safety

MDPI

Article

Assessment and Management of Risks from Occupational Exposure to Electromagnetic Fields (0 Hz to 300 GHz): A Compass to Keep the Right Course Through European and Italian Regulations

Laura Filosa [1] and Vanni Lopresto [2,*]

[1] INAIL, Italian National Institute for Insurance against Accidents at Work, 30161 Rome, Italy; l.filosa@inail.it
[2] ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, 30161 Rome, Italy
* Correspondence: vanni.lopresto@enea.it

Abstract: This paper outlines the specific provisions of Italian legislation regarding workers' exposure to electromagnetic fields (EMFs) from 0 Hz to 300 GHz compared to the minimum health and safety requirements set in European Directive 2013/35/EU. In particular, the path to be followed to assess and manage occupational exposure to EMFs is outlined in relation to the distinction between 'professional' and 'non-professional' exposure of workers, as well as to the precautionary limits regarding exposures from power lines (50 Hz) and broadcast and telecommunication fixed systems (100 kHz–300 GHz) established by Italian regulations. The reasons underlying such an approach—mainly relying on the intent to reconcile scientific evidence with risk perception in public opinion—are analysed and discussed with the aim of increasing the knowledge of national regulatory provisions on occupational risk assessment, which may be more stringent than the requirements envisaged by international guidelines and community regulations.

Keywords: electromagnetic fields; exposure assessment process; health and safety risks; occupational exposure; Italian regulations

Citation: Filosa, L.; Lopresto, V. Assessment and Management of Risks from Occupational Exposure to Electromagnetic Fields (0 Hz to 300 GHz): A Compass to Keep the Right Course Through European and Italian Regulations. *Safety* **2024**, *10*, 104. https://doi.org/10.3390/safety10040104

Academic Editor: Raphael Grzebieta

Received: 9 September 2024
Revised: 30 November 2024
Accepted: 5 December 2024
Published: 12 December 2024

1. Introduction

Over the last few decades, the International Commission on Non-Ionising Radiation Protection (ICNIRP)—a non-profit scientific organisation collaborating with the World Health Organization (WHO) and the International Labour Organisation (ILO)—developed and updated several guidelines for limiting exposure of workers and the general public to electromagnetic fields (EMFs) from 0 Hz to 300 GHz (belonging to the frequency spectrum of non-ionising radiation) for the purpose of providing protection against adverse effects, i.e., effects causing detectable impairment of the health of the exposed individual or of his or her offspring (health hazards), as well as effects that can cause harm or injuries (safety hazards). ICNIRP guidelines have been periodically revised and updated as advances have been made in the relevant scientific knowledge [1–5].

The adverse direct and indirect effects arising from exposure to EMFs, established on the basis of scientific evidence, are acute effects. That is, they occur within a short time interval from the exposure to the field each time the exposure level reaches a certain threshold value: once the threshold is exceeded, the magnitude of the effect increases proportionally to the exposure level.

The established direct effects from acute exposure to EMFs—i.e., biophysical effects arising from direct interaction of EMFs with the human body—are short-term health or sensory effects, such as the non-thermal effects of stimulation of peripheral nerves and muscles or sensory organs induced by low-frequency fields (up to 10 MHz), as well as

tissue heating due to energy absorption in body tissues from high-frequency fields (above 100 kHz), namely thermal effects.

The indirect effects—i.e., effects caused by the presence of an object in an electromagnetic field, which may become the cause of a safety or health hazard—are the spark discharges or contact currents caused by touching conducting objects, the interference with medical devices or metal elements implanted or worn on the body, the projectile risk from ferromagnetic objects in static magnetic fields, and the initiation of electro-explosive devices (detonators) and fires or explosions by sparks caused by induced fields, contact currents, or spark discharges [1–3].

The relevant biological effect at the lowest level of exposure represents the scientific criterion for defining the exposure limits for protection from ascertained acute effects. To this end, ICNIRP has adopted a conservative approach by applying reduction factors to the resultant thresholds to provide exposure restriction values in order to ensure that the limits would remain protective from health effects even if exceeded by a substantial margin. Reduction factors account for biological variability in the population, variations in baseline conditions and environmental factors, dosimetric uncertainty associated with deriving exposure values, and as a conservative measure more generally.

In this regard, the exposure restrictions differ between occupationally exposed individuals and members of the general public. Occupationally exposed individuals are defined as adults who are exposed under controlled conditions associated with their occupational duties, trained to be aware of risks that may arise from exposure to EMFs at the workplace—e.g., due to sensory effects and indirect effects that may occur under certain occupational exposure conditions, such as during work activities related to magnetic resonance imaging (MRI)—and to employ appropriate harm-mitigation measures. An occupationally exposed worker must also be subject to an appropriate health and safety program that provides the above information and protection. Conversely, the general public is defined as individuals of all ages and of differing health statuses, which includes more vulnerable groups or individuals who may have no knowledge of or control over their exposure to EMFs as members of the general public.

The above-reported differences suggest the need to include more stringent restrictions for the general public by applying reduction factors to the limits defined for occupational exposures. Nevertheless, occupationally exposed individuals are not deemed to be at greater risk than the general public, providing that appropriate screening and training are provided to account for all known risks [1–5].

It is to be noted that ICNIRP guidelines do not address suggested long-term effects of exposure to EMFs since there is currently no well-established scientific evidence of a causal relationship, although epidemiological research has provided suggestive but unconvincing evidence of an association between possible carcinogenic effects and exposure to extremely low-frequency (ELF) magnetic fields from power lines (50/60 Hz) [6], as well as to radiofrequency (RF) electromagnetic fields in intensive cell phone users [7]. Based on limited evidence of increased risk observed in epidemiological studies, the International Agency for Research on Cancer (IARC) classified the exposure to ELF magnetic fields (in 2001) [8] and to RF electromagnetic fields (in 2011) [9] as possibly carcinogenic to humans (Group 2B). However, IARC highlighted that these results are neither conclusive nor sufficient to demonstrate a causal link about a possible association between chronic EMF exposure and the risk of developing cancer, as bias or confounding could not be ruled out with reasonable confidence.

The European Commission is also committed to monitoring studies and developments in scientific knowledge on the effects of exposure to EMFs. In this regard, in 2015, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)—headed by the Directorate-General for Health and Consumer Protection of the European Commission—published an opinion on the potential health effects of exposure to electromagnetic fields (EMFS) [10]. A thorough examination of relevant scientific data was carried out, along with metadata analyses, to put forth an opinion on various topics per-

taining to public health, which did not produce any conclusive evidence about EMF being dangerous at exposure levels below the limits recommended by ICNIRP. Nevertheless, the Scientific Committee recommended further research, particularly as it pertains to very long-term exposure and potential risks of exposure to multiple sources.

In 2023 the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) on request of the European Commission, produced an opinion concerning the need of a revision of the exposure limits in the Council Recommendation 1999/519/EC and Directive 2013/35/EU, in view of the latest scientific evidence available with regard to radiofrequency EMFs (100 kHz–300 GHz) [11]. The SCHEER Opinion (2023) considered meta-analyses, systematic reviews, and single research papers published after the SCENIHR Opinion (2015) on potential health effects of exposure to radiofrequency (RF) electromagnetic fields (EMF). The SCHEER could not identify moderate or strong level of evidence for adverse health effects resulting from chronic or acute RF EMF exposure from existing technology at levels below the limits set in the annexes of Council Recommendation 1999/519/EC and Directive 2013/35/EU. Nevertheless, the SCHEER Opinion (2023) acknowledged that the latest (2020) ICNIRP exposure guidelines [5] respond to the developments in RF-EMFs and introduce new dosimetric quantities and limits to them, that can protect humans more effectively from emerging technological applications of RF-EMFs, and, therefore, advised positively on the need of a technical revision of the annexes in the Council Recommendation 1999/519/EC and Directive 2013/35/EU with regard to radiofrequency electromagnetic fields (100 kHz to 300 GHz).

Moreover, in 2024 the SCHEER produced a report updating on potential health effects of exposure to electromagnetic fields (EMF) with regard to frequencies between 1 Hz and 100 kHz [12]. The SCHEER Report (2024) could not identify recent (post 2015) systematic reviews or meta-analyses on low frequency EMF exposure to update the previous (2015) SCENIHR assessment and noted that there is no convincing evidence for a causal relationship between ELF magnetic fields exposure and self-reported symptoms. The SCHEER Report (2024) also noted that the weight of evidence on the health effects of Intermediate-Frequency (IF) EMF exposure is uncertain due to contradictory information from different lines of evidence, and that no conclusive results can be reached based on human studies, either.

Recent studies addressing workplace exposures to both ELF magnetic fields and RF electromagnetic fields have not shown an increasing risk of tumours regarding EMF exposure at work [13–15]. Furthermore, two recent animal studies investigated the carcinogenic potential of long-term exposure to radiofrequency EMFs associated with mobile phones and mobile phone base stations [16–18]. Although both studies used large numbers of animals, best laboratory practice, and exposed animals for the whole of their lives, they showed inconsistencies and important limitations that affect the usefulness of their results, so their findings do not provide evidence that radiofrequency EMFs are carcinogenic, nor can they be considered for setting exposure guidelines [5]. In summary, at the current stage of scientific knowledge, no long-term effects of EMFs on the induction or development of cancer have been substantiated.

