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Immission control

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Immission control

Contents

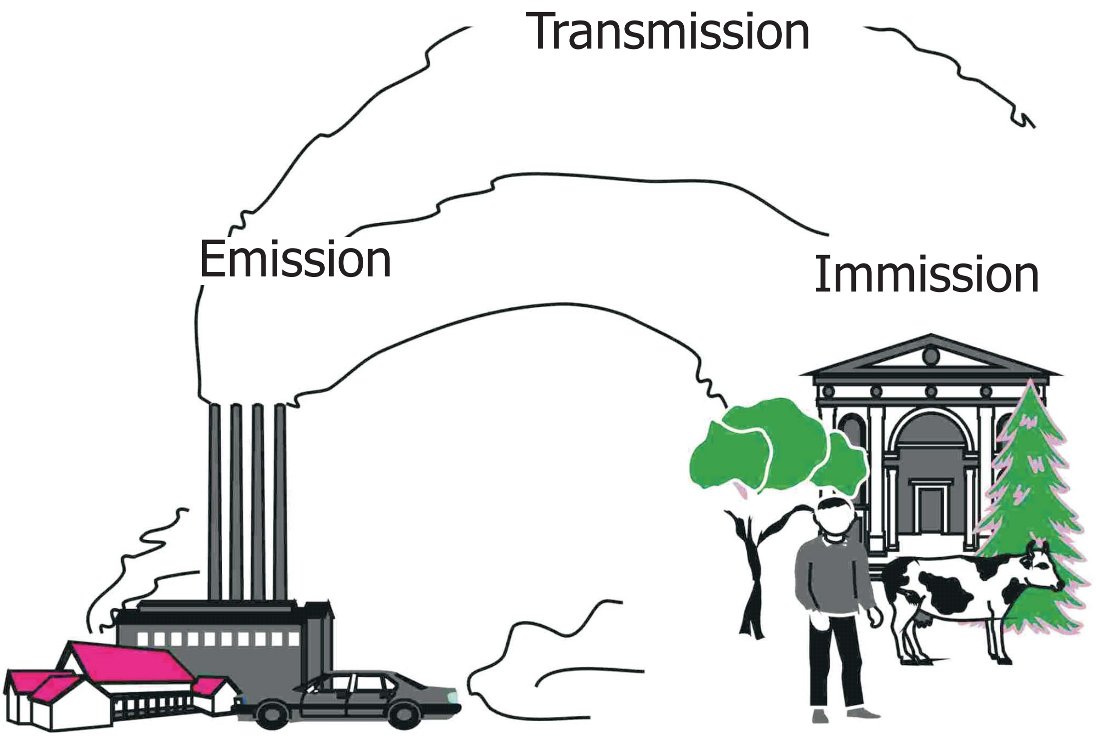
The complex domain of immission control includes air pollution, noise, vibrations, light, heat, radiation and similar environmental impacts (e.g. electromagnetic fields). Using the example of air pollution, noise and electromagnetic fields, the requirements of immission control in spatial planning, which go further than the corresponding specialist law, are explained in specific terms.

1 Basic principles

1.1 Definitions, demarcations

Immission control includes all efforts aimed at protecting environmental assets including human health against harmful or bothersome impacts (immissions) (▷ *Environmental assessment*). In accordance with the Federal Immission Control Act (*Bundes-Immissionsschutzgesetz, BImSchG*), immissions include air pollution, noise, vibrations, light, heat, radiation and similar environmental impacts (e.g. electromagnetic fields). The immissions of various emitters (polluting entities such as industrial plants, transport or traffic) result from the emission–transmission–immission chain of effects (see Fig. 1). Depending on the nature of the entity, i.e. chemical, biological or physical, very different conditions must be taken into consideration along the propagation path (transmission). The emissions and immissions of some types of pollutants can be managed: for example, with airborne pollutants this can be achieved by high chimneys, filter technology or environmentally-friendly production methods. In the case of noise, a noise barrier may serve to limit the noise. However, high-frequency or magnetic fields penetrate solid bodies, which thus cannot really be shielded.

