EU4Digital

EU4Digital Facility

Telecom Rules

How to accelerate 5G launch in EaP region?

MS Teams | 6 October 2020

Agenda

1. Electromagnetic field protection

2. Electromagnetic field protection and 5G

EU4Digital

EMF: Electromagnetic field protection

Protection of people and the environment against electromagnetic fields

Due to the dynamic development of mobile telephony, at the beginning of the 1990s, the **World Health Organization (WHO),** operating as a part of the United Nations, undertook research into the biological effects of radiofrequency electromagnetic waves. As a result of this work, precise guidelines were established in 1998 to limit exposure to electromagnetic fields up to 300 GHz in order to ensure that people and the environment are protected against known adverse health effects. These guidelines, in cooperation with the WHO, have been developed by an organization of independent scientists, operating as a part of the **International Commission on Non-Ionizing Radiation Protection (ICNIRP).** On this basis, on 12 July 1999, the Council of the European Union adopted a document, usually abbreviated to **Recommendation 1999/519/EC**. It is regarded as a basic European Union act relating to the protection of the public against electromagnetic fields.

Recommendation 1999/519/EC defines two quantities:

1 Basic restrictions

relating to phenomena directly occurring in the human body - especially the thermal effect

2 Reference levels

indicating limits which are considered safe to meet, for the practical verification (by measuring) that exposure to electromagnetic fields does not exceed the limit values

EU4Digital

EMF: Environmental exposure - basic restrictions

SAR limit value

The basic restrictions in the 10 MHz to 10 GHz radiofrequency band are defined in Recommendation 1999/519/EC by the Specific Absorption Rate (SAR) expressed in [W/kg]. The SAR coefficient is a measure of the rate of absorption of electromagnetic energy converted into heat in human body tissues, and in practice, it means the power absorbed by a unit of body mass. As a result of electromagnetic field penetration into the human body, a certain part of this field is absorbed and converted into heat by tissues. It has been established that the increase in human body temperature by a degree of Celsius occurs when the body absorbs 1 W/kg for one hour or the equivalent of 4 W/kg for 6 minutes. As a result, the SAR limits were set as averaged over 6 minutes:

- for the whole human body averaged value: 0,08 W/kg,
- for local exposure (head and trunk): 2 W/kg,
- for local exposure (limbs): 4 W/kg.

The SAR limit value indicated in Recommendation 1999/519/EC is 0,08 W/kg, averaged over the whole human body, has been determined with a very high safety factor (50).

Calculation approach

The SAR value = 4 W/kg averaged over 6 minutes, indicated in the ICNIRP Recommendation (absorption of electromagnetic energy at such a rate may lead to a thermal effect of increasing body temperature by no more than 1°C).

A 10-fold safety factor was then adopted, thus obtaining a SAR value acceptable for occupational exposure (in terms of occupational health and safety) and providing a sufficient margin of safety.

Further, a safety factor of 5 times more has been adopted, thus obtaining the SAR value acceptable for continuous environmental exposure

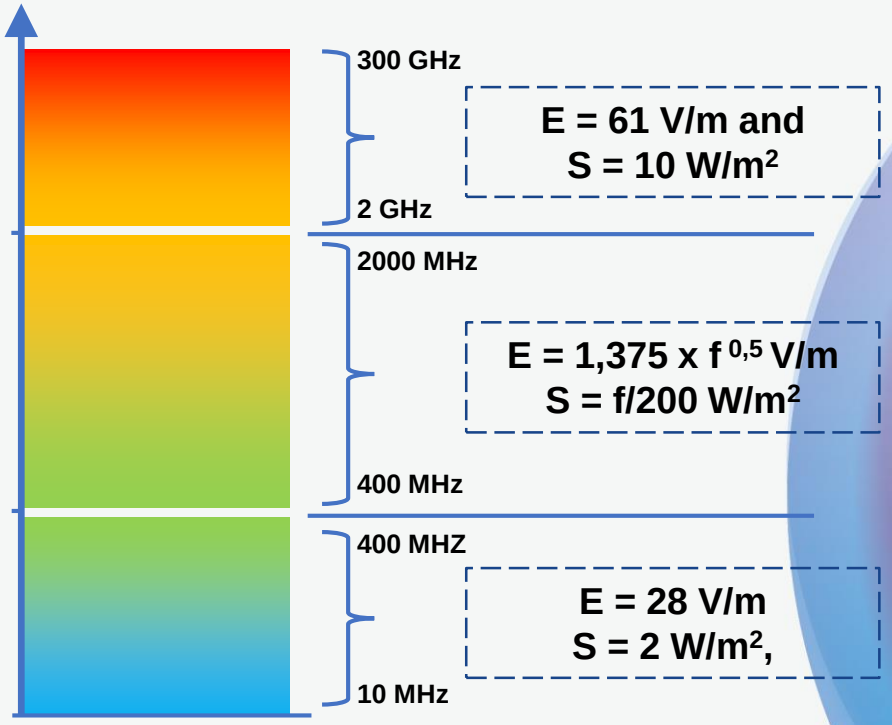
Recommendation 1999/519/EC allows a SAR value 50 times lower than that which would lead to an increase of 1 degree Celsius in human body temperature and 10 times lower in occupational exposure.

EU4Digital

EMF: Environmental exposure - reference levels

Reference levels

The reference levels defined in Recommendation 1999/519/EC are closely linked to the basic restrictions. They are designed to ensure that, irrespective of the duration of staying within the area where the requirements laid down for the reference levels are met, the effects of exposure to electromagnetic fields do not exceed the basic restrictions. As a result, if there is no exceedance of the reference level, there will certainly be no exceedance of the basic limit (and therefore no thermal effect). The radiofrequency reference levels are defined by measurable quantities, field strength [V/m] and the power density S expressed in [W/m^2].
The following reference levels have been established, expressed as limit values for the electrical component of field E and power density S, depending on the radiofrequency range.



Reference levels: field strength E and power density S for typical frequencies used in mobile networks as defined by Recommendation 1999/519/EC

Reference level	Frequency [MHz]				
	800	900	1800	2100	2600
Field strength E [V/m]	38,9	41,3	58,3	61,0	61,0
Power density S [W/m^2]	4,0	4,5	9,0	10,0	10,0

An electromagnetic field present in an environment whose value does not exceed the above reference levels shall be considered as safe. The following reference levels can therefore be defined for the frequencies where typical mobile base stations operate.

