Swiss Re

Electrosmog – a phantom risk

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Foreword

"Electrosmog" is suspected of causing or promoting cancer and other diseases. Prevailing opinion assumes, however, that the electrical engineering and power industries can only be held liable if science provides conclusive proof – which it has not done to present – that weak electromagnetic fields (EMF) impair health. This publication comes to the opposite conclusion and shows that, on the basis of present knowledge alone, it must be expected that plaintiffs will win suits dealing with this issue.

The following chapters explain in detail why it is not possible to answer with certainty the question of whether weak electromagnetic phenomena pose health risks. While it is true that epidemiological studies could provide evidence that human beings subject to certain conditions of exposure fall ill with greater frequency, such statistics can never be taken as a basis for drawing conclusions with regard to a specific case. As long as the causes of cancer and other diseases have not been identified beyond all doubt, statements concerning them are, at best, conjecture.

The crucial question, therefore, is not what results EMF research will yield in the foreseeable future, but how society will evaluate such conjecture. On the one hand, it seems unjust not to award compensation to victims only because the cause of their illness cannot be established beyond doubt; on the other, it is equally unjust to declare someone liable on the mere assumption that he may have caused the harm.

For the insurance industry, this standoff gives rise to an extremely dangerous risk of change composed of two parts: the classical development risk, that is, the possibility that new research findings will demonstrate electromagnetic fields to be more dangerous than has hitherto been assumed; and the sociopolitical risk of change, in other words, the possibility that changing social values could result in scientific findings being evaluated differently than they have been thus far.

The direction of this change is outlined by the gradual transition of liability law from its original form of fault liability, through strict or absolute liability, to the liability – in part already practised – of mere presumption or suspicion. The legal instrument of liability is increasingly being used or even misused as a means of coping with the problems of life, be it in the pursuit of political goals in a fight against what is perceived to be an increasingly alienated world, or for the profane purpose of self-enrichment.

Thus, we assess the risk of change as being extraordinarily explosive not because weak electromagnetic fields might, contrary to expectations, prove to be hazardous after all (similar to asbestos fibres, which years ago were gradually proved to be deleterious to health). We consider the risk of change to be so dangerous because it is evident that a wide range of groups have great political and financial interest in electrosmog being *considered* hazardous by society.

If these interest groups prevail, current and future EMF liability suits could be decided in favour of the plaintiffs, thereby confronting the insurance industry with claims on a scale which could threaten its very existence. Even at this stage, it is to be expected that the costs for defence will be immense.

In this sense, this publication is a warning. The EMF problem is more dangerous and more threatening for the insurance industry than has generally been supposed – due not to the incalculably small health risks, but to the incalculably great risk of sociopolitical change.

Yet this publication is intended to do more than simply warn. It will also shed light on the theoretical, scientific background as well as the sociopolitical context of this change, and will present the EMF problem as a typical example of a "phantom" risk: that is, a prospective hazard, the magnitude of which cannot be gauged and which perhaps does not even exist, but which is nonetheless real – if only in that it causes anxiety and provokes legal actions.

The insurance industry will see itself confronted with such phantom risks ever more frequently in the future. Apart from the urgent need for measures to limit losses in the EMF area, there is the more comprehensive task of developing new strategies for dealing with risks of technological development and of sociopolitical change. The insurance industry can contribute to this development, but only in close cooperation with all those involved.

While this publication presents no solutions, it does point out where they are to be sought: in the values, laws, customs and conventions which govern human interaction in highly complex societies. Such rules cannot be modified unilaterally – on the contrary, they will have to be negotiated and agreed upon, time and again. We are ready and willing to enter into this dialogue, and invite you to take part in a forward-looking discussion of pragmatic and feasible solutions.

Dr. Bruno Porro
Member of the Executive Board

Introduction
The only reliable answer is Perhaps

The public discussion about so-called electrosmog focuses on two questions: Do electromagnetic fields and radiation – for the sake of brevity, EMF – impair health? And are manufacturers and/or operators of installations and devices which generate such fields and radiation liable for any harm they cause?

The EMF problem: both complicated and complex

Generally, it is expected that the question as to whether electromagnetic fields and radiation pose a health risk will be answered sooner or later with a clear Yes or No, which would then more or less automatically clarify the question of legal liability. This expectation is erroneous because it is based on a mistaken assumption: namely, that the relationships between EMF exposure and diseases such as cancer, immune deficiency, Alzheimer's and Parkinson's are merely complicated. In fact, however, we are dealing with complex relationships which cannot even be identified, let alone understood, using the research methods presently available.

The answers concerning these relationships lie beyond the limit of what is now knowable. This can be illustrated by a simple analogy from the history of science: it was only after the microscope had been invented that man was able to see that there are bacteria, viruses and other microscopic life forms which cause diseases. Today, science is searching for methods and instruments which – comparable to the microscope – can be used to gain greater insight into complex systems such as the human organism, and perhaps one day even to understand them. Until that time, the effects of electromagnetic phenomena on the human organism will remain a matter of conjecture and supposition. These are too vague, however, to provide a reliable yes-or-no answer to the question posed at the outset concerning the harmfulness of EMF. The only reliable answer is Perhaps.

In order to make this Perhaps as definite as possible, it would be necessary to consider every bit of information available. We would first have to grapple intensively with quantum theory and the theory of relativity in order to gain a rough idea of what physicists understand when they speak of fields and radiation, energy and force, space and time. We would also have to discuss all the hypotheses regarding the genesis of cancer and other diseases in order to understand what physicians and physiologists know – and don't know – about the causes of these diseases. All this would then have to be considered against the background of the more than 2500-year history of the concept of causality in order to comprehend why science now understands causality and natural law differently than it did even as recently as the beginning of this century; and finally, we would also have to examine how science's new understanding of causality affects lawmaking and court decisions. However, this would in turn lead farther, to the discussion of social and political issues as controversial as they are fundamental.

At the interface between law and science

Such a multidisciplinary approach to the EMF problem is problematical, however, because each of the disciplines involved has its own way of thinking, its own methodology and language: and with no specialized knowledge, the conclusions reached in the respective disciplines would have to appear contradictory to us. On the other hand, we cannot disregard these contradictions because it is precisely here, at the interface between law and science, that the EMF problem has its actual origin. This is because with only inconclusive scientific findings to go on, the legal systems now find themselves facing the task of achieving a just balance between the individual's need for protection and the interests of society as a whole. How should we deal with technologies which obviously benefit many, but which may possibly do serious harm to some few?

EMF from the viewpoint of the insurance industry

Since no one has more experience in the systematic handling of risks than the insurance industry, it is quite properly expected that the insurance industry will contribute to solving this problem. However, many interest groups are attempting to exploit politically the insurance industry's stance toward the EMF issue. They seize, for example, on the industry's willingness or lack of willingness to provide cover for EMF risks, over-interpreting these statements as proof of the harmlessness or harmfulness, respectively, of electromagnetic phenomena. The insurance industry must reject all such efforts. Insurers can evaluate the issue of EMF neither scientifically nor philosophically, neither medically nor legally, and certainly not at all with regard to party politics. They can only state a position in regard to each of these questions from their own perspective.

EMF from the viewpoint of risk management

This is the approach upon which this publication is based: we shall discuss the EMF issue from the viewpoint of risk management. We do not see our task in settling the epistemological, physical, technical, physiological, legal, sociological or political questions, but shall attempt instead to show how the risks associated with EMF appear in light of presently available information, and describe the options for risk management. Rather than attempting to solve the problem, we will restrict ourselves to outlining alternatives for dealing with it, whereby we will concentrate – in keeping with the purpose of insurance – on the transfer of risk.

EMF health risk and EMF liability risk

The chief prerequisite for a systematic discussion of EMF risks is to distinguish consistently between the EMF health risk and the EMF liability risk. Only then does it become clear that the question of liability will not be decided through the clarification of scientific and medical aspects. On the contrary, the current trends in the development of modern societies offer reason to fear that a liability risk will exist even in the absence of any proof that weak electromagnetic fields present a danger to health. In order to depict this situation in a clear and readily understandable manner, this publication has been divided into four chapters.

While the chapter entitled “EMF health risks” discusses the health hazards, the chapter “EMF liability risks” deals with the danger of claims for compensation, particularly against the electrical engineering and electronics industries. The chapter “EMF risks for insurers” shows that, from an underwriting perspective, the *health* risk represents no unusual task, but that under certain conditions the *liability* risk may assume existence-threatening proportions for insurers and that it will be possible to provide cover only if the general public fulfils certain elementary conditions which make insurance possible. The measures to be taken by insurers in this regard are the subject of the “Summary”.

