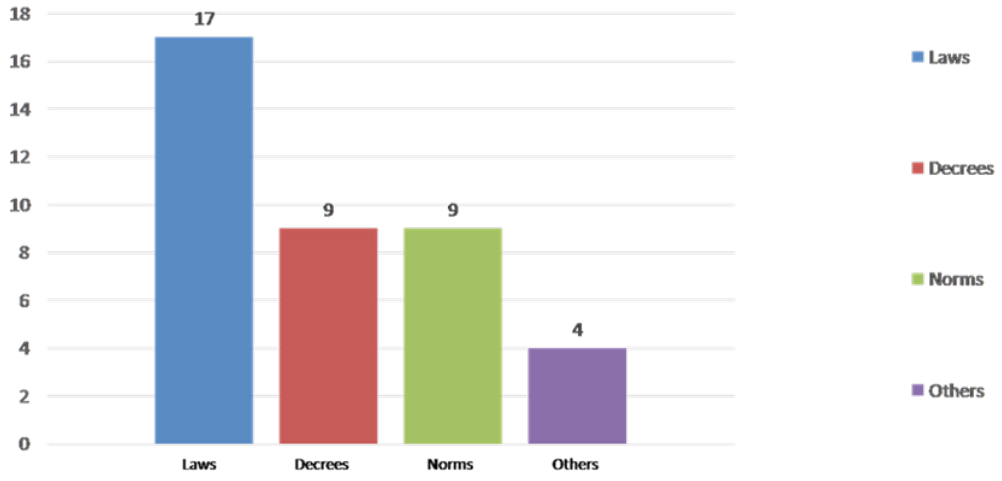
1. Does your country have a standard or specification that determines the exposure limits?

Figure 1A: Does your country have a standard or specification that determines the exposure limits?



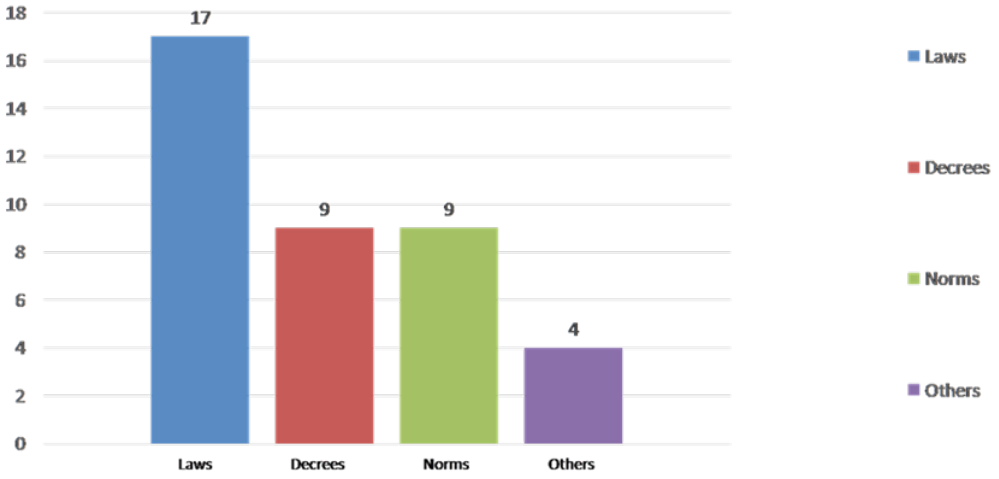

2. Which type of legislation and/or regulation exists in your country?

Figure 2A: Which type of legislation and/or regulation exists in your country?



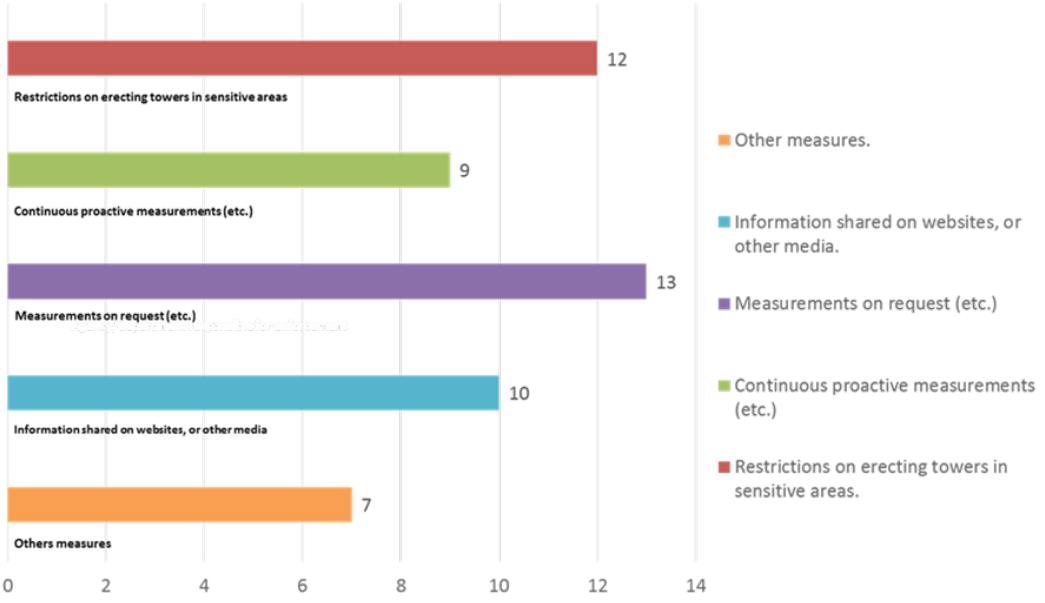

3. What kind of organizational structure of responsible authorities exists in your country?

Figure 3A: What kind of organizational structure of responsible authorities exists in your country?



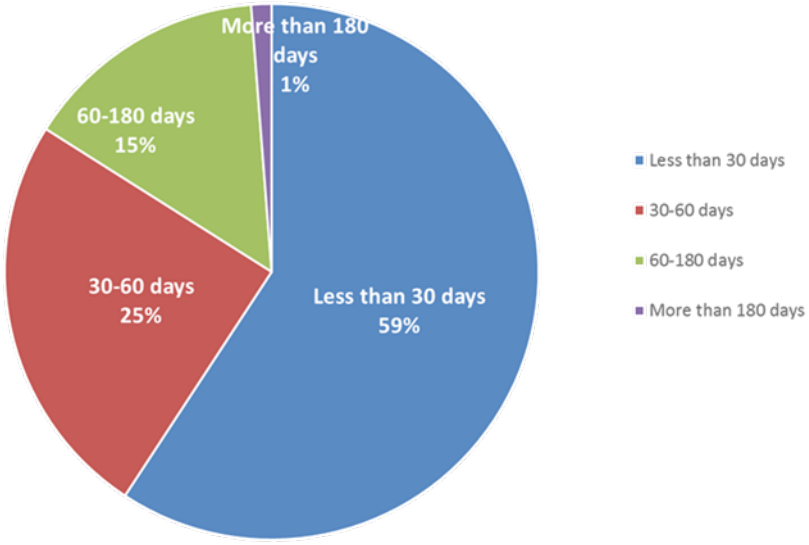

4. What kind of measures are taken with consideration to possible sensitive areas (schools, hospitals, etc.) and vulnerable populations (pregnant women, children, etc.)?

Figure 4A: What kind of measures are taken with consideration to possible sensitive areas (schools, hospitals, etc.) and vulnerable populations (pregnant women, children, etc.)?