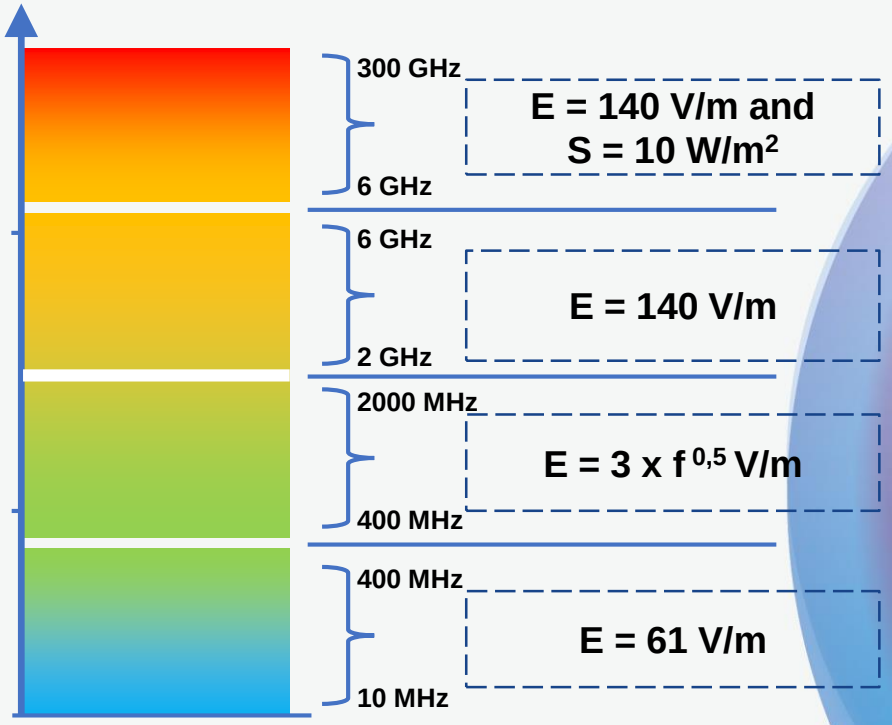
EU4Digital

$$S = \frac{E^2}{120\pi} \approx \frac{E^2}{377}$$

EMF: Environmental exposure - reference levels

SAR limit value

Electromagnetic fields present in the working environment for occupational exposure (in terms of health and safety) are subject to milder regulation than those present in the environment (concerning the general public). This is due to the safety factors previously presented. The minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) are regulated by Directive 2013/35/EU of 26 June 2013. In accordance with Annex III, the admissible value of body averaged SAR over any period of 6 minutes must not exceed 0,4 W/kg. Annex III of Directive 2013/35/EU also sets out limit values for the electric component of field E and power density S, depending on the radiofrequency range



Electromagnetic fields present in the working environment for occupational exposure below the above reference levels shall be considered safe.

EU4Digital

EMF: Electromagnetic field protection – New ICNIRP guidelines (1/2)

New ICNIRP guidelines

ICNIRP released new Guidelines in March 2020. After 20 years and based on a vast review of the scientific knowledge and public consultation, the new ICNIRP guidelines confirm the appropriateness of existing limits for the exposure to electromagnetic fields with slight adaptations to the measurement methods and protection limits concerning higher 5G frequencies.

The guidelines cover many applications such as 5G technologies, Wi-Fi, Bluetooth, mobile phones, and base stations. This publication replaces the 100 kHz to 300 GHz part of the ICNIRP (1998) radiofrequency guidelines, as well as the 100 kHz to 10 MHz part of the ICNIRP (2010) low-frequency guidelines.

The European Commission is now looking carefully into ICNIRP's findings, and will re-examine the situation in relation to the 1999 Council Recommendation based on a review by its relevant scientific committees (Scientific Committee on Health, Environmental and Emerging Risks - SCHEER - or the Scientific Advice Mechanism - SAM)

Health protection

Accordingly, the main ICNIRP (1998) restrictions currently remain protective and have been mostly retained in the new guidelines. Minor changes that have been made to improve the precision of the restrictions have resulted in more-conservative restrictions, but as the differences are small relative to the strongly conservative restrictions themselves, these changes will not make an appreciable difference to health protection against exposure from current RF EMF-emitting devices. However, there are two new restrictions in ICNIRP (2020) that have the potential to further strengthen health protection. The first relates to the development of technologies that utilize EMF frequencies >6 GHz, such as 5G, with new restrictions to better protect against excessive temperature rise in the body. The second relates to brief RF EMF exposures (<6 minutes), to ensure that transient temperature rise is not sufficient to cause pain or adversely affect tissue – although ICNIRP (1998) had a restriction for a brief (circa 50 ms) pulsed RF EMF to the head, the present guidelines provide protection for exposure durations up to 6 minutes and over the whole body. ICNIRP is not aware of any situations where exposure compliant with the 1998 guidelines has resulted in transient temperature rises that has adversely affected health, but this new restriction will ensure that new or future technological uses will also not adversely affect health.

EMF: Electromagnetic field protection – New ICNIRP guidelines (2/2)

1

Long-term effects

The difference with ICNIRP 1998 is that it gives the impression that long-term effects are now included. However, in the main body of ICNIRP 2020 and in Appendix A, the term “long-term” does not occur once and in Appendix B four times, within all cases a denial of the existence or the harmfulness of these “long- term” effects.

2

Technical changes to the basic restrictions

Whole body average exposure restrictions
Changes to the ‘transition frequency’ for local exposure
Local, 6-minute average, exposure restrictions up to the transition frequency (≤6 GHz)
Local, 6-minute average, exposure restrictions above the transition frequency (>6 GHz)
Restrictions for a brief (<6 minutes), local exposures

3

Technical changes to the reference levels

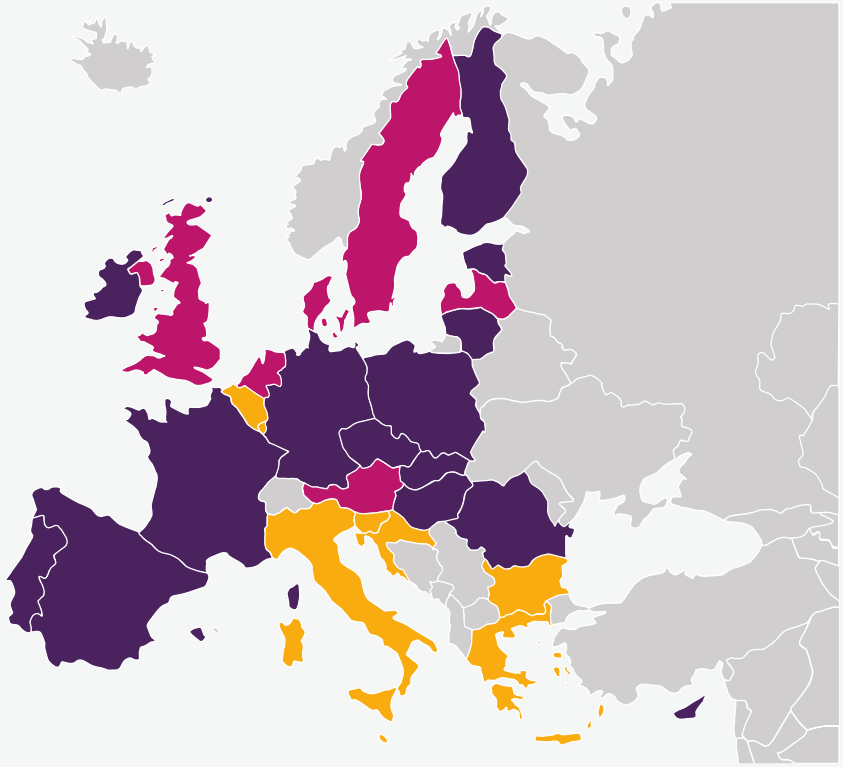
Additional reference levels
Removal of reference levels
Greater specification of compliance rules
Differences in reference level values

> “The new guidelines provide and more detailed exposure guidance, in particular for the higher frequency range, above 6 GHz, which is of importance to 5G, and future technologies using these higher frequencies. The most important thing for people to remember is that 5G technologies will not be able to cause harm when these new guidelines are adhered to.”
>
> ~ ICNIRP Chairman, Dr Eric van Rongen

EU4Digital

EMF: Exposure of the general public, field strength (V/m)

Overview of limits for exposure of the general population to radiofrequency EMF in the EU
(grey: non-EU countries)



Setting environment EMF limits

Recommendation 1999/519/EC, as a set of guidelines, has become the basis for the definition of environmental electromagnetic field limits in the national legislation of the Member States of the European Union. The Member States, in their responsibility to protect their citizens, may set their own - more stringent - restrictions than those defined in Recommendation 1999/519/EC. In most Member States, the permissible levels of electromagnetic field (EMF) in the environment have been established in accordance with Recommendation 1999/519/EC and 9 countries have adopted their own stricter environmental regulations to protect the environment from electromagnetic fields.

