Arbitrary Radio Frequency exposure limits:

Impact on 4G network deployment

CASE STUDIES
BRUSSELS, ITALY, LITHUANIA,
PARIS AND POLAND

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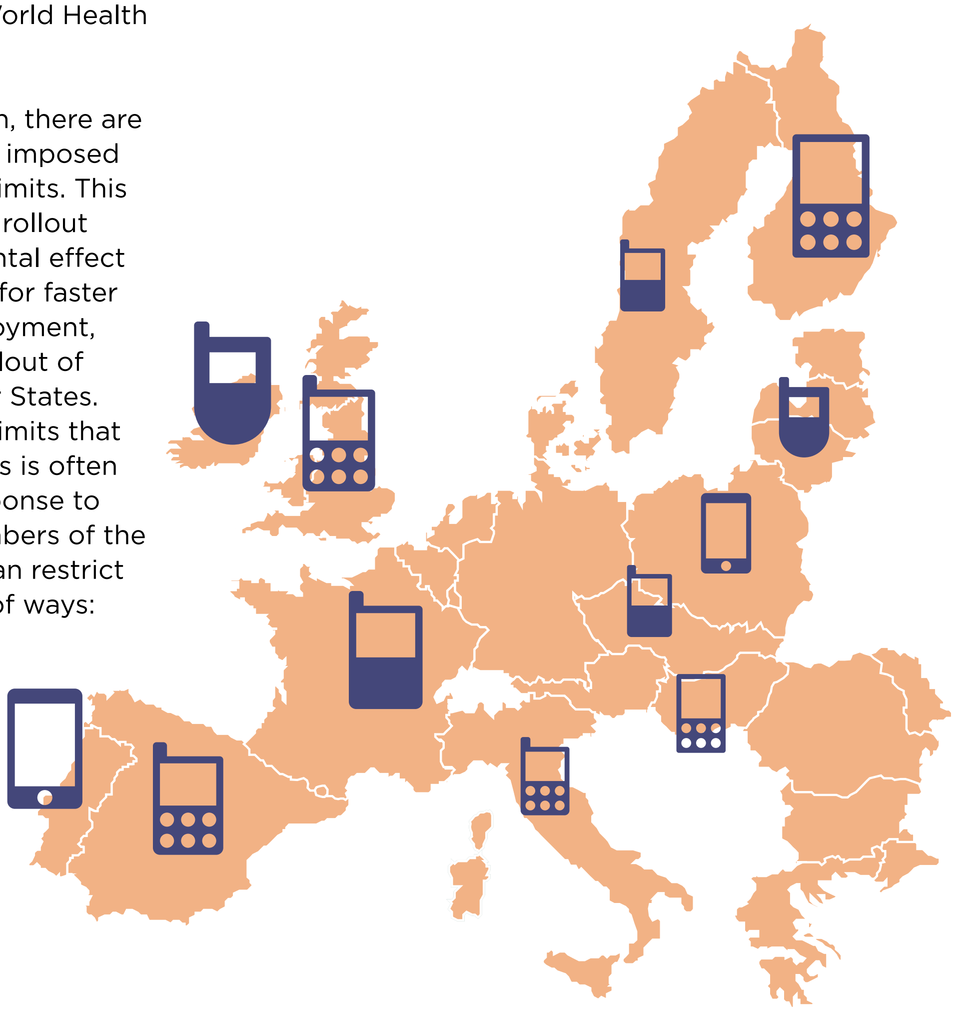
Executive Summary

Europe needs a comprehensive connectivity agenda that boosts investment, creates new jobs, drives innovation and removes obstacles to the deployment of innovative technologies. The Digital Agenda seeks to accelerate this growth through the use of the digital technologies.

The GSMA welcomes the adoption of harmonised, Electromagnetic Fields/Radio Frequency (EMF/RF) exposure limit policies based on the international guidelines. In Europe exposure to electromagnetic fields is regulated[1] (Recommendation 1999/519/EC) on the basis of the 1998 guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which are recommended by the World Health Organization (WHO).

Despite the 1999 Recommendation, there are some markets in Europe that have imposed significantly lower EMF exposure limits. This already has an impact on network rollout and has started to have a detrimental effect on the deployment of technology for faster mobile broadband (4G/LTE) deployment, and may negatively impact the rollout of faster broadband in other Member States. Adoption of lower EMF exposure limits that are without credible scientific basis is often seen as a politically attractive response to concerns expressed by some members of the community. But these measures can restrict 4G/LTE deployment in a number of ways:

- Reduced flexibility in network deployment;
- Reduced coverage (particularly indoor) for consumers;
- Reduced opportunities for site sharing
- Increase in number of base stations needed for delivering same level of service.



1. 1999 Recommendation 1999/519/EC on the limitation of the exposure of the general public to EMF and the Directive 2013/35/EU on the exposure of workers to the risks arising from physical agents (EMFs)

	CURRENT EMF EXPOSURE LIMIT (JAN 2014)	SCOPE OF APPLICATION	ROLLOUT OF 4G/LTE PROGRESS	FURTHER NOTES
ICNIRP	41 V/m (at 900 MHz)	All publically accessible places		
Belgium (Brussels)	6V/m (at 900 MHz)	Living places	Eased, but further restrictions expected	
France (Paris)	ICNIRP based	Paris charter : -> 5V/m (eq. 900 MHz) for 2G+3G -> 7V/m (eq. 900 MHz) for 2G+3G+4G		
Italy	6V/m	Indoor/outdoor living places	Eased, but awaiting further guidelines	about 64% of existing antenna sites unusable for LTE rollout with current regulation
Lithuania	6.1 V/m	All publically accessible places		
Poland	7 V/m			

On the basis of the findings of the study the GSMA:

- Calls on the European Commission to promote good practice by Member States through harmonization of Electromagnetic Fields/Radio Frequency (EMF/RF) exposure limit policies based on the international guidelines.
- Calls on Member States to follow the EC 1999 recommendation and latest SCENIHR opinion that exposure limit policies should be based on the international guidelines.
- Calls on the European Commission and Member States to adopt evidence based policies that enable the deployment of mobile broadband and other wireless technologies.