A record of a thought process

For the sake of easy readability and comprehension, we will dispense with a scientific presentation of our long-term studies on the EMF issue. We will concentrate instead on the essentials and point out where solutions are to be sought: not before the courts or in the research laboratories, but in the sociopolitical controversy on how to deal with risks. That is why this publication is to be seen not as a “final result”, but as the record of a thought process within Swiss Re, the principal objective of which has been to gain as precise a grasp of the problem as possible. A large number of scientists and experts from Europe, the United States and Japan have contributed to this effort in numerous personal conversations. To all of them, we extend our thanks, particularly for their readiness to cross the indistinct boundaries of their respective disciplines and to help us highlight the cross-disciplinary nature of the EMF issue.

Any discussion of the health risk posed by EMF involves five questions: What are electromagnetic fields and radiation? What dangers do they represent for the human organism? How great is the risk of health impairment through electromagnetic exposure? How is this risk to be assessed? And how can we handle this risk?

What are electromagnetic fields and radiation?

Physicists understand a field to be a region of space under the influence of a force. The gravitational field of the earth, for example, is filled with gravitational forces which pull us toward the centre of the earth. Electrical fields consist of electrical forces exerted by charged particles such as protons and electrons. Particles with like charges repel one another, while those of opposite charge attract one another. It is a result of this attraction that these elementary particles form the atoms which in turn make up molecules, cells, organs and living beings. Thus, we consist of matter which is held together by electrical fields.

If the electrical forces of bonded particles cancel each other out, the particles appear to be electrically neutral. If disparate materials are brought into contact, however, a gradual exchange of charged particles occurs through the surfaces where the materials touch. For example, if a man puts on a woollen pullover by pulling it over his head, negatively charged particles wander from the wool to his hair. Between his then negatively charged hair and the positively charged pullover, an electrical potential builds up: his hair and the pullover attract one another. If he then rapidly pulls off his pullover, there is not enough time for the negatively charged particles to spring from his hair back to the wool. This leaves a surplus of negatively charged particles on his hair, with the result that the individual hairs repel one another; his hair stands on end and remains that way until the surplus of charged particles drains off as a weak electrical current through his body to the earth.

Magnetic fields

Charged particles in motion – in other words, electrical currents – generate a magnetic field. When current flows through a cable, a magnetic field propagates from it. If we wind the cable into a coil and cause a current to flow through it, a rotating magnetic field is created in its interior. If we then install a freely rotating magnet there, it will be drawn along by the magnetic forces of the charged particles in the current and will turn. This is the principle of the electric motor. Conversely, if we turn the magnet, its magnetic field moves the charged particles in the cable, producing an electrical current. This is the principle of the generator.

Electromagnetism

These relationships are referred to as electromagnetism. Charged particles in motion produce magnetic fields; magnetic fields in motion generate electrical currents. The earth's magnetic field, too, is produced by electrical currents, in this case by strong currents within its interior.

The origin of magnetism

But why, then, is a common, obviously "non-electrical" household magnet – *magnetic?* Electrons rotate about their own axes, comparable to figure skaters who, when turning a pirouette, rotate on one spot without moving from it. Even if an electron appears to be at rest, it is in fact constantly in motion and therefore always surrounded by a magnetic field. Depending on the constellation of the elementary particles, the magnetic forces may cancel each other out, in which case the atoms or molecules do not appear to be magnetic; or the forces may reinforce one another, in which case the object exhibits magnetism.

Alternating electrical fields, alternating magnetic fields

As most people are aware, there are two types of current: direct current, in which charged particles move from one end of a cable to the other, and alternating current, in which the charged particles move back and forth, comparable to a pendulum. The fields generated by these charged particles also move correspondingly, becoming alternating electrical or magnetic fields as a result. Whereas a man's hair stands on end in a direct-current field, it is made to oscillate by an alternating-current field. Sensitive individuals perceive this as a slight vibration of their body hairs when, for example, they stand directly beneath a high-tension line.

Electromagnetic radiation

Let us imagine a single such charged particle and its fields in an alternating current. When the charged particle comes to a halt, the motion of its fields is slowed. Therefore, we would expect the fields in motion to come to a halt at precisely the same point in time as their charged particle. According to the theory of relativity, however, information can propagate no faster than the speed of light: that is to say, only with finite speed. This means that the outer areas of the fields do not immediately receive the information that "their" charged particle is decelerating, but only after a delay. Although the charged particle is already at rest, its fields are still in motion. If the charged particle moves back and forth very rapidly, the fields lose their connection to their charged particle: they separate from their source and propagate through space as electromagnetic radiation – comparable to a tone leaving the string of a piano and passing through space. Familiar examples of electromagnetic radiation are light, heat and radio signals.

The limits of man's knowledge of physics

What are forces and radiation composed of? Physics does not yet know. On the one hand, light behaves like a wave, yet on the other it exhibits properties of particles: this is why physicists speak of the wave-particle duality. This phenomenon cannot be explained without giving up our traditional ideas of space and time, a discussion of which would far exceed the scope of this publication. We will restrict ourselves, therefore, to providing a simplified summary of the physical aspects. Fields consist of forces, and may be gravitational, electrical or magnetic in nature. The effect of these forces is to accelerate – either by attraction or repulsion – any field source of the same type. In direct current fields the force is constant, while in alternating current fields it is continually reversing its direction, and any attracted and repelled particles are made to oscillate as a result. We can imagine radiation as alternating current fields which separate from their source and propagate freely through space.

How dangerous are electromagnetic fields and radiation?

Since our bodies are composed of particles which are all surrounded by electrical and magnetic fields of varying strengths, every part of our organism can, in principle, be moved or caused to oscillate by fields or radiation impinging from outside. An eye cell prepared in an aqueous solution in a test tube, for example, exhibits pronounced magnetic characteristics. Like the needle of a compass, it orients itself according to the field of a magnet placed in its vicinity.

In a living human being, of course, eye cells cannot change their orientation in response to momentary swings in the magnetic field because they are part of a firm tissue. In order for particles actually to be moved, they must either be freely movable, as in the example of hair, or the forces acting upon the particles must be strong enough to tear them loose from their surrounding bonds.

Only a question of dosage?

Following the principle of Paracelsus, according to which the dosage alone determines whether a substance is poisonous, it might be assumed that the degree of danger to health is determined solely by the strength of the field or radiation – in much the same way as the temperature of a stone may be determined simply by measuring the amount of energy added to it from outside. However, our organism represents a complex system, which itself produces and consumes energy and reacts to the addition of energy in very different ways.

Consider this example from the world of the cinema: the lamp of the film projector gives off light energy which is reflected from the screen, absorbed by our eyes, converted to electrical energy in the retinas, and passed along in the form of nerve signals to the visual centre of our brains. In this way we see Anthony Perkins, for instance, as he swings his knife in Hitchcock's film *Psycho* – and our hearts race.

EMF as signals

The reaction of an organism is determined, therefore, not only by the quantity of energy absorbed, but also by the information transmitted and/or its interpretation. This is why physiologists prefer to speak not of causes and effects, but of signals and responses. In the film, the signal consists of the information that "a murder is about to occur". Depending on the temperament and movie-going experience of the viewers, the biological responses may range from a bored yawn to a coronary infarction.

Let us now imagine that one of the viewers, in response to the above murder scene, were to jump up in fright and flee the cinema. This biological response obviously entails the expenditure of much more energy than was contained in the signal that triggered it. This example illustrates a relationship that is especially important for gaining a correct understanding of the EMF issue, namely that organisms can amplify the energy of signals. The actual cause of the biological response is this amplification process, not the signal itself, which "merely" triggers it.

Energy effects

It is therefore necessary to distinguish between energy effects and signal effects as two different dangers posed by electromagnetic phenomena. Energy effects harm organisms when individual molecules, cells or organs absorb so much energy that they are totally or partially destroyed. The rays of the sun, for example, can heat our skin cells so powerfully that we get sunburnt. Short-wave solar radiation – that is, radiation at wavelengths shorter than the ultraviolet range – contains still more energy and thus can even break apart the chemical bonds in the genes of skin cells. One possible consequence is the formation of cancer cells. Microwaves and radio waves contain considerably less energy than short-wave solar radiation, but penetrate more deeply into the body and can therefore heat up tissues at deeper levels. This is the effect seen when microwaves in an oven cause the water molecules in a piece of meat to oscillate rapidly: the meat is heated and cooked from within.

