National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Electromagnetic Fields in the Irish Context

RIVM Report 2015-0073

E.F. Hall et al.

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Electromagnetic Fields in the Irish Context

RIVM Report 2015-0073

Colophon

E.F. Hall (author), RIVM
K.J. Rijs (author), RIVM
R. Stam (author), RIVM
J.F.B. Bolte (author), RIVM
M.J.M. Pruppers (author), RIVM

Contact:
Mathieu Pruppers
Centre for Sustainability, Environment and Health
mathieu.pruppers@rivm.nl

This investigation has been performed by order and for the account of the Department of Environment, Community and Local Government of Ireland, within the framework of contract E/121517/01.

This is a publication of:
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Synopsis

Electromagnetic Fields in the Irish Context

The Irish Government commissioned the National Institute for Public Health and the Environment of the Netherlands (RIVM) to report on the current scientific knowledge on the possible health effects of exposure to electromagnetic fields. The focus of the report was on electromagnetic fields from high-voltage overhead power lines and from base stations for mobile telecommunication. In addition, RIVM investigated the policies of five European countries and Ireland concerning the exposure of the public to electromagnetic fields. How these policies are implemented in practice was also described.

Firstly, the nature of electromagnetic fields and the varied sources that produce them are clarified. Then the exposure limits recommended by the European Union are explained. These limits have been introduced to prevent well-known adverse health effects, such as the stimulation of nerves and the heating of the body or parts of it. In addition, health effects are described for which no conclusive evidence exists, such as a possible increased risk of developing childhood leukaemia and tumours in the head.

The five countries investigated (France, the Netherlands, Slovenia, Sweden and the United Kingdom) differ in the way they deal with the European exposure limits. Some countries have translated the European recommendation into binding national legislation. Others have not done so or they apply different limits. Furthermore, the countries investigated differ in their approach to scientific research into the health effects or to monitoring programmes. Moreover, the extent to which citizens are involved in decision-making on the construction of high-voltage overhead power lines and the siting of base stations for mobile communication varies per country. Sometimes citizens are involved in the decision-making process from start to finish, sometimes only at the end or not at all.

All the countries invest in some form of structured interaction between government, industry and citizens. In addition, the governments of the countries studied provide the public with information on electromagnetic fields and health, for instance through websites or leaflets.

Keywords: electromagnetic fields; potential health effects; practices in other countries; policy options

Publiekssamenvatting

Elektromagnetische velden in de Ierse context

In opdracht van de Ierse overheid heeft het RIVM de huidige wetenschappelijke kennis over mogelijke gezondheidseffecten van elektromagnetische velden op een rij gezet. De nadruk ligt op de elektromagnetische velden afkomstig van hoogspanningslijnen en basisstations voor mobiele telefonie. Daarnaast heeft het RIVM het beleid van vijf Europese landen en Ierland over de blootstelling van de bevolking aan elektromagnetische velden in kaart gebracht. Ook is beschreven hoe dat beleid in de praktijk wordt uitgevoerd.

Allereerst zijn de aard van elektromagnetische velden en de verschillende bronnen die ze produceren toegelicht. Vervolgens zijn de blootstellingslimieten toegelicht die de Europese Unie aanbeveelt. Deze zijn ingesteld om bekende gezondheidseffecten te voorkomen, zoals het prikkelen van zenuwen en het opwarmen van het lichaam of delen daarvan. Ook zijn effecten beschreven waar wel aanwijzingen voor zijn, maar waar geen onomstotelijk bewijs voor bestaat, zoals een mogelijk verhoogde kans op leukemie bij kinderen en tumoren in het hoofd.

De vijf onderzochte landen, te weten Frankrijk, Nederland, Slovenië, Zweden en het Verenigd Koninkrijk, verschillen onder andere in de manier waarop ze omgaan met de Europese blootstellingslimieten. Sommige hebben de Europese aanbevelingen hiervoor vertaald naar bindende nationale wetgeving. Andere hebben dat niet gedaan of hanteren andere grenzen. De onderzochte landen hechten ook in verschillende mate aan wetenschappelijk onderzoek naar gezondheidseffecten of monitoringprogramma's. Ook verschilt de mate waarin burgers betrokken zijn bij besluitvorming over de aanleg van hoogspanningslijnen en de plaatsing van basisstations voor mobiele telefonie. Soms zijn burgers van een land van begin tot het eind bij het besluitvormingsproces betrokken, soms alleen aan het einde, en soms helemaal niet.

De vijf landen investeren wel allemaal in een vorm van gestructureerde interactie tussen overheid, industrie en burgers. Een andere overeenkomst is dat de overheden de bevolking voorzien van informatie over elektromagnetische velden en gezondheid, bijvoorbeeld via websites of folders.

Kernwoorden: elektromagnetische velden; mogelijke gezondheidseffecten; praktijk in andere landen; beleidsopties

Contents

Executive summary

In Ireland, as in other countries, there is concern that exposure to electromagnetic fields (EMF) from mobile phone base stations and high-voltage power lines may have adverse effects on human health. Given the recent resurgence in interest in EMF in the context of major pylon constructions, the Department of Environment, Community and Local Government commissioned the National Institute for Public Health and the Environment (RIVM) of the Netherlands to prepare a report synthesizing the existing published scientific information on the potential health effects and on how some other countries deal with this issue. This report, which is an update of the assessment of the 2007 Report of the Irish Expert Group on the Health Effects of Electromagnetic Fields, focuses primarily on the potential health effects that arise from the exposure of the public to EMF from high-voltage power lines and base stations for mobile communication.

The first part of the report deals with the nature of EMF and the variety of sources that produce these fields. The exposure limits recommended by the Council of the European Union, which are based on guidelines provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), are explained. These limits are based on the well-documented, short-term health effects of high-level exposure to extremely low frequency (ELF) fields via electrical stimulation and to radiofrequency (RF) fields via heating of the body or parts of the body. The discussion of other potential health effects is based on recently published conclusions on the health effects of EMF in systematic reviews by leading organizations in the field of health protection. Studies have been undertaken that examine possible links with cancer and the various other potential health effects of ELF and RF fields. These studies have mainly focused on chronic exposures and exposures below the limits in the European recommendation. The evidence for these health outcomes is inconclusive and the exact reasons for this inconclusiveness vary, depending on the type of potential health effect. Based on the latest findings, it can be concluded that the evidence for the various long-term health effects of ELF or RF fields at strengths below the limits in the European recommendation is either limited, inadequate or absent (criteria for the strength of the evidence that are defined by the IARC). It is clear, therefore, that research carried out in this area since the 2007 Report of the Expert Group has provided some additional, limited evidence regarding the health effects associated with exposure to electromagnetic fields, but the evidence overall remains inconclusive. This is in line with the conclusions of SCENIHR in its 2015 Opinion and it reaffirms the overall conclusions of the 2007 Report.

To date, there is insufficient evidence to establish a causal relationship between exposure to ELF magnetic and electric fields and cancers. However, epidemiological studies have indicated a statistical relationship between long-lasting exposure to ELF magnetic fields from power lines and a more frequent occurrence of childhood leukaemia. Other studies have been unable to discover a mechanism that could explain this association. This means that the assumption of a causal relationship

cannot be supported, in spite of the number of studies that have been undertaken since 1979. There has been research conducted into a potential relationship between long-term mobile phone use and tumours in the head. The evidence has been inconsistent and may be explained by methodological inadequacies. For this reason, the existence of a relationship between exposure to RF fields from long-term mobile phone use and tumours in the head cannot be confirmed, but it can also not be entirely dismissed.

In the second part of the report, the institutional arrangements, policies and practices related to public exposure to EMF are discussed for five selected countries (France, the Netherlands, Slovenia, Sweden and the UK). For each country, information is presented on the following areas:

- implementation of the European recommendation on limiting exposure to EMF;
- resources dedicated to EMF and public health issues;
- interaction structures between (national) government, industry and citizens;
- citizen participation in decision-making on the siting of high-voltage power lines and base stations; and
- governmental communication on EMF and health.

Concerning the implementation of the European recommendation on limiting exposure to EMF, three different approaches have been identified amongst EU Member States. In the first group, the European recommendation has been translated into binding national legislation. In the second group, the national limits based on the European recommendation or ICNIRP are not binding, there are more lenient limits, ICNIRP levels are used as a basis for mandatory risk assessment or there is no regulation. In the third group, there are stricter basic restrictions and/or reference levels based on the precautionary principle or due to public pressure.

The level of resources that countries dedicate to EMF policy options implemented with respect to public health issues also varies. For instance, the five countries have taken different positions with respect to a dedicated research programme or national monitoring. All countries investigated have had or still have some form of structure for interaction between (national) government, industry and citizens. In some countries, these structures have been dedicated specifically to either ELF or RF issues, while in other countries they have been dedicated to both. Examples of these structures include stakeholder dialogue processes, covenants or national round-table discussions.

The extent to which citizens are able to participate in decision-making on the siting of high-voltage power lines and base stations also varies. Some countries have extensive consultation procedures in place for citizens from the start of the decision–making process. In others, authorities may consult citizens later on in this process or not at all. In all the countries investigated, the national governments provide the public with information on EMF and health. This can range from information on dedicated websites, such as the results of measurements of EMF and educational videos, to leaflets on the potential health effects of exposure to ELF.

1 Introduction

1.1 Background

In Ireland, as in many countries, there is concern that exposure to electromagnetic fields from mobile phone base stations and high-voltage power lines may have adverse effects on human health. Ireland has adopted the common "precautionary principle" in this matter by:

- adopting internationally recognised standards and guidelines for both occupational exposure and public exposure to electromagnetic fields;
- participating in international bodies and fora that address these concerns, such as the World Health Organization.

In March 2007, the Government, through the Department of Communications, Marine and Natural Resources (DCMNR, now DCENR), published the Report of the Expert Group established to examine the health effects of electromagnetic fields (EMF) and to summarize the available scientific evidence (Expert Group, 2007). Later that year, Government policy for the health effects of electromagnetic fields became the responsibility of the Minister for the Environment, Community and Local Government.

Given the recent resurgence in interest in EMF in the context of major pylon constructions, the Department of Environment, Community and Local Government (DECLG) is considering how best to address the issue and provide robust analysis and advice on the matter.

1.2 Assignment

The Department of Environment, Community and Local Government commissioned the National Institute for Public Health and the Environment (RIVM) of the Netherlands to prepare a report which

- synthesizes the existing peer-reviewed research into key, clear points with a particular focus on the potential health effects of electric and magnetic fields arising from high-voltage power lines and electromagnetic fields from base stations for mobile communication;
- assesses the management of EMF-related issues in other jurisdictions under the headings:
  a. implementation of the European recommendation;
  b. resources dedicated;
  c. interaction between (national) government, industry and citizens;
  d. citizen participation in decision-making;
  e. governmental communication.

1.3 Goal

The final report should include balanced scientific information on the potential health effects and on how other countries deal with this issue. The information in the report should be useful for the preparation and response to all kinds of issues regarding electromagnetic fields and

health. This will provide Ireland with the building blocks for a framework for governance on electromagnetic fields.

1.4 Scope of the report

The following was agreed as the main focus of the report:

- The report will cover the frequency range from 0 to 300 GHz. Optical radiation (infrared, visible light, ultraviolet) will not be included.
- Only exposure of the public will be studied. Occupational exposure and exposure of patients will not be included.
- Primarily infrastructural sources of electromagnetic fields, such as high-voltage overhead power lines and base stations for mobile communication, will be studied. Broadcast transmitters and radar will not be included.

1.5 Sources of EMF

The focus in this report is on infrastructural sources. The report particularly addresses the transmission grid and base stations for mobile communication.

The report will also give a brief outline of non-infrastructural sources of EMF. Examples of these sources are other components of the electricity grid (such as substations, the distribution grid, transformers, underground cables); cordless phones (DECT) and base stations for wireless information transmission (Wi-Fi); household appliances, electrical equipment and equipment for mobile communication (smart phones, lap tops). In analysing the literature on the potential health impact, research on mobile phones cannot be omitted. However, in analysing practices in other jurisdictions, the report will not deal in detail with sources other than infrastructural sources. Other issues, such as the addictive aspects of mobile communication equipment or the views of parents, cannot be separated from the discussion on the potential adverse health effects due to children’s use of mobile communication equipment.

2 Scientific assessment

2.1 Introduction

This chapter discusses the assessment of the literature on the potential health effects of exposure to electromagnetic fields. Before progressing to this assessment, the physical aspects of electromagnetic fields and the sources producing these fields are introduced and discussed, as well as the exposure limits recommended by the Council of the European Union.

2.2 Electromagnetic fields

Electromagnetic fields consist of two components: an electric field and a magnetic field. An electric field arises when there is a difference in electric potential (i.e. a voltage) between two objects or when magnetic fields change in strength or direction. When an electric charge moves or an electric field changes in strength or direction, a magnetic field arises that also changes in strength or direction. For example, an electric field arises between the ground and a power line because a power line has a relatively large electric potential compared to the ground. When an alternating electric current flows through the power line (i.e. the electric fields change in strength and direction over time), an alternating magnetic field is induced.

Most electric and magnetic fields move in waves in a certain direction and have a certain amplitude. The number of waves (peaks or troughs) per second is called the frequency and the international standard unit of frequency is the hertz. Because variable magnetic fields induce variable electric fields and vice versa, the variable electric and magnetic fields are closely linked. When linked, they are jointly called electromagnetic fields. In this report, the abbreviation EMF is used to indicate electric fields, magnetic fields or electromagnetic fields. The level of coupling is not complete near the source of EMF. Further away from the source, the electric and magnetic fields are completely linked. The distance from the source to where the electric and magnetic field are completely coupled becomes smaller with increasing frequency.

Fields that do not change over time (i.e. have a frequency of 0 hertz) are called static fields. No consensus exists on which range of frequencies above 0 hertz belongs to which category of EMF. The entire range of frequencies is called the electromagnetic spectrum. EMFs are classified according to their frequency.

In this report, a classification has been used that is also used by the Scientific Committee on Emerging and Newly Identified Health Risks, which advises the European Commission (SCENIHR, 2015). EMF with frequencies above 0 hertz are classified by SCENIHR into extremely low frequency (ELF; 1 – 300 hertz), intermediate frequency (300 hertz – 100 kilohertz), and radio-frequency (RF; 100 kilohertz -300 gigahertz) fields. Radiation with frequencies higher than 300 gigahertz is classified into optical radiation (infrared, visible light, and ultraviolet) and ionizing

radiation. This report focuses on ELF and RF fields. Table 1 shows examples of sources with different frequencies.

Table 1. Examples of sources of static, extremely low frequency, intermediate frequency and radio-frequency fields

classification of fields	frequencies	sources
Static fields	0 hertz	permanent magnets, (appliances that use) direct current (DC) power transmission and video display units
Extremely Low Frequency (ELF) fields	1 – 300 hertz	power lines, electrical appliances using alternating current (AC) electricity (e.g. vacuum cleaner) and certain trains
Intermediate Frequency fields	300 hertz – 100 kilohertz	induction hot plates, video display units and certain anti-theft devices
Radio-Frequency (RF) fields	100 kilohertz– 300 gigahertz	mobile phone base stations, mobile phones, cordless phones (DECT), wireless information transmission (Wi-Fi), and metal detectors

2.3 Exposure limits and sources

2.3.1 Introduction

People are exposed to EMF if they are present in the fields mentioned in the section above. Often, exposure also refers to the strength of the field that the individual is exposed to.

The Council of the European Union has recommended limits on the strength of EMF to which members of the general public may be exposed (exposure limits; Council of the European Union, 1999). These recommendations are based on guidelines provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998), which in turn are based on the known health effects of these fields.

Biological effects and health effects

In its constitution, the World Health Organization defines health as a 'state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.'

When dealing with the possible effects of exposure to EMF, there is a difference between biological effects and health effects. A biological effect is any change induced in a living organism by a stimulus or change in the environment. A biological effect does not automatically or necessarily lead to an effect on health. For instance, sweating during running or jogging is a biological effect, but not a health effect. The human body has the ability to react to all kinds of outside influences and, if necessary, to adapt itself to these influences. An adverse health effect arises only when the body cannot react effectively because the changes in the body are too great, last too long or become irreversible.

The research into possible adverse health effects due to exposure to EMF looks for evidence on the mechanism through which the exposure could damage health. The question of whether EMF with strengths below those in the international guidelines can affect health adversely is still under debate.

Exposure limits for the general public in the ICNIRP guidelines and in the European recommendation are called basic restrictions. Which physical (dosimetric) quantity is used to specify the basic restriction depends on the frequency of the fields. For low and intermediate frequency fields, the basic restrictions are based on the induction of electric fields and currents in the human body. In the European recommendation, the current density is used to quantify these electrical currents. The unit used for current density is ampere per square metre (A/m^2). More recent ICNIRP guidelines for frequencies below 100 kilohertz use a different quantity for basic restrictions (internal electric field strength), with some adjustments to their values (ICNIRP, 2010). In 2009, ICNIRP published a review of scientific evidence for frequencies above 100 kilohertz (ICNIRP, 2009a) and confirmed the 1998 Guidelines (ICNIRP, 2009c) – these limits are used in the European recommendation. The limits in the European recommendation have not been revised since 1999.

Exposure to fields with frequencies above 100 kilohertz can cause energy absorption in the human body and therefore a rise in body temperature. The specific absorption rate (SAR) is a measure of the energy per unit time that is absorbed in a unit mass of the body. The unit of the SAR is watt per kilogram bodyweight (W/kg). The SAR is averaged over a period of 6 minutes to determine whether basic restrictions are met (ICNIRP, 1998). The basic restrictions for frequencies of 10 gigahertz to 300 gigahertz prevent heating of the surface areas of the body. For fields with frequencies of 10 gigahertz to 300 gigahertz, the physical quantity power density (unit W/m^2) is used because the depth of the penetration is relatively small.

The physical quantities used to determine the basic restrictions are impractical to measure. For this reason, reference levels have been developed to assess the strength of EMF outside the body. The physical quantities used for reference levels can be measured more easily (i.e. electric field strength (symbol: E), magnetic field strength (symbol: H), magnetic flux density (symbol: B), power density (symbol: S), current through any limb (symbol: I_l), contact current between a person and an object (symbol: I_c), and for pulsed fields, specific energy absorption (SA)). When the measured strength of the field does not exceed the reference levels, the basic restrictions will not be exceeded. When the strength of the field exceeds the reference levels, this does not necessarily imply that the exposure also exceeds the basic restrictions. It is, however, necessary to further examine whether or not the basic restrictions are being exceeded. The reference levels, therefore, serve as an easy means to apply preliminary assessment of the exposure levels.

The source of exposure is the conductor, the appliance or the transmitter that produces EMF. Exposure to these fields happens on a daily basis. Such fields originate from a variety of different sources, both natural and human-made. The sun, the earth, a thunderstorm and the human body (through nerve and muscle activity) produce these fields; these are all examples of natural sources. EMF may also be intentionally produced by devices, such as by mobile phones, wireless Internet, radio and television, but also as 'by-products' of power lines and electrical appliances. Exposure to EMF is strongest close to the source and decreases as the distance to the source increases.

Human-made fields, to which the general public may be exposed, are the focus of this scientific assessment. Although relatively strong fields can be produced by medical devices or in working environments (e.g. from magnetic resonance imaging (MRI) or welding devices), these will not be discussed here. The sources in the following sections are based upon a recent analysis conducted by RIVM (Stam et al., 2014).

2.3.2 Electricity generation and transport

Direct current (DC) power lines and contact wires of DC trains generate static fields and sometimes a ripple of ELF fields with a frequency of 50 hertz. Alternating current (AC) power lines and contact wires of trains generate ELF fields with a frequency of 50 hertz (in some European countries $16^2/_3$ hertz). This is a relatively low frequency, so the electric and magnetic fields are not closely coupled and have to be assessed separately.

Electric fields from power lines are relatively strong and, because the voltage of a power line varies very little over time, their strength is relatively constant. People are not however exposed to electric fields from power lines when they are in a building, as electric fields can not pass through walls. Within a building, people are more likely to be exposed to electric fields that are produced by electrical appliances. Magnetic fields pass through the walls of a house. The strength of magnetic fields from power lines varies with distance and, because the current that generates these fields depends on the consumption of power, over time. Directly under the conductors of power lines or above underground cables, exposure to magnetic fields is strongest and its

strength falls as the distance to the power line increases. The generation, distribution and use of electricity generate ELF fields. Therefore, in addition to power lines, ELF fields also arise from other parts of the power grid (transformers, power substations).

2.3.3 Other sources of ELF fields

Other sources of ELF fields to which the general public may be exposed are electrical appliances used in and around the house, such as kitchen appliances, electrical tools, and appliances used for cleaning (e.g. vacuum cleaners). The general public can also be exposed to ELF fields from public transport (e.g. in trains, trams, buses, from the electric motors and the overhead contact wires) and anti-theft devices in shops.

2.3.4 Mobile communication

The first mobile phones used analogue signals. Since the 1990s, digital signals have been used. Exposure to RF fields was higher through the use of analogue phones than it is through the use of digital phones. When a mobile phone is used, the signal is relayed to a base station nearby and vice versa. Therefore, both mobile phones and base stations produce RF fields. The instantaneous exposure from a mobile phone, when used, is higher than that from a base station because it is closer to the body.