Introduction

Mobile plays a pivotal role in the European economy, both as an industry in its own right and as an enabling platform for an increasing range of adjacent industries and services. The mobile industry in Europe provides services central to many other players of the economy and to the daily lives of almost every citizen.

Europe has the highest mobile penetration rate in the world. Across Europe, it is forecast there will be 2.1 billion mobile connections by the end of this decade. Advanced mobile broadband networks are delivering faster data rates, low latency and expanding coverage. Mobile connected devices in Europe are predicted to soar to almost one billion by 2020, with total connected devices estimated to reach almost six billion.[1]

According to the GSMA's "The Mobile Economy Europe 2013"[2] report, the total Connected Life market revenue opportunity is estimated at over €234 billion in Europe by 2020, which includes service improvements and innovative new services, as well as the scope to make material cost savings. A Connected Europe, based on embedded mobile connectivity, will fuel further growth by enabling new business models and providing new market and revenue opportunities across many sectors of the economy. Additionally competition and price cuts have increased the affordability of mobile services for consumers.

The growth and benefits of the mobile industry to date have been phenomenal. The mobile ecosystem (both directly and indirectly) generated €261 billion in GDP – around 2.1% of total GDP – for Europe in 2012. This is in addition to the provision of other social, environmental, health and education benefits across Europe.

Recent studies indicate that the European mobile industry faces falling revenues and earnings just at the time when key investments are required in next generation mobile infrastructure.

The GSMA study on Mobile Wireless Performance in the EU and the U.S.[3] highlighted, for example, that by the end of 2013 nearly 20% of U.S. mobile connections will be 4G/LTE – the corresponding figure for Europe stands at less than 2%. Cisco reports that average mobile data connection speeds in North America in 2012 were about 75% faster than those in Europe, with the difference set to grow to 100% by 2017.[4] The Mobile Economy Europe 2013[5] report confirms that Europe has lost its edge in mobile and is now significantly underperforming other advanced economies, including the United States and parts of Asia.

Europe needs a comprehensive connectivity agenda that boosts investment, creates new jobs, drives innovation and removes obstacles to the deployment of innovative technologies.

1. Source: GSMA Intelligence https://gsmaintelligence.com/topics/3097/dashboard/
2. Mobile Economy Europe 2013, GSMA, September 2013 http://gsmamobileeconomyeurope.com/
3. Mobile Wireless Performance in the EU and the U.S., GSMA, May 2013 http://www.gsmamobilewirelessperformance.com/
4. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012–2017, Cisco, February 2013
5. Mobile Economy Europe 2013, GSMA, September 2013 http://gsmamobileeconomyeurope.com/

REGULATORY FRAMEWORK AT EUROPEAN AND NATIONAL LEVEL

An important step towards this boost in investment has been taken by the European Institutions in focussing on new telecommunications infrastructure. There have been positive developments to reduce the cost of deploying high speed electronic communications networks, and others which simplify the conditions for the deployment. Enabling the rollout of small cells to enhance competition and reduce network congestion is also an important step.

However, when it comes to the deployment of mobile technologies, in particular 4G/LTE, in certain Member States, operators are facing another regulatory challenge: extremely restrictive electromagnetic field (EMF) exposure limits without credible scientific basis.

In Europe exposure to EMFs is regulated on the basis of the 1998 guidelines of the International Commission on Non-Ionising Radiation Protection (ICNIRP), which are recommended by the World Health Organization (WHO).[6] These limits were confirmed as protective against all established health risks by ICNIRP in 2009 and by European Commission scientific advisory committees from 1998 – 2009[7]. Therefore, there is no scientific basis to assert greater health protection by imposing more restrictive EMF limits.

The GSMA welcomes the adoption of Electromagnetic Fields/Radio Frequency (EMF/RF) exposure limit policies based on the ICNIRP guidelines and calls for harmonised public exposure limits consistent with the ICNIRP guidelines.

Despite the 1999/519/EC Recommendation, there are some markets in Europe that have imposed EMF exposure limits significantly lower than the ICNIRP reference limits for the public. This has an impact on network rollout and has started to have a detrimental effect on 4G/LTE deployment, and may negatively impact the rollout of faster broadband in other Member States as well.

Adoption of lower allowable EMF exposure limits that are without credible scientific basis is seen as a politically attractive option in order to respond to the concerns expressed by some members of the community. But, as will be explained in this paper, there are a number of important policy-related implications associated with such a measure and a significant technical impact:

- Restrictions for 4G/LTE deployment (less flexibility in network deployment, coverage gaps with negative consequences on the consumers, no positive business model)
- Reduced opportunities for site sharing (non-optimal design of transmitting systems)
- Increase in number of base stations with associated increase in administrative burden, energy use, environmental impact, cost implications and levels of public concern.

The differentiation among Member States in terms of the legal framework concerning the EMF exposure limits undermines the efforts to create a Digital Single Market, since the environmental rules governing deployment of networks differ across the EU, and, as a result, certain regions of the EU will continue to lag behind in mobile network investments, and the consumers will not benefit from the full potential of digitisation.

This document analyses five specific cases where national/local legislations have negatively affected the rollout of faster mobile broadband: Brussels, Italy, Lithuania, Paris and Poland.

6. 1999 Recommendation 1999/519/EC on the limitation of the exposure of the general public to EMF and the Directive 2013/35/EU on the exposure of workers to the risks arising from physical agents (EMFs)
7. For more info on ICNIRP limits see Appendix 1

BELGIUM (BRUSSELS)

REGULATION IN PLACE AND IMPACT TO DATE

In Belgium, before January 2009, the exposure limits were a federal/national competency. The applicable norm was at that time 20.6 V/m cumulative over all sources (frequency reference 900 MHz). In January 2009, the Constitutional Court ruled that this was a regional competency.