The danger of such radiation sources is frequently overestimated because people fail to consider that the energy density of the radiation diminishes geometrically with increasing distance from its source. This is readily understandable if one takes a common electric stove as an example. Immediately above a hot burner, the electromagnetically induced heat radiation is so powerful that we would soon burn our fingers if we were to hold them there. Yet at a distance of as little as half a metre, the radiation is so weak as to be harmless. The assumption that weak radio signals could harm human beings is more or less equivalent to the fear that one could burn one's fingers on a stove in the kitchen while sitting in the living room.

Another misunderstanding results from the widely held opinion that *radiation* is always dangerous, even if it is extremely weak. Apart from the common association with radioactivity, this fear is based on the assumption of a proportional cause-and-effect relationship: that is, if strong radiation severely impairs health, a fraction of this radiation will impair health proportionately. In fact, however, energy processes always proceed in quanta, that is, in graduated stages. If we steadily add energy to a system, certain effects occur not in response to the amount of energy added, but at irregular intervals, and only when the system has reached the energy level required for the specific effect. In other words, the addition of energy – sunlight, for example – will always heat a skin cell, but the cell will not be damaged by this heat until its internal temperature rises above 47° Celsius. Thus, thermal damage always requires the addition of a relatively large amount of energy.

Signal effects

Signal effects, on the other hand, can be brought about by even the weakest fields because, as was illustrated in the example of the terrified cinema-goer, an organism can convert weak signals into powerful biological responses – much as a radio receiver amplifies the weak signals emitted by a transmitter. Working on the generator principle outlined above, an external alternating magnetic field can induce electrical currents in the body, which under certain circumstances can lead to heart flutter, provoke visual disturbances or affect biochemical processes.

This is analogous to the drop that causes a barrel to overflow. However, this analogy fails to reflect the complexity of the human organism. We would instead have to imagine a barrel that constantly produces and consumes water itself, is also filled from numerous sources, and at the same time discharges water from many openings. Moreover, the barrel would have to have a control mechanism capable of compensating even enormous fluctuations in the water level by opening overflow values or liberating built-in water reserves in the blink of an eye.

The amounts of energy involved in weak electromagnetic phenomena are of an order that is equivalent, in the above analogy, to individual water droplets, or even water molecules. These phenomena are thus so weak that, for practical purposes, a single such field cannot disturb an intact organism.

Electrosmog

Nonetheless, harm to the organism is conceivable. First, it would be possible for many droplets to make their way into the barrel all at once. This corresponds to the hypothesis of electrosmog: some researchers conjecture that the profusion of electromagnetic phenomena in environments with high densities of electrical devices produce a kind of smog which over the long term stresses organisms in a manner similar, for example, to low-volume, but continuous noise. As yet unclear is the significance of this electrical stress for the organism as a whole, especially when it is compared quantitatively with other stress factors such as chemicals or psychological factors.

Melatonin hypothesis

Secondly, it is conceivable that the regulatory mechanism itself could be impaired. One example of such thinking is the melatonin hypothesis. Melatonin is an important hormone which is thought to have a cancer-suppressing effect. It is produced by the pineal gland, which is located deep in the brain. One of the mechanisms regulating the production of melatonin is the retina of the eye: the more light there is, the less melatonin is produced. Experiments show that magnetic fields also act on the pineal gland, leading to a decrease in melatonin production. The fields do not damage the gland, but send it a signal not to produce melatonin at the present time. This is why we cannot exclude the possibility that magnetic fields of technical origin may influence the pineal gland, cause a reduction in melatonin production and thus indirectly weaken an organism's defences against tumours. Apart from the circumstance that the cancer-suppressing effect of melatonin is questionable, the impaired function of the pineal gland is a purely qualitative observation and provides no specific evidence of any kind as to whether and to what extent the defence system against tumours is actually impaired.

Problems in EMF research

The case is similar with all other hypotheses regarding possible connections between signs of irritation and pathological processes. They are indeed conceivable, but can neither be proved nor disproved, let alone quantified. Instead of discussing these hypotheses individually, it is more important to show why it is so difficult for research to shed light on these relationships.

Powerful fields and radiation leave clear signs: overheating and burns change tissues in characteristic ways, for example. In principle, therefore, we are dealing with damage which as a rule can be attributed just as unambiguously to certain types of electromagnetic exposure as a broken bone can be attributed to a fall while skiing. A case in point: during work on a radar transmission antenna, the radar transmitter was inadvertently put into operation and one of the technicians exposed to powerful microwave radiation. The man died a short time later. An autopsy revealed burn-like tissue changes which were clearly attributable to the thermal load resulting from the microwave radiation.

Such accidents and experiments on in-vitro molecules, cells and organs clarify beyond any doubt the general relationship between certain types of electromagnetic exposure and thermal damage. Because a skin cell heated to more than 47°C not only may, but will unavoidably be destroyed, we may conclude that if a skin cell has been destroyed through heat, it must have absorbed a corresponding amount of energy.

Weak fields and radiation, on the other hand, need not necessarily trigger biological responses, but they may. If we expose our bodies to weak fields, this exposure will not certainly, but only possibly lead to certain reactions. In addition, the various biological responses may also be triggered through other signals. To return to our earlier example, reduced melatonin production may be attributable not only to the effects of magnetic fields, but to many different, possibly even unknown processes.

We see, then, that research conducted in this area strives to clarify two fundamentally different relationships. On the one hand, there are classical cause-and-effect relationships which often can even be demonstrated experimentally. If a cell is overheated, it is always destroyed. In order to identify such relationships, it is not even necessary to have precise knowledge of intercellular processes. For practical purposes, it is sufficient to determine simply that a relationship exists.

On the other hand, research deals with complex cause-and-effect interrelationships, in which observable biological responses can be triggered or influenced in unknown ways by weak signals.

Contrary to the generally held assumption that research is being conducted to prove that weak EMF phenomena cause cancer, the aim of research is to find out *whether* electromagnetic phenomena influence such diseases, and – if so – in what way and under which conditions: it cannot even be excluded that such phenomena might have a salubrious effect. Research will not be able to provide unequivocal answers until the causes of these diseases have been identified completely. Should we some day know what role weak electromagnetic fields play in cancer, then it will only be because we will also know what causes cancer. Until that time, science will have no choice but to continue advancing, studying and rejecting new hypotheses until finally, from many individual findings, a conclusive overall picture of cancer and other diseases emerges.

Epidemiological studies

As an alternative to this arduous path of studying causes, more and more attempts are being made to demonstrate health-impairing effects of electromagnetic phenomena by means of epidemiological studies. For example, several studies show that children growing up in the vicinity of high-voltage lines develop leukaemia more frequently than the norm. However, to see this as proof or even clear evidence that electromagnetic fields have a carcinogenic or cancer-promoting effect is to draw a conclusion that contradicts all the rules of statistics and is scientifically untenable. This is because these studies note only the correlation between the presence of certain sources of EMF – the electrical lines – and the relative incidence of this disease among children who live nearby. Yet these studies neither measured the field strengths or radiation intensities to which the children were effectively exposed, nor were they able to determine whether signs of irritation actually occurred. Moreover, statistical studies never conclude anything about the type of relationships which may exist between two phenomena.

In another example, a Scandinavian study found that after more than ten years of work, railway-track inspectors develop brain tumours about twice as frequently as the average among the population. This could also be seen as definite proof of the danger posed by the fields extending from the electrical contact wires. However, the author of the study, Tore Tynes, points out that track inspectors are exposed not only to electromagnetic fields as they walk along the railway tracks each day, but also to many other factors, including known dangers to health such as metal dust and the vapours of wood preservatives used to treat the railway ties.

In order to help clarify the questions involved in the EMF issue, statistical studies would have to satisfy a crucial criterion: the groups of people compared would have to differ only in their degree of electromagnetic exposure. All other circumstances, their manner of living and even their genetic predispositions would have to be identical. Only if this criterion is satisfied would it be justified to assume that the abnormal incidences of disease are directly related to electromagnetic exposure.