A wide consensus exists on the ICNIRP guidelines, which constitute the basis of European regulations for the protection of workers and the general public from exposure to EMFs, i.e., the Council Recommendation 1999/519/CE of the 12th of July 1999 on the limitation of exposure of the general public to EMFs [19] and the European Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from EMFs [20]. It is worth noting that the occupational exposure restrictions in the Directive are legally binding for member states, whereas the restrictions for the general public in the Recommendation are not legally binding per se but have been endorsed by the Commission's Scientific Steering Committee (Recital 10 of Council Recommendation 1999/519/EC) and confirmed by the European Commission in 2016 as state-of-the-art and as the basis for general public EMF product standards [21]. Consequently, the EMF exposure limits referred to in [19,20] have been transposed into

national legislations of member states, which, however, may establish additional or more rigorous provisions, as occurred in Italy [22].

The peculiarity of Italian legislation relies on Italian Framework Law no. 36 of 22 of February 2001 for the protection of workers and the general public from exposure to EMFs (hereafter referred to as Framework Law 36/2001) [23]. The Framework Law was issued following the widespread use of mobile communications technologies in the nineties of the last century, which triggered a perception of risk in public opinion not always based on scientifically confirmed information [24]. Consequently, Italian legislation on the limitation of exposure to EMFs enacted over the last twenty years was driven both by the aim of protecting health from the established acute effects of EMFs and by the intent of mitigating public opinion concern about potential long-term effects of EMFs, for which, however, there is no conclusive scientific evidence [1,3,5,20].

To this end, albeit that EMFs from 0 Hz to 300 GHz belong to the frequency spectrum of non-ionising radiation, Italian legislators decided to adopt the ALARA principle (i.e., "As Low As Reasonably Achievable"), first introduced in 1977 by the International Commission on Radiologic Protection (ICRP) to balance the risks and benefits of using ionising radiation for diagnostics [25]. The ALARA principle, based on the concept of reducing radiation exposure to the lowest reasonably achievable dose levels, is not only a sound radiation safety principle but also a regulatory requirement for all "radiation protection programs to prevent unnecessary exposure as well as overexposure", as indicated in Directive 2013/59/EURATOM [26].

Borrowing the ALARA principle, Italian Framework Law 36/2001, together with Prime Ministerial Implementing Decrees (DPCMs), namely DPCM of 8 July 2003 on low frequencies [27] and DPCM of 8 of July 2003 on high frequencies [28], established more rigorous restrictions regarding the exposure of the general public attributable to power lines (PL) at grid frequency (50 Hz) and to broadcast and telecommunication fixed systems (BTFS) from 100 kHz to 300 GHz, compared to the limits for the general public referred to in Council Recommendation 1999/519/EC.

The distinction between 'professional' and 'non-professional' exposure of workers to EMFs, established by Article 3 of Framework Law 36/2001, is the other remarkable peculiarity of Italian legislation inspired by the ALARA principle with the aim of reducing EMF exposure in the workplace. By virtue of such a provision, the national precautionary limits referred to in the aforementioned decrees [27,28] apply to workers who are not exposed to EMFs for professional reasons—i.e., those who perform duties that do not justify exposure to levels of EMFs above the limits envisaged for the general public.

This paper provides an overview of the regulatory framework on the limitation of EMF exposure of workers and the general public established by European regulations and analyses the peculiarities of Italian legislation concerning EMF occupational exposure compared to the minimum health and safety requirements referred to in Directive 2013/35/EU [20]. Furthermore, a path to be followed to assess and manage EMF risk at the workplace is outlined, taking into account the specific provisions referred to in Italian Framework Law 36/2001 [23] and related implementing decrees [27,28], as well as the indications of technical standards and best practice guides issued by the Italian Electrotechnical Committee (CEI) [29] and the European Commission [30]. Finally, some considerations are provided regarding the ALARA approach inspiring Italian legislation on the protection of workers and the general public from exposure to EMFs compared to the rationale underlying the relevant European regulations, intended to provide the minimum health and safety requirements for protection from established adverse effects caused by EMFs.

2. Regulatory Framework

2.1. European Regulatory Framework on EMF Protection

Directive 2013/35/EU on the limitation of exposure of workers to EMFs [20] outlines a framework of exposure limit values (ELVs) and action levels (ALs), which are derived

from the occupational limits of ICNIRP 1998 guidelines [1] concerning thermal effects of exposures to time-varying electromagnetic fields (100 kHz to 300 GHz) and from the occupational limits of ICNIRP 2009 [2] and ICNIRP 2010 [3] guidelines concerning non-thermal effects of exposures to static magnetic fields and time-varying electric and magnetic fields (1 Hz to 10 MHz), respectively. It is to be noted that there are some differences between ICNIRP 2010 guidelines [3] and Directive 2013/35/EU [20]—such as the possibility of exceeding the exposure limits for health effects, formally recognized in Article 10 dealing with derogations, which is not foreseen by the ICNIRP guidelines—and the distinction between low and high AL introduced in the Directive. Moreover, both ICNIRP 2014 [4] and 2020 [5] guidelines are not considered by Directive 2013/35/EU, as they were issued subsequently. Likewise, Council Recommendation 1999/519/EC [19] outlines a framework of basic restrictions (BRs) and reference levels (RLs) for the limitation of exposure of the general public to EMFs up to 300 GHz, which are based on the limits for the general public of ICNIRP 1998 guidelines [1].

Both the BRs and ELVs are expressed in terms of basic quantities (dosimetric limits) that correlate observed effects with the exposure level within the human body, whereas the RLs and ALs are precautionary values expressed in terms of measurable quantities in the environment in unperturbed conditions (i.e., absence of the exposed subject), which are derived from the basic quantities under standardized worst-case exposure conditions in order to simplify the process of verifying compliance with the BRs and ELVs, respectively. Additional RLs and ALs are defined for the purposes of protection against indirect effects, as compliance with the relevant BRs or ELVs may not necessarily avoid risks from indirect effects such as interference with medical devices, contact currents, and spark discharges [20]. In case the RLs or the ALs are exceeded, it is necessary to prove that the relevant BRs or ELVs are respected and that safety risks can be excluded. Alternatively, technical and/or organisational measures, such as the provisions aimed at avoiding or reducing risks at the workplace reported in Article 5 of Directive 2013/35/EU, must be implemented.

2.2. Italian Legislation on EMF Protection

Directive 2013/35/EU was transposed into Italian legislation through Legislative Decree no. 159 of 1 August 2016 (Legislative Decree 159/2016) [31], which amended Title VIII (physical agents) of Legislative Decree no. 81 of the 9th of April 2008—"Consolidated Act on Health and Safety at Work" (Legislative Decree 81/2008) [32]—by completely rewriting Chapter IV (Protection of workers from the risks of exposure to electromagnetic fields), revising Chapter VI (sanctions), and replacing Annex XXXVI (EMF exposure limits). The exposure limits referred to in Annex XXXVI of Legislative Decree 81/2008 and subsequent modifications and amendments (s.m.a.) are identical to those reported in Annex II (non-thermal effects) and Annex III (thermal effects) of Directive 2013/35/EU; it is to be noted that the 'action levels' (ALs) referred to in the European Directive are named 'action values' (AVs) in Legislative Decree 81/2008 and s.m.a. Italian transposition also introduced, in clause 6 of Article 208 of Legislative Decree 81/2008 and s.m.a., the employer's obligation to communicate to the territorially competent supervisory body, by way of a technical report, the planned overcoming of the lower AVs (i.e., lower ALs) for magnetic fields or the ELVs related to sensory effects. It is worth noting that such obligation does not refer to the accidental overcoming of exposure limits—in which case the employer must update the assessment of risks and the measures taken to restore safety conditions, pursuant to Article 210, paragraph 7 of Legislative Decree 81/2008 and s.m.a.—but to the anticipated and programmable exceedances of the limits related to sensory effects, and only where justified by the working practice or process.

In order to properly address EMF risk assessment at the workplace, the combined provisions of both Legislative Decree 81/2008 and s.m.a. and Framework Law 36/2001 must be taken into account, along with the Prime Ministerial Decrees (DPCMs) of 8 July 2003 implementing the Framework Law, namely:

- DPCM 8 July 2003 on low frequencies (LF): "Establishment of exposure limits, attention values and quality goals for protection of the general public from exposure to electric and magnetic fields at grid frequency (50 Hz) generated by power lines" [27].
- DPCM 8 July 2003 on high frequencies (HF): "Establishment of exposure limits, attention values and quality goals for protection of the general public from exposure to electric, magnetic and electromagnetic fields generated at frequencies between 100 kHz and 300 GHz" [28] as amended both by Article 14 of Conversion Law no. 221 of 17 December 2012 (Law 221/2012) [33]—which partially modified the detection criteria of immission values for the relevant exposure restrictions—and by Article 10 of Law no. 214 of 30 December 2023 (Law 214/2023)—which revised the national restrictions on HF-EMF exposure of the general public [34].