EMF exposure limits in Belgium vary from region to region. In **Flanders**, the regional authority adopted a norm that applies a specific 3 V/m per antenna in residential locations (only to mobile operators), while a general cumulative norm of 20.6 V/m (900 MHz) is applicable to all the sources (four times stricter than ICNIRP). This norm causes a limited impact to network deployment in the region. In **Wallonia** the current norm is 3 V/m per antenna in residential locations. This norm is not frequency dependent as in the other regions or as ICNIRP. The Walloon Decree of the 3rd of April 2009 is imposing a strict control mechanism of a priori and a posteriori controls.

Until recently the norm in **Brussels** was 3 V/m (frequency reference being 900 MHz) cumulative over all sources (frequencies between 100 kHz to 300 GHz) except broadcasters.[8] This value is 200 times more stringent than the ICNIRP values. It was applicable since September 2010 to all sites (except <800 mW equivalent isotropically radiated power[9]) with a limitation to 25% of 3 V/m per operator ($\sqrt{3^2 \div 4} = 1.5$ V/m).

As a side effect, in 2011 a study by AMEC Earth & Environmental GmbH for the GSMA[10] found that the operators estimated that approximately 400 new base stations would need to be added 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, an additional thousand tons of CO_2 released to the atmosphere annually.

The impact of the legislation in Brussels required operators to reduce the power of most of their base stations, thereby affecting both the network coverage (especially indoors) and their capacity (the ability to cover a given number of calls or exchanges of data simultaneously). Due to the restrictive norm, operators could not increase capacity needs for 3G nor can they deploy 4G/LTE in Brussels.[11] This leads to gridlock for the networks and reduced service to customers seeking to use their mobile for all the applications that they have come to expect.

CHANGE TO REGULATION AND IMPACT ON 4G/LTE

At the end of January 2014 the Brussels Parliament approved a Decree aimed at raising the current standard of 3 V/m that regulates the radio waves transmitted by mobile phone antennas. The intention is to move up from 3 V/m to 6 V/m (at 900 MHz). The norm will only be applicable to places accessible to the public. Execution of the 6 V/m standard text is expected to be in February-March 2014. Broadcasters are still excluded.

The text is certainly a step forward but does not offer a long-term solution for 4G/LTE. It will have to be changed again in the coming years to allow operators to respond to anticipated capacity needs in 4G/LTE. The deployment of 4G/LTE with a standard that remains restrictive (6 V/m is

8. In adopting the Brussels norm the authorities stated that it applied to mobile signals because they were pulsed but not to broadcast as they were not-pulsed. However, a report by the Institut scientifique de Service public (ISSeP) concluded that 3G signals are non-pulsed whereas some broadcasting technologies are pulsed. (Étude du caractère pulsé des rayonnements émis par les systèmes de télécommunications sans fil. Etude réalisée à la demande de l'IBGE. Institut scientifique de Service public (ISSeP). Rapport n°172/2012. Liège, 18 janvier 2012).
9. In radio communication systems, equivalent isotropically radiated power (EIRP) is the amount of power that a theoretical isotropic antenna (which evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum antenna gain. The EIRP is used to estimate the service area of the transmitter, and to coordinate transmitters on the same frequency so that their coverage areas do not overlap.
10. Energy Impact of Lower RF-EMF Exposure Limit – Brussels Capital Region, AMEC Earth & Environmental GmbH, August 2011 http://www.gsma.com/publicpolicy/wp-content/uploads/2013/07/GSMA_FINAL_REPORT_2011-08-29inENGL_prot.pdf
11. Communication of the BIPT Council of 15 February 2013 on the radiation standards in the Brussels Capital Region. Belgian Institute for Postal Services and Telecommunications, February 15, 2013.

still 50 times stricter than the international recommendations) results in a significant increase in the site density of the existing network.

Building new antennas will create additional problems: 1) the reduced norm has created a high level of public concern in the population; more base stations will not reduce this; 2) operators face difficulties in finding suitable buildings to house these additional sites at the precise location where they are needed; besides, new locations are costly in building and yearly rental payments to the landlord; 3) the building and environmental permit administration will be overloaded and struggle to handle the files of the three operators in a reasonable timeframe, leading to further delay in extending the 4G/LTE service to customers.

ITALY

REGULATION IN PLACE AND IMPACT TO DATE

Since 1998[12] Italy has been using limits which are far more restrictive than the international approach (see Table 1, Table 2 and Table 3).

TABLE 1 EXPOSURE LIMITS ESTABLISHED BY DPCM JULY 8TH 2003

FREQUENCY	ELECTRIC FIELD [V/M]	MAGNETIC FIELD [A/M]	POWER DENSITY [W/M^2]
0.1-3 MHz	60	0.2	–
3 MHz – 3 GHz	20	0.05	1
3-300 GHz	40	0.1	4

TABLE 2 ATTENTION VALUE[13] AND QUALITY TARGET[14] ESTABLISHED BY DPCM JULY 8TH 2003

FREQUENCY RANGE	ELECTRIC FIELD [V/M]	MAGNETIC FIELD [A/M]	POWER DENSITY [W/M^2]
0.1MHz – 300 GHz	6	0.016	0.1

TABLE 3 COMPARISON BETWEEN ICNIRP REFERENCE LEVELS AND ITALIAN LEVELS FOR THE PUBLIC EXPOSURE TO RF FIELDS

FREQUENCY BAND [MHZ]	ICNIRP LIMIT [V/M]	ITALIAN LIMIT [V/M]
800	39	6
900	41	
1800	58	
2100	61	
2600	61	

12. D.M. 381/1998, then Framework Law n. 36/2001 and DPCM July 8th 2003 concerning radiofrequencies
13. Attention value: level not to be exceeded in long term exposure conditions (≥ 4 h/day) in living spaces
14. Quality target: level not to be exceeded in outdoor intensely frequented places

The existence of several exposure limits within the regulatory framework – without either a clear distinction of the application scopes for their verification or the verification methodology itself – introduces an ambiguity into the interpretation so that, in practice, the lowest value (6 V/m) is always considered as the actual exposure limit, thus making the other levels useless.