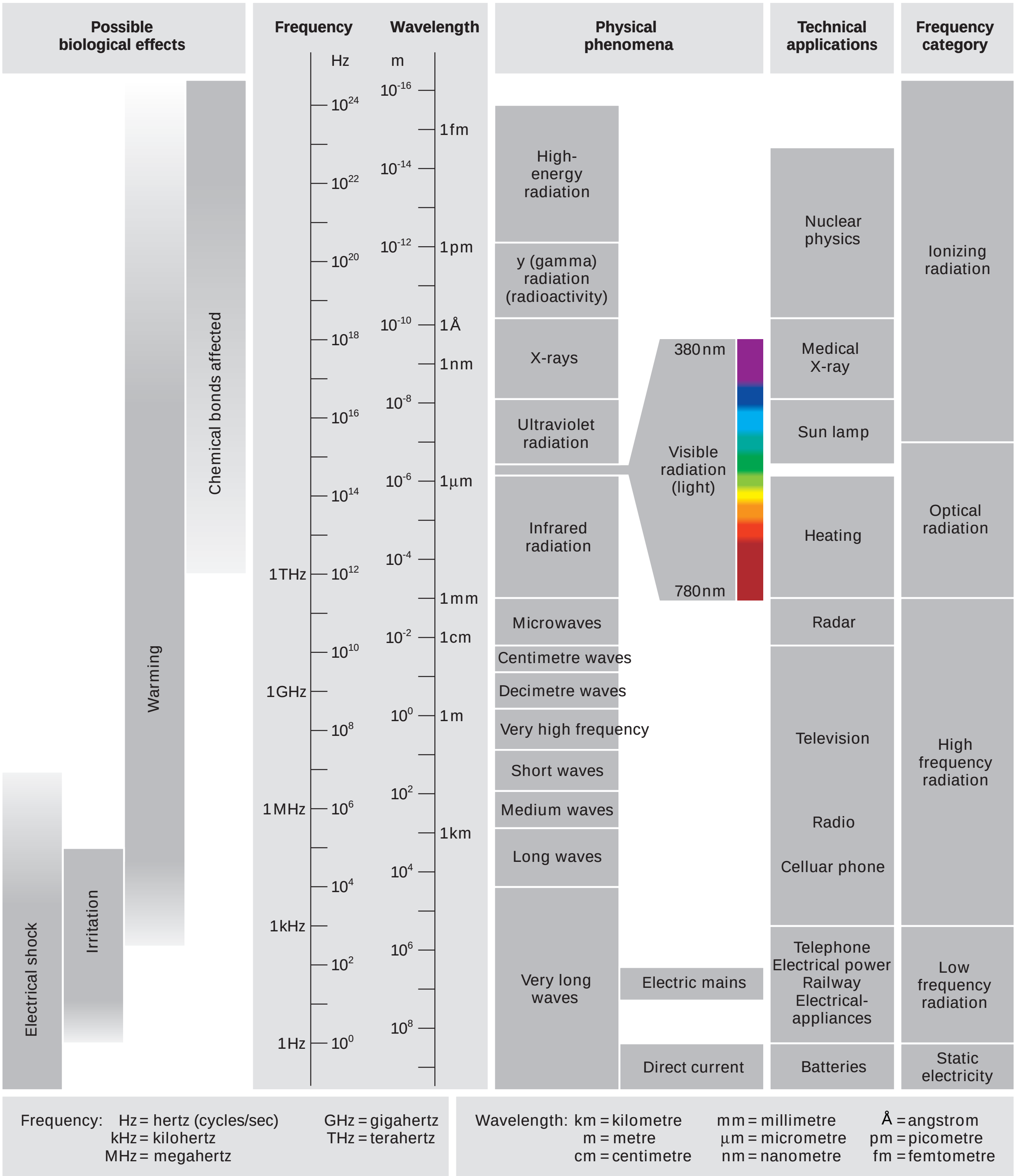
In practice, this criterion cannot be met, which is the reason that epidemiological studies are, in the final analysis, an unsuitable instrument for researching EMF. Televisions, radios, telephones, telefaxes, cellular phones, artificial lights, neon signs and other technical applications of electromagnetism are always associated with certain life styles, which without any doubt can also have an effect on health. Let us assume that an epidemiological study were to demonstrate that television viewers fall ill more frequently than people who never use electronic mass media. This would by no means establish which factor places greater stress on the organism: the fields and radiation emanating from the television receiver, the content of the television programmes watched, or the sedentary habits of the viewers.

Summary

At the beginning of this chapter, we asked what health hazards are posed by electromagnetic phenomena. The spectrum of possible effects ranges from clearly demonstrable, life-threatening damage, to signs of irritation which affect the organism only indirectly, if at all. According to prevailing opinion, these effects are directly related to the strength of the fields and radiation involved. In fact, this applies to thermal damage only, however: only with the *thermal* effects of EMF is it possible to determine limits beyond which damage must occur and below which it cannot occur, and therefore to exclude the possibility of such damage.

Such limits cannot be determined for *irritation.* It is true that every signal also represents an input of energy. Since the signals are amplified by the organism, however, it is theoretically possible for even the weakest signal to induce biological responses and in this way affect organic processes. This yields the hypothetical possibility of indirect relationships between weak electromagnetic exposure and, in the final analysis, every complex process taking place in the organism, including such diseases as cancer, Alzheimer's, Parkinson's and so forth. The apprehension that fields produced, for example, by electrical lines or devices could represent a danger to health rests entirely upon this hypothetical possibility. No proof of this relationship has yet been offered, and judging by the present state of affairs, none should be expected in the foreseeable future because this would presuppose the development of research methods and instruments capable of offering a genuine understanding of complex systems such as the human organism.

The table below gives an overview of the wide spectrum of electrical and magnetic fields and electromagnetic radiation, showing technical applications as well as the biological effects established to date.



How great are the health risks posed by EMF?

To recapitulate: when gauging the health risks posed by EMF, it is necessary to consider the aspects of thermal damage and irritation. Thermal damage is directly proportional to the strength and duration (or frequency) of exposure. The more powerful the electromagnetic fields or radiation, and the more frequently a person is exposed, the more probable it becomes that thermal damage will occur, and the greater the risk to that person's health.

Where irritation is concerned, however, it is again necessary to distinguish between two cases: those of known physiological relevance and those where such relevance is only conjectural. Instances of known relevance include any influence that powerful alternating magnetic fields might have: for example, on the mechanisms that regulate heart rhythm. Here, as with thermal damage, it is possible to determine the probability of such effects with fair precision where the strength and frequency of exposure is known. The risk is measurable, and it is even possible to determine limits below which any danger to health can be practically excluded.

Where irritation is of unknown biological relevance, the situation is different. Since we do not know what effect the irritation has on the organism as a whole, it is not possible to establish whether or not the electromagnetic exposure that may cause it represents a danger to health. It is thus impossible to determine whether weak fields increase the probability of disease, let alone gauge the magnitude of this danger. In order to determine this, we would have to know whether and to what degree weak electromagnetic phenomena affect these pathological processes.

We may conclude, therefore, that powerful electromagnetic exposures represent a measurable health risk. On the other hand, one cannot measure the risk to health posed by weak electromagnetic exposure that does not result in clearly identifiable irritation. This risk is incalculably small.

How are risks to be assessed?

Powerful electromagnetic fields represent a known danger against which we can protect ourselves effectively. The purpose of risk assessment is to determine how far the health risk must be reduced in order to become acceptable. It must be decided – regardless of what individual or social standards are applied – how much risk we are prepared to accept, because this is the basis for determining the amount of effort and expense required for protection.

In the case of weak fields, we are dealing not with a known hazard entailing a calculable probability of loss, but with uncertainty. Since we do not know how great the risk is, we can neither assess it or decide whether it is acceptable. The subject on which we must instead focus is how much *uncertainty* we are prepared to accept.

How should EMF risks be handled?

We will conclude this section with some remarks concerning the handling of risks: first, the health risk posed by powerful radiation. This risk can be eliminated completely by completely eliminating the sources of radiation, and considerably reduced by taking appropriate protective and precautionary measures. The latter is common practice and is achieved in most countries by means of technical standards, regulations and the statutory definition of limits.

The uncertain health risk presented by weak fields cannot be reduced in any systematic manner because there is no limit under which every – hypothetical – hazard would be precluded with certainty. It is often argued that, logically, the health risk should decrease as fields and radiation are eliminated or reduced in strength, in just the same way that a reduction in air pollutants reduces the risk of lung diseases. It seems only sensible, therefore, to reduce electrosmog as well. The problem is that exhaust gases and dust have been proved harmful beyond any doubt, while the bionegative effect of weak fields is purely hypothetical. It therefore seems that encapsulating electrical installations so as to contain their fields would offer little benefit. This would indeed be technically possible, but extremely expensive. From the perspective of risk management, it is more expedient to use the same (limited) financial resources in other ways – to reduce air pollutants, for example – since this would with certainty reduce a public health danger, whereas curtailing magnetic fields would only result in a conjectural improvement. One practicable compromise that springs to mind is to design and use devices and installations in such a way as to reduce EMF exposures generally: though it would probably yield no increase in safety, it could do no harm.