- Legal limits derived from EU recommendation indicated in Recommendation 1999/519/EC.
- No legal limits or limits less strict than in EU recommendation indicated in Recommendation 1999/519/EC.
- Stricter limits than in EU recommendation indicated in Recommendation 1999/519/EC.

EU4Digital

EMF: Exposure of the general public, field strength (V/m)

In the first group of member states the EU recommendation has been transposed in binding national legislation or national policy. This means that the basic restrictions and reference levels must be applied. Member states in this group are Cyprus, Czech Republic, Estonia, Finland, France, Hungary, Ireland, Lithuania, Malta, Poland, Portugal, Romania and Spain. In Germany and Slovakia the reference levels have become de facto exposure limits. In France there is an additional legal obligation to provide information on options for exposure reduction when selling or promoting a mobile phone and to provide citizens with measurement results for the strength of radiofrequency EMF in their homes or in public buildings.

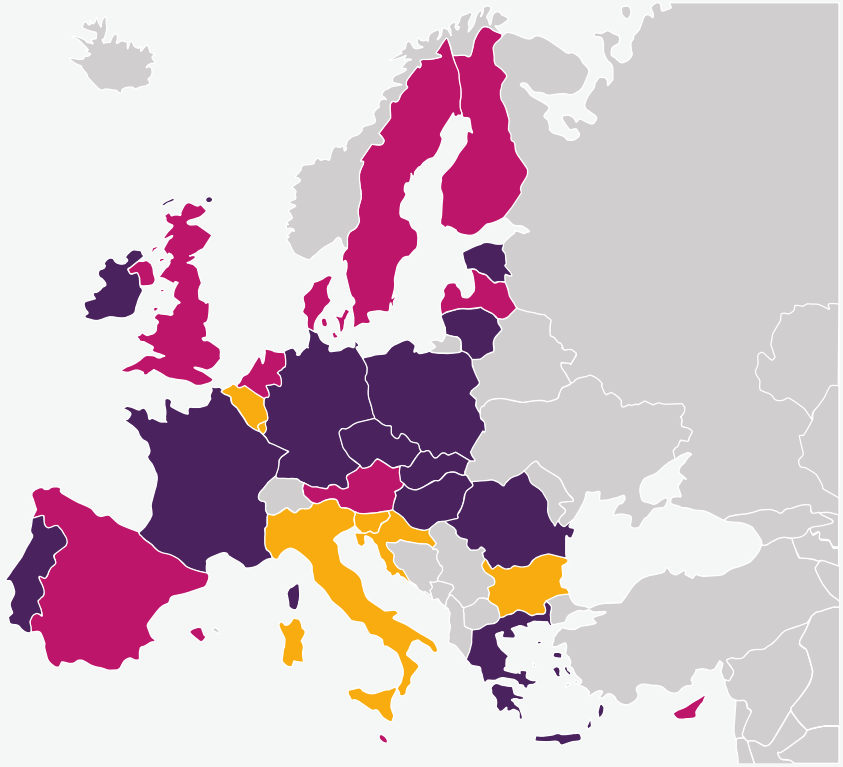
In the second group of member states, the national limits based on the EU recommendation or ICNIRP are not binding, there are more lenient limits or there is no regulation. Member states in this group are Austria, Denmark, Latvia, the Netherlands, Sweden and the United Kingdom. In some countries, for example the Netherlands and the United Kingdom, telecommunication companies have signed up to a voluntary code to respect the limits in the EU recommendation in places accessible to the public. In the United Kingdom the national planning policy framework for local government also requires that applications for expansion of base stations certify that these limits will not be exceeded.

In the third group of member states, there are stricter reference levels and/or basic restrictions based on the precautionary principle and/or due to public pressure. The limits chosen are sometimes based on the principle ‘as low as reasonably achievable without endangering service’. One practical choice for stricter limits can be to adopt the lower limit for interference in the European standards for electromagnetic compatibility (for example in Belgium). In other countries the reasons for particular limits are unclear or arbitrary (for example in Greece and Italy). In some member states the stricter reference levels are applied as exposure limits that may not be exceeded. Since there is a great diversity in particular rules and limits.

EU4Digital

EMF: Exposure of the general public, power frequency field strength (W/m^2)

Overview of limits for exposure of the general population to power frequency EMF in the EU
(grey: non-EU countries)



Setting environment EMF limits

Recommendation 1999/519/EC, as a set of guidelines, has become the basis for the definition of environmental electromagnetic field limits in the national legislation of the Member States of the European Union. The Member States, in their responsibility to protect their citizens, may set their own - more stringent - restrictions than those defined in Recommendation 1999/519/EC. In most Member States, the permissible levels of electromagnetic field (EMF) in the environment have been established in accordance with Recommendation 1999/519/EC and 9 countries have adopted their own stricter environmental regulations to protect the environment from electromagnetic fields.

- Legal limits derived from EU recommendation indicated in Recommendation 1999/519/EC.
- No legal limits or limits less strict than in EU recommendation indicated in Recommendation 1999/519/EC.
- Stricter limits than in EU recommendation indicated in Recommendation 1999/519/EC.

EU4Digital

EMF: Exposure of the general public, power frequency field strength (W/m^2)

In the first group of member states, the EU recommendation has been transposed in binding national legislation or national policy. This means that the basic restrictions and reference levels must be applied. EU member states in this group are the Czech Republic, Estonia, France, Greece, Hungary, Ireland, Luxemburg, Lithuania, Poland, Portugal and Romania. In the Czech Republic, the reference levels differ from the EU recommendation, but the basic restrictions are the same. In France, the limits only apply to new or modified installations. In Germany and Slovakia, the reference levels in the EU recommendation are applied as de facto exposure limits, without reference to basic restrictions.

In the second group of member states, the national limits based on the EU recommendation or ICNIRP are not binding, there are more lenient limits or there is no regulation. However, it may be that the authorities or grid companies apply the limits in the EU recommendation in practice. EU member states in this group are Austria, Cyprus, Denmark, Finland, Latvia, Malta, the Netherlands, Spain, Sweden and the United Kingdom.

In the third group of member states, there are stricter basic restrictions and/or reference levels, based on the precautionary principle or due to public pressure. These stricter reference levels are often applied as a de facto exposure limit that may not be exceeded. Since there is a great diversity in particular rules and limits.

Whether or not they have legally binding limits on the strength of power frequency fields, in some of the EU member states in the first and second group a precautionary policy has been advised by the government or voluntarily agreed to by the sector to limit the exposure of members of the general population to power frequency magnetic fields. Alternatively, the legislation contains an obligation to minimize fields as far as this can be done with reasonable cost and with reasonable consequences. The motivation is to keep fields as low as reasonably possible in the light of scientific uncertainty.

EU4Digital

EMF: Reference EMF levels in EU

Exposure limits for radiofrequency fields (public)

	Radiofrequency			
	Electric field (V/m)		Power density (W/m)	
Country	900 MHz	1800 MHz	900 MHz	1800 MHz
Austria	41.25	58.34	4.5	9
Belgium	6	6	0.1	0.1
Bulgaria	6.14	6.14	0.1	0.1
Cyprus	41	58	4.5	9
Finland	41.4	58.55	4.5	9
France	41	58	4.5	9
Germany	41.25	58	4.5	9
Greece	31.9 / 34.5	45.1 / 48.8	2.7 / 3.15	5.4 / 6.3
Italy	6 / 20	6 / 20	0.1 / 1.0	0.1 / 1.0
Lithuania	41.25	58.34	4,5	9
Poland	41.25	58.34	4,5	9
Netherlands	41.25	58.34	4.5	9
Norway	41.25	58.34	4.5	9
Sweden	[41.25]	[58.33]	[4.5]	[9]
Switzerland	4 / 41.25	6 / 58.34	0.1	0.1
UK of Great Britain and Northern Ireland	41.25	58.34	4.5	9.0

Belgium: Proposal to increase the EMF was suspended.