2.3.5 Other sources of RF fields

Cordless phones with a limited range (DECT) also produce RF fields. Exposure to RF fields produced by DECT phones is generally lower than exposure to fields from mobile phones. RF fields also arise from wireless information transmission (e.g. Wi-Fi) and wireless power transmission (e.g. electric toothbrush battery chargers). Other examples in the home are wireless remote controls, plasma and LCD screens, and microwave ovens. Additional sources of exposure can be radio and television transmitters, digital TV technology, radar systems (e.g. for speed measurements and for localizing and navigating ships and planes), certain anti-theft devices, metal detectors, identification chips and body scanners in airports.

2.3.6 Sources of other fields

Static fields are produced by permanent magnets, direct current (DC) power transmission, electrical appliances and transport systems that use direct current, as well as by video display units (e.g. for computers).

The number of intermediate frequency field sources has increased recently and will continue to do so. Examples of intermediate frequency field sources are induction cookers, new types of light bulbs (i.e. compact fluorescent lamps), video display units, radio transmitters, electric vehicles, badge readers and anti-theft devices.

2.4 EMF and health

2.4.1 Introduction

In this section, the potential effects of EMF on health are discussed. This section is not meant as an exhaustive review of the primary literature. It summarizes recently published conclusions about the health effects of EMF taken from systematic reviews by leading organizations in the field of health protection. A search for relevant integrative reports and health risk assessments was conducted in February 2014 on the websites of

the following national and international organizations: Advisory Group on Non-Ionising Radiation (AGNIR, UK); Agence nationale de sécurité sanitaire alimentation, environnement, travail (ANSES, formerly AFSSET); Australian Radiation Protection and Nuclear Safety Authority (ARPANSA); European Health Risk Assessment Network on EMF Exposure (EFHRAN); Health Council of the Netherlands (in Dutch: Gezondheidsraad); International Agency for Research on Cancer (IARC); ICNIRP; National Institute for Public Health and the Environment (the Netherlands); Public Health England (formerly Health Protection Agency); Royal Society of Canada; Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR); Swedish Radiation Safety Authority (in Swedish: Strålsäkerhetsmyndigheten, SSM); World Health Organization (WHO). Reports (in English and Dutch) were selected for further analysis when they were more recent than 2006 (with the exception of a 2002 IARC monograph on static and extremely low-frequency electric and magnetic fields; this exception was made because of its historic importance), and if they contained a sufficient description of a methodology - which itself had to be sufficient - and paid sufficient attention to the quality of the underlying research publications.

The following discussion of potential health effects focuses on three types of health effects with decreasing levels of certainty about the link with EMF: established health effects, uncertain health effects and potential health effects for which the evidence does not support a link with EMF. It is important that evidence is found from more than one type of study (i.e. epidemiological studies, experimental studies in human volunteers and animals, and in vitro studies). Furthermore, no firm conclusions can be drawn when only a few small studies have been performed, when conflicting results are found (i.e. studies observing an effect, as well as studies observing no effect) or when research has methodological defects (e.g. inadequate control groups, inadequate size or statistical methods, risk of bias and confounding). Such criteria are used by environmental epidemiologists and organizations such as SCENIHR, WHO, ICNIRP and IARC to determine whether or not there is sufficient evidence for health effects to be established.

Scientific advisory bodies

In the area of protection against possible health effects due to exposure to EMF, international organizations (e.g. United Nations, the European Commission) and national governments or health agencies are generally advised by scientific advisory bodies.

- The International Agency for Research on Cancer (IARC) is a specialized cancer agency of WHO. Its mission is to coordinate and conduct research on the causes and mechanisms for human cancer and to develop scientific strategies for cancer control. IARC prepares Monographs that identify environmental factors that can increase the risk of human cancer.
- The International Commission on Non-Ionizing Radiation Protection (ICNIRP) provides scientific advice and guidance on the health and environmental effects of EMF in order to protect people (workers, patients, the general public) and the environment from adverse effects. ICNIRP is independent from commercial, national and vested interests. Its advice is published in the form of ICNIRP guidelines to limit exposure. Documents produced for publication by ICNIRP alone or in collaboration with other organizations should be agreed by consensus. In preparing recommendations, ICNIRP considers the principles upon which protection measures can be based, while leaving the responsibility of formulating appropriate regulations and codes of practice to the various international and national authorities or institutions.
- The WHO International EMF Project assesses the health and environmental effects of exposure to static and time-varying EMF in the frequency range 0 to 300 gigahertz. It is open to any WHO Member State government or representatives of national institutions that are concerned with radiation protection. The EMF project continually develops a wide range of material to disseminate available information to national EMF protection programmes and to the general public, such as the Environmental Health Criteria monographs (EHC), the WHO handbook on 'Establishing a Dialogue on Risks from Electromagnetic Fields' and several fact sheets. EHC are based on 'peer-reviewed' scientific literature and on former assessments conducted by IARC and ICNIRP.
- When preparing its policy and proposals relating to EMF, the European Commission relies on the independent Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) to review new information periodically that may influence the assessment of risks to human health and to provide regular updates on the scientific evidence base. SCENIHR produces opinions in response to specific requests. The role of the SCENIHR is confined to the assessment of the available scientific evidence. Research, risk management, regulatory proposals and environmental considerations fall outside its scope.
- Many Member States of the European Union have their own national scientific council, committee, institution or agency that advises the national government on how to deal with protection against possible health effects of exposure to EMF. Examples of this are the Health Council of the Netherlands and Public Health England. In Ireland, such a council, committee, institution or agency has not yet been established.

2.4.2 *Extremely low frequency fields (ELF)*

A well-documented effect of ELF fields is the electrical stimulation of cells and tissues. If the electrical stimulation is strong enough, it may affect health by, for instance, causing perception of a faint flickering light in the periphery of the visual field, uncomfortable or painful stimulation of the nerves, and stimulation of excitable muscle tissues such as cardiac muscle tissue. The ICNIRP (ICNIRP, 1998; ICNIRP, 2010) exposure limits for ELF fields and those in the European recommendation are based on preventing these health effects, although ELF fields usually do not exceed these limits in daily life. The fact that ELF fields cause electrical stimulation of cells and tissue has been scientifically proven.

IARC categories

The International Agency for Research on Cancer (IARC) evaluates whether environmental factors such as chemicals and electromagnetic fields can increase the risk of cancer in humans. As an overall evaluation, they assign one of four categories to the environmental factor. IARC states that this categorization 'is a matter of scientific judgment, reflecting the strength of the evidence derived from studies in humans and in experimental animals and from other relevant data' (IARC, 2002). Based on the strength of the evidence, the environmental factor is assigned to one of the following possible groups:

Group 1- Carcinogenic to humans: The evidence that the environmental factor causes cancer is sufficient. Examples: asbestos; benzene; chromium (VI) compounds; formaldehyde; ionizing radiation (all types); silica dust; UV radiation; tobacco smoking.

Group 2A - Probably carcinogenic to humans: Limited evidence exists in humans and sufficient evidence in experimental animals. Examples: emissions from high-temperature frying; inorganic lead compounds; occupational exposures in spraying and application of non-arsenical insecticides; shift work that involves circadian disruption.

Group 2B - Possibly carcinogenic to humans: Limited evidence exists in humans and less than sufficient evidence in experimental animals. Evidence that does not originate from human or animal studies is also considered in this category. Examples: extremely low-frequency magnetic fields; radiofrequency electromagnetic field; welding fumes; carbon nanotubes; coffee (bladder cancer); exhaust fumes; nickel (for other examples, see http://monographs.iarc.fr/ENG/Classification)

Group 3 - Not classifiable as to its carcinogenicity to humans: Inadequate evidence exists in humans and inadequate or limited evidence exists in experimental animals. Examples: static electric and magnetic fields; extremely low-frequency electric fields; insulation glass wool; jet fuel; rock wool; sulphites; tea.

Group 4 - Probably not carcinogenic to humans: The existing evidence suggests that the environmental factor does not cause cancer in humans and in experimental animals. Evidence that does not originate from human or animal studies is also considered in this category. This group only contains caprolactam (raw material for nylon).

IARC categorizes the strength of the evidence in three levels: sufficient evidence (a causal relationship is established); limited evidence (a relationship is observed but chance, bias or confounding can not be ruled out with reasonable confidence); inadequate evidence (published studies do not have sufficient quality, consistency or size); evidence suggesting lack of carcinogenicity (published studies of sufficient quality, consistency and size do not show an association).

Other potential short-term or long-term health effects have also been explored, but have to date not been proven. A frequently examined potential health effect of ELF fields is cancer. To date, there is insufficient evidence for a relationship between exposure to ELF magnetic and electric fields and cancers (IARC, 2002; WHO, 2007; ICNIRP, 2010; EFHRAN, 2012; SCENIHR, 2015; SSM, 2014). For breast cancer, there is sufficient evidence for the absence of a relationship with ELF exposure (WHO, 2007; SSM, 2014). However, epidemiological research has repeatedly shown a statistical relationship between long-lasting exposure to ELF magnetic fields from power lines and an increased prevalence of childhood leukaemia (SCENIHR, 2015; SSM, 2014; EFHRAN, 2012; IARC, 2002; ICNIRP, 2010).

A difficulty in assessing the risks from these findings is that biological studies have been unable to discover how ELF magnetic fields may cause the development of childhood leukaemia. Mechanisms other than electrical stimulation of cells and tissue have been explored, but no clear evidence has been found for a genotoxic effect (i.e. resulting in gene mutations, potentially causing cancer and reproductive effects) or other biological effects that may influence the development of cancer (SCENIHR, 2015). This means that the assumption of a causal relationship is unwarranted. Along with the fact that the epidemiological research which has observed a relationship with childhood leukaemia has limitations, SCENIHR (2015) considers the evidence to be too weak to determine whether or not the observed relationship is causal. When it comes to the relationship between EMF and cancer in general, IARC evaluated that the evidence in humans for a relationship between ELF magnetic fields and childhood leukaemia is limited. Nonetheless, IARC has classified ELF magnetic fields as ‘possibly carcinogenic to humans’ (Group 2B) because a relationship has consistently been observed which cannot be dismissed as being due to an artefact arising from study methods (IARC, 2002).

Power lines and childhood leukaemia: Group 2B

The possible effects of ELF EMF on health can be divided into the categories of 'scientifically proven' and 'scientifically unproven'. Exposure to ELF fields can result in the electrical stimulation of cells and tissues in the human body. If the ELF fields are sufficiently strong, scientifically proven health effects such as nausea, loss of balance, nerve pain, muscle contractions or disturbed heart function can occur. International safety limits on the strength of ELF EMF are set to prevent these health effects. Various other possible health effects have been examined, such as childhood leukaemia, but they are scientifically unproven. This raises the question as to why IARC classified ELF magnetic fields as 'possibly carcinogenic to humans'. IARC categorizes an environmental factor into Group 2B if limited evidence exists in humans and less than sufficient evidence in experimental animals.

In the case of ELF, the limited evidence in humans concerns the fact that a number of epidemiological studies found a relationship between long-lasting exposure to a certain level of ELF magnetic fields from power lines and an increased occurrence of childhood leukaemia. However, this relationship fails to show that long-lasting exposure to ELF magnetic fields from power lines actually causes an increase in childhood leukaemia. Other types of studies, such as animal studies, do not find a relationship between ELF exposure and leukaemia or are unable to discover how ELF magnetic fields could cause the development of childhood leukaemia.

No evidence of long-term adverse health effects from ELF *electric fields* has been found, although few studies have been performed. For this reason, IARC classified ELF electric fields as not classifiable as to their carcinogenicity for humans (IARC, 2002). This was confirmed recently by SCENIHR (SCENIHR, 2015).

A relationship between ELF magnetic fields (at strengths to which the general public may be exposed) and neurodegenerative diseases (primarily Alzheimer's disease and Amyotrophic Lateral Sclerosis (ALS)) has been examined. The results of these studies are inconclusive (WHO, 2007; ICNIRP, 2010; EFHRAN, 2012; SCENIHR, 2015; SSM, 2014). More research would be required to reach a more definitive conclusion (SSM, 2014; EFHRAN, 2012). No relation was found between ELF magnetic fields and cardiovascular diseases (WHO, 2007; ICNIRP, 2010; EFHRAN, 2012; SSM, 2014), changes in the neuroendocrine system (e.g. stress related hormones, melatonin) (WHO, 2007; ICNIRP, 2010), changes in general physiology (e.g. heart rate, respiration rate; SSM, 2014) or reproductive and developmental abnormalities (e.g. still birth, preterm birth, low birth weight; SCENIHR 2015; EFHRAN, 2012; ICNIRP 2010). However, SCENIHR (2015) concluded that more research is necessary to determine whether or not maternal residential ELF exposure during pregnancy may affect childhood health (i.e. asthma or obesity). Finally, there may be a relationship between exposure to ELF fields and the brain's electrical activity. It is unclear whether such changes are relevant to health and they generally occur at magnetic

field strengths greater than those found for public exposure near electricity installations (WHO, 2007; SSM, 2014). More research is necessary to determine whether a relationship exists between ELF magnetic fields and brain electrical activity, as the studies performed to date have been too heterogeneous, for instance regarding measured exposure duration and statistical methods (SCENIHR, 2015).

2.4.3 Radiofrequency fields (RF)

One established short-term effect of RF fields is the heating of the body or parts of the body. When people are exposed to strong RF fields for long enough, normal compensatory mechanisms to cool down the body may not suffice. This may cause damage to cells and tissues, particularly in low blood-flow areas vulnerable to heating, such as the eyes. However, RF fields to which the general public are exposed are normally not high enough to cause excessive heating of the human body. The European recommendation (1999) on the limitation of RF fields is based on preventing the harmful thermal effects of RF fields on humans.

One frequently discussed health effect of RF fields is their potential effect on cancer development, particularly in the head, due to mobile phone use. Scientific studies to date have failed to provide conclusive evidence for a relationship between RF fields and cancer (ICNIRP, 2009a; AGNIR, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014). However, an effect on cancer cannot be ruled out (Health Council of the Netherlands, 2013). Although some epidemiological studies have observed an association with tumours in the head, the longest duration of examined mobile phone use has been up to 15 years. Moreover, some of these studies have methodological problems. IARC classified RF fields as 'possibly carcinogenic to humans' (Group 2B) (IARC, 2013). They based their conclusions on studies which suggest that the intensive and long-term use of mobile phones may be related to glioma and acoustic neuroma on the side of the head where the phone is used. In their most recent report, SCENIHR concluded on the association between RF EMF and health that no clear evidence exists for an increased risk of tumours in the head, other cancers of the head and neck region or elsewhere in the body (e.g. leukaemia). They added that the most recent studies suggest that no association between mobile phone use and glioma exists (SCENIHR, 2015). Based on the results of the animal studies presented in a recent systematic review, it was concluded that it is highly unlikely that long-term continuous or repeated exposure to RF EMF may have initiative or promotive effects on the development of cancer (Health Council of the Netherlands, 2014).

With regard to potential effects in cells and tissues *in vitro*, more research may be needed to determine whether exposure to RF fields has a genotoxic effect (i.e. resulting in gene mutations, potentially causing cancer and reproductive defects) (ICNIRP, 2009a; SSM, 2014). SCENIHR concluded that evidence has been found for an absence of a genotoxic effect (SCENIHR, 2015). In addition, studies have been performed that examined other aspects of cell function. It is still unknown whether and in what way these processes relate to human health. Exposure to RF fields is unrelated to intracellular calcium signalling or reactive oxygen species production, although animal studies provide weak indications of possible effects on oxidative stress

(SSM, 2014). Furthermore, no evidence has been found for an effect from exposure to RF fields on cell proliferation, differentiation, apoptosis and cell transformation. However, more research could be done in the areas of exposure to RF fields and nitric oxide signalling, cellular gap junctions and receptor clustering (ICNIRP, 2009a).

Mobile telephones and brain tumours: Group 2B

The possible effects of RF EMF on health can also be divided into the categories of 'scientifically proven' and 'scientifically unproven'. Exposure to RF fields can cause heating of the body or parts of the body. The proven adverse health effects of RF fields that are sufficiently strong are heat stress and burns. International safety limits on the strength of RF EMF are set to prevent these adverse health effects. Various other possible health effects have been examined, but they are all scientifically unproven. This raises the question of why IARC classified RF EMF as being 'possibly carcinogenic to humans'. IARC categorizes an environmental factor into Group 2B if limited evidence exists in humans and less-than-sufficient evidence exists in experimental animals. Examples of environmental factors in group 2B are carbon nanotubes, coffee (bladder cancer), exhaust fumes and nickel.

In the case of RF, the limited evidence in humans concerns a possible long-term effect from mobile phone use. Some studies found that a heavy use of mobile phones was related to tumours in the head, but these studies have limitations, such as inadequacies in the exposure estimates based on records of past mobile phone use. The use of mobile phones has risen markedly in the past couple of years, so if there is a relationship with tumours in the head, one would expect an increase in the occurrence of tumours in the head. This increase has not been found in the past couple of decades based on cancer registries.

Research to date does not provide sufficient evidence of health effects other than the thermal effects of exposure to RF fields below the limits in the European recommendation. Thermal effects are effects caused by the heating of tissues due to exposure to time-varying fields (with frequencies above 100 kHz) of sufficient strength. SCENIHR advises that '*It must be stressed that, on a molecular level, by its principle nature, the interaction of RF EMF is non-thermal'. Therefore, the terms 'thermal' and 'heating' apply to the entire ensemble of particles and have no meaning for individual particles.*' (SCENIHR, 2015). Low-level exposure to RF fields is not related to neurological disease (ALS, dementia, multiple sclerosis, Parkinson's disease) (EFHRAN, 2012; SCENIHR, 2015). No scientifically conclusive evidence exists that RF fields affect cognitive functioning, such as memory (ICNIRP, 2009a; AGNIR, 2012; EFHRAN, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014), cardiovascular morbidity (AGNIR, 2012; EFHRAN, 2012; Demers et al., 2014), and endocrine systems (ICNIRP, 2009a; Demers et al., 2014; SCENIHR, 2015; SSM, 2014). Research so far shows that low-level RF fields have no effect on reproductive (e.g. human sperm) and

developmental outcomes (e.g. malformations at birth)(ICNIRP, 2009a; AGNIR, 2012; EFHRAN, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014) although more research may be necessary to confirm this (ICNIRP, 2009a; Demers et al., 2014; SSM, 2014). No effect on the eyes from exposure to low-level RF fields has been found (ICNIRP, 2009a; Demers et al., 2014), but research is lacking on any effect that exposure to RF fields might have on clarity or sharpness of vision (Demers et al., 2014). Various other, non-cancer health outcomes have been examined. Research suggests that RF field exposure at mobile phone strength may affect brain electrical activity and sleep (ICNIRP, 2009a; AGNIR, 2012; EFHRAN, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014). But the effect is relatively small and it is unknown what the significance of this is for an individual's health (AGNIR, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014).

WHO is preparing an Environmental Health Criteria monograph with an overall health risk assessment for RF EMF (WHO, 2014), but the final document was not available at the time the present report was written. ICNIRP is currently revising its guidelines on limiting exposure to EMF with frequencies ranging from 100 kilohertz to 300 gigahertz (ICNIRP, 2015), but has also stated that the 1998 guidelines are still valid for that frequency range.

2.4.4 Static and intermediate frequency fields

The established short-term health effects of exposure to (or movement in) strong static *magnetic* fields are vertigo, loss of balance, nerve stimulation and changes in blood flow (AGNIR, 2008; ICNIRP, 2009b). However, these effects do not occur when the field is weaker than the limit given in the European recommendation (Council of the European Union, 1999). Studies examining whether static magnetic fields with strengths below ICNIRP guidelines can cause health effects in the general public are sparse. Additional research is necessary before conclusions can be drawn (AGNIR, 2008; EFHRAN, 2012; SCENIHR, 2015; SSM, 2014). IARC concluded in 2002 that there is insufficient evidence to assess the health effects of static electric fields (IARC, 2002). The only known health effects of static electric fields are direct perception of fields through their interaction with body hair and discomfort from microshocks (WHO, 2006). Few studies have been performed on the potential health effects of exposure to intermediate frequency fields and no conclusions can be drawn on any health effects (EFHRAN, 2012; SCENIHR, 2015; SSM, 2014).

2.4.5 Electromagnetic Hypersensitivity (EHS)

Some individuals report that they are able to detect when they have been exposed to EMF with strengths that are below the limits in the European recommendation ('low-level EMF'). Some individuals also report that they experience a variety of physical and mental health problems, such as fatigue, headaches, depression, dizziness and problems with sleeping, after exposure to EMF. This phenomenon is called electromagnetic hypersensitivity, but various terms have been used (e.g. electrosensitivity or Idiopathic Environmental Intolerance with attribution to EMF). There are several definitions of electromagnetic hypersensitivity, but none of them is commonly agreed and scientifically accepted.