In order to achieve absolute safety, it would be necessary to eliminate every risk. This would involve dispensing with every technology which exposes the human organism to even minimal amounts of artificially produced electromagnetic radiation. The final consequence of this would be to do away with all devices and installations which use electricity in any way: electric lights, for example, or radios and telephones, aircraft, subways, computers and wristwatches. Even bicycling would have to be given up because when we bicycle, we move more rapidly through the earth's magnetic field and can thus induce stronger electrical currents inside our bodies than when we walk.

Bearing and transferring EMF health risks

We may conclude that, practically speaking, EMF health risks cannot be eliminated entirely. They can at best be reduced, insofar as they are known and measurable. In any case, however, a residual risk will remain: every human being will still be exposed to the known dangers inherent in powerful radiation and the uncertain dangers posed by weak fields. The only risk that can be transferred is that of the material consequences of health impairment: the costs of medical treatment, for example, or loss of earnings and the costs of rehabilitation. Here, it is no longer necessary to distinguish between the two types of dangers discussed above. From a sober and purely financial point of view, the reason why a person develops cancer is immaterial. The crucial thing is to ensure that available medical treatments are within reach financially. This is the job of health insurers, for whom the problems discussed in this chapter have no significance – in contrast to liability insurers – because health insurers cover the costs of treatment practically without regard to the cause of disease. For liability insurers, risk derives from something quite different: namely, whether hypothetical relationships between weak electromagnetic fields and various diseases will be considered causal in nature.

In order to examine the liability risks associated with EMF, a certain change in perspective will be necessary. Thus far, we have discussed the hazards posed by electromagnetic phenomena. In doing so, we have considered the health of those who are exposed to such radiation and fields as possibly endangered. In the case of liability risks, the hazard proceeds from potential plaintiffs and consists in claims for compensation which threaten the assets of the defendant. Consequently, liability risks do not result from the health risks, but are instead determined by the reasons for and the frequency with which legal actions are brought – and how the courts find.
To illustrate this point, we may draw a rather extreme analogy from criminal law: whether or not a defendant is convicted of murder depends not on whether he committed the murder, but solely on how the court assesses the known facts.

Just and right judgements

Disregarding juridical details and the substantial differences among different national legal systems, every court has two tasks: to ascertain the truth and to render judgements based on the truth thus established. Justice is understood to be the equal judgement of equal truths. Rendering correct judgements or verdicts presupposes that the truth be known. Only if it has been established beyond doubt that a defendant was the perpetrator of a murder does a verdict of "guilty" become just: justice is served only if the adjudged man did in fact commit the murder.

Factors in ascertaining the truth

If for the sake of simplicity we presume that courts are always just in reaching their decisions, their judgements will be determined exclusively by the result of efforts to ascertain the truth. This involves three factors: the evidence; the qualitative criteria which this evidence must satisfy, that is, the extent to which it is permissible to interpret what is known; and the categories used to assess that which is deemed to have been proved, that is to say, for example, what causality is understood to be. In the analogy of the criminal trial, the verdict depends on three things: whether it can be proved that the alleged murderer committed the deed; when the evidence is deemed to constitute proof; and what murder is understood to be. In comparison to "murder", however, "cause" is a very vague legal term. It follows the lines of the scientific understanding of causality and therefore appears to be defined precisely. In fact, however, the concept of causality held by science has changed fundamentally in this century.

Searching for the cause of death

Let us consider a simple example. On a day late in winter, a man driving a car along a narrow side road through the woods unexpectedly encounters a patch of smooth ice. His car crashes into a tree, and he is slammed against the steering wheel and dies. What is the cause of death?

In the statistics, the cause of death is registered as a "traffic accident". The death certificate specifies heart failure. The members of the man's family argue that death was caused by the failure of the air bag because had it functioned properly, the man's chest would not have slammed against the steering wheel, his pericardium would not have haemorrhaged and his heart would not have failed. This assertion is contradicted by a lawyer, who maintains that the cause was actually the two heart attacks the man suffered earlier. If they had not occurred, medical experts confirm, the man would probably have survived the accident.

The concept of causality held by classical science

Somewhat more than a hundred years ago, none of these factors would even have been considered as the cause – in the scientific sense – not because there were neither cars nor air bags at that time, but because classical science defined a cause to be that which, as a result of natural law, always and necessarily precedes the effect. This natural law itself was designated as causality, a principle which stipulates that this cause *must necessarily* lead to a specific effect. Yet because neither heart attacks nor malfunctioning air bags nor car accidents must necessarily lead to death, they do not represent causes in the meaning of classical science.

Laplacian determinism

Causal thinking was formulated in its most striking form towards the end of the eighteenth century by the French scholar Laplace, who asserted that if we knew all the laws of nature and succeeded in precisely determining the location and motion of all of the atoms in the universe at a given point in time, we would then be in a position to predict all of the future. This view, which is referred to as Laplacian determinism, became the model or paradigm of classical science. Since it seemed possible to recognise natural laws and from them to derive equations by means of which the future could be predicted and shaped, science considered the discovery of such laws to be its foremost task.

The epistemological consequences of the theories of relativity and quantum mechanics

Early in this century, however, the theories of quantum mechanics and relativity showed that Laplace's idea is based on false assumptions. Laplace had assumed that natural laws would constrain atoms to behave in specific ways. This would mean, to name only one example, that two identical radioactive iodine 131 atoms, under the same conditions, would have to decay at the same point in time. In fact, however, they decay at random points in time: that is, they behave randomly.

If we observe a large number of iodine atoms, however, we note that the mass behaves in a regular manner, despite the random behaviour of the individual atoms. The proportion of atoms decaying in a given time always remains constant, leading to the use of the term *half-life*, the period of time after which half the atoms will have decayed. In the case of iodine 131, the half-life is about eight days.

As a result of such observations, the prevailing concept of causality was brought into question generally. Until that time, a natural law could only be understood to mean that a particular thing was either always the case, or never the case. However, such a natural law can be stated only for the entirety of all radioactive iodine atoms: it is *always* the case that after eight days, half of all iodine atoms will have decayed. The point in time at which individual atoms decay can only be conjectured. With a probability of fifty percent, it will occur within a period of eight days. A specific atom, however, may decay immediately or only after weeks or months.

Causal and statistical laws

Thus, science suddenly had to deal with two types of natural laws: the causal, which state that which must necessarily occur and for what reason; and the statistical, which state how frequently something has occurred hitherto and therefore how probable it is – under precisely the same conditions – that it will occur again in the future.

In the course of this century, it has become ever more apparent that practically all causal laws are in reality mere statistical observations. Newton's law of gravity, for example, states that the force of attraction between two bodies – the sun and earth, for example – is directly proportional to the mass of those bodies and inversely proportional to the distance between them. Recognising this was a feat of brilliance, particularly since Newton also developed the mathematical methods required for its calculation, and thus created the bases for classical mechanics and modern technology. Today we know that Newton's law of gravity describes "only" the average behaviour of certain bodies. Individual bodies such as the planet Mercury behave differently than they "should" according to the law of gravity.

Laws and principles, rules and consistency

No law of nature explains why a particular thing happens, let alone why it must necessarily happen. The laws of nature are not the laws behind events: they only describe the event. They describe the consistency with which an event will occur and not the rules according to which it occurs. Thus, for example, astronomy knows no law according to which the sun must rise again tomorrow. It has observed consistencies, however, on the basis of which it may be assumed that, indeed, the sun will very probably rise again tomorrow.

All knowledge is presumptive knowledge

At first glance, there is only a minor quantitative distinction between *certain* and *highly probable*. In fact, however, the difference is fundamental and qualitative because it is the difference between *must* and *can*, between *yes/no* and *perhaps*, between *doubtful* and *doubtless*, between *certain* and *uncertain*, between *possible* and *impossible*. It is the difference between *knowledge* and *conjecture*. And because all scientific knowledge is based on statistical observations, the knowledge of science is mere presumptive knowledge.

This self-critical insight of scientific research is by no means a step backward. Up until the beginning of this century, science was able to study only questions which could be answered with Yes or No. It was inconceivable that the sun would only perhaps rise. As a result, research was limited to straightforward, symmetrical, constantly recurring forms and processes. Everything that was crooked, slanted, spontaneous or seldom-seen lay outside the purview of science, failed to fit into the conventional categories of thought and was left to the "inexact sciences" such as biology and medicine. The latter were able to describe such phenomena verbally, but were incapable of predicting them by means of mathematical models and equations.