Bulgaria: In 2020 it is planned to prepare a scientific study on the impact of EMF

Italy: In 2019 a scientific study on the impact of EMF

Poland and Lithuania: EMF norms increased in 2020

Switzerland: Proposal to increase the EMF was suspended.

EU4Digital

5G and EMF: main concerns related to effective 5G implementation in countries are strict EMF levels

According to researches and studies conducted in Italy and Poland, countries which currently have or had stricter EMF limits than in EU recommendation indicated in Recommendation 1999/519/EC, the strict will negatively impact on 5G implementation due to the following issues:

1) Increased CAPEX and OPEX expenditures related to 5G rollout resulting from:

- Excessive investment costs in BS infrastructure, and increased associated rental and energy costs:
  - Limited range of the base station grids
  - Increase in a number of masts with associated increase in administrative burden, energy use, environmental impact, cost implications and levels of public concern
- Reduction of site sharing opportunities
- Unable to use existing site location, and specifically on buildings
- Less flexibility in optimizing the BS distribution and parameters

2) Delay in 5G rollout resulting from:

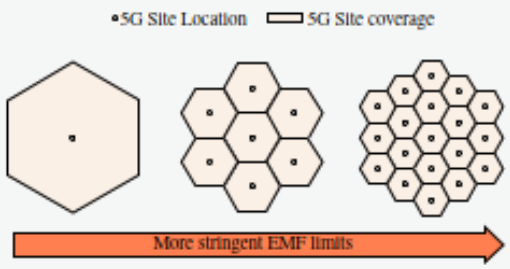
- Overload and delays in the licensing process on the operator and regulators' sides
- Higher levels of public concern due to a larger number of base stations

3) Lower QoS provided to subscribers

4) Less effective spectrum usage

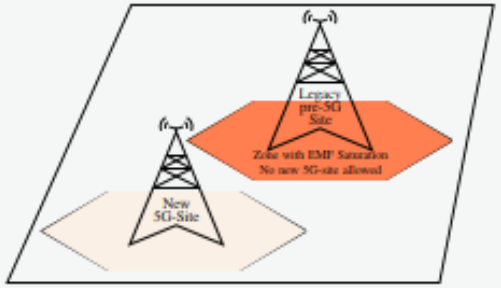
EU4Digital

5G and EMF: Challenges in implementation of 5G



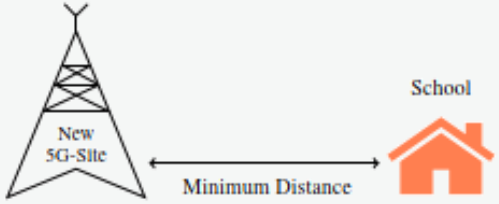
(a) Extensive 5G cell densification

Stringent EMF exposure limits imply a reduced flexibility in the 5G network deployment that in turn sets heavy limitations for the operators in the installation of new sites. The more stringent the EMF limits are, the lower is the power that each BS is allowed to radiate over the territory. This results then in a higher number of sites needed to serve a given area. As a result, the operator will experience a general increase in CAPEX costs. In the worst case, the operator may also decide to not serve a given area with 5G services, due to prohibitive CAPEX costs.



(b) Presence of an EMF saturation zone

Presence of EMF saturation zones. Since the EMF limits are already saturated in the surroundings of the site, it is not possible to install a 5G site in the same location. Clearly, this condition is experienced independently of the technology features adopted by the 5G BS. As a consequence, the operator will have to install the 5G BS in a new site, thus increasing the CAPEX costs, and possibly reducing the QoS perceived by the users. Eventually, the EMF saturation effect may be also exploited by an operator already serving an area to deny the installation of a new 5G BS site belonging to a competitor. To this end, a large amount of radiated power is declared by the operator during the authorization phase, while the actual value set during operation is much lower.



(c) EMF regulation based on a minimum distance

FIGURE 2. Three examples relative to the impact of EMF limits and EMF regulations on the 5G network planning.

Regulations may also impose a minimum distance between a 5G site and a sensitive place (e.g., a school or a hospital). This condition prevents again the installation of a new 5G BS at the best location. The operator has then to choose another location, which likely results in sub-optimal planning.

EU4Digital

Source: Planning 5G Networks under EMF Constraints: State of the Art and Vision, 2020, IEEE

5G and EMF: Effectiveness in implementation of 5G

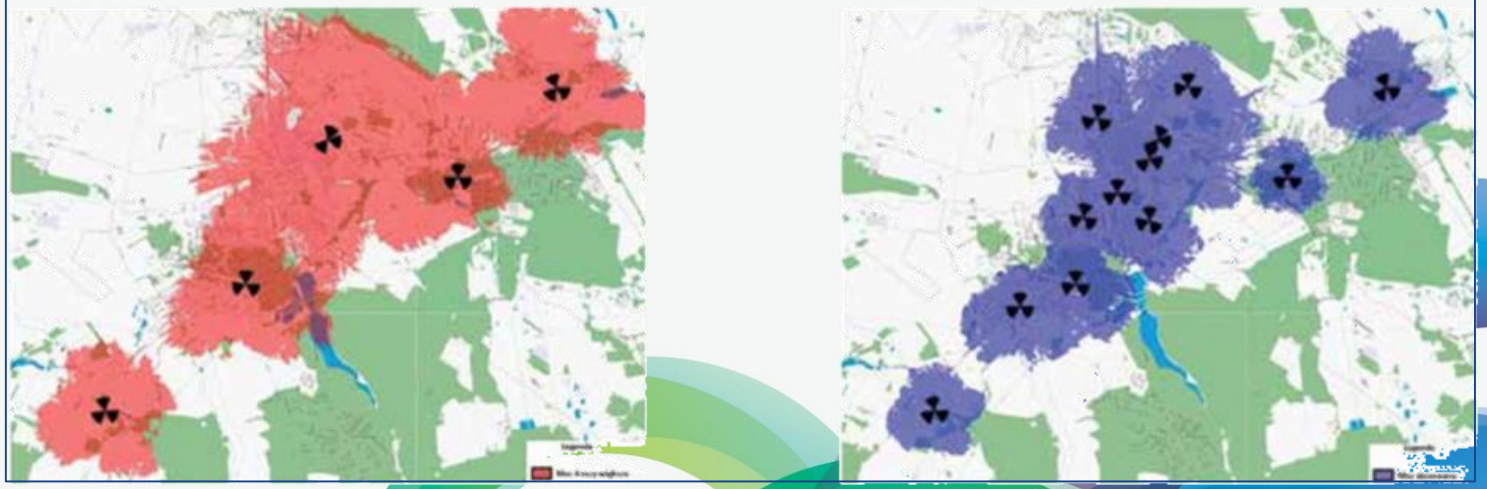
Setting environment EMF limits

The deployment of 5G networks will necessarily involve the installation of new Base Station (BS) equipment to support the requirements of next-generation mobile services. In a scenario where there exist already many sources of ElectroMagnetic Fields (EMFs), including overlapping 2G/3G/4G technologies of competing network operators, there is a growing concern that the planning of a 5G network will be severely constrained by the limits on maximum EMF levels established in wide set of regulations.

The strict EMF levels may lead to:

- Limited range of the base station grids
- The necessity to build much denser net of base stations (cost inefficient) and thus enforce increase of oversized investments costs
- Inability to share with existing technologies

Example of how same/larger areas can be covered with a smaller number of base stations with EC recommended EMF exposure limits (red) versus restrictive limits (purple)



Source: Arbitrary Radiofrequency exposure limits: Impact on 4G network deployment Case Studies Brussels, Italy, Lithuania, Paris and Poland, GSMA

EU4Digital

Case study: Italy

EMF limit

- 6 V/m, 0,1 W/m^2
- Additional local government requirements distance of 100 m between a BS site and a sensitive place, regardless of the amount of power radiated by the BS
- Italian regulations establish to evaluate the average EMF levels on a time interval of 24 hours, differently from the ICNIRP guidelines, which indicate a time interval of 6 minutes.