The aforementioned national decrees incorporate the set of restrictions on EMF exposure of the general public as referred to in Council Recommendation 1999/519/EC, except for exposures to ELF magnetic fields attributable to power lines (PL) at grid frequency (50 Hz) whatever the voltage [27], and to HF electromagnetic fields attributable to broadcast and telecommunications fixed systems (BTFS) from 100 kHz to 300 GHz [28,33,34]—for which more conservative exposure restrictions are established compared to those envisaged by Council Recommendation 1999/519/EC, as detailed here below:

- Exposure Limits (ELs)—exposure restrictions defined in terms of immission values (RMS, root-mean-square) for the purpose of protecting health from acute effects, which must not be exceeded in any case [27,28,33].
- Attention Values (AtVs)—exposure restrictions defined in terms of immission values (RMS) for the purpose of protection from possible long-term effects of EMF exposure, which apply in places or within buildings with permanence no lower than 4 h per day [27,28,33,34].
- Quality Goals (QGs)—exposure restrictions defined in terms of immission values (RMS) for the purpose of progressive minimization of environmental exposure to EMFs, which apply both in the planning of new settlements or new installations envisaging permanence no lower than 4 h per day [27] and in highly frequented outdoor areas [28,33,34].

It is worth noting that the above-reported national limits—as detailed in Table 1 with reference to PL at 50 Hz and in Tables 2–4 with reference to BTFS from 100 kHz to 300 GHz—do not derive from ICNIRP guidelines or dosimetric evaluations but are based on precautionary considerations concerning suggested effects of long-term exposure to EMFs [23].

Table 1. Italian restrictions on EMF exposure of the general public to power lines at grid frequency (50 Hz) [27].

E-Field Exposure Limit [a]	B-Field Exposure Limit [a]	B-Field Attention Value [b]	B-Field Quality Goal [c]
5 kV/m (RMS value)	100 μT (RMS value)	10 μT (median over 24 h)	3 μT (median over 24 h)

[a] Restrictions on exposure to electric and magnetic fields generated by power lines at the frequency of 50 Hz, defined for the purpose of protecting health from acute effects and to be intended as RMS immission values measured or calculated at a height of 1.5 m from the floor. [b] Precautionary measures for protection from possible long-term effects related to exposure from magnetic fields generated by power lines at the frequency of 50 Hz in places with permanence no lower than 4 h per day, defined as the median over 24 h of RMS immission values measured or calculated at a height of 1.5 m from the floor under normal operating conditions. [c] Precautionary measures for the purpose of progressive minimization of exposure to magnetic fields generated by power lines at the frequency of 50 Hz, defined as the median over 24 h of RMS immission values measured or calculated at a height of 1.5 m from the floor under normal operating conditions, which apply in planning new installations of power lines in proximity to places with permanence no lower than 4 h per day as well as of new settlements envisaging permanence no lower than 4 h per day [27].

Table 2. Italian restrictions on EMF exposure of the general public to broadcast and telecommunication fixed systems (100 kHz–300 GHz)—Exposure limits [a] [28].

Frequency	E-Field (V/m)	H-Field (A/m)	Power Density (W/m^2)
$0.1 < f \leq 3$ MHz	60	0.2	–
$3 < f \leq 3000$ MHz	20	0.05	1
$3 < f \leq 300$ GHz	40	0.01	4

[a] Exposure restrictions defined for the purpose of protecting health from acute effects that must not be exceeded in any case, defined as RMS immission values measured or calculated at a height of 1.5 m from the floor and to be averaged over any temporal interval of 6 min [28].

Table 3. Italian restrictions on EMF exposure of general public to broadcast and telecommunication fixed systems (100 kHz–300 GHz)—Attention values [a b] [28].

Frequency	E-Field (V/m)	H-Field (A/m)	Power Density (W/m^2)
0.1 MHz < f ≤ 300 GHz	6	0.016	0.10 (3 MHz–300 GHz)

[a] RMS immission values measured or calculated at a height of 1.5 m from the floor and to be averaged over 24 h [33]. [b] Precautionary measure for protection from possible long-term effects related to EMF exposure within buildings used for permanence no lower than 4 h per day and their external appurtenances used as habitable spaces such as balconies, terraces, and courtyards, excluding flat roofs [28,33].

Table 4. Italian restrictions on EMF exposure of the general public to *broadcast and telecommunication fixed systems* (100 kHz–300 GHz)—*Quality goals* [a b] [28].

Frequency	E-Field (V/m)	H-Field (A/m)	Power Density (W/m^2)
0.1 MHz < f ≤ 300 GHz	6	0.016	0.10 (3 MHz–300 GHz)

[a] RMS values measured or calculated at a height of 1.5 m from the floor and to be averaged over 24 h [33]. [b] Immission values calculated or measured outdoor in highly frequented areas, established with the aim of progressive minimization of EMF exposure [28].

Law no. 214 of 30 December 2023—"Annual law for the market and competition 2022" (Law 214/2023)—partially modified, under the provisions in Article 10, the national EMF exposure restrictions that apply to the general public and non-professional exposures of workers [34]. In particular, as reported in Table 5, the aforementioned article established the increase in the AtVs and QGs for EMF exposures relating to BTFS from 100 kHz to 300 GHz with respect to the immission values referred to in DPCM 8 July 2003 on HF [28] "in order to strengthen the mobile network and guarantee users and enterprises the offer of high-quality connectivity services, without prejudice to public health" and "in compliance with the rules, recommendations and guidelines of the European Union". It is to be noted that the provisions referred to in Article 10 of Law 214/2023 did not modify the detection criteria established by Article 14 of Law 221/2012 [33] and that the updated national limits remain below the RLs for the general public set in Council Recommendation 1999/519/EC.

Italian Framework Law 36/2001 [23] also introduced a remarkable distinction between 'professional' and 'non-professional' exposure of workers to EMFs, which is not explicitly stated in Directive 2013/35/EU [20]. Specifically, the Framework Law defines 'professional exposure' to EMFs as "any type of exposure of workers who, due to their specific work activity, are exposed to electric, magnetic and electromagnetic fields" (as per Article 3, paragraph 1, letter *f*) and exposure of the general public as "any type of exposure to electric, magnetic and electromagnetic fields, with the exception of the exposure referred to in letter *f*) and intentional exposure for diagnostic or therapeutic purposes" (as per Article 3, paragraph 1, letter *g*). By virtue of such a definition, 'non-professional' exposures of workers to EMFs—i.e., the occupational exposures to EMFs that are unrelated and not necessary to the specific task

assigned in relation to the needs of the production process—are to be assimilated to those of the general public for which the related tighter restrictions apply.

Table 5. Italian restrictions on EMF exposure of the general public to broadcast and telecommunication fixed systems (100 kHz–300 GHz) as updated by Law 214/2024 [34]—Attention Values [a] [b] and Quality goals [a] [c].

Frequency	E-Field (V/m)	H-Field (A/m)	Power Density (W/m^2)
0.1 MHz < f ≤ 300 GHz	15	0.039	0.59 (3 MHz–300 GHz)

[a] RMS values measured or calculated at a height of 1.5 m from the floor and to be averaged over 24 h [33]. [b] Precautionary measures for protection from possible long-term effects related to EMF exposure within buildings used for permanence no lower than 4 h per day and their external appurtenances used as habitable spaces such as balconies, terraces, and courtyards, excluding flat roofs [28,33]. [c] Immission values calculated or measured outdoor in highly frequented areas, established with the aim of progressive minimization of EMF exposure [28].

Under such premises, the general provisions referred to in Title I (common principles) of Legislative Decree 81/2008 and s.m.a. must be applied to all workers in order to prevent and protect against health and safety risks in the workplace. Without prejudice to the foregoing and by virtue of the combined provisions of Legislative Decree 81/2008 and Framework Law 36/2001 regarding the assessment of risks deriving from exposure to EMFs at the workplace, it is necessary to distinguish between the workers who perform specific tasks involving 'professional' exposure to EMFs and the workers whose duties do not justify exposure to EMFs above the limits established for the general public.

Accordingly, the provisions in Legislative Decree 81/2008 and s.m.a.—namely the limits for occupational exposure referred to in Article 208 and Annex XXXVI (identical to the limits in Annexes II and III of Directive 2013/35/EU)—must be applied to the workers exposed to EMFs for 'professional reasons', whereas the limits for the general public set by DPCMs 8/7/2003 [27,28] as subsequently amended [33,34] must be applied to non-professional exposure of workers.

In Figure 1 is summarised the Italian regulatory framework regarding the protection of workers and the general public from exposure to EMFs up to 300 GHz, while in Figure 2 the flow-chart of EMF exposure assessment process under Italian regulatory framework is described. Moreover, in Table 6 is reported a comparison between EMF exposure restrictions defined by Italian and European regulations for some relevant frequencies and applications.