A change of model

After it had been recognised that even the principles formulated in physics were not causal in nature, but statistical, models such as Laplacian determinism were given up. Modern science no longer attempts to explain why a particular thing must necessarily occur, but instead studies the conditions under which it can occur. Instead of thinking in yes/no categories, modern science thinks in probabilities. This has enabled science to extend the scope of systematic study to include the world of the possible as well. Presumptive knowledge is knowledge of what can happen, but may not.

This change of paradigm, which was initiated early in this century through the insights of nuclear physics and is now starting to take concrete form in new scientific disciplines such as complexity research, has been accompanied by a fundamental change in the concept of causality. While classical science considered a cause to be only that which *must necessarily* bring about an effect as a result of the causal principle, today a cause is also considered to be that which may bring about an effect.

A cause may be everything or nothing

As shown by the example of the car accident and the question concerning the cause of death, this change in the concept of causality is practical. On the other hand, the softening of the concept of causality results in a grave problem. As was shown earlier, there is a substantial qualitative distinction between *must* and *can*. In probability calculations, *must* corresponds to a numerical value of 1. If a particular thing must happen under specific conditions, it will in fact occur in 100% of the cases in which those conditions are satisfied. It is a certain event. Conversely, the numerical value of 0 denotes impossible events, that is, events which can in no case occur under the specified conditions. The entire spectrum of the possible falls between the values of 0 and 1. If we now designate as a cause a particular thing which brings about an effect with a probability of 0.99, we must also designate as a cause a thing which brings about the effect with a probability of only 0.01. Why? Designating a high probability to be casusal appears permissible only because the quantitative distinction between 1 and 0.99 appears to be negligibly small. If we hold this argument to be correct, we must, according to the rules of logic, also accept the following: if 0.99 is causal, then 0.01 less, or 0.98, is also causal. Yet, in that case, 0.97 must also be causal, and so forth, until finally a cause must be considered to be even that which brings about the effect with a probability of 0.01.

In conclusion, we may state that a particular thing which leads to an effect in 99.99% of all cases is to be designated as a cause in the same way as a thing which brings about the effect in only in 0.01% of all cases. Because that seems nonsensical, attempts are frequently made to define causality as a function of the degree of probability: for example, air bag failure might be considered a cause of death if its consequences are more frequently fatal than not.

Causes are not attributable

This reflects a fundamental misunderstanding of the concept of probability, however, because in each individual case, the failure of the air bag could have played either no role at all, or the decisive role. Statistics do indeed permit the supposition that air bags increase the changes of survival, but say nothing about the cause of death in any individual case.

This seems contradictory, because earlier we took the statistical half-life of radioactive iodine atoms as a basis for drawing a conclusion about the probable behaviour of individual atoms. In that case, however, we had observed identical atoms under identical conditions, but in accidents the conditions are never exactly the same: they are only similar. This is why the statistics include both cases in which the victim died despite having an air bag that worked, as well as the cases in which the victim would certainly have been saved by an air bag had one been present.

In order to make a quantitative statement about the direct relationship between air bag reliability and the fatality rate, it would be necessary – as was explained in the preceding chapter with regard to epidemiological EMF studies – to meet a crucial criterion. The accidents compared must differ only in regard to the air bag: that is, all other conditions must be absolutely the same. Then, and only then, would we have reason to suppose that the probability of survival with air bags is 80%. However, since accidents are never the same, it is also impossible to know why one victim died and another did not. As a consequence, we do not know the cause and are therefore unable to attribute the effect to any specific cause.

The problem of minimal changes in initial and underlying conditions

In summary, we may say that according to the causality that classical science accepted as law, the same causes always and necessarily bring forth the same effects. For a long time, this was taken as the basis for concluding that similar causes were always followed by similar effects; and this is why it was also scientifically permissible to consider as a cause a particular thing which in practice nearly always – but not necessarily – brought about the effect. Minimal changes in the initial and underlying conditions appeared to be insignificant. Modern science has recognised, however, that different effects may occur even under identical conditions. As yet unanswered is the question of whether this can be attributed to coincidence or to unidentifiable and unmeasurable influences. Whatever the case may be, it is certain that even the most infinitesimal changes in the initial and underlying conditions of complex processes can lead to different or even diametrically opposing results. Whether or not the effect occurs can depend on the most "insignificant" factors. As long as they elude our grasp, we describe them as coincidences. As soon as it can be demonstrated that one of these factors discernibly increases the probability of the effect, however, we refer to it as a cause. The decisive criterion for causality is therefore only that a thing discernibly increases the probability that an effect will occur.

The claim that the man in the accident died because traffic had been re-routed around a construction site from the ice-free main road to the icy side road sounds absurd until someone provides statistical evidence that the probability of accidents on side roads is higher than on main roads. If in this specific case it were also to turn out that the supervisor of the construction site had the option of re-routing traffic via an ice-free main road, we can already imagine ourselves confronted with liability issues, because in that case, the construction site supervisor would have demonstrably increased the probability that the man would die.

Let us return for a moment to the court's general task of ascertaining the truth. As a prerequisite for liability, most legal systems define a necessary element of cause: that event or condition without which the effect *could not* have occurred. That, however, is the question of causality, for it is only when we eliminate in our thoughts those causes which *must necessarily* lead to the effect that we can be certain that the effect would not have occurred. If, on the other hand, we only eliminate a *possible* cause, the effect still remains possible.

Decisions regarding uncertainty

Courts are in no better position than the scientists to offer certainty, to ascertain absolute truth. Both must limit themselves to presumptions. In contrast to scientists, however, courts must hand down decisions. The parties expect not a Perhaps, but a clear Yes or No. They want a clear decision on what *must* be done, not an indefinite statement on what *might* be done.

By what compass should the legal system steer? Starting from the classical concept of causality, it is practically impossible to prove that electromagnetic fields can be a cause of disease. This is because it would involve showing the conditions under which EMF leads to disease. Or should the legal system proceed on the basis of modern science's understanding of causality? In this case it would be sufficient to prove that weak fields can increase the probability of disease. And it is precisely this which cannot be excluded: the possibility that electromagnetic exposure might favour the incidence of certain diseases. In that case – according to our present understanding – electromagnetic fields would be a cause of disease just like a flu virus which may, but need not necessarily, result in influenza.

New knowledge, new uncertainties

One could conceivably object that this problem is not new: that the courts have never been able to attribute effects to individual causes with absolute certainty, and thus that nothing has changed. The premise is correct, but the conclusion is false. Though the practical criterion for causality may not have changed, its theoretical foundation has, and with it the field of scientific research. As long as science searched for causal principles, it postulated cause-and-effect relationships only between events which virtually always occur together. The relationships between phenomena which occur together occasionally, on the other hand, were not studied and therefore could not become the object of legal discussion. However, as a consequence of the change in the scientific model, science now no longer searches only for necessary causes but also for possible ones. In an ever-increasing number of apparently coincidental relationships, science is now discovering statistical laws which are likewise being described as causal in nature.

This gives rise to a new uncertainty. Until now, there was doubt only with regard to whether a particular thing was to be deemed a cause if it brought about an effect in nearly all, but not all cases. Now an additional uncertainty exists as to whether a particular thing is to be deemed a cause if the possibility of its bringing about the effect cannot be *excluded*, even though the effect practically never occurs. To the known difficulty of distinguishing between *certain* and *possible*, there now comes that of distinguishing between *possible* and *impossible*. There is one elementary difference, however: earlier, the concept of causality was reserved for the top end of this scale. It separated the certain from the enormous and unexplored spectrum of the possible. Today, however, the concept of causality starts at the bottom end of the scale: causes include everything which cannot be proved *not* to be a cause.
We have lost both certainty regarding the certain and certainty regarding the impossible.

When is the possible to be deemed a cause?

In effect, the question becomes: When is a possibility equivalent to a cause in the meaning of legal liability? Or, How much certainty is required to hold someone accountable?

The need for agreement

This is a question not of truth, but of the rules of the game. Whether a tennis ball is already “out” if it touches the line demarking the court, or only if lands fully outside the line, can be determined only by the rules of the game. But what if, thanks to new technical possibilities, the point of impact can be determined with a precision of a thousandth of a millimetre and a ball lands precisely on the outer edge of the line? In that case, it is necessary to agree on new rules which cover this case as well.

A cause is whatever it is defined to be

Thus, the new scientific concept of causality creates a need for new agreements. It is necessary to define new rules which are suitable for resolving the cases of doubt which have now become apparent. Existing law does provide the courts with a certain degree of latitude to qualify the causality relevant to legal liability. Just as rules of play are not formulated by the judges of tennis matches, however, it is not within the competence of the courts to pass laws. This is the exclusive right of legislatures. A cause in the scientific sense is whatever science defines it to be. A cause in the sense of legal liability is whatever society defines it to be.