Additionally, authorities and agencies for protection against EMF sometimes adopt values, in the compliance assessment procedures, that are lower than 6 V/m by appealing to some precautionary principles, for example, to prevent the possibility that other operators would install antennas in the future causing the limit to be exceeded.

The limits must be respected taking into account the contribution of all the operators providing services in a certain area and the pre-existing electromagnetic background level (e.g. radio and TV broadcast transmitters). Furthermore, in order to take into account of the potential site-sharing among operators, local agencies for the environment protection have the authority to impose the respect of lower limit for each operator, thus applying a fair sharing of the so called "electromagnetic space". Therefore, the study of compliance of base stations has to be very accurate both in the design phase of new sites and in the expansion phase of existing ones. Operators try to balance the requirements of coverage and quality of service with the requirements of compliance with EMF exposure limits but face a strict and long authorization process, resulting often in a sup-optimal system in terms of coverage and quality of service with respect to the design goal.[15]

CHANGE TO REGULATION AND IMPACT ON MOBILE NETWORKS

The Government revised the norm in December 2012 by varying the EMF evaluation methods and the scope-of-application of exposure limits, attention value and quality target. The new law introduces new concepts for the EMF exposure assessment that could have a positive impact on the costs of mobile network deployment. Some of the measures of the norm, though, would still have the effect of increasing the overall management costs. The new normative law prescribes that it should be accompanied by appropriate Application Guidelines drawn up by agencies for environmental protection (ISPRA and ARPA). However, even after one year since the publication of the new regulation, the Application Guidelines have not yet been delivered by the environmental agencies reducing the effect of the whole regulation.

LITHUANIA

REGULATION IN PLACE AND IMPACT TO DATE

The EMF exposure limits in Lithuania are fixed at 6.1 V/m, cumulative over all sources (frequencies between 300 MHz to 300 GHz) and is applicable in all areas publicly accessible. This value is more than 30-50 times stricter than ICNIRP limits, depending on the frequency at which the comparison is made.[16]

Lithuania inherited these strict EMF limits from the time of the Union of Soviet Socialist Republics. However, it was not until 2005-2010, during 3G deployment and the increasing density of GSM sites that operators had to start shutting down city macro cell sites because of the EMF limits. The problem has increased in the past two years due to further increase in site density, implementation of new technologies such as 4G/LTE in 1800 MHz and 2.6 GHz bands and Remote Radio Units (RRUs). Since 2011 about 10% of sites have been forced to be closed and operators have been obliged to redesign sites in order to continue to provide services to customers.

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15. For example, in 2009 some operators were licensed to use the third 3G carrier and started the deployment of the networks with multiple carriers to meet the increasing capacity requirements. The desired third-carrier deployment has been hindered because of the very strict EMF exposure limits in force. In fact, the electromagnetic space was exhausted in a high number of 3G sites: in some cases the pre-existing carriers were depowered to allow the activation of the additional one, thus causing a degradation of both quality of service and coverage; in other cases, the degradation level was unacceptable and did not allow the third-carrier deployment. By considering the normative in force (maximum radiated power and 6 V/m limit), a study conducted on three cities showed that a percentage of sites included between 36% and 57% were not usable for the desired expansion because of their non-compliance with EMF exposure limits, compared to the full compliance if ICNIRP limits were used.
16. This exposure limits do not apply to cell of site with equivalent radiated power <25 W, but usually macro cells of site have 500W-900W equivalent radiated power.

Additionally the EMF application code is rather complex and requires operators to perform several calculations per each site/ technology, hence causing extra costs and associated delay in bringing new base stations on air, or updating to new technology.

With the development of new, faster technologies, bringing increased data speeds to customers on their mobiles, the problem is expected to increase even further. For example, new technologies such as LTE Advanced with implementation on higher radiated power multiple input multiple output (MIMO)[17] schemes and new spectrum (800 MHz) will be deployed. Under the current regulatory framework, 50-100% of city macro cell sites would need to be redesigned and probably around 30-50% of city sites would not meet the criteria even after redesign to accommodate these new technologies. This would result in a necessity to significantly increase the density of the existing networks, building new base stations which will both increase costs and have a negative environmental effect. In the meanwhile Lithuanian operators already face vast problems in finding locations for new base stations and reconstructing existing ones, which is also linked to the strong fear of the possible harm of EMF from antennas.

According to studies of VGTU (Vilnius Gediminas Technical University Faculty of Electronics)[18] and forecast of operators there will need between 240 and 400 additional city macro cell sites for each operator. This will cause an increase of electricity consumption of approximately 8,000-10,000 MWh a year and, consequently, of CO_2 emissions.

CHANGE TO REGULATION

In 2013 the EMF issues were discussed within the Health Ministry responsible for EMF regime and proposals to improve EMF code were made. The proposals aim at reducing costs to implement new Radio Access Network (RAN) technologies by limiting the paperwork required. The changes will be implemented in the second half of 2014 according to the agreement between the Ministries of Health and Economy. Unfortunately an agreement on exposure limits was not reached as the Health Ministry is reluctant to accept higher limits.

FRANCE (PARIS)

REGULATION IN PLACE AND IMPACT TO DATE

As in the vast majority of the EU Member States, France applies EMF exposure limits based on ICNIRP guidelines.[19]

In 2009, as a result of the commitments made at the “Grenelle des Ondes” consultation, following the roundtable discussions on ‘’Radiofrequencies, health and the environment”, a committee was formed (COPIC Steering Committee).[20] The group brought together civil servants, local politicians, regional associations and telephone operators and aimed at studying the feasibility of lowering exposure to electromagnetic waves emitted by antennas while maintaining coverage and service quality.