Societal concern about the possibility of a link between low-level EMF and non-specific physical symptoms has led to a number of epidemiological and experimental studies in the past ten years. Research conducted so far has not found scientifically conclusive evidence for the ability of people to detect low-level EMF or for a causal relationship between EMF and non-specific symptoms (ICNIRP 2009a; AGNIR, 2012; Demers et al., 2014; SCENIHR, 2015; SSM, 2014). More research may be necessary to confirm that no relationship exists. For instance, Demers and colleagues (2014) concluded that certain individuals who could be able to detect EMF exposure may have been overlooked due to group averaging or because they require longer exposure to develop symptoms. SCENIHR (2015) concluded that, while most of the experimental studies have not found an effect resulting from exposure, two studies have identified individual participants who may react to ELF magnetic fields. SCENIHR also concluded that replication of these findings is essential before any weight is given to these results (SCENIHR, 2015). Demers and colleagues (2014) urged that these individuals who have reported non-specific symptoms be taken seriously, regardless of the underlying cause, and that new ways to provide effective treatment should be investigated (Demers et al., 2014).

'Electrosensitivity'

Some patients consult their general practitioner (GP) with symptoms that are difficult to link to a specific disease. There are a variety of non-specific symptoms that differ from individual to individual, such as headaches, muscle and joint aches, cardiac arrhythmia, skin problems, fatigue and concentration problems. Some of these patients also specify that they experience these symptoms when they approach high-voltage power lines, broadcast transmitters, mobile telephones and the Wi-Fi modem at home. These symptoms are certainly real and may severely hamper their daily activities, sometimes resulting in sick leave from work or remaining permanently indoors. In the absence of scientific clarity on the cause of the symptoms, the GP must, whatever the cause may be, address the symptoms and offer help and advice.

2.4.6 Conclusions on the health effects of ELF and RF fields

There are three types of health effects with decreasing levels of certainty about the link with EMF: established health effects, uncertain health effects and potential health effects for which the evidence does not support a link with EMF.

Studies have been performed examining the various uncertain and potential health effects of exposure to ELF and RF fields. These studies have mainly focused on chronic exposures and exposures below the limits in the European recommendation or after chronic exposure. As illustrated in this chapter, the evidence for these health outcomes has been inconclusive and the reason for the inconclusiveness varies, depending on the type of potential health effect.

1 Established health effects (sufficient evidence)
The short-term health effects of high-level exposure to ELF fields via electrical stimulation and of RF fields via heating of the body have been scientifically established. Such effects, therefore, form the basis of the exposure limits in the European recommendation (Council of the European Union, 1999).

2 Uncertain health effects (limited or inconsistent evidence)
Based on the current findings, it can be concluded that the evidence for the various potential long-term health effects of exposure to ELF or RF fields with strengths below the limits in the European recommendation is limited or inconsistent.

While epidemiological studies have repeatedly shown a statistical relationship between exposure to ELF magnetic fields from power lines and a more frequent occurrence of childhood leukaemia, other studies have been unable to discover a mechanism that could explain this association. This means that the assumption of a causal relationship is unwarranted.

Evidence for a relationship between long-term mobile phone use and tumours in the head is inconsistent. The absence of consistency may be due to methodological inadequacies. Therefore, the existence of a relationship between exposure to RF fields from long-term mobile phone use and tumours in the head cannot be confirmed, but can also not be entirely dismissed.

3 Potential health effects (inadequate or absent evidence)
Research conducted so far has not found scientifically conclusive evidence for the ability of people to detect low-level EMF or for a causal relationship between EMF and non-specific symptoms. However, some individuals were observed detecting ELF fields and only more research could clarify this and show whether the effects are replicable for those individuals in other studies. This conclusion is more cautious than the pronounced conclusion of the Expert Group in 2007: "Research has not established any link between EMF exposure and the occurrence of EHS symptoms."

In general, these conclusions are consistent with those of WHO, SCENIHR and the 2007 Expert Group commissioned by the Irish Government (Expert Group, 2007; see text box).

Conclusions of the 'Irish' Expert Group (2007)
The 2007 Report of the Expert Group on the Health Effects of Electromagnetic Fields, commissioned by the Irish Government, provided science-based information on EMF (Expert Group, 2007). The Expert Group stated that its conclusions were consistent with those of similar reviews conducted by authoritative national and international agencies. It concluded:

- regarding ELF fields from high-voltage power lines:
  - "ELF fields induce electric fields and currents in tissues that can result in involuntary nerve and muscle stimulation, but only at very high field strengths."
  - "No adverse health effects have been established below the limits suggested by international guidelines."
  - "There is limited scientific evidence of an association between ELF magnetic fields and childhood leukaemia. This does not mean that ELF magnetic fields cause cancer, but the possibility cannot be excluded. Yet considerable research carried out in laboratories has not supported this possibility and, overall, the evidence is considered weak, suggesting it is unlikely that ELF magnetic fields cause leukaemia in children."
- regarding RF fields from base stations:
  - "RF fields act on the human body by heating tissue. (...) RF fields normally found in our environment do not produce any significant heating."
  - "While non-thermal mechanisms of action have been observed, none have been found to have any health consequence."
  - "So far, no adverse short or long-term health effects have been found from exposure to the RF signals produced by (...) base station transmitters. RF signals have not been found to cause cancer."
  - "RF signals from base stations and wireless technologies are much too low to affect health."
- regarding Electromagnetic hypersensitivity (EHS):
  - "Research has not established any link between EMF exposure and the occurrence of EHS symptoms."

3 Practices in dealing with EMF and health issues in selected European countries

3.1 Introduction

In this chapter, a number of practices is discussed which countries employ to deal with issues relating to EMF and health. The practices are related to the following five areas:

- implementation of the European recommendation on limiting exposure to EMF;
- resources dedicated to EMF and public health issues;
- interaction structures between (national) government, industry and citizens;
- citizen participation in decision-making on siting high-voltage power lines and base stations;
- governmental communication on EMF and health.

Selection of countries
Five counties were selected to study their practices regarding the aforementioned areas. Following discussions with the steering group assembled by DECLG, it was decided not to investigate the maximum range of available practices, but rather to select those that could be of interest to Ireland. Furthermore, the information gathered should be relevant to the Irish context. It was therefore decided that a number of countries in Europe would be selected. The countries selected for study were (in alphabetical order): France, the Netherlands, Slovenia, Sweden and the UK.

Information gathering
For the first area under study - Implementation of the European recommendation on limiting exposure to EMF - an up-to-date RIVM database of international policies on EMF was examined. As this database is restricted to information on formal legislation and exposure limits used in the selected countries and contains little information on the other areas, it was necessary to supplement this examination with consultations with experts in the five selected countries to check details of their regulatory and public participation frameworks. Prior to this consultation, the websites of the relevant Ministries and scientific institutes in these countries were searched to obtain information on these items. The experts were consulted via conference calls, which were used to clarify certain issues and fill in any gaps. To aid the consultation process, a questionnaire was constructed based on the five items under study and was sent to the experts in advance of the interview. Once the individual country reports had been compiled, they were sent to the experts interviewed for verification. In total, seven experts were consulted, six of whom gave feedback on the country reports. The list of experts who were consulted via conference calls and who provided comments on their country report can be found in Appendix 1.

The information gathered is presented in this chapter. Per item studied, the practices and structures per country are divided between those pertaining to ELF-fields and those pertaining to RF-fields.

3.2 Implementation of the European recommendation on limiting exposure to EMF

In 1999, the Council of the European Union published Recommendation 1999/519/EC on the limitation of exposure of the general public to EMF (0 hertz to 300 gigahertz). It contains basic restrictions for the current density induced and the rate of energy absorbed in the body by EMF and reference levels for the strength of EMF outside the body (see also Section 2.3.1). It is important to stress that the reference levels are not intended to be limits per se, although some countries may have chosen to define the reference levels as exposure limits.

The basic restrictions and reference levels in the European recommendation are derived from the 1998 Guidelines for limiting exposure to time-varying EMF by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (ICNIRP, 1998). The European recommendation adds the provisos that costs and benefits are taken into account, as well as the duration of exposure. ICNIRP is a recognized non-governmental organization of the World Health Organization and collaborates with WHO in the preparation of ICNIRP reviews of scientific evidence and in the development of WHO Environmental Health Criteria for static, ELF and RF fields (see Chapter 2). ICNIRP reviewed and restated its 1998 RF guidelines in 2009 (ICNIRP, 2009c) and these are currently undergoing revision (ICNIRP, 2015). It is not known whether the exposure limits will be revised. In 2010, ICNIRP published new guidelines for frequencies in the range between 1 hertz and 100 kilohertz (ICNIRP, 2010), which have not been adopted by the EU for public exposure as yet, but are included in the Electromagnetic Fields (EMF) Directive 2013/35/EU for occupational exposure. The new guidelines introduce restrictions for all parts of the body. The differentiation between body and head versus the extremities is no longer used.

Because the European recommendation is not legally binding, EMF policy in EU Member States can be divided between three different approaches (Stam, 2011). In the first group of Member States, the European recommendation has been translated into binding national legislation. This means that the basic restrictions and reference levels must be applied. In the second group of Member States, the national limits based on the European recommendation or ICNIRP are not binding, there may be more lenient limits, no regulation at all or ICNIRP levels are used as a basis for mandatory risk assessment, as is the case in the UK. In the third group of Member States, there are stricter basic restrictions and/or reference levels based on the precautionary principle or due to public pressure.

Table 2 presents some values for the reference levels used in Ireland and in the five countries studied and those from the European recommendation. For clarity, the table only gives values for the two frequency ranges, ELF (50 hertz) and RF (900, 1,800 and 2,100 megahertz). See Table 1 for sources in these frequency ranges. As explained in Section 2.3.1, reference levels have been derived from the basic restrictions. Several physical quantities are used as reference levels and these quantities are a measure of the strength of EMF outside the body. Most of the countries have adopted the values of the reference

levels in the European recommendation. The Netherlands has not formally adopted values for the reference levels and Slovenia has adopted stricter limits, which are also mandatory exposure limits in terms of the external field outside the body. A measured value of one of these physical quantities can be compared to the corresponding value in the table to determine whether a reference level is exceeded and what further action is needed (depending on the chosen EMF policy).

Table 2. Reference levels pertinent to power lines and base stations (partially based on Stam, 2011)

frequency		**reference level**	**recom-mended by EU**	**France**	**The Nether-lands**	**Slovenia *****	**Sweden**	**UK**	**Ireland**
ELF	50 Hz	electric field strength (V/m)	5,000	5,000 *	- **	*500*	5,000 ****	-	[5,000]
		magnetic flux density (μT)	100	100 *	- **	*10*	100 ****	-	[100]
RF	900 MHz (GSM)	electric field strength (V/m)	41	41	-	*13*	[41]	[41]	41
		equivalent plain wave power density (W/m^2)	4.5	4.5	-	*0.45*	[4.5]	[4.5]	4.5
	1,800 MHz (GSM)	electric field strength (V/m)	58	58	-	*18*	[58]	[58]	58
		equivalent plain wave power density (W/m^2)	9	9	-	*0.9*	[9]	[9]	9
	2,100 MHz (UMTS)	electric field strength (V/m)	61	61	-	*19*	[61]	[61]	61
		equivalent plain wave power density (W/m^2)	10	10	-	*1*	[10]	[10]	10

* For new or modified installations, technical conditions for electricity distribution.

** Recommendation to local government: create no new situations of long-term presence of children in magnetic flux density greater than 0.4 μT around power lines.

*** Applies to homes, hospitals, health resorts, public buildings, tourism buildings, schools, nurseries, playgrounds, parks, recreational areas. Otherwise limit for external electric and magnetic field strength equal to reference level in 1999/519/EC. Power frequency limits apply to new or reconstructed sources only.

**** Reduce exposure radically deviating from what could be deemed normal in the environment concerned, when possible, at reasonable expense with reasonable consequences.

All limits are given as root mean square (rms) value. Normal typeface: reference level for the external field in the meaning of Recommendation 1999/519/EC, derived from basic restriction. Application is mandatory unless value is in square brackets. Italic typeface: mandatory exposure limit in terms of the external field outside the body.

3.2.1 ELF fields: Transmission grid

3.2.1.1 France

In France the European recommendation has been translated into binding national legislation governing extremely low frequency fields for *new* or *modified* installations (Act of 17 May 2001, article 12bis) (République Française, 2001), see Table 2.

The Agency AFSSET (now fused to form ANSES) published a review document on ELF fields in 2010. The opinion paper on ELF fields found that no change to exposure limits was necessary, but that, as a precautionary approach, measures should be taken to avoid increasing the numbers of people exposed near high-voltage power lines (more than 50 kV). It was recommended that no new schools or other buildings where sensitive people would reside should be permitted within 100 metres of high-voltage power lines.

The Parliamentary Office for evaluation of scientific and technological options (OPECST) commissioned an investigation into the issue of health (human and animal) and the environmental impacts of high and very high-voltage (more than 200 kV) power lines (Raoul, 2010). The report, which was published in 2010 following the AFSSET report, recommended limiting exposure for children under 6 to 0.4 µT to address the association between residence near overhead power lines and increased risk of childhood leukaemia.

In 2010, the Ministry of Ecology, Energy and Sustainable Development and the Ministry of Economic Affairs, Industry and Employment published a report (Follenfant and Leteurtrois, 2010) to examine the feasibility of AFSSET's aforementioned recommendations. This report specified how a possible precautionary policy on EMF from power lines could be implemented. The report advised a limit of 1 µT for new situations, following the example of Switzerland and advised the implementation of this policy through local spatial planning procedures. Perhaps in preparation for this, an Act was published in 2011 (with supplementary test in 2012) to provide monitoring of EMF near power lines.

In 2013, the Ministry of Ecology, Sustainable Development and Energy issued a non-binding instruction to local authorities to avoid, as much as possible, building new premises in which sensitive persons would reside (hospitals, nurseries, schools, etc.) in areas where the magnetic field level is above 1 µT due to power lines.

In France, a regulation has been in force since 2001 that specifies the technical conditions for the distribution of electricity. This regulation states that, for all new installations in permanent use for the supply of electricity to the public or for rail transport using electricity, the maximum electric field strength should be 5,000 V/m in places accessible to the public and maximum magnetic flux density should be below 100 µT.

Furthermore, a law passed in 2000 gives the regional authority (prefecture) the authority to forbid the construction or remodelling of houses, schools, retirement homes, hospitals and nursing homes within a certain distance from high-voltage power lines and masts with a

voltage of 130 kV or higher. Maximum distances were stipulated in 2004, which depend on the voltage (République Française, 2004).

3.2.1.2 The Netherlands

In the Netherlands, the national limits based on the European recommendation or ICNIRP are not binding in regard to extremely low frequency fields. However, in 2005 the Ministry of Infrastructure and the Environment issued a recommendation, as a precautionary policy, that local authorities and grid companies should avoid creating new situations involving the long-term presence of children in areas close to high-voltage overhead power lines with an annually averaged magnetic flux density greater than 0.4 μT (0.4% of the reference level in the European recommendation). This recommendation was based on the scientific evaluation conducted by the Health Council of the Netherlands, which found - based on epidemiological studies - indications of an association between residence near overhead power lines and the incidence of childhood leukaemia (Health Council of the Netherlands, 2000). In March 2014, the Ministry of Infrastructure and the Environment asked the Health Council for an update of this evaluation following several publications that found no indications for the association. The Government can use this new evaluation, which is planned for 2016, to assess whether the present precautionary policy needs to be reconsidered.

Based on criteria set to remain reasonable (considering societal impact; costs), the precautionary policy is limited to new situations since the health effects are unclear and because measures in existing situations often have substantial social consequences (such as the relocation of dwellings or high-voltage overhead power lines). Furthermore, new situations often offer many more options and prevention can be considerably cheaper than redevelopment. It is therefore recommended that when determining spatial plans and the trajectory of high-voltage overhead power lines, or in the event of changes to existing plans or existing high-voltage overhead power lines, the creation of new situations in which children are present for a long period in the areas around high-voltage overhead power lines within which the annually averaged magnetic field is greater than 0.4 μT (the magnetic field zone) should be avoided as much as is reasonably possible (State Secretary of Housing, Spatial Planning and the Environment, 2005).

Although there is no link with the precautionary policy on situations near overhead power lines, there is additional policy under construction for existing power lines: "... The government wants some high-voltage power lines in the vicinity of homes to be moved underground. The owners of some 400 homes where this will not be possible can have their homes bought from them under a government scheme, starting in 2017. It will take 15 years to move the overhead power lines underground, and the House of Representatives and Senate will need to approve the necessary legislative amendments. The total cost of the project will run up to € 580 million. ..." (Government of the Netherlands, 2015a); and also: "... The scheme will be voluntary; nobody will be forced to move house. Homeowners will qualify if their homes are located directly beneath 220 or 380 kV high-voltage power lines or if their homes are located directly beneath 50, 110 or 150 kV high-voltage

power lines and outside a residential cluster. ...” (Government of the Netherlands, 2015b).

3.2.1.3 Slovenia

In Slovenia, the reference levels are stricter than those in the European recommendation in regard to extremely low frequency fields. A limit of 10% of the reference level in the European recommendation applies to new or modified sources near homes, schools, kindergartens, hospitals, sanatoria, playgrounds, parks, recreational areas, public buildings and buildings with a tourist destination.

These threshold values were announced by the Government in 1996 in a Decree on Electromagnetic Radiation in the Natural and Living Environment. As a result of the concern about the potential health effects of EMF and political pressure, the Government judged that the state of the science in this field justified the application of protective measures in the form of environmental protection. Thus, the principle of precaution was enforced (Gajšek, 2004). The Decree is enforced by the Slovenian Radiation Protection Administration, a subsidiary of the Ministry of Health (Republic of Slovenia Ministry of Health, 2015).

3.2.1.4 Sweden

In Sweden, the reference levels in the European recommendation have been implemented in non-binding recommendations pertaining to extremely low frequency fields.

In addition, in conjunction with the Environmental code and legislation of 1998, guidance for policy makers has been published which explains how the precautionary principle is to be applied to electric and magnetic fields of 50 hertz. For existing situations, exposure to a magnetic flux density that differs strongly from what could be deemed normal in the environment concerned should be reduced when possible at reasonable cost and with reasonable consequences. For new situations, an effort has to be made to reduce exposure when designing and constructing sources of ELF fields (Stam, 2011).

In the context of this national guidance, Svenska Kraftnät, the Swedish National Grid has adopted a specific precautionary policy. When planning new power lines (220 and 400 kV), Svenska Kraftnät shall ensure that magnetic fields do not normally exceed 0.4 μT in areas where people either live or stay for long periods of time. When renewing concessions for existing power lines, Svenska Kraftnät shall consider adopting measures that reduce exposure to magnetic fields where they deviate significantly from normal conditions, provided that the costs and consequences are reasonable (Svenska Kraftnät, 2010).

3.2.1.5 United Kingdom

With respect to public exposure in the United Kingdom, government policy is to comply with the ICNIRP guidelines (National Grid, 2015a) in the terms of the 1999 recommendation (National Grid, 2015b). There is no specific legislation for the guidelines and they are recommended through UK health and safety legislation.

Public Health England (PHE) advises that the exposure guidelines set by ICNIRP should be adopted. This advice is based on a comprehensive scientific review published in 2004 by the former National Radiological Protection Board (NRPB) (McKinlay et al., 2004). NRPB merged into the Health Protection Agency in 2005 and then into Public Health England in 2013. The UK Government expects the guidelines to be implemented in line with the terms of the European recommendation on public exposure and expects the risks and benefits of action to be considered in implementing the guidelines.

Although the ICNIRP guidelines are considered to be protective of the general population as a whole, the Stakeholder Advisory Group on Extremely low frequency electric and magnetic fields (SAGE) was set up to consider additional precautionary measures in response to the unexplained association between power frequency magnetic fields and childhood leukaemia. Information on the SAGE process can be found in Section 3.4.1.5.

SAGE recommended to the Government, *inter alia,* the introduction of optimum phasing (relative order of the three phases of each of the - mostly - two circuits) for high-voltage power lines in its First Interim Assessment "Power lines and Property, Wiring in Homes, and Electrical Equipment in Homes" (SAGE, 2007; see also Section 3.4.1.5). In the Government's response to that report (HM Government, 2009), it supported the SAGE recommendation and agreed to work with the electricity industry to introduce optimum phasing of high-voltage overhead power lines in those circumstances in which this would reduce public exposure to ELF fields and it would be cost effective to do so. This has led to the voluntary Code of Practice "Optimum phasing of high-voltage double-circuit power lines" (Department of Energy and Climate Change, 2012a). This Code of Practice sets out key principles for the electricity industry to undertake optimum phasing of all new high-voltage (132 kV and above) double-circuit power lines and to convert existing power lines, when practicable. It also sets out how Government will monitor compliance with the code.

The companion Code of Practice "Power Lines: Demonstrating compliance with EMF public exposure guidelines" (Department of Energy and Climate Change, 2012b) specifies how compliance with ICNIRP guidelines for exposure of the public to electric and magnetic fields in the UK will be assessed. The quantitative limits in these guidelines concern the direct effects of the fields, i.e. the induction of currents and electric fields within the body. The guidelines also cover indirect effects that occur as a result of charges induced on conducting objects in electric fields. This Code of Practice also outlines procedures for assessing EMF compliance for underground cables and substations.

The aim of these Codes is to provide assurance and clarity to the public, local authorities, the electricity industry, statutory stakeholders and relevant consenting bodies about how public exposure to the electric and magnetic fields produced by high-voltage power lines will be reduced and monitored, and about the measures the electricity industry will use to calculate and demonstrate compliance with the ICNIRP guidelines in terms of the European recommendation.