Incalculably great liability risks

The question posed at the outset as to what court decisions could be expected in future EMF liability cases thus proves to be unanswerable. If society wishes to consider weak electromagnetic fields a cause of illness, these fields will be deemed a cause of illness – and the possibility cannot be excluded that courts will hand down decisions to this effect. This is not a mere possibility: presumptive liability has already become practice in some areas of the law. How far this trend will continue cannot be foreseen. At present, the EMF liability risk is no longer calculable. In contrast to the health risks posed by EMF, however, this risk is not incalculably small, but in view of the conceivable extent of damage, incalculably great.

Handling risks

Handling the liability risk proves to be extremely difficult. Given present social trends, the possibility cannot be excluded that the manufacturer of an electrical medical device could be held liable both because, in developing the device, he created a possible health hazard, and because, in suspending production, he prevented the possible treatment of disease.

As long as it remains unclear what causes will be deemed sufficient grounds for liability later on, the liability risk cannot be reduced systematically. The only possibility remaining is to bear the liability risk. This proves to be problematic because the possible loss of assets cannot be estimated, and it is therefore impossible to make adequate provision. All the greater is the need, understandably, to transfer the risk and to seek insurance protection. Yet this option, too, is subject to narrow limits, as will be shown in the next chapter.

From the viewpoint of the insurance industry, *expected* losses do not represent a danger: indeed, insurance makes no sense unless losses are to be expected. The insurer's own risk results from the possible *discrepancy* between expected and actual loss experience. One must therefore ask: What constitutes the risk of change? What unexpected claims from old insurance relationships could confront the insurance industry? And how, despite the risk of change, would it be possible to provide insurance protection?

Risks of change for health insurers

Analogous to the distinction between EMF health risks and EMF liability risks, we will first consider the risks to health insurers. For them, the risk of change would consist in the possibility of abruptly rising health-care costs in connection with EMF. The depletion of ozone in the upper atmosphere is a similar case. Due to the "holes" in the ozone layer, more ultraviolet radiation from the sun is impinging directly upon the earth's surface, and this could result in a massive increase in the incidence of skin cancer and a commensurate rise in health-care costs.

With regard to technical EMF emissions, however, one must conclude that health insurers are not threatened by any discernible risks of change. Either weak electromagnetic fields are safe, in which case they will also be harmless in the future; or they are already contributing to illnesses to an unknown extent, in which case this proportion can hardly increase suddenly in the future. For health insurers, therefore, the EMF problem is irrelevant. Though it is uncertain whether, or to what extent, weak fields present health risks, it is not to be feared that these risks will change at short notice.

Without identifiable cause, no responsible party; without a responsible party, no liability

In contrast to health-care costs which are incurred whether or not we know what caused the disease, the idea of EMF liability presupposes fundamentally that a specific case of illness can be attributed in a causal sense to electromagnetic exposure. The event triggering the loss is not the illness itself, but the assumption that it might have been brought about by a certain cause.

As far as weak EMF phenomena and diseases such as cancer, Alzheimer's disease and Parkinson's disease are concerned, there is no evidence of such a causal connection; indeed, there was not even a conjectural connection until a few years ago. Thus far, impairments to health in connection with electrical devices have been observed only as a consequence of accidents or of design or production flaws. Therefore, the risk of change must be understood as the possibility that the routine use of electrical devices and installations for their intended purposes, and in accordance with the state of the art – all of which has long been considered harmless – could suddenly be deemed hazardous to health.

Development risk

This could happen for two reasons: first, new scientific findings might provide objective proof that EMF health risks are significantly greater than has been assumed thus far. This possibility represents the classic development risk. Secondly, scientific findings might be assessed differently in a subjective sense due to changing social values. This we describe as the risk of sociopolitical change.

Risk of sociopolitical change

The development risk posed by EMF is small. Even a pessimistic assessment of the present status of research would not assume that electromagnetic exposure could ever prove to be a grave health risk compared with poisonous chemicals in food and the environment, or artificial radioactivity, for example; and not at all as compared with risk factors such as stress, smoking, alcohol and overweight.

Animosity towards large-scale industry

The sociopolitical risk, on the other hand, must be classified as extraordinarily high because the legal instrument of liability is increasingly being used or even misused as a means of coping with the problems of life. As recently as the beginning of this century, everything which occurred was considered as being determined by natural laws, and thus predictable. It seemed possible to master nature and to overcome every disease; paradise on earth seemed within our reach, and the dream of eternal life seemed real. Instead of the hoped-for security, however, natural science brought about the collapse of its own edifice of thought. Certainties were superseded by suppositions, and confidence by doubt. The media often distorts this into apocalyptic visions of the world's unavoidable destruction: if not through war, climatic catastrophe and environmental destruction, mankind will be carried off by new diseases and epidemics. The belief in science which prevailed at the beginning of our century has been replaced by a general scepticism which finds expression on the one hand in increasing animosity toward technology, and on the other in growing mistrust vis-à-vis central structures. Despite all social and economic progress, an ever-increasing number of people is willing to accept large-scale industry only as a necessary evil. An ever-broadening political movement considers the nuclear industry, chemical industry, petroleum groups and now also the electrical industry to be the cause of all of the world's present-day ills, and has declared them its political bogeyman.

What is left that isn't a health hazard?

In the wake of this development, general uncertainty is spreading. On the one hand, science is unable to explain why people get cancer. On the other hand, it continues to teach that such diseases occur not by coincidence, but as a consequence of the individual's circumstances and habits. What is one supposed to do? There is no food, no way of living and certainly no technology which is not to some extent suspected of causing disease or polluting the environment, and thus – at least indirectly – of diminishing the quality of our lives. We can do nothing without running the danger that our actions will be to our own detriment or that of others. But who decides what is right and what is wrong, what is detrimental and what is beneficial, what is to be permitted and what is to be prohibited? Natural science denies responsibility, and politics proves to be unequal to the task of bringing about a social consensus on what risks people are willing to enter into conjointly, and what share of these risks each individual must bear.

Motives behind liability actions

This lack of clarity prompts people to resort to the courts, even if they do so for motives which vary according to legal system and cultural background: political motives, for example. Since court cases attract the attention of the public, they are systematically used as platforms for fanning the flames of existing doubt concerning certain products' and technologies' compatibility with the environment or health. Another motive is personal enrichment, which appears to grow more attractive in direct proportion to the level of compensation which can be expected.

Phantom risks

It now becomes understandable why weak electromagnetic fields in particular rather than other, comparable phenomena meet with such great interest. EMF research has already found out too much to be able to ignore the conceivable health risks, yet has not found out enough to gauge them. These risks are imaginable but not demonstrable, which is why they are occasionally referred to as *phantom risks.* Even though we do not know whether they actually exist, they are real to the extent that they exist in people's minds and thus affect them if only to stimulate insecurity and concern. There is nothing that frightens people more than an uncertain danger, even though it may not exist.

Temptations to bring action

Were it certain that weak electromagnetic fields represent a definite hazard, there would be far less public interest. There are plenty of recognised health hazards to which people expose themselves even voluntarily. Due to its phantom-like nature, however, the EMF problem is almost ideally suitable for liability claims aimed at achieving enrichment or political effect: all the more so because the subject matter is so complex and complicated that average people can very easily be misled into drawing false conclusions. There is a great political and financial interest in convincing society to see electrosmog as a health hazard.

Existence-threatening risks from the past

This exerts great sociopolitical pressure on legislators and courts. Should they yield to this pressure, every manufacturer and operator of electrical and electronic installations could be sued more or less successfully. In the worst case, the insurance industry would be confronted with claims amounting to some tens of billions of dollars. The very existence of liability insurers is threatened, and this is no phantom risk. The current trend in court decisions, in the US for example, has long since demonstrated that such threat scenarios can become reality. The situation need not of necessity turn out so terribly, but even in a best-case scenario, the costs incurred for defence will be nothing less than enormous.

If everyone is a victim, the insurance system will collapse

Looking into the past, the question arises as to whether existing contracts can provide any cover at all for such a change in social values. This is because any workable method for calculating adequate premiums – that is, premiums sufficient to cover losses – presupposes absolutely that there are clearly defined liability relationships between the members of society. Only in this case does each individual have a real chance of acting so as to avoid causing harm to others. Insurance protection applies in the event that the insured, despite all his efforts, has caused harm for which he is liable on the basis of these rules. Such cover may also reasonably include the development risk: that is, the possibility that an activity which had hitherto seemed harmless might, in the light of new scientific findings and on the basis of *current* rules, prove to be hazardous. If the rules themselves are changed, however, those changes could suddenly give rise to liability relationships which, at the time the contract was concluded, were impossible to foresee, let alone calculate. Should the generally observable trend toward presumptive liability continue, all the members of the relevant risk community could suffer losses suddenly and simultaneously. Since none of those insured would remain unscathed, these losses would no longer be transferable, and the insurance system – the mutual-benefit community – would collapse.