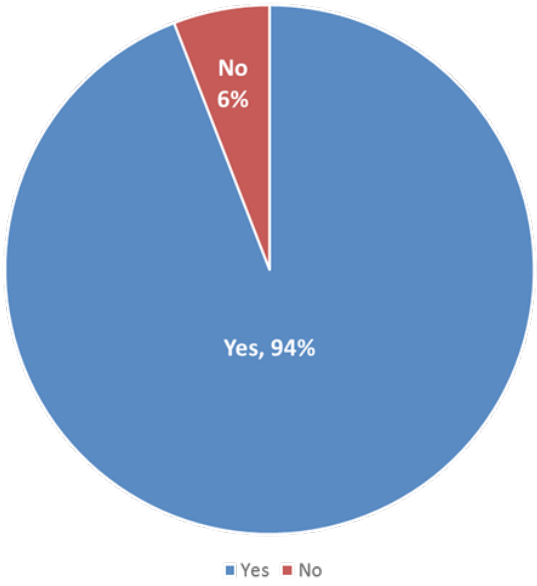

5. What is the approximate timeframe to assess a radiocommunication site?

Figure 5A: What is the approximate timeframe to assess a radiocommunication site?



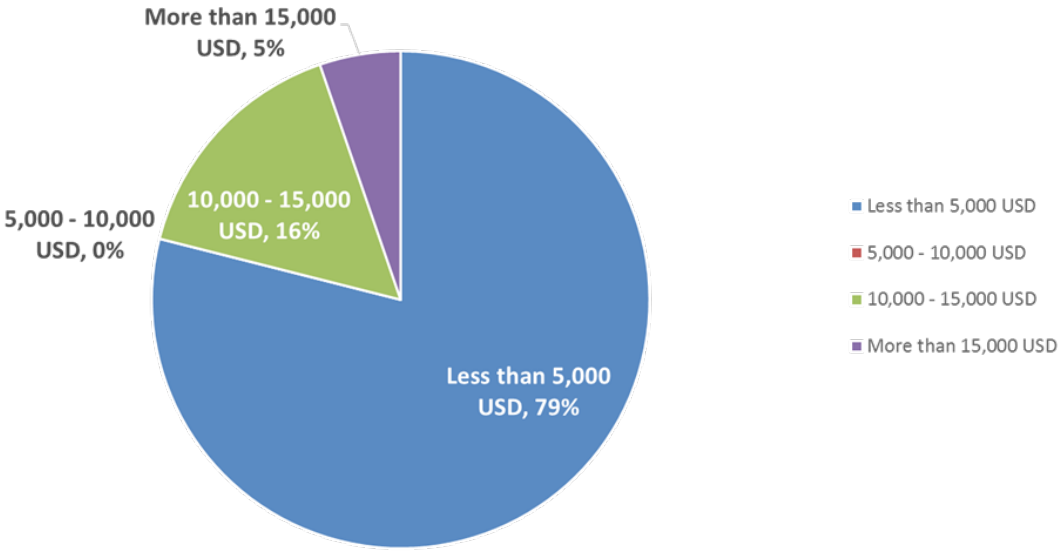

6. Is the time frame specified in a law/decree/norm/guidelines, etc.?

Figure 6A: Is the time frame specified in a law/decree/norm/guidelines, etc.?



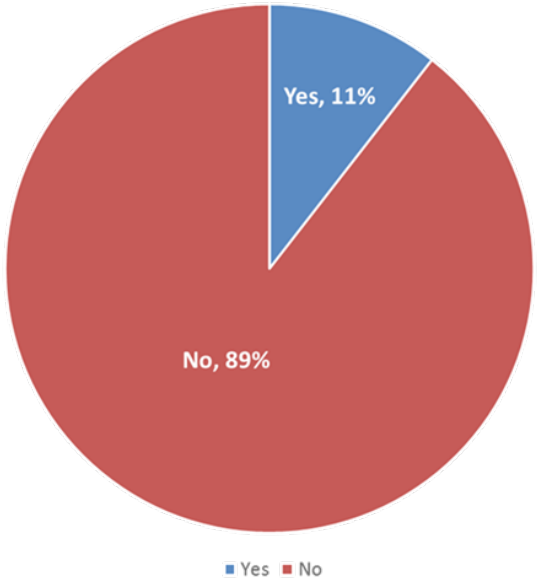

7. What is the approximate expense of assessing a conventional (used in populated areas) radiocommunication site?

Figure 7A: What is the approximate expense of assessing a conventional (used in populated areas) radiocommunication site?



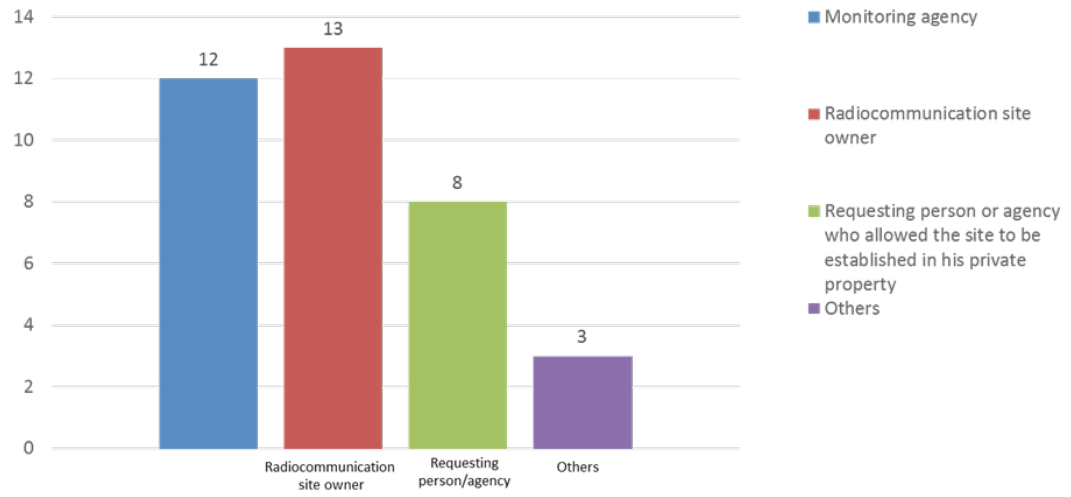

8. Are such expenses specified in a law/decree/norm/guidelines, etc.?

Figure 8A: Are such expenses specified in a law/decree/norm/guidelines, etc.?



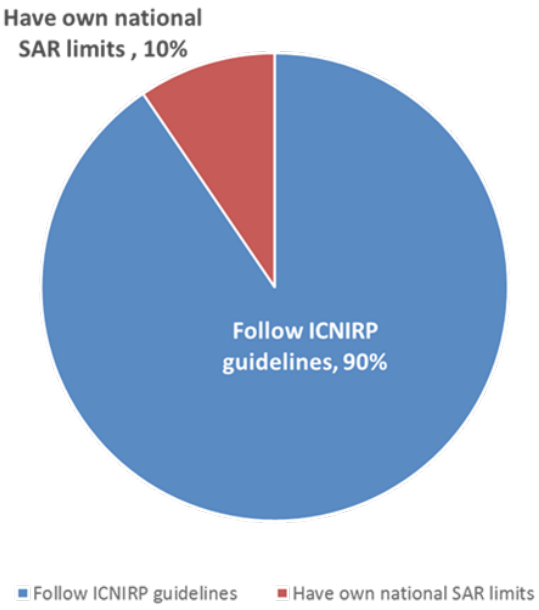

9. Who will pay for the assessment of a radiocommunication site?

Figure 9A: Who will pay for the assessment of a radiocommunication site?




10. What is the Specific Absorption Ratio (SAR) limit for mobile terminals in your country?

Figure 10A: What is the Specific Absorption Ratio (SAR) limit for mobile terminals in your country?




11. Is there any special legislation and/or regulation for the deployment of radiocommunication infrastructures in your country? If yes, please specify.

Figure 11A: Is there any special legislation and/or regulation for the deployment of radiocommunication infrastructures in your country? If yes, please specify.