Implementation of 5G network

A similar situation is expected in relation to 5G network implementation.

Implementation of 4G network

- According to the study of the site, compliance has been carried out in the urban area of a few Italian cities under the hypothesis of expansion of the existing 3G sites (full carriers) together with the LTE deployment.
- According to the study it was predicted that in 2017, 71% of the base station in urban area will be saturated, where
  - 100% base station in city centre will be saturated;
  - 71% outside the city centre will be saturated;
- Saturated means that site exceeded a threshold of 83% of acceptable EMF limit (≥5 V/m form 6 V/m). It means that the capacity on site cannot be expanded (by adding new sectors) and accommodate of new technologies is not possible unless reconfigurations
- As a result from 2015 to 2017, 62% of the total existing installations was reconfigured. Most reconfigured sites were and remain in saturation conditions.

Percentage of non-usable sites for HSPA/UMTS + LTE Deployment

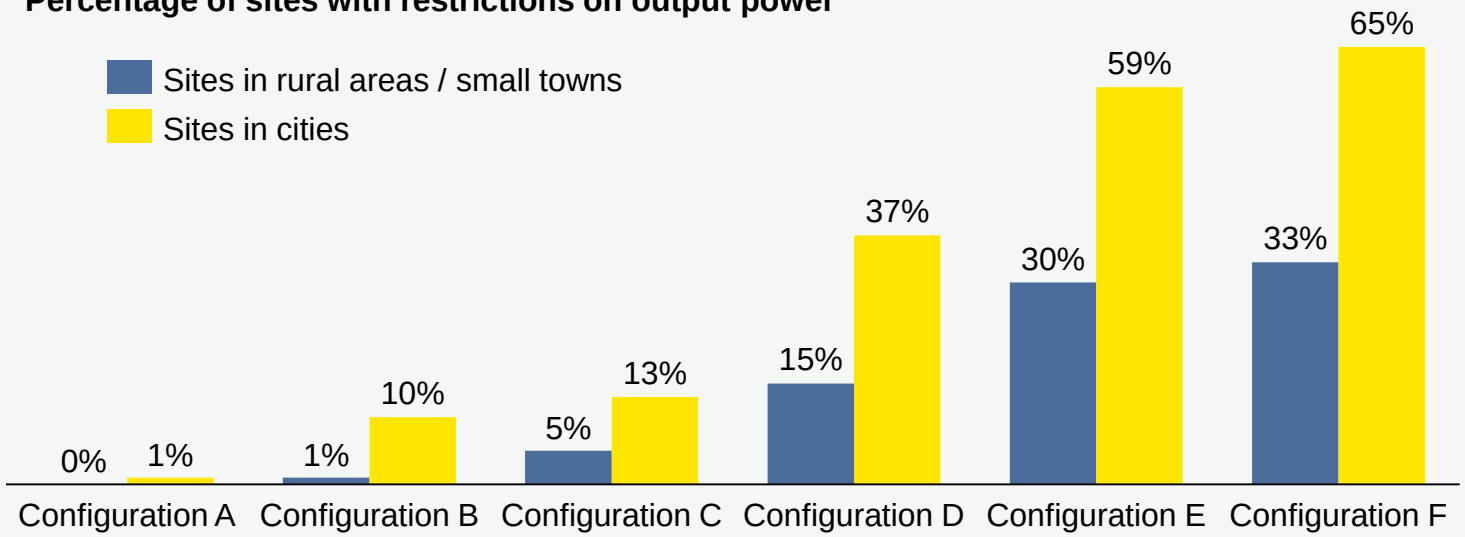
City	Peak Power Italian limit [6V/m]	Peak Power ICNITP limit [>= 40V/m]
Torino	72%	0
Bologna	44%	0
Firenze	77%	0
Average	**64%**	**0**

EU4Digital

Source: GSMA - Arbitrary Radiofrequency exposure limits: Impact on 4G network deployment, 2014

Case study: Poland (before 2020)

Percentage of sites with restrictions on output power



Site configuration	Technology
A	UMTS2100
B	GSM900 / UMTS2100
C	GSM900 / GSM1800 / UMTS2100
D	GSM900 / GSM1800 / UMTS2100 / LTE1800
E	GSM900 / GSM1800 / UMTS2100 / LTE1800 / LTE2600
F	GSM900 / GSM1800 / UMTS2100 / LTE1800 / LTE2600 / LTE800

EMF limit

- 6 V/m, 0,1 W/m^2

Implementation of 4G network

According to GSMA data (2014) most of the base stations in cities were saturated (have restrictions on output power). Such general conclusion was confirmed by EMF measurements conducted by the National Institute of Telecommunications in 2018.

EU4Digital

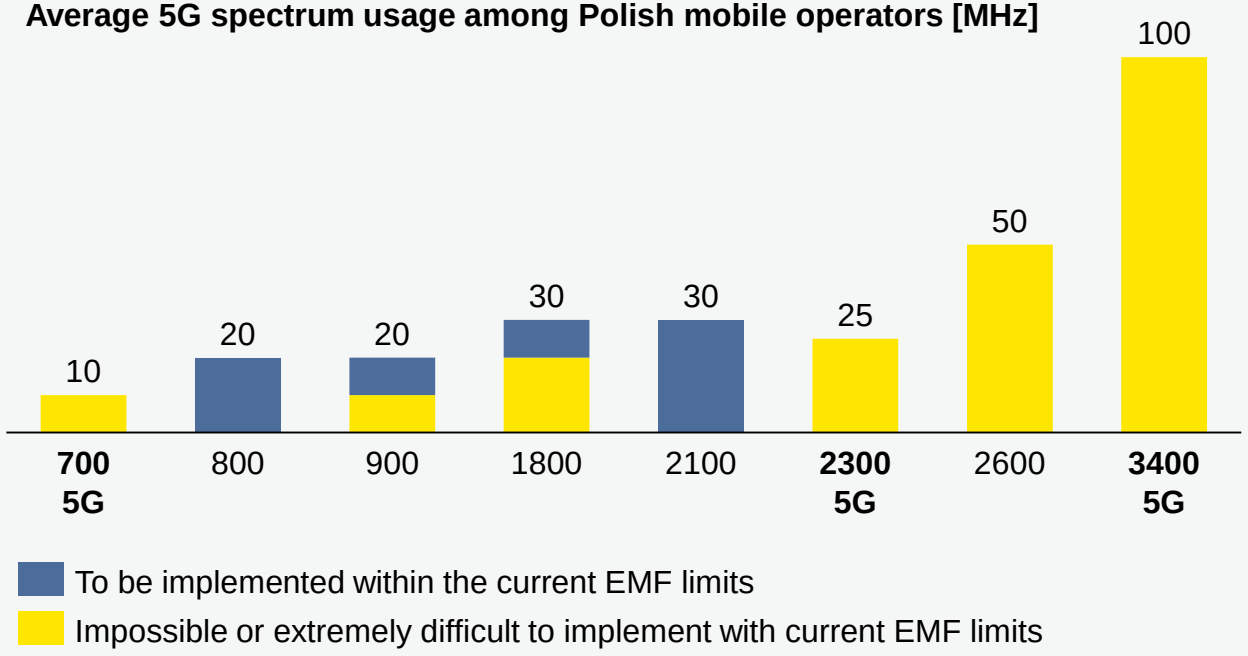
Source: GSMA - Arbitrary Radiofrequency exposure limits: Impact on 4G network deployment, 2014

Case study: Poland

Implementation of 5G networks

- In 2018, the network operator in Poland had on average 150 MHz of spectrum on the frequencies 800, 900, 1800, 2100 and 2600 MHz. In densely populated urban areas with this 150 MHz, operators can only use around 70 MHz.
- This means that due to power density limits of about 80 MHz, the available spectrum cannot be used in densely populated urban areas and is simply wasted. Moreover, in densely populated urban areas it is not possible to use any other frequency bands: 700, 2300 or 3400 MHz - whether they are intended for 5G or other types of technology. In urban areas, on the other hand, operators can only use around 110 MHz of the spectrum.
- According to Polish law, the Ministry of Digitization points out that if the permissible PEM levels remain unchanged, the number of base stations will have to be increased more than 7 times in order to ensure proper mobile network capacity (due to the growing traffic generated by users).