No calculatory basis for EMF liability cover

Looking into the future, there are two questions to be answered: under what conditions can insurance protection be provided, and at what price? One absolute prerequisite for covering liability risks is to have clear liability relationships. This presupposes a political decision on what will be deemed a cause under liability case law in the future, and how scientists' statements of probability will be assessed juridically as bearing on the causal nature of individual, concurrent disease factors. This, in turn, presupposes a societal consensus on the handling of collective risk, as well as a just distribution of the burden among those who benefit from a technology and those who – presumably or in fact – have suffered harm from it in any way.

As long as this remains a subject of controversy and is not decided, there can be no calculatory basis for providing insurance protection. The insurance industry would have to bear the risks itself because it could not transfer them, and this in turn would mean that the sociopolitical risk of change could not be borne at all in a feasible manner. The situation must – and can – be alleviated to a large extent through action by the legal systems to restore clear liability relationships.

Only then will it be possible to discuss the question of the price of cover seriously: a price that will be calculated from the claims to be expected within clearly defined liability relationships. Development risk would remain a problem, but one which could be addressed either through appropriate premium rates, or by the insurer reducing his own risk to a reasonable level by means of limited contract periods, cover limits, and other conventional and proven instruments. The gap still remaining between the insurance protection available and the demand for cover could then be closed through the creative development of new forms of insurance. But for this, too, it is first necessary to create the necessary political and legal base.

Summary
Limiting the damage and communicating

The EMF problem is composed of three sub-problems. First, there is a multidisciplinary problem involving natural science, technology and medicine: How do weak electromagnetic fields affect the human organism? Second, there is a socio-legal problem: How should society deal with technologies which cannot be used with absolute safety and which therefore may represent a hazard? And third, there is an underwriting problem: How can the insurance industry help in dealing with such phantom risks?

What's needed – despite the uncertainty – are decisions

The scientific / technical / medical problem is characterised by the uncertainty inherent in the methodology. It is not only that we do not know whether and to what extent electromagnetic phenomena contribute to diseases: the real problem is that we *cannot* know these things. The scientific methods now available are at best able to identify general statistical correlations between electromagnetic exposure and biological effects. As far as specific cases are concerned, nothing more than vague conjectures will be possible in the foreseeable future.

The characteristic feature of the socio-legal problem is the lack of an authoritative decision on how the vague information, conjectures and probability statements provided by science are to be assessed. According to prevailing opinion, the problem posed by this sociopolitical indecisiveness would resolve itself if the scientific questions were to be answered beyond doubt. It is therefore expected that research will solve the EMF problem. Though this expectation cannot be fulfilled, and for good reason, the methods and objectives of science determine how human beings see the world; and since these paradigms – the rules of scientific work – have changed fundamentally, we see the world differently today than we did even as recently as the beginning of this century. Relationships have been identified which do not fit into the conventional categories. The legal concept of causality, for example, was derived from classical natural science's understanding of causality and thus stands in partial contradiction to the probabilistic thinking of the present. The EMF problem cannot, therefore, be resolved through further research alone: on the contrary, there is a need for new, practice-oriented categories for assessing the research results currently available.
The law must be adapted to the modern understanding of our environment and present-day interpersonal relationships. The inner logic of natural scientific and judicial laws must – once again – be brought into harmony.

A task for all of society

As a consequence, the EMF problem cannot be delegated to individual groups or institutions: that would be like leaving the formulation of a contract to just one of the parties. Dealing with phantom risks is a task for all of society, a task which in the final analysis will go so far as to require further development of the democratic decision-making process and the partial reordering of society itself. It is not acceptable to force risks upon individual human beings; neither is it in the interest of the general public to dispense with technological opportunity because of the possibility that individuals might suffer harm. What is required, therefore, is a general consensus on how much risk individuals may reasonably be expected to accept: or in plain terms, What maximum number of people are we willing to accept who may suffer harm within a given period as a consequence of the practical application of a certain technology? If the response to this question is "None," it will be necessary to dispense with technology entirely.

Dissolution of social bonds and entitlement thinking

Two consequences can be drawn from this: first, every citizen should be prepared to bear part of the collective burden of risk. Secondly, society must show its solidarity with victims by helping them to deal at least with the financial loss involved. Yet people in modern industrial societies are neither willing to participate in collective risks – they will tolerate their share at best – nor do they consider themselves under any obligation to help those who have suffered harm. As a logical consequence, they demand compensation: from the state, from the – presumedly – responsible party, or from the insurer.

Is there need for a legal reform?

The solution to the EMF problem could thus consist in a binding agreement on who is to be responsible for damages when the cause is not clearly known or can only be conjectured. Present liability law seems unsuited to do this, since its aim is always to attribute damages to a specific cause, not to distribute the burden among the individual contributing parties. Yet in cases where damages cannot be attributed to specific parties, the result is inevitably unjust. Either a plaintiff receives no compensation even though he was not responsible for the harm he suffered; or a defendant is made liable for damages though he may not have caused them, or was at least not their sole cause. Here, there is a danger that "Might makes right" will triumph over compensatory justice. This cannot be in the interest of society, since injustice has the effect of destabilising social systems.

The insurance industry is directly affected by the change in social values

Certainly, the insurance industry is not responsible for this social process, but it is immediately affected by it. The current trend may threaten the very existence of individual insurers. What is more, effective cover for liability risks will only be possible under certain sociopolitical conditions. Both in its own interest and in the interest of society, the insurance industry must therefore recognise, understand and assist in shaping these sociopolitical developments.

This gives rise to specific tasks for insurers: to deal with risks resulting from the past, and to aid in creatively shaping the future of liability risk handling.

Limit losses

First and most urgently, insurers must limit their own losses. This means a re-examination of existing contracts.

Prepare threat scenarios

Second, insurers will find that closing their eyes to the possible consequences of current trends is no help. Depending on developments in case law, the insurance industry could face extremely high claims from existing contracts. It will only be to each insurer's advantage, therefore, to form a clear, unvarnished picture of the claims which may confront him. Threat scenarios can diminish the surprise effect, provide breathing room, and make it possible to develop preventive strategies to deal with and, if necessary, ward off possible claims. Swiss Re's specialised services will be happy to provide advice and assistance.

Reduce retained risks

Third, companies should reduce their own future risks to a reasonable level through the use of conventional and proven instruments. Here, too, Swiss Re is available as a discussion partner.

Develop new forms of cover

Fourth, insurers must also ensure that risk capital sufficient to cover future liability risks is available over the long term. To achieve this, it may be necessary to change over from classic insurance to modern forms of risk financing. This demands close, innovative cooperation between industry, the direct insurer, the reinsurer and the financial markets.

Communicate

Against this backdrop, the EMF problem can also be seen as a problem in communications caused by a banal but far-reaching misunderstanding: in most cases, insurance contracts are seen only as a bilateral relationship between an insurance company and a policyholder. *De jure*, this is correct, but *de facto* all policyholders have numerous contacts with one another, forming a highly complex fabric of interrelationships. The job of the insurer is not only to organise communities of risk-sharers, but also to assist in shaping the relationships between individual members of those communities as they relate to insurance.

One important communications task, for example, is to make it clear to industry that – as a community which shares liability risk – it is itself responsible for creating societal conditions suitable for the always more or less risky business of developing and commercially utilising technology. Insurers can provide cover against the eventuality that individual enterprises – for whatever reasons – will be obliged to pay compensation. It is impossible, however, for insurers to cover industries as a whole, let alone entire sectors of the economy, against the financial consequences of adverse societal and legal conditions. The insurance industry has understood very well that industry is subject to unbearably high liability risks. It would now be helpful if industry, for its part, were to understand that the insurance industry, too, is not in a position to bear every risk.

The need for insurance protection against EMF liability risks has been recognised. It is being taken very seriously by the insurance industry, and there is no doubt that it wishes to satisfy this customer need. Under present conditions, however, insurers are bound by narrow underwriting limits because the legal systems are still caught up in a gradual process of change with an uncertain outcome. And while the insurance industry has a responsibility in helping to shape this change, it must not allow itself to be misused as a financier for funding this societal process.

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