After four years of activity in working groups across all stakeholders, a final report on these working groups’ activities was handed in to the Ministers for Ecology and for the Digital Economy in August 2013. As part of the study, 300 million base station exposure simulations were made. The study found that the exposure levels are already very low in France compared to the ICNIRP reference levels: 99% of the simulated points were lower than 1/10th of the French safety limits.[21] The report assessed that a reduction in exposure to 0.6 V/m[22] would lead to a sharp deterioration of network coverage, in particular inside buildings. In this case, to restore only the initial coverage (without taking into account the capacity or the

17. Multiple-input and multiple-output, or MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology.
18. VGTU study, 2013
19. Decree of May 3, 2002.
20. The COPIC was formed from the operational committee (COMOP) on models and experiments concerning exposure and attempting to reach a concerted approach to issues raised by mobile telephony
21. About 90% of the exposure levels were under 0.7 V/m and 99% under 2.7 V/m. The median exposure level was 0.14 V/m.
22. A value proposed by some activist groups.

quality of service) operators would need to, at least, triple the number of antennas in the country. Moreover the exposure would increase with the integration of 4G/LTE network but would remain, in 99% of cases, below 1/10th of ICNIRP levels.

In conclusion the study pointed out that the overall exposure to EMF is already very low in France compared to the reference levels recommended by the European Commission based on the ICNIRP guidelines. An arbitrary reduction of the EMF limits could cause a strong deterioration of coverage and the need for the operators to increase the number of antennas in order to restore the quality of the service.

In this situation, Paris represents an exception. Even if the regulatory limits (ICNIRP based) apply there, the City of Paris (as a major landlord) negotiated separate agreements with mobile operators. In March 2003 they signed a special charter framing up the roll out of the network in place, which was initially meant to be a best practice siting code. In January 2006, a new charter was signed by the Mayor of Paris and entered into application for two years. The new text integrated the 3G fields' measurements into the limit value of 2 V/m over 24 hours, posed greater attention to the integration of the antennas into the environment and introduced a new index of average exposure.

CHANGE TO REGULATION

In January 2013 the municipality of Paris and mobile operators Bouygues Telecom, Free Mobile, Orange FT and SFR signed the agreement for a new "Charte Parisienne de telephonie mobile". The City of Paris, which is a significant landlord owning almost one-third of the sites committed to facilitating and helping the roll out of base stations, including on public real estate. On the other hand, mobile operators commit to giving the population every possible guarantee in terms of health and safety.

CONCLUSIONS

Currently operators are deploying 4G in France on 800 MHz, 1800 MHz and 2600 MHz mobile networks. Investments on 4G networks accelerated and, as of November 2013, 7,896 sites had been approved for mobile high-speed broadband. The Parisian charter created a situation of a risk of saturation of the existing network, threatening the deployment of 4G/LTE in Paris, due to the high density of sites required to provide customers with all that is needed for them to make the most use of their phones for all the services under the current regulatory framework. There is also a risk of increased delays in the roll out of base stations, since the computer based simulations must be presented and approved by the City of Paris (with a potential re-engineering of sites), before any new installation.

POLAND

REGULATION IN PLACE AND IMPACT TO DATE

The EMF permitted exposure level in Poland is maximum 7 V/m (for frequencies from 300 MHz to 300 GHz) in areas defined as "*accessible to the public*". As in the case of Lithuania, these norms are derived from provisions implemented in the 1960s by the Soviet Union.

The legal framework of environmental protection against EMFs is complex and consists of several legal acts. In many cases local administration authorities misinterpret those acts when addressing on-going and very serious social concerns regarding EMF exposure in the country.

The permitted EMF exposure levels in Poland are too low to allow optimal network deployment in numerous frequency bands in one location. Currently, the most serious situation as a result of rigorous EMF exposure limits is observed by mobile operators in large urban areas where, in light of technological development and the use of additional frequency bands, the 7 V/m exposure limit does not allow network deployment in additional frequency bands in one location. For example, a base station with 2100 MHz equipment fulfils the 7 V/m limit and adding equipment to utilise the recently awarded 1800 MHz for 4G/LTE is not possible in the current legal framework; an additional base station must be constructed purely for 1800 MHz, and even so, its full potential cannot be utilized.

CONCLUSIONS

In light of the upcoming 800 MHz/ 2.6 GHz auction and the investment obligations announced in the consultation process there are serious doubts as to the ability of operators to fulfil the targets set out by the national regulatory authority.

CONSEQUENCES OF STRICT EMF EXPOSURE LEGISLATION

From the cases described above it is clear that arbitrary EMF exposure limits much stricter than international or EU recommendations have serious implications not only but particularly for the deployment of 4G/LTE networks.

New technologies, such as HSPA+ and LTE, enabling broadband internet access, as per the targets set out in the Digital Agenda 2020, need to be supported by an efficient use of spectrum. With unreasonably strict EMF exposure limits it is not possible to use all frequencies due to the fact that adding new systems on the existing base stations would result in them exceeding the permitted EMF exposure limits, and will therefore be illegal. This will cause a **waste of spectrum** that will not be utilized to its full potential.

The need to design the mobile networks in compliance with EMF exposure limits that are more restrictive than European recommendations, results in **less flexibility in the network deployment**, first of all in terms of access to and optimal location of sites. In addition, network operators, in order to respect unreasonably strict EMF exposure limits, have to reduce the output power of their antennas. Such reduction affects coverage and creates gaps in the network, which then affects the quality of the service provided to consumers.

A forecast study of 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.

The results (Table 4) show that by considering the antenna peak-power and the limit of 6 V/m, a percentage of sites between 44% and 77% is not usable for the implementation of the new ultrabroadband technologies, compared to the full compliance if ICNIRP limits were used.