Figure 1: Airborne pollutants: the emission–transmission–immission chain of effects



Source: The authors

In 1974, at the outset of the discussions on environmental policy, the German Federal Immission Control Act, as a specialised environmental law that is nonetheless aimed very broadly at all significant protected environmental assets, established the legal foundations for immission control (▹ *Spatially-relevant sectoral planning*). The Act focuses on the construction and operation of commercial and industrial facilities requiring a permit (e.g. power plants) and the stipulations for facilities not requiring a permit (e.g. domestic furnaces). In addition, the Act regulates the detection of emissions and immissions, the nature of facilities and substances as well as the quality and operation of vehicles or the construction and modification of roads and railways (▹ *Transport planning*). It also contains specifications for ▹ *Air pollution control and noise abatement planning*. About 40 federal ordinances render the provisions of the Federal Immission Control Act more specific. Other federal laws (e.g. the Aircraft Noise Protection Act [*Fluglärmschutzgesetz*]) and ordinances of the federal states as well as administrative regulations (e.g. the Technical Instructions for Air Pollution Control [*TA Luft*]) also serve to strengthen immission control. Likewise, the provisions on ▹ *Spatial planning* of the Federal Government and the federal states as well as in ▹ *Urban land-use planning* impose requirements on immission control. The ▹ *European Union* has been shaping the national legal bases for immission control for some time through a number of directives. Immission control requirements are imposed not only for new facilities and planned projects, but can also be imposed retrospectively, depending on the legal basis. However, in the case of existing transport and traffic routes, the parties affected cannot subsequently claim protection against health-impairing noise through legal remedies.

The environmental policy strategy for immission control is based on a 'dual strategy': firstly, emissions must be limited in line with the latest technology, even if no damage is to be feared from immissions (precautionary principle); secondly, limit values on immissions strive to protect environmental assets against harmful effects (hazard protection). In addition to health hazards, a *substantial* nuisance and *substantial* disadvantages are also deemed to be harmful impacts. In principle, new facilities may only be approved if sufficient protection against hazards is ensured. The relevant indicator is usually the total immissions for a single harmful pollutant (e.g. nitrogen dioxide), which results from the total of the existing load (prior load) and the additional load expected from the planned project.

1.2 The relationship between planning law and immission control law

For plans and projects subject to immission control (for an overview, see Annex 1 of the Act on the Assessment of Environmental Impacts [*Gesetz über die Umweltverträglichkeitsprüfung, UVPG*]), a fundamental distinction must be made between official decisions on the permissibility of projects under the Federal Immission Control Act on the one hand, and decisions that are subject to a ▹ *Weighing of interests* in accordance with ▹ *Planning law* and/or the ▹ *Planning approval* process on the other hand. This is because the approval or 'bound decision' according to the Federal Immission Control Act is a permit for control purposes, which usually gives the applicant a right to approval of the project if they meet the legal requirements. Hence, the degree of discretion afforded to the authorities is limited to the assessment of permissible immissions as part of the approval process for the facilities. In the case of comprehensive spatial planning and planning approval processes, on the other hand, the authority usually has comprehensive discretion in the weighing of interests or to refuse permission. The authority can thus not only effect the legally enshrined protection against hazards, but also ensure the principle of environmental precaution by extending the scope of protection. Moreover, in particular, forms of comprehensive spatial planning (▹ *Regional planning*; ▹ *Preparatory land-use plan*; ▹ *Binding land-use plan*) and ▹ *Landscape planning* in practice serve to prepare and guide the use of land for building and other purposes through descriptions and stipulations. This means that the permissible level of land use is determined at an early stage. If, for example, an industrial or commercial area is identified in accordance with the Federal Land Utilisation Ordinance (*Baunutzungsverordnung*, *BauNVO*) in the ▹ *Binding land-use plan*, no approvals can be granted there for facilities that lead to higher immissions or interference levels than those permitted in that type of area. This is also clearly true for the different noise levels to be observed depending on the specific land-use area.