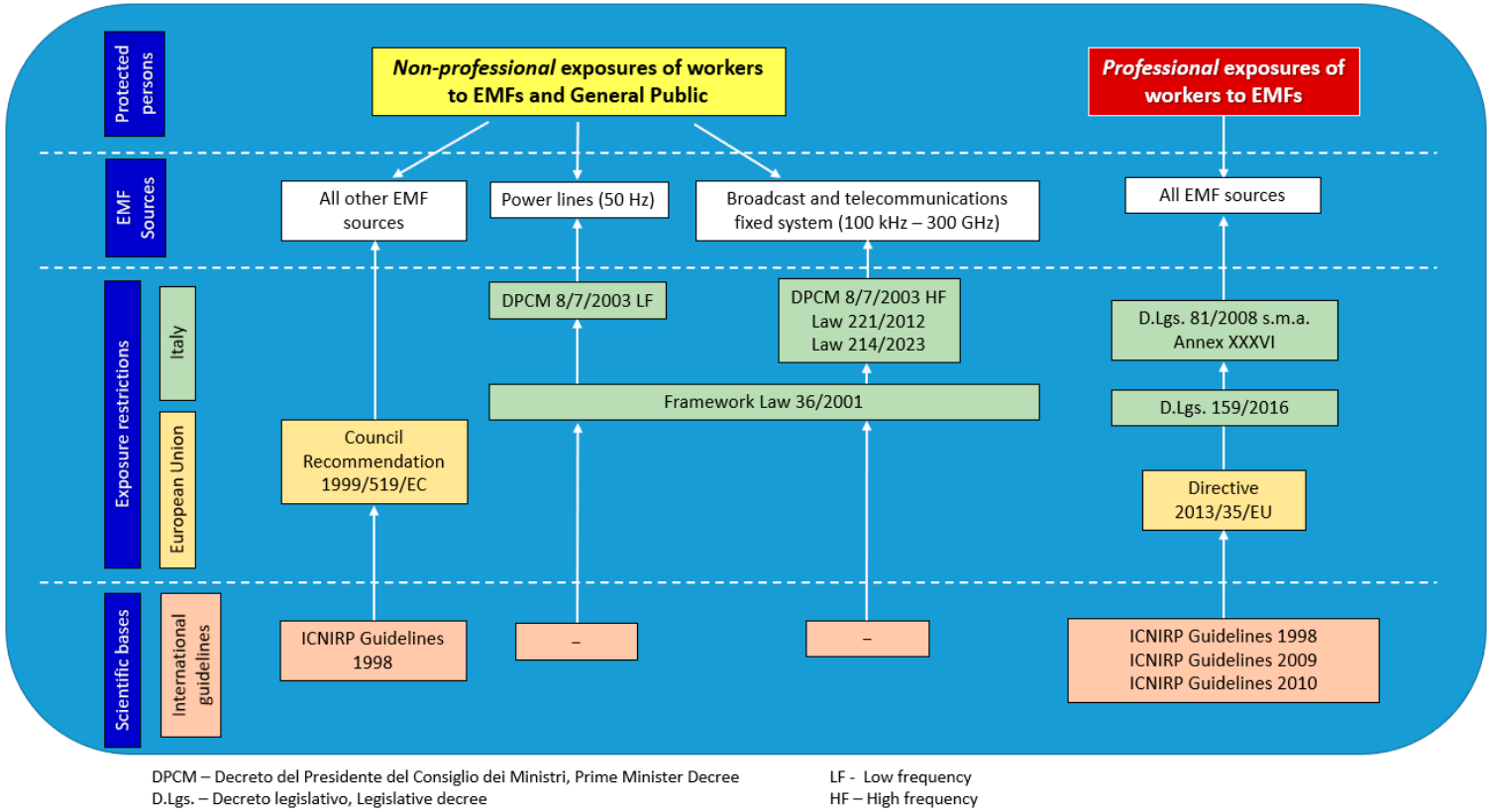

Figure 1. Italian regulatory framework regarding the protection of workers and the general public from EMF exposures.

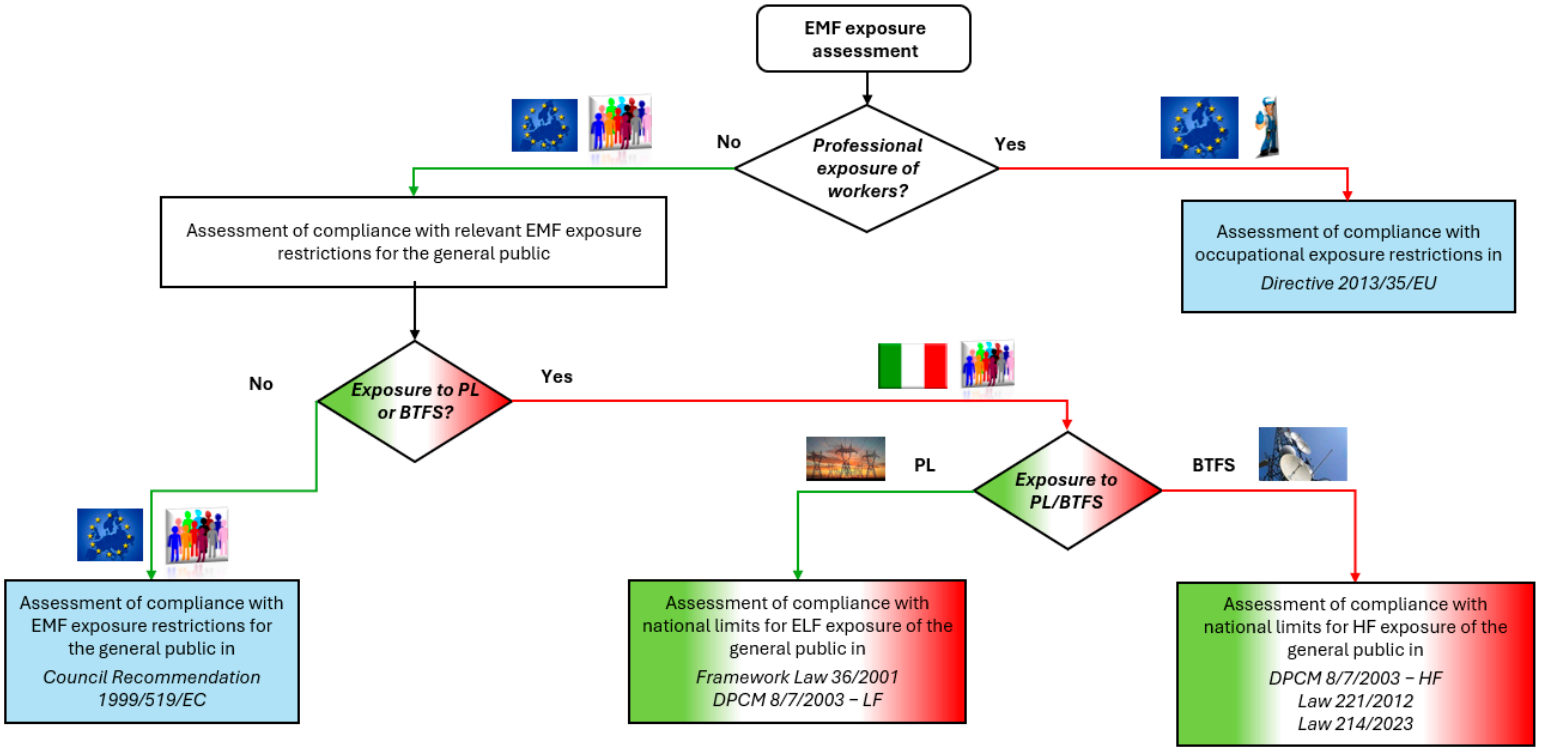

Figure 2. Flowchart of the EMF exposure assessment process under the Italian regulatory framework. Note—PL: power lines at grid frequency (50 Hz); BTFS: broadcast and telecommunication fixed systems (100 kHz–300 GHz).

Table 6. Summary of the EMF exposure restrictions set by the Italian and European regulations for some relevant frequencies and applications.

Exposure Tiers and Regulatory References	Exposure Restrictions	Relevant Frequencies and Applications								
		50 Hz (PL)		**100 MHz (FM)**	**400 MHz (DVB-T)**	**900 MHz (GSM)**	**1800 MHz (GSM)**	**2100 MHz (UMTS)**	**2600 MHz (LTE)**	**3700 MHz (5G)**
General Public and Non-Professional Exposure of Workers Italian DPCM 8/7/2003 (PL and BTFS)	Exposure Limits	5 kV/m	100 μT	20 V/m	20 V/m	20 V/m	20 V/m	20 V/m	20 V/m	40 V/m
	Attention Values	–	10 μT	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m
	Quality Goals	–	3 μT	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m	15 V/m
General Public and Non-Professional Exposure of Workers Council Recommendation 1999/519/EC (all other EMF sources)	Reference Levels	5 kV/m	100 μT	28 V/m	28 V/m	41 V/m	58 V/m	61 V/m	61 V/m	61 V/m
Professional Exposure of Workers Directive 2013/35/EU (transposed into Title VIII, Chapter IV of Italian Legislative Decree 81/2008 and s.m.a.)	Action Levels (Action Values)	10 kV/m (Low AL) 20 kV/m (High AL)	1 mT (Low AL) 6 mT (High AL)	61 V/m	60 V/m	90 V/m	127 V/m	140 V/m	140 V/m	140 V/m

Note—PL: power lines at grid frequency (50 Hz); BTFS: broadcast and telecommunication fixed systems (100 kHz–300 GHz); FM: frequency modulation; DVB-T: Digital Video Broadcasting-Terrestrial; GSM: Global System for Mobile communications (2G); UMTS: Universal Mobile Telecommunications System (3G); LTE: Long-Term Evolution (4G); 5G: 5th-Generation mobile communications.