Average 5G spectrum usage among Polish mobile operators [MHz]



EU4Digital

Source: BCG - Impact of Power Density Limits on wireless connectivity: is Poland threatened with a delay in 5G development?, 2018

Case study: Belgium

EMF limit

- Flanders - 3 V/m per antenna in residential locations (only to mobile operators), general cumulative norm of 20.6 V/m (900 MHz)
- Wallonia - 3 V/m per antenna in residential locations.
- Brussels - 6 V/m.

Implementation of 5G network

According to Belgian MNO the full implementation of 5G, including all features, will not possible under current EMF limit.

Implementation of 4G network

- Until 2014 the norm in Brussels was 3 V/m
- According to the analysis conducted in 2011 to MEC Earth & Environmental GmbH it was estimated that implementation of LTE under strict limit (3 V/m) will result in addition of 400 new base stations to the already existing 1,000 sites in the Brussels Capital Region. Approximately 10% of the macro cell sites would require technical modifications and upgrade. This would cause an increase in the associated electricity consumption of roughly 40% or 4,100 MWh per year, implying higher energy costs and, as a negative side effect.
- In 2014 the norm in Brussels was expanded from 3 V/m to 6V/m, which is not a long-term solution for implementation of 4G/LTE and 5G networks.

EU4Digital

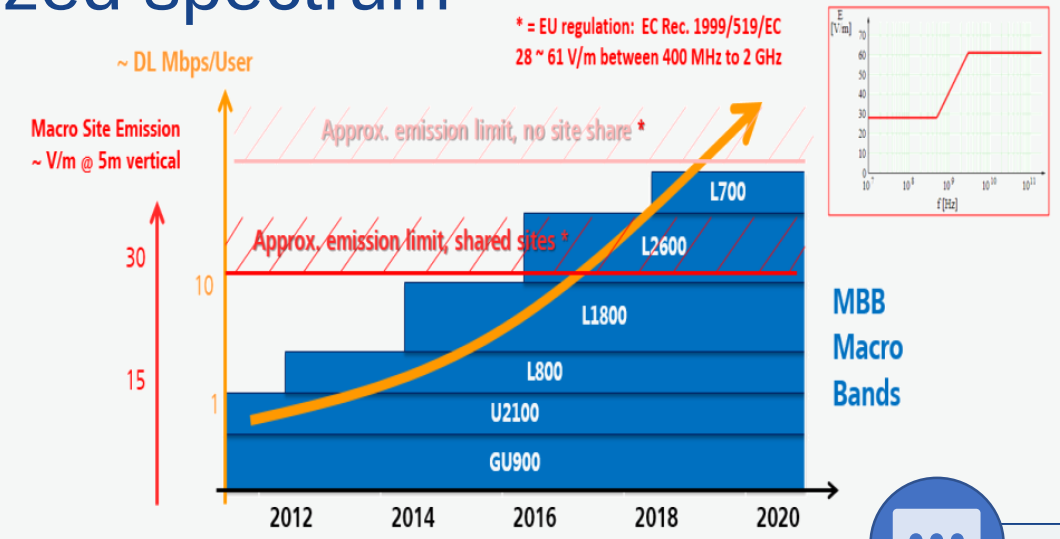
Source: GSMA - Arbitrary Radiofrequency exposure limits: Impact on 4G network deployment, 2014

5G and EMF: Main correlations

Feature	Relevance to EMFs	Expected EMF Increase/Decrease
Increase of utilized spectrum	Increased number of radiated power.	+ Increase of total EMF level
MIMO	Increased number of antennas radiating power. Impact of computing the radiated power when assessing the compliance with EMF limits.	-/+ The impact on the EMFs levels depends on the specific MIMO configuration and on the adopted approach for measuring the EMF levels.
Beamforming	Compared to currently installed BSs, in which a single antenna (or very few) emanate power over a wide area, this feature may result in generally lower EMFs levels. However, since the radiation is concentrated into selected portions of territory, there may be an increase of EMFs in these points.	- General decrease w.r.t. currently deployed BSs. + Increase in selected locations.
mmWave	Path loss increase of radiated signals on mmWave bands.	- (Possible) decrease w.r.t. BSs exploiting micro-waves.
Small Cells	Installation of additional sources of power. Less power required to macrocells.	- (Possible) decrease w.r.t. the current cellular network. + (Possible) increase in proximity to the small cells.
Softwarization	Sharing of the hardware infrastructure by multiple operators. Fewer antennas installed in the shared sites.	- Large decrease w.r.t. the case in which each operator installs its own physical equipment in the same site.
2G/3G Dismission	Reduction of the current EMF saturation levels in urban zones.	- Large decrease w.r.t. the case in which all the legacy technologies are maintained.

EU4Digital

5G and EMF: Increase of utilized spectrum



700 MHz	FDD uplink 30 MHz	SDL 20 MHz	FDD downlink 30 MHz
800 MHz	FDD downlink 30 MHz	FDD uplink 30 MHz	
900 MHz	FDD uplink 35 MHz	FDD downlink 35 MHz	
1500 MHz	SDL 40 MHz		
1800 MHz	FDD uplink 75 MHz	FDD downlink 75 MHz	
2100 MHz	FDD uplink 60 MHz	FDD uplink 60 MHz	
2300 MHz	FDD uplink 100 MHz		
2600 MHz	FDD uplink 70 MHz	FDD downlink 50 MHz	FDD uplink 70 MHz
3500 MHz	TDD 200 MHz		
3700 MHz	TDD 200 MHz		
26 GHz	TDD 1 GHz - 3 GHz		

Assuming that in phase the 5G networks will be implemented in 700 MHz, 3500 MHz and 3700 MHz bands it will almost double the frequency resources used by cellular network. Which will increase the EMF levels.

