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Risk Policy in the Design of Environmental Limit Values

Abstract
Environmental limit values represent the core of current environmental legislation and probably will remain widely used beside the other tools of environmental regulation. Therefore, their proper design is of outmost importance in being able to reply to the ever changing needs of environment protection. While current limit values are usually based on concepts of natural science, we focus on how limit values can be improved by the intended involvement of socio-natural scientific factors in their design process.

Introduction
Environmental policy became one of the focus areas of governmental functions in recent years. Not only politicians have discovered that dealing with environmental protection can be the basis of their success, but we can say that the whole society is aware of the fact that the many different industrial and communal activities must respect the environment. Different tools had been developed to orientate the actors of the society towards a more environmental friendly behaviour. These tools include environmental legislation, economic pressure and the use management tools that motivate the actors for self-regulation. Of these different apparatuses, the first that appeared was environmental legislation, and which is still the most implemented and the mostly developed one of them.
The means of environmental regulation in general, to influence environment related behaviour, can be grouped in two main parts. First, environmental regulation prescribes to meet quantitative, numerical requirements, and then can frame standards for the use of

predefined technologies. Quantitative, numerical requirements may involve the use of limit values, lists, and directions for security and situations for emergency. Nowadays, the most widely and frequently used of these quantitative tools are limit values. As an illustration, with reference to the Hungarian laws and ministerial decrees, about 80-90% of the environmental regulation were and are based on limit values in Hungary.

The reason for its popularity can be interpreted by its pleasing advantages. First, limit values are independent of technologies and processes – a limit value of a compound introduced for air quality should be also applicable in heavy industry or in case of any biotechnological processes. The control of an environmental actor, that is to know weather he complies or not with these limit values, is easier, compared to verification processes that target the fulfilment of technological directives. Finally, limit values seem to be easier to develop for the regulation of a new compound in contrast to the other environmental legislation tools.

In the present paper, we start with introducing some of the problems that environmental policy has to and will have to deal with in the recent future. Then, we analyse which area of environmental regulation is well developed, and present its advantages and disadvantages. We describe the current basis of its development, and point out the main weakness of the procedure. Later, we make the reader familiar with the basic concepts of incertitude in risk calculations, based on a recent literature study. In conclusion, we resume the situation and present our suggestions for possible improvements.

Problem Outline

Limit values usually refer to some kind of environmental damage, that if it happens, a certain sanction will be applied on the actor. The limit value and the sanction are both key elements in pressurizing the actor towards an activity that respects the environment. However, here we only analyse the design process for setting a certain level of a limit value, leaving the analysis of sanctions for further investigations.

Limit values bear some disadvantages, too. Because of their original character, they should have been defined for every different material considered being important for control. This is an impossible task being given the enormous number of the different compounds found in technological processes and side effect products. There are attempts to control combined effects with limit values, but recent research results revealed the particular complexity of this task. After the first decades of environmental legislation, practice showed that defining a limit value for a certain compound is not as simple as it appeared to be, and should be included into a complex process of social negotiation.

The main point of debate of the current study is to give suggestions to the following problem: how could the experts develop levels of environmental limit values that reply better to the demands of real-life situations? To cover the subject in detail, we will focus on these three questions: How can the current design process of the levels of limit values be described? Which tools could help us to improve the usefulness of limit values? Where and how should these tools be applied to acquire better limit values?

A Design Process of Limit Values in Environmental Policy

The development of a limit value usually tracks the following pathway. At the commencement, people became aware of a certain environmental change, usually negative, and hence start to talk about a certain environmental damage. Scientists analyse the environment, and characterize a compound, or a series of compounds that can be responsible for the change, if the situation is found to be related to chemical-biological reactions. The need for the environmental regulation of these compounds appears, and the adequate authorities initiate the process of establishment of a limit value for this compound. Here, they turn to natural scientists of different disciplines, to analytical chemists, to chemical engineers, biological chemists, experts in health protection, asking what should be the level for this compound that can be set as a limit in the regulations. Scientist then analyse the compound, try to describe its possible reactions and effects in the environment, try to run sample model reactions. They construct dose-response curves for biological effects, develop mathematical relationship models for reversible and irreversible effects (Stresser, 2000). The scientists present the results to the regulators, who, based on the reasoning provided by the concepts of natural science, link the limits to certain sanctions, and formulate a law, decree or decision.