Another voluntary Code of Practice "Power Lines: Control of Microshocks and other indirect effects of public exposure to electric fields" (Department of Energy and Climate Change, 2013a) has also been published. This Code relates to situations, such as when new power lines are designed, in which it is necessary to apply the public exposure guidelines to these indirect effects.

The ICNIRP guidelines are relevant for the design and construction of new high-voltage power lines located near existing residential properties. The Planning Act 2008 introduced a threshold for development consent for overhead lines of 132 kV or greater to be considered as Nationally Significant Infrastructure Projects (NSIPs). The Planning Act 2008 (as amended by the Localism Act 2011) passed responsibility for dealing with development consent applications for NSIPs to the Planning Inspectorate, which examines applications and makes recommendations to the Secretary of State at the Department for Energy and Climate Change (DECC) with respect to decisions on energy applications. Decisions are taken in accordance with the Overarching National Statement for Energy in conjunction with the National Policy Statement for Electricity Networks Infrastructure (EN-5) (Department of Energy and Climate Change, 2013a). The latter policy statement includes an impacts section in which EMF are considered and a simplified route map for dealing with EMF. The impacts section states that Government policy requires that any exposure of the public should comply with the ICNIRP guidelines in terms of the European recommendation, that the electricity industry has agreed to follow this policy and applications should show evidence of this compliance (see also Section 3.4.1.5).

3.2.2 RF fields: Base stations for mobile communication

3.2.2.1 France

In France, the European recommendation was translated into binding national legislation with regard to radiofrequency EMF in 2002 (decree n° 2002-775, signed 3rd May 2002). This means that the basic restrictions and reference levels must be applied.

For each new base station site, the operator must file a statement of compliance concerning threshold values for public exposure with the National Frequencies Agency (ANFR).

On January 29, 2015 the National Assembly adopted a law on moderation ('sobriété'), transparency, information and consultation on exposure to EMF (Assemblée Nationale, 2015)[1]. According to this new law:

- limits for EMF from electronic communication at places where the public is exposed will be established by decree;
- results of measurements made by official bodies will be made publically available by ANFR;
- if measurements are taken within homes, the results will be made available to the occupants and owners;
- owners/operators of antennas within a municipality's territory will provide the authorities, on request, with the technical dossier of

[1] This adoption took place during the review process of this report.

the installation; in new or altered situations, the technical dossier will be submitted for approval; the authorities will make this information available to the public, who will have the opportunity to comment on it; if need be, the authorities will set up a dialogue between the different stakeholders;
- ANFR will annually measure levels of exposure; ANFR will define levels of atypical exposure and will inform the authorities about this; operators are obliged to take technically feasible measures to reduce these field strengths, whilst ensuring that coverage and the quality of service is guaranteed.

In addition, the law includes obligations regarding the use of mobile phones and Wi-Fi. Moreover, within one year after this law has taken effect, the Government will provide Parliament with a report on electrosensitivity.

3.2.2.2 The Netherlands

In the Netherlands, the limits for radiofrequency fields from the European recommendation have not been translated into binding national legislation. For base stations, however, the basic restrictions and reference levels are respected via the National Antenna Policy. The purpose of this policy is to guarantee that there is sufficient space for the installation of base stations, as long as they do not jeopardize public health, the environment and public safety. Under this policy, the Government, the Association of Netherlands Municipalities and the five providers of mobile telecommunication agreed, through the Antenna Covenant, to respect the basic restrictions and reference levels (Netherlands National Government, 2010). Base stations lower than 5 metres do not need a building permit, but these masts may be positioned on existing buildings such as church towers and the rooftops of tall buildings. On an *ad hoc* basis, the Radiocommunications Agency Netherlands monitors the exposure from base stations at a random sample of locations that are open to the general public.

3.2.2.3 Slovenia

In Slovenia, the limits are stricter than those in the European recommendation with respect to radiofrequency EMF. In contrast to power frequency limits, the stricter radiofrequency limits apply to both new and existing sources. For frequencies higher than 10 kilohertz, exposure limits for electric and magnetic field strengths of 31% of the reference levels in the European recommendation (10% for power density) apply in "sensitive areas" (homes, schools, hospitals, etc.). In all other locations, the reference levels in the European recommendation are applied as *de facto* exposure limits that may not be exceeded (Stam, 2011).

These threshold values were announced by the Government in 1996 in a Decree on Electromagnetic Radiation in the Natural and Living Environment. As a result of the concern about the potential health effects of EMF and political pressure, the Government judged that the state of the science in this field justified the application of protective measures in the form of environmental protection. Thus, the principle of precaution was enforced (Gajšek, 2004). The Decree is enforced by the Slovenian Radiation Protection Administration, a subsidiary of the Ministry of Health (Republic of Slovenia Ministry of Health, 2015).

3.2.2.4 Sweden

In Sweden, the reference levels in the European recommendation have been implemented in non-binding recommendations pertaining to radiofrequency EMF (Swedish Radiation Safety Authority, 2008). If the limit values in the European recommendation are exceeded, the Swedish Radiation Protection Authority may, pursuant to the Radiation Protection Act, issue orders obliging the transgressor to comply with the limits (European Commission, 2002). In addition, there is a recommendation concerning the hands-free use of cell phones (Nordic competent Authorities, 2004).

3.2.2.5 United Kingdom

In the United Kingdom, as in the case of low frequency EMF, the guidance on limits for radiofrequency EMF is recommended through UK health and safety legislation.

The UK Government expects the guidelines for radiofrequency EMF to be implemented in line with the terms of the European recommendation on public exposure and expects the risks and benefits of action to be considered in implementing the guidelines.
In England, base stations are handled on a local authority scale through the National Planning Policy Framework and related guidance (Department for Communities and Local Government, National Planning Policy Framework, 2012). Planning legislation applies to "development", and applications are required for larger and more visually obvious sites, such as fixed masts and prominent antennas on buildings. Smaller and less conspicuous sites, such as microcells and picocells, would not normally require planning permission.

Applications for telecommunications development should be supported by the necessary evidence to justify the proposed development (see also Section 3.5.2.5). This should include, inter alia:

- for *an addition to an existing mast or base station*, a statement that self-certifies that the cumulative exposure, when operational, will not exceed ICNIRP guidelines; or
- for *a new mast or base station*, evidence that the applicant has explored the possibility of erecting antennas on an existing building, mast or other structure and a statement that self-certifies that, when operational, ICNIRP guidelines will be met.

Evidence of prior consultation of parties, such as nearby schools, is also required (see also Section 3.5.2.5).

The Mobile Operators Association signed up to a voluntary code of best practice on Mobile Network Development in 2002, which applied across the UK. As the planning regulations in England changed in 2013 and technology and industry have also changed since 2002, the code was updated in 2013 for England (Mobile Operators Association, 2013) (see also Section 3.5.2.5). As the regulation in the other administrations change, the operators will seek to update the code in line with changes, though keeping the basic principles the same, such as ICNIRP certification and early consultation. In the code, the mobile operators state their commitment to complying with the ICNIRP public exposure guidelines. They are committed to ensuring that all sites are compliant

and that certificates of ICNIRP compliance are provided with all applications for planning permission.

3.3 Resources dedicated to EMF and public health issues

3.3.1 ELF fields: Transmission grid

3.3.1.1 France

In France, Réseau de Transport d'Electricité (RTE) is the French electricity transmission system operator. It is a public service company responsible for operating, maintaining and developing the network. Most high-voltage power lines in France are overhead and the "extra high-voltage" transmission lines, as defined by RTE, have voltage levels of 225 and 400 kV (the frequency is 50 Hz). There are some high-voltage underground cables but these are mainly in towns. Besides the interconnector between France and Spain, there are no DC transmission lines.

The General Directorate of Health within the Ministry of Social Affairs and Health (République Française, 2014a) is the government department that manages health issues related to EMF. The French Agency for Food, Environmental and Occupational Health & Safety, ANSES, assesses the risks to health of environmental impacts, including exposure to EMF (ANSES, 2014). ANSES is a public administration organisation accountable to the Ministries of Health, Agriculture, the Environment, Labour and Consumer Affairs. Within the department of risk assessment, the unit on physical exposures deals with non-ionizing radiation (including ELF and RF fields) to the tune of ca. 2 FTE. As ANSES has coordinating tasks to fulfil, they also hire external experts when necessary.

Since the publication of a regulatory text in 2012 resulting from the environmental law "Grenelle 2", the electricity transmission service operator RTE has been in a position to fund measurements in the vicinity of power lines above 50 kV if exposure to the public is expected. These measurements are performed by independent laboratories following a standard protocol. The results of these measurements are given to ANSES and they are made public via a website administered by RTE, which gives access to the measurement results via an interactive map (RTE, 2014). Every year up to 2017, RTE will give ANSES the results of the previous year's measurements (around 500 measurements per year). After 2017, measurements will focus on new lines or new populations exposed and a 10-year control cycle. There is an agreement between RTE and the Association of Mayors of France, (outside any regulatory text) whereby a Mayor may request RTE to fund a measurement to be performed by an independent laboratory (AMF et RTE, 2010). This agreement also gives citizens the possibility to request a measurement through their Mayor.

There is no dedicated research programme for ELF-fields in France. However, there are calls for research into ELF-fields within the Environmental Health and Occupational Health research programme. This programme has a total budget of 8 million euros.

3.3.1.2 The Netherlands

High-voltage overhead power lines in the Netherlands have five voltage levels: 380, 220, 150, 110 and 50 kilovolts (kV) and consist mostly of two circuits. The frequency is 50 hertz. TenneT is the national transmission system operator that manages all high-voltage power lines, except the 50 kV lines. The 50 kV lines are managed by local system operators. The total length of high-voltage overhead power lines amounts to nearly 4,000 km. There are some DC sea cables that are used to transport electricity from Norway and from offshore wind farms. DNV GL (former KEMA) is one of the consultants that supports TenneT with technical advice.

The Ministry of Infrastructure and the Environment, and the Ministry of Economic Affairs are the main national government actors with regard to extremely low frequency fields generated from high-voltage overhead power lines, especially with respect to planning new lines. TenneT initiates the process of planning a new or changing an existing overhead power line. The local authority is the main actor in the siting of new "sensitive designated uses", such as dwellings, crèches and day-care centres, near existing overhead power lines. RIVM supports the precautionary policy by managing a website with a map of the transmission and distribution grid showing, per (type of) power line, an indication of the width of the magnetic field zone and a Guideline for calculating the extent of the magnetic field zone in a specific situation.

It is difficult to estimate the number of staff in governmental organizations and attribute it to EMF and health policy regarding extremely low frequency fields generated from overhead power lines. It amounts to ca. 3 FTE (including Ministries, Health Council, Antenna Bureau and RIVM). The additional financial resources amount to roughly € 0.2 – 0.4 million, including funding of (part of) the Knowledge Platform on EMF (see Section 3.6.1.2).

The Netherlands started a research programme "Electromagnetic Fields & Health" under the coordination of the Netherlands Organisation for Health Research and Development (ZonMw) in 2007. In 2013, the last projects of the € 16.6 million budget were granted. Some projects deal with extremely low frequency fields or radiofrequency fields, respectively, and some deal with both. The programme was prompted by public concern about the possible health impact of exposure to EMF. Besides generating scientific information, the programme is meant to boost Dutch research into EMF and their possible impact on health and to increase the number of experts in the Netherlands, e.g. for the permanent Electromagnetic Fields Committee of the Health Council of the Netherlands. The Health Council of the Netherlands is an independent scientific advisory body that provides the Government and Parliament with advice in the field of public health and health/health care research.

3.3.1.3 Slovenia

The public company Electricity Transmission System Operator (ELES) is the transmission network system operator in Slovenia. It is owned by the Republic of Slovenia. Most high-voltage power lines are overhead and the transmission network consists of facilities on three different

voltage levels: 400 kV, 220 kV and 110 kV (the frequency is 50 Hz). There are no DC transmission lines.

The Ministry for Agriculture and the Environment is the competent authority responsible for enforcing the Decree on Electromagnetic Radiation in the Natural and Living Environment (see also Implementation of the European recommendation). This Ministry also published the "Rules on initial measurements and operational monitoring of sources of electromagnetic radiation and the conditions for their implementation", in which the monitoring of sources of EMF is determined in more detail.

The Slovenian Radiation Protection Administration (SRPA) is part of the Ministry of Health and its area of competence is dealing with concerned citizens. At the SRPA, two persons work a few hours per month on average on EMF issues. This mainly involves answering questions from citizens via email or telephone to promote awareness. SRPA does not have financial resources dedicated specifically to EMF issues. However, it has financed some measuring campaigns in the past at the cost of a few 1,000 euros per year.

The Institute for Non-Ionizing Radiation (INIS) is an independent, non-governmental organization that conducts research and development in the field of EMF (INIS, 2014a). The Institute is an accredited body for the measurement of EMF in the frequency range of 0-40 GHz and it was authorized by the then Ministry for Environment and Spatial Planning to perform initial measurements and the operational monitoring of sources of EMF.

There is no national measurement programme defined by legislation. Initial measurements and operational monitoring should be provided by the operator of the source (in accordance with the Rules mentioned above). The operator, ELES, is responsible for the management and implementation of this. The results are reported to the Environmental Agency, which falls under the Ministry of Environment and Spatial Planning and oversees the implementation of legislation in this field. The operational monitoring data can be accessed via the website of the Environmental Agency (ARSO, 2014).

3.3.1.4 Sweden

Svenska Kraftnät manages Sweden's national grid, which is owned by the Swedish state. The national grid includes about 15,000 km of overhead power lines with voltage levels of 220 and 400 kV (frequency is 50 Hz). There are some high-voltage underground cables, but these are mainly located in cities. Most transmission lines are AC, although there are some high-voltage DC lines and cables.

In Sweden, the main national authorities involved in EMF and health are the Swedish Radiation Safety Authority (SSM), the National Board of Housing, Building and Planning, the National Electrical Safety Board and the National Board of Health and Welfare. The Swedish Public Health Agency was established on January 1, 2014 and most of the work concerning environmental health (including the health effects of exposure to EMF) at the National Board of Health and Welfare has been transferred to this new agency. The National Board of Health and Welfare still deals

with disability allowances for electrosensitive people. The fact that electrosensitive people may receive an allowance does not imply that the National Board of Health and Welfare believes that electromagnetic sensitivity is a disease or that EMF cause electromagnetic sensitivity. Rather, this is a reflection of how disability is defined in Sweden. The Swedish Work Environment Authority deals with EMF issues relating to the working environment.

SSM reports to the Ministry of the Environment; it has approximately 2-2.5 FTE dedicated to EMF issues (both ELF and RF fields) and other costs of approximately. € 60,000 /year, which include laboratory and exposure measurement costs. The other aforementioned authorities have ≤ 1 FTE per authority for these issues. Local authorities are responsible for supervising exposure levels and they also deal with health issues; SSM is responsible for providing guidance to local authorities. As an expert authority, SSM also has a mandate to increase the level of knowledge about EMF, e.g. through training programmes. For example, it has given courses to local authorities focused on EMF in relation to health aspects and national legislation. Furthermore, the agency answers questions on EMF from the public; these can be sent via email or the public can call one of the agency's experts during a dedicated time slot of 1.5 hours, twice a week.

SSM does not have a permanent monitoring or measurement programme in place. However, their most recent measurement programme, conducted in 2010/2011, assessed the strength of low frequency magnetic fields in 193 Swedish dwellings from sources such as railways, power lines, transformer stations, household appliances and stray currents (SSM, 2012). The purpose of the study was to assess what a normal level is (< 0.2 μT) for low frequency magnetic fields in residential environments and what can be considered a sharply increased level (> 2 μT). These results are useful when communicating with the public.

In 2002, the responsible authority in Sweden set up an international Scientific Council for EMF and health. The work of the Scientific Council now falls under SSM. The remit of the Scientific Council is to follow and evaluate scientific developments and to give advice to SSM. Based on major scientific reviews, the Scientific Council has produced a series of annual reports that discuss and assess relevant new data and put these in the context of available information. This will result in a gradually developing health risk assessment of exposure to EMF. The annual budget for this work is around € 87,000.

3.3.1.5 United Kingdom

In the United Kingdom, the largest power lines (400 kV and 275 kV) are owned and maintained by National Grid, a private company. In England and Wales, there are 7,000 km of overhead transmission lines at 275 kV and 400 kV (frequency of 50 Hz). The high-voltage power lines are mainly overhead, but in some high density areas there are underground cables. There are some DC transmission lines and these are mostly used for importing electricity from mainland Europe and from offshore wind farms.

The main authorities involved in ELF fields and health are Public Health England (PHE), the Department of Health, the Health and Safety

Executive, the Department of Energy and Climate Change, the Department of Business, Innovation and Skills and the Department for Communities and Local Government. The Department of Health and the Department of Energy and Climate Change each have around 0.5 FTE for EMF (both ELF and RF fields) and health.

PHE is an Executive Agency, sponsored by the Department of Health, which aims to protect and improve the nation's health and well-being, and reduce health inequalities. It has approximately 5 FTE in the EMF dosimetry group (both ELF and RF fields) and core funding for two laboratories, based at the PHE Centre for Radiation, Chemicals and Environmental Hazards (CRCE). PHE also pursues research funding opportunities and operates a services department which aims to support UK industry in demonstrating compliance with the ICNIRP guidelines.

At present, there is only one dedicated research programme on ELF fields, which is funded by the EMF Biological Research Trust (EMFBRT, 2010). The Trust was set up after the privatization of the electricity supply industry to continue its promotion of external, independent research into the possible biological effects of ELF EMF and their relevance, if any, to human health. A Scientific Advisory Committee (EMFBRT, 2011), which is independent of the electricity supply industry, sets up the research strategy. A major focus of the research programme is on the mechanism of possible biological effects. The Trust's activities are funded by donations from National Grid.

The UK Childhood Cancer Study (UKCCS) was a large and comprehensive case-control epidemiological analysis of the possible causes of childhood cancer. One of the themes under study was childhood exposure to power frequency EMF. Most of the UKCCS research in this area has now been completed. However, the Research and Steering Committee has identified EMFs as one of the continuing strategic areas of the study. Other recent epidemiological studies of note include those published by The Childhood Cancer Research Group (CCRG), the University of Oxford, and the Small Area Health Statistics Unit (SAHSU), Imperial College London.

There are currently no monitoring or measurement programmes, although the Electricity Networks Association offers a measurement service for concerned individuals. The National Grid maintains a website with information on ELF fields (National Grid, 2015c). It also has an EMF Helpline and a dedicated email address for questions from the public on EMF and health issues.

3.3.2 RF fields: Base stations for mobile communication

3.3.2.1 France

In France, the Ministries of Health, Environment and Electronic Communications are involved in managing issues related to RF fields and the agency ANSES assesses potential health risks from exposure to EMF; for ANSES' resources (see also Section 3.3.1.1).

The National Frequencies Agency (ANFR, 2014a), a public administrative institution reporting to the Minister in charge of electronic communications, was created by the Telecommunications Regulation Act

in 1996. The Agency ensures compliance with the limit values for public exposure (see also Section 3.2.2.1).

ANFR has 3 members of staff who deal with issues concerning RF fields and public exposure. They spend about half their time on communication activities, such as answering questions from the public via the website, answering enquiries from local and regional authorities and attending consultation meetings. The remainder of their work is technical and related to their responsibilities for measurements.

In 2012, the Ministry of Ecology, Sustainable Development and Energy published a set of regulatory texts creating a national monitoring and measuring mechanism funded by a 5% tax on network operators. This tax is also used to fund research, see below. Since 2014, anyone can request an exposure measurement (at home and in public areas). The measurements are free, provided that the person completes a form, which is then signed by an authorized body, such as the Mayor of their local authority. ANFR is responsible for the management and implementation of these measurements, which are carried out by private companies following a measurement protocol defined by ANFR. The results of these measurements are given to ANSES, and they are made public on the website Cartoradio (ANFR, 2014b), which is managed by ANFR. The forecast for 2014 was that approximately 5,000 measurements would be carried out in total: 4,000 for the general public and 1,000 for the Ministry of Environment for a national campaign. The estimated budget for the measurements in 2014 is 2.3 million euros. In previous years, around 1,000 site measurements were carried out each year, either at the request of the public or randomly within the framework of agreements between operators and local authorities.

As well as containing the data of approximately 30,000 measurements, Cartoradio also displays the location of the radio frequency transmitters present in France on a map. In May 2012, 159,000 authorized installations were represented in Cartoradio, 53,000 of which were mobile phone installations using GSM 900 or GSM 1800 and 49,000 installations using UMTS. There is also a version of Cartoradio for mobile phones that is available at the AppStore and GooglePlay.

Since 2010, the main research funding for the health effects of radiofrequency fields has come from the aforementioned 5% tax on network operators. Two million euros per year of this tax are allocated to research funding. Since 2011, ANSES has been in charge of developing and launching annual calls for research projects in this field using this budget.

Between 2005 and 2010, the Foundation “Santé et Radiofréquences” (Health & RF) coordinated research on the health effects of EMF. The Foundation launched four calls for proposals and selected 25 projects covering the following areas: epidemiology, clinical studies, animal studies, in vitro studies, methodology, dosimetry and exposure measurement, humanities and sociology. The first results of these studies were published in 2009.

The topics of its last call were:

- impact of exposure to RF fields on children, teenagers and future generations;
- greater knowledge about exposure of the general population and workers;
- impact of cumulative exposure from different sources;
- impact of long-term low-level exposure;
- management of public debates on the issue of RF fields and health.