3. EMF Risk Assessment and Management

The process of EMF risk assessment—referred to in Article 209 of Italian Legislative Decree 81/2008 and s.m.a. (transposition of Article 4 of Directive 2013/35/EU but with some integrations in order to take into account the provisions of Italian legislation)—develops through the following steps: the identification of EMF sources and workers exposed to EMFs, followed by the assessment of compliance with the relevant EMF exposure restrictions by means of measurements and/or calculations or on the basis of readily accessible information. The assessment, measurements, and calculations of EMF exposure levels must be carried out taking into account the Practical Guides of the European Commission [30] and the relevant technical standards of the European Committee for Electrotechnical Standardization (CENELEC) [35] and of the Italian Electrotechnical Committee (CEI) [29], as well as information available in officially recognized data banks [36].

The risk assessment process is concluded with the identification of any prevention and/or protection measures aimed at avoiding or reducing risks—including technical and organisational measures, training and information, and health surveillance referred to in Articles 210, 210-bis, and 211, respectively—as well as with their adaptation to the workers at particular risk—such as workers wearing active or passive implanted medical devices (e.g., cardiac pacemakers), workers with medical devices worn on the body (e.g., insulin pumps), and pregnant workers—for which the AVs referred to in Annex XXXVI of Legislative Decree 81/2008 and s.m.a. (i.e., the ALs in Annexes II and III of Directive 2013/35/EU) may not provide adequate protection or avoid safety risks from indirect effects of EMFs. The outcome of risk assessment must be reported in the mandatory risk-assessment report, namely the Risk Assessment Document referred to in Articles 17 and 28 of Legislative Decree 81/2008 and s.m.a., which must be signed by the employer [32,37].

3.1. CEI 106-45 EMF Guide

CEI 106-45 EMF Guide [29], issued in January 2021 by the Italian Electrotechnical Committee (CEI)—sub-committee CT 106 "Human exposure to electromagnetic fields"—provides a detailed overview of the Italian regulatory framework on EMF risk assessment at the workplace, together with guidance for managing the afore-described asymmetry between European and Italian regulations concerning occupational exposure to EMFs. To this end, the Guide integrates the contents of the European technical standard EN 50499:2019 [35]—which provides a general procedure for the assessment of occupational EMF exposure in order to determine compliance with the relevant ELVs and/or ALs referred to in Directive 2013/35/EU—and the specific provisions of Italian regulations, thus giving operative support and interpretative clarifications for the identification, assessment, and management of EMF risks at the workplace.

The synoptic tables, enclosed in CEI 106-45, refer to various EMF sources commonly present in occupational environments, including power lines, base transmitting stations, television broadcast systems, and electric arc welders. The tables summarise the information necessary to properly address EMF risk assessment, such as the identification of EMF sources, the relevant normative references, the zoning of the workplace, and the specific requirements regarding workers at particular risk. The Guide is also accompanied by a set of annexes in which specific topics are explored—including risk assessment for workers at particular risk, simultaneous exposure to multiple sources and multiple frequencies, spark discharges, and motion control within static magnetic fields.

Italian Zoning of the Workplace

The zoning of the workplace proposed in CEI 106-45 is derived from the organisational procedure described in Annex E of EN 50499:2019, with some integrations to consider the specific provisions of Italian legislation. The zones are defined based on the results of EMF exposure assessment at the workplace, with the aim of both avoiding undue exposure and reducing the risk. The zones are not intended as areas defined by rigid or strict boundaries, corresponding to the exact surface in which the different levels of exposure can be exceeded.

For convenience, the zones may correspond to existing areas in the workplace, such as specific parts of a building or an environment that contain equipment that may cause exposure above the limits for the general public. The zones are defined in CEI 106-45 as described below:

- *Zone 0a*: workplace in which EMF exposure levels are compliant with the restrictions for the general public referred to in Framework Law 36/2001 and the related implementing decrees or in which all the equipment has been assessed as suitable for use by the general public. Prolonged stays (≥4 h) are permitted. Further requirements may apply to workers wearing active implanted medical devices e.g., 0.5−mT AV related to interference from static magnetic fields [32].
- *Zone 0b*: workplace in which EMF exposure levels from power lines (PL) at grid frequency (50 Hz) or from broadcast and telecommunication fixed systems (BTFS) from 100 kHz to 300 GHz are compliant with the ELs for the general public referred to in Framework Law 36/2001 and the related implementing decrees but may exceed the relevant AtVs and/or QGs. Prolonged stays (≥4 h) may not be permitted [23]. Further requirements may apply to workers wearing active implanted medical devices.
- *Zone 1a*: workplace in which EMF exposure levels may be greater than the limits for the general public but are compliant with the low ALs or the ELVs for sensory effects referred to in Annex XXXVI of D.Lgs. 81/2008 and s.m.a. [32]. Access is permitted only to workers exposed for professional reasons to EMFs [23].
- *Zone 1b*: workplace in which EMF exposure levels are compliant with the high ALs or the ELVs for health effects but may exceed any applicable sensory effects ELVs or low ALs [32]. Access is permitted only to workers exposed for professional reasons to EMFs [23]. Control measures may be required to ensure that any exceedance of sensory effects ELVs is only temporary—such as the protective measures specified in Article 209 as well as information and training referred to in Article 210-bis, to be taken in case the low ALs for the electric field are exceeded [32].
- *Zone 2*: workplace where EMF exposure levels may be greater than health effects ELVs referred to in Annex XXXVI of D.Lgs. 81/2008 and s.m.a. [32]. Access is forbidden to all workers—including those exposed for professional reasons to EMFs—unless remedial measures are taken to reduce exposure below health effects ELVs and any safety risk can be excluded, or unless conditions subsist to authorize derogations pursuant to the provisions referred to in Article 212 [32].

Figures 3 and 4 describe the zoning of the workplace defined in [29] with regards to EMF exposures attributable to PL (50 Hz) and BTFS (100 kHz–300 GHz), respectively, for which the national limits for the general public referred to in Framework Law 36/2001 and the related implementing decrees apply.

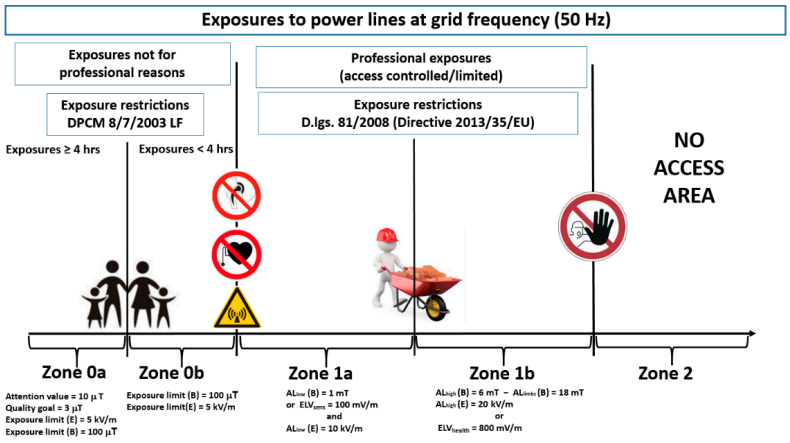

Figure 3. Zoning of the workplace as defined by CEI 106-45 for power lines at 50 Hz [29].

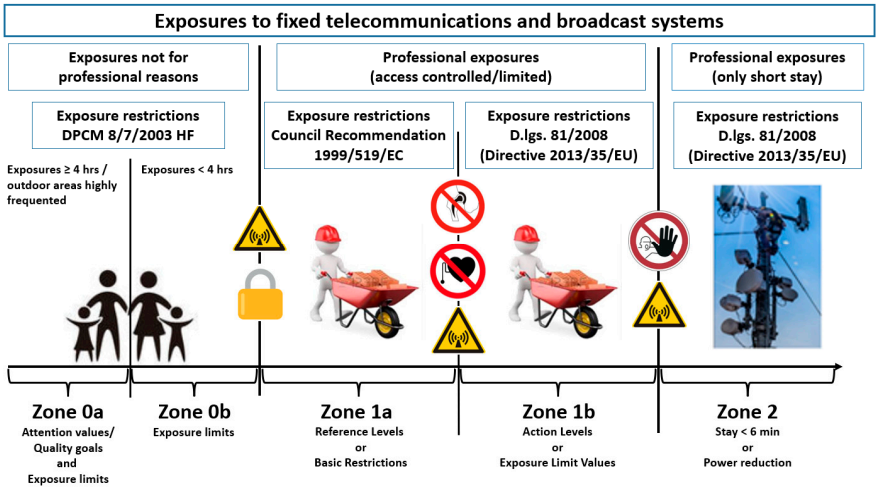

Figure 4. Zoning of the workplace as defined by CEI 106-45 for BTFS (100 kHz–300 GHz) [29].