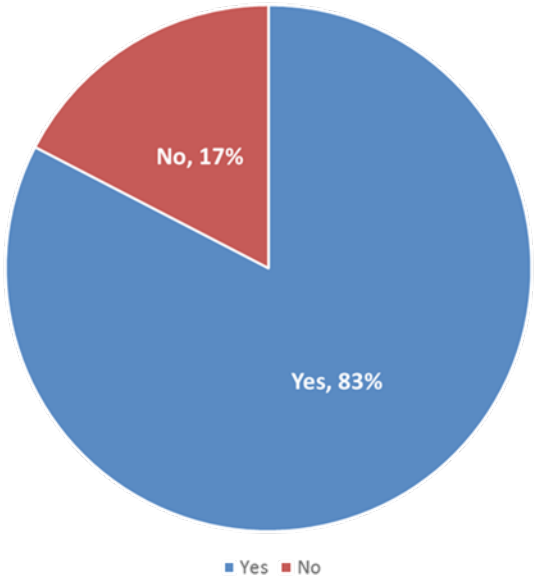
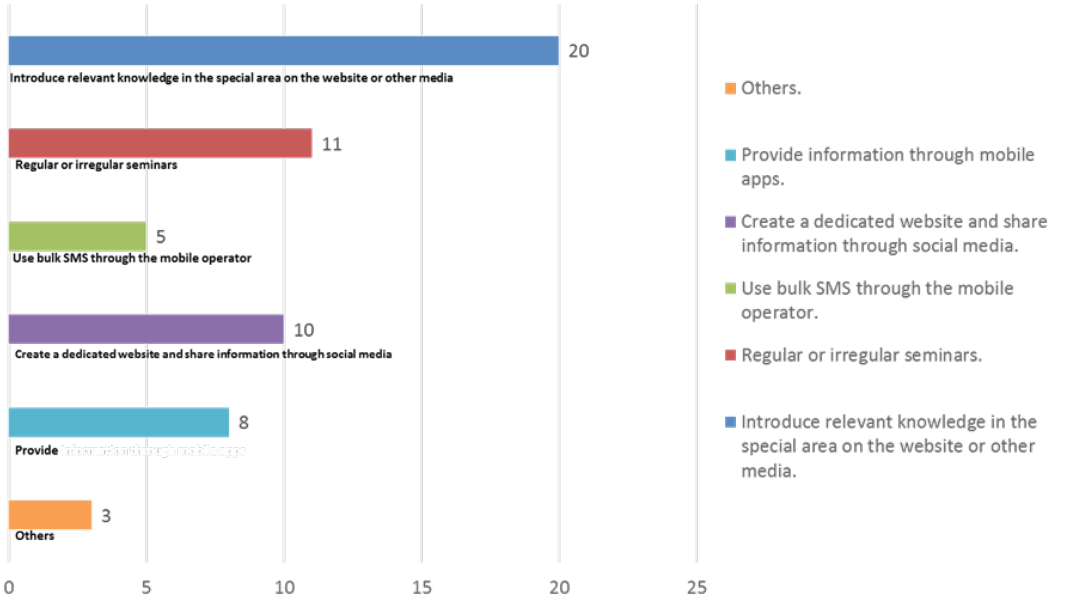



Figure 12A: Detailed answers related to special legislation and/or regulation for the deployment of radiocommunication infrastructures in countries.

| | |
|---|---|
| **Israel** | 1996 law on non-ionzed exposure; see http://www.infocell.org/imgs/uploads/law.pdf and 2009 decrees |
| **Chile** | Norma: Ley 18168 de Chile |
| **United Kingdom** | There is planning policy guidance: http://www.mobilemastinfo.com/planning-policy/planning-policy-and-practice.html And a Code of Best Practice on Mobile Network Development in England.<br>http://www.mobilemastinfo.com/best-practice/mobile-operators-code-of-best-practice-article.html |
| **Uruguay** | Normas de la URSEC y de las Intendencias.Hay varias. Tienen que ver desde el punto de vista de impacto ambiental, zonas prohibidad, limitación de emisiones radioeléctricas, compartición de infraestructura, etc. |
| Israel | Planning and building Law |
| **Sudan** | The Telecommunications Act and relevant regulations, stipulations and policies] |
| **Cameroon** | Décision n°054/MINPOSTEL du 18 avril 2013 fixant les conditions d'installation des pylônes et des mâts à usage des télécommunications au Cameroun |
| **Mali** | L'ordonnance N°2011-023/P-RM du 28 septembre 2011. |
| **Cameroon** | La décision n° 054/Minpostel/ du 18 avril 2013 fixant les conditions d'installation des pylônes et des mâts à usage des Télécommunications au cameroun |
| **Norway** | https://lovdata.no/dokument/NL/lov/2000-05-12-36?q=strålevern |
| **Colombia** | Para el servicio de radiodifusión sonora la norma aplicable es el Plan Técnico Nacional de Radiodifusión Sonora |
| **Armenia** | Order N 933 of the Minister of Health, from 16.08.06, <>_sanitary rules and norms N 2.1.8-010-06 |
| **Kazakhstan** | Communication, Informatization and Information Committee (Kazakhstan) - Law No. 567 of 5 July 2004 on communications<br>- Government Order No. 164 of 31 January 2001 approving Rules for the development and use of public telecommunication networks, and resources for a single telecommunication network for the requirements of state bodies, defence, security and law enforcement authorities of the Republic of Kazakhstan<br>- Government Order No. 543 of 21 May 2002 approving the Rules of the Interagency Radiofrequency Commission of the Republic of Kazakhstan<br>- Government Order No. 932 of 21 August 2002 concerning certain questions pertaining to the use of the radio frequency spectrum by the Republic of Kazakhstan<br>- Government Order No. 451 of 31 March 2009 approving the list of universal telecommunication services and Rules for subsiding the cost of universal telecommunication services<br>- Government Order No. 990 of 27 June 2009 approving Rules for converting radio frequency spectrum and methods for establishing the technical and economic basis of expenditure on converting radio frequency spectrum |
| **Australia** | In Australia, the rollout of new free standing towers are subject to State and local government planning laws. This gives communities a say on construction projects in their area. State government and local planning laws set out requirements for community consultation. In addition, Schedule 3 of the Telecommunications Act 1997 affords carriers special powers and immunities to rollout certain facilities without undergoing a local or state government planning process. These facilities are listed in the Telecommunications (Low-impact facilities) Determination 1997 (LIFD) and fall within strict type, size, colour and location limitations. The LIFD encourages carriers to rollout infrastructure that has minimal the impact of on the community while also expediting the supply of services. (https://www.comlaw.gov.au/Details/C2015C00540/Html/Text https://www.comlaw.gov.au/Details/F2004C01082 ) Facilities installed under the LIFD are required to comply with the Industry Code for Mobile Phone Base Station Deployment, which imposes consultation requirements similar to local government processes. The Telecommunications Code of Practice 1997 sets out further obligations on carriers. In this way, communities are still given an opportunity for consultation.<br>(http://www.acma.gov.au/theACMA/industry-code-mobile-phone-base-station-deployment, https://www.comlaw.gov.au/Details/F2004C01081) |
| **State of Palestine** | Telecommunication Act No. 3 (1996); Telecommunication Regulation No. 1 (1996); Licensing agreement signed with the Palestinian Telecommunication Company (1996); Interconnection instructions. |
| **Benin** | Référence : Décret N° 2015-490 DU 07 Septembre 2015 portant protection des personnes contre les effets des champs électriques, magnétiques et électromagnétiques de 0 à 300 GHz. Lien : http://arcep.bj/textes-juridiques/decrets/ |
| **Hungary** | If the antenna mast does not exceed 6 meters tall and any size of the antenna construction does not exceed 4 meters, the radiocommunication infrastructure can be operated without any construction permission. However in such a case the radiolicense holder must enclose a declaration to the deployed application that include a calculation proving the radiation is below the helath reference level in public places. |
| **Bolivia (Plurinational State of)** | Viceministerio de Telecomunicaciones Normas municipales de autorizacion de instalacion de torres y soportes de antenas y redes de telecomunicaciones. |
| **Brazil** | Federal Law n° 11934/2009 Anatel Resolution n° 303/2002 |

12. What constitute some good practices on how to raise the awareness in the population/country on issues concerning human exposure to electromagnetic fields?