In October 2013, ANSES released its opinion on radiofrequency health effects (ANSES, 2013). The Agency made a number of recommendations on base stations:

- that the development of new network infrastructures should be subject to prior studies concerning the characterization of exposures, taking into account the accumulation of existing levels with those that would be generated by new installations, in order to promote concerted discussion regarding new installations or the modifications of transmitters;
- documenting the conditions pertaining to existing installations that cause the highest exposure of the public and investigating to what extent these exposures can be reduced by technical means.

3.3.2.2 The Netherlands

In the Netherlands, the Ministry of Infrastructure and the Environment, and the Ministry of Economic Affairs are the main national government actors with regard to radiofrequency fields from base stations. The Radiocommunications Agency Netherlands, a specialized agency of the Ministry of Economic Affairs, is responsible for obtaining and allocating frequency space and monitoring its use. This is done by a permanent network and by mobile measurement systems mounted on cars. Each year the network of main roads is covered. The public is not able to order a measurement.

The Netherlands has five operators who have gained permission to use frequency space for mobile telecommunication. The operators work together within the mobile operators association MoNet on subjects such as providing information to the public and negotiations with the authorities. In the roll out of their telecommunication networks, they need siting locations. Local authorities are involved in the siting process for new base stations. The Netherlands has approximately 36,000 antenna installations and this number is still rising, mainly due to the roll out of the 4G networks and due to increasing capacity demands.

The Antenna Bureau, which falls under the Radiocommunications Agency Netherlands, is the information agency of the Dutch Government concerning antennas. The Bureau gives advice and information on the technical aspects of antennas, the regulatory framework, and health effects. Each year, the advisors of the Bureau answer about 1,000 questions, contribute to around 75 local information meetings held throughout the country (on request) and give about five courses free of charge: several basic courses, one refresher course and also courses for special groups, such as roof workers. They also contribute to

events for government officials, general practitioners or owner-occupiers' associations.

The Antenna Bureau manages the public disclosure of the national Antenna Register, which provides information on technical data of base stations and other transmitters, such as broadcasting transmitters and those used by radio amateurs (date of first use; height of the antenna above ground level; direction of the main beam; frequencies; emitted power; safe distance: the distance in the main beam at which the exposure equals the value of the reference level for members of the general public). The Antenna Register also contains the locations of the antennas (name of municipality and geographical coordinates according to WGS84 with an accuracy of 15 m). A study will be carried out to make the national register more future-oriented (e.g. safe distance for workers and employees, as well as how to deal with 'hopping' or dynamic frequency-usage). Each month, the Bureau updates the Register for the public; historic data from 2011 onwards are available on the website (Antennebureau, 2015).

It is difficult to estimate the number of staff in governmental organizations and attribute it to EMF policy regarding radiofrequency fields from base stations; it is approximately. 4 - 5 FTE (including Health Council, Ministries, Antenna Bureau and RIVM; excluding specialists and technical people within the Radiocommunications Agency Netherlands that deal with e.g. regulation and measuring). The extra financial resources amount to roughly € 0.2 – 0.4 million, which includes funding of (part of) the Knowledge Platform on EMF (see Section 3.6.1.2).

The Ministry of Infrastructure and the Environment is responsible for setting exposure limits. The National Institute for Public Health and the Environment (RIVM) supports the Ministry of Infrastructure and the Environment on a structural basis in formulating and executing policy to protect citizens from the potential negative health effects of exposure to EMF. RIVM participates in the research programme "EMF & Health" and the Knowledge Platform on EMF.

The research programme "Electromagnetic Fields & Health" conducted by the Netherlands Organisation for Health Research and Development (ZonMw) started in 2007 and most projects end in the period 2010-2019. Projects are on both ELF and RF, as was discussed in Section 3.3.1.2. The Institute for Risk Assessment Sciences (IRAS, University of Utrecht) is involved in the COSMOS study (Imperial College London, 2014a) and in the FP7 projects Mobi-kids (CREAL, 2015a) and GERoNiMO (Generalised EMF Research Using Novel Methods) (CREAL, 2015b). The goal of this project is to close gaps in knowledge about the health effects of exposure to EMF and, where appropriate, propose non-technological means to reduce exposures.

3.3.2.3 Slovenia

The Ministry for Agriculture and the Environment is the competent authority for the enforcement of the Decree on Electromagnetic Radiation in the Natural and Living Environment (see also Implementation of the European recommendation).

This Ministry also published the "Rules on initial measurements and operational monitoring of sources of electromagnetic radiation and the conditions for their implementation", in which the monitoring of sources of EMF is determined in more detail.

The Slovenian Radiation Protection Administration (SRPA) is part of the Ministry of Health and its area of competence is dealing with concerned citizens. At the SRPA, two persons work an average of a few hours per month on EMF issues. This mainly involves answering questions from citizens via email or telephone to promote awareness. SRPA does not have financial resources dedicated specifically to EMF issues. However, it has financed some measuring campaigns in the past at the cost of a few 1,000 euros per year.

The Institute for Non-Ionizing Radiation (INIS) is an independent, non-governmental organization that conducts research and development in the field of EMF (INIS, 2014a). The Institute is an accredited body for the measurement of EMF in the frequency range of 0-40 GHz and it was authorized by the then Ministry for Environment and Spatial Planning to perform initial measurements and operational monitoring of sources of EMF.

There is no national measurement programme defined by legislation. Initial measurements and operational monitoring should be provided by the operator of the source (in accordance with the Rules mentioned above). The operator is responsible for the management and implementation of this.

In 2007, the Ministry of the Environment funded a nationwide project to create an EMF source database including over 10,000 measurements over the RF field spectrum. The results can be accessed via the Environmental Atlas (a GIS map) of Slovenia on the Ministry of the Environment website (ARSO, 2014).

The Forum EMF project, which is described in greater detail in Section 3.4.1.3, has carried out systematic measurement campaigns near base station antennas of GSM and UMTS and other EMF sources, including power lines and transformers in public areas chosen all over Slovenia. The measurements took place in the Slovenian municipalities that accepted the invitation to participate in this free campaign. The annual reports of the measuring campaigns from 2005 to 2011 are published on the Forum EMF website (Projekt Forum EMS, 2014).

INIS has produced a resource, E-Map EMF, which is a set of mobile applications and a web application map (INIS, 2014b) to allow the general public access to information on the sources and strengths of radiofrequency fields in Slovenia. The calculated field strength at a height of 1 metre above the ground is depicted in different colours on a map. The sources are base stations and radio and television transmitters, and the colour scale represents a percentage of the limit values set in Slovenia. The map also provides information about the operator and the type of transmission, as well as access to measurements that have been done. This resource has been co-financed by the Ministry of Education, Science and Sport, Forum EMF project (see also Section 3.4.1.3) and the

European Union - European Regional Development Fund. It is also accessible via the Forum EMF website (Projekt Forum EMS, 2014).

INIS is currently participating in the FP7 GERoNiMO project (Generalised EMF Research Using Novel Methods) (CREAL, 2015b). The goal of this project is to close gaps in knowledge about the health effects of exposure to EMF and, where appropriate, propose non-technological means to reduce exposures.

3.3.2.4 Sweden

In Sweden, the main national authorities involved in EMF and health are the Swedish Radiation Safety Authority (SSM), the National Board of Housing, Building and Planning, the National Electrical Safety Board and the National Board of Health and Welfare. The Swedish Public Health Agency was established on January 1, 2014 and most of the work concerning environmental health (including the health effects of exposure to EMF) at the National Board of Health and Welfare has been transferred to this new agency. The National Board of Health and Welfare still deals with the disability payments to electrosensitive people. The Swedish Work Environment Authority deals with EMF issues relating to the working environment.

SSM reports to the Ministry of the Environment; it has approximately 2-2.5 FTE dedicated to EMF issues (both ELF and RF fields) and other costs of around € 60,000 /year, which include laboratory and exposure measurement costs. The other aforementioned authorities have ≤ 1 FTE per authority for these issues. Local authorities are responsible for supervising exposure levels and they also deal with health issues; SSM is responsible for providing guidance to local authorities. As an expert authority, SSM also has a mandate to increase the level of knowledge about EMF, such as through training programmes. For example, it has given courses to local authorities on EMF in relation to health aspects and national legislation. Furthermore, the agency answers questions on EMF from the public; these can be sent via email or the public can call one of the agency's experts during a dedicated time slot of 1.5 hours, twice a week.

To monitor RF fields, SSM has developed a mobile RF field mapping system. This consists of an isotropic antenna mounted on the roof of a car, which can be driven at speeds of up to 30 km/hr. The system sweeps 30 MHz - 3 GHz and has a frequency resolution of 1 MHz, and can measure down to about 10 nW/m^2 per MHz. It acquires one spectrum per second. This system is used to measure RF fields once a year in one specific area with the goal of finding hotspots and noting trends in levels over time. An additional goal is to select a new area each year for RF measurements in order to perform a more complete scan of Sweden. If hot spots are found, SSM can go back and perform more accurate measurements. SSM also performs measurements when new technology is introduced and if they suspect that high values are present. The public is not able to order a measurement.

In 2002, the responsible authority in Sweden set up an international Scientific Council for EMF and health. The work of the Scientific Council now falls under SSM. The remit of the Council is to follow and evaluate

scientific developments and to give advice to SSM. Based on major scientific reviews, the Council has produced a series of annual reports that discuss and assess relevant new data and put these in the context of available information. This will result in a gradually developing health risk assessment of exposure to EMF. The annual budget for this work is around € 87,000.

3.3.2.5 United Kingdom

In the United Kingdom, the main authorities involved in RF fields and health are Public Health England (PHE), the Department of Health, the Health and Safety Executive, the Department of Energy and Climate Change, the Department of Business, Innovation and Skills, the Department for Communities and Local Government and the Office of the Communications Regulator (Ofcom). Local authorities are involved in base station planning.

PHE is an Executive Agency, sponsored by the Department of Health, which aims to protect and improve the nation's health and well-being, and reduce health inequalities. It has approximately 5 FTE in the EMF dosimetry group (both ELF and RF fields) and core funding for two laboratories based at the PHE Centre for Radiation, Chemicals and Environmental Hazards (CRCE). PHE also pursues research funding opportunities and, at present, it is involved in the FP7 projects Mobi-kids (CREAL, 2015a) and GERoNiMO (CREAL, 2015b). The Department of Health and the Department of Energy and Climate Change each have approximately 0.5 FTE for EMF and health.

The Mobile Telecommunications and Health Research Programme (MTHR) (MTHR, 2012) was established in 2001 as part of the UK Government’s response to the recommendations of the Independent Expert Group on Mobile Phones in the so-called Stewart report (IEGMP, 2000). The research focused on the uncertainties and knowledge gaps identified by the expert group. The Programme had a total funding of £ 13.6 million, provided jointly by government and industry. Although the research mainly focused on exposure from mobile phones, some research was also conducted on exposure from base stations and a programme on TETRA (communication system in use by Emergency Services) was funded by the Home Office. The programme was wound up in 2012, after 11 years in which 31 research projects were supported. Future research will be commissioned and managed on behalf of the funders through the Department of Health’s Policy Research Programme.

The UK COSMOS study, run by Imperial College London, is part of an international cohort study of mobile phone use and health (Imperial College London, 2014a). It was previously funded by the MTHR and is now jointly funded by industry and government under the Research Initiative on Health and Mobile Telecommunications, which is managed through the Department of Health’s Policy Research Programme. The aim of the study is to carry out long-term health monitoring of a large group of people to identify any possible health issues linked to using mobile phones over a long period of time.

The Study of Cognition, Adolescents and Mobile Phones (SCAMP) has recently been commissioned by the Department of Health via the Research Initiative on Health and Mobile Telecommunications (Imperial College London, 2014b). This study investigates whether the use of mobile phones and wireless technologies might affect children's cognitive development. It is the largest study in the world to address this issue. It will focus on cognitive functions such as memory and attention, which continue to develop into adolescence.

Ofcom is the communications industry regulator, with wide-ranging responsibilities across the UK's communications markets, including managing the UK civil radio spectrum. Between 2001 and 2012, Ofcom and its predecessor, the DTI Radiocommunications Agency (RA), conducted a programme of measurements which showed that emission levels around mobile phone base stations were consistently found to be only a very small fraction of the safety levels for exposure based on the 1998 ICNIRP guidelines published by the Health Protection Agency (HPA; now Public Health England). Although the ongoing programme of measurements has now finished, Ofcom remains able to survey sites if requested to do so. Ofcom's remit is the measurement of field strengths to ensure compliance with ICNIRP guidance.

The emphasis of the programme is on schools and hospitals (following recommendations in the Stewart Report), although Ofcom will consider requests for surveys in locations where there is unrestricted public access and concern about signal levels. The surveys are a chargeable service. But assessments for schools and hospitals are free of charge in recognition of the general level of concern around emissions from mobile telephone masts, particularly near buildings such as schools and hospitals.

3.4 Interaction structures between (national) government, industry and citizens

3.4.1 ELF fields: Transmission grid

3.4.1.1 France

In 2009, the Parliamentary Office for evaluation of scientific and technological options (OPECST) commissioned an investigation into the issue of health (human and animal) and the environmental impact of high and very high-voltage power lines. To gather information for the report, extensive interviewing of all stakeholders in France was conducted, including scientists, pressure groups, politicians and operators. Round-table discussions were also conducted with various stakeholders. The OPECST report was published in 2010 (Raoul, 2010) (see also Section 3.2.1.1).

The building of a high-voltage power line has recently been a cause for concern in Normandy, perhaps compounded by the fact that this line is linked with the next generation nuclear power plant in Flamanville. There have also recently been concerns about high-voltage power lines in the centre of France, in areas that are predominantly agricultural land. Here, the main concerns have come from farmers who are worried that the ELF-fields will have an effect on the health of their livestock, especially cows. A few years ago, concerns in the Pyrenees about plans

for a high-voltage power line crossing the border to Spain led to the decision to build this interconnection line underground. In general, the voicing of concerns has been less vociferous than it has been regarding plans for the siting of base stations.

3.4.1.2 The Netherlands

In formulating the precautionary policy with regard to high-voltage overhead power lines in the Netherlands, the former Ministry of Housing, Spatial Planning and the Environment consulted representatives from, *inter alia,* the Association of Provincial Authorities (IPO), the Association of Netherlands Municipalities (VNG), the Federation of Energy Companies (EnergieNed) and several parties that act on behalf of homeowners. They had discussions as to how this policy could best be implemented. According to the State Secretary, the consultations generated a significant degree of consistency and consensus in the responses of the various parties. There appears to be a need for a national, uniform policy that focuses on new situations. It is in this context that the zoning instrument (see the precautionary policy in Section 3.2.1.2) was suggested (State Secretary of Housing, Spatial Planning and the Environment, 2005).

In planning new overhead power lines or when changing existing lines or determining or changing spatial plans near existing power lines, the three main actors (government, industry and citizens) work together in some way. Experience has shown that citizens should be kept up to date and consulted on a regular basis.

3.4.1.3 Slovenia

The project "Forum EMF" was launched in September 2003 to promote science-based knowledge on the possible effects of EMF (both ELF and RF fields) and to provide information on all aspects of EMF in society (Projekt Forum EMS, 2014). The project was an initiative of the three Ministries (Environment; Health; Information Society) responsible for EMF issues, scientists and research institutions in cooperation with industry, operators, representatives of local and regional authorities and non-governmental organizations.
Forum EMF plays a major role in the risk communication process and has prepared documents and activities to provide better information to the public. This includes the reviewing of scientific literature for the general public, the production and distribution of information material, the initiation of symposia, expert hearings, a public information telephone number, educational workshops and information events. The information provided includes the results from systematic measurement campaigns of EMF sources carried out by the project team in public areas chosen all over Slovenia.

3.4.1.4 Sweden

SSM's Scientific Council on Electromagnetic Fields and Health meets twice a year. In connection with one of these meetings, other organizations are invited to attend an information meeting, such as important stakeholders.

3.4.1.5 United Kingdom

In 2004, the then National Radiological Protection Board (since merged into HPA, now PHE), recommended the adoption of the ICNIRP

guidelines (NRPB, 2004). In addition, the uncertainties in the underlying evidence base led NRPB to recommend that the Government should consider the need for further precautionary measures in respect of people's exposure to ELF fields.

This motivated the Department of Health to set up the Stakeholder Advisory Group on Extremely Low Frequency Electric and Magnetic Fields (SAGE) in November 2004. The aim of the SAGE process was to bring together a range of stakeholders to identify and explore the implications for a precautionary approach to ELF fields and make practical recommendations for precautionary measures. A dialogue process was constructed to involve all the key stakeholders. Stakeholders were defined according to their knowledge, experience, professional responsibility and the impact that any future government decisions would have on them. They included representatives from industry, national government departments, regulators and advisory bodies, academics, individuals, local and national campaign groups and professional bodies. The dialogue was funded jointly and equally by the Department of Health, Children with Leukaemia and the National Grid. This ensured that no single funding body could exert inappropriate influence over the process. The remit of SAGE was to provide advice to the Government; it was then up to the Government to take decisions on policy.

SAGE published its First Interim Assessment "Power lines and Property, Wiring in Homes, and Electrical Equipment in Homes" in April 2007 (SAGE, 2007). The report considered a wide range of possible health effects and mitigation options, such as the "corridor option", in which no development would occur within a certain distance from high-voltage power lines. It also considered optimal phasing of lines to reduce electric and magnetic fields, the design and promotion of low magnetic field appliances, changes in domestic wiring practice and the provision of information to the public.
The Government responded to the SAGE recommendations in 2009 (HM Government, 2009) and, in doing so, took into account the advice of the HPA (now PHE). The recommendation to optimally phase high-voltage overhead power lines was accepted, although it was noted that the majority of overhead lines were already optimally phased. The option of implementing "no-build corridors" was not adopted, with the Government stating that it was a disproportionate measure in light of the existing evidence for childhood leukaemia alone. The Government also found that SAGE's cost-benefit analysis did not support the option of creating corridors around power lines on health grounds. A recommendation on providing more information to the public was accepted. Furthermore, the Government recognized that work is needed to ensure that new building developments and the siting of new power lines take into account the 1998 ICNIRP exposure levels and the EU Recommendation. To this end, the Government stated that it will work proactively with the electricity industry and local authorities to explore the formal incorporation of the international standards into the planning system.

The Government response produced mixed reactions from the SAGE membership and it was recognized that the Government only adopted recommendations for which the investment of time or money required to implement them was very low or no-cost (either the recommendation

was handled by existing practice or was a low-cost measure in its own right)[38]. This guided the recommendations that were produced from SAGE Phase 2. In Phase 2, SAGE examined the science behind the EMF issue and matters related to the distribution of electricity from sub-stations to the home. The second interim assessment was published in June 2010 and it includes many recommendations relating to distribution networks (SAGE, 2010). SAGE was disbanded in 2011.

3.4.2 RF fields: Base stations for mobile communication

3.4.2.1 France

In 2009, the Ministry of Health, with the support of the Ministry of Sustainable Development and the State Secretariat for Strategic Studies and Development of the Digital Economy, organized national round-table discussions on "Radiofrequencies, health and the environment". This approach, also called "Grenelle des ondes", brought together state and public agencies, local elected officials, operators and broadcasters, civil society, trade unions and the scientific community. It focused particularly on the issue of mobile telephony. Participants' proposals were heard and debated throughout the discussions to identify additional measures to be implemented, to enhance transparency and promote the precautionary approach. The debates were regarded as societal debates, not scientific debates. The round-table discussions were considered to be a very useful process and they were not deemed as being challenging to manage.

Following the debates, the Government announced ten broad objectives that constitute the roadmap for the State and the participants in the round table. The objectives were based on the four principles of transparency of information and funding, attention to the concerns raised, precaution and consultation among stakeholders.

The following ten objectives were formulated:

- deliver accessible information to the general public;
- deploy communication with local officials and health professionals;
- take appropriate care of people complaining of hypersensitivity;
- implement a precautionary approach commensurate with users and employees;
- ensure a rational monitoring of exposure levels;
- redevelop the provisions for monitoring exposures;
- facilitate individual exposure control;
- strengthen the powers of local elected officials;
- redevelop the organization of research;
- set up a committee to monitor the implementation of these actions.

To implement this roadmap, three working groups comprising of stakeholders were formed in July 2009: a working group dedicated to informing citizens, health professionals and workers; a second dedicated to the issue of exposure control, including its terms of access and funding; and a final group in charge of reflections on the research and its funding.

In addition, an operational committee "COPIC" (initially "COMOP") was installed in July 2009, which continued to work until July 2013.

Consisting of thirty national stakeholders (associations, equipment manufacturers, mobile operators, experts, associations of local elected officials and state departments), the committee's tasks were to study:

- the feasibility of lowering exposure to EMF emitted by mobile phone antennas while maintaining coverage and the quality of service;
- the improvement of local information and consultation procedures for the implementation of base stations.

During this time, experiments on exposure were conducted in six pilot municipalities to determine whether it was technically and economically feasible to reduce exposure. In addition, experiments on information provision and consultation were conducted in nine pilot municipalities. The French Government considered that, if overall public exposure to mobile phone base stations could be lowered without reducing coverage or the quality of service and the costs were economically acceptable, then this measure should be considered. The final report of COPIC was published in July 2013. The exposure evaluation showed very low levels compared with the limits. The reduction of exposure to a level of 0.6 V/m would require at least 3 times more antennas to ensure the same coverage.