3.2. Health Surveillance

According to Italian regulations, health surveillance for workers exposed for professional reasons to EMFs is carried out periodically, usually once a year or at a lower periodicity based on the decision of the occupational physician, pursuant to Article 211, clause 1 of Legislative Decree 81/2008 and s.m.a. [32]. Furthermore, pursuant to Article 211, clause 2, medical control is provided to workers who report unwanted or unexpected effects on health, including sensory effects, along with appropriate health surveillance if deemed necessary by the physician. The medical control referred to in this clause is also guaranteed if exposure exceeding the ELVs for sensory effects or the ELVs for health effects has been detected.

An authoritative reference at the national level is also represented by the Guidelines for Health Surveillance of Workers Exposed to Electromagnetic Fields—issued by the Italian Association of Medical Radiation Protection (AIRM) in 2012 and revised in 2021 with an up-to-date review of scientific and medical literature [38]—which illustrates the health surveillance protocols recommended to occupational physicians involved in EMF risk assessment at the workplace, as summarized in Table 7.

Table 7. Summary of health surveillance protocols recommended by AIRM Guidelines to occupational physicians involved in EMF risk assessment at the workplace [38].

Frequency Range	Preventive Medical Examinations (to Ascertain Any Presence of Conditions of Particular Risk)	Periodic Medical Examinations (to Ascertain Any Onset of Conditions of Particular Risk)	Extraordinary Medical Examination [c] (Exceeding of ELVs/Unwanted or Unexpected Effects Onset)
Static magnetic fields and magnetic fields with frequency < 1 Hz	Medical examination Anamnestic questionnaire for active and passive medical devices	Annual medical examination [a] for workers acknowledged at particular risk and for those systematically exposed above ELVs, but with different periodicity according to worker's conditions and to the level of exposure (flexibility/derogation principle) Medical examination to be repeated every four years [b] Anamnestic questionnaire for active and passive medical devices	Medical examination Any medical examination in relation to the extent of exceeding ELVs and/or to reported effects (e.g., oculist and/or cardiologic consulting)
Low-frequency fields (1 Hz—100 kHz) and intermediate-frequency fields (100 kHz—10 MHz)			
High-frequency fields (10 MHz—300 GHz)			Medical examination Any medical examination in relation to the extent of exceeding ELVs, to the body districts involved and/or to reported effects (e.g., oculist, cardiologic, dermatological consulting, etc.)

[a] To verify the evolution of clinical conditions of particular sensitivity. [b] To verify the persistence of absence of conditions of particular sensitivity and to renew targeted information when updating the Risk Assessment Document. [c] To verify the onset of acute effects and to manage their evolution, to assess the association between unwanted/unexpected effects with the exposure, and to monitor their evolution.

4. Discussion and Conclusions

Despite the vast, continually evolving scientific and legislative literature regarding occupational exposure to EMFs, a "compass" is often needed to maintain the right course in assessing health and safety risks arising from EMF exposure in the workplace, owing to the additional provisions set by national regulations compared to the minimum health and safety requirements envisaged by international guidelines and European regulations.

In the European Union, Council Recommendation 1999/519/EC and Directive 2013/35/EU set limits for the purpose of protection of the general public and workers, respectively, from exposure to EMFs from 0 Hz to 300 GHz. The aforementioned limits are derived from the relevant restrictions recommended in ICNIRP guidelines, which address established adverse effects caused by exposure to EMFs—i.e., acute effects for which a causal link with EMF exposure has been scientifically ascertained, and the biophysical mechanism of interaction is well defined.

To this end, a conservative approach is adopted in ICNIRP guidelines to provide exposure restriction values for occupationally exposed individuals by applying reduction factors to threshold field levels for the onset of harmful effects on health, in order to ensure that the limits would remain protective even if exceeded by a substantial margin. Further reduction factors are applied to provide exposure restriction values for the general public, which includes more vulnerable groups or individuals who may have no knowledge of or control over their exposure to EMFs.

Accordingly, the exposure restrictions recommended by ICNIRP and transposed in European regulations can be considered overprotective against established health effects caused by EMFs, occur at exposure levels well above the exposure limit values. Given the foregoing, occupationally exposed individuals are not deemed to be at greater risk than the general public, providing that appropriate screening and training is provided to account for all known risks.

It is, however, to be noted that the thresholds for indirect effects of EMFs are usually lower than those for direct effects; in particular, interference problems with active medical electronic devices may occur at exposure levels below the recommended reference levels for the general public referred to in Recommendation 1999/519/CE, and should therefore be the object of appropriate precautions and protective measures, as stated in Recital 23 in the Preamble of Directive 2013/35/EU.

Moreover, the exposure restrictions referred to in ICNIRP guidelines and transposed in the Recommendation and Directive do not address suggested effects from long-term exposure to EMFs, for which there is, at present, no conclusive scientific evidence of possible adverse effects on human health. In this regard, the European Commission is committed to monitoring studies and developments in scientific knowledge: if established scientific evidence emerges, the Commission will consider the most appropriate means to address these effects as stated in Recital 7 in the Preamble of Directive 2013/35/EU.

The system of protection against the risks from exposure to EMFs outlined in European regulations is intended to establish the minimum health and safety requirements, in order to enable member states to apply the minimum requirements in an equivalent manner. Therefore, member states can establish national limits and provisions tighter than the minimum requirements envisaged in EU regulations.

This is the case for Italian legislation, which introduced—pursuant to the provisions of Framework Law 36/2001 and the related implementing decrees on the protection of workers and the general public from exposure to EMFs—a remarkable distinction (not explicitly stated in Directive 2013/35/EU) between the workers who perform specific tasks involving professional exposure to EMFs and the workers whose duties do not justify exposure to EMFs above the limits for the general public.

As a result, Italian legislation on protection from EMFs at the workplace is characterised by a dichotomy between 'professional' exposure—for which the occupational limits of European Directive 2013/35/EU apply—and 'non-professional' exposure of workers—for which the national limits for the general public apply, which are more conservative than the restrictions set in Council Recommendation 1999/519/EC with regard to the

exposures attributable to power lines (PL) at 50 Hz and to broadcast and telecommunication fixed systems (BTFS) from 100 kHz to 300 GHz, as described in Figure 2.

Unlike the European restrictions on EMFs, the limit values set by Italian regulations do not derive from scientific grounds but are based on precautionary considerations with the purpose of reducing exposure to the lowest reasonably achievable levels for both the general public and workers not exposed for professional reasons to EMFs.

As shown in Table 6, the 'Exposure Limit' of 20 V/m for electric field strength at the frequency of 2600 MHz (referred, e.g., to environmental exposure from 4G-LTE base transmitting stations) is 33% of the corresponding 'Reference Level' in Council Recommendation 1999/519/CE, while the 'Attention Value' and the 'Quality Goal' of 15 V/m for electric field strength at the same frequency that applies, respectively, within buildings used for permanence no lower than 4 h per day and in highly frequented outdoor areas, are both 24.5% of the relevant 'Reference Level'. Likewise, the 'Quality Goal' of 3 μT for magnetic flux density referred to environmental exposure from power lines at 50 Hz, which applies in the planning of new settlements or installations envisaging permanence no lower than 4 h per day, is 3% of the corresponding 'Reference Level'.

The decision of Italian legislators to establish precautionary limits on exposures attributable to the aforementioned EMF sources—largely present in both residential environments and workplaces—is driven by the purpose of protecting public health from acute effects and suggested long-term effects of EMFs, with the intent of mitigating public opinion concerns regarding the potential carcinogenic effects of chronic exposure to EMFs, which, however, are not addressed in international guidelines and European regulations as not supported by conclusive scientific evidence regarding a causal relationship. In this regard, legislators have applied the ALARA principle—borrowed from safety standards for ionising radiation protection—which is a sound safety approach to manage risks at work with the purpose of limiting the exposure to EMFs to the lowest reasonably achievable levels and durations, and of preventing occupational exposures unrelated or not necessary to the specific task assigned. As a result, the precautionary limits established in Italian legislation—which apply to EMF exposure of both the general public and workers not exposed for professional reasons—appear particularly restrictive as compared to the limits for the general public in Council Recommendation 1999/519/EC as well as to the national limits envisaged by many member states of the European Union.

It is the authors' opinion that such an approach was adopted by national legislators to reconcile the protection of public health with the intention of mitigating the concern that, in the late 1990s and early 2000s, was beginning to arise in public opinion regarding EMF emissions because of the rapid development and spread of mobile telephone network infrastructures.

Over the past few years, there has been a wide-ranging national debate on the possible revision of the limits for EMF exposures, driven by the development and deployment of the ultra-wideband (5G) mobile phone network. Eventually, the law for the market and competition of 30th of December 2023, no. 214 (Law 214/2023) partially modified the structure of the national limits to EMFs at high frequencies (100 kHz–300 GHz) by increasing the limit values for the general public (and non-professional exposures of workers) while remaining prudently below the reference levels for the general public of Council Recommendation 1999/519/EC. Such a choice is not fully based on scientific criteria but, once again, rather on a pragmatic mediation for responding to the concerns still present within public opinion, much like 25 years ago at the time of the promulgation of Framework Law 36/2001.