While this plan of action seems to be rather scientific and methodologically well established, the following phase reveals, that limit values are adjusted on a trial-and-error basis, as when the introduced level of the limit value, or the sanction is not well applicable in the real-life situations, the regulator modifies them. Given that the level was too easy to acquire, and their accomplishment did not result in a better environment, the regulator proposes a level that is more sever and is more likely to assure a better quality of the environment. In case the level was too hard to acquire, the actors were not interested in modifying their techniques, because it would need a financial investment from their part that is impossible to accomplish. Consequently, the regulator usually sets the limit value to a new level that is more sensible for the actor to respect. In both examples, the limit value differs from its original level developed by natural scientific deductions. These modifications can prolong the appearance of the finally usable limit values with years or even tens of years, as the regulations can usually be modified only on a yearly basis, and the reply of the actors varies on the time level of years, accordingly. Therefore, the described situation demonstrate a design process that originally was really based on the facts of natural science, but is followed by an extended trial-and-error procedure to find *the* level of a limit value that is possible to accomplish and is motivating for the actor to modify its technology at the same time. This trial-end-error phase in the design process consider non natural scientific factors in an implicit manner, like economical influences, reaction of the actors to a new regulation, managerial factors, public debates of technology (Hronszky, 2002). The explained method gave for some compounds “working” limit values that are useable in real-life, limit values that work in certain industries. However, does not in others. Yet, we still have a long list of materials, that have a limit values in environmental regulation, but they hardly have a relation with the quotidian problems of environmental regulation.

The concepts of incertitude, uncertainty and ignorance in risk analysis

The basis of many decisions processes of industrial management implies the use of risk factors. Therefore, the conscious involvement of risk factors in the design of limit values sounds reasonable, and in fact, they are currently taken into account. However, during the formation of environmental standards, experts consider risk factors only in an implicit way, if they consider them at all. Limit values reflect some kind of an environmental damage that is imposed by a certain probability. Obviously, experts will then legislate the limit values for cases those risk is relatively high in a more severe way. Namely, for environmental damages those outcome is considered more harmful, or for damages that occur with a higher probability when the limit value is not considered. Consequently, for the implementation of the risk concept in the definition of limit values, we should handle both probability and outcome, in an explicit, intentional way. Let us describe more in detail two notions that are also at the basis of risk calculations.

Stirling (1999), points out that while a mathematical apparatus for risk calculations is already available, they can only be used if our knowledge about likelihoods and outcomes are accurate. However, many situations provide only unspecified information of these factors, hence the multidimensional risk factors, and so the limit values can become inaccurate for the decision making process. In the case of *uncertainty,* when our knowledge is based on a poorly defined likelihood, scenario analysis can be applied to improve our knowledge. When *ambiguity* is present, that is the outcomes are poorly defined, sensitivity analysis can provide an effective way to get a better knowledge of the problem. Finally, when both likelihood and outcomes of a technological risk are inadequately expressed, we talk about *ignorance.* These considerations show that in typical "post-normal" research the source of information of the above techniques should originate not on the calculations, but on expert opinions and public participation. Concerning damage, framing decisions about the different aspects and dimensions of risk is necessary based on the social discourse. This enables us to identify the issues relevant in the calculation, as it is explained by Stirling (1999).

Applying Concepts of Risk in the Design of Limit Values

We think that the design process of limit values, should originally based on natural scientific reasons, but the conscious involvement of socio-natural scientific factors would significantly reduce the time necessary to arrive to a final level of the environmental limit value, that accomplishes its main purpose, and motivates the actors to modify their technology and produce less of the compound under discussion. One important socio-natural scientific factor, beside economical, psychological, managerial and others, could be the use of the concept for risk calculations in the classification of limit values. We should group the limit values into different categories: to a category where the limit value corresponds to an environmental event those risk is calculateable, thus the knowledge on both the probability and the outcome are accurate, and environmental events those risk is only estimateable, should be regulated separately. *Figure 1* explains how limit values can be separated into two groups, using the concepts of Stirling (2000).