AFSSET (now ANSES) published a review document on RF fields in 2009. In this work, they were assisted by expert groups, including experts in the human and social sciences for their opinion on RF fields. One citizen representative was also included in the RF fields group. The groups consulted scientists and stakeholders. The opinion on RF fields recommended that further research should be carried out, including epidemiological studies on base stations. Other recommendations included reducing exposures to children from mobile phones (e.g. by encouraging moderate use) and reducing exposures in areas with high ambient exposure.
OPECST commissioned an investigation into the issue of wireless communications and health, and an update of the 2002 OPECST report. To gather information for the report, extensive interviewing of all stakeholders in France and abroad took place, including scientists, pressure groups, politicians and operators. Round-table discussions were also conducted with the various stakeholders. The OPECST report was published in 2009 in 2 volumes (Gest, 2009a; Gest, 2009b) and an English summary (French Republic, 2009) and this report informed the aforementioned round table.

On the issue of effective governance, the report recommended that a distinction be made between exposure to a mobile phone and exposure to a base station, whereby the precautionary principle is applied to mobile phones alone and attention is paid to the concerns of those living near base stations. The report also recommended putting in place a strong risk communication policy, whereby citizens have access to transparent and complete information through the Cartoradio website and are rapidly able to have a measurement of citizens' exposure free of charge. In addition, the report recommended subjecting base station applications to the building licence procedure and strengthening the prerogatives of Mayors. The Mayors should be allowed to have measurements of exposure levels carried out before and after the filing

of an application to install a base station and they should be able to conduct an annual measurement campaign.

In many cities and towns, the mobile operators have signed a charter with the local government. In 2013, for example, the city of Paris and four operators signed the Charter of Paris on mobile phones. This charter defines the maximum levels of exposure to radiofrequency fields. At the request of the City, operators agree that the measured level of exposure should never exceed 5 V/m, or 7 V/m for 4G, in closed living areas (apartments, offices, etc.). The operators accepted this constraint in order to meet the strong growth in use and mobile traffic in the capital.

3.4.2.2 The Netherlands

In the Netherlands, Antenna Covenant agreements are made about the 'placement plan' of permit-free base stations on houses or other buildings. The placement plan is for information purposes only. It can be used to guide discussions and agreements between the municipalities and the mobile operators. For example, an operator specifies a search radius for planned antennas. During the discussion of the plan, the municipality can help with finding suitable locations.

In the Antenna Covenant, it was also agreed that municipalities may impose requirements on the visual aspects of an antenna, in line with the local building aesthetics.

A mobile operator cannot simply place a permit-free base station on a residential building that has tenants. The Covenant has a procedure for prior approval by the residents of the building (see *Citizen participation in decision-making*).

3.4.2.3 Slovenia

Many activities and initiatives on RF fields involving interaction between the different stakeholders have taken place within the Forum EMF project described in Section 3.4.1.3.

A scientific advisory board on EMF and health within Forum EMF has reviewed the scientific literature concerning EMF and possible health effects. In a consensus meeting, the experts concluded that the research performed to date gives no indication of hazardous health effects from exposure to EMF from mobile communication below the limits recommended by the ICNIRP. This board also responded to various controversies in the media and participated in several open public hearings and workshops.

One of the successful activities of Forum EMF was a "rent a dosimeter" campaign, whereby citizens could rent a personal dosimeter for a few days to measure their own exposure to EMF. INIS is carrying on this programme of renting out personal dosimeters. The measurements can be viewed on a map on the INIS website. As on the E-map EMF app described in Section 3.3.2.3, values represent a percentage of the limit values set in Slovenia.

3.4.2.4 Sweden

SSM's Scientific Council on Electromagnetic Fields and Health meets twice a year. In connection with one of these meetings, other organizations are invited to attend an information meeting, such as important stakeholders.

The rollout of the third generation system (3G) for mobile telephony caused much discussion, opposition and concern about adverse health effects in Sweden. In 2005, this led industry, authorities, municipalities and non-governmental organizations to form a joint Transparency Forum (Mjönes and Hyrke, 2011), initiated by SSM (then SSI). The aim of the project was to improve the dialogue and transparency in society regarding exposure to RF-fields in Sweden – particularly focusing on 3G roll-out – and to increase the mutual understanding of different stakeholders' roles and value judgements.

The basis of the Transparency Forum was the risk communication model (RISCOM) for delicate situations. A key element in the model is that all stakeholders are involved in the planning and realization of the project on equal terms. It was decided that three seminars should be organized, during which it would be possible for all stakeholders to state their true opinions and to be questioned on their views by the others. The themes for the seminars were:

- roles and arenas of the different stakeholders;
- the research basis for the risk estimation;
- precautionary principles and exposure limits.

An evaluation of the project found that the majority of participants thought that the project had resulted in an improved dialogue on the 3G system. By different stakeholders actually meeting each other and exchanging different opinions and values, it was felt that there had been an increase in understanding of each other's roles and values.

3.4.2.5 United Kingdom

In the case of RF fields, there has not been a process of interaction similar to the SAGE dialogue for ELF fields. Nevertheless, the Independent Expert Group on Mobile Phones (IEGMP), which was set up by the Government in 1999, interacted with the public in their gathering of evidence.

The terms of reference of the IEGMP were to consider present concerns about the possible health effects from the use of mobile phones, base stations and transmitters, to conduct a rigorous assessment of existing research and to give advice based on the present state of knowledge. The IEGMP was also tasked to make recommendations on further work in order to improve the basis for sound advice.

In order for a wide range of views to be considered by the Expert Group, adverts calling for written evidence were placed in national newspapers, in the New Scientist and on their website. The Expert Group received replies from 174 individuals and organizations. They also held open meetings around the country for the public to air their views. These were advertised in local newspapers and through press releases.

The report of the IEGMP (the Stewart report) (IEGMP, 2000) made many recommendations on the planning process for base stations, which included that:

- for all base stations, including those with masts under 15 metres, permitted development rights for their erection should be revoked and that the siting of all new base stations should be subject to the normal planning process;
- at national Government level, a template of protocols should be developed, in concert with industry and consumers, which can be used to inform the planning process and which must be assiduously and openly followed before permission is given for the siting of a new base station;
- a robust planning template should be set in place within 12 months of the publication of the report, which incorporates a requirement for public involvement, an input by health authorities/health boards and a clear and open system of documentation which can be readily inspected by the general public;
- a national database should be set up by Government, giving the details of all base stations and their emissions; this should include the characteristics of the base stations and should be an essential part of the licence application for the site;
- an independent, random, ongoing audit of all base stations should be carried out to ensure that exposure guidelines are not exceeded outside the marked exclusion zone and that the base stations comply with their agreed specifications;
- particular attention should be paid initially to the auditing of base stations that are near schools and other sensitive sites;
- in relation to macrocell base stations sited within school grounds, that the beam of greatest intensity should not fall on any part of the school grounds or buildings without agreement from the school and parents. Similar considerations should apply to macrocell base stations sited near school grounds;
- in making decisions about the siting of base stations, planning authorities should have the power to ensure that the RF fields to which the public will be exposed would be kept at the lowest practical levels that are commensurate with the effective operation of the telecommunications system.

These recommendations led to changes in the planning process, including more consultation on the siting of base stations (see also Section 3.5.2.5).

3.5 Citizen participation in decision-making on the siting of high-voltage power lines and base stations

3.5.1 ELF fields: Transmission grid

3.5.1.1 France

In France, the “prefect” (the State's representative in a “department” or region) organizes the public consultation process for the siting of high-voltage overhead power lines. The transmission system operator, RTE, is a stakeholder in this process and ANSES may be asked to explain the scientific evidence regarding ELF fields and human health. The province (the “department”) decides whether or not the plan can go ahead.

3.5.1.2 The Netherlands

When formulating the precautionary policy with regard to high-voltage overhead power lines in the Netherlands, the public was consulted. The purpose of this project was to obtain citizens' opinions on the possible health effects and policy options, and their information needs. Although the participation rate of citizens was low, some conclusions could be drawn. Participants agreed that the possible adverse health effects are an important issue; however, they associated power lines more with symptoms such as sleeplessness, fatigue and headaches, than they did with childhood leukaemia. The precautionary approach in response to uncertain scientific indications was highly appreciated, but there were also feelings expressed such as "if the Government pays attention to this situation, then there must be something very wrong". Homeowners were worried about a fall in property value. There was also a clear need for extra information on general aspects, as well as specific local developments (State Secretary of Housing, Spatial Planning and the Environment, 2004).

During the formal process of planning new power lines and new houses near existing power lines, citizens have a formal say in the matter. Discussions between the Government, the transmission system operator and citizens sometimes lead to (relatively small) changes in the positioning of pylons. Objections have been lodged against most of the ministerial decisions (in Dutch: Rijksinpassingsplan) for planning new high-voltage overhead power lines and some of the spatial plans near existing lines at the Administrative Jurisdiction Division of the Council of State, which is the country's highest general administrative court.

3.5.1.3 Slovenia

No specific information was found on this topic for Slovenia.

3.5.1.4 Sweden

The Swedish transmission system operator, Svenska Kraftnät, has a consultation process in place for when it plans to expand the national grid (Svenska Kraftnät, 2014). All those affected by the planned power line have the opportunity to air their views. The target group for consultation includes property owners, local residents, municipalities, county councils and interest groups. The consultation process may include public meetings, mailings and advertisements. Anyone who wishes to can be heard verbally or in writing regarding a proposed line.

The first consultation takes place after a feasibility study has been carried out. During this feasibility study consultation, anyone who wishes to comment on it can do so. These comments and Svenska Kraftnät's reactions to them are documented in a consultation report. Svenska Kraftnät chooses a proposed power line route after reviewing the comments received in the consultation report and taking the results of any surveys and studies into account. Then an environmental impact assessment is carried out and there is again the opportunity for anyone who wishes to comment to do so. The comments received, and Svenska Kraftnät's reactions to them, are compiled in a consultation report, just as in the preliminary study.

The Environmental Impact Assessment, along with the consultation report, are part of Svenska Kraftnät's application for the concession to build and use a power line. This application is submitted to the Swedish Energy Markets Inspectorate. The Swedish Energy Markets Inspectorate sends a request for comment to affected property owners and government authorities in order to obtain feedback on the planned route. Under certain conditions, such as if all parties agree, the Inspectorate can issue a concession. Otherwise, the Inspectorate hands the case over to the Government. The decision on the concession is made by the Government after another consultation with all concerned.

Svenska Kraftnät gives a one-off payment to affected property owners as compensation. Compensation includes both a market value reduction on the property and other damage that occurs through the building of power lines. In addition, a flat rate of 25% is calculated on the reduction of market value.

SSM is also involved in giving approval for a new power line. They are required to check that the precautionary principle has been applied.

3.5.1.5 United Kingdom

The planning process for dealing with proposals for nationally significant infrastructure projects was established by the Planning Act 2008. The Planning Act (as amended by the Localism Act 2011) passed responsibility for dealing with development consent applications for Nationally Significant Infrastructure Projects to the Planning Inspectorate, which examines applications and makes recommendations to the relevant Secretary of State. For energy applications, the Secretary of State at the Department for Energy and Climate Change (DECC) will make the decision on whether to grant or to refuse development consent. The Secretary of State also considers concerns and objections with a view to determine whether or not a public inquiry should be held.

The Planning Act 2008 introduced a threshold for development consent for overhead lines of 132 kV or greater to be considered as Nationally Significant Infrastructure Projects (NSIPs) and prescribed that consent for these NSIPs would be determined under the Planning Act regime. In June 2013, the threshold for overhead lines was amended further by The Planning Act 2008 (Nationally Significant Infrastructure Projects) (Electric Lines) Order 2013 (legislation.gov.uk, 2014).

Citizens can participate in the planning process by registering with the Planning Inspectorate to become an interested party once an application has been formally accepted by the Secretary of State (The Planning Inspectorate, 2012). This gives them an opportunity to participate in the examination of the application by the Examining Authority. Citizens also have a chance to influence a project by taking part in the developer's pre-application consultation process.

The installation of an electric line that is not an NSIP is subject to the consent process under Section 37 of the Electricity Act 1989. DECC administers the Electricity Act 1989 for overhead lines below 132kV and associated permits in England and Wales (Department of Energy & Climate Change, 2013b). Section 37 of the Electricity Act 1989 takes

into account the views of the local planning authority, local people, statutory bodies (such as the Environment Agency) and other interested parties. All applications go through the local planning authority and appear on the local planning register. In some cases, there may be a public inquiry before the Secretary of State makes a decision, usually as a consequence of an objection being received from the local planning authority.

3.5.2 RF fields: Base stations for mobile communication

3.5.2.1 France

In France, the Government encourages the organization of local consultation for the siting of a base station. To this end, a circular was issued in 2001 recommending the creation of consultative structures to deal with plans for new facilities, to ensure their integration into the environment and to address health issues. These consultative structures encompass representatives of the local authorities, residents associations and parents, and representatives from regional services, such as the environmental and public health services and ANFR, as well as the operators. These structures provide a forum for consultation on siting decisions and, in many cases, public information meetings are held. They also lead to the drawing up of charters between the operators and the local authorities; most big towns now have their own charter.

3.5.2.2 The Netherlands

In the Netherlands Antenna Covenant, the parties agreed in 2010 on the procedure for obtaining the approval of residents before installing a permit-free antenna installation on a residential building. Obviously, the owner of the building has to approve plans to put a base station on his rooftop, but tenants too, if present, have to give their approval. All the tenants in the building receive an information package and are asked to vote by ballot either in favour or against the installation of the base station. If more than 50 per cent of the tenants oppose it, the base station will not be installed. To ensure the impartial character of the approval procedure, the full procedure, including the counting of the votes, is run by an independent certified administration bureau.

3.5.2.3 Slovenia

In 2004, a code of good practice on the siting of masts and base stations signed by the telecommunication industry was launched by the project Forum EMF (see also Section 3.4.1.3) to supplement Government regulations. The goal was to strengthen links with the community through open dialogue. The code promised to improve the flow of information regarding siting and established a good foundation for cooperation between the public and governmental and non-governmental organizations, service providers and academics. The combination of current legislation and the implementation of the good practice code were considered to be the best way to address community concerns about EMF sources in the environment. Furthermore, it was thought that open communication and discussion between the owners of the EMF source, local council and the public during the planning stages could help create public understanding and greater acceptance of a new facility.

3.5.2.4 Sweden

In Sweden, the planning authority for the siting of base stations is the municipality. It is not mandatory to consult the public; each municipality can decide whether and to what extent it will consult the public. For the siting of single antennas, permission from the owner of the building is required, but there is no consultation process.

3.5.2.5 United Kingdom

The work of the Independent Expert Group on Mobile Phones (IEGMP), which was set up by the Government in 1999, has a major bearing on the consultation regarding RF fields in the UK (see also Section 3.4.2.5).

Base stations are handled at the local authority level through the National Planning Policy Framework and related guidance. The planning framework requires applications to be supported by evidence, which includes the outcome of consultations with organizations that have an interest in the proposed development, particularly when a mast is to be installed near a school or college. The operators inform the local authorities of their annual roll-out plans. The local planning authority is responsible for notifying local communities about applications received and the consultation arrangements.

In 2013, a new Code of Best Practice on Mobile Network Development (Mobile Operators Association, 2013) in England was published to replace the previous Code, which was published in 2002 (see also Section 3.2.2.5). The new Code provides guidance to mobile network operators, their agents and contractors, and to local planning authorities. The revised Code was developed by a Working Group consisting of representatives from: Arqiva; the Department for Communities and Local Government; the Department for Culture Media and Sport; the Department for Environment, Food and Rural Affairs; English Heritage; the Mobile Operators Association; National Parks England (also representing the Association of Areas of Outstanding Natural Beauty); and the Planning Officers Society.

The new Code sets out the respective roles of national government, local authorities and network operators in telecommunications planning. It also sets out good practice in the planning process. Detailed guidance is contained in a series of appendices.

A Traffic Light Rating Model allows a site to be rated by the operator according to its likely sensitivity in terms of the environment, planning and community considerations. A Consultation Strategy is then devised that sets out the appropriate level of consultation and the different types of consultation activities applicable for that site, depending on the rating. For example, for a rating of Red (or Amber), a higher level of public consultation may be needed before a planning application is submitted.

3.6 Governmental communication on EMF and health

3.6.1 ELF fields: Transmission grid

3.6.1.1 France

INERIS hosts a website which supports local authorities and informs the public about EMF exposures and regulations: www.ineris.fr/ondes-info/.

From this website, limit values can be calculated for any frequency and exposure configuration.

In 2014, the Ministry of Health issued a new version of its booklet providing information on extremely low frequency EMF. This leaflet informs the public about the possible effects on health (République Française, 2014a).

The website "La Clef des Champs" (RTE, 2014), which is administered by the transmission system operator, RTE, provides considerable information for the public to help them with their understanding of ELF-fields. Besides an interactive map bearing the locations of base stations in France and the results of measurements of ELF-field strengths, the website includes, *inter alia,* videos, a quiz and a downloadable brochure with Q&As (RTE, 2012).

3.6.1.2 The Netherlands

In the process of planning new power lines in the Netherlands, citizens are informed during "open house" information markets. Experts from the transmission system operator, TenneT, and from the Ministries – supported, if necessary, by external experts – give information on planning procedures, technical aspects and possible health effects.
The Knowledge Platform on EMF is one of the means of communication used about the possible health risks of exposure to EMF. The Knowledge Platform was founded in 2007 by a Ministerial Decree. The main reasons for this decision were the differences in communication statements made by several parties that were sometimes set against each other by the media. For members of the general public, it was difficult to judge which information was right and which was wrong. A cooperation structure was set up between six participants: the National Institute for Public Health and the Environment (RIVM); Netherlands Organisation for Applied Scientific Research (TNO); an international consultancy company specialized in Energy and Sustainability (DNV-GL, former KEMA); Radiocommunications Agency Netherlands, which communicates through the Antenna Bureau; the Municipal Public Health Services, which communicate directly to citizens (GGD-en); the Netherlands Organisation for Health Research and Development (ZonMw), which distributes funding within the "Electromagnetic Fields & Health" research programme. These participants assess scientific information on its merits and relevance for society. The Knowledge Platform works independently of interests in industry, societal groups and government policies.

The Health Council also acts as an advisor to the Knowledge Platform. This enables the platform to include advice from the Health Council in response to specific questions. The Knowledge Platform is also represented in the commission of the Health Council.

A Communication Forum and a Science Forum prepare the statements of the Knowledge Platform, supported by the Platform Bureau. The Communication forum consists of professionals with a background in: contacts with citizens concerning health questions related to their local living environment; communication with local and national authorities concerning EMF and health; and media communication. The Science Forum is a team of experts from all the six participants. A Science

Forum member represents the participating organization and is tasked with making the organization's knowledge on EMF available to the Knowledge Platform. An example of a Knowledge Note (in English) can be found on the website of the Knowledge Platform (Knowledge Platform on EMF, 2012).

The Knowledge Platform organizes the national Sounding Board on EMF in order to identify and discuss the relevant scientific and societal issues with NGOs, industry, science and government.

3.6.1.3 Slovenia

The public is informed via government websites and, more frequently, in direct communication with interested and/or concerned individuals. Much information can be found on the project Forum EMF website (see also Section 3.4.1.3) (Projekt Forum EMS, 2014) and the website of INIS (INIS, 2014a). INIS is one of the most important actors with regard to EMF and health in Slovenia.

The website of the transmission network system operator ELES (ELES, 2014), a state owned company, provides answers to frequently asked questions about EMF, including information on limit values and on adverse health effects. The Environmental Agency provides access to the operational monitoring data via its website (see also Section 3.3.1.3).

3.6.1.4 Sweden

Svenska Kraftnät published a leaflet in 2010 explaining a new policy it had adopted (Svenska Kraftnät, 2010) (see also Section 3.2.1.4). This leaflet explains that, when planning new power lines, Svenska Kraftnät will ensure that magnetic fields do not normally exceed 0.4 μT in areas where people spend long periods of time. Furthermore, when renewing concessions for existing power lines, Svenska Kraftnät will consider adopting measures that reduce exposure to magnetic fields. Measures shall be taken where people are exposed over long periods of time to magnetic fields that deviate significantly from normal conditions, providing that the costs and consequences are reasonable. In situations in which people spend long periods of time in areas where the magnetic fields exceed 4 μT, Svenska Kraftnät is prepared to take measures to reduce the magnetic field or will offer to purchase buildings.

3.6.1.5 United Kingdom

In both the SAGE assessments (see also Section 3.4.1.5), the importance of communicating effectively with the public was highlighted. To address this issue, the HPA (now part of PHE) established the ELF EMF Communication Working Group (EWG) to assist in communicating its precautionary advice to the public concerning actions that can be taken to reduce exposure from sources of extremely low frequency magnetic and electric fields. The group considered existing HPA advice in light of the public information envisaged in the assessments of SAGE and the HPA and government responses to those assessments, and assisted in the development of this information. In the process, the EWG also consulted a sample of citizens from PHE's so-called "people's panel" (consisting of around 1,000 people). The result was a raft of new webpages on the HPA website.