Figure 13A: What constitute some good practices on how to raise the awareness in the population/ country on issues concerning human exposure to electromagnetic fields?




13. What constitute some good practices on how to bring the exposure information to the attention of the population?

Figure 14A: What constitute some good practices on how to bring the exposure information to the attention of the population?


14. Does your country enforce obligations for radiocommunication site owners? If others, please specify: 13 responses.

Figure 15A: Does your country enforce obligations for radiocommunication site owners?

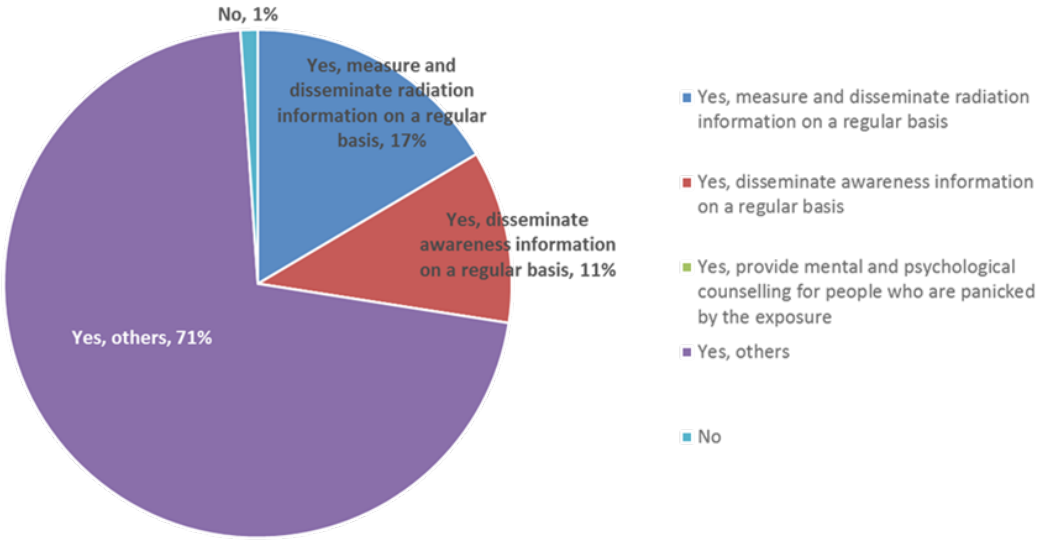



Figure 16A: Detailed answers related to obligations for radiocommunication site owners.

- **Chile** *SERMECOOP* Están indicadas en la Norma: Ley 18168 de Chile
- **United Kingdom** *GSM Association (International)* There is a voluntary approach to community engagement as set out in the Code of Practice and operator voluntary
- **Sudan** *National Telecommunications Corporation (NTC) (Sudan)* Adherence to NTC specifications, stipulations and regulations
- **Cameroon** *Ministère des Postes et des Télécommunications (Cameroon)* communiquer les mesures à l'ART
- **Mali** *Autorité Malienne de Régulation des Télécommunications/TIC e (Mali)* Obligation de respect des normes CIPRNI
- **Cameroon** *Ministère des Postes et des Télécommunications (Cameroon)* mesurer les rayonnements et les Communiquer à l'ART à l'effet de justifier le respect des valeurs limites
- **Colombia** *Ministerio de Tecnologías de la Información y las Comunicaci (Colombia)* Para el servicio de radiodifusión sonora deben realizar un cerramiento al sitio de radiocomunicación para evitar el acceso al público en general
- **Armenia** *Ministry of Transport and Communication (Armenia)* Occupational health protection of employees, preventive medical examinations of employees
- **Australia** *Department of Communications and the Arts (Australia)* The Australian Communications and Media Authority (ACMA) is the regulator for EME issues.(http://www.acma.gov.au/)
- **State of Palestine** *Ministry of Telecommunications & Information Technology (State of Palestine)* For example, making the necessary modification to the station, if the permitted limit is exceeded.
- **Hungary** *National Media and Infocommunications Authority (Hungary)* The radiolicense holder must enclose a declaration to the deployed application that include a calculation proving the radiation is below the helath reference level in public places.
- **Bolivia (Plurinational State of)** *Viceministerio de Telecomunicaciones* Realizan mediciones y presentan en el informe ambiental anual a la Autoridad Ambiental Competente. Los operadores de telecomunicaciones realizan mediciones periodicas y presentan el informe ambiental anual a la Autoridad Ambiental Competente.

# Annex 2: List of contributions for ITU-D Study Group 2 and Rapporteur Group meetings directly related to Question 7/2

**Inputs received for Rapporteur Group and Study Group meetings**

| Web | Received | Source | Title |
|---|---|---|---|
| **2/444** | 2017-01-20 | Rapporteur for Question 7/2 | Report of the Rapporteur Group meeting on Question 7/2, Geneva, 20 January 2017 |
| **2/434** | 2017-02-22 | China (People's Republic of) | Suggestions for the revision of ITU-D SG2 Question 7/2 |
| **2/428** | 2017-02-17 | Bangladesh (People's Republic of) | Best practice strategies on raising public awareness regarding the effects of electromagnetic fields due to radio communication systems |
| **2/425** | 2017-02-17 | ATDI | Revision of Resolution 62: Measurement concerns related to human exposure to EMF |
| **2/419 [OR]** | 2017-02-17 | Rapporteur for Question 7/2 | Final Report for Question 7/2 |
| **2/410** | 2017-02-08 | ATDI (France) | Proposed revision of Question 7/2 |
| **RGQ/246** | 2017-01-09 | ATDI | Modifications to the Draft Final Report for Question 7/2 |
| **RGQ/238** | 2017-01-03 | Rapporteur for Question 7/2 | The modification suggestions to the draft Final Report of Q7/2 |
| **RGQ/195 [OR]** | 2016-10-27 | Rapporteur for Question 7/2 | Draft Final Report for Question 7/2 |
| **2/382 [OR]** | 2016-09-22 | Rapporteur for Question 7/2 | Draft report for Question 7/2 |
| **2/372 +Ann.1** | 2016-09-13 | Telecommunication Development Bureau | Overview of input received through the ITU-D Study Group 2 consolidated survey for Questions 6/2, 7/2 and 8/2 |
| **2/346** | 2016-08-31 | China (People's Republic of) | Some electromagnetic radiation monitoring system related introduction in China |
| **2/344** | 2016-08-31 | China (People's Republic of) | The further summary and analysis of the relevant strategies and policies for human exposure to EMF in some countries |
| **2/287** | 2016-07-28 | ATDI | Proposed modifications to Question 7/2 report |
| **2/263** | 2016-04-22 | Rapporteur for Question 7/2 | Report of the Rapporteur Group Meeting on Question 7/2, Geneva, 22 April 2016 |
| **RGQ/164** | 2016-04-22 | Rapporteur for Question 7/2 | Working document: draft Question 7/2 report following the 22 April 2016 Q7/2 meeting |
| **RGQ/163 +Ann.1** | 2016-04-22 | World Health Organization (WHO) | WHO: Electromagnetic Radiofrequency Fields National Management and Regulatory Approaches |