1.3 Protection level under planning law

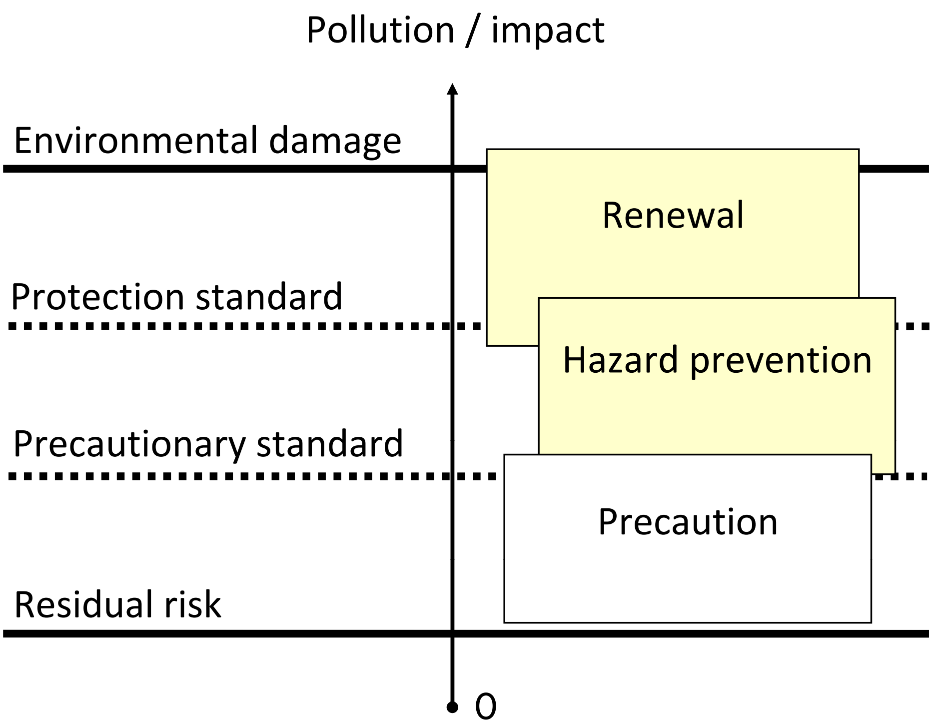
As part of the official decisions under planning or planning approval law (▹ *Planning law*; ▹ *Planning approval*), the question of the desired immission quality must also be clarified. The discussion on environmental protection since the 1970s has led to a reversal of policy from corrective protection in the event of damage and hazards to a precautionary and forward-looking planning of environmental quality. However, there often are no *binding* target figures for a desired environmental quality, which would render spatial planning objectives more concrete (first discussed by Kühling 1986; Kühling/Schebek 2015). The following points (Koch/Prinz/Altenbeck 1981) must therefore be distinguished:

- (Environmental) damage, deemed to be a negative and hence socially intolerable consequence of an event, must be eliminated in accordance with regulatory requirements (e.g. according to the ‘polluter pays’ principle). An example of this is the subsequent imposition of operational measures imposed by the approval authority when permissible limits are exceeded. The aim of renewal is to achieve compliance with the statutory protection standards, e.g. as stipulated in the Technical Instructions for Air Pollution Control.
- Hazard describes a condition, circumstance or process, which may with *sufficient probability* cause damage to humans, the environment or other *protected assets*. The reciprocal interplay of high probability and considerable intensity leads to the definition of a risk that must be prevented. In most cases, protection standards are determined in this regard, which serve to preclude the demonstrable impact of harmful effects by means of a safety factor. For the purposes of approval under a sectoral law or planning approval for projects, the permissible immission quality is determined in accordance with these standards. This, however, does not guarantee that all risks are excluded or that sufficient precautions against damage have been adopted.
- In addition to renewal and hazard prevention, the precautionary principle aims to prevent a potentially environmentally harmful situation if the environmental damage is not unlikely or is conceivable. Hence, the aim is to prevent theoretically *potential* or *presumed* environmental damage and not, as in the case of hazard prevention, sufficiently probable environmental damage (e.g. subject to the assessment standard of effective environmental precaution pursuant to sections 1 and 12 of the Act on the Assessment of Environmental Impacts). This means that those potential hazards, which do not yet amount to a hazard but

only to a *suspected risk* or *potential cause of concern* must also be taken into account (Federal Administrative Court [*Bundesverwaltungsgericht*, *BVerwG*], judgment of 19 December 1985, case no. 7 C 65.82, *BVerwGE* [Official Reports of the Federal Administrative Court 72, 300). In other words, environmental hazards or damage should not be able to occur in the first place (Kühling 2014a).

Figure 2 illustrates the general context of these terms. The demand for precaution is particularly clear in general urban development law (▷ *Building law*). Through the general planning objectives of 'Securing an environment worth living in' and 'Developing the natural foundations of life' in section 1(5) sentence 2 of the Federal Building Code (*Baugesetzbuch, BauGB*), immission control concerns in planning have a significance that goes beyond the standards established in legislation. This becomes particularly clear when determining the environmental concerns in section 1(6) no. 7 lit. h of the Federal Building Code or in section 50 of the Federal Immission Control Act, which stipulates, as illustrated by the example of the desired air quality, that the best possible air quality should be maintained in areas where the immissions do not exceed the defined limit values. This gives concrete expression to the high level of environmental protection sought by the EU in accordance with Article 191 of the Treaty on the Functioning of the European Union, according to which Community environmental policy aims to achieve a high level of protection based on the principles of precaution and prevention. This level of protection of the EU does not stop at the mere principle of protection (protection against environmental damage or health hazards), but stipulates a quasi-ban on deterioration and a requirement to minimise risks.