Nevertheless, the recent legislative intervention by Law 214/2023, which updated the national EMF exposure limits at high frequencies (HF), can facilitate the upgrade of existing base transmitting stations (BTS) of mobile networks for the purpose of improving the quality of service in terms of coverage, with positive effects on citizens in terms of voice and data while reducing the economic impact on operators and the proliferation of antennas in the territory—in the technical consideration that the more the power of a BTS

increases the less mobile devices emit. The aforementioned considerations are supported by the Report on "Digital Growth and Ultra Broadband" by the Italian Digital Agency headed by the Presidency of the Council of Ministers [39], in which the national strategy for pursuing the objectives of the digital agenda is addressed, with particular reference to the national plan for ultra-wide band and digital growth. In this regard, the increase of HF-EMF national limits represents an important flywheel in order to face the digital transition and to guarantee users and enterprises the offer of high-quality connectivity services without prejudice to public health.

Likewise, the aforementioned intervention of national legislators constitutes a step forward in order to bridge the gap between Italian and European regulations on the protection of workers and the general public from exposure to EMFs, in line with the development policies of the European Commission and the indications from internationally recognised scientific organisations, which take into account technical progress, changes in the most relevant standards or specifications, and new scientific findings concerning electromagnetic fields.

In conclusion, the authors believe that this study on the specific provisions of Italian regulations regarding the exposure of workers to EMFs (0 Hz to 300 GHz) can contribute to increasing the knowledge of national regulatory approaches on occupational risk assessment, management, and communication, as well as helping the professionals involved in EMF risk assessments, who should carefully consider any stricter provisions established by national legislation compared to the minimum health and safety requirements envisaged by international guidelines and European regulations.

Author Contributions: Conceptualization, V.L. and L.F.; methodology, V.L. and L.F.; writing—original draft preparation, V.L.; writing—review and editing, V.L. and L.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors report no conflicts of interest. The authors alone are responsible for the writing and content of this paper, which represents solely their personal opinions and does not in any way involve the affiliation bodies.

References

1. International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). *Health Phys.* **1998**, *74*, 494–522. [PubMed]
2. International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines on Limits of Exposure to Static Magnetic Fields. *Health Phys.* **2009**, *96*, 504–514. [CrossRef] [PubMed]
3. International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). *Health Phys.* **2010**, *99*, 818–836. [CrossRef] [PubMed]
4. International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines for limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time varying magnetic fields below 1 Hz. *Health Phys.* **2014**, *106*, 418–425. [CrossRef] [PubMed]
5. International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz). *Health Phys.* **2020**, *118*, 483–524. [CrossRef] [PubMed]
6. Feychting, M.; Kaune, T.W.; Savitz, D.A.; Ahlbom, A. Estimating exposure in studies on residential magnetic fields and cancer. *Epidemiology* **1996**, *7*, 220–224. [CrossRef] [PubMed]
7. INTERPHONE Study Group. Brain tumour risk in relation to mobile telephone use: Results of the INTERPHONE international case-control study. *Int. J. Epidemiol.* **2010**, *39*, 675–694. [CrossRef] [PubMed]
8. International Agency for Research on Cancer (IARC). IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields. *IARC Monogr. Eval. Carcinog. Risks Hum.* **2002**, *80*, 1–395. [PubMed]

9. International Agency for Research on Cancer (IARC). IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. *IARC Monogr. Eval. Carcinog. Risks Hum.* **2013**, *102 Pt 2*, 1–460. [PubMed]
10. Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF). Adopted by SCENIHR on 27 January 2015. Available online: https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf (accessed on 11 October 2024).
11. Scientific Committee on Health, Environmental and Emerging Risks (SCHEER). Final Opinion on the Need of a Revision of the Annexes in the Council Recommendation 1999/519/EC and Directive 2013/35/EU, in View of the Latest Scientific Evidence Available with Regard to Radiofrequency (100 kHz–300 GHz). Adopted by SCHEER on 18 April 2023. Available online: https://health.ec.europa.eu/document/download/aaf66644-cfb2-4f9b-8a73-df7ef2b3a2a4_en?filename=scheer_o_044.pdf (accessed on 11 October 2024).
12. Scientific Committee on Health, Environmental and Emerging Risks (SCHEER). Final Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF): Update with Regard to Frequencies Between 1 Hz and 100 kHz. Adopted by SCHEER on 17 May 2024. Available online: https://health.ec.europa.eu/document/download/85ef39d5-49dc-4b5a-b875-54e578d1d2bc_en?filename=scheer_o_063.pdf (accessed on 11 October 2024).
13. Li, W.; Ray, R.M.; Thomas, D.B.; Yost, M.; Davis, S.; Breslow, N.; Gao, D.L.; Fitzgibbons, E.D.; Camp, J.E.; Wong, E.; et al. Occupational exposure to magnetic fields and breast cancer among women textile workers in Shanghai, China. *Am. J. Epidemiol.* **2013**, *178*, 1038–1045. [CrossRef] [PubMed]
14. Gao, H.; Aresu, M.; Vergnaud, A.C.; McRobie, D.; Spear, J.; Heard, A.; Kongsgård, H.W.; Singh, D.; Muller, D.C.; Elliott, P. Personal radio use and cancer risks among 48,518 British police officers and staff from the Airwave Health Monitoring Study. *Br. J. Cancer* **2019**, *120*, 375–378. [CrossRef] [PubMed]
15. Vila, J.; Turner, M.C.; Gracia-Lavedan, E.; Figuerola, J.; Bowman, J.D.; Kincl, L.; Richardson, L.; Benke, G.; Hours, M.; Krewski, D.; et al. Occupational exposure to high-frequency electromagnetic fields and brain tumor risk in the INTEROCC study: An individualized assessment approach. *Environ. Int.* **2018**, *119*, 353–365. [CrossRef] [PubMed]
16. NTP. *Technical Report on the Toxicology and Carcinogenesis Studies in Hsd:Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones*; National Toxicology Program; NTP: Durham, NC, USA, 2018.
17. NTP. *Technical Report on the Toxicology and Carcinogenesis Studies in B6C3F1/N Mice Exposed Towhole-Body Radio Frequency Radiation at a Frequency (1900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones*; National Toxicology Program; NTP: Durham, NC, USA, 2018.
18. Falcioni, L.; Bua, L.; Tibaldi, E.; Lauriola, M.; De Angelis, L.; Gnudi, F.; Mandrioli, D.; Manservigi, M.; Manservisi, F.; Manzoli, I.; et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. *Environ. Res.* **2018**, *165*, 496–503. [CrossRef] [PubMed]
19. 1999/519/EC: Council Recommendation of 12 July 1999 on the Limitation of Exposure of the General Public to Electromagnetic Fields (0 Hz to 300 GHz). *Off. J. Eur. Communities* **1999**, *L199*, 59–70. Available online: https://eur-lex.europa.eu/eli/reco/1999/519/oj (accessed on 20 August 2024).
20. Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the Minimum Health and Safety Requirements Regarding the Exposure of Workers to the Risks Arising from Physical Agents (Electromagnetic Fields) (20th Individual Directive Within the Meaning of Article 16(1) of Directive 89/391/EEC) and Repealing Directive 2004/40/EC. *Off. J. Eur. Union* **2013**, *L179*, 1–21. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013L0035&from=EN (accessed on 20 August 2024).
21. European Commission—Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. Statement on the Application of Council Recommendation 1999/519/EC of 12 July 1999. Letter GROW/C3/DP/mm (2016) 2534933 to CENELEC TC 106X 2016. 29 April 2016 (CENELEC Internal Document). Available online: https://commission.europa.eu/about/departments-and-executive-agencies/internal-market-industry-entrepreneurship-and-smes_en (accessed on 11 December 2024).
22. Stamm, R. *Comparison of International Policies on Electromagnetic Fields*; National Institute for Public Health and the Environment, RIVM: Bilthoven, The Netherlands, 2018; Available online: https://www.rivm.nl/sites/default/files/2018-11/Comparison%20of%20international%20policies%20on%20electromagnetic%20fields%202018.pdf (accessed on 20 August 2024).
23. Legge 22 Febbraio 2001, n.36, Legge Quadro Sulla Protezione Dalle Esposizioni a Campi Elettrici, Magnetici ed Elettromagnetici [Italian Law No. 36 of 22 February 2001, Framework Law for the Protection from Exposure to Electric, Magnetic and Electromagnetic Fields]. *Off. J. Ital. Repub.* 2001. No. 55. Available online: https://www.gazzettaufficiale.it/atto/vediMenuHTML?atto.dataPubblicazioneGazzetta=2001-03-07&atto.codiceRedazionale=001G0084&tipoSerie=serie_generale&tipoVigenza=originario&action=select-all (accessed on 11 October 2024).
24. Filosa, L.; Lopresto, V.; Valutazione e Gestione dei Rischi per la Salute e la Sicurezza Derivanti Dall'esposizione ai Campi Elettromagnetici (CEM)—Una Bussola per Mantenere la Giusta Rotta sul Campo. Dossier Ambiente 136. 2021. Available online: https://amblav.it/prodotto/dossier-ambiente-136-cem-esposizione-umana-ai-campi-elettromagnetici-cosa-e-come-sta-cambiando/ (accessed on 11 October 2024). (In Italian).