| Web | Received | Source | Title |
|---|---|---|---|
| RGQ/137 | 2016-04-01 | China (People's Republic of) | Summary and analysis of the relevant strategies and policies for human exposure to EMF in some countries |
| RGQ/129 | 2016-03-29 | ATDI | RF human hazards: ITU intersectoral activities, and exposure distances around wireless terrestrial transmitters |
| 2/244 +Ann.1 | 2015-08-27 | Hungary | Online Publication of the Non-Ionizing Radiation Measurement of the National Media and Infocommunications Authority of Hungary |
| 2/235 | 2015-08-27 | Korea (Republic of) | Regulation status and research activities on EMF Effects to human body in the Republic of Korea |
| 2/210 | 2015-08-04 | ITU-R Study Groups – Working Party 6A | Liaison Statement from ITU-T SG5 to ITU-D SG2 on Human exposure to RF fields from broadcast transmitters |
| 2/208 +Ann.1 | 2015-07-24 | G3ict | Contribution of G3ict - The Global Initiative for Inclusive Information and Communications Technologies to the Working Party 5D (WP 5D) - IMT System |
| 2/201 | 2015-07-29 | China (People's Republic of) | The further analysis of human exposure to electromagnetic fields |
| 2/200 (Rev.1) | 2015-07-29 | Rapporteur for Question 7/2 | Revised Work plan for Question 7/2 |
| 2/199 | 2015-07-28 | Rapporteur for Question 7/2 | Questionnaire for strategies and policies concerning human exposure to electromagnetic fields |
| 2/147 | 2015-07-12 | ITU-R Study Group 1 | Liaison Statement from ITU-R SG1 to ITU-D SG2 Question 7/2 on liaison activities with CENELEC |
| RGQ/77 +Ann.1 | 2015-04-30 | World Health Organization | WHO International EMF Project |
| RGQ/66 | 2015-04-13 | China (People's Republic of) | Strategies and policies concerning human exposure to electromagnetic fields |
| RGQ/51 +Ann.1 | 2015-03-17 | BDT Focal Point for Question 7/2 | Electromagnetic Fields (EMF) regulations for broadcasting installations |
| RGQ/11 | 2014-12-15 | Rapporteur for Question 7/2 | Draft work plan for Question 7/2 |
| 2/94 | 2014-09-10 | China (People's Republic of) | Proposed draft work plan for Question 7/2 |
| 2/83 +Ann.1 | 2014-09-07 | BDT Focal Point for Question 7/2 | EMF |
| 2/53 | 2014-08-28 | China (People's Republic of) | Study proposal on strategies and policies concerning human exposure to electromagnetic fields |

| Web | Received | Source | Title |
|---|---|---|---|
| 2/34 | 2014-08-05 | Telecommunication Standardization Bureau | Draft technical report on EMF Considerations in Smart Sustainable Cities |
| 2/25 +Ann.1 | 2014-07-22 | Switzerland (Confederation of) | Protection against non-ionizing radiation (NIR) – Regulatory policy of Switzerland |

**Liaison Statements (LS)**

| Web | Received | Source | Title |
|---|---|---|---|
| RGQ/211 | 2016-11-24 | ITU-R Study Groups | Liaison Statement from ITU-R Working Party 5C to ITU-D SG2 on ongoing collaboration |
| RGQ/197 | 2016-10-27 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D Study Group 2 (Question 7/2) on Information about work that is being carried out within work under study in ITU-T Q7/5 |
| 2/350 | 2016-09-09 | ITU-R Study Group 1 | Liaison Statement from ITU-R SG1 to ITU-D SG2 on Question ITU-R 239/1- Electromagnetic field measurements to assess human exposure |
| 2/282 | 2016-07-20 | ITU-R Study Group 1 | Liaison Statement from ITU-R Study Group 1 to ITU-D Study Group 2 on WHO: Fundamental Safety Principles for protection against non-ionizing radiation |
| 2/273 | 2016-05-25 | ITU-R Working Party 5A, 5B and 5C | Liaison Statement from ITU-R Working Party 5A, 5B and 5C to ITU-D SG2 on Human exposure to Electromagnetic Fields (EMFs) |
| 2/272 | 2016-05-18 | ITU-T Study Group 5 | Liaison statement from ITU-T Study Group 5 to ITU-D Study 1 and 2 on updates on ITU-T SG 5 activities relevant to ITU-D study groups |
| 2/271 | 2016-04-28 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D SG2 on Information about work that is being carried out within work under study in ITU-T Q7/5 |
| RGQ/118 | 2016-03-09 | ITU-R Study Groups – WP 5D | Liaison statement from ITU-R WP 5D to ITU-D SG2 Q7/2 on information about work that is being carried out within work under study in ITU-T Q7/5 (Human Exposure to Electromagnetic Fields (EMFs) due to radio systems and mobile equipment) |
| RGQ/101 | 2016-02-04 | ITU-R Study Groups – Working Party 6A | Liaison Statement from ITU-R SG6 WP6A to ITU-D SG2 Q7/2 on establishment of Rapporteur Group on RF hazard issues |
| RGQ/90 | 2015-11-24 | ITU-T Study Group 5 | Liaison Statement from ITU-T SG5 to ITU-D SG2 on comments to the WHO Monograph on Radio Frequency fields: Environmental Health Criteria, Chapter 2 on Sources, measurements and exposures and Chapter 3 on Radiofrequency Electromagnetic Fields Inside The Body |
| RGQ/89 | 2015-11-24 | ITU-T Study Group 5 | Liaison Statement from ITU-T SG5 to ITU-D SG2 on comments to the ICNIRP documents |

| Web | Received | Source | Title |
|---|---|---|---|
| **RGQ/88** | 2015-11-24 | ITU-T Study Group 5 | Liaison Statement from ITU-T SG5 to ITU-D SG2 on Information about work that is being carried out within work under study in ITU-T Q7/5 |
| **RGQ/33** | 2015-03-03 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D Study Group 2 on the Executive Summary of the ITU-T Study Group 5 Meeting |
| **RGQ/29** | 2015-02-25 | ITU-R Study Group 6 | Liaison Statement from ITU-R Study Group 6 to ITU-D Study Groups on Radiated disturbances from PLT and wired telecommunication systems |
| **RGQ/26** | 2015-02-20 | ITU-R Study Groups – Working Party 6A | Liaison Statement from ITU-R Study Groups WP6A to ITU-D Study Groups on Human exposure to RF fields from broadcast transmitters |
| **RGQ/23** | 2015-02-10 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D Study Group 2 on comments to the WHO Monograph "Radio Frequency fields: Environmental Health Criteria, Chapter 2: Sources, measurements and exposures" |
| **RGQ/22** | 2015-02-09 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D Study Group 2 Question 7/2 concerning Q7/2 work items for the 2014-2018 study period (reply to ITU-D SG 2- Document 2/113) |
| **RGQ/3 (Rev.1)** | 2014-11-18 | ITU-T Focus Group on SSC | Liaison Statement from ITU-T Focus Group on Smart Sustainable Cities (FG-SSC) on Activities of the Focus Group on Smart Sustainable Cities |
| **2/36** | 2014-08-06 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D SG2 Question 7/2 with Information about work that is being carried out within work under study in ITU-T Q7/5 |
| **2/14** | 2014-01-17 | ITU-T Study Group 5 | Liaison Statement from ITU-T Study Group 5 to ITU-D Study Group 1 Question 23/1 on human exposure to EMF |
| **2/6** | 2013-09-13 | ITU-R Study Groups – Working Party 1C | Liaison Statement from ITU-R Working Party 1C to ITU-D SG1 and ITU-T SG5 on human exposure to electromagnetic fields |

# Annex 3: Bibliography

ICNIRP 1998: Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), 1998.

ITU-R Handbook on Spectrum Monitoring, section 5.6 on "Non-ionizing radiation measurements", 2011.

ITU: EMF Guide, 2014.