Figure 2: Environmental policy and environmental planning



Source: The authors

This has always been confirmed by German case law: As part of their urban land-use planning, local authorities are not limited to protection against harmful environmental effects within the meaning of section 3 of the Federal Immission Control Act, but are also authorised to pursue precautionary environmental protection (Federal Administrative Court, judgment of 14 April 1989, case no. 4 C 52.87; Buchholz 406.11 section 9 of the Federal Building Law [*Bundesbaugesetz, BBauG*]/Federal Building Code no. 36). A corresponding concretisation of this through precautionary standards can serve to implement the planning objectives for safeguarding and developing environmental quality. From a technical point of view, various aspects have to be taken into account (Kühling/Schebek 2015):

- The focus on immissions and/or impact: Potential or probable effects of immissions can usually only be assessed based on figures that indicate comprehensive pollution of the area concerned. In approval processes in accordance with the Federal Immission Control Act, de minimis thresholds are used under certain circumstances as emission standards for the assessment of insignificant effects (no. 4.6.1.1 of the Technical Instructions for Air Pollution Control) without further examining the prior or comprehensive pollution of the area concerned. Hence, it is not possible to precisely determine immission-related impacts.
- Regional differentiation: Differing capacities or sensitivities of the natural balance or the characteristics of the site in question often require regionally or locally differentiated immission standards which are specific to a given project. The case-by-case assessment necessary for planning should also be addressed here.
- Demand for an approach that spans all protected assets and pollutants: The introduction of Environmental Impact Assessments (EIA) explicitly requires consideration of the reciprocal impacts of protected environmental assets (example: airborne pollutants that affect health via the soil–feed–food pollution pathway).
- Consideration of risk acceptors: The sensitivity of the various protected assets or uses must generally be assessed from the most unfavourable point of impact.

Inevitably, the boundary between hazard protection and precaution often remains blurred and offers scope for interpretation. However, Figure 2 shows clearly that the objectives and assessment criteria of the precautionary principle usually fall outside the legally established limits of hazard protection. The consideration of this aspect of immission control is also necessary because thus far the individual impact of each material or physical pollutant has only been considered in isolation, without taking into account the possible significance of the overall or combined impact of compound pollution (Kühling 2012; ▹ *Environmental justice*).

In the specialist literature and in practice, there is a veritable plethora of terms for evaluation standards, such as reference values, guideline values, maximum immission concentration, minimum standard, no-effect level, etc. (*SRU* [German Advisory Council on the Environment] 1996). Given all of these different terms, it is at first glance hardly clear to what extent protection or precautionary aspects play a role. Moreover, it is often not clear whether they represent purely technical/scientific assessments or whether they result from value-based decisions based on other criteria (e.g. economic feasibility). It is therefore necessary to critically analyse the specific protective or precautionary scope of assessment standards. In the absence of any valid standard-setting process as yet, the Risk Commission (2003) has developed a feasible proposal for this purpose.

2 Immissions caused by airborne pollutants

In addition to naturally occurring air pollution, trade and industry, domestic heating as well as transport and traffic as sources of pollution determine the extent of immissions. At the same time, the indirect effects resulting from the deposition or accumulation of pollutants in soils, plants or waters/sediments must also be taken into account.