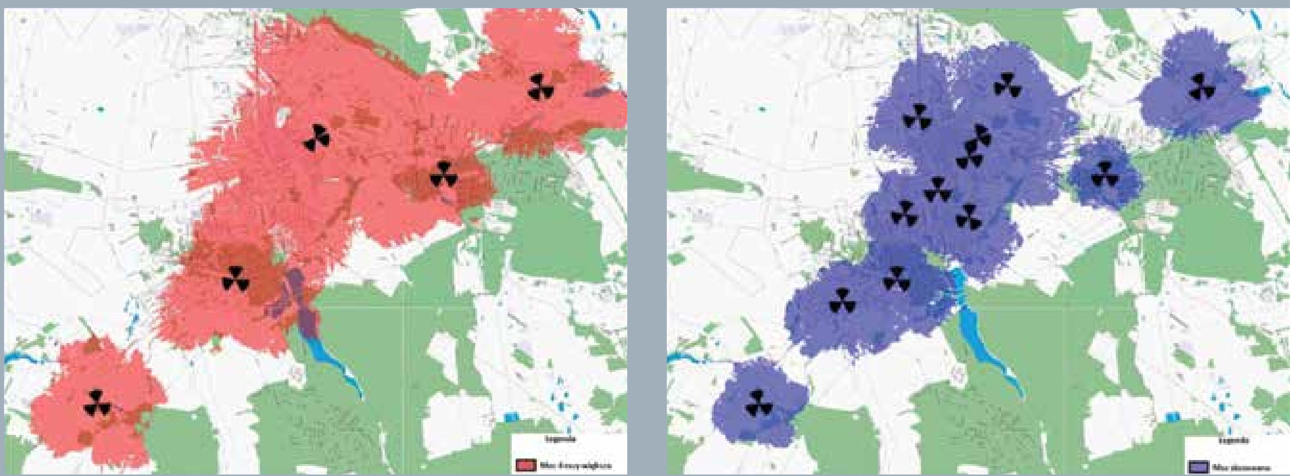
TABLE 4 PERCENTAGE OF NON-USABLE SITES FOR HSPA/UMTS + LTE DEPLOYMENT

CITY	PEAK POWER ITALIAN LIMIT (6 V/M)	PEAK POWER ICNIRP LIMIT (≥ 40 V/M)
Torino	72%	0
Bologna	44%	0
Firenze	77%	0
Average	**64%**	**0**

Furthermore, the compliance with the exposure limits **prevents the possibility to operate in *sitesharing* mode** with different radio system (GSM, 3G and LTE) and different operators, because the presence of several sites fills all the allowable EMF exposure level.

The inevitable consequence of such situations is an **overall increase in the numbers of base station sites** to ensure network coverage and a good quality of service. This implies a significant **economic and environmental impact** in terms of energy consumption and landscape modification.

FIG. 1 MAP 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)



Several studies have evaluated the environmental impact and its related economic costs. In Italy, for example, it was concluded that operators pay about €300 million of annual energy bill and about 1.2 Mt of CO_2 per year would be released into the atmosphere.

The results of a study carried out by ISPRA[23] based on a measurement campaign made in 2007, showed that the average consumption of a base station per year was 35,000 kWh/year which is about equal to the average consumption by 10 families.

Given the 60,000 base stations in Italy in the 2007[24], the total energy consumption of all the sites was 2.1 TWh/year, 0.6% of the whole national electric consumption.[25]

As far as the hypothesis of 3G/HSPA and LTE deployment and EMF exposure assessment based on the peak radiated power and the 6 V/m limit (the actual procedure) are concerned, an increment of 38,400 sites is expected, that is 64% of the total number of base stations. The corresponding increase of the energy consumption is 1.3 TWh/year with an emission of CO_2 of about 0.77 Mt/year. By knowing that each new site needs about 40 m^2, 154 hectares of land would be diverted from other uses for building the new sites. An increase of the site number, but not of base stations number, will cause an increment of the overall power consumption and, in addition, a higher production of CO_2 due to the overall Life Cycle Assessment (LCA) footprint.

23. Report ISPRA 112/2010 www.isprambiente.gov.it/it/pubblicazioni/rapporti?b_start:int=60
24. Osservatorio CEM, ISPRA 2007
25. Terna, 2007

The impossibility to optimize radio-coverage and investments results in **obstacles for the realization of the network infrastructure**, with evident **negative consequences on the end users** which will not benefit from the innovative services offered by the implementation of 4G/LTE technology.

In Europe, as well as in the rest of the world, the mobile access-network technology has developed in compliance with international standards that define the requirements to be applied for the equipment of the overall radio mobile network. Those standards, do not consider, in general, any limitation on the radio frequency radiated power for the equipment, provided that the exposure limits are respected in accessible locations, allowing the flexibility to use the most appropriate design in relation to the target on the quality of service. The equipment are also designed in compliance with environmental constraints and requirements (compliance with EMF limits, disposable and recyclable material, reduction of energy consumption) proposed by regulatory bodies and industrial associations (such as ETSI and CENELEC). Hence, the companies operating in countries with arbitrary low limits have the problem of integrating network equipment developed in compliance with international exposure limits into a scenario where exposure limits are much lower, causing less flexibility in the choice of the appropriate network development with respect to the desired quality of service. This causes notable difficulties in offering to citizens and companies the same mobile connectivity solutions provided to companies operating in countries with higher limits.

In **Italy**, for example, when 3G/HSPA network was deployed, in several circumstances a **non-optimal design of the radiating system** (e.g. in terms of antenna positioning and orientation) could not be avoided and the sub-optimal transmitted power choice did not guarantee an adequate quality of service. In the rural areas, the current regulatory framework and the EMF exposure evaluation techniques adopted by control bodies risk making the 4G/LTE mobile network investments useless. In fact, it will be necessary to find new sites because a percentage of the existing ones cannot host the new systems and it will not be possible to provide an adequate service, equally distributed over the territory.

In **Belgium**, operators have launched 4G/LTE offers covering cities across the country. Nevertheless, the impossibility to deploy 4G/LTE within Brussels **jeopardized the existence of any positive business model**, especially considering the high number of people commuting every day to Brussels from the two other regions. The situation may change in 2014 with the new EMF Brussels limits but these may need to be further raised in the future to meet expected consumer demand.