ITU-D Report on Question 23/1: Strategies and policies concerning human exposure to electromagnetic fields.

Health Canada: Canada Safety Code Radiofrequency Exposure Guidelines, 2015.

Mazar: Radio Spectrum Management: Policies, Regulations and Techniques. Chapter 9: RF Human Hazards, 2016.

Mazar: Human Radio Frequency Exposure Limits: an update of reference levels in Europe, USA, Canada, China, Japan and Korea; EMC Europe Wroclaw, 2016.

Potential health effects of exposure to electromagnetic fields (EMF), SCENIHR Opinion, Brussels, 2015.

# Annex 4: Information available related to exposure to EMF in some European countries

| | |
|---|---|
| Bosnia: | http://rak.ba/bos/ |
| Croatia: | http://narodne-novine.nn.hr/clanci/sluzbeni/2011_08_98_2036.html |
| Denmark: | https://www.retsinformation.dk/forms/r0710.aspx?id=29325 |
| Estonia: | https://www.riigiteataja.ee/akt/163816 |
| Finland: | http://ec.europa.eu/enterprise/sectors/electrical/documents/emc/legislation |
| France: | http://www.anfr.fr/fileadmin/mediatheque/documents/expace/Anfr_BrochureGenerale_pap_0411.pdf |
| Greece: | http://www.eeae.gr |
| Hungary: | http://www.njt.hu/cgi_bin/njt_doc.cgi?docid=84814.118610 |
| Ireland: | http://www.comreg.ie |
| Israel: | http://www.sviva.gov.il/subjectsEnv/Radiation/Pages/Cellular_Facilities.aspx |
| Liechtenstein: | http://www.avw.llv.li/ |
| Romania: | http://www.ancom.org.ro |
| Slovakia: | http://www.uvzsr.sk/docs/leg/534_2007_elmag_ziarenie.pdf |

# Annex 5: European Commission's Scientific Steering Committee (SCENIHR)

The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)[28] provides opinions to the European Commission on emerging or newly-identified health and environmental risks and on broad, complex or multidisciplinary issues requiring a comprehensive assessment of risks to consumer safety or public health and related issues not covered by other Community risk assessment bodies. SCENIHR has published several reports related to EMF, the last report was published in 2015.[29] The main conclusions are summarized here.

The results of current scientific research show that there are no evident adverse health effects if exposure remains below the levels recommended by the EU legislation. Overall, the epidemiological studies on radiofrequency EMF exposure do not show an increased risk of brain tumors. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region. Previous studies also suggested an association of EMF with an increased risk of Alzheimer's disease. New studies on that subject did not confirm this link.

Epidemiological studies associate exposure to Extremely Low Frequency (ELF) fields, from long-term living in close proximity to power lines to a higher rate of childhood leukemia. No mechanisms have been identified and no support from experimental studies could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation.

Concerning EMF hypersensitivity (idiopathic environmental intolerance attributed to EMF), research consistently shows that there is no causal link between self-reported symptoms and EMF exposure.

[28] Its work is now undertaken by the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER).

[29] Potential health effects of exposure to electromagnetic fields (EMF), SCENIHR Opinion, Brussels, 2015.

# Annex 6: Case studies

### The relationship between brain cancer and the introduction of mobile phones (Australia)

Mobile phone use in Australia has increased rapidly since its introduction in 1987 with whole population usage being 94 per cent by 2014. The study[30] explored the popularly hypothesised association between brain cancer incidence and mobile phone use, they examined age and gender specific incidence rates of 19,858 male and 14,222 female diagnosed with brain cancer in Australia between 1982 and 2012, and mobile phone usage data from 1987 to 2012.

Age adjusted brain cancer incidence rates rose slightly over time in males but not in females. In 2012, rates were about 50 per cent higher in males than in females.

**Conclusion:**

After nearly 30 years of mobile phone use in Australia among millions of people, there is no evidence of any rise in any age group that could be plausibly attributed to mobile phones.

### Radiofrequency fields and health (Canada)

Radiofrequency (RF) energy or fields are a part of everyday life. They are produced by sources such as radio and television broadcasting, mobile radiocommunication transmitting facilities, cell phones and radar.

The remarkable growth of radiofrequency technology over the last few years has raised public concerns about possible associations between RF energy and adverse health outcomes. Canada, in fact, was one of the first industrialized countries to recognize the need for RF exposure guidelines. Health Canada developed its first RF exposure limit guideline, known as Safety Code 6, in 1979. Since then, Safety Code 6 has been updated several times with the most recent revision in 2015. The exposure limits outlined in Safety Code 6 are set far below the lowest level of RF exposure that could produce potentially harmful effects in humans. It is based on the weight of evidence, including most recent science, from hundreds of peer-reviewed RF studies. It has been reviewed and recommended by independent third parties such as the Royal Society of Canada; and its limits, based on established biological effects, are among the most stringent in the world. http://www.hc-sc.gc.ca/ewh-semt/radiation/cons/radiofreq/index-eng.php.

### Electromagnetic radiation online monitoring system (People's Republic of China)

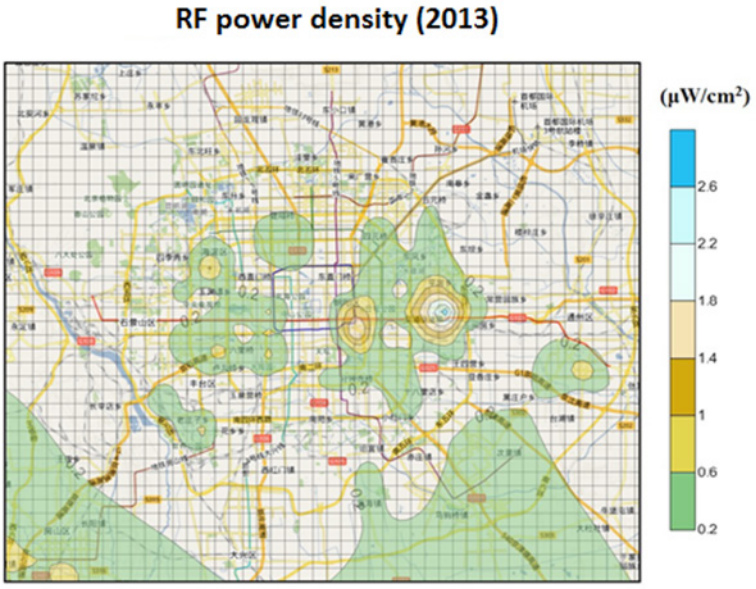
The requirements for electromagnetic radiation monitoring focus on environmental protection, power line and mobile communication fields, need online monitoring, real-time publication, and public science popularization. Based on that the electromagnetic radiation online monitoring system developed in the People's Republic of China, has the function of online monitoring, real-time transmission, and real-time publication. The data can be published through large screen displays, website, APPs, and Wechat, together with popular science on the issue.

Safetytech (a company) developed the first electromagnetic radiation monitor, frequency range from 1 to 18GHz, print the monitoring data through portable Bluetooth printer on the spot. The newest electromagnetic radiation online monitoring system implement the function through powered entirely by solar energy, wireless data transmission, and develop monitoring center software system platform, data publishing platform, etc. According to differences between erection and operation, the system is divided into base-station delicate, vehicular, moveable, unmanned aerial vehicular, and fixed electromagnetic radiation online monitoring system.

[30] Has the incidence of brain cancer risen in Australia since the introduction of mobile phones 29 years ago? Chapman et al., Cancer Epidemiology, 42(199–205) June 2016.

Investigation to the electromagnetic environment in cities needs RF information, spatial distribution information, etc. Safetytech implemented an electromagnetic environment investigation in Beijing downtown in 2013, divided the city to 352 grid point by 2km×2km, monitor each grid point center. The RF electromagnetic strength range from 0.2V/m to 6V/m, the average is 0.89V/m. The distribution of the electromagnetic environment in Beijing as shown in **Figure 17A**.