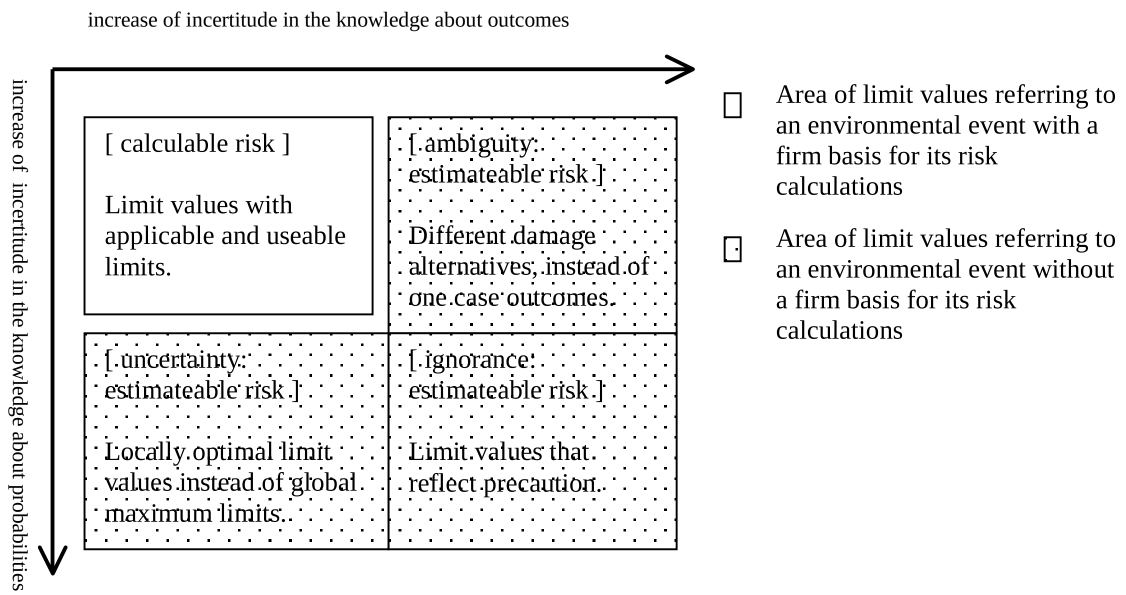

Figure 1. Distinction between limit values based on calculateable and estimateable risks.

Most likely, the limit values that belong to the first group of limit values that bear a calculateable risk factor can be more easily obtained with natural scientific calculations, and limit values of the other group require longer trial-and-error periods. In the group of limit values whose risk is only estimatable, we can make further distinctions, according to Figure 1: limit values of an environmental event those risks probability is not well known, then those with a risk referring to an outcome barely shaped and finally environmental events, where both probability and outcome are only estimated using special techniques. Practice shows, that experts are engaged to develop limit values where the damage is well known, or at least it is thought to be linked to a certain compound, and rarely work on complex effects, for example, where the large number of possible interactions between the compounds is usually only partly known, or in the medium-high range of dose-response curves (Streffer, 2000). When the limit value is based on risk calculations where originally the knowledge of the probability were uncertain, regulators arrived to a limit values that consisted of local optimum values, instead of the original global maximums, based on mathematical relationships. Where the knowledge about outcomes left the regulators in ambiguity, the final limit values usually reflect the preparation for different alternative damages. In the case of ignorance, usually the limit values do not function at all, and they result a continuous modification of their level.

Let us show some examples from environmental regulation to these areas of limit values from our personal practice. Limit values of certain polluting compounds can be classified to the first group, like those of CO_2, SO_2, NO_x, where very long term experiences, and the traceable reaction allow exact knowledge on the probability and the outcome of effects related to these compounds (The Law LIII. in 1995 of the Hungarian Parliament). These limits are well established and rarely modified. Limit values of PAH molecules can be classified to the group where the outcomes are considered to be known with short or long term carcinogenic effects – PAH molecules through their epoxides bind to the guanine of DNA chain and cause sever skin cancer. (Kozák, Farkas, Kozák, 1999.) However, due the large variety of these molecules, and to the lack of dose-response experiments, the probabilities of outcomes are not well known. We do know that these molecules are carcinogenic, but we hardly know an exposure of which concentrations will cause a skin cancer in 5 years, for example. Existing global limit values are rather used as guidelines, for example to compare the results of a monitoring investigation (Virender et al. 2001), and suggestions are given for local concentration limits. For other compounds – even like cyanide, that is classified as “priority pollutant” under the Clean Water Act – outcomes were well described and various well established dose-response relationships were given (Annachhatre, Amorkanev, 2000; Boening, Chew, 1999.), new situations, see continental scaled disasters, present new areas of outcomes, that are not defined in current regulations (Ferguson, 2000), experts advise the design of different limit values for different situations, as normal operation and emergency situations. As we can see, for certain compounds, limit values are already well established, but others need to undergo a procedure of re-designment.

Conclusions

A way to dramatically improve the development of limit values, instead of shaping the existing considerations, is the intended involvement of new factors into the design process. These factors should origin from the area of socio-natural sciences, beside the already existing natural scientific factors. Among the several socio-natural scientific reasons, we suggest that one not only should *concern* to involve *risk policy* and risk analysis in the design process, but to *base* the formation of *limit values on the results of risk analysis*. Limit values can be classified into two main groups in regard to risk calculations: the first group involves limit values with a firm basis for risk calculations, while the other group assembles limit values whose risk calculations are without a firm base in a certain way.

Endword

This study was aimed to reveal the importance of the procedure how limit values are designed for environmental policy. The first part of the paper presented the usual way of the design process of limit values. Then, the notions and the basic concepts of risk calculations applicable to the design were introduced. Finally, we have described, how this concepts of risk can be applied to classify limit values in a new way.

This paper introduced a new way of classification of limit values that can help a more conscious involvement of risk factors in their design process. The elements of the presented analysis are just the first steps of this research project. The development in detail of the concept described, that is how the different areas should apply to the design process - involving the legislation of particular compounds, and the efficiency of limit values of the compounds-, are planned for enquiry for the coming year. We hope that focusing on the process of the design of limit values will lead us finally to more useful and more efficient environmental regulation and thus to a better environment.

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