Finally, the increased number of antennas needed in the networks and the non-fully-operational infrastructures have **significant cost implications**, not only for operators. The site acquisition process is costly, both for the operators and the local administration offices. The introduction of lower exposure limits would entail a very large number of simultaneous site acquisition applications for the offices to handle. In some cases, for example Belgium, governments are asking for constant EMF measurements and are taxing the antennas and site installations.

All this would result in an inability to achieve the objectives of the Digital Agenda, severely limiting the ability for end users to benefit from innovative services.

FUTURE CHALLENGES

Mobile communication systems have evolved from generations where the main focus was voice, the second generation (2G), Global System for Mobile Communications (GSM) to systems were other types of services are supplied, namely data services. Currently there are different technologies available to provide customers with high speed mobile broadband: 3G/WCDMA, High Speed Packet Access (HSPA) technology and HSPA Evolution, Long Term Evolution (LTE) and LTE-Advanced (LTE-A). 4G/LTE is the next step on the GSM technology road map after HSPA. The first commercial Long Term Evolution (LTE) networks were launched in Oslo, Norway and Stockholm, Sweden in December 2009. By the middle of 2013 more than 200 LTE networks were in operation worldwide. Global 4G/LTE coverage is projected to rise to approximately 60% of the world's population by 2018.[26]

4G/LTE is designed to deliver very fast data speeds of up to 100 Mb/s downlink and 50 Mb/s uplink (peak rates) – this is faster than most home broadband services. 4G/LTE has the advantage of being backwards compatible with existing GSM and 3G technologies, enabling mobile operators to deploy 4G/LTE and continue to provide a seamless service across existing networks.

To respond to the increase of demand in terms of traffic and capacity, LTE-Advanced was launched. LTE-A is designed to enable even higher data rates by supporting higher order MIMO (Multiple In Multiple Out) antenna technology and combining multiple carriers. The LTE Advanced target is to achieve peak data rates of 1 Gbps (gigabits per second - 1000 Mb/s), representing a major enhancement of 4G/LTE. It includes leveraging wider bandwidth, more antennas, carrier aggregation[27] and heterogeneous networks (HetNets)[28]

The introduction of more systems and frequency bands in the network has an impact on the output power. Higher data speed means higher energy levels due to the fundamental physics of a certain minimum energy per bit being needed for successful communication. Nevertheless all mobile technologies adapt their transmitted power to operate at the lowest level possible by taking account of the type of service (voice or data) and the quality of the radio link between the mobile device and nearby base stations. The deployment of LTE-Advanced will still be possible below the exposure limits recommended in the ICNIRP international guidelines.

Unfortunately though, as this paper has shown, in countries where exposure limits are significantly more restrictive than those recommended by ICNIRP, such technology could be impossible to deploy.

26. Source: GSMA Intelligence https://gsmaintelligence.com/analysis/2013/11/global-lte-network-forecasts-and-assumptions-201317/408/https:/gsmaintelligence.com/analysis/2013/11/global-lte-network-forecasts-and-assumptions-201317/408/
27. Carrier aggregation or channel aggregation enables multiple 4G/LTE carriers to be used together to provide the high data rates required for LTE-Advanced.
28. Heterogeneous Networks implies the use of multiple types of access nodes in a wireless network. A Wide Area Network can use macrocells, picocells, and/or femtocells in order to offer wireless coverage in an environment with a wide variety of wireless coverage zones, ranging from an open outdoor environment to office buildings, homes, and underground areas.

CONCLUSIONS

Adoption of lower (restrictive) EMF exposure limits that are without credible scientific basis is seen as a politically attractive option in order to respond to the concerns expressed by some members of the community. However, as explained in this paper, there are a number of important policy-related implications associated with such a measure and a significant technical impact:

- Restrictions on 4G/LTE deployment (less flexibility in network deployment, coverage gaps with negative consequences on the consumers, no positive business model)
- Reduced opportunities for site sharing (non-optimal design of radiating systems)
- Increase in number of masts with associated increase in administrative burden, energy use, environmental impact, cost implications and levels of public concern.

The differentiation among Member States in terms of the legal framework concerning the EMF exposure limits undermines the efforts to create a Digital Single Market, since the environmental rules governing deployment of networks differ across the EU, and as a result certain regions of the EU will continue to lag behind in mobile network investments, and the consumers will not benefit from the full potential of digitisation. For these reasons, GSMA supports a consistent application of the ICNIRP guidelines by all Member States.

GLOSSARY

Antennas are the physical structures that transmit the radio waves. They are usually rectangular in shape and about 1.5 m tall, 0.4 m wide and 0.3 m deep.

Base station is the general term for antennas and transmitters. It covers all sizes of sites – micro cell to macro cell.

Carrier aggregation or channel aggregation enables multiple 4G/LTE carriers to be used together to provide the high data rates required for LTE-Advanced.

Electromagnetic field (EMF) is a physical field produced by electrically charged objects. One of the main characteristics which define an electromagnetic field (EMF) is its frequency or its corresponding wavelength. Fields of different frequencies interact with the body in different ways. One can imagine electromagnetic waves as series of very regular waves that travel at an enormous speed, the speed of light. The frequency simply describes the number of oscillations or cycles per second, while the term wavelength describes the distance between one wave and the next. Hence wavelength and frequency are inseparably intertwined: the higher the frequency the shorter the wavelength.

Femto cell is a small, low-power cellular base station, typically designed for use in a home or small business.

Heterogeneous Networks implies the use of multiple types of access nodes in a wireless network. A Wide Area Network can use macro cells, pico cells, and/or femto cells in order to offer wireless coverage in an environment with a wide variety of wireless coverage zones, ranging from an open outdoor environment to office buildings, homes, and underground areas.