25. Recommendations of the ICRP. ICRP Publication 26. *Ann. ICRP* **1977**, *1*, 1–53. Available online: https://journals.sagepub.com/doi/pdf/10.1177/ANIB_1_3 (accessed on 20 August 2024).
26. Directive 2013/59/EURATOM of the Council of 5 December 2013 Laying Down Basic Safety Standards for Protection Against the Dangers Arising from Exposure to Ionising Radiation, and Repealing Council Directives 89/618/EURATOM, 90/641/EURATOM, 96/29/EURATOM, 97/43/EURATOM and 2003/122/EURATOM. *Off. J. Eur. Union* **2014**, *L13/1*, 1–73. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32013L0059 (accessed on 20 August 2024).
27. Decreto del Presidente del Consiglio dei Ministri 8 luglio 2003, Fissazione dei Limiti di Esposizione, dei Valori di Attenzione e Degli Obiettivi di Qualità per la Protezione Della Popolazione Dalle Esposizioni ai Campi Elettrici e Magnetici Alla Frequenza di Rete (50 Hz) Generati Dagli Elettrodotti [Italian Prime Minister's Decree 8 July 2003, Establishment of Exposure Limits, Attention Values and Quality Goals for the Protection of the General Public from Exposure to Electric and Magnetic Fields at Grid Frequency (50 Hz) Generated by Power Lines]. *Off. J. Ital. Repub.* 2003. No. 200. Available online: https://www.gazzettaufficiale.it/eli/id/2003/08/29/03A09749/sg (accessed on 11 October 2024).
28. Decreto del Presidente del Consiglio dei Ministri 8 Luglio 2003, Fissazione dei Limiti di Esposizione, dei Valori di Attenzione e Degli Obiettivi di Qualità per la Protezione Della Popolazione Dalle Esposizioni a Campi Elettrici, Magnetici ed Elettromagnetici Generati a Frequenze Comprese tra 100 kHz e 300 GHz [Italian Prime Minister's Decree 8 July 2003, Establishment of Exposure Limits, Attention Values and Quality Goals for the Protection of the General Public from Exposure to Electric, Magnetic and Electromagnetic Fields Generated at Frequencies Between 100 kHz and 300 GHz]. *Off. J. Ital. Repub.* 2003. No. 199. Available online: https://www.gazzettaufficiale.it/eli/id/2003/08/28/03A09711/sg (accessed on 11 October 2024).
29. Norma CEI 106-45 (2021-01) Guida CEM−Guida Alla Valutazione dei Rischi per la Salute e la Sicurezza Derivanti Dell'esposizione ai Campi Elettrici, Magnetici ed Elettromagnetici (CEM) tra 0 Hz e 300 GHz nei Luoghi di Lavoro [Italian Standard CEI 106-45:2021 EMF Guide–Guide to the Assessment of Health and Safety Risks Arising from to Exposure to Electric, Magnetic and Electromagnetic Fields (EMFs) from 0 Hz to 300 GHz at Workplaces]. 2021. CEI 106-45 (2021-01):17850. Available online: https://www.intertekinform.com/en-us/standards/cei-106-45-2021-1209390_saig_cei_cei_2926703/?srsltid=AfmBOoqHMiQqYUwDRTTK00iL4_qK8latll_QuSUv4399IPmCM9bW1bTE (accessed on 11 December 2024).
30. European Commission—Directorate-General for Employment, Social Affairs and Inclusion, Unit B3. Non-Binding Guide to Good Practice for Implementing Directive 2013/35/EU Electromagnetic Fields. Volume 1—Practical guide, Volume 2—Case studies, Volume 3—The Guide for SME. EU Commission, DG Employment, Social Affairs and Inclusion. 2015. Available online: https://osha.europa.eu/it/legislation/guidelines/non-binding-guide-good-practice-implementing-directive-201335eu (accessed on 20 August 2024).
31. Decreto Legislativo 1 Agosto 2016, n. 159, Attuazione Della Direttiva 2013/35/UE Sulle Disposizioni Minime di Sicurezza e di Salute Relative All'esposizione dei Lavoratori ai Rischi Derivanti Dagli Agenti Fisici (Campi Elettromagnetici) e che Abroga la Direttiva 2004/40/CE [Italian Legislative Decree No. 159 of 1 August 2016, Implementation of Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the Minimum Health and Safety Requirements Regarding the Exposure of Workers to the Risks Arising from Physical Agents (Electromagnetic Fields) That Abrogate Directive 2004/40/EC]. *Off. J. Ital. Repub.* 2016. No. 192. Available online: https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2016-08-01;159!vig= (accessed on 11 October 2024).
32. Decreto Legislativo 9 aprile 2008 n.81 (D. Lgs. 81/2008)—Testo Coordinato con il D. Lgs. 3 Agosto 2009, n. 106—Attuazione Dell'art. 1 Della Legge 3 Agosto 2007, n. 123, in Materia di Tutela Della Salute e Della Sicurezza nei Luoghi di Lavoro [Italian Legislative Decree No. 81 of 9 April 2008–Act Coordinated with Legislative Decree No.106 of 3 August 2009–Implementation of Clause 1 of the Law No. 123 of 3 August 2009 on Health and Safety Protection in Workplaces. *Off. J. Ital. Repub.* 2008. No. 180, Revision July 2023. Available online: https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2008-04-09;81 (accessed on 11 October 2024).
33. Legge di Conversione 17 Dicembre 2012, n. 221, Conversione in Legge, con Modificazioni, del Decreto Legge 18 Ottobre 2012, n. 179 Recante Ulteriori misure Urgenti per la Crescita del Paese (c.d. Decreto Crescita 2.0), Coordinato con la Legge di Conversione 17 Dicembre 2012, n. 221, Art. 14 "Interventi per la Diffusione Delle Tecnologie Digitali", Commi 10, 11 e 12 [Italian Law No. 221/2012, Conversion in Law, with Modification, of Decree No. 179 of 18 October 2021 on Additional Urgent Measures for Country Growth (so Called Growth Decree 2.0), Coordinated with the Conversion law No. 221 of 17 December 2012, Article 14, Clauses 10, 11 and 12, "Interventions for Digital Technologies Diffusion"]. *Off. J. Ital. Repub.* 2012. No. 294. Available online: https://www.gazzettaufficiale.it/eli/id/2012/12/18/012G0244/sg (accessed on 11 October 2024).
34. Legge 30 Dicembre 2023, n. 214, Legge Annuale per il Mercato e la Concorrenza 2022 (23G00220), Articolo 10 "Adeguamento dei Limiti dei Campi Elettromagnetici" [Italian Law No. 214/2023, Annual Law on the Maket and Competition 2022 (23G00220), Article 10 "Revision of the Limits of Electromagnetic Fields"]. *Off. J. Ital. Repub*. 2023. No. 303. Available online: https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:legge:2023-12-30;214 (accessed on 11 October 2024).
35. EN 50499:2019; Procedure for the Assessment of the Exposure of Workers to Electromagnetic Fields. 2019. Available online: https://standards.iteh.ai/catalog/standards/clc/9e9a550f-3ff7-426d-88ce-8d7be3bb030d/en-50499-2019?srsltid=AfmBOopGQYecQaqPgn7_bVPJQA4kvpiVJg-eHvXcUHFjhQoGHwxCNZqe (accessed on 11 October 2024).
36. INAIL, Italian National Institute for Insurance against Accidents at Work. Portale Agenti Fisici—Banca Dati Campi Elettromagnetici [Physical Agents Portal−Electromagnetic Fields Database]. Available online: https://www.portaleagentifisici.it/fo_campi_elettromagnetici_list_macchinari_avanzata.php?lg=IT (accessed on 20 August 2024).

37. Filosa, L.; Lopresto, V. Semi-quantitative methodology to assess health and safety risks arising from exposure to electromagnetic fields up to 300 GHz at workplaces according to Italian regulations. *Int J Occup Saf Erg.* **2022**, *11*, 1–12. [CrossRef] [PubMed]
38. Associazione Italiana di Radioprotezione Medica (AIRM), AAVV. *Linee Guida per la Sorveglianza Sanitaria dei Lavoratori Esposti Campi Elettromagnetici*; [Italian Association of Medical Radiation Protection (AIRM) VV AA. Guidelines for Health Surveillance of Workers Exposed to Electromagnetic Fields]; Depigraf: Caserta, Italy, 2021; ISBN 978-88-909379-4-1. (In Italian)
39. Italian Presidency of the Council of Ministers, AGID—Agency for Digital Italy. Report on Digital Growth and Ultra Broadband. 2024. Available online: https://www.agid.gov.it/it/agenzia/strategia-quadro-normativo/crescita-digitale-banda-ultra-larga (accessed on 11 October 2024). (In Italian)