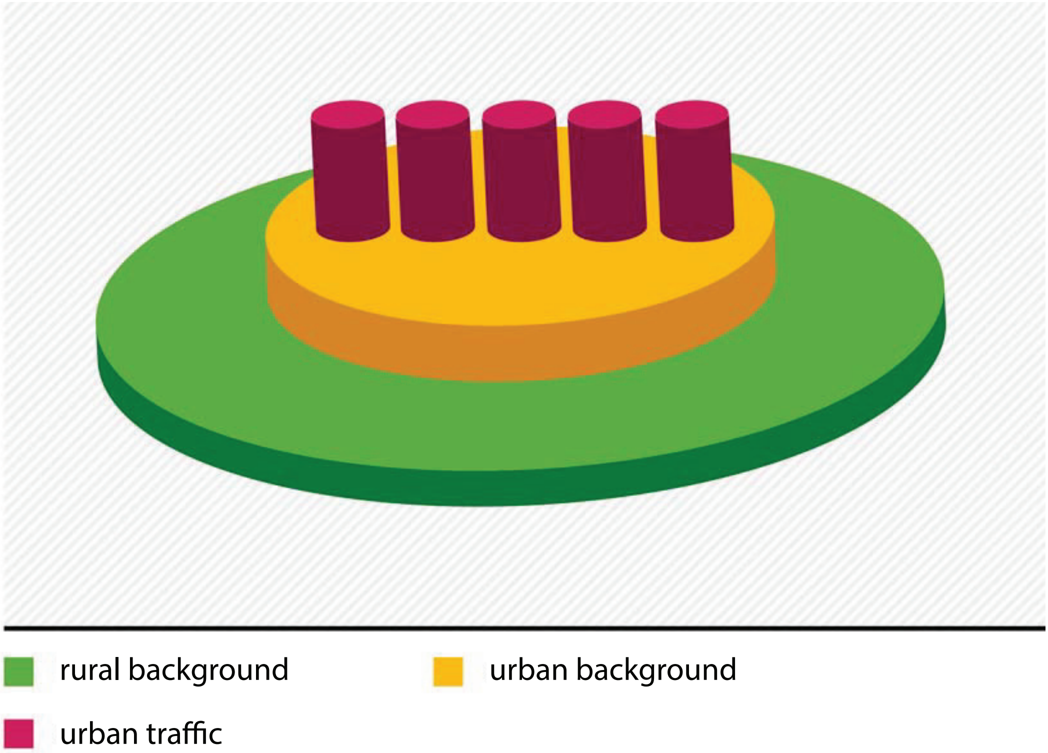
The Federal Immission Control Act and the numerous specifications in subordinate regulations such as federal immission control ordinances or the Technical Instructions for Air Pollution Control relate to substances that can cause harmful impacts on protected assets. A distinction is often made between gaseous substances (inorganic and organic), mineral acids (aerosols), particulate substances and mixtures of substances. A distinction can also be made based on quantitatively significant substances (such as nitrogen oxides, carbon monoxide, suspended solids, ozone), substances with more source-related significance (such as hydrogen chloride or fluoride, special organic substances, odour-intensive substances), substances with a particular impact risk (such as carcinogenic, mutagenic, teratogenic substances) or those with particular toxic properties. Kühling and Peters (1994) provide a general overview of the principal health-impairing or ecotoxicological impacts to be assessed from the perspective of site use.

While there has been a decrease in significant substances in recent decades, other substances remain at a more or less constant level. Especially in cities, the level of immissions from nitrogen dioxide (NO_2) and particulate matter (PM_{10}) is still unfortunately too high. Similar to previous years, it was expected that in 2013 the permissible annual average value of $NO_2$of 40 µg/m^3 would be exceeded at about 70% of the measuring stations located close to traffic (*UBA* [German Environment Agency] 2014a). In the case of particulate matter, too, the permissible PM_{10} daily average values are regularly exceeded at measuring stations located close to urban traffic. Further, the rate of exceeded limit values due to weather conditions in the period from 2000 to 2013 varied between around 10% and almost 70% (*UBA* 2014a). Kallweit and Wintermeyer (2013) determined that the impact of illness due to PM_{10} amounted to about 47,000 premature deaths per year in Germany, which corresponds to an average lifetime loss of about ten years per 1,000 inhabitants. Another concern is the continuous deposition of eutrophic substances or heavy metals (such as mercury), which causes them to accumulate in the soil.

The collected concentration values are combined in 'exposure regimes' (see Fig. 3): The 'rural background' regime refers to areas that are largely unaffected by local emissions (large-scale pollution level), while 'urban background' is characteristic of the air quality in the city (road traffic, heating, industry, etc.) and the large-scale background, the 'urban traffic' regime, prevails along busy roads. Further information on emission volumes and measurements from all over Germany are available from the German Environment Agency.

In questions of spatial development, the parameters of *prior pollution* (pre-existing pollution), *additional pollution* due to the planned project and the *overall pollution*, which is the sum of the prior pollution and additional pollution, are usually required to describe a future immission situation. Depending on the issue, existing pollution is usually recorded by continuously operating measuring stations, discontinuous measuring methods or biological indicators. The additional expected concentration or deposition of airborne pollutants for the various sources of pollution, on the other hand, is usually calculated using dispersion models.