Current usage

5G usage – 1-st phase

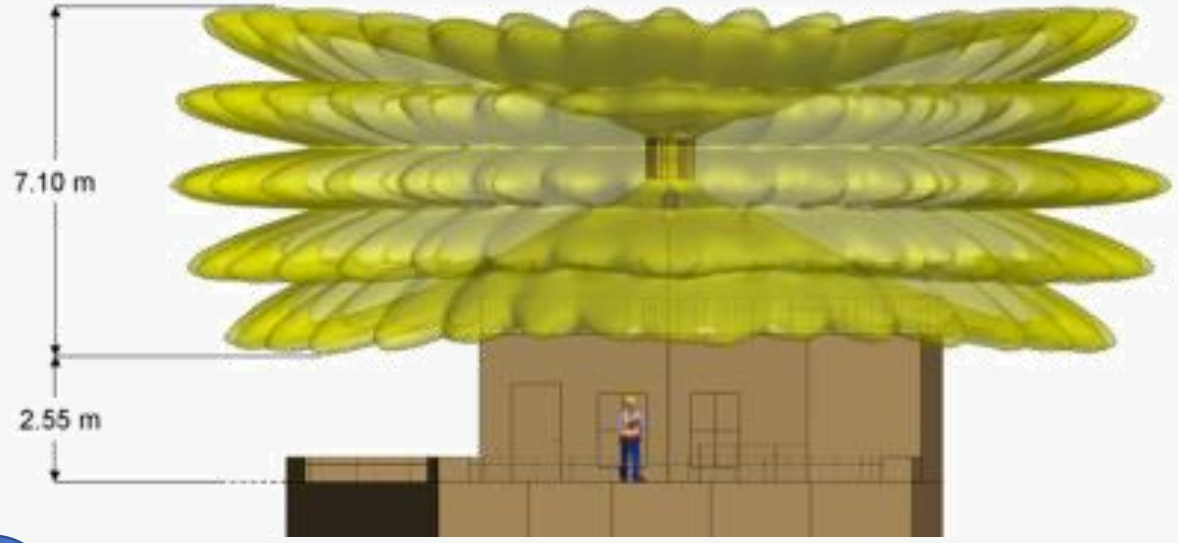
Current usage/5G usage – 2-nd phase

EU4Digital

5G and EMF: Impact of EMF level on exclusion zone

Exclusion zone ICNIRP limit 10 W/m²

Ericsson simulation



Stimulation assumptions

- 5G site
- 3.5 GHz, three sectors
- 28 GHz, one sector
- Actual maximum power (25% of max)

Source: Ericsson, Impact of EMF limits on 5G network roll-out, ITU Workshop on 5G, EMF & Health Warsaw, December 5 2017

Huawei simulation

800 900 1800 2100 2600 → 13,5 m

800 900 1800 2100 2600 + 700 + 1400 → 15,9 m

800 900 1800 2100 2600 + 700 + 1400 + 3,5G M-MIMO → 21 m

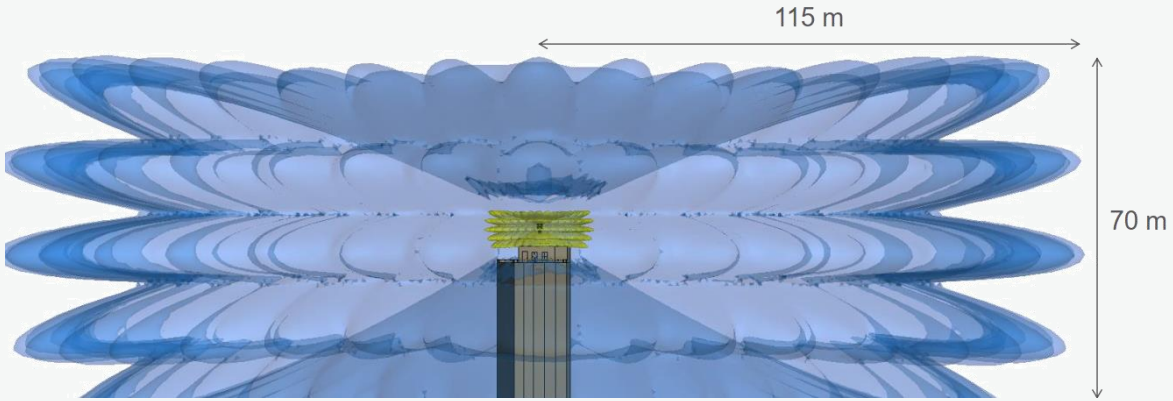
Freq [MHz]	Output Power [W]	Max Antenna Gain [dBi]
700	40	15
800	40	16
900	40	16,5
1800	80	17,5
2100	60	18
2600	80	19
1400	80	16,5
3500	120	23 (user beam)

Source: Huawei, Safe use of 5G mobile systems Technology & Standardization aspects, ITU Workshop on 5G, EMF & Health, Warsaw, December 2017

EU4Digital

5G and EMF: Impact of EMF level on exclusion zone

Exclusion zone ICNIRP limit 0,1W/m²



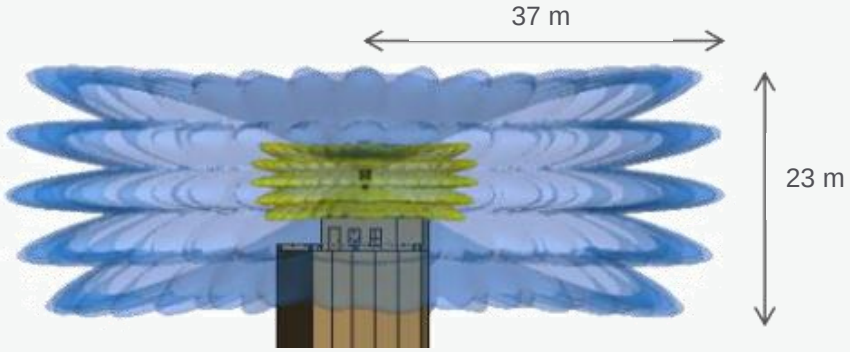
Exclusion zone 10 W/m²

INCRIP limit

Exclusion zone 0,1 W/m²

1/100 of INCRIP limit

Exclusion zone ICNIRP limit 1W/m2



Exclusion zone 10 W/m²

INCRIP limit

Exclusion zone 1 W/m²

1/10 of INCRIP limit

EU4Digital

Source: Ericsson, Impact of EMF limits on 5G network roll-out, ITU Workshop on 5G, EMF & Health Warsaw, December 2017

5G and EMF: measurement

Massive MIMO and beamforming	NR cell-specific signals	Frequency bands above 10 GHz
▸ Potentially higher EIRP and larger EMF compliance boundaries (exclusion zones) than for conventional antennas if theoretical maximum power is used for all beams	▸ In previous UMTS and LTE systems, cell-specific synchronization and reference signals were used to estimate the EMF levels. In 5G NR is a completely new approach regarding cell-specific signals	▸ International EMF limits more conservative in the nearfield which may lead to larger compliance distances for small cell base stations

- More complex EMF compliance assessments - EMF assessment methodology and standards available but need to be further refined
- Approach to the measurement of EMF level (maximal or average)

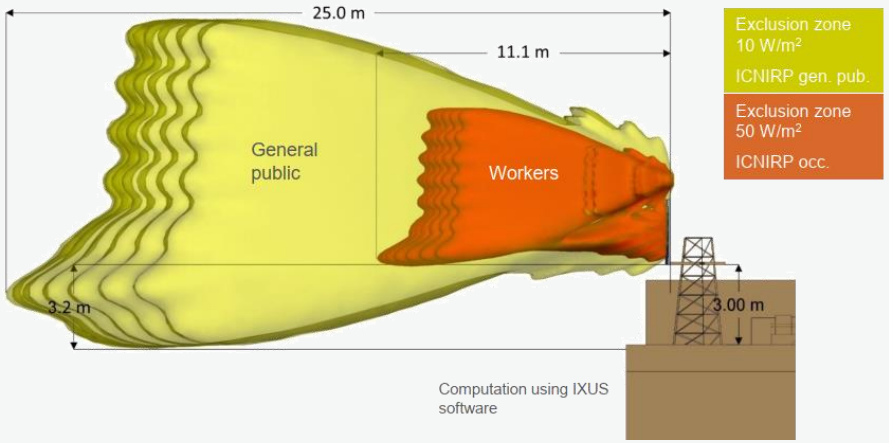
EU4Digital

5G and EMF: measurement

Setting environment EMF limits

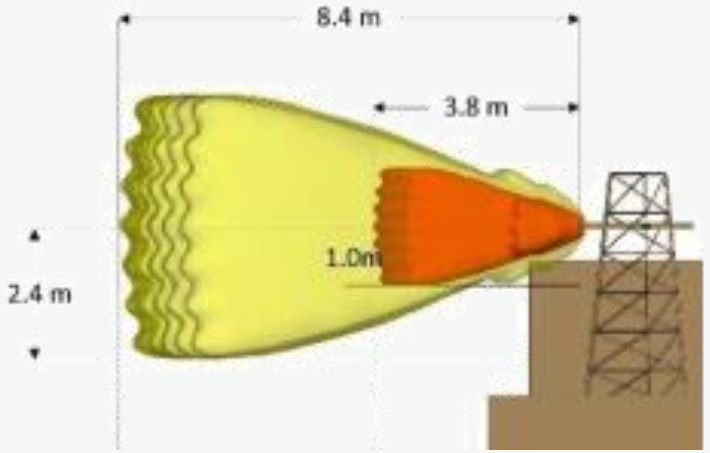
EMF compliance may be a challenge for 5G massive MIMO sites if assuming theoretical maximum power for all beams