Figure 17A: The distribution of the electromagnetic environment in Beijing




### Online publication of the non-ionizing radiation measurement (Hungary)

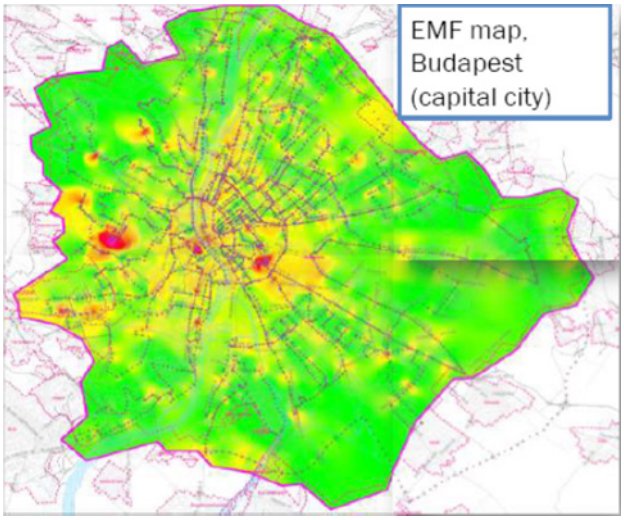
The health aspects of electromagnetic radiations in Hungary were within a specialised institution – National Research Institute for Radiobiology and Radiohygiene (NRIRR) of the National Public Health Service. Among their duties they take part in the licensing of the construction of radio facilities and carry out individual measurements. However, because of capacity and expertise, the National Media and Infocommunications Authority of Hungary (NMIAH) installed a national EMF monitoring and information network in agreement with the NRIRR.

The measurement programme involves collecting data using twenty five (25) area monitoring instruments by moving them to new locations every two weeks. Measurements spots were selected educational institutions, nurseries and schools situated close to radio facilities. Tests are also carried out occasionally on requests by private individuals.

On the bases of the former work, Hungary expanded measuring activities, like, continuous programs in public places, testing new/specific stations, and path-registered measurements. Hungary also developed versatile web-publication, like, statistics between individual measurements, results of single handheld measurements, ranked results, different sites for each measurement programs, path-registered measurements, and application form for programs and web analytics.

**Figure 18A** shows the most cases the level of measured field is lower than 0.2V/M (green). High blocks of flats have lots of antennas, also some mobile base stations (yellow). The highest level of EMF field coming from broadcast stations (bigger red areas). Mobile base stations on lower building can cause higher field in small area (small red points).

Figure 18A: The EMF map




**Regulation and research on EMF effects to human body (Republic of Korea)**

All the radio facilities shall be installed in accordance with the safety installation standards to ensure that they do not harm the human body or damage other facilities. The Ministry of Science, ICT and Future Planning (MSIP) is responsible for EMF regulations in Korea except the EMF coming from power lines, which is regulated by the Ministry of Trade, Industry and Energy (MOTIE). The MSIP shall establish the EMF exposure limits and the related measurement methods, the ministry also needs to establish the devices and installations subject to the EMF limits, and rating and labeling method.

The manufacturer, the importer and the installer or owner of radio facilities shall ensure that the radio facilities comply with the EMF exposure limits, and the installers shall install safe facilities in keeping a safety distance if necessary. The owners of each radio stations shall report the EMF test result for the radio stations to the MSIP. The MSIP may order the installer to set up safe facilities or to restrict/stop the operation of the radio facilities if it does not comply with the EMF human exposure limits.

The National Radio Research Agency (RRA) is in charge of the measurement related standards and certification system as a certification body. The measurement methods for electromagnetic field strength and SAR are prescribed in RRA Notifications. The EMF rating and labeling system has been enforced since August 1, 2014, which were required by the MSIP Notification. The operators of radio stations should put the rating labels of EMF strength of the radio station by applying the exposure criterion indicated at an appropriate place. For portable devices, which are used in contacting the user's ear, the manufacturers or importers of the devices should affix the SAR rating labels to the products, and/or display the measured highest SAR values in the manual.

The public concerns for the EMF are very high in the Republic of Korea. Around 400-500 public appeals regarding the electromagnetic field radiation from base stations are submitted to administrations and operators every year. Government and operators deal with the complaints and offer proper answers and related information which are based on scientific evidence. Regarding the power lines and sub-stations, about 170 complaints have been filed to Korea Electric Power Corporation (KEPCO) recently. KEPCO deals with the complaints actively to lessen the public concern for the power line EMF.

Two projects "A study on the EMF exposure control in smart society" and "A study on health effects and protection of EMF" were launched in 2013, and were merged into a new project this year, which was funded by the MSIP. The project has been conducted under the superintendence of Electronics and Telecommunications Research Institute (ETRI) in collaboration with several universities and academic societies (e.g., Korean Institute of Electromagnetic Engineering and Science). The project title is "A Study on the EMF Exposure Control in Smart Society".

### Relationship between tumors in the head and frequent long mobile phone calls (The Netherlands)

With the fast increase of mobile telecommunication and wireless internet also concern is growing. The Health Council of the Netherlands closely follows the scientific literature on exposure to radiofrequency fields.[31] It has not been proven that making frequent long-term mobile phone calls leads to tumors in the head. For the current report the council has systematically evaluated both the epidemiological and animal experimental data and explicitly considered the quality of the studies.

According to the Health Council, there is no established association between long-term and frequent use of a mobile telephone and an increased risk for tumors in the brain or head and neck area. However, such association can also not be excluded, but the council considers it unlikely.

**Suggestion:**

a) Keep exposure as low as reasonably possible, although there's no reason for measures to reduce exposure. For instance, it is not necessary for equipment to emit electromagnetic fields with a larger power or during a longer time period than necessary for a good connection.

b) It's important that ongoing studies into long-term health effects of the use of mobile telephones be continued, particularly because the exposure to radiofrequency fields continuously changes as the result of changes in the use and the development of new mobile telecommunication devices.

### Health effects of non-ionizing fields (New Zealand)

Applications and uses of technology incorporating radio transmitters have burgeoned over the past few years and are likely to continue to do so. Many new devices communicate over cellular phone networks or Wi-Fi, and networks using these technologies have expanded considerably. Several health and scientific bodies have periodically reviewed recent research, and findings from these are summarized in the report.[32]

**Conclusion:**

a) While a great deal of research has been carried out to investigate the potential effects of exposures to RF fields on health, particularly exposures associated with cellphone use, there are still no clear indications of health effects caused by exposures that comply with the limits in the New Zealand RF field exposure standard.

b) Although the research on cellphone use and brain tumours resulted in RF fields being classified as a 'possible' carcinogen by IARC, several reviews and meta-analyses published since the IARC assessment consider that more recent research weighs against there being a cause and effect relationship, and the complexity of the existing data and difficulties in making further progress have also been highlighted.

c) Recent dosimetry work has found that at some frequencies the reference levels in the New Zealand standard are not as conservative as expected, and that under some circumstances the basic restriction may be exceeded when small children are exposed to fields that are close to the reference level. This is not of immediate concern for two reasons: measurements in New Zealand show that exposures in areas where children might be expected are always very small fractions of the reference level (so the basic restriction will never be exceeded), and the amount by which the basic restriction might be exceeded is small in comparison to the safety factor of 50 built into the basic restriction.

[31] https://www.gezondheidsraad.nl/en/publications/gezonde-leefomgeving/mobile-phones-and-cancer-part-3-update-and-overall-conclusions.

[32] http://www.health.govt.nz/publication/interagency-committee-health-effects-non-ionising-fields-report-ministers-2015.