Figure 3: Schematic representation of the exposure regimes



Source: UBA 2014a

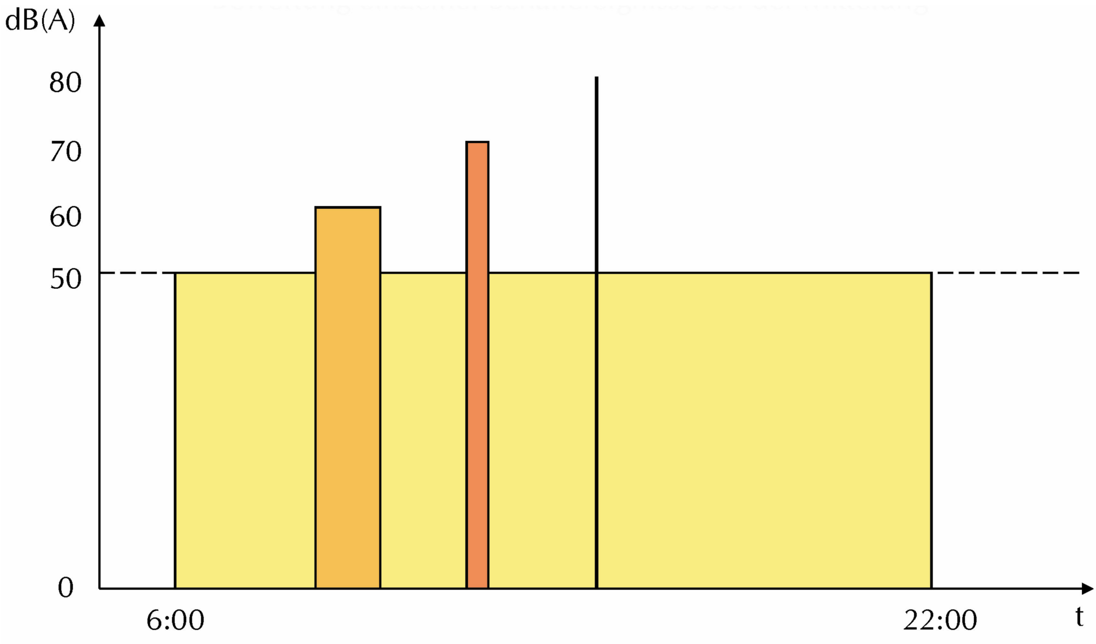
Once the expected total exposure to a substance has been determined for a given project, the level of exposure can be assessed using an evaluation scale. The legal standard of hazard prevention (see above) is less suitable for the desired level of protection in spatial planning. Kühling and Peters (1994) or Heller (2014) provide assessment criteria for a large number of airborne pollutants that are used to take into account the planning consideration of environmental precaution (Kühling 1986) and the level of protection under planning law outlined above.

The share of the additional pollution in the total pollution helps to identify the impact of the project in question on the existing pollution situation. If appropriate, emission control measures may be specified. In the case of urban traffic, this question is often not easy to answer, since supra-local pollution (rural background), other urban sources (urban background) and urban traffic immissions coincide and the measures taken in regard to a single road or specifically for motor vehicles are often not very effective. See ▹ *Air pollution control and noise abatement planning*.

3 Noise immissions

A clear distinction must be made between the physically measurable properties of noise on the one hand and the subjective perception of noise (as a disturbance/nuisance) by those affected by it on the other. Accordingly, noise is often assessed very differently depending on whether the sound is natural and familiar (and often desired, such as rustling leaves or the gurgling of mountain streams) or whether it originates from non-natural sources – despite similar measured values. Unwanted sound is called noise. The effects of noise on humans range – depending on the intensity and duration of the impact and other factors – from mere nuisance to health hazard (*UBA* 2010; Babisch 2011). The risk of heart attacks is at the foreground of the impact of widespread noise. Fauna also responds to anthropogenic noise immissions with a change in behaviour, e.g. by changing breeding behaviour or more songbirds in cities (Slabbekoorn/Ripmeester 2008).

Figure 4: Averaging to evaluate individual sound events



Noise with the following sound pressure levels and exposure times results in an equivalent continuous sound pressure level of 50 dB(A):
50 dB(A) for 960 minutes
60 dB(A) for 96 minutes
70 dB(A) for 9,6 minutes
80 dB(A) for 0,96 minutes

Source: The authors

The physically measurable sound pressure level is usually indicated with the unit dB(A). The evaluation curve A adjusts the sound to the human perception of hearing. The physical quantity (sound pressure or sound intensity) is logarithmically scaled (a level increase of 10 dB(A) means a tenfold increase in the sound power or a doubling of the perceived loudness). Values that are averaged over a longer period of time (e.g. 8, 16 or 24 hours in road traffic) usually apply. Short-term individual levels are hardly significant in the averaging. However, they can achieve a level that can have an impact on health (e.g. by waking up someone sleeping at night). Figure 4 illustrates the effect of short-term high levels on temporal averaging. Further problems with noise protection are described by Kühling (2014b).

Sources of noise should be distinguished according to the following categories: construction noise, industrial and commercial noise, air traffic noise, neighbourhood noise, rail traffic noise, sports and leisure noise, and road traffic noise. The current regulatory system (individual regulations of the Federal Immission Control Act) is based exclusively on the respective sources in isolation from each other, meaning that noise is assessed and delimited on the basis of individual sources. This means that, as a rule, the overall impact of noise from multiple sources is not assessed. The legal provisions on noise protection (e.g. Technical Instructions for Noise Control – Commercial Noise, 16th Federal Immission Control Ordinance – Road and Rail Noise, 18th Federal Immission Control Ordinance – Recreational Noise) are thus somewhat at odds with the purpose of the Federal Immission Control Act, which aims to limit harmful environmental effects (as total immissions). In the meantime, a standard for obtaining a sum of traffic noise has been elaborated (VDI [*Association of German Engineers*] 2013). According to the explanatory memorandum to the 16th Federal Immission Control Ordinance (German Federal Council [*Deutscher Bundesrat*] 1989), the example of the defined limit values for traffic noise shows that the costs of noise protection were also taken into account, meaning that the limit values do not only reflect the findings of noise impact research alone.