Max Tx power 200W



- 3.5 GHz, 200 W
- Massive MIMO (64 elements)
- EIRP of 72 dBm
- Installation on existing site with 2G, 3G and 4G antennas
- Theoretical maximum power (100% simultaneous utilization) assumed for all antenna

Max Tx power 44W



- Statistical model to determine actual maximum power of 5G massive MIMO antennas has been developed: found to be around 25% of theoretical maximum power for 8x8 array antennas

Output power levels (High traffic hours)

- Mean = 20,9%
- Median = 20,1%
- 95th percentile = 28,5%
- Max = 39,1%

Source: Ericsson, Impact of EMF limits on 5G network roll-out, ITU Workshop on 5G, EMF & Health Warsaw, December 5 2017

EU4Digital

5G and EMF: measurement - French example

Measurements problems

In April 2020 The National Frequency Agency (ANFR) published study[1] including the assessment of the exposure of the general public to 5G electromagnetic waves, presenting first measurement results on 5G pilots in the 3,400-3,800 MHz band. The measurement have been conducted for 3 scenarios

- Measurements without traffic - base station only sent signalling, no users were connected
- Measurements with continuous traffic in a blocked beam - the base station sent a constant and continuous stream of data in a given direction
- Measurements with file transfer configuration in a given direction on-demand downloads using different size files.

Site	Measured electric field strength				
	Without traffic	Transmitting continuously at full load in a given direction	Transmitting predefine volume of traffic during 6 min		
			1 GB	10 GB	Max
1 (Huawei)	0.1-0.2 V/m	9 V/m	1.1 V/m	3.9 V/m	6.5 V/m
2 (Huawei)	0.1-0.2 V/m	8.3 V/m	0.8 V/m	2.4 V/m	3.9 V/m
3 (Nokia)	0.05-0.6 V/m	6 V/m	1.6 V/m	4.8 V/m	8.2 V/m

As a result of the study it was decided to include in the national guidelines on the presentation of simulation results of exposure to waves emitted by radio installation, indicator based on foreseeable use of 5G: one gigabyte of data sent in a given direction every 6 minutes.

EU4Digital

1) *Assessment of the exposure of the general public to 5G electromagnetic waves; Part 2: first measurement results on 5G pilots in the 3,400-3,800 MHz band April 2020*

5G and EMF: Small cells

EU regulations

In July 2020 EC published recommendation[1] on specifying the characteristics of small-area wireless access point, which shall apply in EU from 21 December 2020. This recommendation defines the physical and technical characteristics of small cells, which are **exempted from any individual town planning permit or other individual prior permits.**
The work on Commission Implementing Regulation started in 2018 and was supported by a study[2] and considered input obtained from two rounds of open public consultations.

Visual parameters

- Volume of the part visible to the general public of a small-area wireless access point serving one or more radio spectrum users shall not exceed 30 litres.
- The small-area wireless access point shall have visual consistency and should not create visual clutter.

Notification of small cells

Operators which have deployed small-area wireless access points shall notify the national competent authority within two weeks from the deployment of each such point about the installation and location of those access points as well as the requirements they meet in accordance with technical and visual requirements

The recommendations do **not apply to small-area wireless access points with an active antenna system**. As long as the applicable standards (following ICNIRP 2020 updated guidelines) do not cover small-area wireless access points with active antenna systems, such small-area wireless access points will not be covered by the EU-light deployment regime for the purpose of ensuring transparent and adequate protection of public health.

1) *Commission Implementing Recommendation 2020/1070 of 20 July 2020 on specifying the characteristics of small-area wireless access points pursuant to Article 57 paragraph 2 of Directive (EU) 2018/1972 of the European Parliament and the Council establishing the European Electronic Communications Code.*
2) *Light Deployment Regime for Small-Area Wireless Access Points (SAWAPs).*

EU4Digital

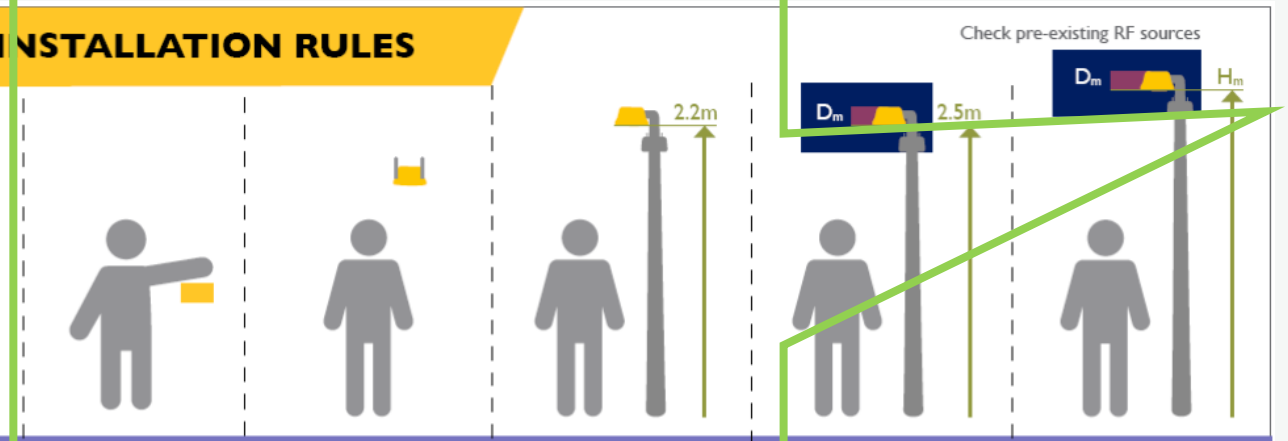
5G and EMF: Small cells

Technical parameters

SIMPLIFIED INSTALLATION RULES

From IEC 62232 Ed.2.0

Installation must be done according to instructions from the manufacturer or entity putting into service



Installation class	E0	E2	E10	E100	E+
Total EIRP	N/A	≤ 2 W	≤ 10 W	≤ 100 W	No limit
Minimum height above walkway	None	None	2.2 m	2.5 m	H_m (calculation)
Exclusion zone	None, touch compliant	Provided in manufacturer's instructions Small D_m not shown on the picture		Provided in manufacturer's instructions D_m in main lobe direction	
Check pre-existing RF sources	N/A	N/A	N/A	$5D_m$ in main lobe direction D_m in other directions	

Source: Small cell Forum based on information from IEC 62232 Ed 2.10, 2017

- Wireless access points shall be in accordance with the installation classes E0, E2 and E10 of the European standard EN 62232:2017.
- E10 shall of access points should be only deployed in outdoor or in large indoor spaces, which have a ceiling height of at least 4 m
- In the case of multiple co-located antenna systems, the EIRP of all co-located antenna systems will be taken into consideration.
- The recommendations do not prejudice local EMF norms.

EU4Digital

EU4Digital

Thank You