### Radiofrequency electromagnetic field exposure levels (Spain)

The enormous popularity of mobile telephony in recent years has not only meant a major technological revolution, but has also produced a highly significant transformation from a social, economic and environmental point of view. Never before in the history of humanity has the appearance of a new technology been so widely accepted by society in such a short space of time.

The construction of towers with television and radio antennae on hilltops has enabled society to enjoy these services for decades. Mobile phones, unlike radio and television, require antennae closer to the users, in order to offer quality mobile voice and data services. As a result of public concern, the deployment of mobile phone antennae has suffered difficulties, particularly as a result of the pressure by the local councils. Aware of this problem, the European Parliament, in Resolution 32008/2211 (INI), among other aspects, encouraged service providers, public authorities and citizens associations to find mutually acceptable solutions with respect to the deployment of mobile phone antennae. In addition, in order to guarantee information to the public on the matter, it called for Member States to publish maps showing electromagnetic field exposure levels, and suggested that these maps be made available online for consultation. The government of Catalonia has implemented a system and produced reports[33] on the exposure levels.

### Protection against non-ionizing radiation (Switzerland)

The Swiss government has put into force a new ordinance on the protection of the general population from Non-Ionizing Radiation (NIR) originating from stationary installations. No restrictions are imposed on mobile equipment like cellular phones or electric appliances because emission reducing strategies for such consumer products must be standardized at the international level. Swiss enforces the reference levels for the general population which were recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). In addition emphasis is given to the precautionary reduction of long term exposure.

**Legal framework:**

The legal framework is laid down in the Swiss federal law relating to the protection of the environment. According to this law NIR in the environment must be limited to a level which is neither harmful nor a nuisance to humans. This level has to be defined in terms of exposure limit values. The basis for deriving these exposure limit values is – according to the law – the state of scientific knowledge or the general experience.

In addition exposure which might be harmful or a nuisance shall be limited in the sense of precaution as much as technology and operating conditions will allow provided this is economically acceptable. A risk needs not to be proven for precautionary measures to be implemented. The precautionary Principle approach is designed to reduce potential risks, specifically potential long term risks which, due to limited knowledge, cannot yet be assessed in a satisfactory way.

**Exposure limit values:**

The data base which underlies ICNIRP's 1998 reference levels is rather limited. Only short term biological effects at rather high intensity were considered by ICNIRP to be sufficiently validated. Consequently there are some doubts as to whether the ICNIRP guidelines provide the degree of protection requested by the Swiss law on environmental protection.

The Swiss limits have been reported to explain approximately 30 per cent of the increasing cost of deploying networks compared to countries adopting the ICNIRP levels. If Switzerland were to adopt the ICNIRP limits it would require 21.5 per cent fewer antenna sites compared to the existing regulations.

[33] http://governancaradioelectrica.gencat.cat/documents/10180/d2f1e114-a4a0-4c69-852e-e179670cd2bb.

**Precautionary principle:**

The principle of precaution is also focused to those situations where people are exposed for a prolonged duration. Exposure is considered long term if a source emits for at least 800 hours per year and if the radiation of this source impinges on a place where human can stay for a prolonged time. The latter places are called “places of sensitive use”.

### Human exposure to radio frequency fields from broadcast transmitters (United Kingdom)

The work described is concerned with measurement strategies and methods, and carried out in the United Kingdom of Great Britain and Northern Ireland (United Kingdom) by the British Broadcasting Corporation (BBC). Guidelines for tolerable levels for human exposure to Non-Ionizing Radiation are published by ICNIRP, Sovereign governments can, do and must set their own national standards under local health and safety arrangements. The ICNIRP guidelines form the basis for most national standards including those in the UK. However, the ICNIRP guidelines are not always applied in their entirety. Selective interpretation can sometimes (and understandably) result in national standards, guidelines and even a legal framework that is more conservative than the ICNIRP guidelines.

The BBC has been operating high power broadcast transmitters for more than 90 years with no known detrimental effects on the staff working at the transmitting sites. Indeed, anecdotal evidence suggests that beneficial effects on health and wellbeing of the typically ‘rural lifestyle’ of staff working at transmitting stations in the countryside outweighs the possible effects of radiation when compared with their colleagues in studio centres in cities. However, it is known that there are high levels of non-ionizing radiation present at and around transmitting stations. Even with a ‘clean’ health record, the BBC’s duty (of care) to staff and to members of the public who are free to approach the boundary fences of the transmitting stations requires that levels of exposure be quantified.

The initial focus of the BBC’s work was public exposure at the boundary fences of the transmitting stations. Occupational access to areas of high field strength within boundary fences is under the control of the BBC and its station operators while public access to areas outside its boundary fences is not. Radiation intensity and public exposure would have been a major consideration when the position of the boundary fences was originally set but over time a whole host of factors will have changed including the exposure guidelines themselves.

This simulation showed that in the specific situation that was modeled – an upright human standing with arms to the side or held out under plane wave ‘illumination’ – the field strength needed to induce the basic restriction SAR was in nearly all cases greater than the ICNIRP reference level; in some instances significantly so. It also showed that the vertically polarized electric field component was dominant in body heating. The body was far less sensitive to the horizontally polarized component (even with arms held horizontally out to the side) or to the magnetic field component.

Without going into details of the tests, the results showed surprisingly good correlation with the ‘Norman’ simulations. This was encouraging for two reasons. First, it gave some confidence that the technique using the computer phantom was valid and second, it opened the door to a standardized method for measurement in the field.

**Conclusion:**

An interesting result of the work was that the dominant field component in the near field zone was the vertical component. This, despite the fact that HF curtain antennas consist of horizontally polarized elements and in the far field generate a horizontally polarized beam. The high vertical components in the near field are mainly the result of local interaction between the elements themselves and the ancillary items. Given that an upright human body is anyway much more susceptible to the vertically polarized field, the horizontal components could realistically be ignored. Further, this means that, as with MF, ankle current measurements should give a good indication of whole body SAR.

**Suggestion:**

Future work might include:

a) Formalization of the 'real world' tests of the MF transmitting antennas to demonstrate correlation with the simulations.

b) Use of this work to develop and formulate a standardized measurement technique. It is suggested that a physical 'dummy' be used with electrical characteristics that allow the ankle currents in the dummy to be the same as those in a real person. Given the variability in the electrical characteristics of real humans, it would be difficult to compare results if the same person was not used in every test.

c) Further experiments to show correlation between simulated and measured ankle currents at HF.

d) Development of techniques to reduce the necessary computing overhead. Some early work using very much simplified human phantoms did not yield very good results.

### Advice on exposure to EMF in Wireless networks (Wi-Fi) environment (United Kingdom)

Public Health England has produce guidelines[34] on exposure to radio signals from wireless networks Wi-Fi). Wi-Fi is the most popular technology used in Wireless Local Area Networks (WLANs). These are networks of devices and computers where communication occurs through radio waves instead of connecting cables. Wi-Fi devices must be equipped with antennas that transmit and receive radio waves in order to allow wireless connections. The devices operate in certain frequency bands near 2.4 and 5 gigahertz (GHz).People using Wi-Fi, or those in the proximity of Wi-Fi equipment, are exposed to the radio signals it emits and some of the transmitted energy in the signals is absorbed in their bodies.

There is no consistent evidence to date that exposure to RF signals from Wi-Fi and WLANs adversely affect the health of the general population. The signals from Wi-Fi are very low power, typically 0.1 watt, in both the computer and the mast (or router) and resulting exposures should be well within internationally-accepted guidelines. The frequencies used are broadly the same as those from other RF applications. Based on current knowledge, RF exposures from Wi-Fi are likely to be lower than those from mobile phones. There is no consistent evidence of health effects from RF exposures below guideline levels and no reason why schools and others should not use Wi-Fi equipment.

[34] https://www.gov.uk/government/publications/wireless-networks-wi-fi-radio-waves-and-health.

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