Directive 2002/49/EC (Environmental Noise Directive) introduces a noise index L_{den}, which, in contrast to the German dichotomy of day/night, now provides for an index (day/evening/night) for total nuisance and a tripartite division into day/evening/night. The preservation of previously quiet areas is now also deemed to be important (▷ *Air pollution control and noise abatement planning*). The detailed results (with graphics) of extensively mapped noise pollution are available on the websites of the German Environment Agency, the federal states and the Federal Railway Authority (*UBA* 2014b). In order to ensure the high level of protection described above, outdoor noise levels analogous to the WHO Guidelines (WHO 1999, 2009) should be observed:

- It should be possible to get a restful night's sleep even with a window open for ventilation (< 30 dB(A) average level). This corresponds approximately to the orientation value (at night) of DIN 18005 for purely residential areas: 40 dB(A), road traffic noise).
- Noise levels should not interfere with communication in residential areas – both outdoors and indoors – during the day (< 45 dB(A) average level outdoors).
- Noise levels should not impede concentration while working (average level in schools etc. indoors < 35 dB(A)),
- In the open landscape, noise impacts due to anthropogenic or non-natural sources should not significantly and qualitatively impair people's experience or ability to enjoy recreation (about < 40 dB(A)).

When new sources of noise arise, the existing elements of quiet time should not be reduced. For planning strategies, see ▹ *Air pollution control and noise abatement planning*.

4 Immissions caused by electromagnetic fields

4.1 Spatial significance

Electric, magnetic and electromagnetic fields (EMF) have been increasing for years due to the use of modern technologies. In addition to mobile and communication radio based on high-frequency EMF, this includes all areas in which electrical energy is used, especially power transmission with low-frequency alternating or direct current. Increasingly, this affects the interests of spatial planning and urban land-use planning or planning approval for the routing when energy networks are to be extended or rebuilt (▹ *Network expansion planning*).

Naturally occurring EMFs are among the ‘natural foundations of life’ and environmental conditions, which must be protected according to the constitution in Germany (Article 20a of the Basic Law [*Grundgesetz, GG*]). At low intensity, they form the basis for living systems when, for example, the human nerve cells in the brain and spinal cord process information and stimulate the muscles to engage in activities. In the last two decades in particular, artificial EMFs have been added to the natural ones. Today, artificial EMFs are a large-scale and permanent occurrence, particularly in inhabited areas. In the field of radio frequency, a significant increase has been observed in just a few years (*LfU* [Bavarian Environment Agency] 2008). The strengths of such EMFs are sometimes more than 10,000 to millions of times higher than natural electromagnetic radiation (Bornkessel/ Schramm/Neikes 2002).

The legal basis for the regulation of electromagnetic fields is the 26th Federal Immission Control Ordinance. The norms for hazard protection established there mainly cover protection against thermal effects caused by high-frequency electromagnetic fields (HF-EMF) and against irritant effects caused by high exposure to low-frequency electromagnetic fields (LF-EMF). This, however, does not take into account all further observed effects on organs below the thermal or irritant effects. For spatial planning, it is therefore usually necessary to interpret and specify assessment standards with regard to effective environmental and health protection (Kühling/ Hornberg 2014).

Any spatial consideration relates initially to the immissions acting on buildings from the outside. The focus is on spaces designed to accommodate people, especially indoor space, since – unlike air pollution and noise – magnetic and electromagnetic fields penetrate protective barriers such as walls. When considering the sources of the EMFs, a general distinction is made between:

- systems with low-frequency alternating fields, e.g. those for high-voltage alternating current transmission (HVAC) as 50 Hz high-voltage overhead lines and traction power lines with 16.7 Hz,
- systems for high-voltage direct current (HVDC) transmission and
- systems that emit high-frequency fields (e.g. mobile radio systems).

4.2 Low-frequency alternating fields

The acute effects of high field strengths on organisms have been well studied and must generally not exceed the limit value of 100 µT established by the 26th Federal Immission Control Ordinance. In addition to the requirement established in the 26th Federal Immission Control Ordinance to minimise field strengths in line with the latest technology and the ban on the overvoltage of buildings through new power lines, further assessments are required for planning considerations below the danger threshold in the low-exposure range (unit: magnetic flux density in microtesla – µT). Distances to residential buildings can be determined in order to concretise the environmental precautions required in spatial planning on the basis of the distance-dependent magnetic flux density.