This information and advice can now be found on the Public Heath England website (PHE, 2013a). It includes guidance on the adverse health effects of electric and magnetic fields and guidance on reducing exposure. The EWG also continued the work of the EMF Discussion Group, set up by HPA in 2006.

3.6.2 RF fields: Base stations for mobile communication

3.6.2.1 France

INERIS hosts a website which supports local authorities and informs the public about EMF exposures and regulations (INERIS, 2014). On this website, limit values can be calculated for any frequency and exposure configuration.

Since 2010, the Government has had a dedicated website with information on radiofrequency fields (République Française, 2014a). This portal provides easy access to all the information resources available. It provides information on adverse health effects, including the effects on children and the issue of hypersensitivity. It also provides an overview of the actions taken by the Government, such as commissioning research and consulting the public. The exposure limits are explained, as are the regulations for siting base stations and the public consultation process. The ANFR website Cartoradio, described in detail in Section 3.3.2.1, provides information on the location of base stations and gives the results of measurements (ANFR, 2014b).

Various leaflets have been published by the French Government. In 2013, the Ministry of Health issued a new version of its leaflet providing information on mobile phone base stations (République Française, 2013). In addition, the Ministry of Ecology, Sustainable Development and Energy issued a leaflet providing information on a new service from 2014 that enables the public to request measurements of EMF near mobile base stations (République Française, 2014b) (see also Section 3.3.2.1).

Between 2005 and 2010, the Health & RF Foundation was tasked with defining, promoting and funding programmes to bring information to the public and to workers concerning health and RF fields. During this period, it hosted an interactive website to inform people about these issues. Other activities included a so-called “blue bus” with an exhibition on RF fields and health effects that travelled through France to inform the public. It also organized an open scientific meeting in Paris in 2009.

3.6.2.2 The Netherlands

In the Netherlands, the Antenna Bureau is the information agency of the Dutch Government. The Antenna Bureau manages a website, produces various leaflets and provides a toolkit on National Antenna Policy for local authorities. On request, the Bureau serves the public, the operators, communities and municipalities, etc., by giving information sessions about antennas. The Bureau discloses the national antenna register for public use and organizes measurements on field strength for information purposes. The Knowledge Platform on EMF is one of the means of communication used to convey the possible health risks of exposure to EMF (see 3.6.1.2).

3.6.2.3 Slovenia

The public is informed via government websites and, more frequently, in direct communication with interested and/or concerned individuals. Much information can be found on the project Forum EMF website (Projekt Forum EMS, 2014) (see also Section 3.4.1.3) and the website of INIS (INIS, 2014a), which, though not part of national government, is one of the most important actors in regard to EMF and health in Slovenia.
The Forum EMF project has produced, *inter alia,* a short educational video on mobile communications and health effects. This video provides information to the public and the health services about different areas of concern.

INIS has developed an e-learning course (INIS, 2014c) which can be found on its website. The contents are intended for both beginners and advanced users. The course has different modules, which include lectures from renowned domestic experts on subjects such as EMF, health and the precautionary principle, and a number of educational videos. There is also the possibility of testing one's knowledge.

3.6.2.4 Sweden

In 2013, SSM published a statement along with the other Nordic radiation safety authorities: "Exposure from mobile phones, base stations and wireless networks" (Nordic radiation safety authorities, 2013). Among other things, it stated that since exposure of the general public, including children, to radio waves from wireless local area networks and base stations is far below the exposure limits, there is no need to limit exposure from these sources any further. In addition, the statement provided some information on reducing exposure from mobile phones and background information on scientific studies.

3.6.2.5 United Kingdom

Public Health England (PHE) provides information on its website (PHE, 2013b). This includes the guidance "Mobile phone base stations: radio waves and health", which describes various types of mobile phone base stations and how exposures are measured, and guidelines for reducing exposure to radio waves. The focus is on mobile phones. Reducing exposure from base stations is not regarded as necessary because exposures are low according to ICNIRP guidelines. The website also gives access to the report issued by the Independent Advisory Group on Non-ionising Radiation (AGNIR) on the adverse health effects of radiofrequency EMF and the HPA's response to this report.

The National Health Service (NHS) has some webpages on mobile phone safety, including exposure from base stations (NHS, 2014). These include information on the risks associated with exposure to RF fields (including risks to children) and recommendations for the safe use of mobile phones. In 2011, the NHS published the leaflet "Mobile phones and base stations" (NHS, 2011), which was produced by the Department of Health. The leaflet provides information on how mobile phones and networks work and gives answers to questions such as how safe base stations are.

The Health and Safety Executive provides some information on EMF on their website, with FAQs on base stations, including information on the ICNIRP guidelines (HSE, 2015).

The mobile phone base station database Sitefinder (Ofcom, 2013) was set up as a result of recommendations issued by the Stewart Report in 2000. It is a voluntary scheme under which mobile network operators make information available on the location and operating characteristics of individual base stations as a service to those people wishing to be informed of this. A search can be done for the location and details of mobile phone base station sites around specific locations. The data within Sitefinder is owned by the mobile network operators, who supplied the data on a voluntary basis. Ofcom hosts the Sitefinder tool on behalf of the Government. Ofcom emphasises that it makes no corrections to the data supplied by the operators and that the dataset is currently out-of-date. The last Sitefinder update was done in May 2012, although some operators stopped providing updates as early as 2005. Ofcom explains that this is largely a result of the Information Commissioner's decision in 2007 to order Ofcom to make the raw data used to populate the database publically available, causing some operators to stop providing the information voluntarily. Furthermore, participating operators have provided their respective datasets at different intervals.

4 Irish situation

4.1 Implementation of the European recommendation in Ireland

In the latest of the two Implementation Reports on the European recommendation (European Commission, 2008), it was reported: 'There is currently no legislative framework set up in Ireland. However, the ICNIRP guidelines have been adopted by the Communications Regulator (ComReg) in relation to licensing conditions for telecommunications operators. The Irish operator of high-voltage power lines, EirGrid, complies with the EU/ICNIRP limits.' And also: 'From Ireland's point of view, the basic restrictions and reference levels set up in the Recommendation support a high level of health protection. In Ireland, no implementation measures are taken on basic restrictions.'

4.2 Organizations and institutions

In Ireland, the Department of Environment, Community and Local Government is responsible for protecting members of the public from the potential adverse health effects of EMF. In line with the 2007 recommendations of the Expert Group established to examine the Health Effects of Electromagnetic Fields (Expert Group, 2007), the Irish Government has decided that the Radiological Protection Institute of Ireland (RPII) should deal both with ionizing radiation and non-ionizing radiation. Although the Irish Government made the decision in principle, this has yet to be given effect in legislation. On the 1st August 2014, the Radiological Protection Institute of Ireland merged with the Environmental Protection Agency (EPA). At present, therefore, the EPA has no function or role concerning non-ionizing radiation.

The main power company in Ireland – the Electricity Supply Board (ESB) – is aware of people's views and concerns on the issue of electric and magnetic fields (European Commission, 2008).

There are several actors in Ireland with different responsibilities with respect to EMF policy options. Broadly speaking and for the present situation, they can be distinguished as:

I. Authorities
   National
   - National Government (executive, legislative and judicial branches)
     - Department of Environment, Community and Local Government (potential health effects of non-ionizing radiation);
     - Department of Communications, Energy and Natural Resources (telecommunications, broadcasting and energy);
     - Department of Health (health care);
   - Health Service Executive (public health aspects);
   - Commission for Communications Regulation (regulation of telecommunications and broadcasting);
   - Commission for Energy Regulation (energy regulation);
   - Local Government (environmental health);

- Health and Safety Authority (safety, health and welfare at work);

International

- European Union (the European recommendation);
- European Parliament (resolution on EMF);

II. Society
- citizens (workers, patients) (potentially exposed people);
- NGOs (pressure groups);
- schools (potentially exposed people);

III. Industry
- Telecom operators (create EMF);
- transmission system operator (create EMF);
- Electricity Supply Board (create EMF);
- normalization bodies (standardization of methods)
  - National Standards Authority of Ireland (NSAI);
  - European Committee for Electrotechnical Standardization (CENELEC);
  - International Electrotechnical Commission (IEC);
- measurement companies (monitoring);
- employer organizations (e.g. Ibec-EPC; protect interests);

IV. Scientific Community
- universities (research and education);
- scientific institutes (research);
- scientific advisory groups (scientific advice)
  - 'health council' or other expert groups;
  - Scientific Committee on Emerging and Newly Identified Health Risks;
- International Agency for Research on Cancer (evaluation of carcinogenic effects);
- International Commission on Non-Ionizing Radiation Protection (exposure guidelines);
- World Health Organization (risk evaluation, EMF-project).

4.3 Electricity network

EirGrid is the Irish Transmission System Operator and 'Grid25' is the development strategy of EirGrid to deliver a sustainable, competitive and secure electricity supply to homes, businesses and industries. One of the largest GRID25 projects is the Grid Link Project (EirGrid, 2014a). In July 2014, RPS Group, an Irish consultancy, prepared a report for EirGrid containing a literature review and the results of measurements taken near the electricity transmission infrastructure in Ireland (RPS Group, 2014). This report concludes: 'The evidence for an association between ELF EMF exposure and carcinogenic effects, particularly leukaemia, is limited and research does not rule in or out the possibility of a causal link.'; 'The infrastructure types measured comprised single and double circuit overhead lines at 110 kV, 220 kV and 400 kV, transformer substations at these voltages and underground cables at 110 kV and 220 kV.'; and 'The maximum magnetic field strength measured at all overhead lines, underground cables and substation perimeters surveyed was well below the ICNIRP public exposure reference level.'

In 1999, ESB published a booklet on electric and magnetic fields in the environment (Electricity Supply Board, 1999). In it, ESB states that 'all of the ESB networks comply with the most up-to-date international EMF

guidelines and recommendations. Despite over 20 years of intensive research into power frequency EMFs, the international scientific consensus is that there is no evidence to prove that these EMFs can cause any harm'.

4.4 Telecommunication networks

ComReg is the statutory body responsible for the regulation of the electronic communications sector (telecommunications, radio communications and broadcasting transmission) and the postal sector (www.comreg.ie). In order to safeguard consumer interest and to ensure compliance with licence conditions, measurements are performed. A report on non-ionizing radiation site surveys is published every quarter (Commission for Communications Regulation, 2014b). In each survey, measurements are reported of the highest field strength at the location accessible to members of the public.

According to ComReg, there are six competing mobile operators in Ireland (Commission for Communications Regulation (2014c). The Irish Cellular Industry Association (ICIA) is an alliance of the mobile operators. The ICIA focuses on consumer-related issues and seeks to build media and public credibility on behalf of the mobile industry in Ireland.

Compliance with ICNIRP exposure limits is a condition of a General Authorization to provide an electronic communications network or service (Commission for Communications Regulation, 2013): condition 8 of that document relates to electromagnetic radiation. An operator of a telecommunications network shall comply with any ICNIRP and CENELEC emission standards and shall ensure that the emissions from their apparatus are within the ICNIRP limits, even when these emissions are aggregated with other emissions already present at the location where their apparatus is to be installed or operated.

4.5 Monitoring and assessment programmes

ComReg has commissioned audit reports to verify that licensed telecommunications operators are complying with their license conditions relating to emission limits for radiofrequency EMF (Commission for Communications Regulation, 2014a).

They provided a measurement service for power frequency electric and magnetic fields for concerned members of the public (European Commission, 2008). It is unknown whether or not this service is still provided.

4.6 Communication activities

The main website with information for the public on EMF in Ireland is www.environ.ie/en/Environment/EnvironmentalRadiation/ElectromagneticFieldsFAQ/. ComReg provides an on-line facility, www.siteviewer.ie, which shows the locations of GSM, UMTS (3G) and LTE (4G) mobile phone base stations throughout Ireland on a map. The Health and Safety Authority makes requests for comments and observations on the proposals for the Draft Safety, Health and Welfare at Work (Electromagnetic Fields) Regulations 2016 (consultation.hsa.ie/Public-Consultations/Electromagnetic-Fields-Regulations-2016/)

Examples of communication activities by the industry are the brochure 'Electric and Magnetic fields in the Environment' by ESB (Electricity Supply Board, 1999); the EMF booklet 'EMF & YOU' with detailed public information on the electricity transmission system in Ireland, recently revised by EirGrid (EirGrid, 2014b); and the 'Frequently Asked Questions' document published by the EMF Subgroup of the ICIA to provide the public with relevant information regarding mobile phones and base stations (ICIA, 2007).

4.7 Research programme

No or only very limited public-funds were allocated to research on the potential health risks of EMF recently in Ireland (European Commission, 2008). In the past, Ireland contributed to internationally coordinated research activities. It has, for example, through the ESB, contributed financially to the UK Childhood Cancer (epidemiological) study and it was a founding member and financial supporter of the WHO International EMF Project for the international coordination and overview that was launched in 1996 (European Commission, 2002).

References

AGNIR (Advisory Group on Non-Ionising Radiation) (2008). *Static magnetic fields. Report of the independent Advisory Group on Non-ionising Radiation*. Health Protection Agency (HPA), Chilton.

AGNIR (Advisory Group on Non-Ionising Radiation) (2012). *Health effects from radiofrequency electromagnetic fields. Report of the independent Advisory Group on Non-ionising Radiation*. Health Protection Agency (HPA), Chilton.

AMF (Association des Maires de France) et RTE (Réseau de transport d'électricité) (2010). *Lignes électriques haute et très haute tension et champs magnétiques de très basse fréquence*. Available from: http://www.rte-france.com/uploads/media/pdf_zip/cem/Mesure_CEM_HT-THT.pdf (last visited: 3 October 2014).

ANFR (Agence Nationale des Fréquences) (2014a). [Online] Available from: http://www.ANFR.fr (last visited: 3 October 2014).

ANFR (Agence Nationale des Fréquences) (2014b). *Cartoradio*[Online] Available from: http://www.cartoradio.fr/ (last visited: 3 October 2014).

ANSES (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail) (2013). *OPINION of the French Agency for Food, Environmental and Occupational Health & Safety concerning the update of the "Radiofrequency electromagnetic fields and health" expert appraisal.* [Online] Available from: https://www.anses.fr/sites/default/files/documents/AP2011sa0150RaEN_1.pdf (last visited: 3 October 2014).

ANSES (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail) (2014). [Online] Available from: https://www.anses.fr/en (last visited: 3 October 2014).

Antennebureau (2015) *Archief overzichten gsm, UMTS en LTE-antennes* [Online] Available from: http://www.antennebureau.nl/onderwerpen/algemeen/antenneregister/archief-overzichten-gsm-umts-en-lte-antennes (last visited: 11 May 2015).

ARSO (Slovenian Environment Agency) (2014). *Portals - Environmental atlas of Slovenia.* [Online] Available from: http://www.arso.gov.si/en/ and http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@ARSO&culture=en-US (last visited: 3 October 2014).

Assemblée Nationale (2015). *Proposition de lois 'Sobriété de l'exposition aux champs électromagnétiques, information et concertation lors de l'implantation d'installations radioélectriques'.* [Online] Available from: http://www.assemblee-nationale.fr/14/ta/ta0468.asp (last visited: 23 March 2015).

Commission for Communications Regulation (2013). *General Authorisation. Conditions for the provision of Electronic Communications Networks and Services.* Available from: http://www.comreg.ie/_fileupload/publications/ComReg0381R4.pdf

(last visited: 25 March 2015) [this General Authorization is pursuant to Regulation 8 of the European Communities (Electronic Communications Networks and Services) (Authorization) Regulations, 2003 (S.I. No. 306 of 2003; available from http://www.comreg.ie/_fileupload/File/S.I.%20No.%20335%20of%202011%20Authorisation%20Regs%20Final.pdf (last visited: 25 March 2015)]. Dublin: ComReg.

Commission for Communications Regulation (2014a). *Programme of Measurement of Non-Ionising Radiation Emissions - Methodology for the Conduct of Surveys to Measure Non-Ionising Electromagnetic Radiation from Transmitter Sites*. Dublin: ComReg.

Commission for Communications Regulation (2014b). *2014 Programme of Measurement of Non-Ionising Radiation Emissions. First Interim Report*. Document No ComReg 14/38, 29th April 2014. Available from: http://www.comreg.ie/_fileupload/publications/ComReg1438.pdf (last visited: 7 January 2015).

Commission for Communications Regulation (2014c). *Irish Communications Market. Quarterly Key Data Report. Data as of Q3 2014*. Document No ComReg 14/134, 11 December 2014. Available from: http://www.comreg.ie/_fileupload/publications/ComReg14134.pdf (last visited: 7 January 2015).

Council of the European Union (1999). *Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC)*. Official Journal of the European Communities L 199: 59-70.

CREAL (Centre for Research in Environmental Epidemiology) (2015a). *Risk of brain cancer from exposure to radiofrequency fields in childhood and adolescence.* [Online] Available from: http://www.crealradiation.com/index.php/mobi-kids-home (last visited: 7 January 2015).

CREAL (Centre for Research in Environmental Epidemiology) (2015b). *Generalised EMF Research Using Novel Methods.* [Online] Available from: http://www.crealradiation.com/index.php/en/geronimo-home (last visited: 7 January 2015).

Demers, P., R. Findlay, K.R. Foster, B. Kolb, J. Moulder, A. Nicol, F. Prato and R. Stam (2013). *Expert panel report on a review of safety code 6. Health Canada's safety limits for exposure to radiofrequency fields*. Royal Society of Canada, Ottawa.

Department for Communities and Local Government (2012). *National Planning Policy Framework*. Available from: http://planningguidance.planningportal.gov.uk/blog/policy/ (last visited: 3 October 2014).

Department of Energy and Climate Change (2011). *National Policy Statement for Electricity Networks Infrastructure (EN-5)*. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/37050/1942-national-policy-statement-electricity-networks.pdf (last visited: 3 October 2014).

Department of Energy and Climate Change (2012a). *Optimum Phasing of high-voltage double-circuit Power Lines - A voluntary Code of*

Practice. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/37446/1255-code-practice-optimum-phasing-power-lines.pdf (last visited: 3 October 2014).

Department of Energy and Climate Change (2012b). *Power Lines: Demonstrating compliance with EMF public exposure guidelines - A voluntary Code of Practice*. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/37447/1256-code-practice-emf-public-exp-guidelines.pdf (last visited: 3 October 2014).

Department of Energy and Climate Change (2013a). *Power Lines: Control of Microshocks and other indirect effects of public exposure to electric fields - A voluntary Code of Practice*. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224766/powerlines_vcop_microshocks.pdf (last visited: 3 October 2014).

Department of Energy and Climate Change (2013b). *Guidance - consents and planning applications for national energy infrastructure projects*. [Online] Available from: https://www.gov.uk/consents-and-planning-applications-for-national-energy-infrastructure-projects (last visited: 3 October 2014).

EFHRAN (European Health Risk Assessment Network on Electromagnetic Fields Exposure) (2012). *Report on priorities of health risk management and communication on EMF exposure*. Available from: http://efhran.polimi.it/docs/EFHRAN_D8_FINALE.pdf (last visited: 16 December 2014).

EirGrid (2014a). *The Grid Link Project - Overview - Project Update - December 2014* [Online] Available from: http://www.eirgridprojects.com/projects/gridlink/overview/ (last visited: 7 January 2015).

EirGrid (2014b). *EMF & YOU Information about Electric & Magnetic Fields and the electricity transmission system in Ireland (revised July 2014)* Available from: http://www.eirgridprojects.com/media/EMF_&_You_Booklet_2014.pdf (last visited: 7 January 2015).

Electricity Supply Board (1999). *Electric and Magnetic fields in the Environment*. Dublin: ESB (http://www.esb.ie/esbnetworks/en/downloads/electric_magnetic_fields_in_environment.pdf).

ELES (Slovenian Electricity Transmission System Operator) (2014). [Online] Available from: http://www.eles.si/en/ (last visited: 3 October 2014).

EMFBRT (2010). *The EMF Biological Research Trust.* [Online] Available from: http://www.emfbrt.org/index.shtml (last visited: 3 October 2014).

EMFBRT (2011). *The EMF Biological Research Trust - Scientific Advisory Committee.* [Online] Available from: http://www.emfbrt.org/sac.shtml (last visited: 3 October 2014).

European Commission (2002). *Implementation report on the Council Recommendation limiting the public exposure to electromagnetic fields (0 Hz to 300 GHz)*. Brussels, European Commission.

European Commission (2008). *Report on the implementation of the Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz – 300 GHz) (1999/519/EC) in the EU Member States. Final commission staff working paper (SI2.489570-SANCO/2OO7/C7/06)*. Brussels, European Commission.

Expert Group on Health Effects of Electromagnetic Fields (2007). *Health Effects of Electromagnetic Fields*. Published by the Department of Communications, Marine and Natural Resources of Ireland. Available from: http://www.environ.ie/en/Publications/Environment/EnvironmentalRadiation/FileDownLoad,2477,en.pdf (last visited: 16 December 2014).

Follenfant, Ph. and Leteurtrois, J-P (2010). *Rapport sur la maitrise de l'urbanisme autour des lignes de transport d'électricité.* Ministère de l'Écologie, de l'Énergie, du développement durable et de la Mer, chargé des Technologies vertes et des Négociations sur le climat et Ministère de l'Économie de l'Industrie et de l'Emploi. Available from: http://www.cgeiet.economie.gouv.fr/Rapports/2010_12_21_Rapport_urbanisme_autour_lignes_transport_electricite_007318-01_rapport_cle2f931a.pdf (last visited: 3 October 2014).