High Speed Packet Access (HSPA) is an amalgamation of two mobile telephony protocols, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), that extends and improves the performance of existing 3rd generation mobile telecommunication networks utilizing the WCDMA protocols. A further improved 3GPP standard, **Evolved HSPA (HSPA+)**, was released late in 2008 with subsequent worldwide adoption beginning in 2010. The newer standard allows bit-rates to reach as high as 168 Mbit/s in the downlink and 22 Mbit/s in the uplink.

International Commission for Non-Ionizing Radiation Protection (ICNIRP) is a publicly funded body of independent scientific experts consisting of a main Commission of 14 members, its Scientific Expert Group and its Project Groups. The expertise is brought to bear on addressing the issues of possible adverse effects on human health of exposure to non-ionising radiation.

Long Term Evolution (4G/LTE) is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements.

LTE Advanced is a mobile communication standard, formally submitted as a candidate 4G system to ITU-T in late 2009, was approved into ITU, International Telecommunications Union, IMT-Advanced and was finalized by 3GPP in March 2011. It is standardized by the 3rd Generation Partnership Project (3GPP) as a major enhancement of the Long Term Evolution (LTE) standard.

Macro cell is a base station providing wide area coverage (a few kilometres radius). This is to distinguish from microcells, pico cells and femto cells.

Micro cell is a cell in a mobile phone network served by a low power cellular base station (tower), covering a limited area such as a mall, a hotel, or a transportation hub. A microcell is usually larger than a pico cell, though the distinction is not always clear. A microcell uses power control to limit the radius of its coverage area.

Multiple-input and multiple-output, or MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology.

Pico cell is a small cellular base station typically covering a small area, such as in-building (offices, shopping malls, train stations, stock exchanges, etc.), or more recently in-aircraft. In cellular networks, pico cells are typically used to extend coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations.

Power density is the amount of power (time rate of energy transfer) per unit area.

Radio Frequency (RF) is a rate of oscillation in the range of around 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals.

Sites/antenna sites are generally the same as base stations though sometimes sites will mean a plot of land for a tower whereas antenna site could mean a rooftop.

Small cells are low-powered radio access nodes that operate in licensed and unlicensed spectrum that have a range of 10 meters to 1 or 2 kilometres. A mobile macro cell which might have a range of a few tens of kilometres.

World Health Organization (WHO) is the directing and coordinating authority for health within the United Nations system.

Third Generation (3G) is the third generation of mobile telecommunications technology that supports services (wireless voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile TV) providing an information transfer rate of at least 200 kbit/s.The UMTS/WCDMA system and CDMA2000 system are typically branded 3G.

APPENDIX 1

ICNIRP established a threshold whole body Specific Absorption Rate (SAR) of 4 W/kg under normal environmental conditions in the frequency range from 100 kHz to 10 GHz. SAR is measured as the power absorbed by biological tissue exposed to an electromagnetic field per unit of mass, and is expressed in W/kg. A different limit value applies to partial body exposures from sources used close to the body such as mobile phones.

By considering a reduction factor of 10 times, in order to take into account all the possible different environmental conditions, the ICNIRP established that the SAR limit of 0.4 W/kg is a restriction that provides adequate protection for professional exposure (for example, technicians in charge of antenna maintenance). Furthermore, the reduction factor for the general public was increased by an additional term of 5, thus resulting 50 times lower than the threshold. It corresponds to a limit of 0.08 W/kg.

SAR is a measure of the absorbed energy and is proportional to the square of incident electric field strength. Incident electric field and related quantities such as power density or magnetic field, are obtained from their equivalent SAR values, through frequency-dependent relationships, assuming worst case absorption conditions, so that if incident field limits are respected then dosimetric limits (SAR) are automatically respected too. Incident field quantities are normally used for fixed radio equipment compliance as they are easily measured and evaluated. SAR values are used for assessment of portable wireless devices such as mobile phones.

For a frequency of 900 MHz, for example, it has been evaluated that a value of SAR of 0.08 W/kg is equivalent to a power density of about 4.5 W/m^2, which is equivalent to an electric field of 41 V/m in planar wave conditions. From the ICNIRP tables regarding EMF exposure limits for the general public versus frequency (see Table 5 below), the lower value falls in the frequency range between 10 and 400 MHz: 28 V/m for the electric field, that means 2 W/m^2 in terms of power density.

TABLE 5 **EXPOSURE LIMITS FOR THE PUBLIC ESTABLISHED BY ICNIRP**

FREQUENCY RANGE	E-FIELD STRENGTH (V/M)	H-FIELD STRENGTH (A/M)	EQUIVALENT PLANE WAVE POWER DENSITY S_{EQ} (W/M^2)
Up to 1 Hz	–	$3.2 \cdot 10^4$	–
1-8 Hz	10,000	$3.2 \cdot 10^4/f^2$	–
8-25 Hz	10,000	$4{,}000/f$	–
0.025-0.8 kHz	$250/f$	$4/f$	–
0.8-3 kHz	$250/f$	5	–
3-150 kHz	87	5	–
0.15-1 MHz	87	$0.73/f$	–
1-10 MHz	$87/f^{1/2}$	$0.73/f$	–
10-400 MHz	28	0.073	2
400-2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$f/200$
2-300 GHz	61	0.16	10

Note:

1. f is as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2 and H^2 are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 KHz see Table 4, note 3.
5. For peak values at frequencies up to 100 kHz, see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 MHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz, it is suggested that the peak equivalent plane-wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, , S_{eq}, E^2 and H^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields, perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

DATA AND STUDIES

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ABOUT GSMA

The GSMA represents the interests of mobile operators worldwide. Spanning more than 220 countries, the GSMA unites nearly 800 of the world's mobile operators with 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in industry sectors such as financial services, healthcare, media, transport and utilities. The GSMA also produces industry-leading events such as Mobile World Congress and Mobile Asia Expo.

For more information, please visit Mobile World Live, the online portal for the mobile communications industry, at www.mobileworldlive.com or the GSMA corporate website at www.gsma.com.

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