A large number of investigations and studies (Kühling/Hornberg 2014; Neitzke/Osterhoff/Voigt 2006) as well as the IARC classification since 2002 of low-frequency alternating magnetic fields as potentially carcinogenic (group 2B) (WHO 2001) now substantiate the suspected hazard or the potential for concern that must be taken into account in terms of precaution. On this basis, Kühling and Müller (2002) and Kühling (2011) have established a standard for effective environmental precautions against health impacts and risks of 0.01 µT as the maximum additional exposure from the alternating magnetic field. Using the example of a 380 kV line, this indicates a required distance of about 600 m (horizontal distance calculated from the middle of the power line route) for areas used by people and thus represents an effective environmental precaution (Kühling/Hornberg 2014). Accordingly, a distance of about 30 to 150 m can be recommended for underground cables of 110 to 380 kV, which also corresponds to a magnetic flux density of 0.01 µT.

4.3 DC fields

The data on the biological impacts of *electric* DC fields are considered insufficient to derive reliable values for health impact thresholds (*SSK* [German Commission on Radiological Protection] 2013). The German Commission on Radiological Protection (*Strahlenschutzkommission*, *SSK*) therefore recommends limiting electric DC fields in order to avoid health impairments or significant nuisance. For HVDC transmission, potential safety distances for precautionary purposes should follow the recommendations for HVAC transmission, as low-frequency components cannot be ruled out in HVDC transmission either.

The ionisation of the air generated at high electric field strengths produces ozone and nitrogen oxides. Experimentally determined ozone values show values below 20 µg/m^3 near the ground for overhead lines. A reliable assessment of the effective environmental precautions should be based in the first instance on a site-specific determination and analysis of the expected prior and additional pollution for ozone. A mechanism of action is also postulated for strong *magnetic* DC fields. However, the magnetic DC field pollution to be expected from HVDC transmission is in the range of variation of the earth's magnetic field.

4.4 High-frequency fields

A viable approach to the non-thermal effects of RF-EMF (unit: power density in W/m^2) from the perspective of environmental precautions lies in the classification of these fields as potentially carcinogenic (group 2B) (Baan/Grosse/Lauby-Secretan et al. 2011; WHO 2011). Usage periods of more than 20 years have now been investigated in Sweden (Hardell/Carlberg/Söderqvist et al. 2013) and show an association between the use of mobile phones and malignant brain tumours. With all the due care taken in the assessment, the described effects justify taking measures for the purpose of preventive health protection (Budzinski 2013). This is also the view of the Swiss authorities (SAEFL 2005) and of the competent higher federal authority in Germany: in using existing wireless communication technologies and in developing new ones, attention must continue to be paid to a precautionary minimisation of the exposure of users and the population, or care must be taken to ensure that citizens are exposed to the lowest possible intensities of high-frequency electromagnetic fields (*BfS* [Federal Office for Radiation Protection] 2013). To specify the effective environmental precautions in the environmental impact assessment, Kühling and Hornberg (2014) give an order of magnitude of 100 $\mu W/m^2$ (0.2 V/m), as set out in the Recommendation for the European Commission on the Limitation of Long-Term Pollution (European Parliament 2001:2).

5 Major accident prevention

With the extension of the principle of separation under immission control law in section 50 of the Federal Immission Control Act of 17 March 1998, distance regulations for protection against the consequences of serious accidents (incidents) within the meaning of Article 3(5) of Directive 96/82/EC for areas exclusively or predominantly used for housing as well as for other vulnerable areas must also be taken into account in planning. This is in line with Article 12(1) of Directive 96/82/EC (Seveso II Directive), according to which a distance must be maintained between hazardous materials zones and areas subject to protection. A guideline for urban land-use planning (*KAS* [German Commission on Process Safety] 2010) distinguishes between three planning cases:

- the designation of new areas specifically for the construction of facilities and their operating zones,
- the designation under planning law of areas for the expansion of facilities and their operating zones and
- the increasing proximity of vulnerable areas to existing facilities and their operating zones due to spread.

Appropriate distances to hazardous materials zones should already be taken into account on a case-by-case basis when delineating planned residential areas as part of the preparation or updating of a preparatory land-use plan. A non-representative survey of 16 cities shows that so far only about half of the cities surveyed have addressed the issue of safety distances as part of the ▹ *Environmental assessment* for urban land-use plans (von Zahn/Stürmer 2013: 57 et seq.).

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