French Republic (2009). *Mobile telephony and health - Summary of the report drafted on behalf of the OPECST by Mr Alain Gest*. Available from: http://www.assemblee-nationale.fr/13/cr-oecst/synthese_telephonie_enanglais.pdf (last visited: 3 October 2014).

Gajšek, P. (2004). *EMF Legislation in Slovenia – need for harmonization*. International Conference on EMF – From Bioeffects to Legislation. Ljubljana, Slovenia, 8 and 9 November 2004.

Gest, A. (2009a). *Les incidences éventuelles sur la santé de la téléphonie mobile - Tome I - Rapport*. Sénat, Session ordinaire de 2009-2010, Annexe au procès-verbal de la séance du 4 novembre 2009. Available from: http://www.senat.fr/rap/r09-084-1/r09-084-11.pdf (last visited: 3 October 2014).

Gest, A. (2009b). *Les incidences éventuelles sur la santé de la téléphonie mobile - Tome II - Auditions Publiques*. Sénat, Session ordinaire de 2009-2010, Annexe au procès-verbal de la séance du 4 novembre 2009. Available from: http://www.senat.fr/rap/r09-084-2/r09-084-21.pdf (last visited: 3 October 2014).

Government of the Netherlands (2015a). *Energy policy - Electricity*. [Online] Available from: http://www.government.nl/issues/energy-policy/electricity (last visited: 6 March 2015).

Government of the Netherlands (2015b). *Energy policy - Government purchase of homes under high-voltage power cables*. [Online] Available from: http://www.government.nl/issues/energy-policy/electricity/government-purchase-of-homes-under-high-voltage-power-cables (last visited: 6 March 2015).

HSE (Health and Safety Executive) (2015) *FAQs - Non-ionising radiation.* [Online] Available from: http://www.hse.gov.uk/radiation/nonionising/faqs.htm (last visited: 11 May 2015).

Health Council of the Netherlands (2000). *ELF Electromagnetic Fields Committee. Exposure to electromagnetic fields (0 Hz - 10 MHz)*.

Publication no. 2000/06E. Health Council of the Netherlands, The Hague.

Health Council of the Netherlands (2013). *Mobile phones and cancer. Part 1: Epidemiology of tumours in the head*. Publication no. 2013/11. Health Council of the Netherlands, The Hague.

Health Council of the Netherlands (2014). *Mobile phones and cancer. Part 2: Animal studies on carcinogenesis*. Publication no. 2014/22. Health Council of the Netherlands, The Hague.

HM Government (2009). *Government response to the Stakeholder Advisory Group on extremely low-frequency electric and magnetic fields (ELF EMFs) (SAGE) recommendations*. Available from: http://www.emfs.info/policy/sage/ (last visited: 15 December 2015).

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans (2002). *IARC monographs on the evaluation of carcinogenic risks to humans. Nonionizing radiation, Part I, Static and extremely low-frequency (ELF) electric and magnetic fields*. Lyon, International Agency for Research on Cancer, Lyon.

IARC Working group on the evaluation of carcinogenic effects to humans (2013). *IARC monographs on the evaluation of carcinogenic risks to humans. Non-ionizing radiation, Part II: Radiofrequency electromagnetic fields*. International Agency for Research on Cancer, Lyon.

ICIA (2007). *Irish Cellular Industry Association. Frequently Asked Questions.* [Online] Available from: http://www.ibec.ie/IBEC/BA.nsf/vPages/Business_Sectors~ICT_Ireland~%27frequently-asked-questions%27-about-mobile-phones-and-base-stations-19-01-2007/$file/ICIA+EMF+FAQ+web+v1.pdf (last visited: 7 January 2015).

ICNIRP (International Commission on non-ionizing radiation protection) (1998). *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*. Health Phys 74: 494-522.

ICNIRP (International Commission on Non-Ionizing Radiation Protection) (2009a). *Exposure to high-frequency EMF, biological effects and health consequences (100 kHz-300 GHz). - Review of the Scientific Evidence and Health Consequences*. International Commission on Non-Ionizing Radiation Protection, Munich. ISBN 978-3-934994-10-2.

ICNIRP (International Commission on Non-Ionizing Radiation Protection) (2009b). *Guidelines on limits of exposure to static magnetic fields*. Health Phys 96: 504-514.

ICNIRP (International Commission on Non-Ionizing Radiation Protection) (2009c). *Statement on the "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)*. Health Phys 97: 257-258.

ICNIRP (International Commission on non-ionizing radiation protection) (2010). *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)*. Health Phys 99: 818-836.

ICNIRP (International Commission on non-ionizing radiation protection) (2015). *Revision of the guidelines on high frequency up to 300 GHz*. [Online] Available from: http://www.icnirp.org/en/activities/work-plan/details/work-plan-hf.html (last visited:15 May 2015).

ICNIRP (International Commission on non-ionizing radiation protection) (2015). *Workshops* [Online] Available from: http://www.icnirp.org/en/workshops/index.html (last visited: 25 March 2015).

IEGMP (Independent Expert Group on Mobile Phones) (2000). *Mobile Phones and Health (The Stewart Report)*. Available from: http://webarchive.nationalarchives.gov.uk/20101011032547/http://www.iegmp.org.uk/report/text.htm (last visited: 3 October 2014).

Imperial College London (2014a). *Cohort study of mobile phone use and health (COSMOS).* [Online] Available from: http://www.ukcosmos.org/index.html (last visited: 3 October 2014).

Imperial College London (2014b). *Study of Cognition, Adolescents and Mobile Phones (SCAMP).* [Online] Available from: http://www.scampstudy.org/ (last visited: 3 October 2014).

INERIS (L'Institut National de l'Environnement Industriel et des Risques) (2014). *Service National d'Assistance sur les champs électromagnétiques.* [Online] Available from: http://www.ineris.fr/ondes-info/ (last visited: 3 October 2014).

INIS (Institute for Non-Ionizing Radiation) (2014a). [Online] Available from: http://www.inis.si/ (last visited: 3 October 2014).

INIS (Institute for Non-Ionizing Radiation) (2014b). *What is e-ticket EMS?* [Online] Available from: https://translate.google.com/translate?depth=1&hl=en&rurl=translate.google.com&sl=sl&tl=en&u=http://www.inis.si/index.php%3Fid%3D350%26L%3D1%253Ftx_datamintsglossaryindex_pi1%255Bidxchar%255D%253Dz%253Ftx_datamintsglossaryindex_pi1%255Bidxchar%255D%253DM (last visited: 3 October 2014).

INIS (Institute for Non-Ionizing Radiation) (2014c). *Electromagnetic Radiation - e-Learning.* [Online] Available from: https://translate.googleusercontent.com/translate_c?depth=1&hl=en&rurl=translate.google.com&sl=sl&tl=en&u=http://www.inis.si/index.php%3Fid%3D21&usg=ALkJrhhXsR06Xd1yUbZAoUDOZZx3rYEtZg (last visited: 3 October 2014).

Knowledge Platform on EMF (2012). *Knowledge Note Electrosensitivity - Health complaints near sources of electromagnetic fields*. Knowledge note 2012-001. Available from: http://www.kennisplatform.nl/Files/2012-08-31KnowledgeNoteonElectrosensitivity.pdf (last visited: 16 December 2014).

legislation.gov.uk (2013). *The Planning Act 2008 (Nationally Significant Infrastructure Projects) (Electric Lines) Order 2013.* [Online] Available from: http://www.legislation.gov.uk/uksi/2013/1479/introduction/made (last visited: 3 October 2014).

McKinlay et al. (2004). *Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300 GHz)*. Documents of the NRPB, Vol. 15, No. 3. Available from: http://webarchive.nationalarchives.gov.uk/20140629102627/http:/www.hpa.org.uk/Publications/Radiation/NPRBArchive/DocumentsOfTheNRPB/Absd1503/ (last visited: 3 October 2014).

Mjönes, L. and L. Hyrke (2011) *Transparency Forum - A Risk Communication Project in Sweden*. In: Pozo, C. del; Papamelelou, D.; Wiedemann, P. M.; Ravazzani, P.; Deventer, E. van (Eds.): *Electromagnetic field exposure: Risk communication in the context of uncertainty*. Rom: Consiglio Nazionale delle Ricerche 2011, S. 7-14.

Mobile Operators Association (2013). *Code of Best Practice on Mobile Network Development in England*. Available from: http://www.mobilemastinfo.com/images/stories/2013_Code_of_best_practice/Code_of_Best_Practice_on_Mobile_Network_Development_-_Published_24-07-2013.pdf (last visited: 3 October 2014).

MTHR (Mobile Telecommunications and Health Research Programme) (2012). [Online] Available from: http://www.mthr.org.uk/ (last visited: 3 October 2014),

National Grid (2015a). *ICNIRP 1998*. [Online] Available from: http://www.emfs.info/limits/limits-organisations/icnirp-1998/ *National Grid information site on EMFs* (last visited: 16 March 2015).

National Grid (2015b). *EU 1999*. [Online] Available from: http://www.emfs.info/limits/limits-organisations/eu-1999/ *National Grid information site on EMFs* (last visited: 16 March 2015).

National Grid (2015c). *A guide to the debate on electric and magnetic fields and health*. [Online] Available from: http://www.emfs.info/ (last visited: 26 March 2015).

NHS (National Health Service) (2011). *Mobile phones and base stations.* [Online] Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/215711/dh_124899.pdf (last visited: 3 October 2014).

NHS (National Health Service) (2014). *Mobile phone safety.* [Online] Available from: http://www.nhs.uk/Conditions/Mobile-phone-safety/Pages/Introduction.aspx (last visited: 3 October 2014).

Netherlands National Government, VNG and Telecom Operators (2010). [*Covenant within the framework of the National Antenna Policy for permit-free antenna installations for mobile telecommunication*]. *Convenant in het kader van het Nationaal Antennebeleid inzake vergunningvrije antenne-installaties voor mobile telecommunicatie.* Sdu Uitgevers, The Hague. Tweede Kamer Vergaderjaar 2010-2011 27561 no. 39 Annex (in Dutch).

Nordic radiation safety authorities (2013). *Exposure from mobile phones, base stations and wireless networks - A statement by the Nordic radiation safety authorities.* Available from: http://www.nrpa.no/dav/1ce2548717.pdf (last visited: 3 October 2014).

NRPB (National Radiological Protection Board) (2004). *Advice on limiting exposure to electromagnetic fields (0 - 300 GHz).* Documents of the NRPB, Vol. 15, No. 2. Available from: http://webarchive.nationalarchives.gov.uk/20140629102627/http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947415497 (last visited: 3 October 2014).

Ofcom (2013). *Sitefinder - Mobile Phone Base Station Database.* [Online] Available from: http://www.sitefinder.ofcom.org.uk/ (last visited: 3 October 2014).

PHE (Public Health England) (2013a). *Electromagnetic fields - Low-frequency electric and magnetic fields.* [Online] Available from: https://www.gov.uk/government/collections/electromagnetic-fields#low-frequency-electric-and-magnetic-fields (last visited: 3 October 2014)

PHE (Public Health England) (2013b). *Electromagnetic fields - Radio waves.* [Online] Available from: https://www.gov.uk/government/collections/electromagnetic-fields#radio-waves (last visited: 3 October 2014)

Projekt Forum EMS (2014). *Home page of the project Forum, EMS.* [Online] Available from: http://www.forum-ems.si/portal.html (last visited 3 October 2014).

Raoul, D. (2010). *Report on "The health and environmental effects of electromagnetic fields produced by high and extra high-voltage lines"*. Senate, Regular Session of 2009-2010, Appendix to the report of the 17 May 2010 session. Available from: http://www.senat.fr/fileadmin/Fichiers/Images/opecst/Rapport.pdf (last visited: 3 October 2014).

République Française (2001). *Arrêté du 17 mai 2001 fixant les conditions techniques auxquelles doivent satisfaire les distributions d'énergie électrique.* [Online] Available from: http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000005631045. (last visited: 24 March 2014).

République Française (2013). *Antennes-relais de téléphonie mobile.* Available from: http://www.radiofrequences.gouv.fr/IMG/pdf/Antennes-relais.pdf (last visited: 3 October 2014).

République Française (2004). *Décret n° 2004-835 du 19 août 2004 relatif aux servitudes d'utilité publique prévues par l'article 12 bis de la loi du 15 juin 1906 sur les distributions d'énergie.* [Online] Available from: http://www.legifrance.gouv.fr/eli/decret/2004/8/19/2004-835/jo/texte (last visited: 23 March 2014).

République Française (2014a). *Les dossiers de la santé - 'Champs électromagnétiques d'extrêmement basse fréquence - Effets sur la santé'.* [Online] Available from: http://www.sante.gouv.fr/ (last visited: 3 October 2014); *Les dossiers de la santé -'Radiofréquences'.* [Online] Available from: http://www.radiofrequences.gouv.fr/ (last visited: 3 October 2014).

République Française (2014b). *Surveiller et mesurer Les Ondes Électromagnétiques.* Available from: http://www.developpement-durable.gouv.fr/IMG/pdf/13192-2_Ondes_electromagnetiques.pdf (last visited: 3 October 2014).

Republic of Slovenia Ministry of Health (2015). *About Slovenian Radiation Protection Administration.* [Online] Available from: http://www.uvps.gov.si/en/ (last visited: 26 February 2015).

RPS Group (2014). *EirGrid Evidence Based Environmental Studies. Study 1: EMF. Literature review of electromagnetic fields (EMF) and human health, and an evidence base of EMF measurements from the Irish Transmission System*. Dublin: EirGrid.

RTE (Le réseau de l'intelligence électrique) (2014). *Carte de mesures - Consultez les mesures de champs magnétiques.* [Online] Available from: http://www.clefdeschamps.info/Carte-de-mesures (last visited: 3 October 2014).

RTE (2012). *Les champs électromagnétiques générés par les lignes à haute tension - 10 Questions, 10 Réponses.* Available from: http://www.rte-france.com/uploads/media/pdf_zip/champs-magn-tiques/Champs-electro-Brochure2012.pdf (last visited: 3 October 2014).

SAGE (2007). *First Interim Assessment: Power Lines and Property, Wiring in Homes, and Electrical Equipment in Homes*. Stakeholder Advisory Group on ELF EMFs. Available from: http://www.emfs.info/policy/sage/ (last visited: 15 December 2015).

SAGE (2010). *Second Interim Assessment 2009 - 2010: Electricity Distribution (including low - voltage and intermediate - voltage circuits and substations) and Report on Discussions on Science*. Stakeholder Advisory Group on ELF EMFs. Available from: http://www.emfs.info/policy/sage/ (last visited: 15 December 2015).

SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) (2015). *Opinion on potential health effects of exposure to electromagnetic fields (EMF)*. European Commission, Health & Consumer Protection DG, Brussels. 20-01-2015. For an easy to read summary, see the website: http://ec.europa.eu/health/scientific_committees/opinions_layman/electromagnetic-fields2015/en/ (last visited: 20 March 2015).

SSM (Swedish Radiation Safety Authority) (2012). *Magnetfält i bostäder*. Report number: 2012:69 ISSN: 2000-0456. Swedish Radiation Safety Authority, Stockholm. Available from: http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Stralskydd/2012/SSM-Rapport-2012-69.pdf (last visited: 3 October 2014).

SSM (Swedish Radiation Safety Authority) (2014). *Recent research on EMF and Health Risk. Ninth report from SSM's Scientific Council on Electromagnetic Fields*. Report number: 2014:16 ISSN: 2000-0456. Swedish Radiation Safety Authority, Stockholm.

Stam, R (2011). *Comparison of international policies on electromagnetic fields (power frequency and radiofrequency fields)*. National Institute for Public Health and the Environment, Bilthoven.

Stam, R., M.J.M. Pruppers and J.F.B. Bolte (2014). [*Sources of electromagnetic fields and exposure of members of the public*] *Bronnen van elektromagnetische velden en blootstelling van burgers*. RIVM rapport 2014-0132. National Institute for Public Health and the Environment, Bilthoven. (in Dutch, with English abstract) Available from: http://www.rivm.nl/Documenten_en_publicaties/Wetenschappelijk/Rapporten/2014/december/Bronnen_van_elektromagnetische_velden_en_blootstelling_van_burgers (last visited: 7 January 2015).

State Secretary of Housing, Spatial Planning and the Environment (2004). *[Letter on 'Health and Environment' to the Parliament*] *Brief 'Gezondheid en milieu' aan de Voorzitter van de Tweede Kamer*. Tweede Kamer, vergaderjaar 2004–2005, 28 089, nr. 7 (in Dutch).

State Secretary of Housing, Spatial Planning and the Environment (2005). [*Recommendations with regard to high-voltage overhead power lines*] *Advies met betrekking tot hoogspanningslijnen*, 3 oktober 2005, kenmerk SAS/2005183118. (in Dutch).

Svenska Kraftnät (2010). *Elektriska och magnetiska fält vid stora kraftledningar*. Svenska Kraftnät, Sundbyberg.

Svenska Kraftnät (2014). *The consultation and permit process when we expand the national grid.* [Online] Available from: http://www.svk.se/Start/English/Projects/The-consultation-and-permit-process/ (last visited: 3 October 2014).

Swedish Radiation Safety Authority (2004). *Mobile telephony and health. A Common approach for the Nordic competent authorities*. Swedish Radiation Safety Authority (inter alia), Stockholm.

Swedish Radiation Safety Authority (2008). *Guidelines for limiting exposure of the population to electromagnetic fields* (in Swedish). Swedish Radiation Safety Authority, Stockholm.

The Planning Inspectorate (2012). *National Infrastructure Planning - Participating in the process.* [Online] Available from: http://infrastructure.planningportal.gov.uk/application-process/participating-in-the-process/ (last visited: 3 October 2014).

WHO (2006). *Environmental Health Criteria 232. Static fields*. World Health Organization, Geneva.

WHO (2007). *Environmental Health Criteria 238. Extremely low-frequency fields*. World Health Organization, Geneva.

WHO (2014). *Radio Frequency fields: Environmental Health Criteria Monograph.* Available from: http://www.who.int/peh-emf/research/rf_ehc_page/en/ (last visited: 11 May 2015).

Appendix 1 Experts consulted on practices in their country

France
Olivier Merckel (French Agency for Food, Environmental and Occupational Health & Safety; ANSES)

The Netherlands
Rob Schutte (Ministry of Infrastructure and the Environment; IenM)
René Vroom (Antenna Bureau)

Slovenia
Nina Jug (Slovenian Radiation Protection Administration; SRPA)

Sweden
Torsten Augustsson (Swedish Radiation Safety Authority; SSM)

United Kingdom
Myron Maslanyj (Public Health England; PHE)
Stuart Conney (Department of Health; DH)

Although every effort was made to consult experts on practices in their own country and to ensure that those consulted had the opportunity to verify the information gathered, they are not responsible for the accuracy or completeness of the information included in Chapter 3.

Glossary

Base station for mobile communication
A wireless communications station installed at a fixed location and used to communicate as part of a wireless telecommunication system.

Electric field strength
The force exerted by an electric field on a point charge divided by the electric charge; unit: volts per meter (V/m).

Electromagnetic field (EMF)
The field of force associated with electric charge in motion, having both electric and magnetic components and containing a definite amount of electromagnetic energy.

Extremely low-frequency (ELF)
Frequency below 300 hertz (Hz).

High-voltage overhead power line
The system of electrical wires suspended in air by pylons, used for the carrying of electricity either from a power plant to a substation, or from a substation to a building such as a plant, commercial building or a home.

IARC
International Agency for Research on Cancer.

ICNIRP
International Commission on Non-Ionizing Radiation Protection.

Magnetic flux density
The amount of magnetic flux (component of a magnetic field perpendicular to an area multiplied by the size of that area) in an area taken perpendicular to the magnetic flux's direction; unit: tesla (T). The magnetic flux density is often used to describe the strength of the magnetic field.

Power density
The amount of electromagnetic energy passing per unit time through a unit area perpendicular to the direction of an electromagnetic wave; unit: watts per square metre (W/m^2). The power density of a signal degrades over distance from the source due to absorption, diffraction, diffusion, dispersion and scattering.

Radiofrequency (RF)
Frequency between 100 kilohertz and 300 gigahertz.

SCENIHR
Scientific Committee on Emerging and Newly Identified Health Risks.

Specific energy absorption rate (SAR)
The rate, averaged over the whole body or over parts of the body, at which energy is absorbed per unit mass of body tissue; unit: watt per kilogram (W/kg).

Static electric field
A physical field near a static electric charge that exerts an attractive or repulsive force on an electric charge.

Static magnetic field
A physical field near a permanent magnet or a direct electric current that exerts a force on a moving electric charge.

Thermal effects
Effects due to heating of tissues as a result of exposure to time-varying fields (with frequencies above 100 kHz) of sufficient strength.

Epidemiology
WHO-definition: "The study of the distribution and determinants of health-related states or events (including disease), and the application of this study to the control of diseases and other health problems. Various methods can be used to carry out epidemiological investigations: surveillance and descriptive studies can be used to study distribution; analytical studies are used to study determinants" (http://www.who.int/topics/epidemiology/en/)

RIVM
Committed to *health and sustainability*